Lower Muskingum River Watershed Management Plan:
Meigs Creek Subwatershed

Prepared by

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ACRONYM REFERENCE

AEP-American Electric Power

AMD-Acid Mine Drainage

AMDAT-Acid Mine Drainage Abatement and Treatment

AWS-Agricultural Water Supply

BMPs-Best Management Practices

BOD-Biological Oxygen Demand

BH-HVRDD-Buckeye Hills-Hocking Valley Regional Development District

BHTC&D-Buckeye Hills Resource Conservation & Development Council

CCC-Civilian Conservation Corps

COD-Chemical Oxygen Demand

CRC&D-Crossroads Resource Conservation & Development Council

CSO-Combined Sewer Overflow

CWH-Coldwater Habitat

DBH-Diameter Breast Height

DO-Dissolved Oxygen

ECEF- Ely Chapman Educational Foundation

EPT-Ephemeroptera (mayfly), Plecoptera (stonefly), Tricoptera (caddisfly)

EWH-Exceptional Warmwater Habitat

FEMA-Federal Emergency Management Agency

FLMR-Friends of the Lower Muskingum River

FWPCA- Federal Water Pollution Control Administration

GIS-Geographical Information Systems

HVCRC-Hocking Valley Community Residential Center

IBI-Index of Biological Integrity

ICI-Invertebrate Community Index

ILGARD-Institute for Local Government Administration & Rural Development

IWS-Industrial Water Supply

LRW-Limited Resource Water

LTM-Long-term Monitoring

MRAB-Muskingum River Advisory Board

MRM-Mineral Resources Management

MS-Master's of Science

MWCD-Muskingum Watershed Conservancy District

MWH-Modified Warmwater Habitat

NEFCO-Northeast Ohio Four County Regional Planning & Development Organization

NFIP-National Flood Insurance Program

NOAA-National Oceanic and Atmospheric Administration

NPDES-National Pollutant Discharge Elimination System

NPS-Non-point Source Pollution

NRCS-Natural Resources Conservation Services

NTNC-Non-Transient Non-Community

NTU-National Turbidity Unit

OAC-Ohio Administrative Code

ODNR-Ohio Department of Natural Resources
- **-ACSI-**Appalachian Clean Streams Initiative
- **-AML-**Abandoned Mine Land
- **DNAP**-Division of Natural Areas and Preserves
- **-MRM-**Mineral Resources Mgt.

ODOD- Ohio Department of Development

ODOT-Ohio Department of Transportation

OEPA-Ohio Environmental Protection Agency
- **-SEP-**Supp. Environ. Projects
- **-OEEF**- Ohio Environmental Education Fund

OES-Order of the Eastern Star

OOGEEP-Ohio Oil and Gas Energy Education Program

ORSANCO- Ohio River Sanitary Commission

OSM-Offices of Surface Mining
- **-ACSI-**Appalachian Clean Streams Initiative

OSU-Ohio State University

OU-Ohio University

PCBs-Polychlorinated Biphenyls

PCR-Primary Contact Recreation

POTW-Publicly Owned Treatment Works

PPM-Parts-Per Million

PWS-Public Water Supply

QHEI-Qualitative Habitat Evaluation Index

RC&D-Resource Conservation & Development

RCRIS-Resource Conservation & Recovery Information System

RECOVER-Regional Coalition for Ohio Valley Environmental Restoration

RM-River Mile

RT&E-Rare Threatened & Endangered

SCR-Secondary Contact Recreation

SEPTA-South-Eastern Probation Treatment Alternative

SSH-Seasonal Salmoid Habitat

STORET-Storage and Retrieval

SWAP-Source Water Assessment and Protection

SWCD-Soil and Water Conservation District

TDS-Total Dissolved Solids

TMDL-Total Maximum Daily Load

TNC-Transient Non-Community

TOC-Total Organic Carbon

TRIS-Toxic Release Inventory Services

TSS-Total Suspended Solids

USACE-United States Army Corps of Engineers

USDA-United States Department of Agriculture
-**ERC**-Economic Research Service

USGS-United States Geological Survey

USFWS-United States Fish and Wildlife Service

VISTA-Volunteers in Service to America

WET-Whole Effluent Toxicity

WLA-Waste Load Allocation

WNF-Wayne National Forest

WPCLF-Water Pollution Control Loan Fund

WQPSDs-Water Quality Permit Support Documents

WQS-Water Quality Standards

WTP-Water Treatment Plant

WWH-Warmwater Habitat

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EXECUTIVE SUMMARY

PURPOSE OF PLAN

The Lower Muskingum River watershed management plan serves as a guide for the Friends of the Lower Muskingum River (FLMR) and its partners to improve and protect water quality in the watershed. The first section of this plan describes the entire Lower Muskingum River watershed and contains a definition of the watershed, historical and background information, watershed group organization and partners, natural resource inventory, water quality and water resource inventory, causes and sources of impairments, geographic information, cultural resources, and the physical attributes of streams and floodplains for the Lower Muskingum River. Conducting water quality characterization and developing action plans for such a large area like the Lower Muskingum watershed is beyond the capabilities of the FLMR group; therefore, this management plan focuses on a section of the watershed, the Meigs Creek Subwatershed.

Water resource quality (especially pertaining to nonpoint source pollution), watershed impairments, watershed restoration and protection goals, implementation, and evaluation will be addressed for only the Meigs Creek Subwatershed in this plan. This section will address the actions that need to be taken in Meigs Creek to restore or protect water quality and thus to meet aquatic life use designations. Additional sections of the Lower Muskingum River watershed will be addressed through future planning efforts and will be attached as additional sections. The goal of the watershed organization is to eventually assess the entire Lower Muskingum River and develop action plans to address nonpoint source pollution in the watershed plan through several manageable stages.

Watershed Stakeholder Involvement

The management plan's Leadership Review Board, a group of community leaders, were charged with reviewing the draft plan and providing comments. The members of the Leadership Review Board met to offer feedback about the strengths and weaknesses of the plan. Members of the Leadership Review Board present at this advisory meeting, which took place on September 16, 2004, were the following people:

Cara Dingus –Senator Voinovich's Office
Johns Grimes – Washington County Commissioner
Karen Sloan – Senator DeWine's Office
Trudy Massey – Bloom Township
Ann Marie O'Grady – Congressmen Ney's Office
Bob Mulligan – ODNR Division of Soil & Water
Dr. Jean Scott – President of Marietta College
Jay Huck – Muskingum County Clerk
Barb Bucey – Morgan Township Clerk
Gary Kaster – American Electric Power, Ohio
Gail Hesse – Ohio Environmental Protection Agency
Amber Michel – Lower Muskingum River Watershed Coordinator

This group of community leaders offered general feedback which highlighted the need for increased communications among stakeholders and emphasized the importance of collaboration in future decision-making processes. They agreed to offer assistance in implemented the Management Plan recommendations by educating local landowners on best management practices and by offering the technical assistance needed to meet current OEPA water quality standards. They also agreed to share the group's findings in an effort to promote public participation and involvement. Moreover, several responded favorably to future opportunities to work together to establish priority projects related to water quality and increased recreation. In addition, this group agreed to remain a resource for the FLMR to rely on for future support and assistance.

SECTION I.
INTRODUCTION

WATERSHED DESCRIPTION

The Lower Muskingum River watershed is located in southeastern Ohio and is defined for the purposes of this plan as having a northern boundary south of Zanesville and a southern boundary at the confluence with the Ohio River at Marietta (Map 1). The Lower Muskingum River watershed is made up of the Muskingum River mainstem and tributaries including three major subwatersheds: Meigs Creek, Olive Green Creek, and Wolf Creek. However, Wolf Creek was not considered for the purposes of this plan because the Wolf Creek Watershed Project is already undertaking watershed planning and implementation efforts in that basin. Other notable tributaries of the Lower Muskingum River, located north to south along the mainstem, include: Blue Rock Creek, Island Run, Bald Eagle Run, Big Run, Cat Creek, and Rainbow Creek.

The Lower Muskingum River watershed encompasses sections of four counties: Muskingum, Morgan, Noble, and Washington. The majority of the watershed is rural but contains many small villages and towns. Marietta, located in Washington County, is the largest city in the watershed with a population of 14,515. Another notable town is McConnelsville, which is the county seat of Morgan County and has a population of 1,676 (U.S. Census Bureau 2000). Both Marietta and McConnelsville are located on the Muskingum River. Sections of the Muskingum River or tributaries are not listed as state scenic or wild rivers. Regulated Phase II Stormwater communities are all in the southern portion of the watershed and include Washington County, Marietta and Muskingum townships, and the City of Marietta.

Geographic Locators

The Lower Muskingum River watershed is comprised of four 11-digit hydrologic units codes (HUC), which are summarized in Table 1 (excluding the Wolf Creek Subwatershed) (Map 2). There are seven streams or stream segments identified and listed in the Ohio EPA 305(b) Report. Four of the seven are segments of the Muskingum River which include: OH24106 – Salt Creek to Miller's Run, OH2492 – Miller's Run to Meigs Creek, OH2417 – Meigs Creek to Big Run, OH241 – Big Run to mouth. Two are sub-basins of the Lower Muskingum River, which include: OH226 – Big Run and OH2474 – Meigs Creek. The final listed basin is Dyes Fork - OH2480, which is a large subwatershed of Meigs Creek.

Table 1

Eleven Digit Hydrologic Unit Codes for the Lower Muskingum River Watershed[1]

11 Digit HUC Code	Location	Size (mi^2)
05040004070	Muskingum River dst. Licking River to above Meigs Creek (excluding mainstem) [2]	182.1
05040004080	Meigs Creek Subwatershed	142 .2
05040004110	Olive Creek Subwatershed & Muskingum River below Meigs Creek to above Big Run (excluding mainstem)	104.2
05040004120	Muskingum River below Big Run to Ohio River (excluding mainstem)	90.2

[1] Lower Muskingum River Watershed excluding Salt Fork Subwatershed (159.3 sq. miles)

[2] 11 digit HUC includes portion of Muskingum River. North of Salt Creek is not considered part of the Lower Muskingum River watershed for plan purposes

CURRENT PLANNING AND MANAGEMENT

The Friends of the Lower Muskingum River (FLMR), which received its 501(c)3 status in 1998, is a partnership of groups and individuals coordinated by Community 20/20. Through Community 20/20, a local non-profit group designed to enhance development in Marietta, the Washington County Friends of the Muskingum River was formed in 2000. In early 2001, the group and its partners expanded its focus to the three county Lower Muskingum River to better adequately deal with the entire watershed's needs. The mission of FLMR is to, "restore, protect and maintain the physical, chemical and biological integrity of the Muskingum River and to protect and promote its natural, cultural, historic and socioeconomic resources." The FLMR has been a 501(c)3 issue advocacy group since early 2003 (see Appendix I.F. Code of Regulations). In conjunction with its partner agencies, the FLMR is steadily increasing public participation, collecting and analyzing existing water quality and biological data, identifying issues and goals, and successfully seeking funding to restore the watershed to its highest ecological potential.

Several community-based citizens groups in the Lower Muskingum River watershed are dedicated to improving educational opportunities in the watershed rather than strictly focusing on water quality issues. Community 20/20 is one such example. This group was founded in 1998 as a citizen-based action group dedicated to creating a vision for the city of Marietta in the year 2020. Priorities for Community 20/20 include developing the Muskingum River as a recreational corridor and creating a group to maintain and improve the existing bike path.

Another community-based citizens group is the Ely Chapman Educational Foundation (ECEF), which is a non-profit educational organization providing educational enrichment for groups with diverse backgrounds. ECEF provides experience-based individualized educational programs emphasizing applied learning in math and science, the fine arts, history, and ecology. They use the most current technology in a non-traditional classroom setting. Special emphasis is placed on the unique history and culture of Ohio's southeastern Appalachian region. ECEF is currently collaborating with other Lower Muskingum watershed project partners in order to explore ways the foundation can support water quality testing in the watershed and incorporate the watershed into its current and future educational programs.

The Muskingum Watershed Conservancy District (MWCD), created in 1933, is dedicated to conservation and recreation conducted in harmony with flood control in the areas drained by the Muskingum River and its tributaries. Funded from income generated by the stewardship of its lands and waters, the MWCD strives to enhance the quality of life in the Muskingum Lakes

Region and beyond. MWCD is the largest conservancy district in Ohio, encompassing 18 counties or one-fifth of the state. MWCD is bounded by the cities: Akron to the north, Marietta to the south, Mansfield to the west, and Cadiz to the east. The 18 counties include Ashland, Belmont, Carroll, Coshocton, Guernsey, Harrison, Holmes, Knox, Licking, Morgan, Muskingum, Noble, Richland, Stark, Summit, Tuscarawas, Washington, and Wayne.

MWCD is also one agency involved in the organization, the Muskingum River Basin Initiative (MRBI). This organization consists of members from the Buckeye Hills Resource Conservation & Development Council (BHRC&D), Crossroads Resource Conservation & Development Council (CRC&D), Northeast Ohio Four County Regional Planning & Development Organization (NEFCO), and many state government agencies. MRBI holds informational meetings for watershed representatives regarding current studies, problems, and funding for future projects of the Muskingum River.

Members of the Muskingum Watershed Forum represent all subwatersheds in the Muskingum River basin. This group meets bi-annually to discuss and plan efforts to improve water quality throughout the Muskingum River watershed. Individuals attending the most recent meeting on October 30, 2003 included representatives from the Ohio EPA, regional offices of the U.S. Department of Agriculture, and county Soil and Water Conservation District (SWCD). Watershed coordinators, members of citizen's groups, and ILGARD staff members also attended. Issues raised at this meeting included recognizing recent watershed group and coordinator accomplishments throughout the basin, recognizing and publicizing unique attributes of the Muskingum River watershed, and facilitating ongoing discussion of water quality problems and solutions throughout the Muskingum River basin.

The Lower Muskingum River Technical Advisory Board is composed of 15-18 individuals who meet regularly to provide technical assistance directly to the Lower Muskingum watershed management planning process. Members of the board represent several state and national government agencies. These agencies include the Ohio Department of Natural Resources (ODNR), the USDA (through county SWCDs), and the Ohio EPA. The board also includes faculty from Ohio State University and Marietta College, representatives from OSU Extension, and local citizens groups. Members have made valuable contributions to the Lower Muskingum watershed management plan, including suggested avenues of research, locations and contacts for additional sources of information, and assistance with data analysis and interpretation.

The Lower Muskingum Leadership Board is made up of individuals in local, county, or statewide leadership positions whom share an interest in working towards the health of the Lower Muskingum River. The Leadership Board provides management recommendations developed through the watershed planning process. The board was also asked to review a draft of the management plan and assist in implementing the recommended management projects.

The Muskingum River Advisory Board (MRAB) is an advisory body that was created in 1986, and is periodically renewed by the Ohio State Legislature. This group consists of 26 members appointed by state legislators, the governor, the Director of the ODNR, and boards of county commissioners from Coshocton, Morgan, Muskingum, and Washington counties. MRAB is required to meet at least annually to discuss improvements to the Muskingum River, and to present a report to the governor, General Assembly, and ODNR. A particular focus of the MRAB is the preservation of the Muskingum River's locks and dams.

Founded in 1997, the Regional Coalition for Ohio Valley Environmental Restoration (RECOVER) is an organization dedicated to the continued improvement of the Mid-Ohio River valley through awareness, education, and cooperative action. RECOVER also strives to ensure the economic prosperity of the Ohio River valley. RECOVER has formally adopted several goals into its organizational plan and bylaws, including: promoting environmentally sound management practices in the region; attracting new, environmentally-friendly industries to the region, while creating no new sources of pollution; promoting individual and community environmental stewardship.

Rivers Unlimited is a statewide group of organizations dedicated to protecting and restoring rivers in Ohio. Founded in 1972, Rivers Unlimited provides technical, organizational, legal, and networking support to watershed and community groups in Ohio. This group has also founded and supports several organizations in Ohio, including the Mill Creek Restoration Project (1993) and the Friends of the Great Miami (1999) and the Ohio Natural Heritage Rivers System. Issues addressed by Rivers Unlimited that are of special concern to the Lower Muskingum watershed include pesticide use reduction; addressing the causes and effects of streambank erosion; sediment loads and their effect on water quality; the effects of development on rivers and water quality. Recently, Rivers Unlimited co-sponsored a study with the Morgan County Chamber of Commerce that examined economic conditions in the Muskingum River corridor. The study, which was conducted by researchers at Ohio State University, found that a cleaner and healthier Muskingum River would have a positive economic impact on the region as more

recreation opportunities were created (Hitzhusen, *et al*. 1998; Hitzhusen, *et al*. 2000; Hitzhusen, *et al*. 2002).

The Lower Muskingum River management plan is supported by a large and diverse group of partners. The partners are drawn both from within the Lower Muskingum watershed and from across Ohio. As shown in Tables 2-5, these partners represent citizen groups, government agencies, industry, and educational institutions.

Table 2

Community Group Partners of the Friends of the Lower Muskingum River and Watershed Management Plan

Community Groups	Interest in Management Plan	Role as Plan Partner
Community 20/20	Improved water quality for citizens	Local participation and support; Technical Advisory Committee
Buckeye Hill Resource Conservation and Development	Water infrastructure / development, NRCS liaison, Farm Bill	Technical assistance, assist with local support, and committee participation
League of Women Voters Marietta/Washington County	Environmental education	Participation and support through FLMR
Buckeye Hills / Hocking Valley Development District	Water / sewer infrastructure improvements	Participation and support through FLMR, information resource
Rivers Unlimited	State-wide coordination with other watershed organizations	Technical assistance, water quality information resource
Ely Chapman Education Foundation	Environmental education	Local support, equipment for volunteer sampling, participation through FLMR
Regional Coalition of Ohio Valley Environmental Restoration	Reduction of airborne pollutants, deposition in surface water	Local support, information resource, Technical Advisory Committee

Table 3

Industry Partners of the Friends of the Lower Muskingum River and Watershed Management Plan

Industry	Interest in Management Plan	Role as a Plan Partner
American Electric Power	Large landowner and regulated industry in watershed	Data and information resource, property access for data collection
Duke Energy	Regulated industry in watershed	Data and information resource

Table 4

Agency Partners of the Friends of the Lower Muskingum River and Watershed Management Plan

Agencies	Interest in Management Plan	Role as Plan Partner
Ohio Environmental Protection Agency	Reduce in non-point source pollution and improved water quality in state	Funding, technical assistance, information and data resource, Technical Advisory Group
ODNR Division of Forestry	Riparian restoration, habitat conservation, wetlands and wildlife restoration	Data and information resource
ODNR Division of Wildlife	Riparian restoration, habitat conservation, wetlands and wildlife restoration	Data and information resource
ODNR Division of Soil and Water Conservation:	Reduce agricultural non-point source pollution in state	Data and information resource, technical assistance, planning assistance
Morgan, Washington, and Muskingum Soil and Water Conservation Districts	Reduce of agricultural non-point source pollution in respective counties	Technical assistance, information and data resource, local support. Technical Advisory Group
Ohio State University Extension	Water quality improvements and education	Technical assistance, information resource, educational assistance
Natural Resource Conservation Service	Reduce agricultural non-point source pollution in state	Local support, data and information resource, Technical Advisory Group
Ohio River Sanitation Commission	Water quality impacts on Ohio River	Technical Advisory Group, data resource
US Fish and Wildlife Service	Protection of endangered species in the watershed	Technical Advisory Group, biological data and information resource
Institute for Local Government and Rural Administration	Watershed restoration and protection in Southeast Ohio	All phases of planning process
Midwest Biodiversity Institute	Bioassessment and habitat analysis, training	Technical assistance

Table 5

Educational Institution Partners of the Friends of the Lower Muskingum River and Watershed Management Plan

Educational Institutions	Interest in Management Plan	Role as a Plan Partner
Ohio University	Educational resource for graduate students	Technical assistance, graduate student research, student work projects, data resource
Ohio State University	Water quality improvements, community based environmental protection	Technical assistance
Marietta College	Undergraduate education, service to local community	Technical assistance

SOCIAL AND CULTURAL RESOURCE INVENTORY

HISTORY

The Lower Muskingum River valley has a rich historical heritage complete with earthworks built by prehistoric Native American Indians, and a remarkable pioneer history including the first permanent settlement in the Northwest Territory. The valley also has a notable river history where a steamboat industry and boat-building mercantile industry were born and helped the river towns thrive. The communities dotted along the Muskingum River owe much of their rich history, romantic beauty, and economic success to the river.

Transportation

Most communities in the valley credit their settlement, industrial development, and continued sustainability to the Muskingum River. Historically, the river has supported economic development, transportation opportunities, and recreation. The river has also been essential for its abundant supply of fish, and its ability to power the numerous gristmills and sawmills along the river. The navigable waters of the river also allowed for the first permanent settlement in the Northwest Territory, Marietta, to be established and named the, "Gateway to the Northwest," because of its prime location for trading (Schneider 1968).

In the 19th century, the only means for mass transportation was to transport by water, which made access to navigable waters vital (Schneider 1968). With the introduction of the steamboat in the 1820s, the Muskingum River valley became one of the most prosperous places in the state. Grain, tobacco, linseed oil, lumber, and livestock were now regularly shipped down the Ohio River to southern markets (Scheiber 1987). Between 1836 and 1841, a system of 10 dams and 11 locks were installed to connect the Ohio and Erie Canal, providing navigable waterways from Marietta to Lake Erie (ODNR website 2004). The Muskingum Canal provided a better path for transporting merchandise from Pittsburgh and New Orleans into interior cities like Columbus (Scheiber 1987).

The introduction and success of railroads made other parts of the state more accessible and decreased dependence on navigable waters. During the "golden years" of railroad service in the Muskingum valley; 1876-1916, lines provided freight and passenger service from Marietta to Parkersburg, Palos, Cumberland, and Zanesville. The railroad commonly transported stone from

quarries at Vincent, grindstone from Marietta, and agricultural products from Cutler (Byers 2000).

The Flood of 1913

The flood of 1913 resulted in widespread and extreme flooding across much of Ohio. The Miami, Muskingum, and Scioto Rivers rose to record stages. Across the state, 500 people were killed, and property damage totals were estimated at greater than $300 million. After surveying the flood damage, the Ohio Legislature passed the Ohio Conservancy Act of 1914. The Ohio Conservancy Act was the first law of its kind in the United States and was intended to recognize and codify the state's role in undertaking public improvement projects to control flooding (Hrach 2000).

In the early 1930s, the United States Congress made money available to flood-prone states, including Ohio, for the construction of dams, reservoirs, and other permanent structures that controlled flooding. In 1933, the Ohio Legislature created the Muskingum Watershed Conservancy District (MWCD), an organization that oversees flood control and conservation issues for the entire length of the Muskingum River. The MWCD used federal dollars and assistance from the Army Corps of Engineers to build 14 dams on the Muskingum, creating 14 new reservoirs in the upper Muskingum River Valley. These reservoirs serve to protect communities downstream in the river's lower reaches from further devastating floods (Hrach 2000).

Natural Resource Exploration

The Lower Muskingum River valley has a history of being rich in the quantity and in the variety of natural resources available for exploitation. Examples of such resources include timber, coal, oil and natural gas, limestone, clay and shale, sand and gravel, sandstones, and salt. Of these resources, coal has proven to be the most influential throughout the history of the region. Ohio's large reserves, especially in southeastern Ohio and in the Lower Muskingum River valley, helped elevate its status to become one of the largest coal producing and consuming states in the United States (Crowell 1995).

In 1748, the presence of coal was first noted in Ohio. It was mined initially for domestic purposes before being discovered by industry for consumption. At the onset of the 19th century

Industrial Revolution, Ohio's role in the coal industry escalated dramatically, and the Muskingum River eventually came to play a major role in the shipment of coal. The addition of a lock and dam system during the period of 1836-1841 allowed for the shipment of coal from the interior regions of Ohio to various ports along the Ohio River. Moreover, the rise of the steamboat facilitated the movement of coal on the Ohio River from one destination to the next (Crowell 1995).

As the United States recovered from the Great Depression, the coal industry across the country still found itself struggling for survival; however, coal mining was not a complete loss in the Muskingum River valley. Partly due to the introduction of strip mining, Muskingum County became one of the seven Ohio counties to produce over one million tons of coal in 1945. Two of the best producing mines along the Muskingum River were Meigs Creek No. 9 and Middle Kittanning No.6. Once again a coal producing powerhouse, southeastern Ohio contributed to over 30,000,000 tons produced by the state of Ohio in the 1940's. The new influx of coal was responsible for powering the railroads and for supplying cheap electricity to people in cities and rural regions (Ohio Coal Association 1945).

Southeastern Ohio's dominance in the coal industry has faded since the boom experienced in the 1940's. By 1960, many of the coal seams were not economically feasible due to factors as diverse as the declining quality of the remaining coal reserves, the limited accessibility to currently viable markets, and the popularity of alternative fuels, such as natural gas and oil (BH-HVRDD 1971). However, several active surface coal mines still exist in the Lower Muskingum River valley, as shown in Table 16.

CULTURAL RESOURCES

Significant Historical Sites

There are a number of important historical sites in the Lower Muskingum River watershed, sites that document the lives of both early European settlers and Native Americans. For example, multiple Hopewell Indian mounds are preserved in Marietta, the largest and best-preserved mound being Cemetery Mound (Marietta Ohio Info website 2003). Another example is Big Bottom State Park, which preserves the site of a battle between Ohio Company settlers and Delaware and Wyandot Indians (The Ohio Historical Society website 2003).

Many historic buildings are preserved in the watershed including the Lafayette Hotel, the Castle, Stockport Mill, the Levee House, and Harmar Village. The Lafayette Hotel was built in 1918 after Marquis de Lafayette. The Castle is the former home of Ohio Senator Theodore Davis and is one of the best-preserved examples of Gothic Revival-style architecture in Ohio. The Stockport Mill is historically significant because it is the last remaining mill anywhere on the Muskingum River. The Levee House, today a restaurant, is the only remaining original riverfront building in Marietta dating back to 1826 (Marietta Ohio Info website 2003). Harmar Village in Marietta stands upon the grounds of what was once Fort Harmar, established in 1785 along the west bank confluence of the Ohio and Muskingum Rivers (Harmar Village website 2003).

Significant Cultural Sites

Several museums along the Lower Muskingum River document and preserve the lives of early Ohioans. One such attraction is the Campus Martius Museum in Marietta. The Ohio Company of Associates as a temporary home originally established campus Martius in 1788 for the early settlers of what would later become the city of Marietta. It is also considered the site of the first organized American settlement in the Northwest Territory. Today, the museum showcases the patterns of migration throughout Ohio history. One block west of Campus Martius is the Ohio River Museum. The museum is composed of exhibits that depict the origins and natural history of the Ohio River, the influence of the steamboat era on the Ohio River, and the relationship shared between man and the Ohio River (The Ohio Historical Society website 2003).

Significant Recreational Sites

Opportunities for recreation abound throughout the Lower Muskingum River Valley region. Many of these resources, such as state parks, public fishing and hunting areas, and campgrounds, involve outdoor pursuits while others promote historical sites and cultural attractions. One example is the Muskingum River State Park and Parkway, which is 120 acres and promotes activities such as swimming, fishing, hunting, picnicking, and hiking (Ohio's Appalachian Country website 2003; BH-HVRDD 1971). Another popular recreation site is Seneca Lake, which is the third largest inland lake in Ohio with 3550 acres (Places Ohio website 2003).

Other significant recreation sites include the Buckeye Trail, the J. Frank Demster Memorial Park, and the Valley Gem Sternwheeler. The Buckeye Trail, founded in 1959 as a planned hiking and horseback-riding trail from Cincinnati to Lake Erie, is Ohio's official state trail (BH-HVRDD 1971). The J. Frank Demster Memorial Park in downtown Malta offers boat access to the river (Malta Parks and Recreation website 2003). Another unique recreational experience is the Valley Gem Sternwheeler in Marietta, reminiscent of the sternwheelers that plied the Ohio and Muskingum Rivers in the 1800's (Valley Gem Sternwheeler website 2003).

Another recreation destination in the Lower Muskingum River Valley region is ReCreation Land, a 30,000-acre reclamation project conducted by AEP on strip-mined land. Over the duration of the project, at least 50 million trees were replanted and 350 lakes and ponds were established. ReCreation Land promotes activities such as fishing, hunting, hiking, camping, and horseback riding. It has been estimated ReCreation Land receives over 100,000 visitors annually and reaps $5 million for the local economy (AEP website 2003).

The region also has two notable wildlife preserves. The Wilds in Noble County is one, a wildlife sanctuary that is recognized as North America's largest wildlife conservation and research center. The Wilds is located on 9000 acres of reclaimed private land donated by AEP. Its focus is on the restoration and maintenance of prairie and wetlands habitats (The Wilds website 2003).

The other preserve, located approximately one mile north of Marietta, Ohio is the Broughton Wildlife and Education Area. This wildlife area encompasses over 500 acres and includes several trails, ponds, a natural stream, a waterfall, and several areas of undisturbed nature. Its array of wildlife makes the park an ideal location and a wide to conduct wildlife and environmental research (Broughton Nature and Wildlife Education Area website 2003).

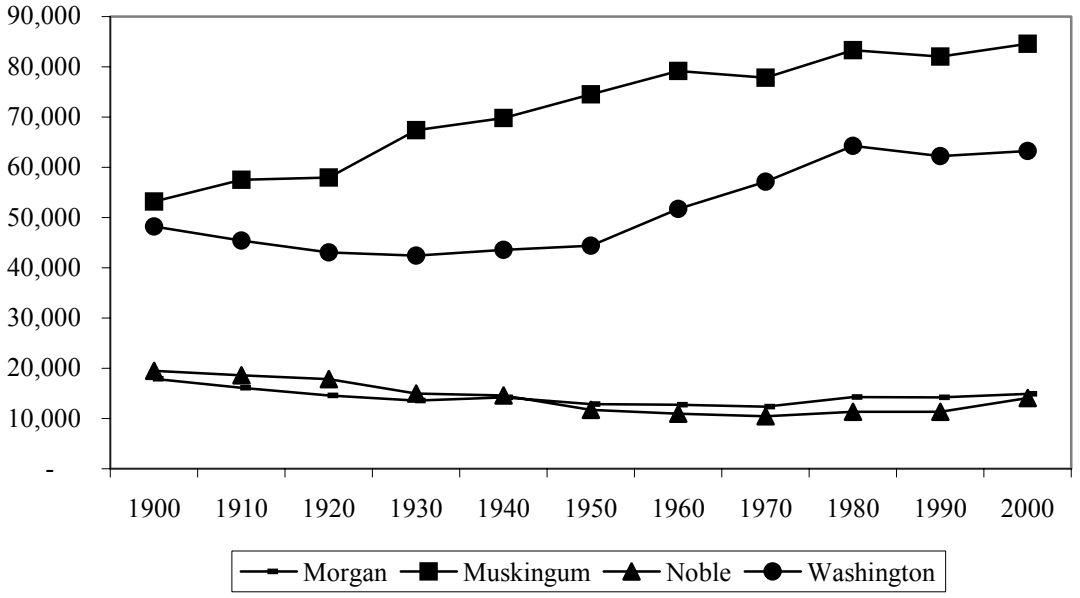
DEMOGRAPHICS

Population

Demographic data reflects a small fluctuation of population growth for the four counties in the Lower Muskingum River watershed throughout the 20th century (Figure 1). Muskingum and Washington Counties experienced population increases, while Noble and Morgan Counties remained relatively unchanged. Washington and Muskingum Counties both contain larger cities, such as Zanesville and Marietta respectively, while Morgan and Noble counties are mostly rural (Ohio Department of Development website 2004).

Figure 1

Population Growth in the Lower Muskingum River Watershed from 1900 to 2000



Source: Ohio Department of Development website 2004

Even though Muskingum and Washington Counties experienced population growth throughout the 20th century, when compared with Ohio's growth rate they were still below the average (Table 6). The state of Ohio experienced a 10.8 % growth rate or population increase, while Washington County had a 3.0% and Muskingum County had a 4.9% population increase.

Morgan County and Noble County have demonstrated a decrease in population over the last 100 years (Ohio Department of Development website 2004).

Table 6

Comparison of Average Population Growth Rates between Counties within the Lower Muskingum River Watershed and the State of Ohio, 1900 – 2000

County	Percent Population Change
Morgan	-1.5
Muskingum	4.9
Noble	-2.5
Washington	3.0
Ohio	10.8

Educational Attainment

Educational attainment for people over the age of 25 in Ohio and the Lower Muskingum River watershed counties has dramatically shifted towards higher levels of education over the last ten years from, 1989 to 1999 (Table 7). The most noticeable changes are the decrease in the percent of the population with less than a high school diploma and an increase in the percent of the population with bachelor's degrees. Regardless of the increase in those obtaining a higher education, it is clear that this achievement has not occurred at a rate equal to that for the entire state. Moreover, the Lower Muskingum River watershed counties overall showed a higher percent of the population having high school diplomas and a lower percent of the population with bachelor's degree than the state (United States Census Bureau 1990 and 2000).

As illustrated in Table 7, the watershed's county population with less than a ninth grade education decreased from 9% to 4% of the population. The population obtaining some high school with no diploma also increased from 1989 to 1999 (17% to 14%), but not to the states extent (16% to 11%). The percent of the population over 25 with a high school diploma or equivalency decreased slightly from 45% to 44% over the census period. Increases in the percent of population were seen in some college (13% to 18%), associate degree (5% to 7%), bachelor's degree (7% to 8%), and graduate or professional degree (4% to 5%).

Those obtaining some college but no diploma in Ohio increased from 17% to 18%, while

this category increased by 5% in the counties of the Lower Muskingum watershed. The percent of the population with an associate degree as their highest level of educational attainment for the state remained stable at 5% from 1989 to 1999; however, it increased from 5% to 7% for the four counties of the Lower Muskingum. One of the most noticeable differences between the state and the counties of the Lower Muskingum watershed is the percent of the population with a bachelor's degree. While this category increased from 11% to 23% in the state from 1989 to 1999, it increased only slightly in the Lower Muskingum watershed from 7% to 8% (United States Census Bureau 1990 and 2000).

Table 7

Percent of Educational Attainment for the Population Over 25 Years of Age in Counties of the Lower Muskingum Watershed and Ohio Combined in 1989 and 1999

Educational attainment	Lower Muskingum Counties 1989	Lower Muskingum Counties 1999	Ohio 1989	Ohio 1999
Less Than Ninth Grade	9%	4%	8%	4%
Grades 9th - 12th, No Diploma	17%	14%	16%	11%
High School Graduate	45%	44%	37%	32%
Some College	13%	18%	17%	18%
Associate Degree	5%	7%	5%	5%
Bachelor's Degree	7%	8%	11%	23%
Graduate Degree	4%	5%	6%	7%

Source: United States Census Bureau 1990 and 2000

Economic Characteristics

The counties within the Lower Muskingum River watershed have a lower average income rate than the rest of the Ohio and the United States. Although median family income rates increased for all the counties of the Lower Muskingum River watershed they are consistently lower than the state and the entire United States from 1994 – 2003 (Table 8). Morgan County experienced the least amount of income growth rate (3.2%), with Muskingum County's income growth rate slightly higher at 3.7%. Noble County experienced the highest average income growth rate (4.3%) of the three counties and is comparable to Ohio and the US (4.5%). Economic data for Washington County was not available.

Table 8

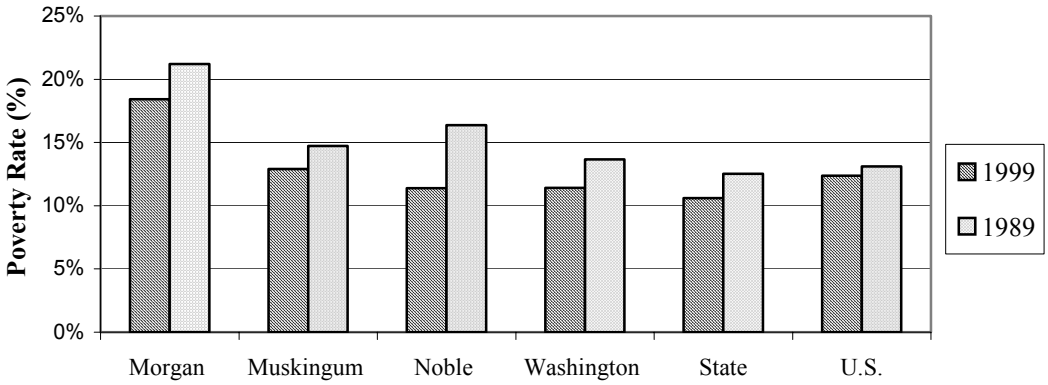
Comparison of Average Median Family Income Growth Rates Between Counties in the Lower Muskingum River Watershed, the State of Ohio, and the U.S., 1994 – 2003

Location	Average Income Growth Rate (%)
Morgan County	3.20
Muskingum County	3.70
Noble County	4.30
Washington County	N/A
Ohio	4.50
United States	4.50

Data from the 1990 census reveals that all counties within the Lower Muskingum River watershed have higher poverty rates than both the state of Ohio and the U.S. (Figure 2). Data from the 2000 census shows poverty rates for the Lower Muskingum River watershed counties are still higher than that of Ohio, and the poverty rate for Washington and Noble Counties are lower than the rate for the U.S. Even though there was a decrease in poverty rates in Morgan County from 1989 - 1999, this county still has a high poverty rate at 18.5% (United States Census Bureau 2000).

Figure 2

Poverty Rates for the Counties in the Lower Muskingum River Watershed, the State of Ohio, and the U.S. in 1989 and 1999



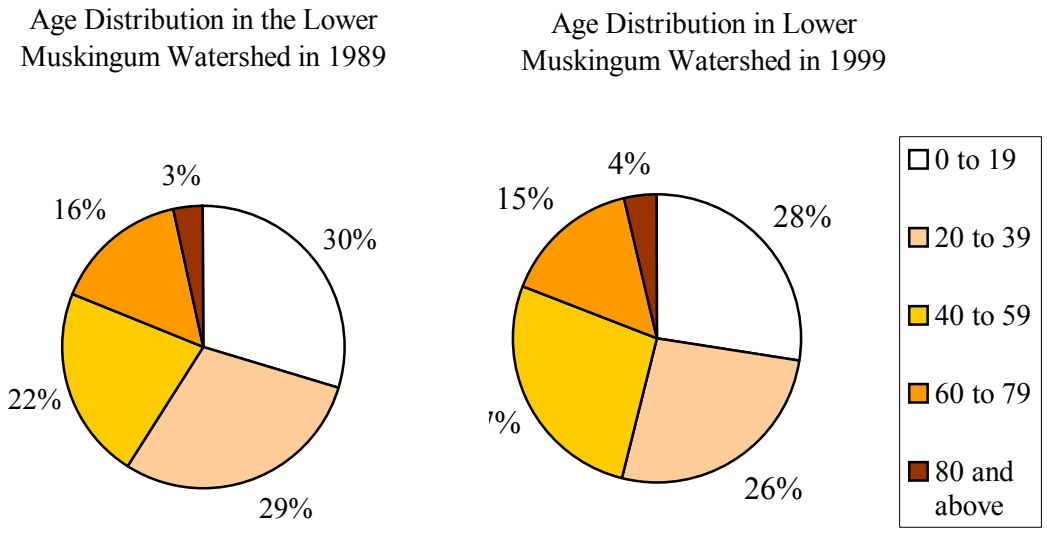
Source: United States Census Bureau, 2000

Age Ratios

According to 2000 U.S. census data, residents in the counties of the Lower Muskingum watershed are in three age groups, which make up 80% of the population: 0 – 19, 20- 39, and 40-59 (Figure 3). Trends between 1990 and 2000 U.S. Census data show a decrease in the 20 – 39 age group from 28% to 26%. This reduction is likely due to the lack of available employment in the region leading to a migration of young people seeking jobs outside the watershed. There was also an increase in the age group 40 – 59 from 22% to 27% (U.S. Census Bureau 1990 and 2000).

Figure 3

Age Distribution of the Counties Containing Portions of the Lower Muskingum Watershed



Source: U.S. Census Bureau 1990 and 2000

Age distribution for the counties in the Lower Muskingum watershed is moderately similar to data on the entire state of Ohio. However, the watershed has a lower percentage of its population between the ages of 20 and 30 than the state. In the state of Ohio, this age class made up about 30% of the population in 1999 and only 26% in the counties of the Lower Muskingum watershed. This trend provides further evidence that younger people are leaving the area due to lack of jobs.

Employment

In general, the industrial landscape of the Lower Muskingum River watershed is dominated by manufacturing, which is regarded as the most important contributor to the economic health of the region. Other important industries in the watershed include wholesale/retail trade, agriculture, and service. The two dominant manufactured products in the region are primary metals and chemicals. Further manufactured products include: stone, clay, glass, fabricated metals, and machinery (BH-HVRDD 1971).

Employment data for the Lower Muskingum River watershed counties illustrate that three of the four counties increased in employment from 1995 to 2000, while Morgan County had an employment decrease. Morgan County experienced a loss of over 350 jobs. Employment in Muskingum, Noble, and Washington counties had job increases by over 4,500, 900, and 550 respectively (US Census Bureau 1990 and 2000). Morgan County's top employer was the manufacturing industry, Muskingum County's was wholesale and retail trade, Noble County's was government, and Washington County was wholesale and retail trade. The two counties that have larger cities, Muskingum and Washington, have wholesale and retail trade as the top employers. The data for Muskingum County does not represent the watershed accurately because the portion of the county within the watershed does not contain the city of Zanesville. Government is a top employer in the two most rural counties in the watershed, the top employer in Noble County, and the second highest employer in Morgan County. Manufacturing is a top three employer in all four counties.

Morgan and Noble counties show no significant change or trends in employment by industry from 1995 to 2000. Muskingum and Washington counties both showed a decrease in manufacturing jobs. Muskingum County showed an increase in wholesale and retail trade employment and Washington County showed an increase in service employment (US Census Bureau 1990 and 2000).

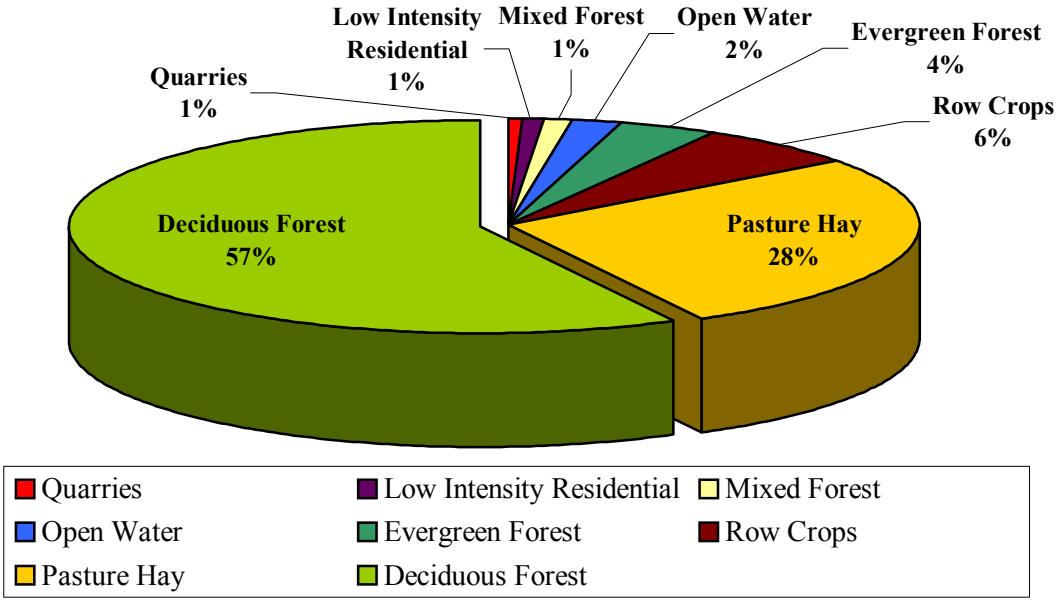
NATURAL RESOURCE INVENTORY

LAND USE CHARACTERISTICS

According to 1994 LANDSAT (satellite) data, approximately 61.9% of the Lower Muskingum watershed is categorized as deciduous, evergreen and mixed forests (Figure 4) (Map 3). All but five percent of the forest is deciduous, with trees such as oaks and hickories on the hillsides, and walnut, elm, cottonwood, and sycamore in the floodplain valleys. Due to the hilly topography, much of the area is better suited for trees than for crops. Agriculture still makes up 33.7% of the land use, with 27.6% of the land being used to grow pasture hay and 6.3% row crops. This relatively high percentage of pasture hay cultivation can be explained by the fact that many of the areas that were surface mined for coal were reclaimed to grow hay. The only remaining land use category over 1% percent is open water at 2.1% (ODNR 1994).

Figure 4

Land Use Data for the Lower Muskingum River Watershed



Source: LANDSAT Satellite Data 1994

Most farms are a combined grain-and-livestock enterprise. The majority of income comes from livestock and livestock products, which includes mainly dairy cows and beef cattle,

and to a lesser extent hogs and sheep. The 6.3% row crop land use is made up of principal grain crops including corn, wheat, oats, and soybeans, and vegetable crops consisting chiefly of tomatoes, sweet corn, snap beans, watermelons, and cucumbers. The lower end of the Muskingum River valley is known for its fertile soils, available water for irrigation, and early growing season. The areas around Marietta; Belpre, Devola, and between Lowell and Beverly have always been noted for vegetable production. The "Marietta tomato" is a well-known forerunner of the summer harvest.

Although farmers in the watershed still employ conventional tillage systems, especially in the flat agricultural lands along the mainstem of the Muskingum River, there has been an increase in awareness about "no-till" and conservation tillage practices throughout the watershed. More and more farmers appear to be adopting these techniques, similar to the national trend. In the contiguous 48 states, from 1989 to 2000, the percentage of no-till systems used on corn crops increased from 7 to 18%, while their use on soybeans increased from 7 to 33% (USDA, ERS 1994).

Crop rotation patterns vary. On the flat farmland along the mainstem of the Muskingum River, a general practice appears to be to rotate vegetable crops with hay about every three years (Kevin Wagner 2003). Farmers with agricultural lands on steeper slopes tend to rotate row crops with hay more frequently in order to help reduce soil erosion and increase organic matter content. Corn and soybean farmers also tend to rotate crops. According to national trends, farmers rotate corn and soybeans on approximately 60% of the acreage in these crops (USDA, ERS 1994). A corn/soybean rotation aids in controlling disease and weeds. The soybeans also fix nitrogen for use by the subsequent corn crop. Farmers also control weeds through the use of herbicides. Round Up is a popular herbicide employed by farmers throughout the watershed to kill weeds and grass. Another tool used to increase production is irrigation, which is mostly utilized by vegetable farmers along the mainstem of the Muskingum River.

Two other conservation-oriented techniques that have become increasingly popular throughout the watershed include rotational grazing patterns for livestock and the planting of grass buffers along waterways (grass waterways are natural or constructed outlets or waterways protected by grass cover (OSU Extension 1996)). Both help to reduce erosion, which has been identified as one of the biggest management concerns throughout the watershed. Much of the agriculture in Noble County, for example, is dictated by topography. Most of the narrow "creek-bottom" land is tilled, while most of the sloped hillsides are planted in no-till or reduced-till crops, meadows or pasture land. Land stewardship in order to reduce erosion and increase productivity is important to Noble County farmers (OSU Extension 2002).

Urban areas account for approximately 1% of the total land use in the watershed. The largest urban areas are found in the southern reaches of the watershed in Marietta and Devola. McConnelsville and Malta are the most populated areas in the middle reaches. Commercial/industrial/transportation land use areas, which account for only 0.26% of the watershed, tend to be concentrated in these urban areas. Trends in land cover change from 1982 to 1997 have shown increases in the percentages of urban and forested land and decreases in total farmland and pasture land in particular.

American Electric Power (AEP) owns approximately 60% of the land within the Meigs Creek Subwatershed. In 1961 AEP established the 30,000-acre reclamation region known as ReCreation Land. It contains over 350 lakes and ponds, along with nearly 380 campsites that are available for public use.

Development Trends

Transportation

Table 9 below depicts the most notable transportation projects currently being pursued within the watershed. All listed projects are located in Washington County and address safety concerns. Currently there are no significant projects occurring in Muskingum, Noble, or Morgan Counties. One notable transportation fact is that Morgan County is the only county in Ohio without a four-lane highway. It is expected that this distinction will limit future development in Morgan County (Ohio Department of Transportation website 2003).

Table 9

Current and Proposed Transportation Projects in Washington County, Ohio

	Route	Description	Recommended Countermeasures	Estimated Cost
High Cost	SR 7	SR 676 to SR 60	New alignment / bypass	$50 million
	SR 60	SR 7 to Marietta Corp. line	New alignment / bypass	$50 million
Low Cost	SR 60	SR 7 to SR 821	Upgrade signs; pavement markings; improve signals	$10,000

Source: Ohio Department of Transportation website 2003

Land Use

There are currently no major land development projects occurring in Morgan, Muskingum, Noble, and Washington Counties. However, one recent event may stimulate development in the near future. On November 1, 2003, American Electric Power, in conjunction with Ohio Power Company, auctioned off 2,648 acres of their ReCreation Lands holdings. Spread throughout Morgan, Muskingum, Noble, and Washington Counties, the acreage was subdivided into 70 tracts and was advertised as attractive for the development of home sites and for the pursuit of recreational opportunities (Schrader Real Estate and Auction Co., Inc. website 2004).

Agricultural

Tables 10-12 illustrate the agricultural climate in Morgan, Muskingum, and Washington Counties from 1991 to 2001 (OSU Extension Data Center website 2004).

Table 10

Farm Production in Morgan County, Ohio from 1991 – 2001

Year	Number of Farms	Average Farm Size (acres)	Land in Farm Use (acres)
1991	610	195	119,000
1992	590	198	117,000
1993	620	184	114,000
1994	630	178	112,000
1995	620	179	111,000
1996	610	177	108,000
1997	630	173	109,000
1998	640	172	110,000
1999	650	171	111,000
2000	650	169	110,000
2001	630	173	109,000

Source: Ohio State University, Extension Data Center website 2004

Table 11

Farm Production in Muskingum County, Ohio from 1991 – 2001

Year	Number of Farms	Average Farm Size (acres)	Land in Farm Use (acres)
1991	1,150	172	198,000
1992	1,110	177	197,000
1993	1,180	165	195,000
1994	1,170	165	193,000
1995	1,170	164	192,000
1996	1,170	164	192,000
1997	1,190	161	191,000
1998	1,210	158	191,000
1999	1,220	157	192,000
2000	1,220	157	191,000
2001	1,180	161	190,000

Source: Ohio State University, Extension Data Center website 2004

Table 12

Farm Production in Washington County, Ohio from 1991 – 2001

Year	Number of Farms	Average Farm Size (acres)	Land in Farm Use (acres)
1991	960	154	148,000
1992	940	156	147,000
1993	970	156	151,000
1994	960	155	149,000
1995	950	154	146,000
1996	950	155	147,000
1997	970	152	147,000
1998	1,000	148	148,000
1999	1,000	147	147,000
2000	1,000	147	147,000
2001	980	148	145,000

Source: Ohio State University, Extension Data Center website 2004

GEOLOGY

Topography

The overall topography of the Lower Muskingum watershed is typical of the unglaciated portion of southeast Ohio. The topography consists of steep hillsides, narrow ridge tops, and multiple small stream valleys. Most ridge tops have elevations from 800 to 1,000 feet. Valleys are typically 0.5 to 1.5 miles wide with broad areas of undulating or rolling slopes. Tributaries tend to be narrow and are separated by steep side slopes and fairly broad ridge tops. The influences of the geology and ancient drainage systems on the topography are evident to the well-trained eye throughout the watershed. Hilltops composed of erosion-resistant sandstones are higher and steeper, while those composed of softer shales are lower and more rounded (Lessig *et al*. 1977; Steiger *et al*. 1996; USDA *et al*. 1998; USDA *et al*. 1990). Along the mainstem, there are gently to strongly sloping terraces of varying width along the narrow flood plain. These terraces are remnants of the ancient Teays-age drainage system (ODNR 2003).

Stratigraphy

The Lower Muskingum watershed lies in the Unglaciated Allegheny Plateau region. Having escaped the Ice Age glaciers, this area contains the state's youngest exposed outcrops. Most of the bedrock is of Pennsylvanian Age, although a band of Permian-age rocks are preserved in the southern reaches of the watershed. The bedrock layers, formed about 245 to 320 million years ago, are sedimentary in nature and consist primarily of shale, sandstone, and coal in the northwestern and central portions of the watershed. The bedrock layers consist of shale and sandstone in the southeast portion. Siltstone and limestone are also present. Sedimentary strata in southern Ohio exhibit a nearly-horizontal bedding trend, with a regional dip to the southeast of approximately three degrees or 25-30 feet per mile (Lessig *et al*. 1977; Steiger *et al*. 1996; USDA *et al*. 1998; USDA *et al*. 1990).

The Pennsylvanian System is divided in ascending stratigraphic order, oldest to youngest, into the Pottsville, Allegheny, Conemaugh, and Monongahela Groups. In Ohio these four groups contain many different coal seams, all of which have been mined to some degree. More than 90% of Ohio's coal production comes from the Allegheny and Monongahela Groups. In Ohio

sedimentary deposits, divisions between the major Pennsylvanian groups, were originally made on the basis of the amount of mineable coal and constitute a practical, rather than a lithological, framework for differentiating formations. However, general trends and patterns of lithological change can be recognized both within and among groups. From the base of the Pottsville Group to the top of the Monongahela Group, the percentage of sandstone decreases while the percentages of shale and limestone increase.

In Perry and Morgan counties, shale, coal, and fine-grained sandstones, with discontinuous exposures of medium-grained sandstones and brackish-to-marine limestones, dominate the bedrock geology. The Conemaugh Group is the most extensively exposed group in Morgan County, while the Allegheny Group is the least exposed. However, the Allegheny Group contains two of the region's dominant coals, the Middle Kittanning (no. 6) and the Upper Freeport (no. 7). Along with layers of limestone, the rocks of the Monongahela Group contain the other two dominant coal beds, the Pittsburgh (no. 8) and Meigs Creek (no. 9). Outcrops of the Monongahela Group can be found throughout the watershed. The Greene and Washington Formations of the Dunkard Group, which are part of the Permian System, underlie most of Washington County and do not contain significant coal reserves (Lessig *et al*. 1977; Steiger *et al*. 1996; USDA *et al*. 1998; USDA *et al*. 1990).

Soils

A soil series or association refers to soils that are of similar color, texture, structure, composition, and arrangement. They are often named for cities or towns near where the soils were first studied. The characteristics of the predominant soil associations found within the Lower Muskingum watershed are shown in Table 13. Taken from the General Soils maps, the soil association that covers most of the area within the Lower Muskingum watershed is the *Gilpin-Upshur-Lowell-Guernsey* series (ODNR 2003a). These soils tend to be low in natural fertility, low in organic matter, and acidic (Ohio History Central 1998). They are also relatively shallow compared to soils in the glaciated portions of Ohio, since they are formed from the slow weathering of bedrock (Table 14).

Table 13

Characteristics of the Predominant Soil Associations

Found within the Lower Muskingum Watershed

Soil Associations	Characteristics	
Westmoreland-Berks-Guernsey	Depth	deep and moderately deep
	Drainage	well drained and moderately well drained
	Slope	strongly sloping to very steep
	Parent material	colluvium and residuum derived from siltstone and clay shale
Lowell-Gilpin-Guernsey	Depth	moderately deep to very deep
	Drainage	well drained and moderately well drained
	Slope	moderately steep to very steep
	Parent material	residuum and colluvium derived from interbedded limestone, siltstone, shale and sandstone
Gilpin-Upshur	Depth	moderately deep to very deep
	Drainage	well drained
	Slope	moderately steep to very steep
	Parent material	residuum derived from interbedded sandstone, siltstone, and shale
Lowell-Gilpin	Depth	deep and moderately deep
	Drainage	well drained
	Slope	strongly sloping to very steep
	Parent material	colluvium and residuum derived from limestone, siltstone, shale, and sandstone
Upshur-Vandalia	Description	reddish and clayey
	Slope	steep and very steep side slopes and moderately steep ridgetops and knobs
	Parent material	residuum from shale on side slopes and ridgetops and colluvium on foot slopes
Morristown-Lowell-Gilpin	Depth	deep and moderately deep
	Drainage	well drained
	Slope	nearly level to very steep
	Parent material	calcareous material mixed by surface mining and colluvium and residuum derived from limestone, siltstone, sandstone and shale.
Upshur-Gilpin-Zanesville	Depth	deep and moderately deep
	Drainage	well drained and moderately well drained
	Slope	nearly level to very steep
	Parent material	loess, colluvium and residuum derived from shale, siltstone and sandstone
Chagrin-Mentor-Chili	Description	brownish and loamy
	Parent material	water-laid material on flood plains and terraces
Tioga-Nolin-Newark	Depth	deep
	Drainage	well-drained and somewhat poorly drained
	Slope	nearly level
	Parent material	alluvium
Chavies-Nolin-Conotton	Depth	very deep
	Drainage	well drained
	Slope	nearly level to strongly sloping
	Parent material	alluvium and stratified gravelly outwash

Source: Lessig et al. 1977; Steiger et al. 1996; USDA et al. 1998; USDA et al. 1990

Table 14

Soil Characteristics of the *Gilpin-Upshur-Lowell-Guernsey* Region

Characteristic	Soils Having the Selected Characteristics
More than 8% slope	88%
More than 3% organic matter in the upper 10 inches	< 1%
More than 27% clay in the topsoil	40%
Seasonal high water table less than 1 foot below the surface	< 1%
Bedrock less than 40 inches below the surface	19%

The hilly topography of the Lower Muskingum watershed causes various problems associated with rapid runoff and erosion and limits the use of modern agricultural equipment. Strip mining has also altered soil characteristics within the watershed and created some additional land use limitations. Reclaimed soils often have a poor moisture-holding capacity due to the large number of rock fragments and the poor structure of the subsoil. Their productive capacity is also limited by a low organic matter content and high bulk density. This limits the available water capacity for plants. The main management concerns for the dominant soil associations within each subwatershed can be found in Table 15 (Lessig *et al*. 1977; Steiger *et al*. 1996; USDA *et al*. 1998; USDA *et al*. 1990). "Soil series should be used in prioritizing of areas for BMP implementation" (Lantz 2005).

Table 15

Dominant Soil Associations, Locations, Uses, and Management Concerns within the Subwatersheds of the Lower Muskingum

Sub-watershed	Dominant Soil Assocations	Location	Common Uses	Major Management Concerns
Northern	Westmoreland-Berks-Guernsey	dissected hillsides and narrow ridgetops	woodland, pasture	erosion, slippage, drainage
	Lowell-Gilpin-Guernsey	smooth ridgetops, hillsides, and benches at higher elevations	woodland, pasture, cropland	erosion, slippage, drainage
	Gilpin-Upshur	ridgetops, hillsides, benches	pasture, woodland, cropland	slope, droughtiness, depth, slippage, erosion
	Tioga-Nolin-Newark	wider parts of flood plains along the major streams and their tributaries	cropland	flooding
	Chavies-Nolin-Conotton	broad multi-level terraces and narrow to wide flood plains adjacent to the Muskingum River	mostly cropland, some urban	droughtiness, erosion, flooding
Meigs	Morristown-Lowell-Gilpin	ridgetops and hillsides in places affected by surface coal mining	woodland, pasture, cropland	erosion, slippage, slope, droughtiness, compaction, surface ponding, stoniness, moderately slow permeability, bedrock between depths of 20 to 40 inches
	Lowell-Gilpin-Guernsey	smooth ridgetops, hillsides, and benches at higher elevations	woodland, pasture	erosion, drainage, slippage, slope
	Gilpin-Upshur	ridgetops, hillsides, benches	pasture, woodland, cropland	slope, droughtiness, depth, slippage, erosion
Olive Green	Upshur-Gilpin-Zanesville	hillsides and narrow to broad ridgetops	woodland, pasture, cropland	slope, moderately slow or slow permeability, high shrink-swell potential, droughtiness, seasonal wetness, bedrock between depths of 20 and 40 inches, erosion, slippage
	Lowell-Gilpin	hillsides and rounded ridgetops	woodland, pasture, cropland	slope, erosion, droughtiness, high shrink-swell potential, slippage, depth
Southern	Upshur-Gilpin-Zanesville	hillsides and narrow to broad ridgetops	woodland, pasture, cropland	slope, moderately slow or slow permeability, high shrink-swell potential, droughtiness, seasonal wetness, bedrock between depths of 20 and 40 inches, erosion, slippage
	Lowell-Gilpin	hillsides and rounded ridgetops	woodland, pasture, cropland	slope, erosion, droughtiness, high shrink-swell potential, slippage, depth
	Upshur-Vandalia	steep and very steep side slopes and sloping and rolling ridgetops	pasture, cropland, woodland	slope, slippage, very slow or slow permeability, erosion
	Chagrin-Mentor-Chili	band 1/2 to 1 miles wide on both sides of the Muskingum River	cropland	flooding

Glacial History

Approximately two million years ago, the southern two-thirds of Ohio was drained by an ancient drainage system known as the Teays drainage. The Muskingum watershed was formed from the combined actions of the Teays drainage and Ice Age glaciers. As glaciers from the north blocked many of the stream valleys of the Teays drainage, water levels within these newly formed lakes began to rise, and eventually overflowed to create what is now known as the Ohio River drainage system. The Muskingum River was formed as part of this process (ODNR, Geofacts 2003). Surface deposits along the mainstem of the Muskingum River consist of glacial outwash, while surrounding areas of the watershed are primarily made up of colluvium (ODNR, OGS 2003). The glacial outwash was deposited when meltwater from the last Wisconsinan glacier to the north breached a divide and deposited the material in the valley of what is now the mainstem. The outwash ranges from thin, relatively impermeable till to thick sand and broad flat-topped gravel beds (Lessig *et al*. 1977; Steiger *et al*. 1996; USDA *et al*. 1998; USDA *et al*. 1990).

Natural Resources

Southeastern Ohio is known for its impressive reserves of bituminous high sulfur coal. Starting in the 1950's, the Meigs Creek (no. 9) coal was mined in Muskingum County near Cumberland, Ohio, by the Central Ohio Coal Company, a subsidiary of American Electric Power. The majority of the surface mining associated with Muskingum Mines occurred north of the Lower Muskingum watershed. However, as coal deposits were depleted, the mines shifted southward and extended into the upper reaches of the Meigs Creek Subwatershed. The mined coal was transported by 160-ton coal haulers to a tipple, located in Brookfield Township, Noble County. Here the coal was loaded on a privately owned electric train that carried it southward for 15 miles along Dyes Fork to Central Ohio Coal Company's preparation plant located in Unionville (Section 12, Meigsville Township, Morgan County, lower reaches of Dyes Fork). From there, the coal was cleaned and shipped 4-1/2 miles overland by conveyor belt south to Ohio Power Company's Muskingum River electric-generating station near Beverly, which was built in 1952-1954. The Muskingum Mine is currently under reclamation; the last coal produced from this mine was in December 2001, following the purchase of the Muskingum Mines by Consol Energy, Inc. in July 2001 (AEP Press Release 1999). It is likely that the electric railroad, overland conveyor belt and preparation belt will be dismantled in the near future (Crowell 2003).

Pictures of the *Big Muskie,* the world's largest walking dragline machine, can be seen as it operated near Coal Hill, Meigs Township, Muskingum County (Crowell 1997). The *Big Muskie* moved more than 2 billion cubic yards of earth- eight times more than the Panama Canal- and yielded 110 million tons of coal while in operation from 1969 to 1991. Its 220-cubic-yard, 240-ton bucket is now on display at the Miner's Memorial Park located near McConnelsville in AEP's ReCreation Land. Besides the Muskingum mine, there are a few active coal mines within the Lower Muskingum watershed, but none of these are located between Philo and Marietta. These surface coal mines include: one each in Madison, Salem, and Washington Township, Muskingum County; three mines in Marion Township and two mines in Elk Township, Noble County; and one mine in Aurelius Township, Washington County (Table 16). Along the Muskingum River in Muskingum County, south of Zanesville, there are several abandoned drift (underground) mines that produced primarily Middle Kittanning (no. 6) coal and some minor amounts of Upper Freeport (no.7) coal and Lower Kittanning (no. 5) coal. A few abandoned drift mines are located about 5 miles south of Philo at Blue Rock. These underground mines were in operation at or just prior to World War II and all were abandoned by 1945. In addition, there are several active sand & gravel operations located along the Muskingum River between Zanesville and Marietta (Crowell 2003).

Table 16

Active Surface Coal Mines in the Lower Muskingum River Watershed

County	Township	Number of Mines
Muskingum	Madison	1
	Salem	1
	Washington	1
Noble	Marion	3
	Elk	2
Washington	Aurelius	1
	Total	9

Source: Crowell 2003

The Lower Muskingum watershed holds claim to reserves of natural gas and high-value, Pennsylvania-grade crude oil. The first Ohio discovery of oil from a drilled well occurred in 1814 in Noble County when a saltwater well driller discovered oil at a depth of 475 feet (USDA *et al*. 1990; OOGEEP 2003). This paved the way for Ohio's first commercial oil well, which was put into production in 1860 in Washington County (OOGEEP 2003; Lessig *et al*. 1977). Morgan County followed with oil and gas production in 1861 (USDA *et al*. 1998). Oil booms in 1875 and 1910 generated a great deal of wealth for investors. Today most Ohio producers are independent, small, family-owned businesses. The Clinton sandstone, a prevalent oil and gas reservoir throughout eastern Ohio, is the most actively drilled zone within the watershed. In 2001, Washington, Noble and Morgan Counties ranked among the top ten most actively drilled counties in Ohio (ODNR 2000).

Other natural products of economic interest in the watershed include sand and gravel, sandstone, limestone, rock salt and brine. Sandstone deposits in Cow Run are the only known economically important sandstones, and were used for canal locks, bridge piers, foundations and retaining walls. Some sandstone, which was formerly quarried from deposits of the Marietta Sandstone member and used for grindstones, is locally mined for aggregate. Both sand and gravel and aggregate deposits are mined along the entire Muskingum River. The Lower Muskingum watershed is also mined for limestone, which is used mainly for road gravel, agricultural lime, crushed stone, and concrete production.

WATER RESOURCES

Climate and Precipitation

Total annual precipitation in the watershed ranges from 38-41". The area within the watershed has a continental climate characterized by a wide range of air temperatures, higher precipitation in the spring and summer, and lower precipitation in the fall and winter. Summers are moderately warm and humid, while winters are reasonably cold and cloudy. The average annual temperature is 55°F (NOAA 2003).

Surface Water

Wetlands make up a very small percentage of the Lower Muskingum watershed. According to 1994 LANDSAT data, woody wetlands compose 0.03% of the land use cover, while emergent herbaceous wetlands make up 0.13%. Information was requested from the Army Corps of Engineers on any wetlands within the watershed that have been delineated as part of Section 404 permits since 1988. Only one has been issued during that time period, in September 2000 for Duke Energy Washington, LLC, in Waterford Township, Washington County. Twelve wetlands, composed mainly of intermittent streams and associated emergent wetlands, were delineated within the 220-acre plot (Earth Tech Inc 2000).

Information about stream length, gradient, drainage area, and elevations can be found in the Ohio Stream Gazetteer published by ODNR (ODNR 2001). Stream information for major tributaries to the Lower Muskingum River is shown in Table 17.

Table 17

Major tributaries to the Lower Muskingum River Watershed

Stream Name	Length (miles)	Ave. fall (ft/mile)	Drainage (sq. mile)
Olive Green Creek	22.0	13.6	83.1
Meigs Creek	21.2	10.7	142
Wolf Creek	47.4	8.5	234
Bluerock Creek	5.2	42.9	10.2
Island Run	6.1	45.1	13.5
Bald Eagle Run	6.4	40.4	10.9
Big Run	9.0	45.2	18.2
Cat Creek	6.9	58.0	12.1
Rainbow Creek	9.8	22.4	18.8

Source: Gazeteer of Ohio Streams, ODNR 2001.

Daily volumetric and 10-year low flow data exists for the mainstem of the Muskingum River in McConnelsville, where a USGS streamflow gage station has been in operation from October 1921 to the current year. Based on 72 years of records, the daily mean flow of the mainstem is 9,013 ft^3/sec (USGS 2003). Data is also available from a USGS gage station on Meigs Creek near Beverly that was in operation from March of 1972 to March of 1975 (USGS 1997). Information on floodplain areas is presented in maps on the following pages. It was derived from GIS information on the ODNR website (ODNR 2000). The flood hazard areas coverage represents the 100-year floodplain as contained in the Federal Emergency Management Agency's (FEMA) most recent National Flood Insurance Program (NFIP) maps at the time of digitizing (2000). Sinuosity and entrenchment indices are discussed in Section II of this plan, specifically for Meigs Creek.

Although there are no natural lakes within the watershed, there are many sedimentation ponds located in AEP's ReCreation land in the Meigs Creek Subwatershed. These ponds were created in the late 1950's/early 1960's as part of the surface mining reclamation process. Many of these lakes and ponds are currently open to the public for recreation purposes, such as boating and fishing. Historically these ponds have been stocked with fish by ODNR.

Ten lakes and four dry dams exist to the north of the Lower Muskingum watershed in the upper Muskingum River valley. The Muskingum Watershed Conservancy District (MWCD), who controls 16,000 acres of water and 38,000 acres of land, manages these lakes and dams. Many of the lakes are plagued by sedimentation problems resulting from erosion. In response the MWCD

has undertaken dredging and erosion control projects in the lakes, and has planted more than 12 million trees.

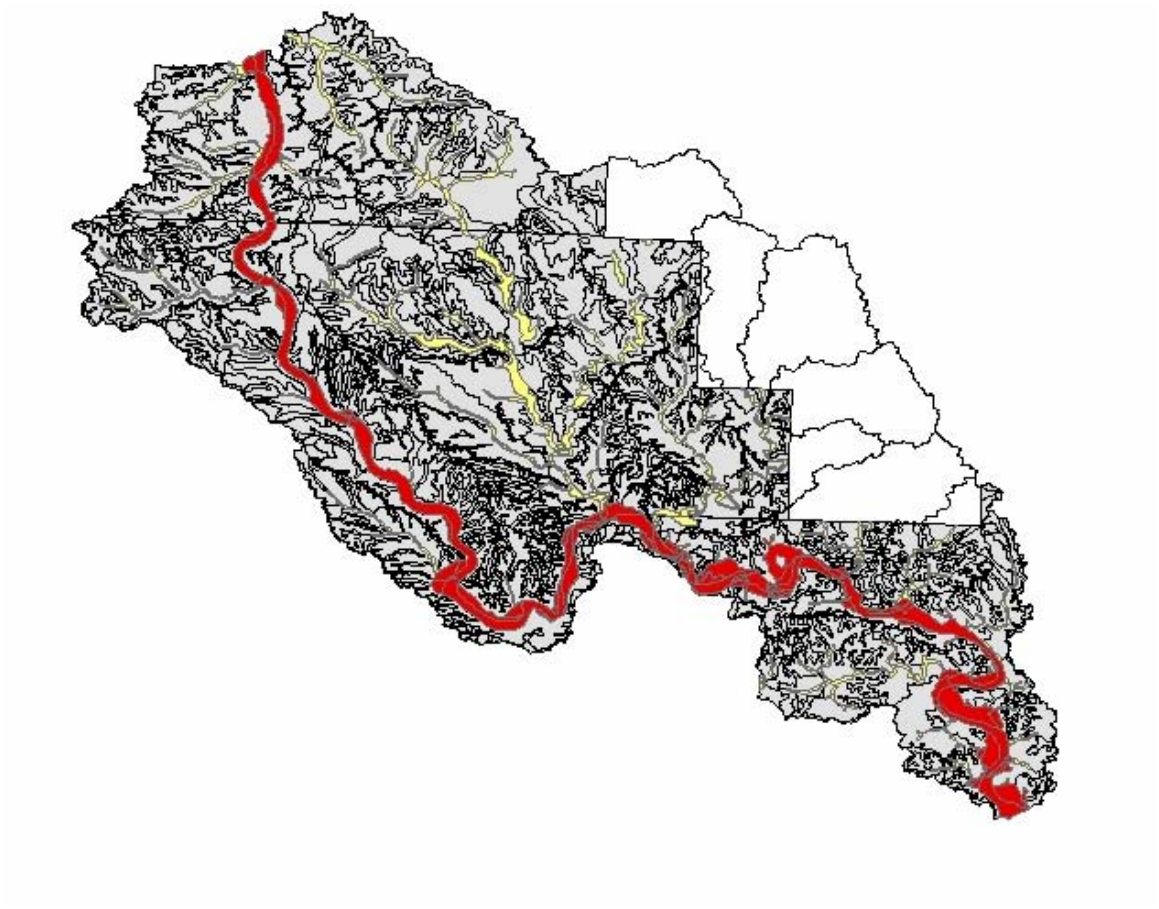
Groundwater

The Ohio EPA Division of Drinking and Ground Waters provided ground water pollution potential data for Washington, Morgan, and Muskingum counties. The DRASTIC method is the primary tool used by the Ohio EPA in evaluating the hydrogeologic sensitivity of the aquifer to contamination. It uses a relative ranking scheme, called the DRASTIC index, to help prioritize ground water resources with respect to their vulnerability to ground water contamination. Seven parameters are used to calculate the DRASTIC index: **D**epth to water, **R**echarge to the aquifer, **A**quifer media, **S**oil media, **T**opography, **I**mpact of vadose zone media, and **C**onductivity of the aquifer. Aquifers with scores greater than or equal to 140 are considered 'highly sensitive' while those scoring less than 100 are categorized as 'low sensitivity'; those between 101-139 are moderately sensitive (Ohio EPA 2003)

The Ohio EPA has identified the area along the mainstem of the Lower Muskingum River as a high sensitivity area for ground water pollution potential, while areas along the major tributaries to the Lower Muskingum River have been categorized as moderately sensitive (Figure 5). In the Meigs Creek Subwatershed, these tributaries include the mainstem of Meigs Creek, Mans Fork, Dyes Fork, Fourmile Run, Onion Run, and Perry Run. Moderate sensitivity areas within the other subwatersheds include Olive Green Creek, Rainbow Creek, Big Run, Cat Creek, Bear Creek, Duncan Run, Bald Eagle Run, and Island Run. The majority of the Lower Muskingum watershed is categorized as a low sensitivity area, largely due to the prevalence of low-yielding bedrock geology.

Figure 5

Groundwater Pollution Potential in the Lower Muskingum Watershed



High Sensitivity

Medium Sensitivity

Low Sensitivity

Unassessed areas in Noble Co.

Not to scale

The aquifers in the high sensitivity area along the Lower Muskingum mainstem are characterized by: recharge rates that average 7-10 inches per year; aquifer medias consisting primarily of sand and gravel; soil medias composed mostly of sandy or silty loams; hydrogeologic settings consisting of buried valleys and alternating sandstone, limestone and shale (thin soil); a depth to water ranging mostly from 5 to 30 feet; and a hydraulic conductivity averaging 1000-2000 gallons per day per square foot (the conductivity is lowest near Beverly at 300-700, and highest near Marietta 2000+).

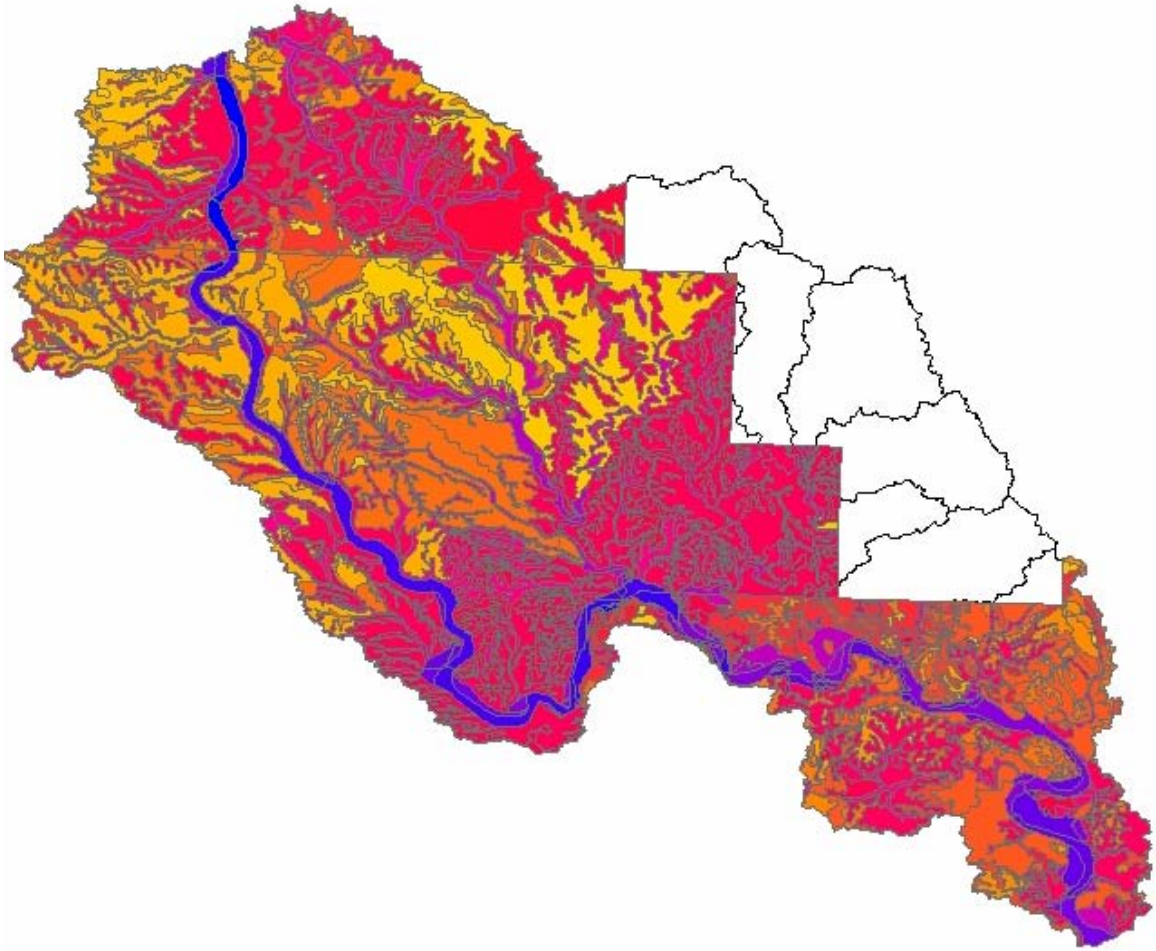
The moderately sensitive areas along the major tributaries to the Lower Muskingum River are characterized by: recharges rates of 4-7 inches per year; aquifer medias of interbedded sandstone, shale, limestone, clay and coal; soil medias that are thin or absent (gravel); a hydrogeologic setting of mainly alluvium; a depth to water averaging 15 to 30 feet; and a hydraulic conductivity of 1-100 gallons per day per square foot.

The low sensitivity areas are characterized by: recharge rates of 2-4 inches per year; aquifer medias of interbedded sandstone, shale, limestone, clay and coal; soil medias composed of shrinking and/or aggregated clay; hydrogeologic settings consisting of alternating sandstone, limestone and shale (thin soil); a depth to water ranging from 30 to 100 feet; and a hydraulic conductivity of 1-100 gallons per day per square foot.

Pesticide DRASTIC ground water pollution potential scores were also calculated for much of the Lower Muskingum watershed (Figure 6). These pesticide scores closely follow those described above with the general DRASTIC score. The entire length of the Lower Muskingum River mainstem is highly sensitive to potential pesticide contamination, while most of the watershed is categorized as moderately sensitive. The bedrock uplands are low sensitivity areas.

Figure 6

Pesticide Pollution Potential in the Lower Muskingum Watershed



The parameters used to calculate DRASTIC scores are not available for the strip-mined areas in the upper and lower portions of the Meigs Creek Subwatershed (the mining was concentrated in Dyes Fork and the eastern side of Mans Fork). DRASTIC data is also not available for Noble County, and ODNR does not plan to collect it due to its limited ground water resources (Heather Raymond 2004). Therefore, the data for the portion of Noble County that lies within the Lower Muskingum watershed can be extrapolated based on the DRASTIC maps for the surrounding counties. Based on Morgan and Washington County's data, the DRASTIC rating for the bedrock uplands in Noble County is approximately 73-75, and the rating for the alluvial region adjacent to the tributaries is most likely between 90 and 113. These scores should be fairly accurate because the bedrock geology is all interbedded limestone, shale, sandstone, and coal seams, and because the alluvial deposits are similar.

Drinking Water Information

As evident from the DRASTIC and public water supply maps, it is essential that the areas along the mainstem of the Lower Muskingum River and its major tributaries be protected in order to assure a safe drinking water supply. Due to the underlying geology, the highest-yielding wells occur in these areas, and most of the ground-water supplies for municipal and industrial purposes are developed in this aquifer. Well yields throughout the remainder of the watershed are extremely low, with average yields ranging from 2 to 5 gallons per minute. Yet these extensive sandstone, shale and limestone bedrock aquifers are a very important source of domestic water supply for southeastern Ohio, and cistern supplies are commonly used throughout these areas (Barrett *et al*. 1995; Mechling *et al*. 1995).

Residents of the Lower Muskingum watershed rely very heavily upon ground water (Table 18). In Washington and Muskingum Counties, 90 to 93 percent of all households rely on ground water for their water supply. The majority of this ground water comes from public water supplies. For instance, in Washington County, about 85 percent of ground water comes from community water systems and in Muskingum County, 62 percent. Private wells, ponds or cisterns serve the remaining residents (Barrett *et al*. 1995; Mechling *et al*. 1995). There are no public surface water intakes for the Lower Muskingum River Watershed. Figures 7, 8, and 9, show the location of the three types of public water systems in Ohio: community public, transient non-community (TNC), and non-transient non-community (NTNC).

Figure 7

Community Public Water Supplies, as of December 31, 2000

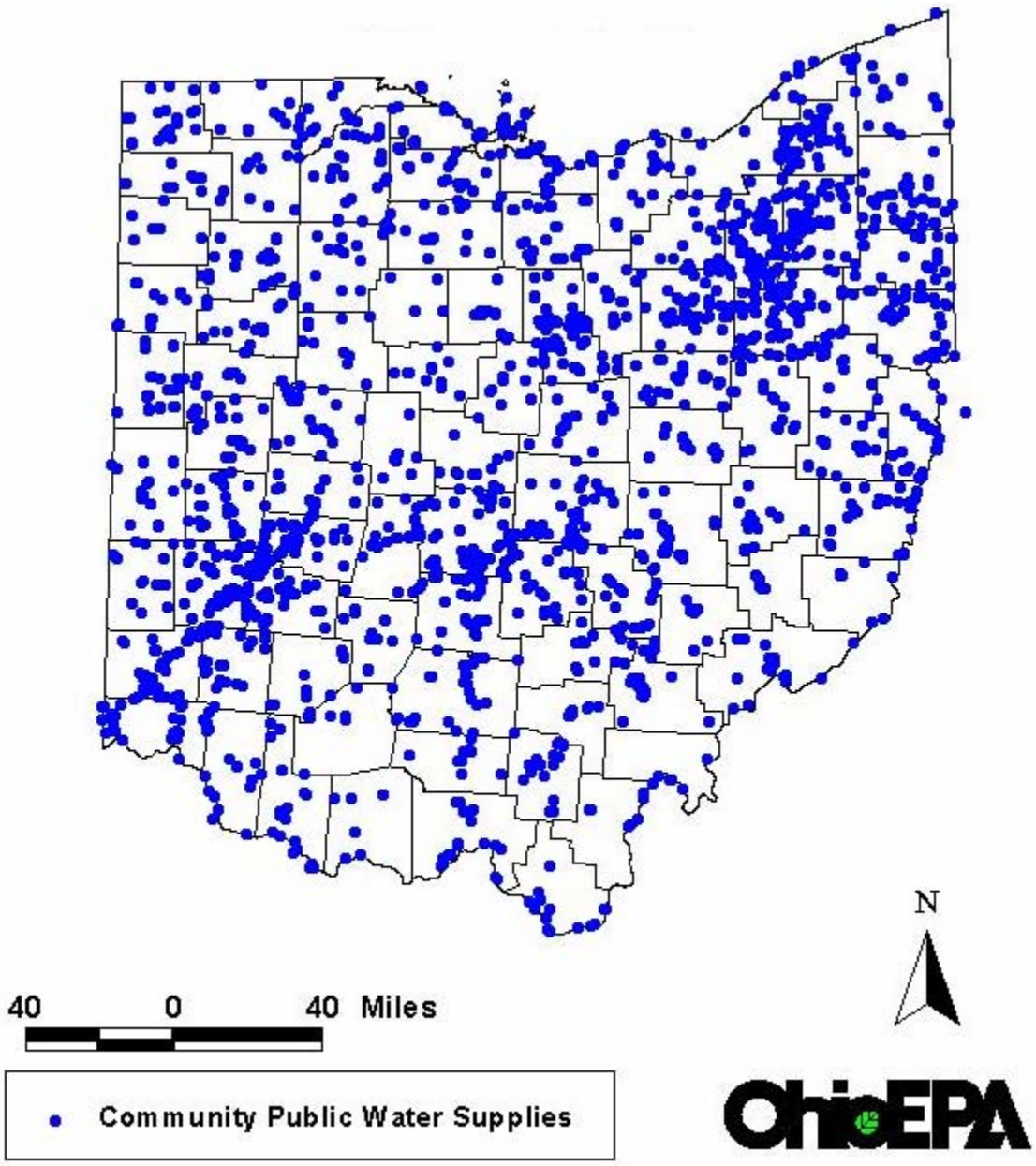


Figure 8

Non-Community Public Water Supplies, as of December 31, 2000

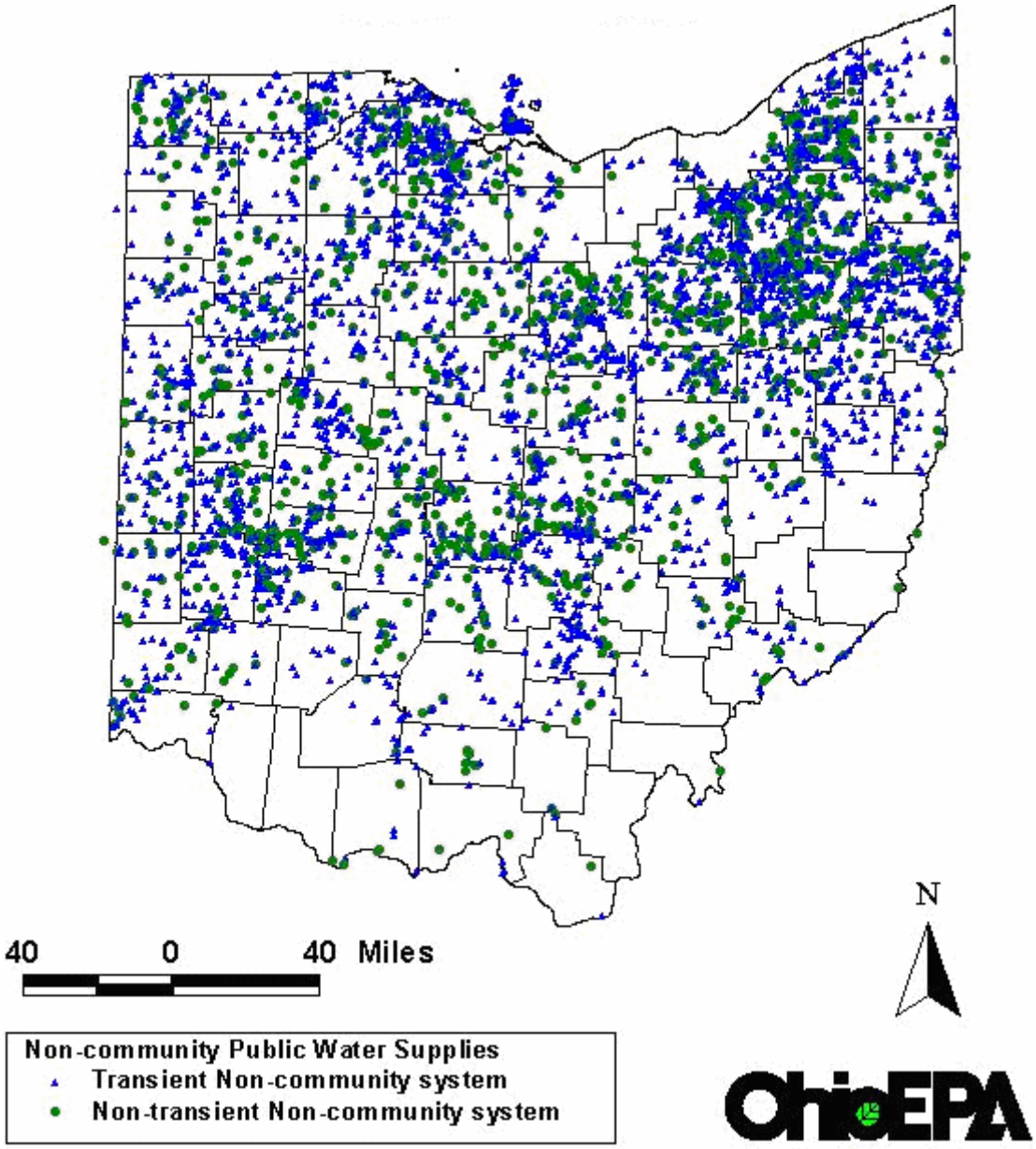


Figure 9

Public Water Systems Using Surface Water Systems, as of December 31, 2000

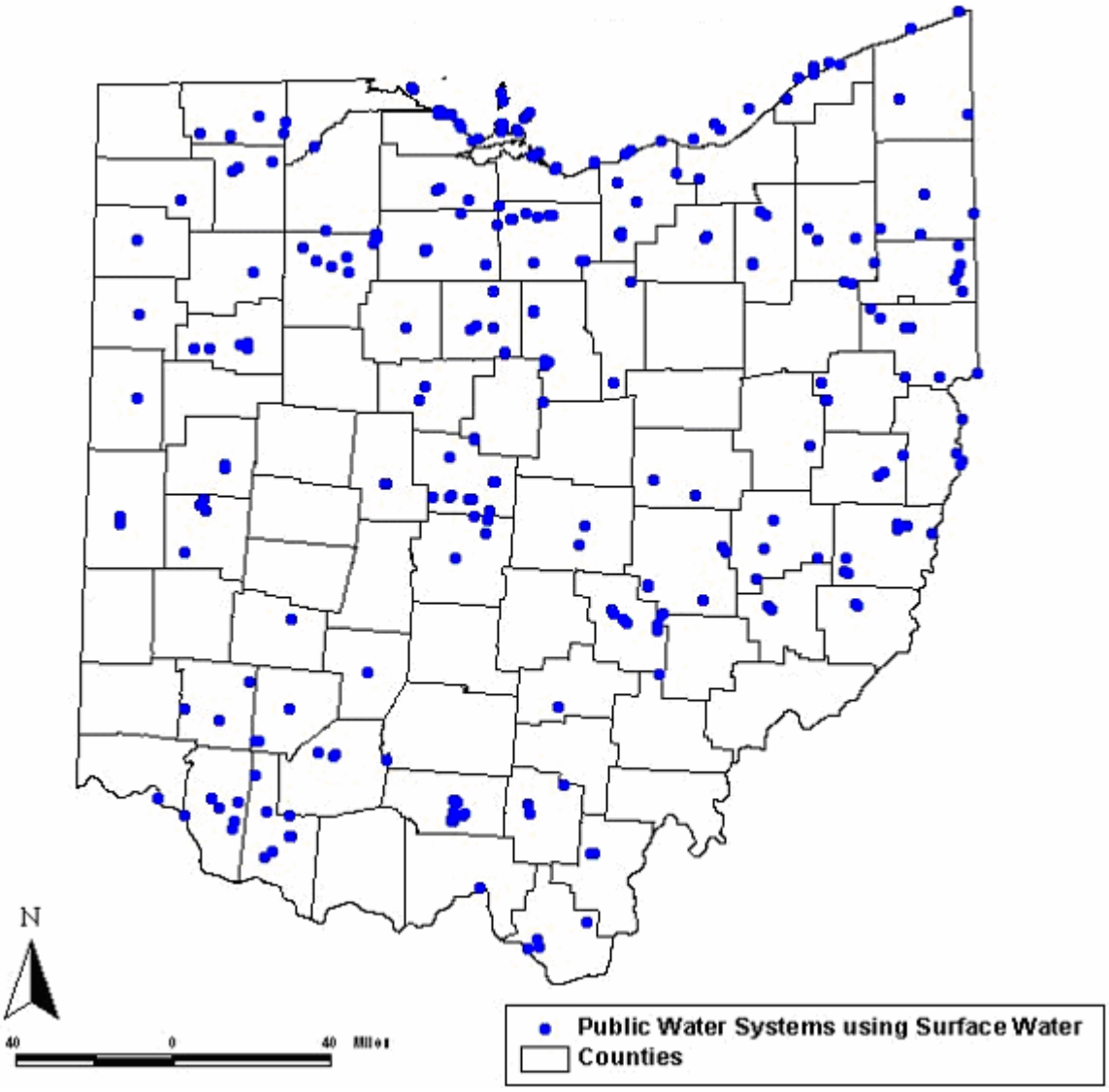


Table 18

Public Water Usage and Primary Source in the Lower Muskingum Watershed

Public Water System	Population Served	Primary Water Source	Usage (GPD)[2]	Treatment Plant Capacity (GPD)
Beverly	1,444	Ground Water	198,700	1,368,000
Lowell	611	Ground Water	86,000	115,000
Marietta	21,520	Ground Water	3,362,800	5,800,000
Putnam Community	2,475	Ground Water	220,933	864,000
Waterford	750	Ground Water	52,488	288,000
Philo	818	Ground Water	132,000	N/A

[1] Abstracted from Inventory of Municipal Water-Supply Systems by County, Ohio (1977) and updated with data provided by Gary Stellrect, Ohio EPA, Division of Drinking and Ground Water, Southeast District Office, Logan, OH.
[2] GPD = gallons per day.

Source: Barrett et al. 1995; Mechling et al. 1995

Information on water use within the entire Muskingum watershed was derived from the United States Geological Survey (USGS), which divides water-use data into four major categories: domestic and commercial, irrigation and livestock, industrial and mining, and thermoelectric power. According to 1990 data for the Muskingum watershed, the vast majority of water use is coming from fresh surface water withdrawals used for fossil-fuel thermoelectric power. Approximately nine hundred million gallons per day are used by two facilities, which together generate 14551.79 gigawatts hours of power per year (USGS 1990). Since additional thermoelectric power plants have been built along the mainstem of the Muskingum River in recent years, this number is likely higher today. The remaining 5.83 million gallons per day of fresh surface water withdrawals are used for stock, livestock, mining, public supply, and industry. Fresh ground water is used in much smaller amounts, with withdrawals of 12.51 million gallons per day. About half of this ground water is used for public supply. The remaining ground water is mostly self-supplied, and is used for domestic and industrial purposes. Twenty-three public wastewater facilities also comprise a small portion of water use in the watershed.

SWAP Plans

The Ohio EPA has completed a Source Water Assessment and Protection (SWAP) plan for each public water system (PWS) in the state that uses ground water as its primary source of drinking water. The three steps that go into developing SWAP plans include: delineating the area from which a public water system receives its water (drinking water source protection area), inventorying potential significant contaminant sources within the drinking water protection area, and determining the susceptibility of the source water (aquifer) to contamination (susceptibility refers to the likelihood for the source water(s) to be impacted by contaminants at concentrations that would pose a concern) (Ohio EPA 2003). SWAP areas within the Lower Muskingum watershed are summarized in Table 19 and in Figure 10.

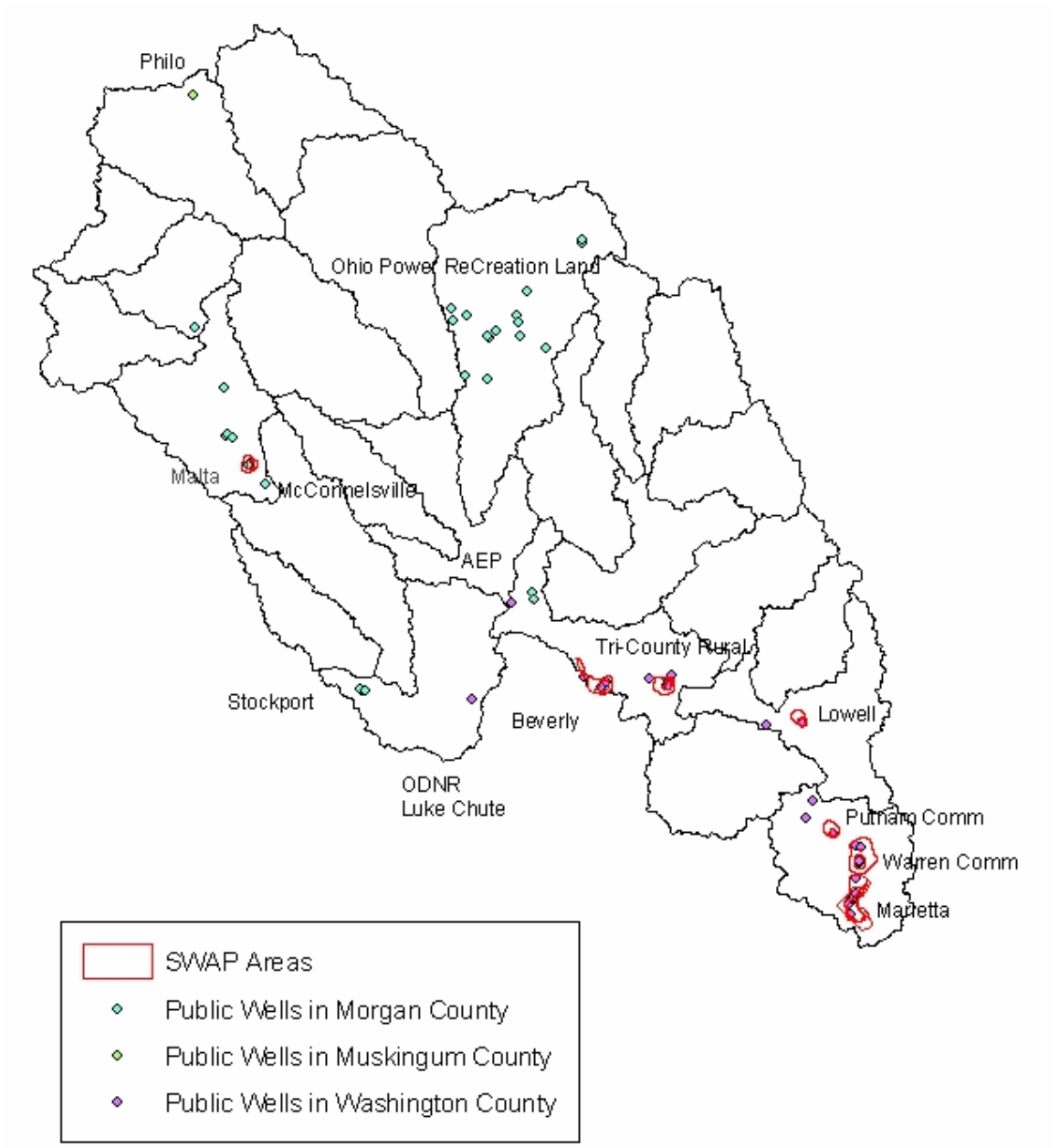
Table 19

SWAP Areas Delineated by the Ohio EPA in the Lower Muskingum Watershed

Site	Wells	Pump rate	Setting
Malta	6	175000	Buried
Beverly	4	750000	Alluvial/River
Lowell	1	67500	Alluvial/River
Marietta	7	7995000	Buried
Marietta	8	7005000	Alluvial/River
Tri-County Rural	3	33750	Alluvial/River
Putman Community	4	262500	Alluvial/River
Warren Community	2	990000	Alluvial/River
AEP Muskingum River	2	1750	Buried
Waterford	2	67500	Alluvial/River

Figure 10

Public Water Supply Wells and SWAP Areas in the Lower Muskingum Watershed



Potential Contaminants

Oil and gas wells are the most abundant potential sources of contamination within the Lower Muskingum watershed (Figure 11). They are found throughout the watershed, with the highest concentrations occurring in the Olive Green Creek Subwatershed. The Blue Rock Creek and the Lower Meigs Creek Subwatersheds southwest of Philo also have a high density of wells. Cemeteries are the next most abundant potential contaminants (Figure 12). About 25 cemeteries exist in the Meigs Creek watershed, 20 in the northern Lower Muskingum watershed, fifteen in the Olive Green Creek Subwatershed, and eight in the southern Lower Muskingum watershed.

Figure 11

Oil and Gas Wells in the Lower Muskingum Watershed.

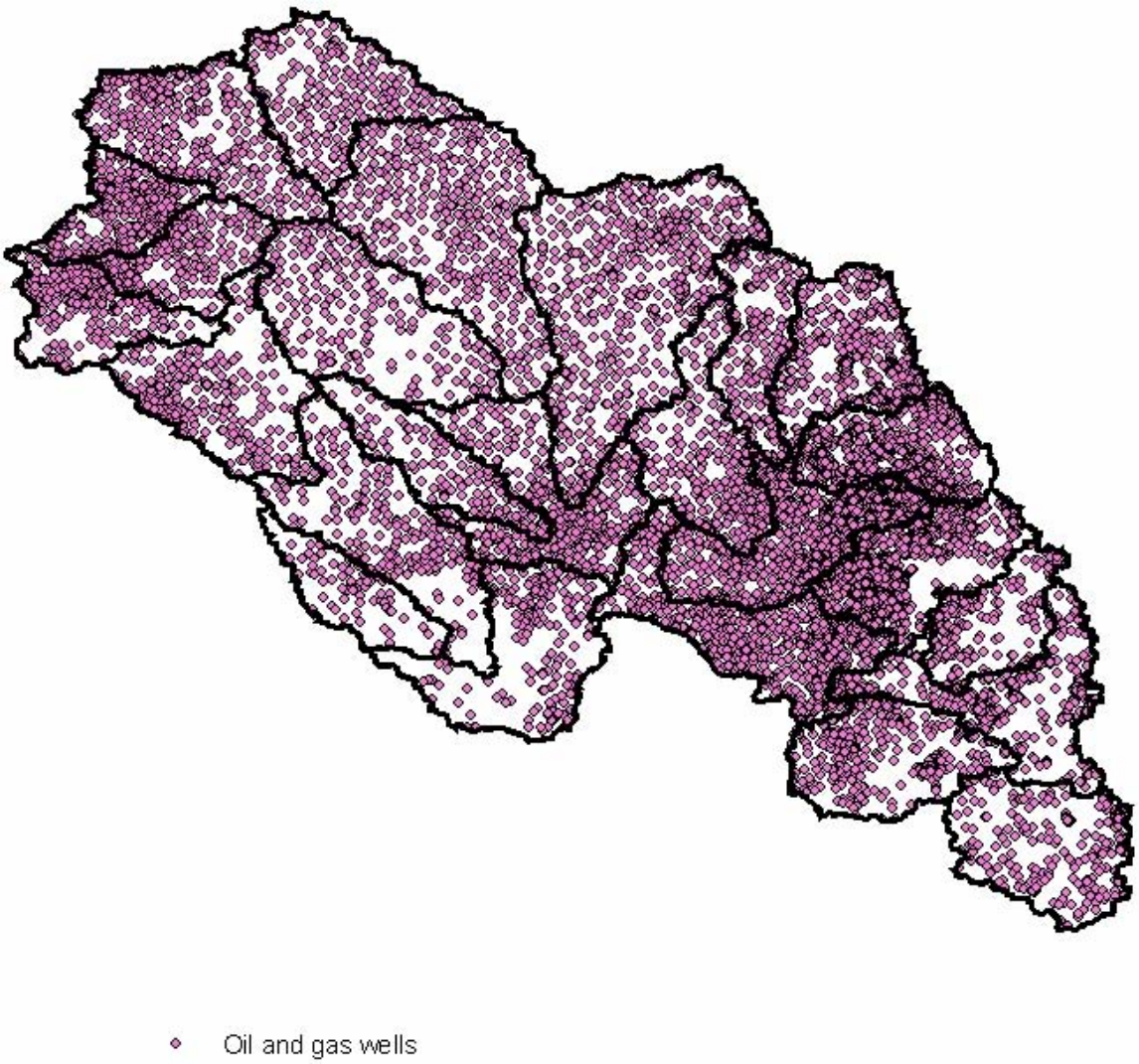
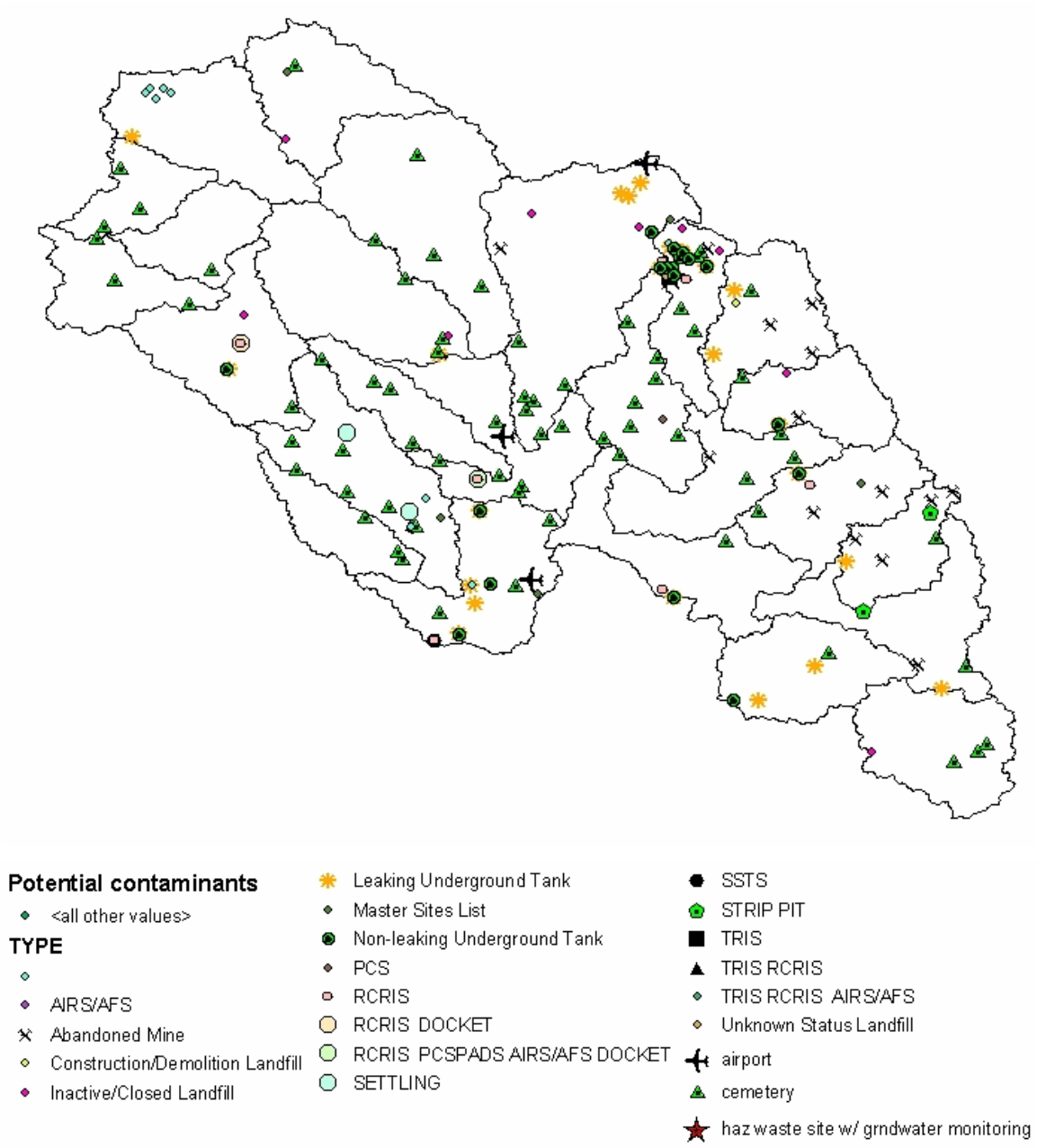


Figure 12

Potential Contaminants in the Lower Muskingum Watershed



Additional potential contaminants within each subwatershed include:

Meigs Creek

In the northern portion of the Dyes Fork Subwatershed, potential contaminants include: an airport, three leaking underground storage tanks, two inactive/closed landfills, and one abandoned mine (Coal Run). At the southern edge of the Mans Fork Subwatershed, a cluster of one closed landfill, two cemeteries, and one leaking underground storage tank are potential contaminants. The Morgan County Airport, located in the lower portion of the Meigs Creek, is another potential source of contamination.

Olive Green Creek

A large cluster of potential contaminants exists in the northern portion of Olive Green Creek. Seven leaking underground storage tanks, ten non-leaking underground storage tanks, one abandoned mine (north west of Belle Valley), one hazardous waste site with groundwater monitoring near Glacier Vandervell Inc., and four cemeteries exist in the northern portion of Olive Green Creek. Data obtained from the US EPA Resource Conservation & Recovery Information System (RCRIS), identified five sites in this region that generate, transport, store, or dispose of hazardous wastes. Data obtained from the Toxic Release Inventory Services (TRIS), identified one facility that manufactures, processes, or imports any of over 300 listed toxic chemicals, which they release directly into the air, water, or land, or are transported off-site (OEPA 2004). In the Sharon Fork Subwatershed, there are three abandoned mines, one construction/demolition landfill, and two leaking underground storage tanks. Potential contaminants in the Little Olive Green Subwatershed include eight cemeteries; in Keith Fork, two underground storage tanks, an abandoned mine, and a closed landfill; and in the lower Olive Green Creek Subwatershed, an abandoned mine and three cemeteries.

Northern Lower Muskingum

Cemeteries are scattered throughout this subwatershed. The stretch along the Muskingum River mainstem spanning from McConnelsville to Stockport contains additional potential contaminants such as: an airport, leaking and non-leaking underground storage tanks, closed landfills, settling ponds for AEP's electric plant, and two RCRIS sites.

Southern Lower Muskingum

The Cat Creek Subwatershed has the largest number of potential contaminants. It has four abandoned mines, two strip pits, a leaking underground storage tank, and a cemetery. Big Run also had mining activity in the past, for it has a lime sludge site, two abandoned mines, and a cemetery. The remaining subwatersheds have fewer potential contaminants, which include mainly cemeteries and some leaking underground storage tanks.

Nitrate-Nitrogen Content Study of Wells

Washington County

In 1988, 180 county wells were sampled for nitrate-nitrogen content, an indicator of water quality. Of the wells analyzed, 75 or 45% had concentrations in the range of 0 to 0.3 parts-per-million (ppm). This range represents natural background levels. Seventy wells or 39% had concentrations in the range of 0.3 to 3.0 ppm. These values may or may not indicate human influence. The 33 wells or 18% had concentrations ranging from 3.0 to 10 ppm may indicate elevated concentrations resulting from human activities. Only two wells or 1% had nitrate-nitrogen concentrations greater than 10 ppm, which exceeds the safe drinking-water standard. The average value for the 180 wells analyzed was slightly under 1.8 ppm (Barrett *et al*. 1995).

Muskingum County.

In a 1987 study by Heidelberg College, 474 wells in the county were sampled for nitrate-nitrogen content. Results showed that 235 wells or 50% contained nitrate-nitrogen concentrations in the range of 0 to 0.3 ppm. This range represents natural background levels. One hundred forty-five wells or 30% had concentrations ranging from 0.3 to 3.0 ppm. The 72 wells or 15% that had nitrate-nitrogen concentrations from 3.0 to 10 ppm may indicate elevated concentrations caused from human activities. Only 22 wells or 5% contained concentrations greater than 10 ppm. The average nitrate-nitrogen concentration for the 474 wells analyzed was 2.12 ppm (Mechling *et al*. 1995).

WATER QUALITY

Ohio EPA Beneficial Use Designations and Statewide Criteria: Overview

This section addresses the documented water quality of the entire Lower Muskingum watershed. It is intended to provide an overview of water quality in the entire watershed. A detailed analysis of sources and causes of impairment beyond the 305(b) and 305(d) water quality report for nonpoint source pollution will be addressed only for the Meigs Creek Subwatershed in Section II of this management plan.

Aquatic Life Designations

The Ohio Water Quality Standards (WQS) stated in chapter 3745-1 of the Ohio Administrative Code consists of designated uses and chemical, physical, and biological criteria for surface waters. These standards are designed to represent measurable properties of the environment. Rivers and streams in Ohio receive "use designations" that reflect the aquatic habitat which the stream can support and how the water is used. Water quality standards are then established to support those uses. Use designations are comprised of two categories, aquatic life and non-aquatic life uses. Non-aquatic life uses are further divided into recreation and water supply designations. Each water body in Ohio is assigned one or more aquatic use designations, one or more water supply designations, and/or one recreation designation.

Aquatic Life Uses

In applications of Ohio WQS to management of water resource issues, aquatic life use criteria frequently control protection and restoration requirements. Generally, emphasis on protecting aquatic life results in attaining water quality suitable for all uses, hence the emphasis of aquatic life uses in water quality reports and planning. The degree of attainment is separated into five categories (Table 20).

Table 20

Description and Qualifications of Use Attainment Degrees

Status Description	Qualifications
Fully attaining	All indices meet criteria
Fully attaining but threatened	All indices meet criteria, but land use activities in the watershed pose an immediate threat to maintaining water quality at this level
Partially attaining	One or two of the three indices do not meet criteria and are not in the poor or very poor category
Non-attaining	None of the indices meet criteria or one organism group indicates a sever toxic impact even if the other organism group indicates attainment

Source: Ohio EPA website 2004

The five different aquatic life uses currently defined in the Ohio WQS, and the intent of each with respect to the role of biological criteria are described as follows:

Warmwater Habitat (WWH)

This designation defines the typical warmwater assemblage of aquatic organisms in Ohio's rivers and streams. Waters designated as WWH are capable of maintaining a balanced, integrated, and adaptive community of warmwater aquatic organisms. Biological criteria are stratified across five ecoregions for the WWH designation. This aquatic use designation represents the principal restoration target for the majority of water resource management planning in Ohio.

Exceptional Warmwater Habitat (EWH)

This designation is for waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms. These assemblages of organisms are characterized by a high diversity of species, particularly those that are highly intolerant, rare, threatened, endangered, or special status species. Biological criteria for EWH apply uniformly across Ohio. The EWH designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.

Modified Warmwater Habitat (MWH)

This designation applies to streams and rivers that have been found incapable of maintaining a balanced, integrated, and adaptive community of warmwater organisms. Streams and rivers designated MWH have been subjected to extensive and essentially permanent hydrological modifications. Aquatic assemblages in these streams generally comprise species that are tolerant of low dissolved oxygen, silt, and high nutrient concentrations. Biological criteria for MWH designation are stratified across five ecoregions and three major modification types-channelization, free-flowing water impoundments, and extensive sedimentation due to mine runoff.

Coldwater Habitat (CWH)

This designation is intended for waters that can support trout stocking and management and/or populations of native coldwater organisms. This is a separate designation from the Seasonal Salmonid Habitat (SSH) designation that applies to Lake Erie tributaries supporting periodic seasonal runs of salmonids. No specific biological criteria exist for the CWH designation; however, the WWH biocriteria are viewed as attainable for CWH streams.

Limited Resource Water (LRW)

This designation applies to waters that have been found lacking the capacity to support any appreciable assemblage of aquatic organisms. Use attainability analysis has demonstrated that extant organisms are substantially degraded, and that the potential for recovery to levels characteristic of any other aquatic designation is precluded. Causative factors for the LRW designation include extensive channel modifications, acid mine drainage, and other factors relating to extensive urbanization. No formal biological criteria exist for the LRW aquatic use designation.

Non-Aquatic Life Designations

Recreation Uses

Recreation use designations are in effect from May 1st to October 15th, except in those streams designated SSH in which case recreation designations apply from June 1st to September 30th. The two recreation use designations most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) designations. Waters

designated PCR are suitable for full-body contact recreation activities such as swimming and canoeing. Waters designated SCR are suitable for suitable for partial body contact activities like wading. Additionally water bodies achieving PCR designation must have a minimum water depth of one meter over an area 100 square feet or where canoeing is feasible. For any water body too small or shallow to meet either criterion the SCR designation applies. Attainment status of PCR and SCR designations is determined using bacterial indicators (e.g. fecal coliform bacteria) as specified in the Ohio WQS. A water body that does not meet WQS bacteria standards for recreation is designated as impaired.

Water Supply Uses

Water Supply Designations are subdivided into three categories: Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). PWS designates those streams or rivers located within 500 yards of a public water supply or food-processing intake, including those streams that are used as emergency water supplies. AWS designated waters suitable for irrigation and livestock watering without treatment, while streams and rivers designated IWS are suitable for commercial and industrial uses, with or without treatment. Chemical criteria for each designation are specified in the Ohio WQS. Attainment is status based primarily on chemical-specific indicators.

Lower Muskingum Watershed Use Designations and Attainments

Aquatic Life Designations

For the Lower Muskingum River watershed, 581.7 total stream miles have been designated an aquatic life use. Of the total designated, 92.9 stream miles (16%) have been assessed. Use attainment status of the 92.9 stream miles is: 21.1 miles are fully attaining, 16 miles are threatened, 51.7 miles are partially attaining, and 4.1 miles are not attaining. Of the stream miles assessed, 39% are attaining their aquatic life use designation while 61% are partially or not attaining.

A total of 40 stream segments have an aquatic life use designation in the Lower Muskingum River watershed. Of the 40 total segments designated, three are sections of the Muskingum River mainstem, fourteen are direct tributaries (subwatersheds) to the Muskingum

River, and the remaining 23 are tributaries to the designated subwatersheds. Eleven of the fourteen direct tributary streams in the Lower Muskingum River watershed are designated Warmwater Habitat (WWH). Of these eleven streams, only Meigs Creek is designated as impaired, and the impairment of the ten other streams is unknown. Little Olive Green Creek, Keith Fork, and Sharon Fork, were designated Exceptional Warmwater Habitat (EWH). Little Olive Green Creek is designated as impaired and as not achieving the EWH habitat designation. All three segments of the Lower Muskingum River are impaired, designated as WWH, and are partially achieving the WWH habitat designation. Aquatic life designations for the entire watershed are shown in Table 21.

Table 21

Aquatic Life Designations for Streams in the Lower Muskingum Watershed

Stream	Assessment Unit	Habitat Designation	Attainment Status	TMDL Impaired
Meigs Creek		WWH	Threatened	Yes
Fourmile Run		WWH	Unknown	No
Dyes Fork		WWH	Indeterminate	Yes
Mans Fork		WWH	Unknown	No
Bald Eagle Run		WWH	Unknown	No
Island Run		WWH	Unknown	No
Bluerock Creek		WWH	Unknown	No
Rainbow Creek		WWH	Unknown	No
Cat Creek		WWH	Unknown	No
Big Run		WWH	Unknown	Yes
Olive Green Creek		WWH	Indeterminate	No
Little Olive Green Creek		EWH	Not Attaining	Yes
Keith Fork		EWH	Unknown	No
Sharon Fork		EWH	Unknown	No
Muskingum River Segment				
Salt Creek to Miller's Run		WWH	Partial	Yes
Miller's Run to Meigs Creek		WWH	Partial	Yes
Meigs Creek to Big Run		WWH	Partial	Yes
Big Run to Mouth		WWH	Partial	Yes

Recreation Designations

All fourteen tributary streams in the Lower Muskingum watershed are designated Primary Contact Recreation (PCR). For each of these streams, the attainment status of this designation is unknown. Fish consumption advisory has been listed for Meigs Creek. Each of

the three Lower Muskingum River segments is designated PCR. The Miller's Run to Meigs Creek segment is listed as not supporting the PCR designation. Fish consumption advisory is listed for each of the three Lower Muskingum River segments. Recreation designations for the watershed are summarized in Table 22.

Table 22

Recreation Designations for Streams in the Lower Muskingum Watershed

Stream	Recreation Designation	Attainment Status	Fish Advisory
Meigs Creek	Primary Contact	Unknown	Yes **
Fourmile Run	Primary Contact	Indeterminate	
Dyes Fork	Primary Contact	Indeterminate	
Mans Fork	Primary Contact	Indeterminate	
Bald Eagle Run	Primary Contact	Indeterminate	
Island Run	Primary Contact	Indeterminate	
Bluerock Creek	Primary Contact	Indeterminate	
Rainbow Creek	Primary Contact	Indeterminate	
Cat Creek	Primary Contact	Indeterminate	
Big Run	Primary Contact	Unknown	
Olive Green Creek	Primary Contact	Unknown	
Little Olive Green Creek	Primary Contact	Unknown	
Keith Fork	Primary Contact	Unknown	
Sharon Fork	Primary Contact	Unknown	
Muskingum River Segment			
Salt Creek to Miller's Run	Primary Contact	Indeterminate	Yes *
Miller's Run to Meigs Creek	Primary Contact	Not Supporting	Yes *
Meigs Creek to Big Run	Primary Contact	Indeterminate	Yes *
Big Run to Mouth	Primary Contact	Indeterminate	Yes *

*"One meal per month" for white bass; "One meal per week" for channel catfish, flathead catfish saugeye, and spotted bass
**No additional information is available from OEPA or USEPA

Water Supply Designations

All of the fourteen tributary streams in the Lower Muskingum watershed are designated Public Water Supply (PWS) and Agricultural Water Supply (AWS). The streams' attainment of these designations is listed as unknown. The three segments of the Lower Muskingum River are also designated PWS and AWS. The attainment of these designations is also unknown. Water supply designations are summarized in Table 23.

Table 23

Water Supply Designations for Streams in the Lower Muskingum Watershed

Stream	Water Supply Designation	Attainment Status
Meigs Creek	PWS, AWS	Unknown
Fourmile Run	PWS, AWS	Unknown
Dyes Fork	PWS, AWS	Unknown
Mans Fork	PWS, AWS	Unknown
Bald Eagle Run	PWS, AWS	Unknown
Island Run	PWS, AWS	Unknown
Bluerock Creek	PWS, AWS	Unknown
Rainbow Creek	PWS, AWS	Unknown
Cat Creek	PWS, AWS	Unknown
Big Run	PWS, AWS	Unknown
Olive Green Creek	PWS, AWS	Unknown
Little Olive Green Creek	PWS, AWS	Unknown
Keith Fork	PWS, AWS	Unknown
Sharon Fork	PWS, AWS	Unknown
Muskingum River Segment		
Salt Creek to Miller's Run	PWS, AWS	Unknown
Miller's Run to Meigs Creek	PWS, AWS	Unknown
Meigs Creek to Big Run	PWS, AWS	Unknown
Big Run to Mouth	PWS, AWS	Unknown

Water Quality of Wetlands

In August 1999, a list of high quality wetlands in Ohio was compiled under the guidance of a group of wetland professionals from organizations such as the Nature Conservancy and the Ohio Natural Heritage Database of High Quality Wetlands in Ohio. The wetlands were deemed high quality because they have rare, threatened or endangered species, are functioning at a high level, or demonstrate one or two functions that are exceptional. High quality wetlands have been identified in Washington County around Watertown, Valley Mills, Willow Island, Beverly, Lowell, and Marietta (Table 24).

Table 24

High Quality Wetlands in Washington County

Site Name	Year*	Rank**	Plant Community	Quad
Devols Dam Floodplains	1982	2	Floodplain Forest	Marietta
Glenn-Sprague Marsh	1994	3	Mixed Emergent Marsh	Watertown
Marietta Township Marsh	1986	3	Mixed Emergent Marsh	Valley Mills
Waterford Mill	1984	3	Water-Willow Riverine	Beverly
Worthington Wetland	1983	2	Mixed Emergent Marsh	Lowell
Zimmer Wet Woods	1988	3	Floodplain Forest	Marietta

* Year of plant community record

** Subjective ranking by surveyor (1-3, 1=best)

Source: Ohio EPA, DSW 1999

Groundwater Quality

Ground water quality monitoring information is currently collected through sampling of the Ambient Ground Water Monitoring Network wells. The Ambient Ground Water Monitoring Network is used as part of the new well approval process for public water supply wells, for compliance sampling for public drinking water systems, and for various special studies.

Studies and Research in The Lower Muskingum Watershed

Government agencies that have studied the Lower Muskingum River watershed since 1988 include the Ohio Environmental Protection Agency (OEPA), Ohio Department of Natural Resources (ODNR), the Ohio Department of Transportation (ODOT), the Ohio River Sanitary Commission (ORSANCO), the United States Army Corps of Engineers (USACE), the United States Geological Survey (USGS), and the Water Quality Lab at Heidelberg College. American Electric Power (AEP) has also conducted independent water quality surveys at Muskingum River discharge sites. Other information indirectly pertaining to Lower Muskingum water quality, including fishing prospects and rare species sightings also exists for the Lower Muskingum watershed.

OEPA Study and Characterization

The Ohio EPA has not conducted comprehensive water quality studies in the Lower Muskingum River watershed since 1988, although selected tributaries and river segments have been studied more recently. Water quality in the watershed generally meets Ohio standards, and other watersheds in Ohio are in much poorer condition; therefore, studies on the Lower Muskingum River watershed are a low priority. The entire Muskingum River watershed is scheduled for comprehensive water quality study in 2010. Since 1988, Ohio EPA has conducted infrequent biological and water quality surveys of the Lower Muskingum River and a handful of tributary streams. The only comprehensive post-1988 Ohio EPA data set for the Lower Muskingum River comes from a study of the river at McConnelsville, published in 1993.

Sedimentation and Surface Water Study

From 1982-1992 the Ohio EPA Division of Water Quality conducted sediment and surface water sampling of the Muskingum River to determine the potential for the Muskingum River to contribute contaminants to the McConnelsville well field. Additional objectives of this study included: determining if fish are bioaccumulating chemical contaminants, re-assessing accumulation of specific metals and solvents adjacent to Gould, assessing surface water, and sediment adjacent to the Malta Wastewater Treatment Plant (WTP) well field discharge. Samples were collected from the Muskingum River mainstem between Gould (RM 52.6) and the McConnelsville dam (RM 48.8), adjacent to the McConnelsville well field, and in the vicinity of Brock's junkyard at the mouth of Slemmons Creek. This study found elevated and/or unsafe levels of metals and organic compounds in Muskingum River surface water and sediments, including lead, copper, tetrachloroethene, trichloroethene, and dichloroethene (OEPA 1993). Table 25 lists concentrations of certain chemicals measured in this study.

Table 25

Chemicals Detected in Muskingum River Water and Sediments

	SEDIMENT mg/kg (ppm)				
River Mile (Location)	Lead	Copper	Tetrachloro-Ethane	Trichloro-Ethene	1,2 Dichloro-Ethane
52.6-52.0 (above Gould)	16-36.9	9-24.6	<0.05	<0.05	<0.05
51.8 (Gould effluent area)	17-7700	21.6-5170	0.005-4,227	0.005-0.278	0.005-0.593
51.7 (T & N effluent area)	251-15,300	53.1-3210	0.005-3433	0.005->573	1.10->351
51.6-51.5 (below T & N)	57.8-170	31.9-90.5	<0.05	<0.05	<0.05
51.1-48.8 (McConnelsville	16.1-50.7	14.7-29.2	<0.05	<0.05	<0.05

	WATER µg/l (ppb)				
River Mile (Location)	Lead	Copper	Tetrachloro-ethene	Trichloro-ethene	1,2 Dichloro-Ethane
52.6-52.0 (above Gould)	<3	<10-12	<5	<5	<5
51.8 (Gould effluent area)	<2-28	145-4350	750	7.5	10.1
51.8 (Gould mixing zone)	<3	11	<5-597	<2.5-15.9	<2.5-8.5
51.7 (T & N effluent area)	71-3950	<10-410	63.2-810	8.1-17.3	13.9-39.0
51.7 (T & N mixing zone)	431-692	28-30	170-780	7-10.9	<5-48.8
51.6-51.5 (below T & N)	7	16	0.7-6	<5	<5
51.1-48.8 (McConnelsville	<3-12	<10-20	<5	<5	<5

Source: OEPA 1993

Water Quality Sampling Data, STORET Database

The United States EPA STORET database lists data from water quality sampling surveys from 1987-1991 on the Lower Muskingum River and several tributary streams. The database includes data taken from sampling sites on Meigs Creek, Olive Green Creek, Dyes Fork, Mans Fork, and at multiple sites on the Muskingum River from Marietta to Philo. Water quality parameters measured include conductivity, alkalinity, temperature, and concentrations of various nutrients, dissolved ionic species, and heavy metals.

Combined Sewer Overflow (CSO) List

Combined sewers are built to collect sanitary and industrial wastewater as well as storm water runoff and transport this combined wastewater to treatment facilities. During rain events, the volume of storm water and wastewater may exceed the capacity of the combined sewers or of the treatment plant. This may cause a portion of the combined wastewater to overflow untreated

into the nearest surface water body. This discharge is known as combined sewer overflow (CSO). The three communities in the Lower Muskingum watershed with known CSOs are Malta, McConnelsville, and Caldwell (Table 26).

Table 26

CSO Sites in Lower Muskingum River Watershed

Location (County)	Permit No.	Total CSOs
Caldwell (Noble)	0PB00005	22
Malta (Morgan)	0PA00095	10
McConnelsville (Morgan)	0PC00000	9

Source: OEPA

ODOT Surveys

ODOT routinely conducts surveys of affected streams as part of the planning process for road and bridge construction. Stream surveys include water quality sampling, fish and invertebrate surveys, and in some cases surveys of plant communities, vertebrate communities, and streambed characteristics. Within the Lower Muskingum River watershed, ODOT survey data is available for Cat Creek, Mans Fork, and Olive Green Creek. Cat Creek was surveyed in 1988, while Mans Fork and Olive Green Creek were both surveyed in 1986 (Appendix I.A: ODOT Biological and Water Quality Survey Data). Table 27 shows the results of the ODOT invertebrate survey in Cat Creek. Table 28 shows the results of the ODOT fish survey in Mans Fork. Table 29 shows the results of water quality sampling in Olive Green Creek.

Table 27

ODOT Invertebrate Survey Data for Cat Creek

Taxa	Common Name	Number of Specimens Observed	Number of Specimens Collected	Total
Astacidae	crayfish	5	0	5
Gammaridae	scud	0	1	1
Aeshnidae	dragonfly	0	1	1
Corixidae	water boatman	29	6	35
Gerridae	water strider	29	15	44
Mesoveliidae	water treader	0	1	1
Sialidae	alderfly	8	6	14
Dytiscidae	diving beetle	6	6	12
Haliplidae	crawling water beetle	0	6	6
Chironomidae	midge	12	6	18
Dixidae	dixa midge	0	1	1
Simuliidae	black fly	1	0	1
Gastropoda	aquatic snail	14	20	34
Sphaeriidae	fingernail clam	0	3	3

Table 28

ODOT Fish Survey Data for Mans Fork

Common Name	Number of Specimens Observed	Number of Specimens Collected	Total
creek chub	10	2	12
striped shiner	86	2	88
silverjaw minnow	18	1	19
bluntnose minnow	14	1	15
golden redhorse	18	2	20
hog sucker	7	3	10
white sucker	2	2	4
channel catfish	1	0	1
rockbass	4	1	5
smallmouth bass	4	1	5
green sunfish	9	2	11
johnny darter	2	2	4

Table 29

ODOT Water Quality Data for Olive Green Creek

Pollutant	Concentration (mg/l)
Dissolved Oxygen	11.7
Ammonia	0.41
Nitrate	2.6
Nitrite	0.01
Phosphate	0.32
Chloride	46
Alkalinity	108
Iron	0.18
Sulfate	112
Total Hardness	248
Other Parameters	
Water Temperature	29 °C
pH	8.7
Turbidity	16 NTU

ODNR Unionid Surveys

Unionid Survey 1993

In 1993, ODNR conducted a unionid survey on river miles 0.0-34.1 in the Lower Muskingum River watershed. This study was conducted in order to compare current unionid (freshwater mussel) populations with those identified in a previous study (Stansbery and King, 1983). Mussel surveys were conducted in beds found at six sites adjacent to lock and dam numbers 1-5 on the Lower Muskingum River (Table 30).

Table 30

Comparison of Unionid Populations among Muskingum River Mussel Beds

Location	Total Individuals	Total Species	Endangered Species	Average Density (Individuals/mi2)
Bed 1 (Luke Chute)	540	26	6	3.1
Bed 2 (Beverly)	1326	19	2	31.0
Bed 3 (Lowell)	2855	25	7	17.8
Bed 4 (Lowell-Devola)	483	21	7	9.0
Bed 5 (Devola)	4730	28	9	41.9
Bed 6 (Devola-mouth)	1205	18	7	31.2

At the time of the Stansbury and King unionid study (1983), five Muskingum River unionids were on the Federal Endangered Species list. According to the 1993 ODNR study, nine Muskingum River unionid species are federal endangered, with a tenth species becoming endangered late in 1993 (Table 31). This study found that the largest unionid populations, largest numbers of species, and greatest species densities on the Lower Muskingum River persist in the free-flowing river reaches found immediately below locks and dams rather, than in pools between and upstream of dams (Ecological Specialists, Inc. 1993).

Table 31

Federally Endangered Mussel Species Recorded in Mussel Beds (RM 34.1-0)

Scientific name	Common name	Date Listed
Cryptogenia stegaria	fanshell	6/21/90
Epioblasma obliuqata	white catspaw	7/10/90
Epioblasma torulosa	tubercled blossom	6/14/76
Hemistena lata	cracking pearlymussel	9/28/89
Lampsilis abrupta	pink mucket	6/14/76
Obovaria retusa	ring pink	9/29/89
Plethobasus cicatricosus	white wartyback	6/14/76
Plethobasus striatus	orange-foot pimpleback	6/14/76
Pleurobema plenum	rough pigtoe	6/14/76

Unionid Survey 1996

In 1996, ODNR conducted a unionid survey on river miles 34.1-77.4 in the Lower Muskingum watershed. The purpose of this study was to determine current unionid status in the Lower Muskingum River from below Zanesville to the Luke Chute Dam. Unionid mussels were surveyed by brailing and diving in five pools adjacent to the lock and dam numbers 6-10 on the Lower Muskingum River (Table 32).

Table 32

Comparison of Unionid Populations among Muskingum River Pools

	1983		1995	
Location	Total Unionids	Total Species	Total Unionids	Total Species
Pool 1 (Philo)	44	9	104	13
Pool 2 (Rokeby Lock)	104	10	219	18
Pool 3 (McConnelsville)	19	7	113	12
Pool 4 (Stockport)	22	6	257	13
Pool 5 (Luke Chute)	26	7	206	15
TOTALS	215	17	899	23

This study identified unionid mussels throughout the Muskingum River, but it failed to find any clearly discernable mussel beds at sampling sites. Unionids were primarily associated with patches of sand and gravel located downstream of dams. This study found unionid species richness and abundance to be greatest downstream of dams. It also concluded that unionid species abundance decreased in the lower reaches of the Muskingum River (RM 34.1-0) (Ecological Specialists, Inc. 1996).

Aquatic Population Surveys

ODNR has conducted periodic surveys of fish populations, invertebrate populations, and water quality in the Lower Muskingum River and several of its tributaries. These studies were conducted from 1984-1999 on Olive Green Creek, Meigs Creek, Dyes Fork, and the entire Lower Muskingum mainstem from Marietta to Philo. Stream surveys include water quality sampling, fish population surveys, and invertebrate surveys. The data also includes IBI, ICI, and QHEI scores for each tributary sampled and for the Lower Muskingum mainstem (Appendix I.B: Summary of IBI, ICI, and QHEI Scores for Lower Muskingum River and Tributary Streams).

USGS Sampling Data

The USGS conducted water quality sampling surveys on the Muskingum River and certain tributary streams from 1985-1997. Sampling sites are located on the Muskingum River at McConnelsville, and on Meigs Creek, Bald Eagle Run, and Dyes Fork. Water quality parameters measured include temperature, pH, turbidity, and concentrations of various nutrients, dissolved ionic species, and heavy metals (Appendix I.C: Summary of USGS and ORSANCO Water Quality Sampling Database, Lower Muskingum River).

USACE Channel Maintenance Dredging Sampling Program

The USACE conducts ongoing dredging and water quality sampling of the Lower Muskingum River as part of the Channel Maintenance Dredging sampling program. Sampling sites are located between the river mouth and river mile 5.71. Water quality parameters measured include temperature, pH, turbidity, and concentrations of various nutrients, inorganic compounds, dissolved ionic species, and heavy metals. Sediment size distribution analyses are also available from sites where elutriate analyses of bed material is accessible.

AEP Copper Concentration and Biological Communities Study 1994-1995

In this study, instream biological and chemical sampling was conducted to assess potential adverse effects of heavy metals contained in coal ash discharge from a coal-fired power plant. The study was conducted adjacent to Ohio Power Company's Muskingum River power plant, about 28 miles upstream from Marietta. This site was selected because elevated levels of copper were previously measured in the discharge from this plant. In this study, total copper, dissolved copper, total suspended solids (TSS), and pH were measured monthly at sampling stations adjacent to coal ash discharge sites. Macroinvertebrate communities were sampled at locations proximal to the coal ash discharge, and at locations removed from discharge influence.

This study found that total copper concentrations at sites adjacent to coal ash discharge sites were higher than levels at upstream sites but that dissolved copper concentrations were similar among all sites. This study also found that the macroinvertebrate community proximal to the coal ash effluent site had the highest number of taxa, the highest total number of individuals, a

high number of mayfly and caddis fly taxa, and the highest Invertebrate Community Index (ICI) score (Appendix I.D: Macroinvertebrate Taxa Collected at the Sampling Sites). Table 33 summarizes the copper concentrations in coal ash effluent sampled in this study. The authors of the study concluded that the high water velocity of the discharge, the concentrations of algae, and organic matter in effluent discharge created a favorable microhabitat that superseded the potential adverse effects of high copper levels (Reash 2002).

Table 33

Summary of Copper Analyses for Coal Ash Effluent Discharge

Parameter	Effluent Discharge	Instream Site One	Instream Site Two	Instream Site Three
Total Copper (ppb)	58	4	11	10
Dissolved Copper (ppb)	20	2	3	4
% Dissolved Copper	32	53	37	31
TSS** (ppm)	14	*	*	*
pH	7.9	*	*	*

* Data Not Collected
**Total Suspended Solids

Ohio Tributary Monitoring Program

The Water Quality Laboratory, located at Heidelberg College, conducts long-term studies of the impacts of land use on regional water resources. Work includes tributary loading studies in the Lake Erie and Ohio River basins, assessments of the ecological integrity of Lake Erie and its wetlands and tributaries, and large-scale studies of groundwater quality through private well testing. The Ohio Tributary Monitoring Program studies total water volume and water quality constituents transported annually in seven of the largest rivers in Ohio, including the Muskingum River. The Muskingum River sampling site is located in McConnelsville, Ohio. Table 34 shows water monitoring stations in Ohio.

Table 34

Ohio Tributary Monitoring Program Stations

River (Location)	Drainage Area Above Station (mi^2)	Land Use Above Station (Percent)			
		Agriculture	Urban	Wooded	Other
Maumee (Waterville)	6330	89.9	1.2	7.3	1.6
Sandusky (Freemont)	1253	84.1	0.9	13	2.0
Cuyahoga (Independence)	708	30.4	9.6	50.1	9.9
Grand (Painsville)	686	40.0	0.9	45.2	13.1
Muskingum (McConnelsville)	7420	52.0	1.7	43.4	2.9
Scioto (Chillicothe)	3854	80.2	4.6	12.9	2.3
Great Miami (Miamisburg)	2685	82.1	4.7	10.3	2.9

The 1996-2001 Report from the Ohio Tributary Monitoring Program presents concentrations of sediments, nutrients, pesticides, and chloride in each of the seven Ohio River tributaries. The report states that pesticide concentrations do not exceed corresponding health standards in any of the seven tributaries, and that the Muskingum River tends to have lower pesticide concentrations than the Maumee, Scioto, Sandusky, and Miami rivers. Of the seven tributaries, the Muskingum River generally has lower or lowest loads of sediment, chloride, and phosphorous. Table 35 summarizes the data collected in this study.

Table 35

Time-Weighted Mean Concentrations of Pesticides, Muskingum River

Pesticide	1995	1996	1997	1998	Health Advisory Concentration*
Acetochlor	0.07	0.053	0.143	0.062	2.0
Alachlor	0.048	0.045	0.015	0.028	2.0
Atrazine	0.457	0.471	0.766	0.397	3.0
Metolachlor	0.35	0.32	0.52	0.38	70.0
Simazine	0.11	0.09	0.07	0.08	4.0

Concentrations are in µg/L (ppb)
*Lifetime Health Advisory Levels for herbicides established by the USEPA

ORSANCO

Ongoing Ohio River Water Quality Sampling Data

ORSANCO conducts ongoing water quality studies of the entire Ohio River mainstem, and has a permanent survey station in Marietta at the mouth of the Muskingum River. The most recent data available is from 1999-2001 (Appendix I.C). Concentrations of heavy metals, nutrients, and inorganic compounds are sampled, as well as temperature and conductivity (ORSANCO 2002).

Total Maximum Daily Load (TMDL) for PCBs

In 1997 the United States EPA (USEPA) entered into a Federal Consent Order to complete a TMDL study for polychlorinated biphenyls (PCBs) for a section of the Ohio River listed on West Virginia's Section 303(d) list. This study established the allowable PCB loadings within the Ohio River study area and quantified the reductions necessary to meet applicable Ohio water quality standards. ORSANCO developed and conducted the study on behalf of the USEPA. This study covers the Ohio River from the Pennsylvania-West Virginia border (RM 40.0) to the West Virginia-Kentucky border (RM 317.1) and includes data taken from the confluence of the Muskingum and Ohio rivers at Marietta, Ohio (RM 171.8). This study found that the Muskingum River contributes PCB loads to the Ohio River that far exceed allowable PCB loadings.

According to the ORSANCO study, PCB loads from the Muskingum River would have to be reduced by 98.9 percent in order for the Ohio River to meet Ohio water quality standards (Table 36). The study also identified multiple potential sources of PCBs in the Muskingum River in both Muskingum and Washington Counties (Table 37).

Table 36

Ohio Tributary Load Allocations and Necessary PCB Reductions

Tributary	Enters Ohio River (RM)	Existing Load (g/day)	Allocated Load (g/day)	Percent Reduction
Allegheny	0.0	39.624	1.053	97.3
Monongahela	0.0	33.507	0.602	98.2
Beaver	25.4	48.687	0.215	99.6
Muskingum	172.2	37.504	0.409	98.9
Little Kanawha	184.6	0.26	0.041	84.1
Hocking	199.3	0.749	0.037	95.1
Great Kanawha	265.7	23.083	0.915	96.0
Guyandotte	305.2	2.904	0.074	97.4

Table 37

Potential PCB Sources in the Ohio River Basin

County	City	Facility name	Activity
Muskingum	Zanesville	ARMCO, Inc.	Manufacturing
Muskingum	Zanesville	Burnham Corporation	Manufacturing
Muskingum	Zanesville	McGraw-Edison Co.	Manufacturing
Washington	Beverly	Muskingum River Plant	PCB Generator
Washington	Marietta	ELKEM Metals Co.	PCB Generator
Washington	Marietta	American Municipal Power	PCB Generator
Washington	Marietta	Marietta Polystyrene Plant	PCB Generator
Washington	Marietta	Washington Electric Co-op	PCB Generator

BIOLOGICAL FEATURES

Fish

More than a decade has passed since major studies were conducted to determine which species of fish live in the Muskingum River. A compilation of EPA data collected from 1986 to 1994 indicates that 71 species of fish can be found within the river. These fish include high quantities of bait- and minnow-type fish and certain species of sport fish (Marietta Times 2000). A 1988 ODNR angler survey recorded high quantities of catfish, bullheads, carp, suckers, bass, white bass, and hybrids (Isbell 1988).

The prevalence of sport fishery continues to increase on the Lower Muskingum River. Today the most popular fish among sport fisherman include: bluegill, largemouth bass, spotted bass, crappie, channel and flathead catfish, sauger, walleye, and saugeye. The saugeye, a hybrid cross between a walleye and sauger, has been stocked in the Muskingum River since the late 1980's (Marietta Times 2000; ODNR 2003b). The School of Natural Resources at Ohio State University conducts ongoing research on the saugeye in order to find out more about their reproductive status and their impact on native stocks. Recent research also studied the impact of elevated water temperatures from the Muskingum River Power Plant and Conesville Power Plant on three species of redhorse (Root and Ackakaya 1999).

Information on the less abundant species was derived from ODNR Division of Natural Areas and Preserves (DNAP) records. A complete list of all the rare, threatened, and endangered species found within the watershed are found in Appendix I.E. These records indicated that five state-listed endangered species, three threatened species, and two species of concern have been observed in the Lower Muskingum River (Grieszmer 2003). The presence or absence of these species can be excellent indicators of water quality. Observed rare species include: northern madtom (*Notorus stigmosus*), seen in 1987; mountain madtom (*Notorus eleutherus*), seen in 1992; goldeye (*Hiodon alosoides*), seen in 1971; pugnose minnow (*Opsopoeodus emiliae*), seen in 1977; ohio lamprey (*Ichthyomyzon bdellium*), seen in 1965, and several species of sensitive darters, seen in 1987, 1991, 1994.

Mussels

The Lower Muskingum River is known for its diverse, dense beds of freshwater mussels. Since the mussels live underwater and are not easily observable, environmentalists, fisherman, and river enthusiasts often overlook them. Mussels are bivalve mollusks that belong to the same group of animals as clams and oysters. Of the eighty mussel species recorded in Ohio, many are found in the Muskingum River. Historically, the Muskingum River has supported more than 63 unionid (freshwater mussel) species (Stansbery and King 1983; Stansbery *et al.* 1985; Ecological Specialists Inc. 1993). Currently, two-thirds of these species are either extinct, extirpated, or in some way threatened (Gross 2000). Among the endangered unionid species in the Lower Muskingum are the last remaining Ohio populations of the fanshell (*Cyprogenia stegaria*), monkeyface (*Quadrula metanevra*), Ohio pigtoe (*Pleurobema cordatum*), and butterfly mussels (*Ellipsaria lineolata*) (Ortt 2001).

Due to its large and diverse number of mussels, the Muskingum River has been the site of numerous malacological (mollusk-related) surveys. These studies have made the Muskingum River one of the best-studied rivers for unionids in the country. Dr. Thomas Watters, a malacologist and senior research associate from the Ohio Biological Survey, has been one of the most active researchers on unionids in the Muskingum. He participated in the last known mussel survey, which was conducted in two stages, one in 1993 and one in 1995 (Ecological Specialists Inc. 1993 and 1996). The survey covered the stretch of the Muskingum River from Zanesville to the mouth of the river in Marietta. Dr. Watters' more recent research projects include "Freshwater mussels and water quality: A review of the effects of hydrologic and instream habitat alterations" (Watters 2000), and "Small dams as barriers to freshwater mussels" (Watters 1996).

Along with attracting researchers, the mussels historically attracted commercial harvesters. The Ohio commercial mussel industry began in the mid 1870's when a process was developed for manufacturing garment buttons from mussel shells. The U.S. Bureau of Fisheries estimated the annual harvest of mussels from 1912 to 1915 at 700 tons from the Muskingum River, with demand driven mainly by the pearl button industry. The development of plastics in the mid-1900's caused the button industry to fade, but the cultured pearl industry of the Far East brought the harvest of freshwater mussels back to a new high. Shells were harvested and exported to Asia, where they were made into nuclei for insertion into oysters creating cultured pearls. Nevertheless, the commercial mussel harvest was banned in Ohio in 1974 (Gross 2000).

The over-harvesting of mussels was a significant contributing factor to their decline. Another factor was the impoundment of the river by dams constructed in the late 1830's and early 1840's. Studies indicate that the majority of mussels appear to favor free-flowing water and a sand-and-gravel substrate. Their current distributions are concentrated in areas immediately below dams, the only river location where this favored habitat now exists. The mussels have also been threatened by pollution, siltation, and runoff into the streams, and are an important indicator species for water quality.

Another potential threat to native unionids is an invasive species known as the zebra mussel. The zebra mussel made its first known attack on Europe in the early 1800s, proliferated in the 20th century, and was carried (probably in ship water ballasts) to North America around 1986, eventually invading all of the Great Lakes (Griffiths *et al*. 1991; USGS 2002). Two species of zebra mussel (genus *Dreissena*) are now prominent freshwater pests; they proliferate readily and adhere in great numbers to virtually any surface. These mussels have established themselves in the Great Lakes, the Ohio River, and rivers feeding into Lake Erie, but fortunately have not yet made their way into the Muskingum. If they did, this mussel would pose a severe threat to the native unionids.

Studies conducted in Europe claim that zebra mussels can interfere with feeding, growth, locomotion, respiration, and reproduction of native mussel species, and that they prefer to attach to live unionids rather than to dead ones or to rocks (Schloesser and Kovalak 1991). Its voracious appetite tends to wipe out phytoplankton and disrupt the food chain. Researchers are observing some of these effects as they study interactions between zebra mussels and native unionids in the Great Lakes. Moreover, zebra mussels can cause severe damage to commercial infrastructure. They cluster on water-intake valves and pipes, bridge abutments, and other structures. They are notorious for their biofouling capabilities, a process involving colonization of water supply pipes of hydroelectric and nuclear power plants, public water supply plants, and industrial facilities (USGS 2002b).

Birds

The Muskingum River plays an important role for both resident and migrant bird species. Endangered species in Ohio that are found along the river include bald eagle (*Haliaettus leucocephalus*), osprey (*Pandion haliaetus,* reintroduced in 1996), and northern harrier (*Circus cyaneus*) (ODNR-DNAP 2003). Sharp-shinned hawks, belted kingfishers, great blue herons,

Canada geese, turkey vultures and various species of waterfowl also make use of the waterway. Commonly found waterfowl include mergansers, scaup, canvasbacks, redheads, pie-billed grebes, mallards, and black ducks. Popular game species include grouse and wild turkeys.

There are several birding "hot spots" located along the river. Local Audubon members know Devol's Dam as a prime site for observing flocks of ducks and geese, and for occasional bald eagle sightings. During the fall, the dam hosts migrants of all kinds. The confluence of the Muskingum and Ohio Rivers provides rich avian habitat that has hosted as many as 1,000 ring-billed gulls during the winter. Local groups, such as the Muskingum River Valley Birding group, are trying to promote interest in area bird species by developing a brochure and map to guide people to birding trails all along the Muskingum River and within the river counties (Grove 2003).

Reptiles and Amphibians

Formal surveys of reptiles and amphibians in the Lower Muskingum watershed have not been conducted. However, there are historical records documenting the occurrence of two endangered species: the eastern hellbender (*Cryptobranchus alleganiensis*) and eastern spadefoot toad (*Scaphiopus holbrookii*) (Moody and Ortt 2003). The Friends of the Lower Muskingum River recently completed an agreement with the Ohio Department of Natural Resources to purchase and preserve some of the lands in Marietta that have been identified as habitat for the endangered eastern spadefoot toad.

Invertebrates

Formal surveys of invertebrates in the Lower Muskingum watershed have not been conducted in the last decade. Earlier studies that were performed involved the gathering of aquatic invertebrate data by the Ohio EPA or American Electric Power (AEP) for water quality studies. Historical data provides no documented sightings of rare, threatened, or endangered invertebrates within the Lower Muskingum watershed. However, there are confirmed records of sightings in Morgan, Muskingum, and Washington Counties of one state-endangered butterfly, the regal fritillary (*Speyeria idalia*). Preferred habitat for this butterfly is tall-grass prairie and other open sites, including damp meadows, marshes, wet fields, and mountain pastures. The

preferred food is nectar from flowers of milkweeds, thistles, red clover, and mountain mint (USGS NPWRC 2003).

Mammals

Once again, formal surveys for mammals in the Lower Muskingum watershed have not been conducted. Common mammal sightings include muskrat, white-tailed deer, raccoons and squirrels. There are several endangered species that may potentially already exist within the watershed but that have not been officially documented. One such species is the river otter, which was successfully reintroduced in Ohio and is now found in the Little Muskingum River watershed. Its populations are likely to spread into the Muskingum River watershed (Wise 2000). Other potentially existing endangered species include black bears and Indiana bats; the latter could be roosting in riparian areas.

Plants

Historical records document the presence of two threatened plant species within the watershed, the downy white beard tongue (*Penstemon pallidus*) and golden-knees (*Chrysogonum virginianum*). There are also several species whose status as endangered species is pending, including the butternut tree (which is in precipitous decline due to butternut canker, a fungal disease), the narrow-leaved toothwort, pale green panic grass, the tennessee bladder fern, and the turk's cap lily. Several different types of forest environments exist within the watershed, ranging from mixed mesophytic to floodplain. Hardwoods, such as oak, maple, and hickory, predominate in the hills. Walnut, elm, cottonwood, and sycamore inhabit the floodplain valleys. Dense paw-paw thickets can also be found along the banks of the mainstem.

The spread of the gypsy moth (*Lymantria dispar*) into Ohio in recent years poses a new threat to forests within the watershed. The gypsy moth is one of the most destructive insect pests threatening eastern American forests, trees and shrubs. The gypsy moth has colonized Ohio on two fronts, spreading from Pennsylvania in the east and from Michigan in the northwest. It is now found in the counties neighboring the Lower Muskingum watershed to the northeast. Severe defoliation by the moth can kill or weaken trees, making them more susceptible to disease, drought, and attacks by other insects. It is not possible to eradicate the gypsy moth, although programs designed to slow its spread have been successful (OSU Extension 2000).

Invasive plant species also threaten the native plants within the watershed. The Nature Conservancy has done a great deal of work both in educating Ohio's citizens about non-native species and in trying to fight their spread. Over 500 non-native species are currently naturalized in Ohio (Cooperrider, *et al*. 2001; TNC 2003), including the autumn olive (*Elaeagnus umbellate*). Also included on the list of non-native invasive species are the multiflora rose, purple loosestrife, Eurasian water milfoil, and several species of honeysuckle. Some of these plants pose serious threats to native species and the ecological integrity of Ohio's native biological diversity. Species like milfoil can proliferate in high densities in waterways, and cause serious impairments to water recreation such as boating, fishing and swimming. The Muskingum Watershed Conservancy District (MWCD) is currently discussing a management proposal for aquatic plants, which have reached nuisance levels and have choked off access to certain parts of several lakes for swimming, boating and fishing. The American Lotus, a large lilly-pad type plant, is among the more visible problem species.

PHYSICAL ATTRIBUTES

Data collection on physical attributes of the entire Lower Muskingum River Watershed is not feasible for this stage of the project. However, available physical data was researched and analyzed for the mainstem of the Lower Muskingum River. A more detailed analysis of physical attribute data of Meigs Creek Subwatershed is described in the next section of this plan. Other sub-basins will be addressed in other phases and added as attachments to this plan at a later time.

Dams

Thirty-four regulated dams are located in the Lower Muskingum River watershed. Of these thirty-four dams eight are installed on the main stem of the Muskingum River for navigational purposes. Paired with locks these dams allow boat traffic on the Muskingum from the mouth in Marietta to Philo at the very edge of the Lower Muskingum River watershed. Two more dams are also located on the Muskingum upstream of the Northern boundary of the watershed. These dams and locks were constructed in the mid 1800's and have been maintained through present day (ODNR 2004). They are of timber crib/concrete construction and have a total principal spillway storage of 27,842 acre-feet (ODNR 2002a). These dams have modified the physical properties of the Muskingum by controlling the stream height and flow of the entire river. Dredging is conducted periodically upstream of the locks and dams to remove sediments that quickly accumulates behind these structures (ODNR 2002b).

The other twenty-six regulated dams of the Lower Muskingum River are earth fill structures created as a result of surface mining operations and their reclamation. These dams are all located in the Meigs Creek Subwatershed where extensive strip mining for coal was previously conducted. Combined, these dams hold back surface water from a drainage area of 33.94 square miles and have a principal spillway storage of 1373.8 acre-feet. The total combined top of dam storage for these dams is 6478.5 acre-feet (ODNR 2002a).

Miles of permanent streambank protection

The Friends of the Lower Muskingum River are a Land Trust and have began to purchase riverside land that is likely habitat to Eastern Spadefoot Toad. The group has purchased 16.5 acres of land along the west side of Muskingum River below Devol's Creek. The Muskingum River Parkway protects a small amount of land surrounding each lock and dam along the River.

REFERENCES

Ambler, C. H., 1932. A History of Transportation in the Ohio Valley, with Special Reference to its Waterways, Trade, and Commerce from the Earliest Period to the Present. The Arthur C. Clark Company, Glendale, California. 456p.

American Electric Power Company, 1999. Financial Press Release. <http://www.aep.com/investors/financialreleases/default.asp?dbcommand=DisplayRelease&ID=517>

American Electric Power Company, 2003. Environmental Stewardship: ReCreation Land. < http://www.aep.com/environmental/stewardship/recland/default.htm>

Barrett, James M., Christina M. Boone, and Larry C. Brown, 1995. Ohio State University Extension. Washington County Water Resources. <http://ohioline.osu.edu/aex-fact/0480_84.html>

Baxter-Potter, W. R., and Gilleland, M. W., 1988. Bacterial pollution in runoff from agricultural lands. Journal of Environmental Quality, vol. 17(1), p. 27-34.

Brookes, A. 1990. Restoration and enhancement of engineered river channels: some European experiences. Regulated Rivers: Research and Management, vol. 5, p. 45-56.

Broughton Nature and Wildlife Education Area website, 2003. <http://www.mariettaohio.org/broughton/broughton.htm>

Buckeye Hills-Hocking Valley Regional Development District (BH-HVRDD), 1971. The First Stage Overall Economic Development Program of the Buckeye Hills-Hocking Valley Regional Development District Council. The Corporation, Marietta Ohio.

Burke, H. R., 1999. Mason-Dixon Line: the Underground Railroad Along the Ohio River. Ohio guidebook, Washington County, Ohio.

Byers, D. E., 2000. The Federal Valley Railroad Company and its Ancestors, 1845-1954. Pressler, A. L., ed. Integrity Press, Westerville, Ohio. 159p.

Chandler, G., 1994. Memories from Yesteryear of Washington, Morgan, and Noble Counties. Jostens Commercial Printing and Publishing, State College, PA.

Cooperrider, T. S., Cusick, A. W., and Kartesz, J. T., eds., 2001. Seventh Catalog of the Vascular Plants of Ohio. Ohio State University Press, Columbus , Ohio. 195 p.

Crowell, D. L., 1995. History of the Coal-Mining Industry in Ohio. Bulletin 72, Ohio Department of Natural Resources, Division of Geological Survey, Columbus.

Crowell, D. L., 1997. History of coal mining in Ohio. Columbus, Ohio: Ohio Department of Natural Resources, Division of Geological Survey.

Crowell, D. L., 2003. Ohio Department of Natural Resources – Division of Geological Survey. Personal Communication.

Doenges, J. S., Allan, C. P., Jontos, R. J. Jr., Liebler, C. A., 1990. Carrying capacity of public supply watersheds: a literature review of impacts on water quality from residential development. Connecticut Department of Environmental Protection, DEP Bulletin 11, 130 p.

Earth Tech Inc., 2000. Wetland Delineation Report, Washington Energy Facility, Waterford Township. Washington County, Ohio. Internal report prepared for Duke Energy Washington, LLC.

Ecological Specialists, Inc., 1993. Unionid Survey of the Lower Muskingum River (RM 34.1-0). Final Report to the Ohio Division of Wildlife, Columbus, OH. 51p. +6 appendices.

Ecological Specialists, Inc., 1996. Unionid Survey of the Lower Muskingum River: Miles 77.4-34.1. Final Report to the Ohio Division of Wildlife, Columbus, OH. 34p.

Grande, D., 2001. Eramet makes pitch to Congress: Local plants wants to halt dumping of ferromanganese on open market. < http://www.mariettaleader.com/022801/eramet.htm>

Grieszmer, B., 2003. Ohio Department of Natural Resources, Division of Natural Areas and Preserves. Personal Communication.

Griffiths, R.W., D.W. Schloesser, J.H. Leach, and W.P. Kovalak, 1991. Distribution and dispersal of the zebra mussel *Dreissena polymorpha* in the Great Lakes region. Canadian Journal of Fish and Aquatic Science 48: 1381-1388.

Gross, W.H., 2000. Ohio's Freshwater Mussels - A Treasure Squandered. <http://www.ohiodnr.com/wildlife/publications/wildohio/summer00/summer00.pdf> [May 2003].

Grove, A., 2003. OSU Extension Morgan County**.** Personal Communication.

Hall, S. G., 2000. Appalachian Ohio and the Civil War, 1862-1863. McFarland and Company, Inc., Jefferson, NC.

Harmar Village website, 2003. <http://www.harmarvillage.com>

Hitzhusen, Fred J; Lowder, Sarah; Ayalasomayajula, Radha, 2000. Muskingum River Economic Valuation - Phase II Working Paper. Department of Agricultural, Environmental, and Development Economics, Ohio State University. <http://www.riversunlimited.org/download/economic_reports/MUSK_RIVER_ECON_VALUATION.pdf>

Hitzhusen – need to find 1998 and 2002.

Hrach, T., 2000. Changed Forever: Valley's Landscape, View of River Altered by 1913 Flood. The Marietta Times. <http://www.mariettatimes.com/communities/rivers/done3.asp>

Isbell, G., 1988. Ohio sport fisheries catch statistics. Ohio Department of Natural Resources, Division of Wildlife, Columbus, Ohio.

Jenkins, H., 1976. A Valley Renewed: the History of the Muskingum Watershed Conservancy District. Kent State University Press, Kent, Ohio. 206p.

Lantz, Aaron., 2005. Personal communication. Ohio Department of Natural Resources.

Lessig, H. D., USDA Soil Conservation Service and Forest Service, ODNR Division of Lands and Soil, and Ohio Agricultural Resource and Development Center, 1977. Soil Survey of Washington County, Ohio. The Service, Washington, D.C.

Likens, G. E., Bonman, F. H., Johnson, N. M., Fisher, D. W., and Pierce, R. S., 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. Ecological Monographs vol. 40(1), p. 23-47.

Malta Parks and Recreation website, 2003. <http://www.malta.20m.com/maltaparks.html>

Marietta Ohio Info website, Mound Builders, 2003. <http://mariettaohio.info/history/index.php> and <http://www.marietta-ohio.com/history/builders/index.php>

Marietta Ohio Info website, Levee House, 2003. <http://www.mariettaohio.org/leveehousecafe/>

Marietta Times, 2000. Fish help measure river's health. <http://www.mariettatimes.com/communities/rivers/health2.asp>

Marietta Times, 2003. Community Section Extras: Rivers. <http://www.mariettatimes.com/communities/rivers/riverindex.asp>

Mechling, Mark, Karen T. Ricker, and Larry C. Brown, 1995. Ohio State University Extension. Water Resources of Muskingum County. <http://ohioline.osu.edu/aex-fact/0480_60.html>

Megahan, W. F., 1980. Nonpoint source pollution from forestry activities in the western United States: results of recent research and research needs. *In:* US Forestry and Water Quality: What Course in the 80s?. Proceedings of the Water Pollution Control Federation Seminar, Richmond VA, 1980, p. 92-151.

Moody, S., 2003. Ohio University – Department of Biological Sciences. Personal Communication.

Morgan County Historical Society, 1980. The History of Morgan County, Ohio to 1980. Morgan County Historical Society, McConnelsville, Ohio.

National Oceanic and Atmospheric Administration (NOAA), 2003. Ohio Climate Summary. < http://lwf.ncdc.noaa.gov/oa/climate/research/cag3/OH.html>

Office of Surface Mining, 2000. A Report on the Cumulative Off-Site Impacts from a Large Area Mine in Southeast Ohio. Office of Surface Mining, Oversight and Inspection Office. Columbus, Ohio.

Ohio's Appalachian Country website, 2003. <http://www.ohioappalachian.com/hill-scripts/index.asp>

Ohio Coal Association, ca. 1945. Ohio Coal: What it Means to the People of the State, Now and in the Future. Ohio Coal Association, Cleveland, Ohio.

Ohio Department of Development website, 2004. <www.odod.state.oh.us>

Ohio Department of Natural Resources, 1994. Geographic Information Management Systems. <http://www.dnr.state.oh.us/gims/default.htm>

Ohio Department of Natural Resources, 2000. Geographic Information Management Systems. <http://www.dnr.state.oh.us/gims/counties.htm>

Ohio Department of Natural Resources, 2001. Stream Gazetteer, second edition. <http://www.dnr.state.oh.us/water/pubs/pdfs/GAZETTEER_OF_OHIO_STREAMS.pdf>

Ohio Department of Natural Resources, 2002a. Dam Inventory Sheets.

Ohio Department of Natural Resources, 2002b. Ohio state parks dredging projects. <http://www.dnr.state.oh.us/news/jun02/0626dredging.htm.>

Ohio Department of Natural Resources, 2003a. Soil Regions of Ohio. <http://www.ohiodnr.com/soilandwater/soilreg3.htm>

Ohio Department of Natural Resources, 2003b. Fishing Prospects for the Muskingum River. <http://www.dnr.state.oh.us/wildlife/Fishing/freport/muskprospects03.htm>

Ohio Department of Natural Resources, 2003. Geofacts Fact Sheet number 10. <http://www.ohiodnr.com/geosurvey/geo_fact/geo_fact.htm>

Ohio Department of Natural Resources, 2004. Muskingum River State Park. <http://www.ohiodnr.com/parks/parks/muskngmr.htm.>

Ohio Department of Natural Resources, Division of Mineral Resources Management, 2000. Report on Ohio's Mineral Industries. <http://www.odnr.com/geosurvey/oh_geol/01_no_4/ohiomi.htm>

Ohio Department of Natural Resources, Division of Natural Areas and Preserves, 2003. List of Endangered Species in Ohio. < http://www.dnr.state.oh.us/endangered/default.htm>

Ohio Department of Natural Resources, Division of Natural Areas and Preserves, 2003.

Ohio Department of Natural Resources, Ohio Geologic Survey, 2003. Map of Glacial Deposits in Ohio. <http://www.ohiodnr.com/geosurvey/glacial.pdf>

Ohio Department of Natural Resources website, 2004. <http://www.dnr.state.oh.us/parks/parks/muskngmr.htm>

Ohio Department of Transportation website, 2003. <www.dot.state.oh.us/JobsAndProgress/seregion.pdf>

Ohio Environmental Protection Agency, 1993. Investigation of Sediment and Surface Water Impacts in the Muskingum River, McConnelsville, Ohio. Columbus, Ohio.

Ohio Environmental Protection Agency, Division of Drinking and Ground Waters, 2003. State of Ohio Source Water Assessment and Protection Program: Ground Water Susceptibility Analysis Process Manual. <http://www.epa.state.oh.us/ddagw/Documents/swap_saprocman.pdf>

Ohio Environmental Protection Agency, Division of Surface Water, 1999. High Quality Wetlands in Ohio. Columbus, Ohio.

Ohio Environmental Protection Agency website, 2004. Watershed Attainment. <http://www.epa.state.oh.us/dsw/watershed/attain/use24.htm>

Ohio Historical Society, 2003. Historical Sites by Region: Southeast Ohio Sites. < http://www.ohiohistory.org/places/southeas.html>

Ohio History Central, 1998. Ohio's Soils. <http://www.ohiohistorycentral.org/ohc/nature/geograph/land/ohsoils.shtml>

Ohio Oil and Gas Energy Education Program (OOGEEP), 2003. Oil and Gas Museum. Factsheet. <http://www.oogeep.org/Museum.htm>

Ohio River Sanitary Commission (ORSANCO), 2002. Ohio River Total Maximum Daily Load for PCBs: Ohio River Miles 40.0-317.1. Cincinnati, Ohio.

Ohio State University Extension, 1992. Nonpoint Source Pollution: Water Primer. OSU Extension Fact Sheet. <http://ohioline.osu.edu/aex-fact/0465.html>.

Ohio State University Extension, 1996. Ohio Agronomy Guide. OSU Extension Bulletin no. 472. <http:// ohioline.osu.edu/b472/index.html>

Ohio State University Extension, 2000. Gypsy Moth in Ohio Landscapes. OSU Extension Fact Sheet. < http://ohioline.osu.edu/hyg-fact/2000/2173.html>

Ohio State University Extension, 2002. All About Agriculture in Noble County. <http://www.ag.ohio-state.edu/~nobl/ag/ag.htm>

Ohio State University, Extension Data Center website, 2004. Agricultural County Statistics. <http://www.osuedc.org/profiles/>

Ortt, M., 2001. Friends of the Lower Muskingum River. Personal Communication.

Places Ohio website, 2003. <www.placesohio.com>

Raymond, H., 2003. Ohio EPA Division of Groundwater. Personal Communication.

Reash, R. J., 2002. Dissolved and total copper in a coal ash effluent and receiving stream: assessment of *in situ* biological effects. In Review.

Root, K. V., and Akcakaya, R, 1999. RAMAS ecological risk model for assessing temperature effects on redhorse sucker species in the Muskingum River. <http://www.ramas.com/redhrse.htm>

Rothwell, R. L., 1983. Erosion and sediment control at road-stream crossings (Forestry). The Forestry Chronicle, vol. 59, p. 14-19.

Scheiber, H. N., 1987. Ohio Canal Era; a Case Study of Government and the Economy, 1820-1861. Ohio University Press, Athens, Ohio. 430p.

Schloesser, D.W. and W.P. Kovalak, 1991. Infestation of Unionids by *Dreissena polymorpha* in a Power Plant Canal in Lake Erie, U.S. Fish and Wildlife Service.

Schneider, N. F., 1968. The Muskingum River: a History and Guide. The Ohio Historical Society, Columbus, Ohio. 48p.

Schueler, T. 1987. Controlling Urban Runoff - a Practical Manual for Planning and Designing Urban Best Management Practices. Metropolitan Washington Council of Government, DC.. 202 p.

Schrader Real Estate and Auction Co., Inc. website, 2004. <http://schraderauction.com/index.cfm/fa/auctions.view/auctionid/562/AID/615.htm>

Shannon, I. V., 1943. Southeastern Ohio in Depression and War: The Disintegration of an Area. Ohio Public Health Association, Columbus, Ohio.

Siebert, W. H., 1951. The Mysteries of Ohio's Underground Railroads. Long's College Book Company, Columbus, OH.

Stansbery, D. H. and King, C. C., 1983. Management of Muskingum River Mussel Populations. Final Report to the Ohio Division of Wildlife, Columbus, OH. 60p.

Stansbery, D. H., Newman, K. E., Borror, K. G., and Stein, C. B., 1985. Literature Records of Bivalve Mollusks of the Muskingum River System, Ohio. Ohio Biological Survey Technical Report no. 8, 472p.

Steiger, Joseph R., 1996. Soil survey of Muskingum County, Ohio. United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with the Ohio Department of Natural Resources, Division of Soil and Water Conservation, Ohio Agricultural Research and Development Center, and Ohio State University Extension. Washington, D.C.: The Service.

The Nature Conservancy, 2003. Ohio's Invasive Plant Distribution Maps. < http://nature.org/wherewework/northamerica/states/ohio/science/art6279.html>

The Ohio Historical Society website, 2003. <http://www.ohiohistory.org/places/southeas.html>

The Wilds website, 2003. <www.thewilds.org>

United States Census Bureau, 1990 and 2000. ILGARD Census Data. <http://ilgard.ohiou.edu/data/index.asp>

United States Department of Agriculture, Economic Research Service, 1994. Agricultural Resources and Environmental Indicators. The Service, Washington, D. C.

United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with United States Department of Agriculture, Forest Service…[et al.], 1998. Soil survey of Morgan County, Ohio. Washington, D.C.: Natural Resources Conservation Service.

United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with Ohio Department of Natural Resources, Division of Soil and Water Conservation, and Ohio Agricultural Research and Development Center, 1990. Soil survey of Noble County, Ohio. Washington, D.C.: The Service.

United States Department of Agriculture, Natural Resources Conservation Service, ODNR Division of Soil and Water Conservation, Ohio Agricultural Resource and Development Center, 1990. Soil Survey of Noble County, Ohio. The Service, Washington D.C.

United States Department of Agriculture, Natural Resources Conservation Service and Forest Service, Ohio Agricultural Resource and Development Center, 1998. Soil Survey of Morgan County, Ohio. The Service, Washington D.C.

United States Environmental Protection Agency, 1996a. Nonpoint Source Factsheet: Managing Nonpoint Source Pollution from Forestry. <www.epa.gov/owow/nps/facts/point8.htm>

United States Environmental Protection Agency, 1996b. Nonpoint Source Factsheet: Managing Urban Runoff. <www.epa.gov/owow/nps/facts/point7.htm>.

United States Environmental Protection Agency, 1996c. Report to Congress: National Water Quality Inventory. U. S. Environmental Protection Agency, Office of Water Program Operations, Washington, D.C.

United States Forest Service, 2003. Wayne National Forest, Lake Vesuvius Recreation Area. < http://www.fs.fed.us/r9/wayne/vesuvius_docs/vesuvius_lake_home.html>

United States Geological Survey, 1990. Water Use for 05040004 – Muskingum. <http://water.usgs.gov/cgi-bin/wuhuc?huc=05040004>

United States Geological Survey, National Prairie Wildlife Research Center, 2003. Butterflies of North America. < http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/oh/toc.htm>

United States Geological Survey, 1997. Streamflow Data for Meigs Creek Gage Station. <http://waterdata.usgs.gov/oh/nwis/dvstat/?site_no=03150250&agency_cd=USGS

United States Geological Survey, 2003. Streamflow Data for the Muskingum River at McConnelsville.

<http://waterdata.usgs.gov/oh/nwis/uv/?site_no=03150000&PARAmeter_cd=00065,00060,0000010>

Valley Gem Sternwheeler website, 2003. <http://www.valleygemsternwheeler.com>

Wagner, K., 2003. Washington County SWCD. Personal Communication.

Walker, R., 1996. Wolf Creek and the Muskingum: Notes on the Settlement of Southeastern Ohio. Gateway Press, Baltimore. 599p.

Washington County Historical Society, 1980. Washington County, Ohio to 1980: A Collection of Topical and Family Sketches. Taylor Publishing Company, Dallas, Texas.

Watters, T. G., 1996. Small dams as barriers to freshwater mussels (*bivalvia, unionida*) and their hosts. Biological Conservation 75(1), p. 79-85.

Watters, T. G., 2000. Freshwater mussels and water quality: a review of the effects of hydrologic and instream habitat alterations. Proceedings of the First Freshwater Mollusk Conservation Society Symposium. 1999, p. 261-274.

Wise, J. 2000. Ohio Division of Wildlife-Otters are Making a Comeback. <http://www.fishlakeerie.com/news/articles-erie/13.html>

Woodward, S. L., 1986. Indian Mounds of the Middle Ohio Valley: a Guide to Adena and Ohio Hopewell Sites. McDonald and Woodward Publishing Company, Newark, Ohio. 130p.

SECTION II. MEIGS CREEK SUBWATERSHED

INTRODUCTION

Background information on demographics, organizational structure, partners, history, geology, land use, topography, and water resources and quality for the Lower Muskingum River Watershed is documented in Section I of this plan. The background information in Section I included those areas within the Meigs Creek Subwatershed and therefore will not be repeated in Section II. The purpose of Section II of this plan is to specifically address water resources and water quality of Meigs Creek Subwatershed. A detailed analysis of Meigs Creek will aid in developing strategies to address nonpoint source water quality impairments and design implementation plans to improve or protect water quality.

WATERSHED DESCRIPTION

Meigs Creek is an eleven digit hydrologic unit, 05040004080, within the Lower Muskingum River Watershed. Meigs Creek Subwatershed drains 142.2 square miles (91,088 acres) within Morgan, Noble, and Muskingum Counties (Map 1). Meigs Creek meanders a length of 21.2 miles before entering into the Lower Muskingum River at River Mile (RM) 29.42 south of McConnelsville in Morgan County. Meigs Creek Subwatershed originates near the small rural towns of Museville and Ruraldale, then flows south through mostly uninhabited forests and fields and finally through the small Village of Unionville before entering into the Lower Muskingum River. The average gradient of Meigs Creek is 10.7 ft/mile. The terrain of the Meigs Creek Subwatershed, has moderately steep to very steep hillsides, gently sloping or strongly sloping ridge tops, and several fairly broad stream valleys. There are no large towns and only approximately 1,500 people live within the watershed (US census 2000). In fact, several of its towns are now historical and seem to have disappeared after the major coal mining operations moved out in the 1950-60's. Approximately 54,400 acres of the land within the watershed is owned by American Electric Power (AEP)/Ohio Power/Central Ohio Coal Company, and AEP has opened much of the central and northeastern portions of the watershed to public access as part of its ReCreation Land. Consol Energy owns approximately 2,000 acres of land within Dyes Fork drainage, and restricts public access due to ongoing reclamation activities. The remaining pieces of land, mostly on the western side of the watershed, are privately owned.

Many of the private landowners appear to have small livestock operations, with cattle and some horses. There are also many farmers with large fields of pasture hay, along with a smaller number that plant corn. Many oil and gas wells are located throughout the Meigs Creek Subwatershed (Map 2).

The Meigs Creek Subwatershed is comprised of five 14-digit hydrologic unit codes (HUC), which are summarized in Table 1 (Map 3).

Table 1

14-digit Hydrologic Unit Codes for the Meigs Creek Subwatershed

14 Digit HUC code	Location	Size (acres)
05040004080010	Upper Meigs Creek (upst. Mans Fk.)	22,930
05040004080020	Mans Fork Subwatershed	17,993
05040004080050	Fourmile subwatershed	7,998
05040004080040	Dyes Fork	28,789
05040004080030	Lower Meigs Creek (dst. Mans Fk. including Perry Run and Onion Run)	13,338

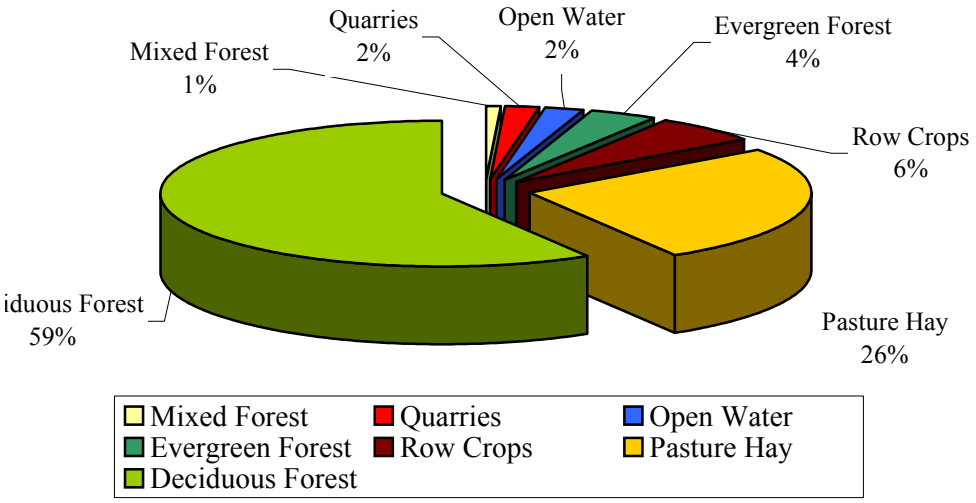
NATURAL RESOURCES INVENTORY

LAND USE CHARACTERISTICS

The majority of the land use in Meigs Creek Subwatershed is comprised of deciduous forest (59 percent) (Figure 1). In total, forest (including deciduous, mixed, and evergreen) make up approximately 64 percent of the land use in the watershed. Farming is prevalent in the watershed making up 32 percent of the land use, with the majority, 26 percent consisting of hay fields and pastures. The type of farming is dictated by the hilly topography of the area, with most farms occurring in the bottomlands with some pasture on hillsides and tops (Map 4).

Figure 1

Land Use Data for the Meigs Creek Subwatershed



Source: LANDSAT Satellite Data 1994

Riparian corridor

The number of miles of stream bordered by various land use categories (LANDSAT Satellite Data 1994) was calculated using a 30 meter buffer in GIS ArcView and river mile maps to create a map of the quality of the riparian buffer (Map 5). Out of approximately 195 miles of stream, 43 percent are bordered by cropland (mainly corn) or pasture with hay or grazing livestock, while deciduous forest surrounds 23 percent, strip mines surrounds 18 percent, shrub

land surrounds 6 percent, and the remaining 10 percent is comprised of mixed forest (4.0%), evergreen forest (2%), transitional (3.9%), and residential (0.1%) (Table 2). Residential areas are essentially nonexistent, with only the small Village of Unionville visible on the land use layer. The eastern portion of the Meigs Creek Subwatershed shows a different pattern of land use. In the Dyes Fork drainage basin, the majority of stream miles are bordered by strip mines. "Strip mines in the 1950's, 60's and early 70's were reclaimed to forestlands, strip mines in the mid to late 1970's, 80's, 90's were reclaimed to grasslands" (Kaster 2004).

Of the total 195 miles of stream in the Meigs Creek watershed 55 miles have a riparian buffer width that is 30 meter or greater while the remaining 140 miles of stream have a riparian buffer width of 30 meters or less (calculated from the sum of stream miles bordered by deciduous, mixed and evergreen forests). One may argue that this number should be larger because single trees border many of the banks of Meigs Creek. However, these single-tree buffers are often 5 meters or less in width, which makes their effectiveness questionable.

Table 2

Miles of stream buffered by various land uses (30 meter buffer)

14-digit Hydrologic units	Cropland & pasture	Deciduous	Mixed	Evergreen	Shrub	Transitional	Strip mines	Residential
Mans	29.9	8.4	2.4	0.4	0.3	4.2	1.8	0
Fourmile	13.3	4.4	1.4	0	1.8	0	0	0
Dyes	3.7	5.2	3.4	1.9	0	0	33.4	0
Lower Meigs	14.9	7.9	0.4	1.2	5.8	0	0	0.2
Upper Meigs	22.4	18.4	0	0	4.3	2.9	0	0
Total	**84.2**	**44.3**	**7.6**	**3.5**	**12.2**	**7.1**	**35.2**	**0.2**

PHYSICAL ATTRIBUTES

Qualitative Habitat Evaluation Index (QHEI)

The Qualitative Habitat Evaluation Index (QHEI) is a physical habitat index used by the Ohio EPA that provides an empirical, quantified evaluation of the general lotic macrohabitat characteristics that are important to fish communities. The score is based on six principal metrics: substrate, instream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle/run quality, and map gradient (Rankin 1989 & 1995, Ohio EPA (b)). Each of the metrics are scored individually and then summed to provide a total site score, with the maximum possible score being 100. QHEI scores of 60 or greater in the WAP eco-region suggests that habitat is not limiting the stream from supporting the Aquatic Life Use designation of Warmwater Habitat (WWH).

Qualitative Habitat Evaluation Index (QHEI) scores were measured throughout Meigs Creek, Table 3. QHEI scores correspond to the eleven macroinvertebrate sampling sites plus one QHEI measurement corresponding to the fish sampling location at Dyes Fork (Map 6). All measurements were recorded at least 50 meters above or below bridges, where habitat was more typical. QHEI scores ranged from 60.8 to 81.0. All sites met the target of 60 or greater, and do not limit the sites from meeting Warmwater Habitat due to habitat. Gravel was the dominant substrate at the majority of sites, and riparian zones varied from wide to none. Onion Run had a relatively low score due to its high percentage of bedrock substrate and its high gradient. Perry Run also had a high gradient, along with a very narrow riparian zone, which contributed to its relatively low score.

Table 3

QHEI scores throughout Meigs Creek Subwatershed

MACRO SITES	River Mile	Substrate	Instream Cover	Channel Morph	Riparian Zone Bank Erosion	Pool Current	Riffle Run	Gradient	QHEI
Perry	0.2	15.5	13.0	12.0	5.3	6.5	4.5	4.0	**60.8**
Onion	0.7	11.0	13.0	15.0	6.5	6.5	5.0	4.0	**61.0**
Horses	2.9	10.5	14.0	15.0	9.0	6.0	3.0	8.0	**65.5**
Guyst	0.9	14.0	16.0	15.0	5.0	6.0	4.0	10.0	**70.0**
Mans	9.7	13.0	15.0	15.0	6.5	7.0	6.0	10.0	**72.5**
Meigs	21.2	15.0	20.0	15.0	5.3	8.0	4.5	8.0	**75.8**
Fourmile	0.5	15.5	19.0	12.0	6.0	12.0	5.0	8.0	**77.5**
Meigs	19.9	14.5	17.0	15.0	7.8	11.0	4.5	8.0	**77.5**
Border	0.3	16.5	20.0	17.0	5.3	10.0	5.0	4.0	**77.8**
Mans	7.2	16.5	16.0	16.0	6.5	9.0	6.0	8.0	**78.0**
Fourmile	6.0	12.5	20.0	16.5	8.0	10.0	4.0	10.0	**81.0**
Dyes	5.8	14.5	16.0	12.5	8.0	10.0	6.5	8.0	**75.5**

Jen Stamp, graduate student at Ohio University, performed the assessments

Historical QHEI data only exists for three sites in the Meigs Creek Subwatershed, and only one of these sites, Dyes Fork RM 5.8, that was reassessed in 2003. The QHEI score at this site dropped from 81.0 in 1989 to 75.5 in 2003 (Table 4). Because the QHEI is subjective, part of the scoring difference may be due to the fact that the same person did not perform the assessment.

Table 4

Historical Ohio EPA QHEI data for Meigs Creek Subwatershed

Stream	River Mile	Year	Drain Area	QHEI
Meigs Creek	0.90	1989	142.0	**80.0**
Dyes Fork	0.30	1989	45.0	**72.5**
Dyes Fork	5.80	1989	38.0	**81.0**

Sinuosity

Sinuosity measurements for the Meigs Creek Subwatershed were made using GIS ArcMap. Stream line graphs (Ohio Department of Administration Services 2004a) were layered on top of 30 meter resolution digital elevation models (Ohio Department of Administration Services 2004b) and valley lengths and stream lengths were measured using the ArcMap measure tool. Sinuosity was calculated by dividing the total stream length by the total valley length. Table 5 displays the sinuosity measurements for Meigs Creek and its major tributaries. Fourmile Run, Onion Run, Perry Run, and Mans Fork were calculated with a sinuosity measurement less than 1.2 which indicates low sinuosity. Meigs Creek (all sections) and Dyes Fork were calculated with sinuosity measurements between 1.2 and 1.5 which indicates moderate sinuosity (Rosgen 1998).

Table 5

Sinuosity measurements for Meigs Creek and its tributaries

Stream	Sinuosity (K)
Meigs Creek	1.3
Meigs Creek (northern section)	1.2
Meigs Creek (southern section)	1.4
Fourmile	1.1
Dyes Fork	1.4
Onion Run	1.1
Perry Run	1.0
Mans Fork	1.1

Entrenchment

Entrenchment measurements were taken for streams within the Meigs Creek Subwatershed. Entrenchment ratios were measured by dividing the flood prone area width by the bankfull width. The bankfull width is the width of the stream when it has reached the top of its banks. The flood prone area width is the width of the water level if the stream were to rise two times the maximum depth of the stream at bankfull. The entrenchment ratio was calculated twice at each site from two different stream cross sections. The two measurements were then averaged for a more accurate estimate of the actual entrenchment of the entire reach. Entrenchment ratios for the sites of the Meigs Creek Subwatershed can be seen in Table 6. Entrenched streams have a

flood prone area width to bankfull width of 1.0 to 1.4. Guyst Fork near its mouth had an average entrenchment ratio of 1.3. Meigs, MC-00-77, with an average entrenchment ratio of 2.0 is moderately entrenched falling into the range of 1.4 to 2.2. All other sites would be considered slightly entrenched with entrenchment ratios greater than 2.2 (Rosgen 1998).

Table 6

Entrenchment ratios of Meigs Creek and its tributaries

Site	Entrenchment ratio (ER)			Comments
	Cross section 1	Cross section 2	Average	
BS-00-05	7.4	4.2	5.8	
MF-00-55	> 10.0	2.1	6.1	Ave. based on ER of 10 for cross section 1
MF-00-75	7.6	7.1	7.4	
MC-00-77	1.4	2.6	2.0	Cross section 1 entrenchment due to road
GF-00-01	1.3	1.3	1.3	
MC-00-83	5.7	3.8	4.8	
BI-00-01	NA	NA	NA	Did not appear entrenched, Measurement not possible
BL-00-70	> 10.0	4.4	7.2	Ave. based on ER of 10 for cross section 1
TR-00-01	2.4	6.1	4.3	
RE-00-03	6.0	8.6	7.3	
BF-00-35	NA	NA	NA	Did not appear entrenched, measurement not possible
HR-00-50	10.5	10.3	10.4	
DF-00-30	4.9	NA	NA	Stream water too deep for measurement
PR-00-03	3.7	3.0	3.3	
FM-00-05	4.2	NA	NA	Large flood plain

Floodplain Connectivity

Meigs Creek is located in a rural area of Ohio and as a result has not been prone to increasing development demands. Therefore the impact from flooding is relatively low. When Meigs Creek floods from its banks there is ample floodplain area. However, state highways do affect the floodplain connectivity and as a result are flooded during periods of heavy rainfalls (Map 7). State Highway 78 runs east and west directly through the mainstem of Meigs Creek and disturbs small portions of the floodplain. In addition State Highway 60 runs through the southern section of the watershed near the confluence of the Muskingum River and the

intersection of State Highway 266. Several other state highways, including 376, 284, and 83 also run through portions of the watershed.

WATER QUALTIY

Meigs Creek Aquatic Life Use Designations and Attainment

All stream sections in the Meigs Creek Subwatershed have aquatic life use designations of Warmwater Habitat (Section I, page 66), but only a few sections have been partially or fully assessed for attainment. An Ohio EPA 305b report indicates the mainstem of Meigs Creek and one of its major tributaries, Dyes Fork, were the only stream segments to be completely assessed. These two stream sections account for about 38 percent of the stream miles in the drainage area. Both segments were determined to be impaired by nonpoint source pollution. Sources of known or suspected impact for Meigs Creek include agriculture, silviculture, reforestation, crop residue management, road construction, coal mining, and siltation. Dyes Fork is known or suspected of being impacted from coal mining and siltation.

Some assessment status information was provided for Onion Run, Fourmile Run, Horse Run, Brannons Run, Guyst Fork, Marshall Creek, and Starrett Creek. Suspected and known sources of impairment for these stream sections were mainly attributed to agriculture and coal mining, but oil and gas production were also included for Horse Run. These stream segments account for about 31 percent of the stream miles in the Meigs Creek Subwatershed.

Luck Run, Perry Run, Little Fourmile Run, Sugartree Run, Tiltons Run, Blanchard Run, Tyson Run, Mans Fork, and Bear Run have not been assessed for nonpoint source pollution. These stream segments account for approximately 31 percent of the Meigs Creek drainage. Table 7 lists all the stream segments of Meigs Creek, their length, assessment status, and sources of known and possible impairment (Ohio EPA 1990).

Table 7

Meigs Creek Subwatershed stream assessment status

Stream Name	Segment Length (miles)	Stream Assessment Status	Sources of known or suspected impact
Luck Run	1	no info	
Perry Run	4	no info	
Little Fourmile Run	3	no info	
Sugartree Run	2	no info	
Tiltons Run	3	no info	
Blanchard Run	3	no info	
Tyson Run	4	no info	
Mans Fork	10	no info	
Bear Run	3	no info	
Meigs Creek	21	NPS impaired	agriculture, crop production, silviculture, forest harvesting, reforestation , residue management, road construction/maintenance, coal mining, surface coal mining
Dyes Fork	19	NPS impaired	surface coal mining
Onion Run	4	some info	crop production
Fourmile Run	9	some info	crop production
Horse Run	7	some info	coal mining, surface coal mining, oil/gas production
Brannons Fork	6	some info	agriculture, crop production, coal mining, surface coal mining, oil/gas production
Guyst Fork	2	some info	agriculture, crop production, coal mining, surface coal mining, oil/gas production
Marshall Creek	2	some info	agriculture, crop production
Starett Creek	2	some info	agriculture, crop production

Water Quality Data

Ohio EPA aquatic life water quality standards exist for very few of the water quality parameters that were collected for this study. Therefore other sources of information pertaining to water quality targets and benchmarks were reviewed. Table 8 summarizes water quality standards and targets that were found from various sources. Information in this table is arranged in order of importance moving from left to right through the columns. When comparing data collected for this study to water quality standards and targets information appearing in the left column moving to the right was used first. Starting in column three (Table 8), Ohio EPA aquatic

life outside mixing zone average (OMZA) standards, then Ohio EPA water column chemistry statistics for all sites in the Western Allegheny Plateau (WAP) for headwaters and wadeable streams within Index of Biotic Integrity (IBI) scores of 40-60 (Ohio EPA 1999), followed by USEPA water quality standards. The seventh column contains mean coal field parameters gleaned from current Ohio EPA water quality database for all size stream sites in the WAP that are meeting Warmwater Habitat (WWH). The last column contains information from Raccoon Creek's TMDL report (Ohio EPA 2002).

Table 8

Summary of water quality standards and targets

Parameter	**Units**	**OEPA aquatic life OMZA**	**USEPA standard**	**OEPA – Associations document**	**Coal field WAP mean**	**RC TMDL targets**
Turbidity	NTU		2.3			
Sulfate	mg/l			51.0-140.0	198.8	
Iron	mg/l		1.0 ŧ		0.9	
Conductivity	µS/cm			413.0-540.0	508.1	
DO	mg/l	4.0		7.9-8.4		
TDS	mg/l	1500.0			452.5	
TSS	mg/l			5.0-9.5	24.9	
Phosphorus	mg/l			0.05		
pH	S.U.	6.5-9.0		7.7-7.9	7.8	
Alkalinity	mg/l			107.0-144.0	111.2	20
Fecal coliform	colonies/ 100ml	2000 *		350.0-1160.0		
Nitrate	mg/l			0.21-0.39		
Strontium	µg/l	770		1700-2050 ə		
Hardness	mg/l				225.3	
Magnesium	mg/l			12.0-18.0		
Manganese	mg/l			0.03-0.22	0.2	0.5
Aluminum	mg/l		0.08 ŧ - 0.75 £		0.97	
Ammonia	mg/l	2.2		0.05		
Sodium	mg/l			10.0 -55.0		
Chloride	mg/l			12.0-24.0		
Calcium	mg/l			57.0-63.0		

* Primary contact
ŧ Criterion continuous concentration
£ Criterion maximum concentration
ə Based on IBI values 20-29

Water quality data for samples collected during summer of 2003 and spring of 2004 in the Meigs Creek Subwatershed are summarized in the following sections (Map 8) (Appendix II.A). A detailed description of water quality data is described in each 14-digit HUC subwatershed section. A total of fifty-one site locations were analyzed for water quality: twenty-nine sites were sampled in the summer 2003, during low flow and fifty-one sites were sampled in spring 2004 during high flow, twenty-nine sites overlap. Ohio EPA Laboratory results were compared with water quality standards and targets described in Table 8. In addition to the laboratory samples collected, field parameters such as dissolved oxygen, transparency tube measurements, temperature, pH, conductivity, and flow were measured. In addition to water quality samples, twenty-seven samples were collected in August 2004 for bacteriological analysis of fecal coliform.

Conductivity

According to the Ohio EPA Association Document, the median WAP values for headwaters and wadeable streams, that scored an IBI value of 40-60, is 413 – 540 μS/cm (Table 8). Data collected within Meigs Creek Subwatershed will be compared to the Ohio EPA Association Document utilizing 413 -540 μS/cm as a target for sites within Meigs Creek Subwatershed.

Of the fifty-one samples taken in the Meigs Creek Subwatershed, 30 sites had conductivity values greater than 540 μS/cm and 20 sites had values greater than 413 μS/cm and less than 540 μS/cm (Map 9). All of the sites except one exceeded the target. The furthest upstream site, Meigs Creek at Flat Road bridge, MC-00-88, had a value of 388 μS/cm. The highest measurement was recorded at Blanchard Spring within the Dyes Fork Subwatershed at 3880 μS/cm in 2003 and 4090 μS/cm in 2004. The highest value measured on the mainstem was 1520 μS/cm in the summer 2003 and is located downstream of the confluence with Dyes Fork.

Conductivity is the measure of amount of cations and anions present in the water. Scatter plots showing conductivity versus all the metals measured for in this study have shown positive correlation between conductivity with sulfate and strontium R^2 values of 0.95 and 0.92, respectively.

Sulfate

Target values for sulfate concentrations from the Ohio EPA Association Document range between 51 – 140 mg/l (Table 8). Twenty-nine sites were greater than 140 mg/l, fifteen sites

were between 51 and 140 mg/l, and eight sites were less than 51 mg/l within Meigs Creek Subwatershed (Map 10). The highest sulfate concentrations measured were 1690 mg/l and 1960 mg/l at Blanchard Spring in Dyes Fork Subwatershed during summer 2003 and spring 2004, respectively. Eight sites within the Meigs Creek Subwatershed had measurements less than the low end of the target range (51 mg/l); all the Fourmile Run sites, one site in Perry Run, PR-00-50, and the headwaters of Mans Fork, MF-11-01 were also below 51 mg/l.

Strontium

Target range values for strontium levels are 1700 – 2050 μg/l as stated in the Ohio EPA Association Document. Forty-six sites in Meigs Creek Subwatershed fall below this target range. However, four sites have values greater than 2050 μg/l and one site falls between 1700 and 2050 μg/l. These five sites are all within the Dyes Fork Subwatershed; they are Brannons Fork, Bicentennial tributary, Blanchard Spring, and the mouth of Dyes Fork (Map 11).

Total Suspended Solids

Ohio EPA Association Document target range values for total suspended solids is 5.0-9.5 mg/l and Ohio EPA Coal field parameters mean value is 24.9 mg/l (Table 8). Using these targets to compare to the data collected during the spring 2004, thirty-seven sites were below 5.0 mg/l, the low end of the target range. Four sites fell between 5.0 and 9.5 mg/l; seven sites were higher than 9.5 mg/l, but less than 24.9 mg/l. Three sites were recorded higher than 24.9 mg/l. Two of these sites were within the Dyes Fork Subwatershed, Renrock and Brannons tributaries, and the other site was at the mouth of Mans Fork at Gerlach Road.

Total Dissolved Solids

Only fourteen sites were analyzed for total dissolved solids. Of these fourteen sites only one site in Meigs Creek exceeded the Ohio EPA criteria, the mouth of Dyes Fork. All other sites were well below the criteria limit of 1,500 mg/l.

Iron

USEPA standard for iron is 1.0 mg/l. Of the fifty-one samples collected one site exceeded this standard, Renrock tributary within Dyes Fork Subwatershed, 1.1 mg/l.

Turbidity

USEPA standard for turbidity is 2.3 NTU. Approximately half of the sites in Meigs Creek Subwatershed exceed this standard (Map 12). The highest recorded turbidity values during the spring 2004 sampling event were in Renrock (11.2 NTU) and Brannons Fork (10.1 NTU) tributaries within the Dyes Fork Subwatershed and the mouth of Dyes Fork (7.8 NTU). Additional high values were recorded at Bear Run (6.2 NTU), within the Mans Fork Subwatershed, and the mouth of Mans Fork (6.2 NTU). However, during the low flow sampling period in the summer 2003 the highest values were measured at the headwaters site in Mans Fork, RM 9.7, MF-00-75, had a recorded 28.6 NTU (3.9 NTU, spring 2004). Another Mans Fork site, RM 1.7, MF-00-10, had a value of 23.7 NTU (2.0 NTU, spring 2004). And as similarly seen during the spring 2004 sampling event the following sites exceeded the standard during the summer 2003 sampling event also; Bear Run (22.9 NTU) and the mouth of Dyes Fork (20.5 NTU).

Phosphorus

Ohio EPA Association Document target for phosphorus is 0.05 mg/l. Nine sites within Meigs Creek Subwatershed exceed this target (Map 13). The highest measurement was recorded during the spring 2004 sampling event on the mainstem of Meigs Creek downstream of Mans Fork at RM 10.1, MC-00-36 (0.82 mg/l). The highest measurement recorded during the summer 2003 sampling event was at the mouth of Mans Fork at RM 0.32, MC-00-03 (0.441 mg/l).

Sodium

The target range for sodium concentrations is 10-55 mg/l as stated in the Ohio EPA Association Document (Table 8). Of the fifty-one sites sampled in Meigs Creek Subwatershed approximately half of the sites exceed the 10 mg/l target and eleven of those sites exceed the 55 mg/l target. Primarily the sites to exceed this upper target are located in Dyes Fork, Guyst Fork, and the mainstem of Meigs downstream of Dyes Fork. Blanchard Spring had the highest recorded value at 686 mg/l.

Chloride

The range of target values for chloride is 12-24 mg/l from the Ohio EPA Association Document. None of the fifty-one sites in Meigs Creek exceed the upper target of 24.0 mg/l.

However, eight sites do exceed the lower target of 12.0 mg/l. These sites are located in Mans Fork, Guyst Fork, Little Fourmile Run, and the headwaters of Meigs Creek.

Dissolved Oxygen

Ohio EPA has a standard for dissolved oxygen of 4.0mg/l. Only one site within the Meigs Creek Subwatershed did not meet this standard, Blanchard Spring, in Dyes Fork Subwatershed with a concentration of 1.33 mg/l. However, this is expected because the Blanchard Spring is groundwater which is naturally deprived of oxygen. The median target range derived from the Ohio EPA association document is 7.9 – 8.4 mg/l. Data collected from Meigs Creek was compared to this target; any measurement less than 7.9 is considered fair condition. Nineteen sites fell into this range of 4.0 – 7.9 mg/l. Areas with the lowest dissolved oxygen measurements were located in Mans Fork RM 3.4 and 4.2 (4.2 mg/l and 5.6 mg/l) and Dyes Fork at Bicentennial tributary and Brannons Fork (5.70 and 5.77 mg/l).

Fecal Coliform

Fecal coliform samples were collected at twenty-seven sites throughout the Meigs Creek Subwatershed during low flow in August 2004 (Map 14). Water quality standard for primary contact of fecal coliform according to the Ohio EPA is that the mean of not less than five samples taken within 30 days shall not exceed 1000 counts/100ml and no more than 10% of the samples should exceed 2000 counts/100ml within the 30 day period. The standard for secondary contact is that not more than 10% of the sample collected with a 30 day period shall exceed 5000 counts/100ml. Samples collected from Meigs Creek Subwatershed were only sampled once throughout the watershed as a first screening approach. Of the twenty-seven sites collected throughout the watershed, none of these sites exceeded 5000 counts/100ml, three sites exceeded the 2000 counts/100ml and sixteen sites exceed the 1000 counts/100ml. The three sites that exceed 2000 counts/100ml are located in Perry Run RM 2.6, PR-00-50, Bear Run, RM 0.2, BR-00-01, and the mainstem of Mans Fork at RM 4.3, MF-00-45.

BIOLOGY

Macroinvertebrates

The Macroinvertebrate Aggregated Index for Streams (MAIS) for the Central Appalachians Ecoregion sixty-nine was used to evaluate the macroinvertebrate data and to assess the biological health of each site. Although use of the Ohio EPA's Invertebrate Community Index (ICI) would have been ideal (DeShon 1985, Ohio EPA 1987, Yoder and Rankin 1995), this study lacked resources for proper identifications to the genus- and species-levels to complete an ICI score. The MAIS was selected as a more appropriate option because it has: a sound statistical basis, was developed in a similar region (the mid-Atlantic highlands), is intended to detect both inorganic and organic pollutants, and allows for processing of a large number of samples.

Incorporated within the MAIS are nine individual metrics, which provide information about the richness, balance, composition, tolerance, habit and trophic structure of the macroinvertebrate community (Table 9). These metrics are combined and calibrated to produce a single numeric score ranging from 0 to 18. Scores from 0 -7 indicate 'very poor' biological condition, 8 - 11 rate 'poor,' 12 - 15 rate 'good,' and 16 - 20 rate 'very good' (Smith and Voshell 1997).

Table 9

Summary of MAIS metrics

Name	Description
MAIS	Macroinvertebrate Aggregated Index Score
%5Dom	Percent abundance of the 5 most abundant taxa combined
modHBI	Modified Hilsenhoff Biotic Index
EPT Index	Number of mayfly, stonefly and caddisfly families
# Ephem	Number of mayfly families
% Ephem	Percent abundance of mayflies
%Hapto	Percent abundance of macroinvertebrates requiring clean, coarse, firm substrates
%Scraper	Percent abundance of macroinvertebrates scraping and feeding upon periphyton
#Intol	Number of families with tolerance values of 5 or less
SDI	Simpson Dominance Index

The Central Appalachian index was used instead of the Western Allegheny Plateau (WAP) index because the WAP index is based on data from only thirteen sites (seven reference sites, six impaired sites) and has not been validated with new data. The development of the Central Appalachian index was based on data from forty-eight sites (twenty-five reference sites, twenty-three impaired sites) and has since been validated with new data (Smith and Voshell 1997, Voshell 2003). Voshell believes that the Central Appalachian index should perform well in the WAP because their research has shown that multimetric indices based on family-level identifications do not change dramatically between ecoregions (Voshell 2003).

Macroinvertebrate sampling methods

Macroinvertebrates were collected during September 2003 by Jen Stamp (Map 15) (Appendix II.B). Sampling was performed in natural substrates over 150-meter stream reaches, in accordance with United States Environmental Protection Agency (US EPA) Rapid Bioassessment protocols (RBP) (Barbour et al. 1999). The kick net (1 meter x 0.9 meter fiberglass screen, 110 μ opening mesh) was used to sample three riffles or runs in the 150-meter reach. The macroinvertebrates were removed from the net after each individual kick and composited to obtain a single homogeneous sample for each site. The dip net (BioQuip standard D-frame, 0.3 meter width, 500 μ opening mesh) was used to sample multiple habitats. Twenty jabs were taken from various habitats (such as cobble, snags, vegetated banks, submerged macrophytes, and sand) within the 150-meter reach. The various habitats were sampled in approximate proportion to their occurrence within the sampling zone. Dip samples were composited to obtain a single homogeneous sample for each site, and were kept separate from the kick net samples. All organisms were placed into jars with 70% ethanol, and were transported to the laboratory for identification to the family level during the winter of 2004 (McCafferty 1983, Merritt and Cummins 1996, Voshell 2002). MAIS scores were calculated from the combined kick and dip net samples. Hemipterans were not included. Replicates were performed at two (7.4 %) of the sites to evaluate precision and repeatability of the macroinvertebrate sampling technique and collection team.

Greenvest macroinvertebrate sampling methods

Greenvest performed benthic macroinvertebrate sampling during the spring of 2002 (Map 15). Methodology was based on "Rapid Bioassessment Protocols for Use in Streams and Rivers"

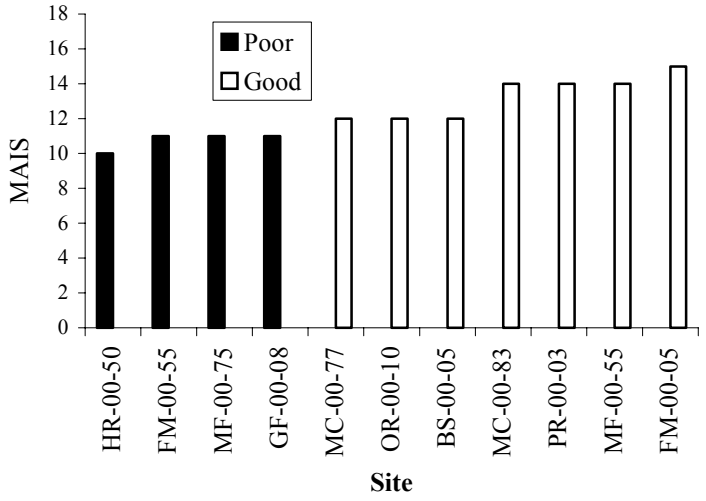
(Plafkin et al. 1989). Samples were collected using a 3 feet by 3 feet nylon kick net with 900μ mesh. Two kicks were collected at each sample location. Kick samples were collected in riffle and/or run areas selected for their similar physical characteristics. Samples were collected by thoroughly disturbing the substrate, by hand, in an area 3 feet by 3 feet. Large rocks were hand scrubbed using a stiff bristled brush. Each replicate was disturbed to a consistent depth and amount. Samples were field identified, where possible. Each kick sample was stored in separate containers and preserved in 70% isopropyl alcohol and formalin solution. Further identification was conducted in the laboratory using a dissecting scope and taxonomic keys by Pennak (1953), Merritt and Cummins (1978), and Peckarsky et al. (1990) (Greenvest Report 2002).
Exact abundances were not given for all families in the Greenvest data. Those given an 'A' for 'abundant' were assigned abundances of 25, while those given a 'C' for 'common' were assigned abundances of 10 (according to the Greenvest report, A = 25+ and C = 10-24).

Macroinvertebrates sampling results in 2003

The majority of sites received a biological condition rating of 'good' (Figure 2). Horse Run, HR-00-50, which received the lowest score, is a site that has been impacted by past surface mining. Mans Fork, MF-00-75, also received a low score probably because bedrock is the dominant substrate, which provides limited habitat and supports fewer taxa. Fourmile Run's, FM-00-55, low score appears to be affected by sedimentation from past livestock activity. Guyst Fork, which also received a rating of 'poor,' had a conductivity of 1647 μS at the time of the sampling and appears to have been impacted by past mining activities. High levels of strontium and sulfates, which were evident in the water samples taken at this site a month prior, account for this high conductivity. Particularly noticeable at the Guyst Fork site were the lack of mayflies. This appears to follow the pattern seen in the "Report on the Cumulative Off-site Impacts from a Large Area Mine in Southeast Ohio" (Office of Surface Mining 2000), in which high levels of sulfates appeared to have a negative effect on mayflies at sites impacted by the same type of surface mining that occurred in Meigs Creek.

Figure 2

MAIS scores and biological condition categories for the eleven sampling sites in Meigs Creek.



Macroinvertebrate sampling results in 2002

In the 'suggestions' section of the Greenvest report, the researchers state, "all streams evaluated were above average to high quality based on in-stream fauna and other characteristics noted. There seems to be high potential to develop recreational areas including fishing, hunting, hiking, boating, camping, etc. or to expand existing areas." The MAIS scores generally support this assertion (Table 10). Starrett Creek, which is located in the Upper Meigs subwatershed, received a score of 18, which is the highest score possible, and is a potential reference site. Three additional sites located in the Upper and Lower Meigs subwatersheds, received scores of 'very good.' The three sites that had the lowest scores are likely impacted by past surface mining and agricultural activities. In their report, the Greenvest researchers commented that the Sleepy Hollow tributary site to Guyst Fork, which received a MAIS score of 12, is former agricultural land that is in its secondary stages of succession. Past surface mining likely accounts for the 'poor' ratings at Tiltons Run and the unnamed tributary to Mans Fork. Modifications to the stream channels appear to have impacted habitat quality; Greenvest researchers commented that the riffles at Tiltons Run were not high quality. The report also comments on high turbidity in Meigs Creek, which was also noted during the 2003 sampling.

Table 10

Summary of MAIS scores from Greenvest spring 2002 sampling.

Greenvest Id	ILGARD Id	Location	Subwatershed	MAIS	Biological condition
C-2	TR-00-02	Tiltons Run	Dyes Fork	9	Poor
A-2	UN-00-40	Unnamed trib	Mans Fork	11	Poor
B-3	GF-02-20	Sleepy Hollow	Upper Meigs	12	Good
A-3	BR-00-50	Bear Run	Mans Fork	15	Good
A-6	YH-00-50	Young Hickory	Upper Meigs	16	Very good
A-1	MC-00-37	Meigs @ Mumfy	Lower Meigs	17	Very good
A-4	MC-00-55	Meigs @ McGonagle	Upper Meigs	17	Very good
B-4	ST-00-03	Starretts Creek	Upper Meigs	18	Very good

Ohio EPA conducted limited macroinvertebrate sampling in 1989 on the mainstem of Meigs Creek, upstream and downstream of Dyes Fork, in addition to the mouth of Dyes Fork (Table 11). All sites met the Warmwater Habitat score of 36 except the mouth of Dyes Fork with a score of 26.

Table 11

Ohio EPA macroinvertebrate results from sampling in 1989

Stream	River Mile	Year	Drainage Area (mi^2)	Total Taxa	EPT	ICI
Meigs Creek	2.30	1989	134.0	59	11	**38**
Meigs Creek	5.20	1989	118.0	60	8	**42**
Meigs Creek	5.40	1989	73.0	48	10	**40**
Dyes Fork	0.30	1989	45.0	50	5	**26**
Dyes Fork	2.90	1989	43.0	56	10	**38**

Fish

A comparison of the results from the 1989 Ohio EPA sampling and the October 2003 sampling reveals that certain sites on the larger streams, mainly Dyes Fork, are still impacted by past mining activity, with sedimentation apparently being the major impairment (Dennis Mishne 2003). The continued impact was evident by the fact that the IBI score of the Dyes Fork site at RM 5.8 has decreased by 10 points since last being sampled in 1989 and no longer meets Warmwater Habitat criteria (part of this may be due to differences in sampling techniques)

(Tables 12 & 13). It is more difficult to assess the trends in the Meigs Creek mainstem since the 2003 sampling points were all upstream of sites that were surveyed in 1988 and 1989. However, the two closest sites, RM 11.2 (2003) and RM 7.6 (1989), only differ by 2 points in the IBI score (48 versus 46, respectively). Therefore conditions over the last decade may have been fairly stable. The smaller tributaries, none of which were sampled by the Ohio EPA in the late 1980's, are all meeting Warmwater Habitat criteria. To attain Warmwater Habitat criteria for Western Allegheny Plateau ecoregion, sites must score 44 or greater. To meet Exceptional Warmwater Habitat, sites must score 50 or higher.

Table 12
IBI scores for sites in the Meigs Creek Subwatershed October 2003.
(Sampling led by JP Lieser, OSU Extension agent)

Stream	River Mile	Drainage Area (mi2)	IBI	Habitat Designation	Status	Sampling date
Dyes Fork	5.8	38	**34**	WWH	Not attaining	03-Oct-03
Meigs Creek	19.9	18	**44**	WWH	Attaining	01-Oct-03
Perry Run	0.2	3.8	**44**	WWH	Attaining	03-Oct-03
Fourmile Run	0.5	12.2	**46**	WWH	Attaining	10-Oct-03
Meigs Creek	11.2	35	**48**	WWH	Attaining	03-Oct-03
Guyst Fork	0.2	6.1	**50**	WWH	Attaining	01-Oct-03
Onion Run	0.7	4.2	**52**	EWH	Attaining	10-Oct-03

Table 13

IBI scores for sites in the Meigs Creek Subwatershed.
(Sampling performed by the Ohio EPA)

Stream	River Mile	Drainage Area (mi2)	IBI	Habitat Designation	Status	Sampling date
Meigs Creek	0.9	142.0	**32**	WWH	Not attaining	10-Oct-89
Meigs Creek	4.4	118.0	**42**	WWH	Not attaining	22-Sep-88
Meigs Creek	5.2	118.0	**36**	WWH	Not attaining	23-Oct-89
Meigs Creek	5.4	73.0	**44**	WWH	Attaining	22-Sep-88
Meigs Creek	7.6	70.0	**46**	WWH	Attaining	23-Oct-89
Dyes Fork	0.3	45.0	**38**	WWH	Not attaining	11-Oct-89
Dyes Fork	0.9	45.0	**18**	WWH	Not attaining	22-Sep-88
Dyes Fork	5.8	38.0	**44**	WWH	Attaining	11-Oct-89

Due to the low number of comparable IBI scores, it is worthwhile to examine species lists to try and assess shifts in distributions and abundances over the last several decades. The

historical fish data for the Meigs Creek Subwatershed was taken from a 1966 honors thesis by Douglas Albaugh, titled "A study of the distribution of the fishes of the Meigs Creek, Ohio, watershed." Using seines and minnow traps, Albaugh captured thirty-seven species at forty-seven sites. The Ohio EPA surveys in the late 1980's were conducted at eight sites (some of which appear to overlap with Albaugh's sites) in Meigs Creek and Dyes Fork and resulted in the capture of thirty-eight species. The most recent sampling in October 2003 took place at seven wadeable sites along the Meigs Creek mainstem and its major tributaries, and resulted in the capture of twenty-four species. Electroshocking was used in both the Ohio EPA and 2003 surveys, which may account for some differences with the Albaugh surveys. Notable trends include:

- A more widespread distribution of the Green sunfish and the Longear sunfish (during Albaugh's study, the Green sunfish had only been found in Mans Fork; during more recent surveys, it was found at four sites outside of Mans Fork, and was the dominant species at the Dyes Fork site, where twenty-eight were captured)
- Bluegills are not as widespread
- The continued absence of the Bluntnose minnow, the most universally distributed and most abundant species in Ohio (Trautman 1957), from Dyes Fork (Albaugh 1966).

Many of the same species are still present and appear to be stable at the wadeable sites surveyed in 2003. These include:

- **Sensitive species** – Banded darter, Southern Redbelly Dace, Rock bass, Golden Redhorse
- **Moderately intolerant** – Smallmouth bass, Longear sunfish, Northern hogsucker, Logperch, Greenside darter, Rainbow darter
- **Moderately tolerant** – Blacknose Dace, Yellow Bullhead, and Bluegill
- **Common highly tolerant** – Creek Chub, Bluntnose minnow, White Sucker
- **Common species** – Striped shiner, Stoneroller minnow, Johnny darter and Fantail darters

Common pollution intolerant species that were captured during the Ohio EPA surveys in the late 1980's included: Black redhorse (Meigs Creek 0.90), Rosyface shiner (Meigs Creek RM 7.6), and Banded darter (Meigs Creek RM 5.40). Three popular sport fishing species that were not captured during the Ohio EPA surveys are the Freshwater Drum, Muskellunge and Pickerel. Many of the species that were stocked by Ohio Power at the time of Albaugh's study are still

present today. These include: Bluegill, Largemouth and Smallmouth bass, Bluntnose minnow, and Channel Catfish.

Some of the harmful impacts normally associated with mining – such as acid mine drainage - appear to have been minimized by careful mining practices and the presence of fairly thick strata of limestone (ODNR 1963). In fact, the author of a historical fish study concluded that strip mining in Dyes Fork did not appear to have distinct effect on distribution of fish (Albaugh 1966). Aquatic life has also benefited from the fact that the entire drainage has been and still is free from significant amounts of pollution by chemicals or sewage.

The sedimentation problems in the Meigs Creek Subwatershed appear to be caused by past land use practices. During the time of Albaugh's study, land drained by the Meigs Creek mainstem was predominantly farmland and woods. Highly erodable soils and inadequate farming practices contributed to erosion and sedimentation problems. Another major contributor in the Dyes Fork drainage, in particular, was mining. Although suspended clay (a natural substrate) played a part in higher levels of turbidity, the crushing of rock and deeper layers of clay by mining operations presumably causes the lighter, sometimes-milky color of the streams (Albaugh 1966).

Modifications of physical habitat from past mining activities have also impacted the streams. At the time of Albaugh's study, several tributaries of Dyes Fork had been impounded, and many old mine pits had filled with water and were flowing into Dyes Fork (Albaugh 1966). Many of these mine-pit lakes and impoundments were stocked with fish, and are used for recreation today. Other alterations of physical habitat include modified channels in several Dyes Fork tributaries, such as Tiltons Run and Blanchard Run, and the construction of settling ponds for a coal-washing plant in Unionville, which is now closed. Since these settling ponds were part of a closed system, the plant did not contaminate Dyes Fork with coal dust (Albaugh 1966).

WATERSHED IMPAIRMENTS

NONPOINT SOURCE POLLUTION

Nonpoint source (NPS) pollution comprises pollutants such as sediment, nutrients (nitrogen, phosphorus), pesticides, heavy metals, and human and animal wastes. Discharges of pollutants from nonpoint sources are generally intermittent, associated with a precipitation event, and occur less frequently than point-source discharges. In contrast to point-source pollution, which originates from small, controlled discharge sources, nonpoint source pollution originates from diffuse sources covering relatively large areas. Some practices that produce sources of nonpoint source pollution are: mining, agriculture, or urban activity. Causes of nonpoint source pollution are the actual agents, or pollutants, that damage or impair aquatic communities and surface water quality, including sediment, nutrients, and heavy metals. According to the USEPA, nonpoint source pollution is the leading cause of impairment of surface water quality in the United States.

Section 319 of the Clean Water Act directs each state to develop and implement programs for the control of nonpoint source pollution. In 1988, the OEPA developed the Ohio Nonpoint Source Assessment program. The purpose of this program is to provide a statewide inventory of the streams, lakes, and groundwater affected by nonpoint source pollution. The Assessment is aided by production of the Ohio Integrated Water Quality and Assessment Report (Ohio EPA: Section 305B 2004). Section 319 also authorizes the USEPA to issue grants to states to assist in implementing approved nonpoint source management programs. Since 1989, more than 200 Section 319 projects have been initiated in Ohio (Leeds *et al* 1994).

Causes of Nonpoint Source pollution

Sedimentation/Siltation

According to the USEPA National Water Quality Inventory 1996 Report to Congress, 36 percent of the surface waters surveyed by states, tribes, and other jurisdictions were impaired by various pollutants. The leading cause of impairments was sedimentation, contributing to

impairments in 51 percent of streams surveyed. Sedimentation encompasses a range of low solubility particulate material, both inorganic (clay, silt, sand, gravel) and organic (plant material), which may be transported via runoff to surface waters. The particle size range and quantity of suspended sediment that may be entrained and transported by runoff is primarily controlled by runoff velocity and discharge quantity. The quantity and type of sediment available for transport may be significantly affected by a variety of development-related conditions such as: construction activity, farming, logging, and mining. These activities and conditions generally increase runoff volumes, increase flow concentration times, decrease slope stabilities, remove stabilizing vegetation, and, in the case of farming and logging, increase the total volume of exposed and erodable soil. In the Meigs Creek Subwatershed causes of sedimentation are from a variety of activities including farming, logging, and mining.

Elevated concentrations of sediment in surface waters may degrade or destroy aquatic habitats by blanketing spawning or feeding areas, eliminating certain food organisms, causing gill abrasion and fin rot, and reducing sunlight penetration, thereby impairing photosynthesis. Suspended sediment also degrades recreational waters, reduces fishery habitats, and adds to treatment costs for public water supplies. Nutrients and toxic substances become attached to eroded sediment particles, which speed-up the introduction of these substances to surface waters and further degrade water quality.

Heavy metals

Heavy metals enter the environment as byproducts from industrial processes, hydrocarbon fuel combustion, metal corrosion, atmospheric deposition from remote sources, landfill leaching, and pesticide/herbicide applications. These metals are commonly referred to as "trace" or "heavy" metals, the most common of which are copper, lead, cadmium, mercury, selenium, and zinc. Heavy metals are among the ingredients in many commonly used products like batteries, fuels, paints, pesticides, and cleaners. In the Meigs Creek Subwatershed heavy metals are, for the most part, non-detectable. When these products are spilled or improperly disposed of, or when materials containing heavy metals break down, they leave behind pollutants that can be readily transported to surface water by storm water runoff.

Slightly elevated heavy metal levels in natural waters may cause the following effects in aquatic organisms: histological or morphological change in tissues; changes in physiology, such as suppression of growth or development; changes in biochemistry, such as blood chemistry and enzyme activity; changes in behavior; and changes in reproductive capability.

Thermal modification

One of the most important water quality parameters in assessing the overall health of aquatic ecosystems is water temperature. Temperature levels control the number and type of species present in water bodies by controlling the rates of certain chemical reactions and processes. Warmer water temperatures accelerate biologic activity, encourage the growth of undesirable algae species, and provide a hospitable environment for harmful bacteria and other pathogens. Warmer temperatures also decrease the solubility of oxygen and carbon dioxide; these processes have multiple harmful effects on aquatic organisms. Because many aquatic species require a minimum level of dissolved oxygen for survival, depletion of dissolved oxygen can cause eutrophication and fish kills.

The major causes of elevated water temperatures are the use of water as an industrial cooling agent, soil erosion, deforestation or devegetation of riparian zones, runoff from heated impervious surfaces, and hydromodification. Of these, the most prevalent cause of thermal elevation is the use of water as a cooling agent in power plants, factories, and other industrial facilities. The contribution of soil erosion, devegetation, and impervious surfaces to elevated water temperatures are less clear-cut, but still identifiable. Increases in soil erosion cause increases in turbidity. This increases light absorption which causes an increase in water temperature. Deforestation and devegetation eliminates shade, allowing more light to hit the water surface and increasing water temperatures. Paved and other impervious surfaces are hotter than natural surfaces; therefore runoff from these surfaces is warmer, and raises overall temperatures in surface waters. In the Meigs Creek Subwatershed, soil erosion and devegetation along riparian zones are the only cause of thermal modification.

Nutrients

After sedimentation, nutrients are the most significant cause of surface water impairments, contributing to impairment in 40 percent of surveyed streams (USEPA, National Water Quality Inventory: Report to Congress 1996). Problematic nutrients that are concentrated in surface waters include nitrogen, phosphorous, and other organic materials (manure, sewage, fertilizers) that contain nitrogen or phosphorous compounds. Nutrients may be introduced to surface waters via agricultural or urban runoff, landfill leachate, residential septic system exfiltration, and municipal wastewater treatment effluent. Possible sources associated with nutrient overenrichment, include fertilizers, detergents, septic systems, sediment mobilization,

animal manure, atmospheric deposition, and internal recycling from sediments. Elevated nutrient concentrations can lead to algal blooms and eutrophication of surface water bodies, thus decreasing dissolved oxygen levels and increasing turbidity. Over time, excess nutrients can cause episodic anoxic conditions, decreased biological diversity, loss of vascular plants, and fish kills. In the Meigs Creek Subwatershed likely sources of nutrient pollution are from animal manure and sediment mobilization.

Aquatic plants

Plants that are not native to an area may be highly invasive, crowding out native plants, reducing biodiversity, and radically changing the way an ecosystem functions. Invasive plants are usually characterized by fast growth rates, high fruit production, rapid vegetative spread and efficient seed dispersal, and rapid germination. Unlike native plants, invasive plants lack the natural predators and diseases that normally serve as population controls in their native habitats. Some of the known ecological impacts of invasive plants include: the loss of endangered or threatened species and their habitats; loss of habitat for native insects, birds, and other wildlife; loss of food sources for wildlife; reduction or destruction of localized or specialized plant communities; reduction in the amount of space, water, sunlight, and nutrients available for native species; changes in soil structure and chemistry; increasing erosion along stream banks; alterations in hydrological flows and conditions; and reduced biodiversity.

Sources of Nonpoint Source pollution

Hydromodification

Hydromodification is defined by the USEPA as any alteration of the hydrologic characteristics of surface waters that could cause water quality degradation. According to the USEPA, the three types of hydrological modification that must be addressed by states as they develop their nonpoint source pollution control programs are channelization and channel modification, dams, and streambank erosion.

Channelization and channel modification refer to any river and stream engineering undertaken for the purpose of flood control, navigation, drainage improvement, or reduction of channel migration potential (Brookes 1990). Channel modification activities deprive wetlands of sediment sources, alter the ability of natural systems to filter pollutants from surface water, and disrupt the life stages of aquatic organisms. Channel modification can also alter instream water

temperature, instream and riparian habitats. It will also increase the downstream movement of nonpoint source pollutants from upstream sources. Previously undertaken channel modification projects often require regular maintenance to preserve completed modifications; maintenance projects can damage riparian habitats, change the physical characteristics of bottom sediments, and accelerate the discharge of pollutants in to surface waters.

The USEPA defines dams as any constructed impoundments that are either 25 feet or more in height and greater than 15 acre-feet in capacity, or six feet or more in height and greater than 50 acre-feet in capacity. Siting and construction of dams are undertaken for a variety of purposes, including flood control, power generation, irrigation, livestock, watering, fish farming, navigation, municipal water supply, sediment retention, recreation and water sports, and for augmentation of low flows. The siting of dams can result in the inundation of wetlands and riparian areas upstream of the dam and in elimination of the flooding needed by these same ecologies downstream of the dam. Activities related to dam construction can cause vegetation removal and soil disturbance, resulting in increased turbidity and sedimentation in streams. Runoff of fuel and other chemicals associated with construction equipment is a potential source of nonpoint source pollution. The operation of dams alters normal hydrological cycles in affected streams and rivers. This may result in stream bed scouring and reduced downstream flushing, a process that can cause increased nutrient concentrations, pH changes, and increased algal growth.

Agriculture

The primary agricultural nonpoint source pollutants are nutrients, sediment, animal wastes, salts, and pesticides. Agricultural activities also potentially impact aquatic organism communities through physical disturbances caused by livestock and equipment, or through the use and management of water. Surface water runoff may also transport inorganic chemical compounds, metals, soluble chemicals, particulate organic solids, viruses, bacteria, other disease-causing pathogens, and salts. Of all nonpoint source impairments, agriculture is the most widespread source of pollution for assessed water bodies, impacting 59 percent of impaired river miles in the United States. Nitrogen (N) and phosphorous (P) are the two major nutrient products of agricultural practices that degrade water quality. Nutrients have several sources in agricultural processes, including: commercial fertilizers, manure from animal production facilities, crop residues containing nutrients and micronutrients, and irrigation water. Nitrogen and phosphorous are naturally present in soils at low levels, but are added in increasingly large amounts to meet crop production needs. Nitrogen and phosphorous are also present in aquatic environments at background levels of roughly 0.3 and 0.01 mg/L, respectively. When these nutrients accumulate

in water bodies at larger concentrations, aquatic plant production tends to increase dramatically, adversely affecting surface water quality.

Sediment is the solid mineral and organic material that is in suspension or being transported from its depositional site by water, wind, ice, or gravity. Processes associated with agriculture cause sediment erosion by rainfall, flowing water, or wind. These eroded particles are transported by surface water and are redeposited as soil. Soil loss via erosion deteriorates soil structure and decreases nutrient concentrations in eroded soil, which decreases the productive capacity of eroded lands. Suspended solids in stream waters degrade habitat quality for fish, invertebrate, plant, and other aquatic organisms. Recreation is also limited, given decreases in fish populations and increases in streams' unhealthy, unappealing appearance. Deposited sediment reduces the transport capacity of ditches, streams, and rivers, contributing to increases in flooding. Inorganic chemicals, including pesticides and ammonium, are transported with eroded sediment in an adsorbed state. Changes in the aquatic environment such as decreased oxygen concentrations or anaerobic stream-bottom conditions can cause these chemicals to be released from sediment into the water column, degrading overall water quality.

Animal waste includes the fecal and urinary wastes of livestock and poultry, process water derived from animal production and care, and any feed, bedding, litter, and soil that comes into contact with either animal wastes or process water. Pollutants that may be contained in animal wastes and could be transported from animal processing facilities include oxygen-demanding substances, nitrogen and other nutrients, organic solids, salts, bacteria and other microorganisms, metals, and sediments. When manure or process water enters surface waters, the nutrients and organic materials that are added can cause excessive growth of aquatic plants and algae, deplete the oxygen supply creating anaerobic conditions, and create conditions that will produce amines, sulfides, and methane. Animal feedlots, which have little to no vegetation and are subjected to severe hoof action, generate runoff carrying large amounts of bacteria, which causes water quality degradation (Baxter-Potter and Gilliland 1988). Additionally, diseases can be transmitted to humans through exposure to animal waste. Harmful microorganisms found in surface water that is contaminated by animal waste include Cryptosporidium, Giardia, and enteric viruses.

Forestry

Forestry was identified as a nonpoint source of water pollution under section 208 of the 1977 Clean Water Act, and again under section 319 of the 1987 Water Quality Act. In 1990, twenty four states, including Ohio, identified silviculture as a source contributing to nonpoint source pollution in their section 305(b) water quality reports (USEPA NPS Forestry Fact Sheet, 1996); silviculture accounted for 9 percent of nonpoint source pollution to surface waters in the 42 states reporting nonpoint source pollution figures on section 305(b) reports in 1990 (USEPA NPS Forestry Fact Sheet, 1996). The types of forestry activities that can affect surface water quality via nonpoint source pollution include road construction and maintenance, road use, timber harvesting, site preparation, prescribed burning, and fertilizer and pesticide application. Pollutants associated with forestry activities include sediments, temperature changes, accumulation of organic debris, and increased concentrations of nutrients and inorganic chemicals.

Roads disrupt the physical watershed environment by changing surface runoff patterns, changing soil density, altering the slopes of hillsides and stream channels, creating barriers to the movement aquatic organisms, and funneling pollutants to surface waters through runoff. Roads are the major source of sediment to surface water bodies from forested lands, and they can contribute up to 90 percent of the total sediment produced by forestry operations (Megahan, 1980 and Rothwell, 1983). Transported sediment can damage aquatic communities by covering food sources, smothering bottom-dwelling organisms, and filling in spawning sites. Suspended sediments increase water turbidity, which in turn can raise water temperatures and lower DO concentrations, and can damage the gills of some fish species, causing suffocation.

Increased water temperatures in surface water bodies can result from the removal of riparian vegetation, either by harvesting or pesticide use. Temperature changes can adversely affect both aquatic organisms and habitats. Organic debris associated with forestry includes residual logs, slash, litter, and soil. Influx of organic material into streams affects water quality by causing increased biochemical oxygen demand, which lowers overall DO levels. Logging slash and debris deposited in stream channels alters streamflow patterns, which may cause restricted flow, increased bank cutting, and increased sedimentation. Nutrients from fertilizers applied in forests can cause harmful effects in receiving surface waters. Sudden removal of large quantities of vegetation through harvesting can cause leaching of nutrients from the soil system into surface and ground waters (Likens *et al*., 1970). Pesticides used to control forest pests and undesirable plant species can be toxic to aquatic organisms. Pesticides with high solubilities can cause acute or chronic harm to aquatic organisms, while less soluble compounds tend to bioaccumulate in fish

tissues. Other compounds that may be concentrated in streams due to forestry operations include motor vehicle fuel, oil, and engine coolants.

WATERSHED RESTORATION AND PROTECTION

The following section is divided into the five 14-digit Hydrologic Unit Code (HUC) divisions within the Meigs Creek Subwatershed. The five subsections are: Upper Meigs Creek (headwaters to above Mans Fork), Dyes Fork, Mans Fork, Fourmile Run, and Lower Meigs Creek (Meigs Creek below Mans Fork to Muskingum River, except Dyes Fork and Fourmile Run). Within each 14-digit HUC section, goals, objectives, action plans, timelines, indicators, resources, and funding sources are identified. Tables of best management practices (BMPs) are described in Appendix II.C and funding sources in Appendix II.D.

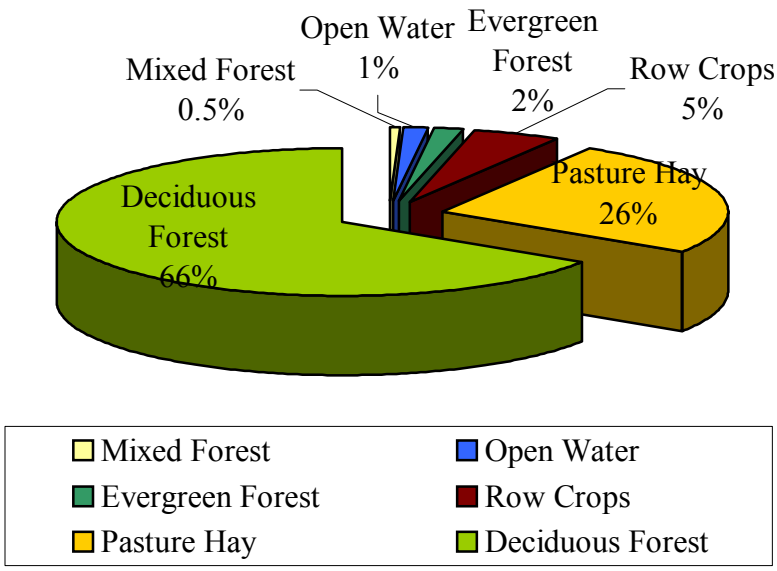
Upper Meigs Creek Subwatershed

Land Use

Land use in Upper Meigs Creek is primarily deciduous forest, 66 percent and pasture land, 26 percent. Most of the remaining land is dominated by row crops, making up five percent (Figure 3). However, the land use within 30 meters of the streams in Upper Meigs Creek Subwatershed is primarily cropland and pasture. Out of 48 stream miles in the Upper Meigs Creek Subwatershed, 22.4 stream miles are buffered by cropland and pasture and 18.4 miles by deciduous trees, 4.3 shrubs, and 2.9 transitional (see Table 2). Population in the Upper Meigs Creek Subwatershed is approximately 306 (US Census 2000).

Figure 3

Land Use in Upper Meigs Creek Subwatershed



Source: LANDSAT Satellite Data 1994

Water quality

Twelve sites were analyzed for water quality in Upper Meigs Creek Subwatershed (Map 16). Current water quality impacts in the Upper Meigs Creek shows impact from past mining practices in Guyst Fork, as shown in figure 4 and 5. Conductivity and sulfate concentrations are both above the high end target in the Guyst Fork. Two sites were sampled within Guyst Fork, GF-02-01 and GF-00-70. Levels of sulfate and conductivity at these sites locations are summarized in table 14. Conductivity and sulfate concentrations remain elevated in the mainstem moving downstream. Elevated conductivity and sulfate concentrations were also measured at the mouth of unnamed tributary at Rayners Lane, which enters the mainstem of Meigs Creek at RM 18.4. Conductivity is a measure of the amount of cations and anions in the water. When correlated with other metals found in the water chemistry, conductivity is closely correlated to sulfate (R^2 value 0.91) and strontium (R^2 value 0.98).

Figure 4

Conductivity concentrations within Upper Meigs Creek

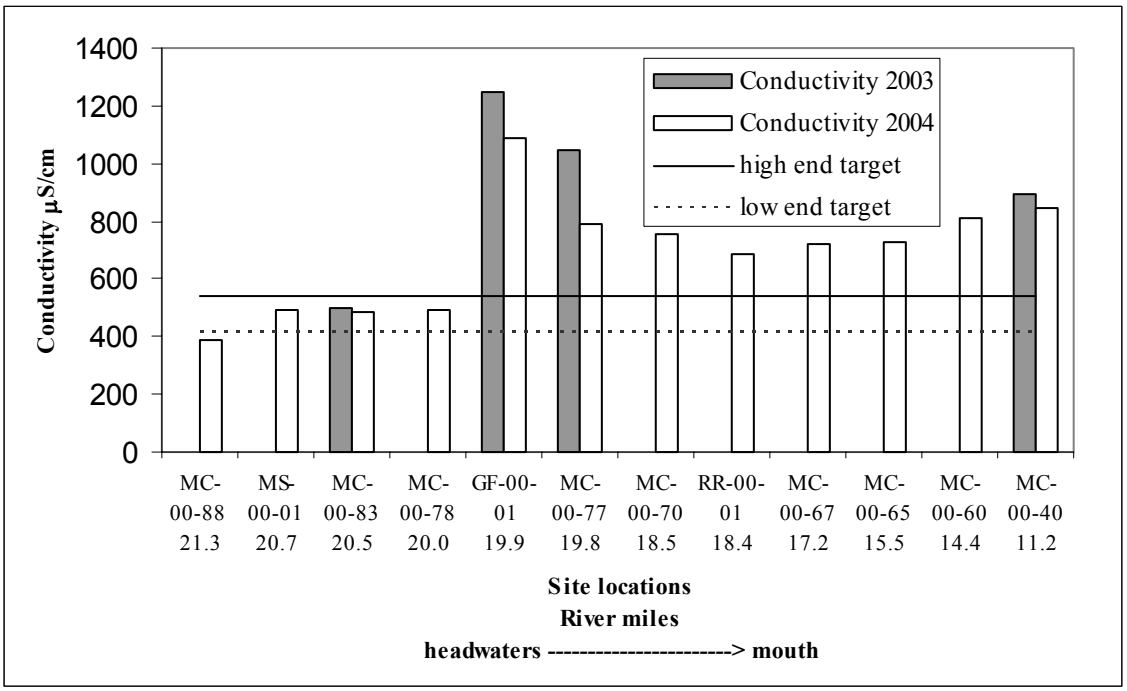


Figure 5

Sulfate concentrations within Upper Meigs Creek

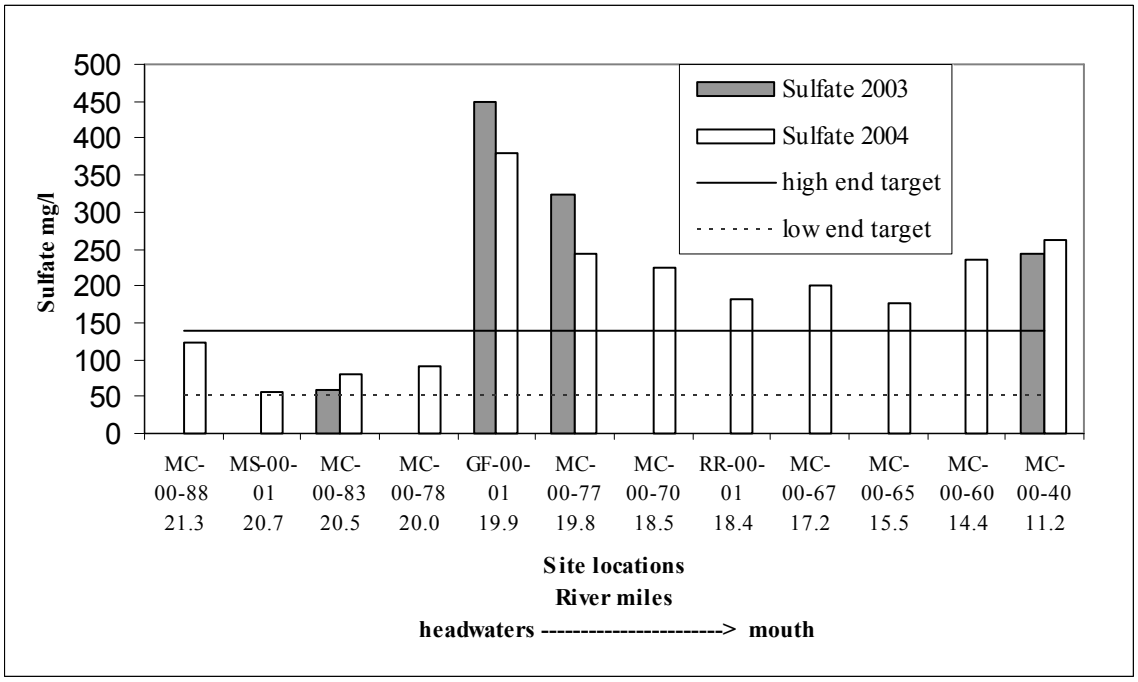


Table 14

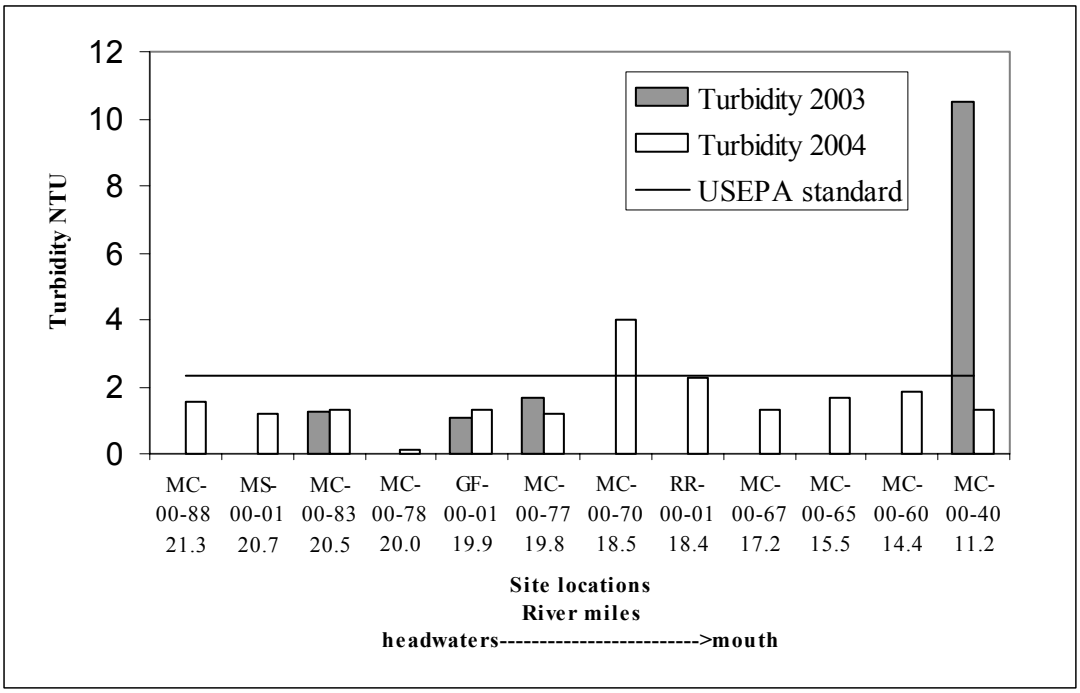
Conductivity and Sulfate concentrations in Guyst Fork of Upper Meigs Creek

Site	Conductivity µS/cm	Conductivity µS/cm	Sulfate mg/l	Sulfate mg/l
	Spring 2004	Summer 2003	Spring 2004	Summer 2003
GF-00-70	1210	2270	359	866
GF-02-01	1410		380	

Turbidity concentrations exceeded the USEPA standard at two mainstem sites within Upper Meigs Creek, MC-00-70 and MC-00-40 (RM 18.4 and 11.2, respectively) (Figure 6).

Figure 6

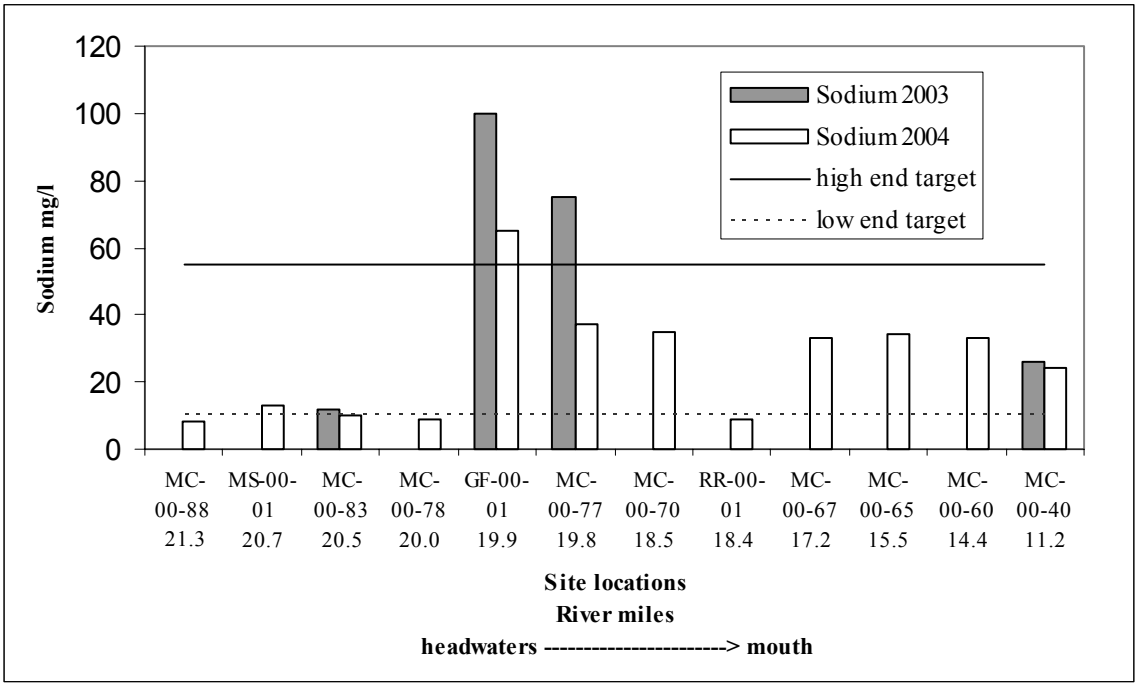
Turbidity concentrations within Upper Meigs Creek



Elevated sodium concentrations are seen in Guyst Fork and on the mainstem of Meigs Creek downstream of the confluence with Guyst Fork (Figure 7). Both sites measured within Guyst Fork had elevated sodium concentrations during both the 2004 and 2003 sampling events.

Figure 7

Sodium concentrations within Upper Meigs Creek



Upper Meigs Creek showed no sites with elevated nitrates except the headwater site in Guyst Fork, GF-00-70, 0.65 mg/l during 2004 and 0.82 mg/l during 2003. The target range for nitrate according to the Ohio EPA association document is 0.2-0.3 mg/l (Table 8). Also in Guyst Fork strontium levels exceed the Ohio EPA standard (770 µg/l) at GF-00-70 (1500 µg/l) and at the mouth, GF-00-01 (1040 µg/l). There were no sites that exceeded the phosphorus target of 0.05 mg/l. One site on the mainstem of Meigs at McGonagle, MC-00-60, recorded a lead concentration of 8.4 mg/l. This was the only site within the entire study that measured above the laboratory detectable limit of 2.0 mg/l, all other sites were less than 2.0 mg/l.

Fecal coliform samples were collected on August 2, 2004 at eight sites within Upper Meigs Creek (Map 16). Six of the eight sites scored higher than 1000 counts/100ml and two of those sites reached 2000 counts/100ml (Table 15). The Ohio EPA standard for primary contact water is not to exceed 1000 counts/100ml within a 30-day period with no less than five sampling events and not to exceed 2000 counts/100 ml at more than 10% of the sites sampled within that

30-day period. The sampling event that was conducted in Meigs Creek was only one day and should be used as an initial screening to select sites for additional sampling. Determining whether fecal coliform is derived from failing septic systems or livestock, land use and populations were researched. Given that population is low; approximately 306 (US census 2000) and only ten houses in the Upper Meigs Creek area within 500 ft of the creek (USGS 1994), humans probably have little effect. Assuming an average of 2.2 people per house, a figure of 22 people was used to calculate loadings. According to local health department 90% of the septic systems are failing. Therefore estimating 19.8 people contribute to failing systems at an average 70 gals/per person/day, equals 1,386 gals/per day, 505,890 gals/per year. However, land use shows 26 percent of the land in Upper Meigs Creek is pasture/hay land and visual evidence (Figure 8) of livestock access to the creek indicates the slight fecal coliform bacteria levels measured are most likely contributed from livestock. However five additional fecal coliform sampling events need to be conducted during a 30-day period to apply the Ohio EPA standard.

Table 15

Fecal Coliform results for sites within the Upper Meigs Creek

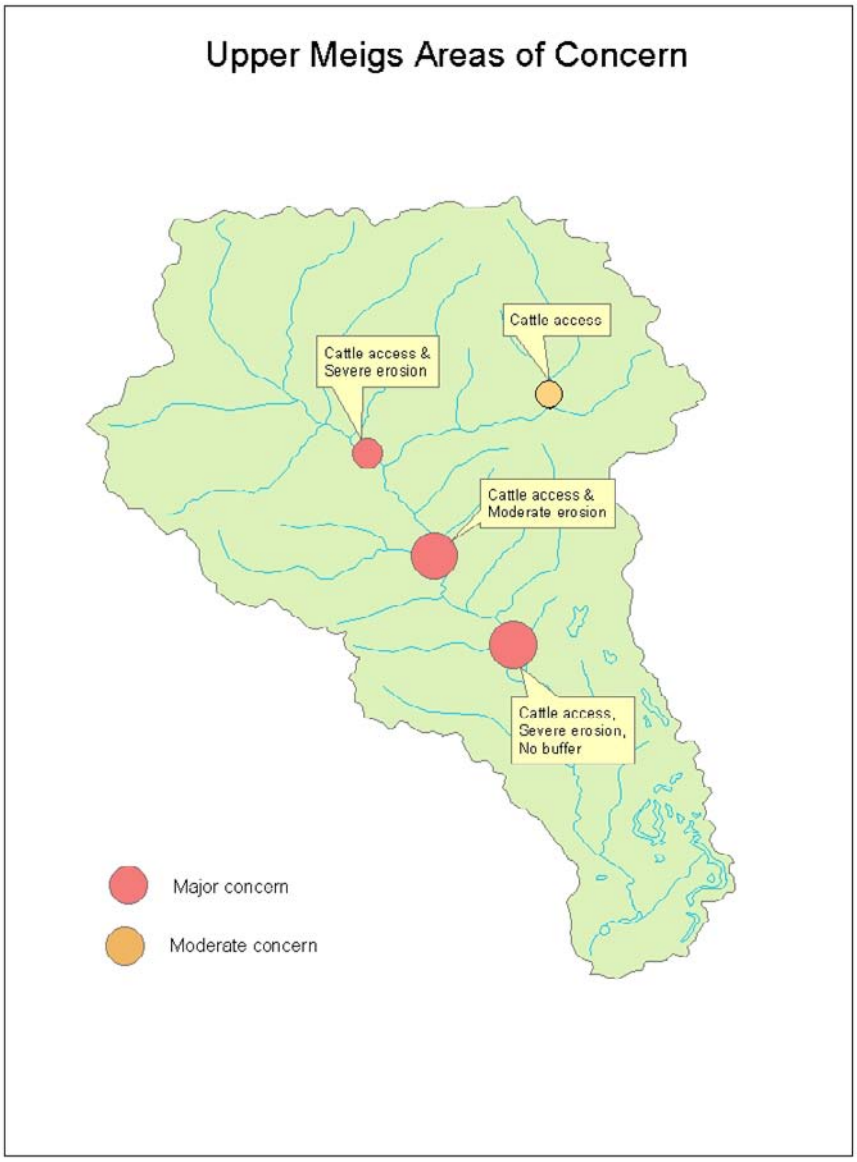
Site	Fecal Coliform count/100ml
MC-00-88	580
MS-00-01	2000
GF-02-01	220
MC-00-77	1200
MC-00-70	2000
RR-00-01	1000
MC-00-67	1900
MC-00-65	1600

Areas of concern

Visual survey of the Upper Meigs Creek area was conducted for visual evidence of cattle access to the streams, lack of riparian buffers, and erosion. Four areas were identified as moderate to major concern. Figure 8, shows the areas of concern in Upper Meigs Creek (Map 16).

Figure 8

Areas of concern in Upper Meigs Creek



Biology

All biological sites within the Upper Meigs Creek Subwatershed are meeting Warmwater Habitat for fish and macroinvertebrates, except the mouth of Guyst Fork, which received one "poor" MAIS score (Map 16).

Problem statement

Upper Meigs Creek Subwatershed shows evidence of impact from past mining activity in Guyst Fork with elevated sulfate. The headwaters of Guyst also show that sodium and nitrates are both above the high end target. In addition to the past mining activity there is some farming on the mainstem of Meigs and Guyst. However, phosphates, which are usually an indicator of run-off from farming practices, are not elevated. Fecal Coliform bacteria levels are marginal and may prove to be a concern in this area, however additional testing is needed in order to apply the Ohio EPA standard. Also of interest is that one site on the mainstem at McGonagle shows elevated lead.

Action Plan

Goal 1: Improve water quality in Guyst Fork to meet a 'Good' MAIS biological condition.

Objective 1: Reduce sulfate concentrations to below 140 mg/l.

Action 1: Research the impact on biology from elevated sulfate concentrations.

Action 2: Research techniques to reduce sulfate from water column where past mining practices have elevated sulfate in the stream. Determine best technique for site reclamation and implement.

Objective 2: Reduce sodium concentration to below 55 mg/l.

Action 1: Research the impact on biology from elevated sodium concentrations.

Action 2: Research techniques to reduce sodium from the water column where past oil and gas wells have been installed. Choose best technique and implement.

Objective 3: Determine biological status of Guyst Fork.

Action 1: Conduct biological sampling along Guyst Fork and on Meigs Creek

mainstem upstream and downstream of Guyst Fork for one year.

Goal 2: Improve water quality on the mainstem of Upper Meigs Creek as a headwaters approach to improving water quality downstream

Objective 1: Determine the source of elevated lead at the McGonagle site, MC-00-60.

Action 1: Continue to sample this site for lead concentrations to determine variations through time and flow regimes.

Action 2: Conduct field investigations around this location in order to track down original source of lead.

Action 3: Research techniques to remediate lead from the stream and implement a remediation plan, if lead proves to be an impact on the biology.

Objective 2: Reduce turbidity at site MC-00-70 to below 2.3 NTU (site MC-00-70 is meeting its TSS target loading).

Action 1: Work with local Soil and Water Conservation Districts and Farm Bureau to educate landowners along the mainstem of Meigs Creek near site MC-00-70 about proper farming practices to reduce impact on the stream.

Action 2: Utilize and work with local Soil and Water Conservation District to educate landowners near MC-00-70 about Farm Bill 2002 opportunities.

Objective 3: Determine if fecal coliform is a potential problem.

Action 1: Conduct five sampling events within 30 days at the following sites that scored between over 1000 counts/100 ml during the initial screening: MS-00-01, MC-00-77, MC-00-70, RR-00-01, MC-00-67, MC-00-65.

Action 2: Work with local health department to educate any landowner who lives near elevated areas.

Objective 4: Reduce the phosphorus and sediment load in Upper Meigs Creek by 10,553 lbs/day and 5.2 lbs/day of phosphorus loading.

Action 1: Stabilize 2.0 miles of streambank to reduce 2,800 lbs/day of sediment and 1.4 lbs/day of phosphorus load from entering into the Upper Meigs Creek. One option to stabilize streambanks are through the CRP program at an estimated cost of $600/acre, 2 miles of streambank with a 300 ft buffer would cost approximately $43,638.

Action 2: Install 5,900 linear feet of fencing at 6 project areas to restrict livestock access to Upper Meigs Creek and reduce sediment load by 7,715 lbs/day and 3.8 lbs/day of phosphorus load at an approximate cost of $28,580.

Table 16

Implementation table for Upper Meigs Creek Subwatershed

Action Plan	Activity	Available resources	Funding source	Timeline (start – end)	Indicator
1.1.1	research sulfate impacts	Ohio EPA and MBI		2005-2006	chart values of sulfate impacts on biology
1.1.2	research sulfate remediation	Ohio EPA and MBI		2005-2006	report of options of sulfate remediation
1.2.1	research sodium impacts	Ohio EPA and MBI		2005-2006	chart values of sodium impacts on biology
1.2.2	research sodium remediation	Ohio EPA and MBI		2005-2006	report of options of sodium remediation
1.3.1	biological sampling	Ohio EPA and MBI		2005-2006	database of biological data
2.1.1	water sampling	Volunteers and FLMR	Ohio EPA laboratory	2005-2006	database of 1-yr of data
2.1.2	field investigation	Volunteers and FLMR		2005-2006	field notes and report
2.1.3	research lead impacts and remediation	Ohio EPA and MBI		2005-2006	report of value of lead impact on biology and remediation options
2.2.1	outreach and education	Volunteers, FLMR, Soil and Water Conservation, Farm Bureau		2005-2006	list of landowners contacted and implementing BMP's
2.2.2	outreach and education	Volunteers, FLMR, SWCD	Farm Bill 2002	2005-2006	list of landowners implementing BMP's using the Farm Bill

Table 16

Implementation table for Upper Meigs Creek Subwatershed, continued

2.3.1	conduct water sampling	Volunteers and FLMR	Ohio EPA	2005-2006	database of six sites measured
2.3.2	outreach and education	Volunteers and FLMR		2005-2006	list of landowners contacted
2.4.1	stabilize streambank	SWCD – Farm Bill	Farm Bill 2002	2007-2009	Number of miles of streambank stabilization BMPs
2.4.2	install livestock fencing and water sources	SWCD – Farm Bill	Farm Bill 2002	2007-2009	Number of feet of fence installed

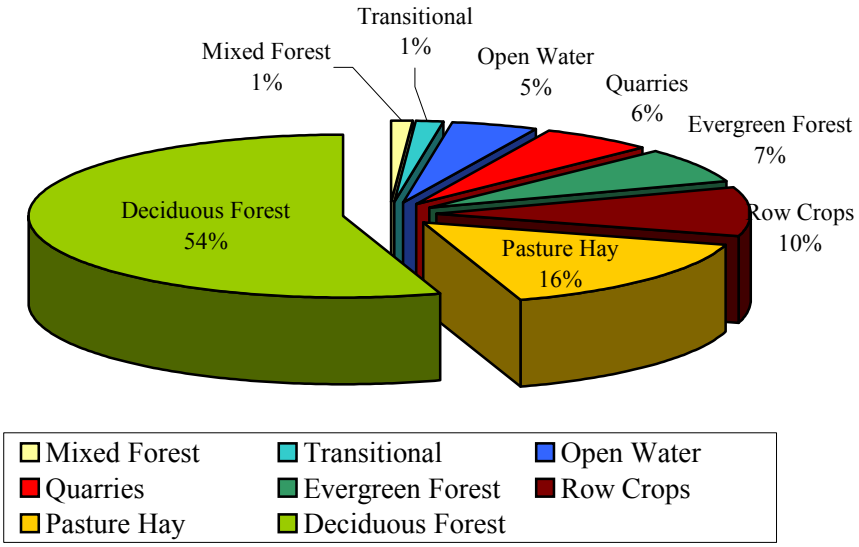
Dyes Fork Subwatershed

Land Use

Dyes Fork Subwatershed is the largest of the five 14-digit HUC subwatershed within Meigs Creek, consisting of nearly 28,789 acres. Figure 9 shows that more than half (54 percent) of Dyes Fork Subwatershed is deciduous forest. Pasture/hay land makes up the second most predominant land use, consisting of 16 percent. Row crops, evergreen forests, quarries, and open water make up most of the remaining land uses with ten, seven, six, and five percent respectively. According to USGS topographic maps, land use within 30 meters of the streams in Dyes Fork Subwatershed is primarily reclaimed strip mine land. Out of 47.6 stream miles in the Dyes Fork Subwatershed, 33.4 stream miles are buffered by reclaimed strip mines (see Table 2). Much of the reclaimed strip mine land has surface water impoundments. There are twenty-six dams that hold back surface water from a drainage area of 33.9 square miles and have a principal spillway storage of 1373.8 acre-feet (See Map 4). The total combined top of dam storage for these dams is 6478.5 acre-feet (ODNR 2002a). Population within the Dyes Fork Subwatershed is approximately 65 people (US Census 2000).

Figure 9

Land Use for Dyes Fork Subwatershed



Source: LANDSAT Satellite Data 1994

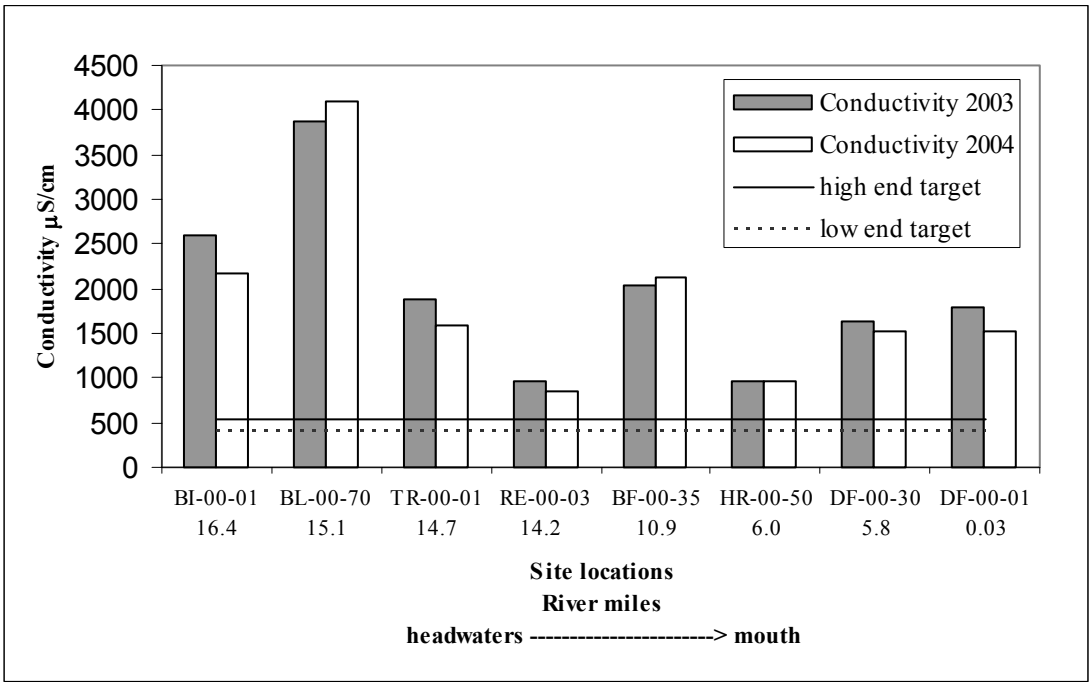
Water quality

Eight sites were analyzed for water quality data in the Dyes Fork Subwatershed (Map 17). Water quality impacts in Dyes Fork Subwatershed are from past coal mining practices. Map 18 shows the coverage of surface mine area in Meigs Creek Subwatershed. Approximately 58,000 acres have been strip mined in Meigs Creek. Typically in areas where coal mining has been so prolific, water quality is impaired from acid mine drainage. However, in the Dyes Fork Subwatershed acid mine drainage is not present. All sites are net alkaline and have neutral pH values. The lack of acid mine drainage can be attributed to the efforts of AEP and Consol, who are actively reclaiming this area, and the natural geology. Dyes Fork Subwatershed lies within the Monongahela Group within the Pennsylvanian Geologic System. The Meigs Creek Coal (#9) lies under a thick layer of limestone called the Benwood Limestone (ODNR 2000).

Conductivity levels are above the high end target range (Figure 10). Conductivity is the measurement of the cations and ions present in the water, therefore the water quality data was analyzed to determine what parameters were causing high conductivity values. Positive correlation was found between conductivity and sulfate (R^2 0.985), strontium (R^2 0.947) and sodium (R^2 0.952).

Figure 10

Conductivity values within Dyes Fork Subwatershed



Sulfate concentrations are above the high end target at all sites in Dyes Fork Subwatershed (Figure 11). Blanchard Spring, BL-00-70, is a discharge from the surface mine and shows the highest concentrations of sulfate, strontium and sodium followed by the mouth of Bicentennial tributary, BI-00-01 (Figure 11, Figure 12, and Figure 13).

Figure 11

Sulfate concentrations within Dyes Fork Subwatershed

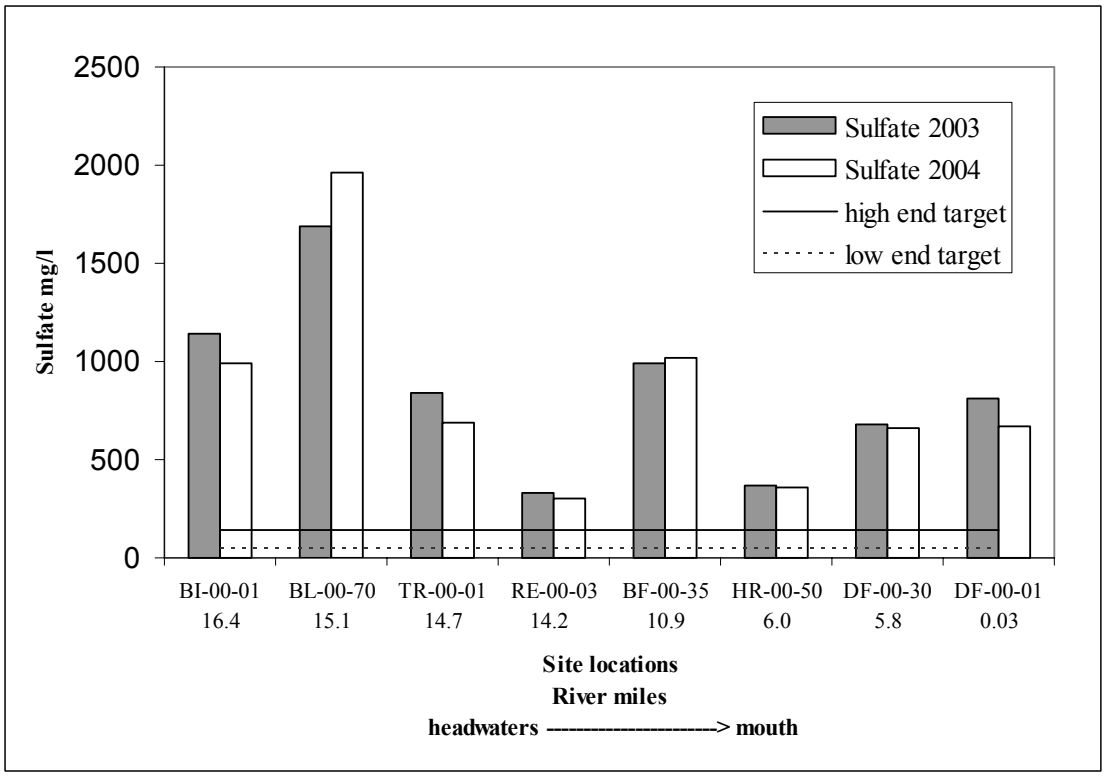


Figure 12

Strontium concentration within the Dyes Fork Subwatershed

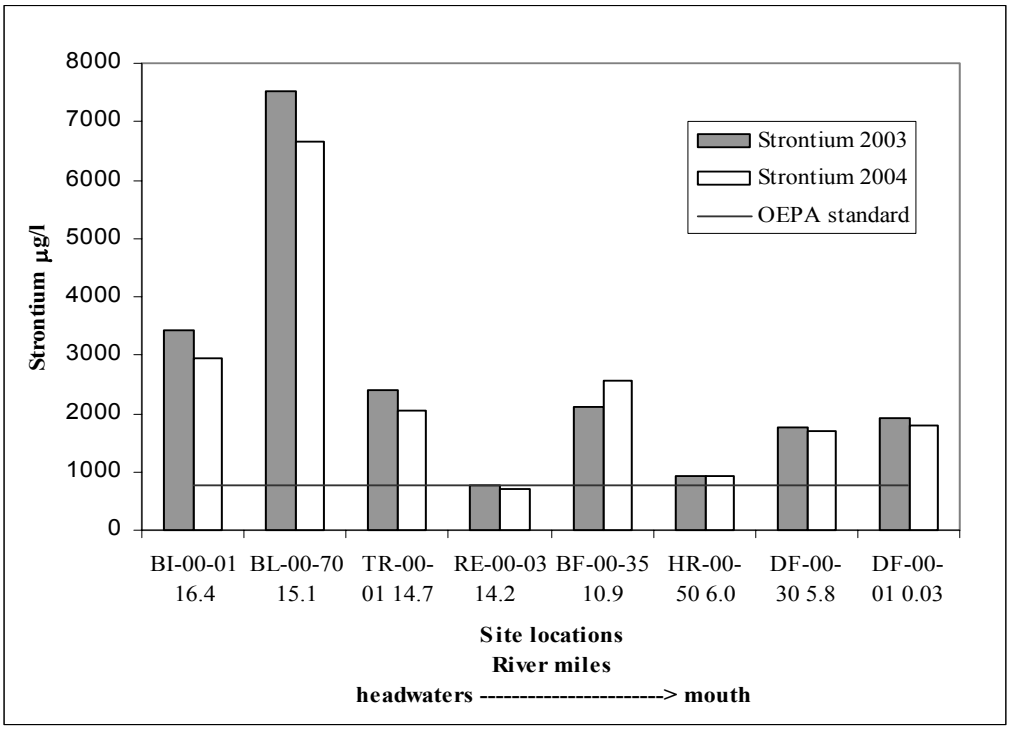
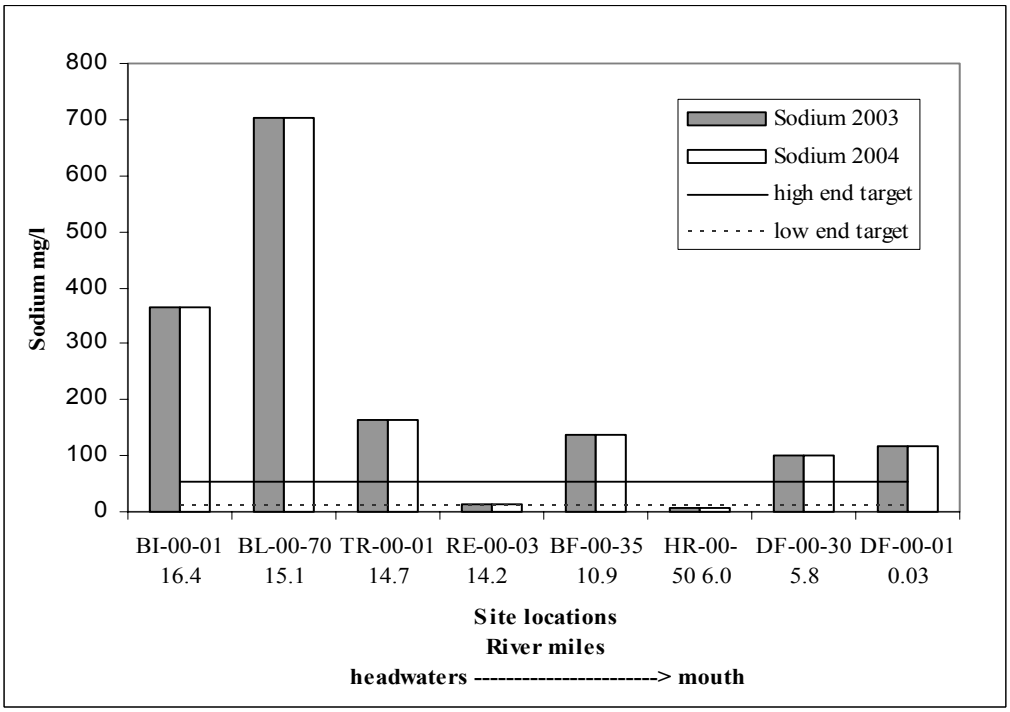


Figure 13

Sodium concentration within the Dyes Fork Subwatershed



Strontium is an alkaline earth metal with chemical and physical properties similar to calcium. It is a soft, silvery metal and decomposes rapidly in water (Winter 2004). All sampling sites outside of the Meigs Creek Subwatershed in the Lower Muskingum River Watershed had concentrations of strontium below the Ohio EPA aquatic life tier II criteria. Concentrations of strontium within Meigs Creek, primarily Dyes Fork, were found to be in exceedance of Ohio EPA tier II aquatic life criterion (770 μg/l) for long-term chronic exposure in 40% of the water quality sampling sites. The Ohio EPA association's document did not contain information for strontium concentration within IBI scores of 40-60. The Oak Ridge National Lab studied the toxicity of strontium and determined the secondary acute value for strontium to be 6.10 mg/L and the secondary chronic value to be 0.620 mg/l. These values are conservative estimates of water quality criteria, because sufficient data was unavailable to derive criteria for regulatory standards. They also found the lower chronic value for daphnids, genera of small crustaceans, to be 42.0 mg/l (Suter and Mabrey 1994).

The likely source of high concentrations of strontium and sodium in the streams of the Meigs Creek Subwatershed are the carbonates associated with the overburden disturbed during past strip-mining operations (Gierlowski-Kordesch and Preston 2004).

Turbidity and total suspended solids are elevated above the high end target at the mouth of the Renrock and Brannons tributaries and the two mainstem Dyes Fork sites, DF-00-30 and DF-00-01 (Figure 14 and 15). Tiltons Run and Horses Run are slightly above the turbidity standard (2.3 NTU). There is a positive correlation between turbidity and total suspended solids (R^2 0.922).

Figure 14

Turbidity levels within the Dyes Fork Subwatershed

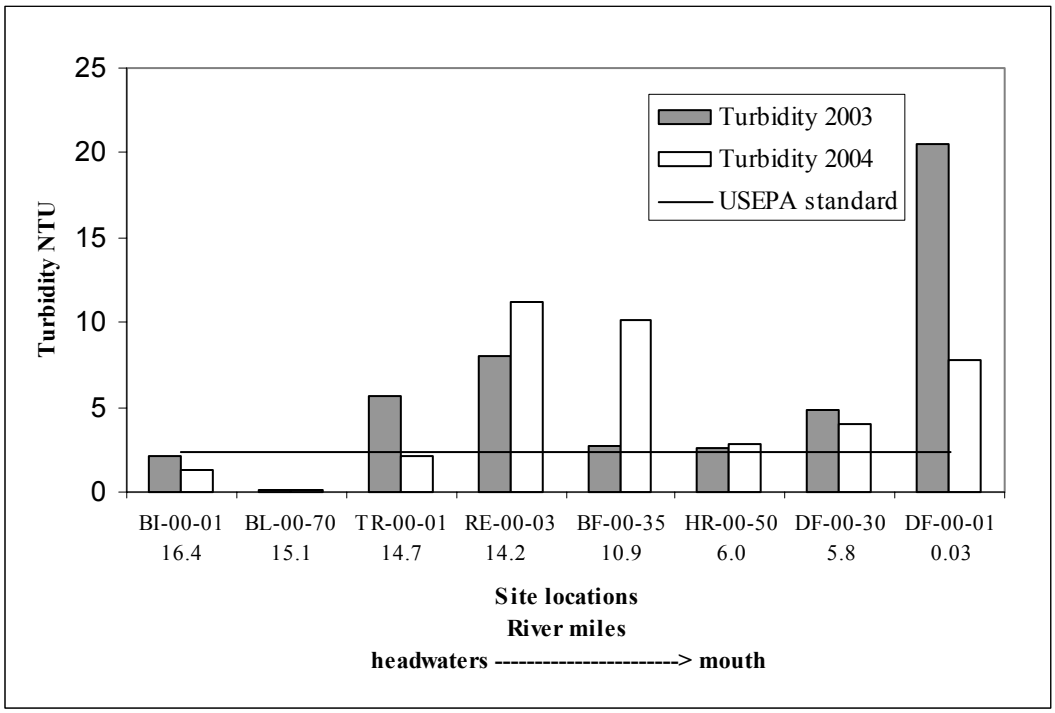


Figure 15

Total suspended solids within the Dyes Fork Subwatershed

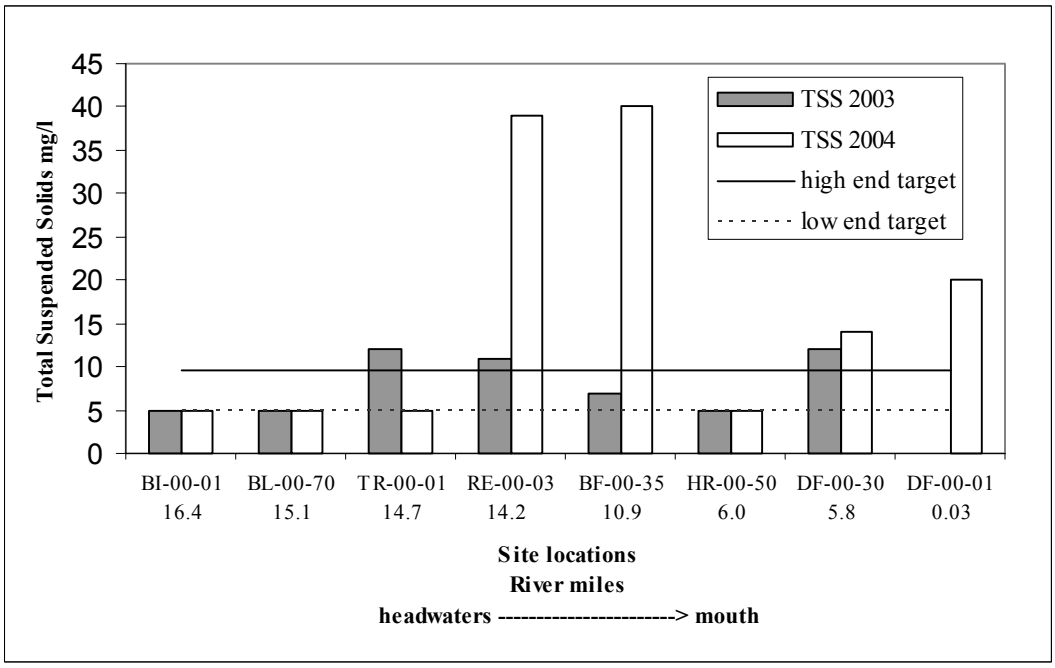
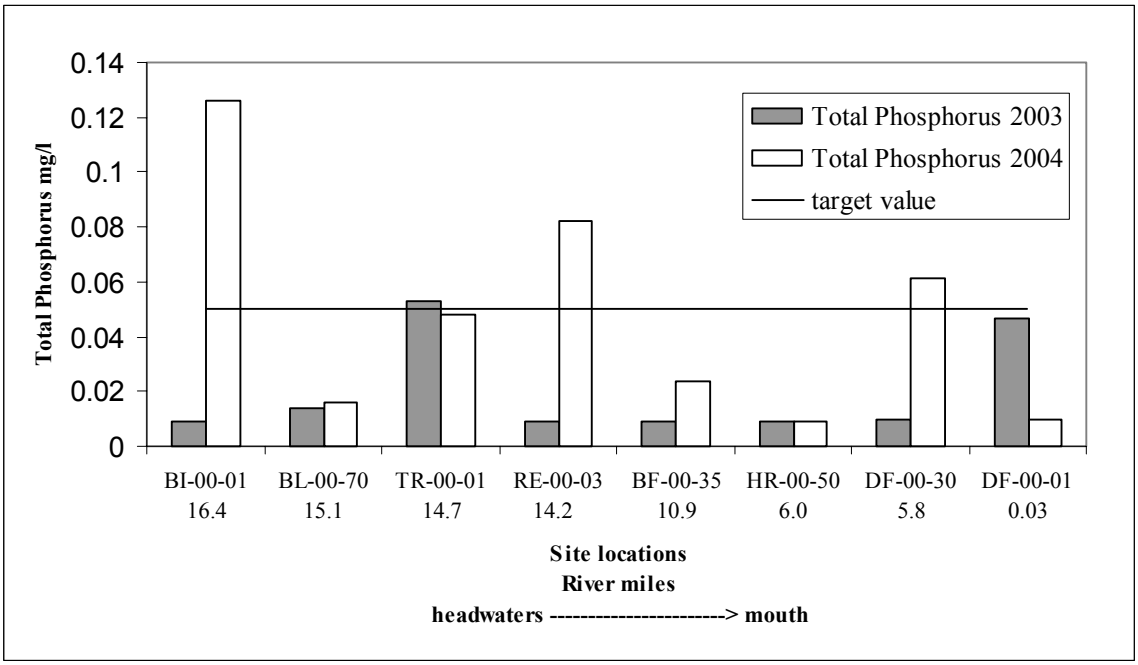


Figure 16 shows Bicenntenial and Renrock tributaries and the mainstem of Dyes Fork at DF-00-30 have elevated phosphorus concentrations only during the spring 2004 sampling event.

Figure 16

Phosphorus concentrations within the Dyes Fork Subwatershed



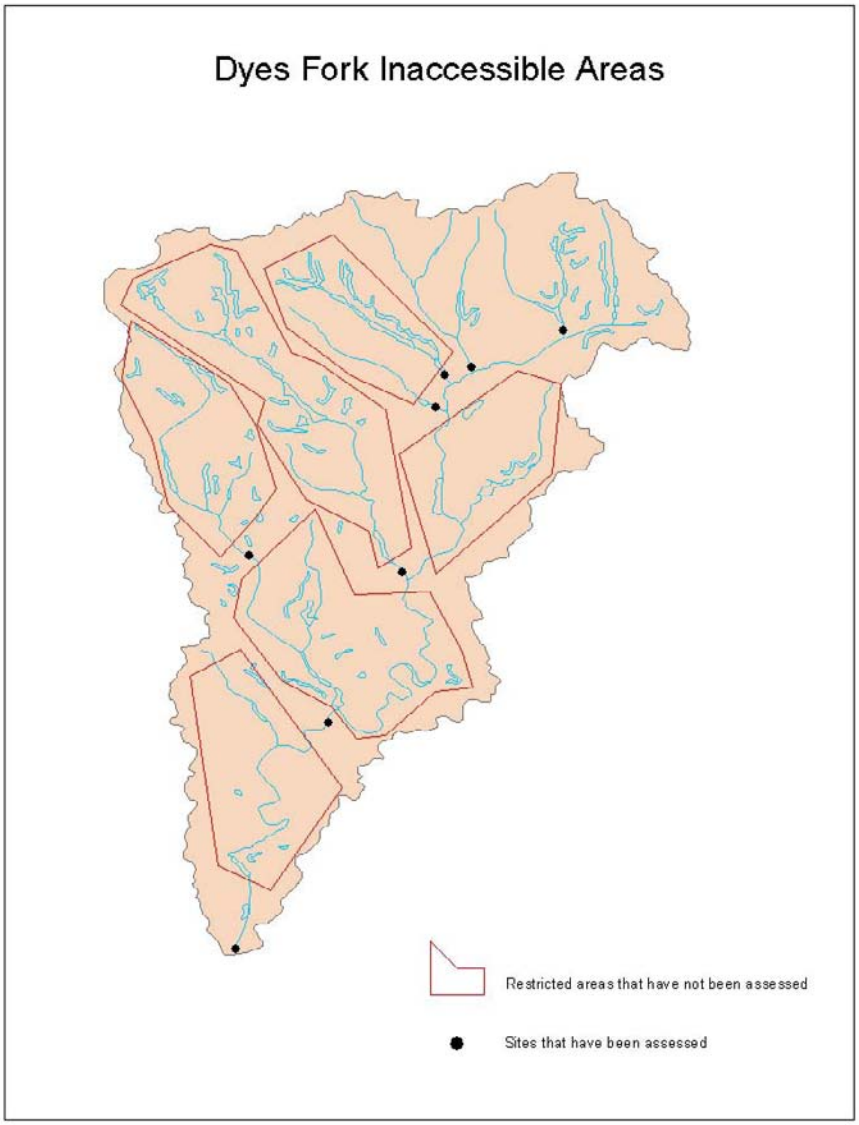
Only one site in Dyes Fork has nitrate concentrations above the high end target, Blanchard Spring site, BL-00-70, 4.0 mg/l during 2003 and 6.7 mg/l during 2004. The target range for nitrate according to the Ohio EPA association document is 0.2-0.3 mg/l (Table 8).

One fecal coliform sample was collected on August 2, 2004 within the Dyes Fork Subwatershed, DF-00-30 (170 counts/100ml) (Map 17). This is below the low-end target of 1000 counts/100ml. The Ohio EPA standard for primary contact water is not to exceed 1000 counts/100ml within a 30-day period with no less than five sampling events and not to exceed 2000 counts/100 ml at more than 10% of the sites sampled within that 30-day period. The low population of people and farming within 500 feet of the creek also suggests there is no or low impact to the water quality from fecal coliform. However five additional fecal coliform sampling events need to be conducted during a 30-day period to apply the Ohio EPA standard.

Areas of concern

Visual survey of the Dyes Fork area was conducted for evidence of cattle access to the streams, lack of riparian buffers, and erosion. Much of the area within Dyes Fork is inaccessible due to current land reclamation operations (Figure 17). However from the accessible area, no sites were identified as areas of concern.

Figure 17
Inaccessible areas within Dyes Fork Subwatershed



Biology

Two biological sites on the mainstem of Dyes Fork are meeting Warmwater Habitat measured during an OEPA sampling event in 1989; Dyes Fork at RM 5.8, DF-00-30, received an IBI score of 44 and Dyes Fork at RM 2.9 received an ICI score of 38 (Map 17). However, IBI scores on the mainstem of Dyes Fork did not meet Warmwater Habitat at RM 0.3 (38) or RM 0.9 (18). ICI score (26) at Dyes Fork RM 0.3 did not meet Warmwater Habitat. Two sites in the Horses Run and Tiltons Run tributaries were measured for macroinvertebrates using the MAIS score. Both sites received a score of nine, indicating 'poor' biological condition.

Problem statement

Dyes Fork Subwatershed shows impacts from past mining activity with elevated sulfate, strontium, sodium, total suspended solids, and turbidity. However, much of this area has been reclaimed by AEP and Consol and has been reforested as part of AEP's carbon sequestration program. In addition, on-going reclamation is also being planned and conducted by Consol. Warmwater Habitat may not ever be attainable in the tributaries where strip mining occurred due to the large number of impoundments within the stream channels. However, one site in particular needs to be investigated further due to extreme elevated water quality parameters, Blanchard Spring, BL-00-70. Another problem Dyes Fork faces is the lack of land use planning. Without proper land use planning as strip mine land is reclaimed and sold, an increase in activity and population will pose new threats on water quality downstream.

Action Plan

Goal 1: Improve water quality on the mainstem of Dyes Fork as a headwaters approach to improving water quality downstream.

Objective 1: Reduce sulfate, strontium, and sodium concentrations to below the target values of 140 mg/l, 770 µg/l, and 55 mg/l, respectively at the Blanchard Spring, Bicentennial, Tiltons, and Brannons sites.

Action 1: Research the impact on biology from elevated sulfate, strontium and sodium concentrations.

Action 2: Research remediation techniques to reduce sulfate, strontium, and sodium from water column where past mining practices occurred.

Action 3: Install a remediation system to reduce levels of sulfate, strontium and sodium concentration at the Blanchard Spring, Bicentennial site, Tiltons, and Brannons sites.

Action 4: Monitor the Dyes Fork downstream of the Blanchard Spring, Bicentennial, Tiltons, and Brannons sites to document the reduction in sulfate, strontium, and sodium.

Objective 2: Reduce total suspended solids (TSS) to lower the turbidity levels to below the USEPA standard of 2.3 NTU and an average target load of 54 and 234 lbs/day at Renrock and Brannons sites, respectively. Average load reduction needed is 175 and 734 lbs/day, respectively.

Action 1: Collect water samples of TSS and turbidity levels at these sites quarterly for one year.

Action 2: Design retention ponds that will reduce the turbidity to 2.3 NTU.

Action 3: Install retention ponds to reduce the turbidity to below 2.3 NTU.

Objective 3: Reduce phosphorus levels to below the target range of 0.05 mg/l at the Bicentennial tributary, Renrock tributary, and mainstem Dyes Fork, DF-00-30. An average phosphorus load reduction of 0.45, 0.05, 6.7 lbs/day are needed to meet the average target load of 0.6, 0.3, and 9.9 lbs/day at each site respectively.

Action 1: Conduct field investigations to determine the source of phosphorus in these three areas during spring flow.

Goal 2: Protect water quality resources that are meeting Warmwater Habitat to keep their attainment status.

Objective 1: Develop a land use plan for Dyes Fork.

Action 1: Work with AEP and Consol to establish riparian setbacks as a deed restriction on large tracks of land being sold.

Action 2: Work with Morgan County planning commission to have sewage lines installed when new water lines are being installed.

Action 3: Educate landowners about Morgan County's adopted floodplain permit system. (Permits can be obtained from Jeff Mcinturf at the Engineer's office in McConnelsville and notices about the need to obtain a permit are sent out each year with property tax bills).

Objective 2: Educate landowners about best management practices for forestry practices.

Action 1: Educate landowners about OSU Extension's Woodland Stewards Program who conduct Timber Practice Workshops for landowners.

Action 2: Work with ODNR Service Forester to develop a model timber plan landowners could use as a template to make their timber agreement with logging companies.

Action 3: Educate landowners by explaining the importance of a Forest Management Plan and an Operation and Maintenance Plan that local SWCD use to approve and verify adequate BMP's.

Table 17

Implementation table for the Dyes Fork Subwatershed

Action Plan	Activity	Available resources	Funding source	Time-line (start – end)	Indicator
1.1.1	research sulfate, strontium, and sodium impacts	Ohio EPA and MBI	Ohio EPA, AEP	2006-2007	chart values of sulfate, strontium, and sodium impacts on biology
1.1.2	research sulfate, strontium, and sodium remediation	Ohio EPA, ODNR-MRM, and MBI	Ohio EPA and AEP	2006-2007	report of options of sulfate, strontium, and sodium remediation
1.1.3	install remediation treatment	Ohio EPA, ODNR-MRM, AEP	Ohio EPA and AEP	2007-2008	Construction of four remediation systems
1.1.4	monitor remediation treatment	Volunteers and FLMR	Ohio EPA	2008-2009	report of monitor results

Table 17

Implementation table for the Dyes Fork Subwatershed, continued

1.2.1	water sampling	Volunteers and FLMR	Ohio EPA laboratory	2005-2006	database of water quality data
1.2.2	Design treatment	Ohio EPA, ODNR-MRM	Ohio EPA, ODNR-MRM, AEP	2006-2007	two sets of design plans
1.2.3	Install treatment	Ohio EPA, ODNR-MRM	Ohio EPA, ODNR-MRM, AEP	2007-2008	two constructed treatments
1.3.1	field investigation and water sampling	FLMR	Ohio EPA laboratory	2005-2006	one report and one database of findings
2.1.1	establish riparian setbacks through deed restrictions	FLMR, AEP, and CONSOL		2005-2008	one section of the land use plan summarizing the deed restrictions
2.1.2	water and sewage line planning	FLMR, County gov't		2005-2008	one section of the land use plan summarizing the water and sewage line infrastructure
2.1.3	outreach about the floodplain permit	FLMR, Morgan County gov't		2005-2008	one section of the land use plan summarizing the adopted floodplain permit
2.2.1	outreach and education about BMP's for forestry	OSU extension	OSU extension	2005-2008	number of landowners who attend the Woodland workshops from Meigs Creek Subwatershed
2.2.2	develop a model timber plan	ODNR service forester	ODNR service forester	2005-2008	one model timber plan
2.2.3	outreach and educate to landowners about the forest plans	SCWD	SCWD	2005-2008	number of landowners who submit forest plans for review at their local SWCD for the Meigs Creek Subwatershed

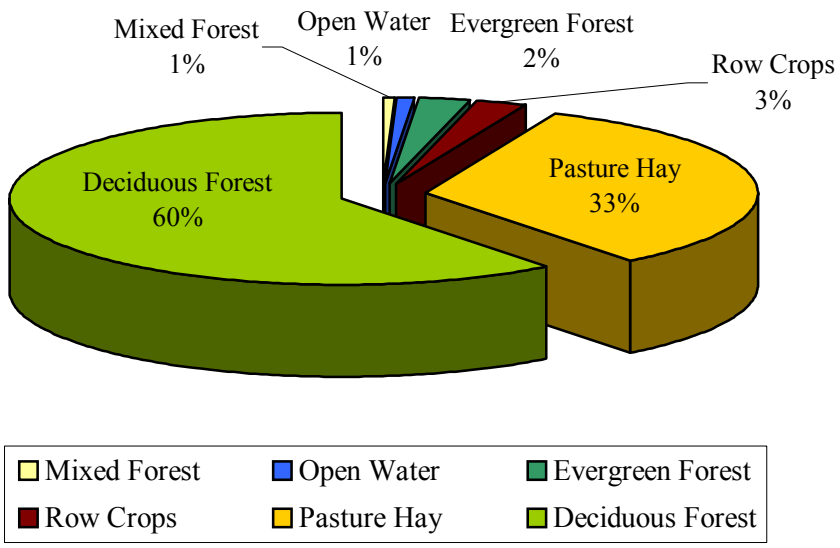
Mans Fork Subwatershed

Land Use

Land use in Mans Fork Subwatershed consists primarily of deciduous forest, 60 percent, and pasture/hay land, 33 percent (Figure 18). However, the riparian zone within 30 meters of the creek is primarily bordered by cropland and pasture. Of the approximately 47.4 stream miles in Mans Fork Subwatershed, 29.9 miles are bordered by cropland and pastures (see Table 2). Population within the Mans Fork Subwatershed is approximately 350 people (US Census 2000).

Figure 18

Land Use in Mans Fork Subwatershed



Source: LANDSAT Satellite Data 1994

Water quality

Water quality samples were collected at ten sites within the Mans Fork Subwatershed (Map 19). Mans Fork Subwatershed has slightly elevated conductivity. Conductivity is the measure of cations and anions in the water. The water quality analysis shows

that parameters that positively correlate with conductivity in the water column are magnesium (R^2 0.966), sulfate (R^2 0.943) and turbidity (R^2 0.922). The mouth of Bear Run, BR-00-01, show the highest conductivity and sulfate concentrations, which are also reflected at the mouth of Mans Fork less than a mile downstream of Bear Run (Figure 19 and 20).

Figure 19

Conductivity concentrations within Mans Fork Subwatershed

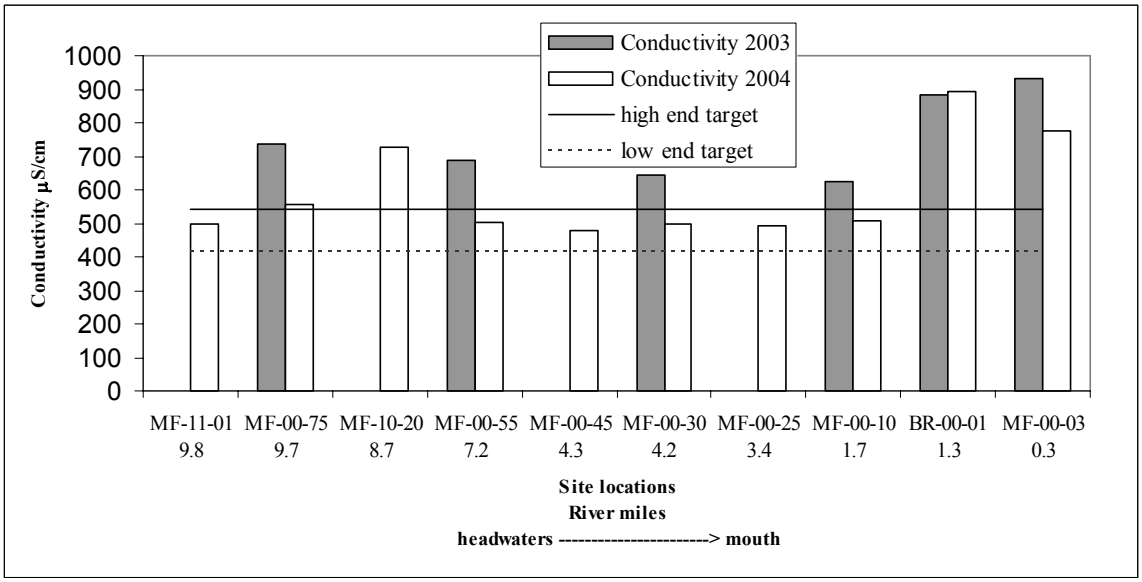
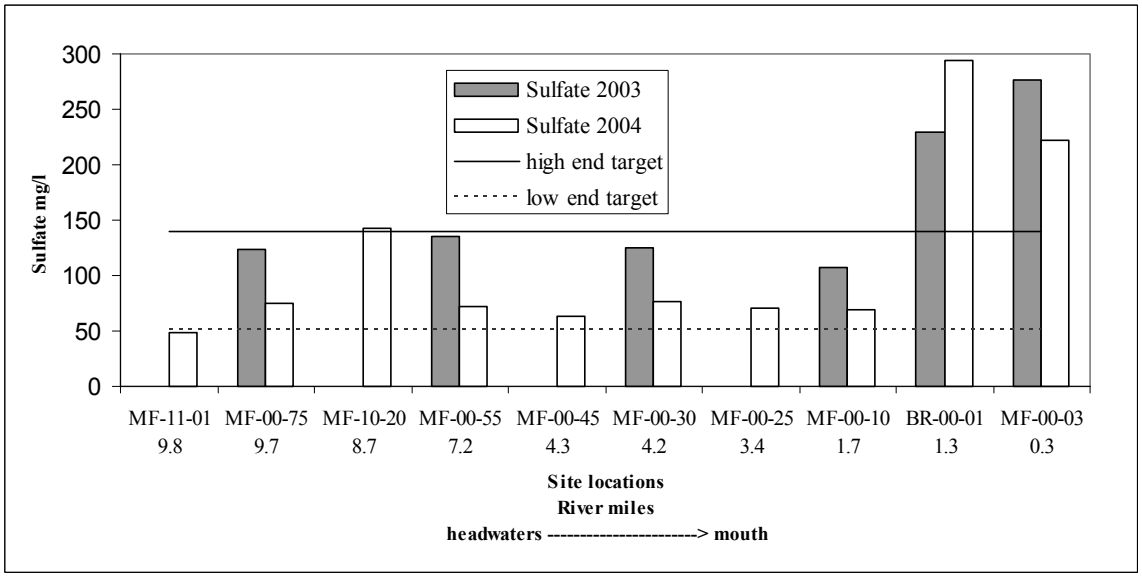


Figure 20

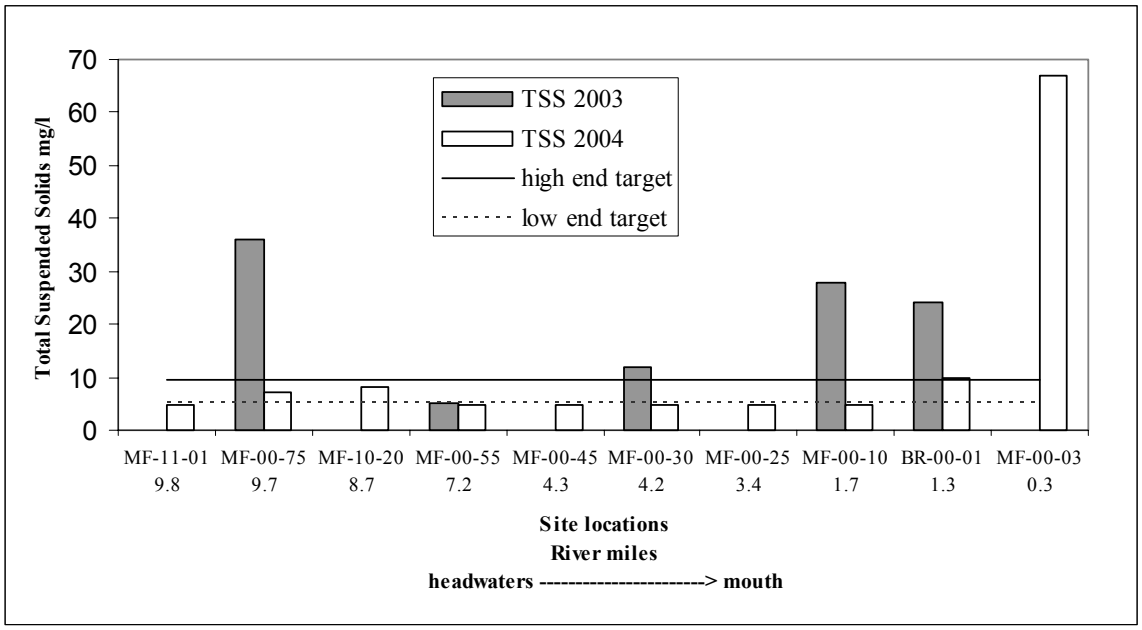
Sulfate concentrations within Mans Fork Subwatershed



Total suspended solids (TSS) were typically high during the summer 2003 sampling event at site MF-00-75, MF-00-30, MF-00-10 and BR-00-01. However the mouth of Mans Fork showed an extremely high TSS value during the spring 2004, other sites did not (Figure 21).

Figure 21

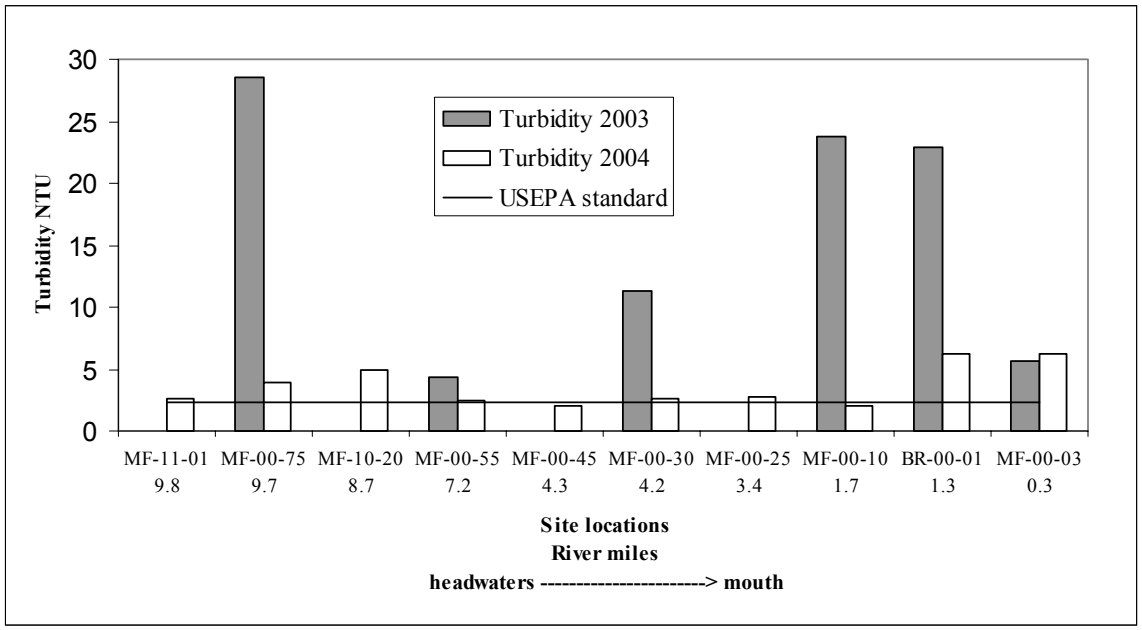
Total Suspended Solids within Mans Fork Subwatershed



Turbidity measurements were higher during the summer 2003 sampling event as compared to the spring 2004 sampling event (Figure 22). The USEPA standard for turbidity is 2.3 NTU; many of the sites in Mans Fork exceed this standard and especially high were sites MF-00-75, MF-00-30, MF-00-10, and BR-00-01. The mouth of Mans Fork exceeded the standard during both sampling events with a 6.18 and 6.24 NTU.

Figure 22

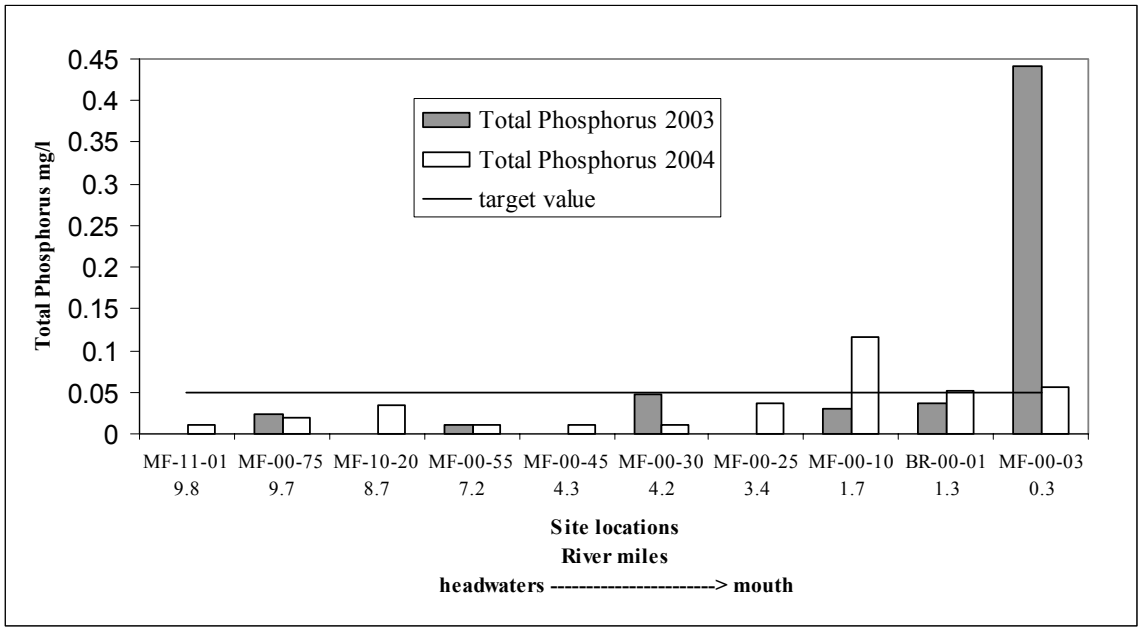
Turbidity levels within Mans Fork Subwatershed



Phosphorus levels in Mans Fork are mostly meeting the target of 0.05 mg/l. However, a high value was recorded at the mouth of Mans Fork during the summer 2003 sampling event, 0.441 mg/l (Figure 23).

Figure 23

Phosphorus concentrations within Mans Fork Subwatershed



All sites within Mans Fork Subwatershed contained less than 800 µg/l of strontium. In addition sodium levels at all sites were less than 15 mg/l and were in equal proportions to chloride.

Fecal coliform samples were collected on August 2, 2004 at nine sites within Mans Fork Subwatershed (Table 18) (Map 19). Six of the nine sites scored higher than 1000 counts/100ml and two of those sites were greater than 2000 counts/100ml (Table 18). The Ohio EPA standard for primary contact water is not to exceed 1000 counts/100ml within a 30-day period with no less than five sampling events and not to exceed 2000 counts/100 ml at more than 10% of the sites sampled within that 30-day period. The sampling event that was conducted in Meigs Creek occurred on only one day and should be used as an initial screening to select sites for additional sampling. Determining whether fecal coliform is derived from failing septic systems or livestock, land use and populations was researched. Population is moderate, with seventy houses counted in the Mans Fork Subwatershed that were within 500 feet of the creek. Assuming there are an average of 2.2 people per house, an average of 154 people are living in the area. According to

local health department 90% of the septic systems are failing. Therefore estimating 139 people contribute to failing systems at an average 70 gals/per person/day, equals 9,730 gals/per day (3,551,450 gals/per year). Land use shows 33 percent of the land in Mans Fork Subwatershed is pasture/ hay land and the visual evidence of cattle access to the creek indicates the fecal coliform bacteria that were measured are most likely from livestock (Figure 24). However, five additional fecal coliform sampling events need to be conducted during a 30-day period to apply the Ohio EPA standard.

Table 18

Fecal Coliform levels measured within the Mans Fork Subwatershed

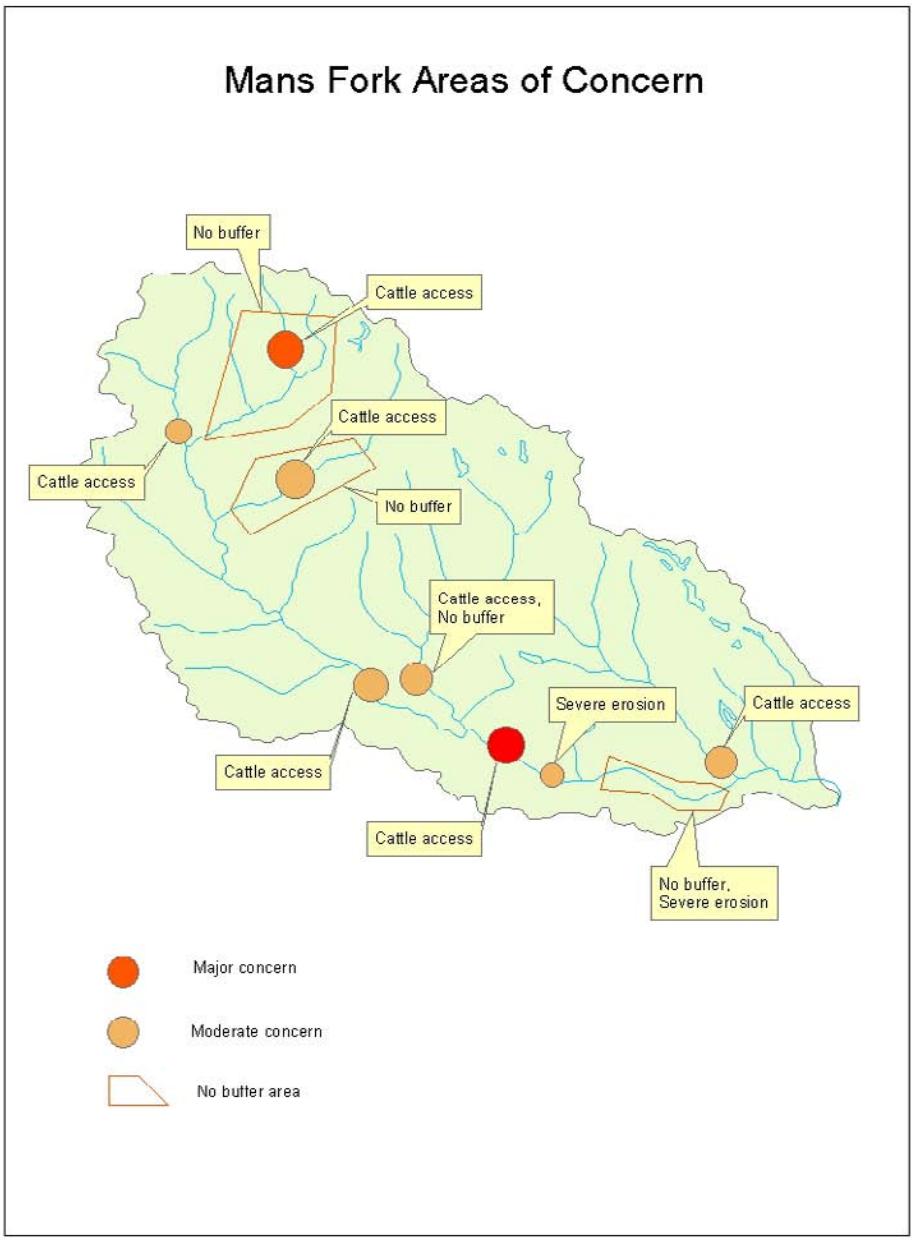
Sites	Fecal coliform counts/100 ml
MF-00-90	750
MF-11-01	1700
MF-10-20	1500
MF-00-45	2300
BS-00-05	580
MF-00-30	920
MF-00-10	1600
BR-00-01	3100
MF-00-03	1100

Area of concern

Survey of the Mans Fork Subwatershed was conducted for visual evidence of cattle access to the streams, lack of riparian buffers, and erosion. Eleven areas were identified of moderate to major concern. Figure 24, shows the areas of concern in Mans Fork Subwatershed (Map 19).

Figure 24

Areas of concern in Mans Fork Subwatershed



Biology

Macroinvertebrate data available for the Mans Fork Subwatershed consist of three sites analyzed by ILGARD using the MAIS indices and two sites analyzed by Greenvest (Map 19). Mans Fork, MF-00-75, and unnamed tributary in Mans Fork, UN-00-40, received a 'poor' biological condition score. Mans Fork, MF-00-55, Border School tributary, BS-00-05, and Bear Run tributary, BR-00-50, received a 'good' biological condition score. The mouth of Mans Fork was analyzed for fish and received an IBI score 18.

Problem statement

Data collected from Mans Fork Subwatershed indicates high levels of sediment. There are many locations where cattle have access to the creek and areas that lack a riparian buffer, which causes erosion. Areas of particular interest to concentrate sediment best management practices on include MF-00-75, MF-00-30, MF-00-10, BR-00-01, and MF-00-03. The occasional high level of phosphorus and fecal coliform levels need to be monitored further as restoration activities begin. Finally, Bear Run shows high levels of sulfate.

Action Plan

Goal 1: Improve water quality in the mainstem of Mans Fork to meet Warm-water Habitat.

Objective 1: Reduce turbidity and total suspended solids at site MF-00-75, MF-00-30, MF-00-10, BR-00-01, and MF-00-03 to below 2.3 NTU and 9.5 mg/l, respectively.

Action 1: Work with local Soil and Water Conservation Districts and Farm Bureau to educate landowners located near areas of concern about proper farming practices to reduce sediment impact on the stream.

Action 2: Utilize and work with local Soil and Water Conservation District to educate landowners located in areas of concern about Farm Bill 2002 opportunities.

Objective 2: Reduce the phosphorus and sediment load in Mans Fork by 1.35 lbs/day to meet the average target load of 7.53 lbs/day of phosphorus and 5,398 lbs/day of sediment to meet the average target load of 1,443 lbs/day of sediment.

Action 1: Stabilize 5.2 miles of streambank to reduce 1638 lbs/day of sediment and 0.82 lbs/day of phosphorus from entering into Mans Fork. One option to stabilize streambanks are through the CRP program at an estimated cost of $600/acre, 5.2 miles of streambank with a 300 ft buffer would cost approximately $113,459.

Action 2: Install 4,950 linear feet of fencing at six project areas to restrict livestock access to Mans Fork at an approximate cost of $26,490.

Objective 3: Determine if fecal coliform is a water quality impairment.

Action 1: Conduct five sampling events within 30 days at the following sites that scored between over 1000 counts/100 ml during the initial screening: MF-11-01, MF, 10-20, MF-00-45, MF-00-10, BR-00-01, and MF-00- 03.

Action 2: Work with local health department officials to educate any landowner who live near elevated areas and work with health department to test well water for safe drinking.

Objective 4: Monitor area where high levels of phosphorus and sulfate occurred.

Action 1: Conduct further field investigation and water sampling to monitor phosphorus and sulfate levels at the mouth of Mans Fork, MF-00-03 and Bear Run, BR-00-01.

Table 19

Implementation table for the mans Fork Subwatershed

Action Plan	Activity	Available resources	Funding source	Timeline (start – end)	Indicator
1.1.1	outreach and education	Volunteers, FLMR, Soil and Water Conservation, Farm Bureau		2005-2006	list of landowners contacted and implementing BMP's
1.1.2	outreach and education	Volunteers, FLMR, Soil and Water Conservation		2005-2006	list of landowners implementing BMP's using the Farm Bill

Table 19

Implementation table for the Mans Fork Subwatershed, continued

1.2.1	stabilize streambank	SWCD – Farm Bill	Farm Bill 2002	2006-2009	Number of miles of streambank stabilization BMPs
1.2.2	install livestock fencing and water sources	SWCD – Farm Bill	Farm Bill 2002	2006-2009	Number of feet of fence installed
1.3.1	conduct water sampling	Volunteers and FLMR	Ohio EPA	2005-2006	database of six sites measured
1.3.2	outreach and education	Volunteers and FLMR		2005-2006	list of landowners contacted
1.4.1	water sampling	Volunteers and FLMR	Ohio EPA laboratory	2005-2006	database of water quality data

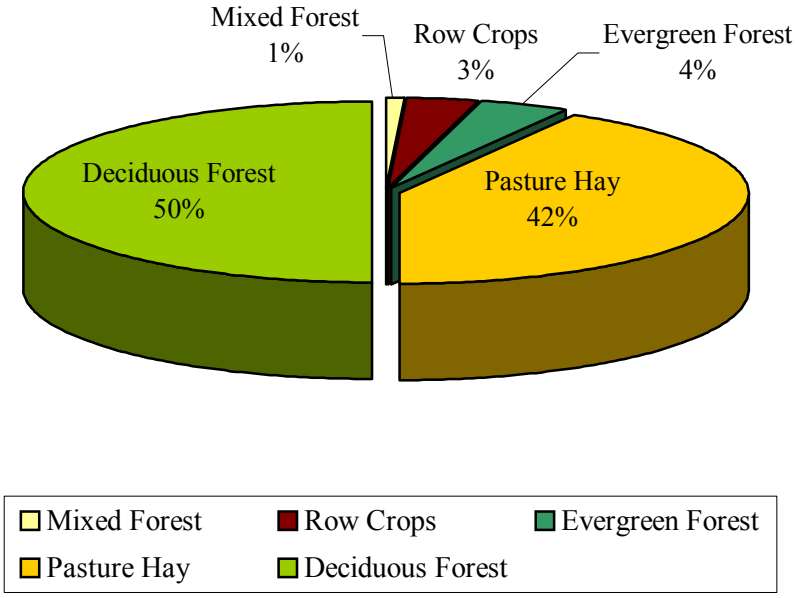
Fourmile Run

Land Use

Fourmile Run Subwatershed is the smallest 14-digit HUC within the Meigs Creek basin, consisting of 7,998 acres. Deciduous forests cover 50 percent of the land and pasture/hay land makes up nearly 42 percent (Figure 25). Riparian buffer within 30 meters of the creek is primarily cropland and pasture. Of the approximately 20.9 stream miles in the Fourmile Run Subwatershed, 13.3 miles of stream are bordered by cropland and pasture (see Table 2). According to the US Census Bureau data from 2000 only 313 people occupy this area.

Figure 25

Land Use in Fourmile Run Subwatershed



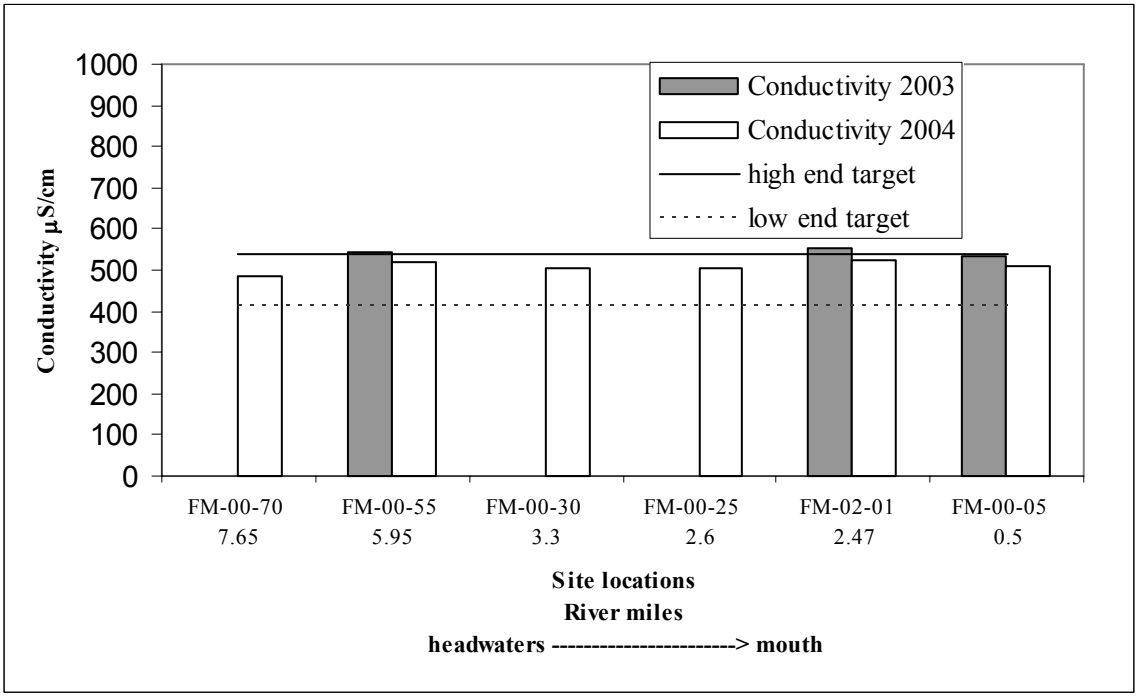
Source: LANDSAT Satellite Data 1994

Water Quality

Six sites were analyzed for water quality parameters within the Fourmile Run Subwatershed (Map 20). Figure 26 shows that all the sites measured within Fourmile Run Subwatershed were below the high-end target for conductivity, indicating low concentrations of dissolved metals. Sulfate, sodium, and strontium levels met the target values. All sites have sulfate concentrates less than 45 mg/l, sodium concentrations less than 10 mg/l, and strontium concentrations less than 410 µg/l.

Figure 26

Conductivity levels within the Fourmile Run Subwatershed



Total suspended solids exceeded the target value at FM-00-55 and FM-02-01 (Figure 27) and the turbidity standard was exceeded at site FM-00-55 and FM-00-05 (Figure 28). Only one site exceeded the phosphorus target of 0.05 mg/l at the mouth of Little Fourmile FM-02-01 with a value of 0.11 mg/l.

Figure 27

Total Suspended Solids within the Fourmile Run Subwatershed

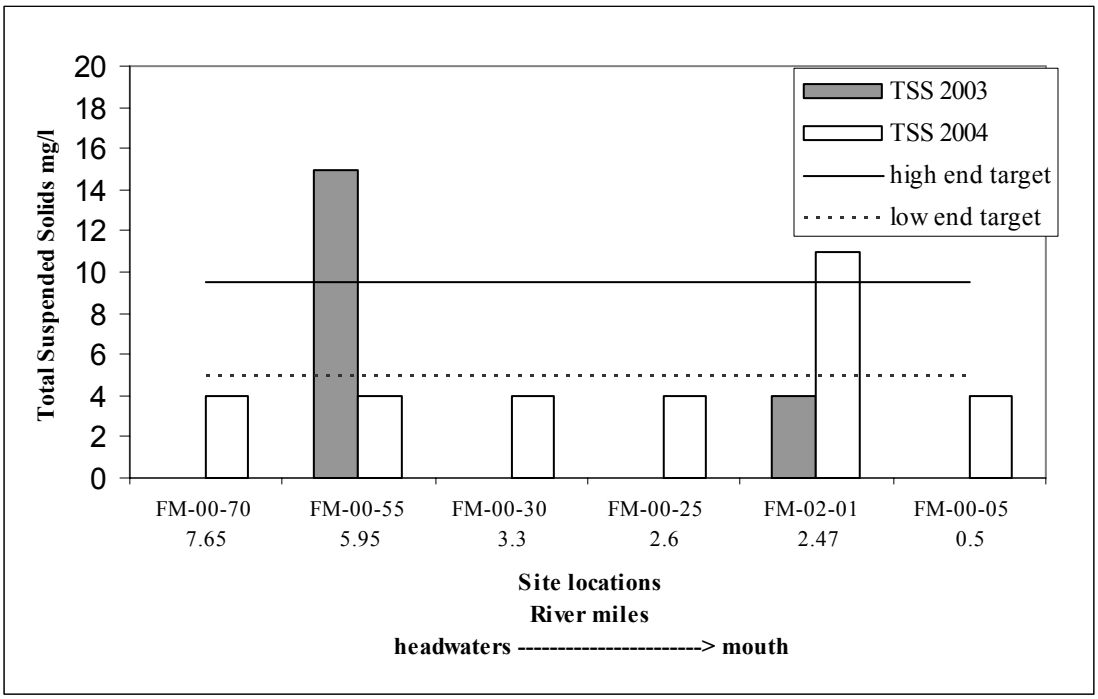
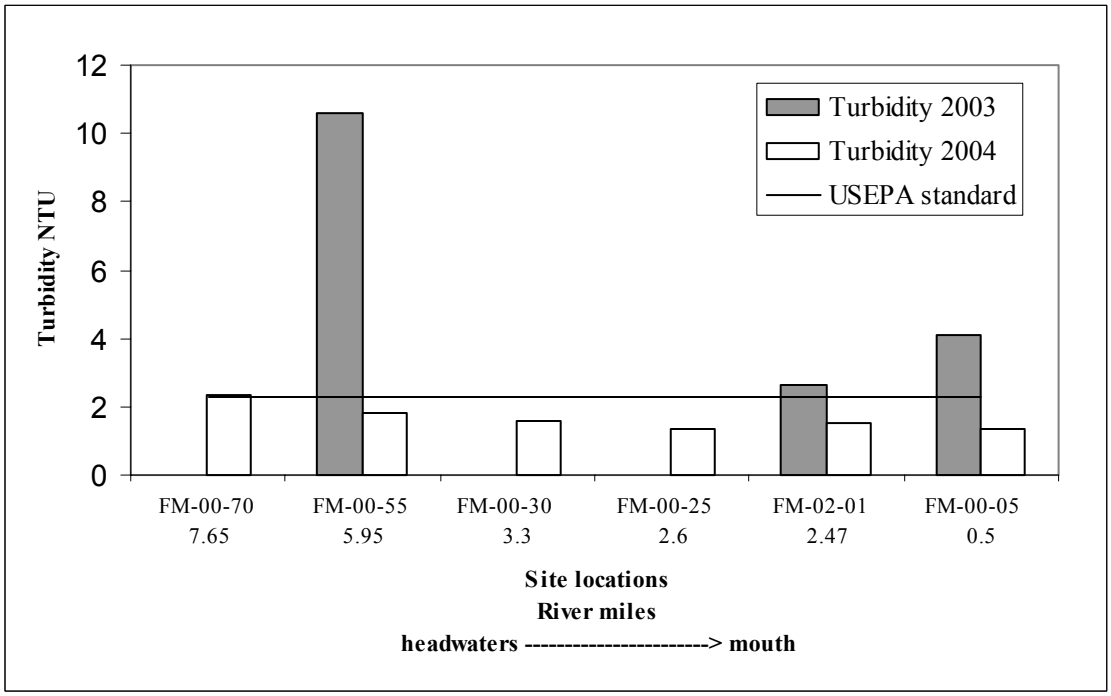


Figure 28

Turbidity within the Fourmile Run Subwatershed



Fecal coliform samples were collected on August 2, 2004 at two sites within Fourmile Run Subwatershed (Table 20) (Map 20). Both sites scored higher than 1000 counts/100ml but less than 2000 counts/100ml. The Ohio EPA standard for primary contact water is not to exceed 1000 counts/100ml within a 30-day period with no less than five sampling events and not to exceed 2000 counts/100 ml at more than 10% of the sites sampled within that 30-day period. The sampling event that was conducted in Meigs Creek occurred on only one day and should be used as an initial screening to select sites for additional sampling. Determining whether fecal coliform is derived from failing septic systems or livestock, land use and populations was researched. Population is 313 with only approximately fifty-two houses within 500 feet of the creek in the Fourmile Run Subwatershed. Assuming there are an average of 2.2 people per house, an average of 114 people living in the area. According to local health department 90% of the septic systems are failing. Therefore estimating 103 people contribute to failing systems at an average 70 gals/per person/day, equals 7,207 gals/per day (2,630,628 gals/per year). Land use shows forty-two percent of the land in Fourmile Run Subwatershed is pasture/hay land. Visual evidence of cattle access to the creek indicates that the fecal coliform bacteria that were measured are most likely from livestock (Figure 29). However, five additional fecal coliform sampling events need to be conducted during a 30-day period to apply the Ohio EPA standard.

Table 20

Fecal coliform levels within the Fourmile Run Subwatershed

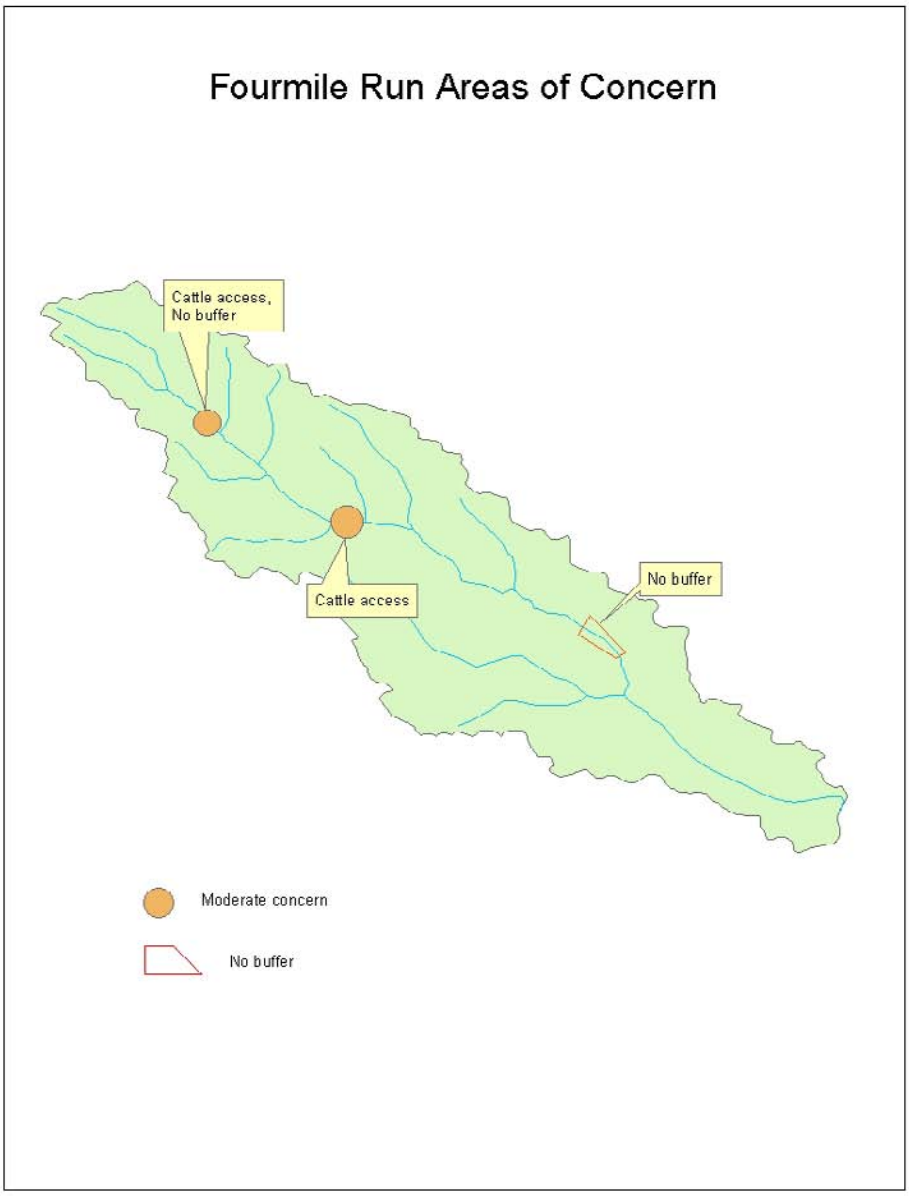
Sites	Fecal Coliform counts/100ml
FM-00-30	1060
FM-00-55	1800

Areas of concern

Visual survey of the Fourmile Run Subwatershed was conducted for evidence of cattle access to the streams, lack of riparian buffers, and erosion. Three areas were identified as moderate to major concern. Figure 29, shows the areas of concern in Fourmile Run Subwatershed (Map 20).

Figure 29

Areas of concern within the Fourmile Run Subwatershed



Biology

Two sites were analyzed for macroinvertebrates using the MAIS indices (Map 20). The headwaters of Fourmile Run, FM-00-55, received a 'poor' biological condition score. The mouth of Fourmile Run, FM-00-05 received a 'good' biological condition score and an IBI score of 46, indicating Warmwater Habitat.

Problem statement

With minimal restoration activities the entire Fourmile Run reach could meet Warmwater Habitat. One site in particular, in the headwaters of Fourmile Run, that received the 'poor' biological score, shows occasional high total suspended solids, turbidity, borderline fecal coliform, and has cattle access (FM-00-55).

Action Plan

Goal 1: Improve water quality at the headwaters site FM-00-55 to meet 'good' MAIS biological condition.

Objective 1: Reduce turbidity and total suspended solids at site FM-00-55 and FM-00-05 to below 2.3 NTU (both sides are meeting their average target load of 204 and 628 lbs/day).

Action 1: Work with local Soil and Water Conservation Districts and Farm Bureau to educate landowners located near areas of concern about proper farming practices to reduce sediment impact on the stream.

Action 2: Utilize and work with local Soil and Water Conservation District to educate landowners located in areas of concern about Farm Bill 2002 opportunities.

Objective 2: Determine it fecal coliform is a problem

Action 1: Conduct five sampling events within 30 days at the following sites that scored between over 1000 counts/100 ml during the initial screening: MF-00-55 and MF-00-30.

Action 2: Work with local health department to educate any landowner who live near elevated areas and work with health department to test well water for safe drinking.

Objective 3: Reduce 695 lbs/day of sediment load and 0.35 lbs/day of phosphorus load.

Action 1: Stabilize 2.9 miles of streambank to reduce 109 lbs/day of sediment and 0.1 lbs/day of phosphorus load from entering into Fourmile Run. One option to stabilize streambanks are through the CRP program at an estimated cost of $600/acre, 2.9 miles of streambank with a 300 ft buffer would cost approximately $63,275.

Action 2: Install 1,750 linear feet of fencing at 2 project areas to restrict livestock access to Fourmile Run and reduce sediment load by 586 lbs/day and 0.3 lbs/day of phosphorus load at an approximate cost of $9,050.

Table 21

Implementation Table for the Fourmile Run Subwatershed

Action Plan	Activity	Available resources	Funding source	Timeline (start – end)	Indicator
1.1.1	outreach and education	Volunteers, FLMR, Soil and Water Conservation, Farm Bureau		2005-2006	list of landowners contacted and implementing BMP's
1.1.2	outreach and education	Volunteers, FLMR, Soil and Water Conservation	Farm Bill 2002	2005-2006	list of landowners implementing BMP's using the Farm Bill
1.2.1	conduct water sampling	Volunteers and FLMR	Ohio EPA	2005-2006	database of two sites measured
1.2.2	outreach and education	Volunteers and FLMR		2005-2006	list of landowners contacted
1.3.1	stabilize streambank	SWCD – Farm Bill	Farm Bill 2002	2007-2009	Number of miles of streambank stabilization BMPs
1.3.2	install livestock fencing and water sources	SWCD – Farm Bill	Farm Bill 2002	2007-2009	Number of feet of fence installed

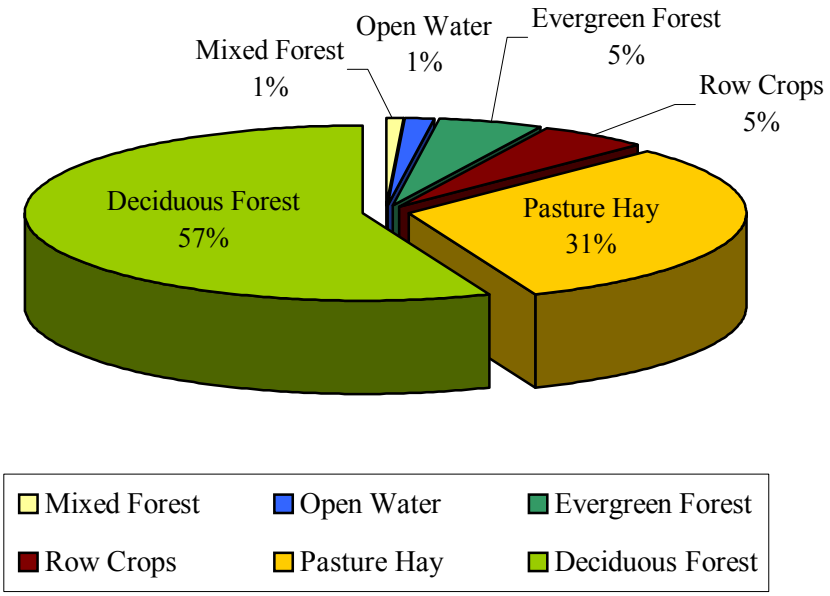
Lower Meigs Creek

Land Use

Lower Meigs Creek Subwatershed is comprised of fifty-seven percent deciduous forest, thirty-one percent pasture/hay land, five percent row crops, and five percent evergreen forests, with the remaining two percent left to open water and mixed forests (Figure 30). Of the approximately 30.4 stream miles in the Lower Meigs Creek Subwatershed, 14.9 miles are bordered by cropland and pasture, 7.9 miles of deciduous forest, and 5.8 miles of shrub land (see Table 2). The Lower Meigs Creek Subwatershed has the largest population compared to the other 14-digit HUC areas, with approximately 502 of the total 1536 people living in the Meigs Creek Subwatershed (US Census 2000).

Figure 30

Land Use in the Lower Meigs Creek Subwatershed downstream Mans Fork (excluding Dyes Fork and Fourmile Run)



Source: LANDSAT Satellite Data 1994

Water quality

Twelve data points are analyzed in the Lower Meigs Creek Subwatershed (Map 21). Water quality data in the Lower Meigs Creek Subwatershed presents a comprehensive look at water quality in the entire Meigs Creek Subwatershed. This is because the input of water quality from all the major 14-digit HUCs and major tributaries (Mans Fork, Dyes Fork, Fourmile Run, Onion Run, and Perry Run) are seen on the mainstem of Lower Meigs Creek. Therefore, concentrations and loadings are compared at the mouths of these major tributaries to show the areas of greatest impact.

Conductivity levels and inputs of concentrations of sulfate, strontium, and sodium are shown highest at the mouth of Dyes Fork (DF-00-01) discharging into Meigs Creek (Figure 31, 32, 33, and 34). These levels remain high in the mainstem of Meigs Creek downstream of the Dyes Fork confluence (RM 5.4) to the mouth of Meigs Creek (RM 0.8)

Figure 31

Conductivity values within the Lower Meigs Creek Subwatershed

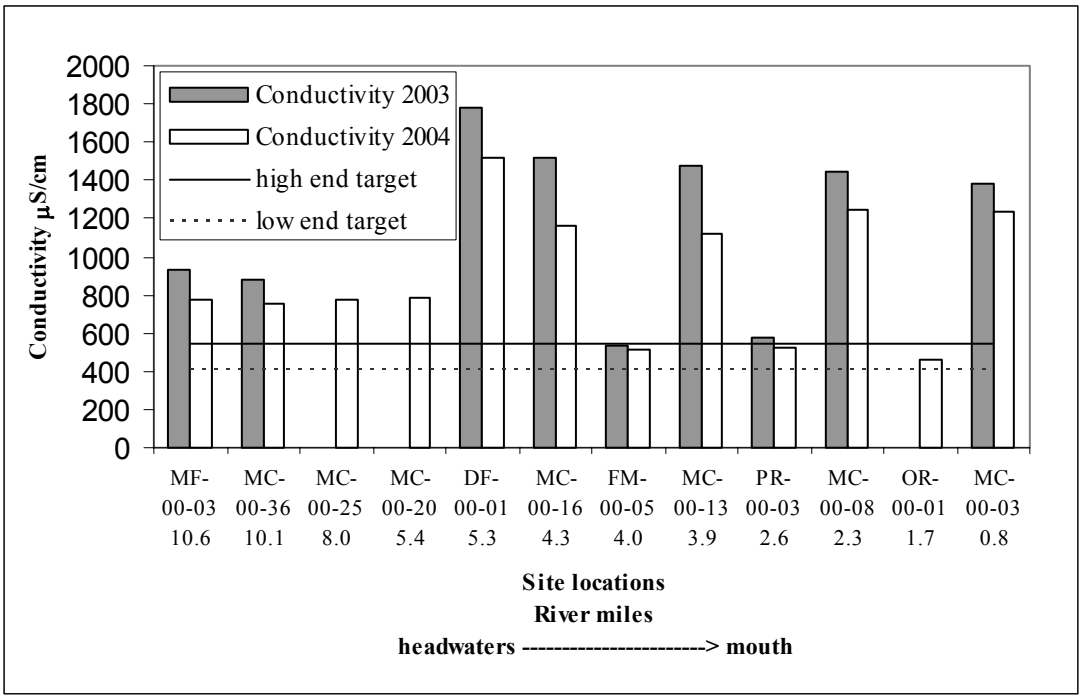


Figure 32

Sulfate values within the Lower Meigs Creek Subwatershed

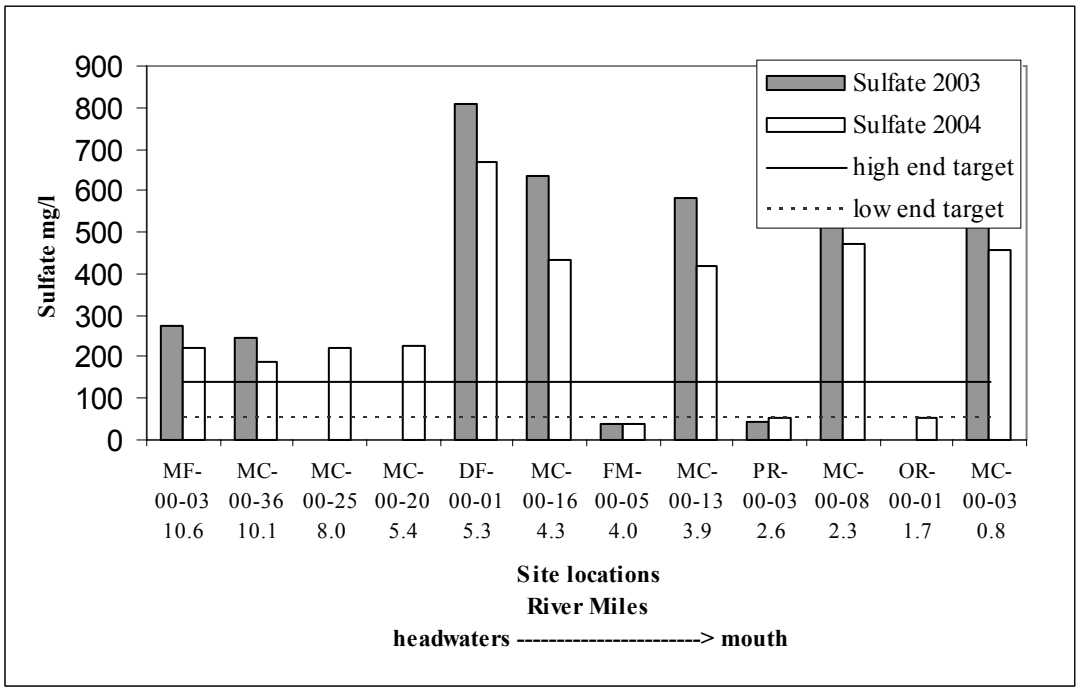


Figure 33

Strontium values within the Lower Meigs Creek Subwatershed

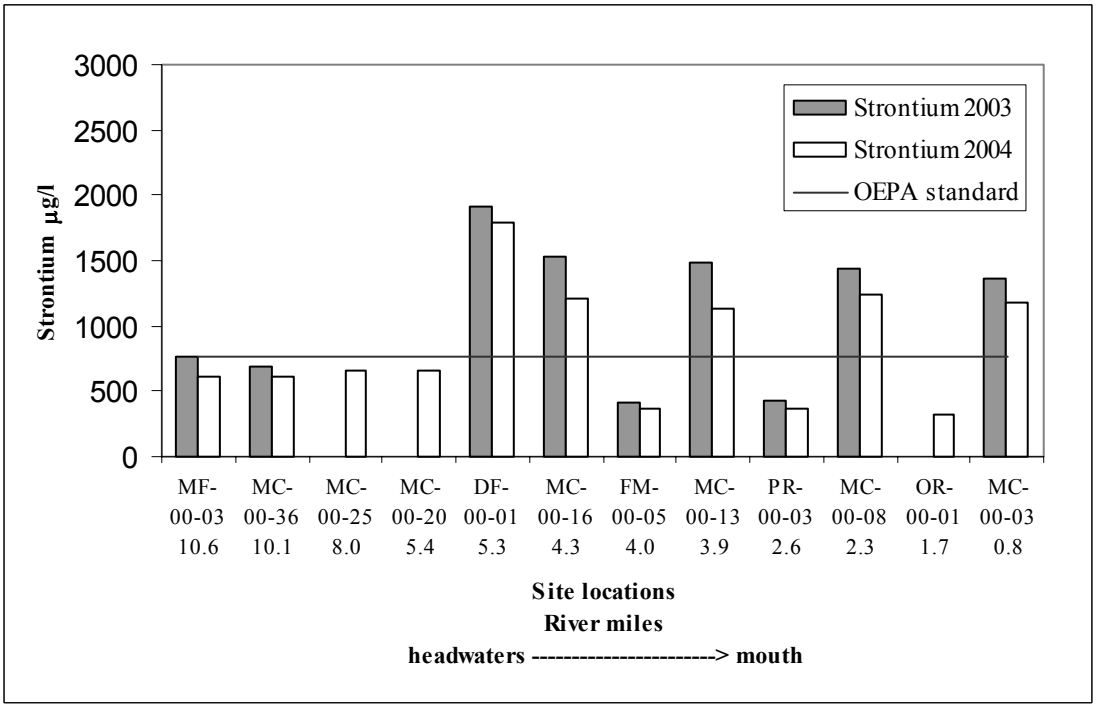
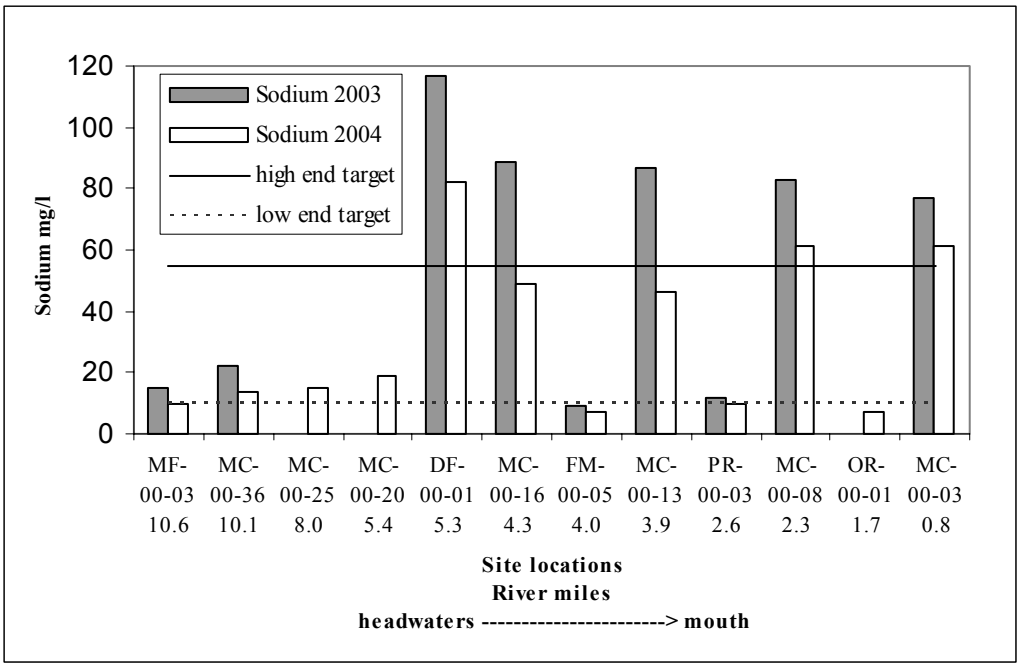


Figure 34

Sodium values within the Lower Meigs Creek Subwatershed



Total suspended solids and phosphorus concentrations showed the greatest impact coming from the Mans Fork Subwatershed (Figure 35 and 36). However total suspended solids discharging from the mouth of Dyes Fork are elevated over the target value (Figure 35).

Figure 35

Total Suspended Solids values within the Lower Meigs Creek Subwatershed

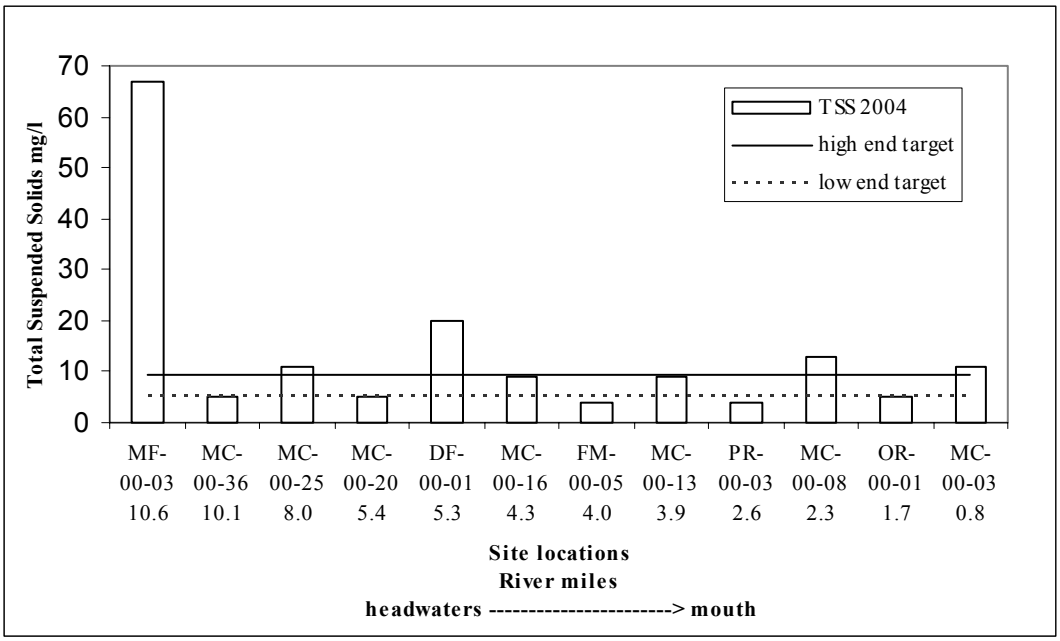
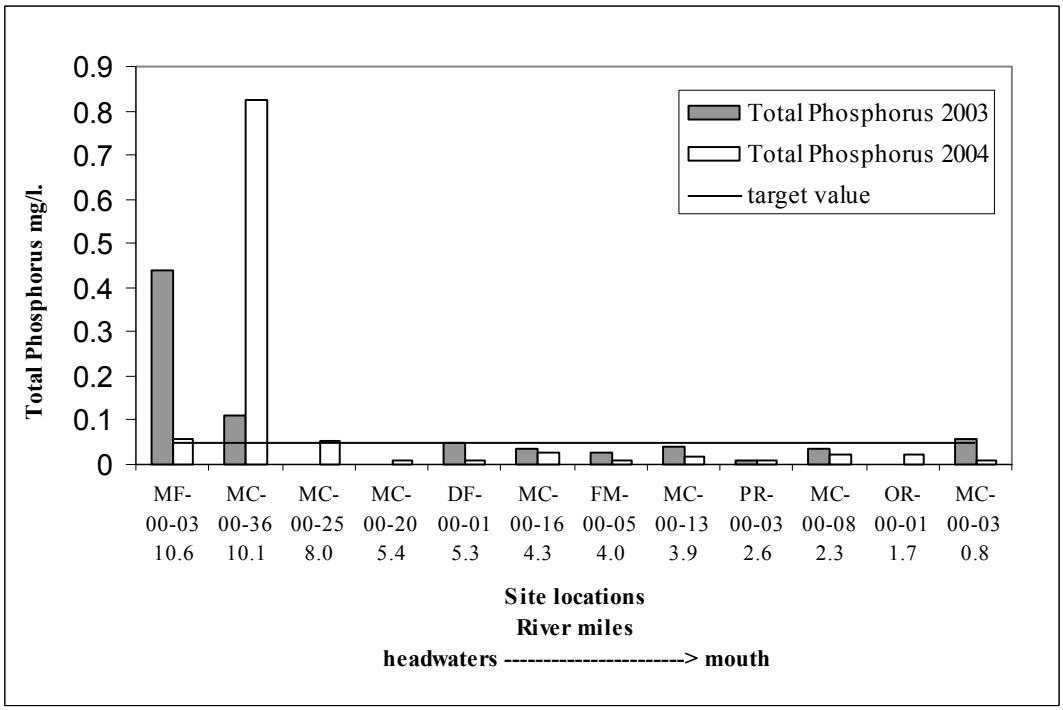


Figure 36

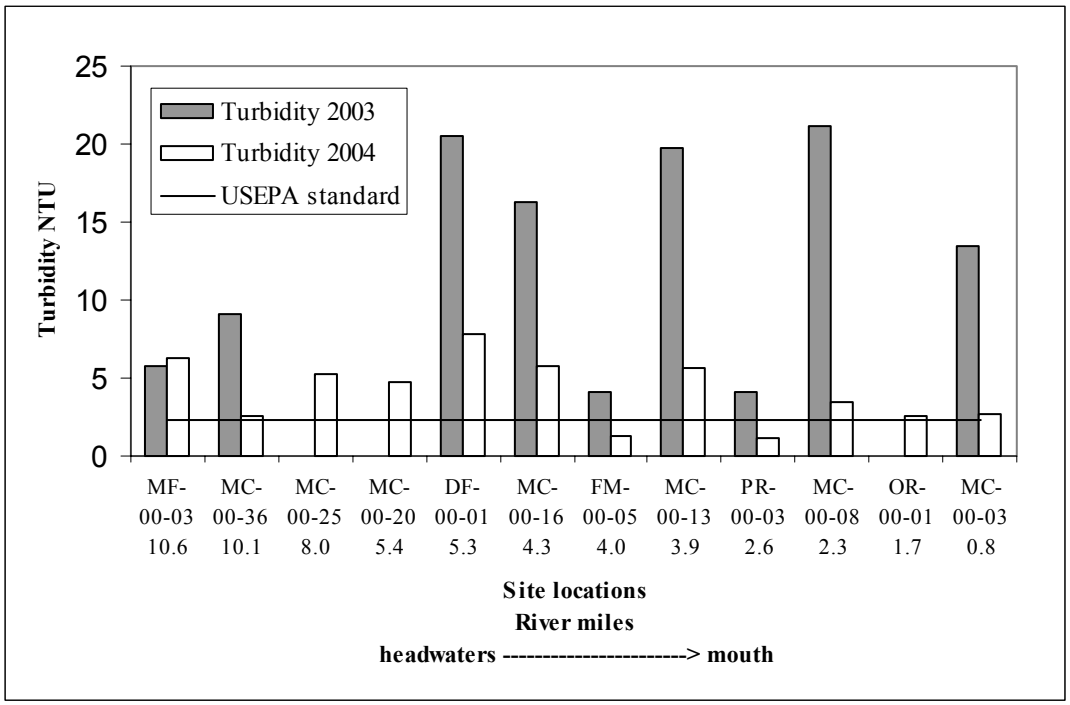
Phosphorus in the Lower Meigs Creek Subwatershed



Turbidity values are elevated above the USEPA target of 2.3 NTU at almost every site measured. The mouth of Dyes Fork and mainstem sites MC-00-13 and MC-00-08 show the highest values of turbidity (Figure 36).

Figure 37

Turbidity values within the Lower Meigs Creek Subwatershed



Water quality loadings

Loadings were calculated for the following parameters: sulfate, sodium, strontium, phosphorus, and total suspended solids. Concentrations of each of these parameters collected were multiplied by either a measured flow, if available, or a calculated flow. Calculated flows were determined using the daily yield from measured flows and the drainage area of each site. Drainage areas were determined using ArcView GIS Basins tool. Target load values (kg/day) were calculated based on estimated annual average flows determined from drainage area multiplied by the high end target value (Table 8).

Loadings of sulfate, strontium, and sodium follow the same trend during the summer 2003 and spring 2004 sampling events. Loadings are higher during the spring 2004 sampling because samples were collected at a higher flow regime. Loadings of each of these parameters are shown being contributed from Mans Fork and Dyes Fork. Loadings remain high on the mainstem downstream of Dyes Fork and start to decrease towards the mouth (Figure 38, 39, 40). The mouth of Dyes Fork is exceeding the target load value for both sodium and strontium which causes the mainstem of Meigs Creek to exceed the target value for 1.5 miles downstream of the confluence.

Figure 38

Sulfate loadings in the Lower Meigs Creek Subwatershed

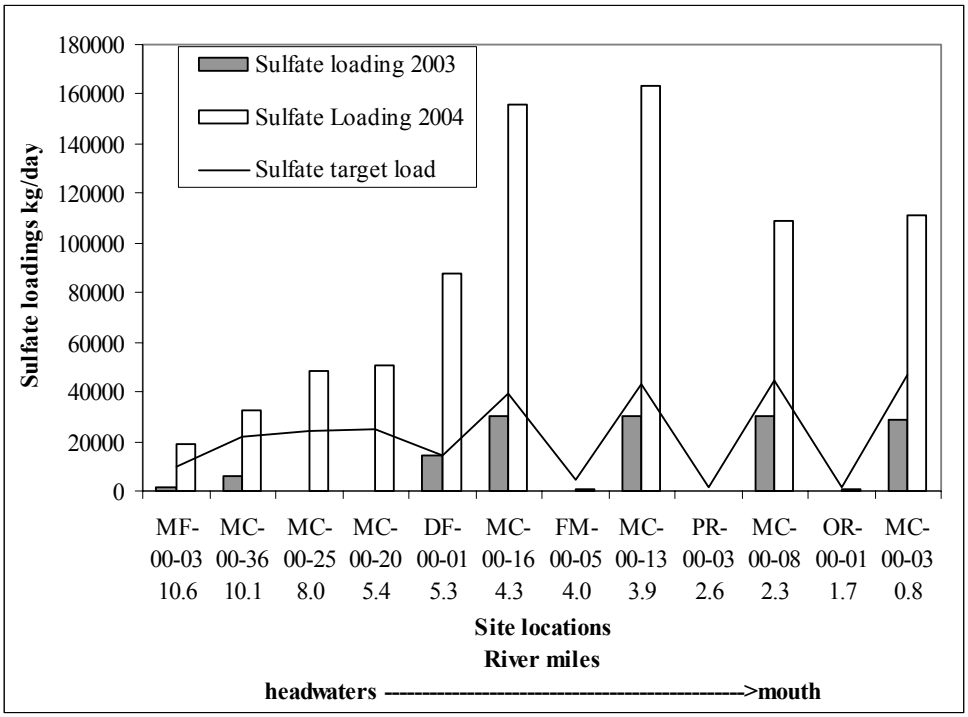


Figure 39

Sodium loadings in the Lower Meigs Creek Subwatershed

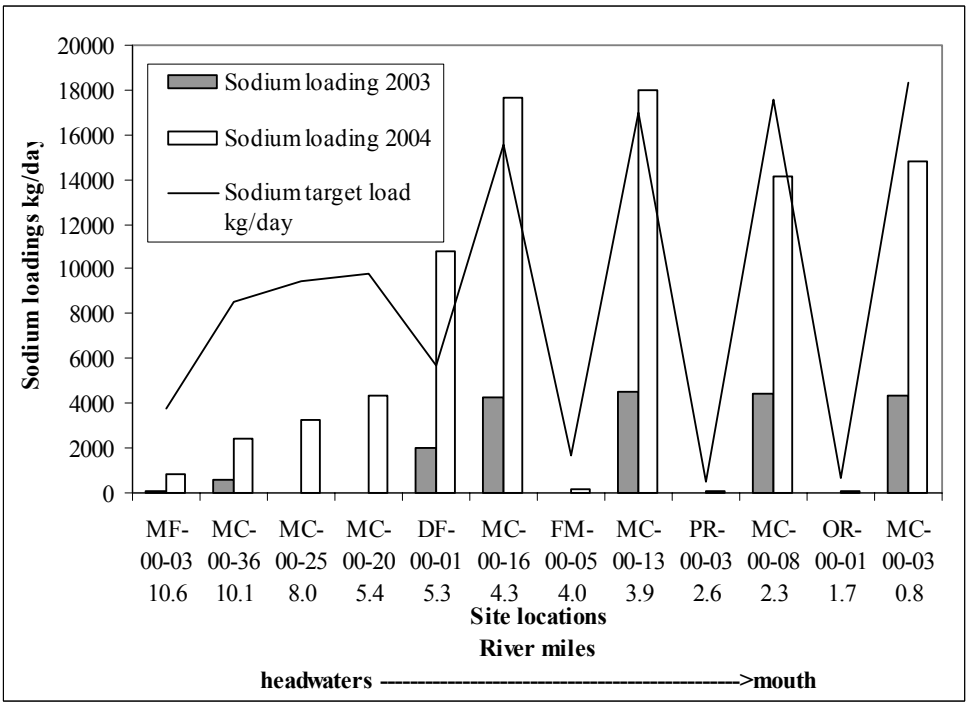
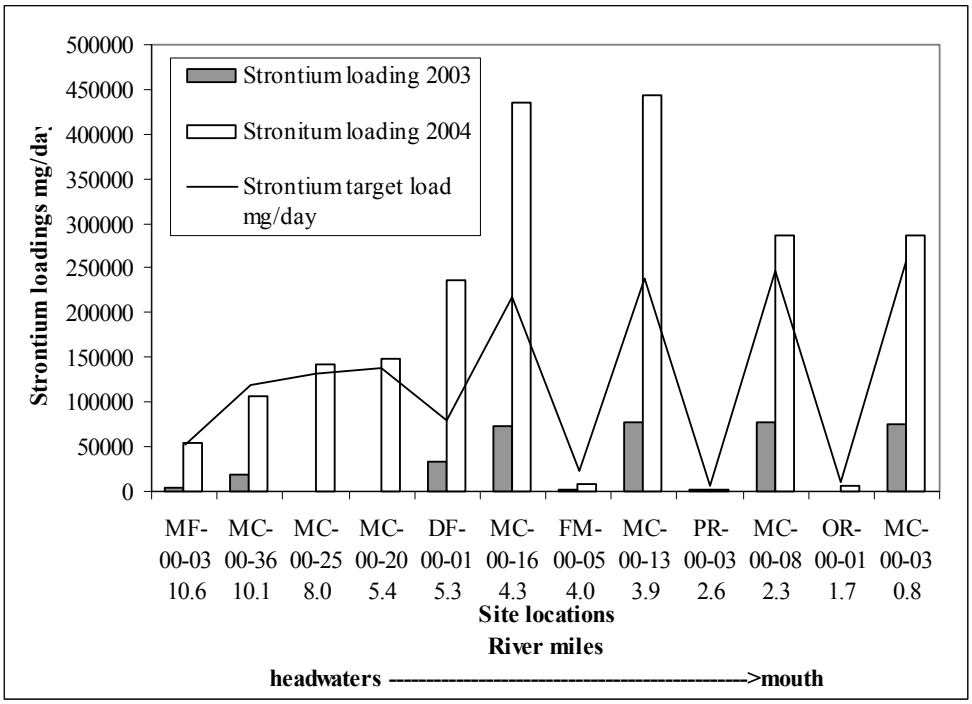


Figure 40

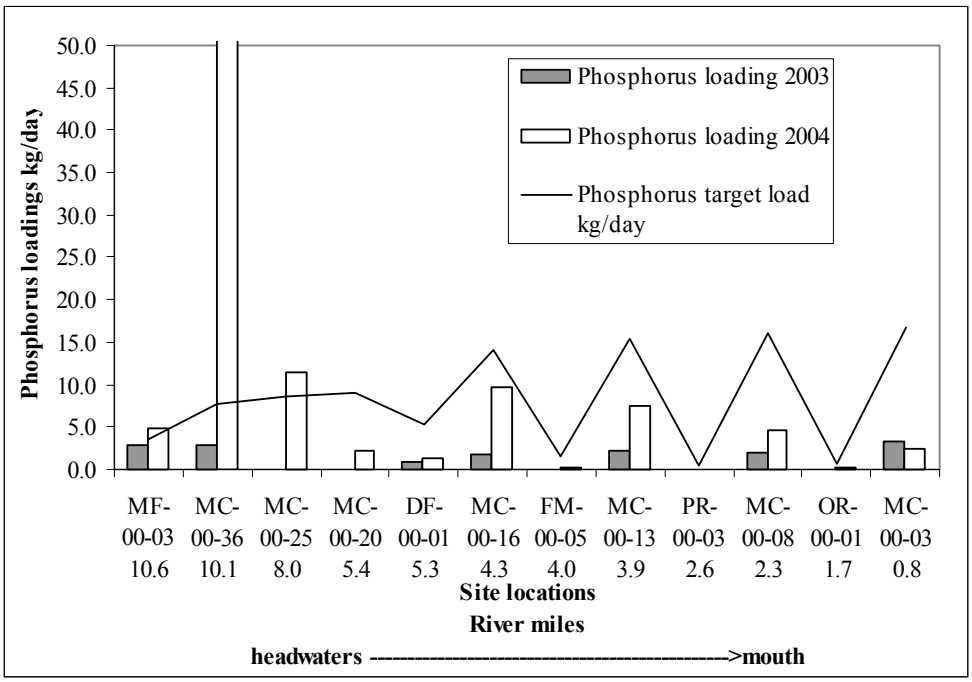
Strontium loadings in the Lower Meigs Creek Subwatershed



Phosphorus loadings are highest on the mainstem of Meigs Creek downstream of the confluence with Mans Fork (Figure 41). Phosphorus loading at MC-00-36 during the spring 2004 sampling event was 145 kg/day, off the scale of the graph in Figure 41. Loadings begin to decrease moving downstream towards the mouth of Meigs Creek along the mainstem.

Figure 41

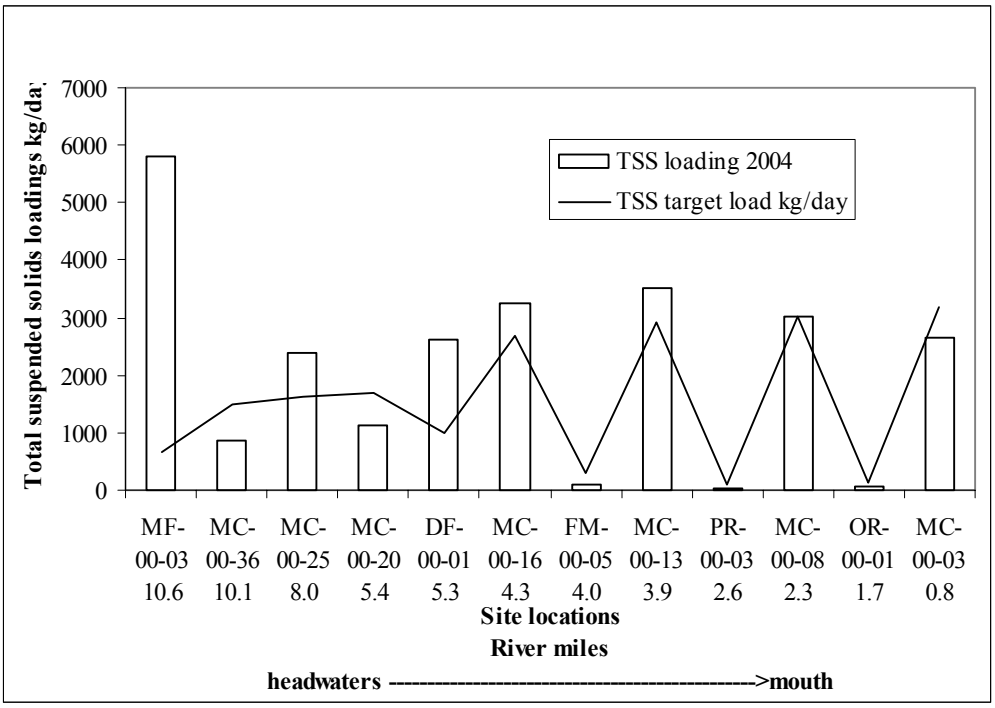
Phosphorus loadings in the Lower Meigs Creek Subwatershed



Total suspended solids loadings vary throughout the Lower Meigs Creek Subwatershed. The highest contribution is seen discharging from the mouth of the Mans Fork Subwatershed followed by the mouth of Dyes Fork (Figure 42).

Figure 42

Total suspended solid loadings in the Lower Meigs Creek Subwatershed



Fecal coliform samples were collected on August 2, 2004 at five sites within Lower Meigs Creek Subwatershed (Table 22) (Map 21). Two of the five sites scored higher than 1000 counts/100ml and one of those sites measured 2000 counts/100ml (Table 22). The Ohio EPA standard for primary contact water is not to exceed 1000 counts/100ml within a 30-day period with no less than five sampling events and not to exceed 2000 counts/100 ml at more than 10% of the sites sampled within that 30-day period. The sampling event that was conducted in Meigs Creek occurred on only one day and should be used as an initial screening to select sites for additional sampling. Determining whether fecal coliform is derived from failing septic systems or livestock, land use and populations was researched. Population is 502 (US census 2000), with approximately fifty-five houses in the Lower Meigs Creek Subwatershed within 500 feet of the creek. Assuming there are an average of 2.2 people per house, an average of 121 people living in

the area within 500 ft of the creek. According to local health department 90% of the septic systems are failing. Therefore, estimating 109 people contribute to failing systems at an average 70 gals/per person/day, equals 7,623 gals/per day (2,782,395 gals/per year). Land use shows 31 percent of the land in Lower Meigs Creek is pasture/ hay land and the visual evidence of cattle access to the creek indicates the fecal coliform bacteria that were measured are most likely from livestock (Figure 38). However, five additional fecal coliform sampling events need to be conducted during a 30-day period to apply the Ohio EPA standard.

Table 22

Fecal coliform levels within the Lower Meigs Creek Subwatershed

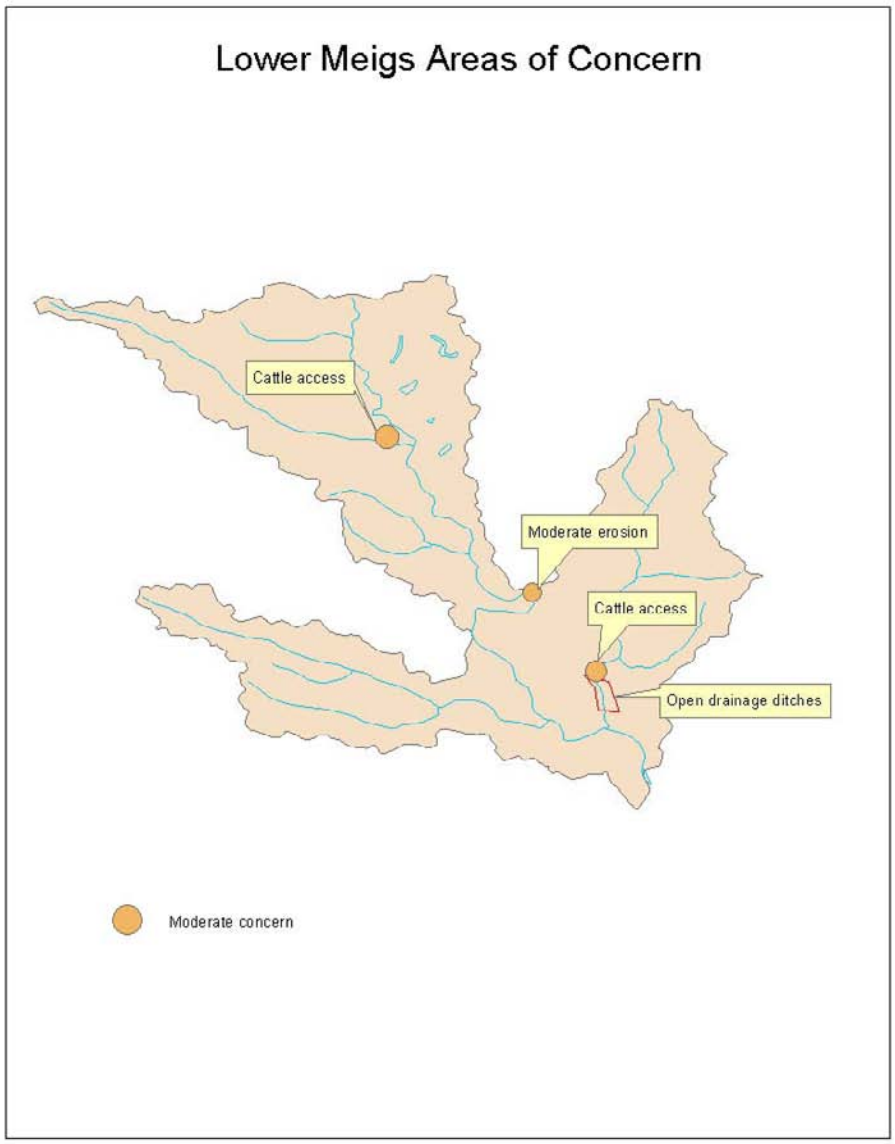
Sites	Fecal Coliform counts/100ml
HN-00-01	740
MC-00-25	2000
MC-00-20	1600
MC-00-08	840
MC-00-03	700

Area of concern

Visual survey of the Lower Meigs Creek area was conducted for evidence of cattle access to the streams, lack of riparian buffers, and erosion. Four areas were identified as moderate concern. Figure 38, shows the areas of concern in Lower Meigs Creek Subwatershed (Map 21).

Figure 43

Areas of concern within the Lower Meigs Creek Subwatershed



Biology

Fourmile Run, Perry Run, and Onion Run were all analyzed in 2002 using the MAIS indices to measure biological condition, and all sites were in 'good' biological condition. Fish were also analyzed at these sites and received IBI scores of 46, 44, and 52, respectively; all were meeting Warmwater Habitat (Map 21). Site MC-00-37 on the mainstem of Meigs Creek indicated 'very good' biological condition using the MAIS score (Table 10). The mouth of Mans Fork was sampled for fish in 2004 and received a score of 18. The mouth of Dyes Fork was analyzed by Ohio EPA in 1989 for macroinvertebrates and fish and received a score of 26 (ICI) and 38 (IBI), both scores did not meet Warmwater Habitat criteria. Also in 1989, the IBI score downstream of the confluence with Dyes Fork on the mainstem of Meigs Creek was 36, which is below the Warmwater Habitat target score of 44. However, macroinvertebrate data collected on the mainstem of Meigs Creek downstream of Dyes Fork met Warmwater Habitat with an ICI score of 42, in 1989.

Problem statement

Lower Meigs Creek Subwatershed shows the impact from Mans Fork and Dyes Fork. Mans Fork contributes elevated phosphorus and total suspended solids while Dyes Fork contributes elevated metals. Turbidity is elevated above the standard at almost every site in Lower Meigs Creek. Erosion and sedimentation are the leading cause of water quality impairment in Lower Meigs Creek. Although the biological condition is 'good', with the macroinvertebrates meeting Warmwater Habitat on the entire mainstem of the Lower Meigs Creek as well as the fish scores meeting WWH upstream of Dyes Fork. Some data is dated to 1989, and it would be beneficial to measure current conditions of macroinvertebrate and fish on the Lower Meigs Creek. Fecal coliform bacteria levels were marginal and may prove to be a concern in this area; however, additional testing is needed in order to apply the Ohio EPA standard. Sites to investigate further for fecal coliform levels include MC-00-20 and MC-00-25.

Action Plan

Goal 1: Improve water quality on the mainstem of Lower Meigs Creek as an approach to improve water quality downstream

Objective 1: Reduce turbidity in the Lower Meigs Creek to below 2.3 NTU at all sites.

Action 1: Work with local Soil and Water Conservation Districts and Farm Bureau to educate landowners along the mainstem of Meigs Creek near areas of concern about proper farming practices to reduce impact on the stream.

Action 2: Utilize and work with local Soil and Water Conservation District to educate landowners about Farm Bill 2002 incentive opportunities.

Objective 2: Determine if fecal coliform is a potential problem.

Action 1: Conduct five sampling events within 30 days at the following sites that scored between over 1000 counts/100 ml during the initial screening: MC-00-20 and MC-00-25.

Action 2: Work with local health department to educate landowners who live near elevated areas about the risks of bacteria in the stream.

Objective 3: Reduce 247 lbs/day of sediment load and 0.12 lbs/day of phosphorus load.

Action 1: Install 1,150 linear feet of fencing at 3 project areas to restrict livestock access to Lower Meigs Creek and reduce sediment load by 247 lbs/day and 0.12 lbs/day of phosphorus load at an approximate cost of $10,330.

Table 23

Implementation plan for the Lower Meigs Creek Subwatershed

Action Plan	Activity	Available resources	Funding source	Timeline (start – end)	Indicator
1.1.1	outreach and education	Volunteers, FLMR, Soil and Water Conservation, Farm Bureau		2005-2006	list of landowners contacted
1.1.2	outreach and education	Volunteers, FLMR, Soil and Water Conservation	Farm Bill 2002	2005-2006	list of landowners implementing BMP's using the Farm Bill
1.2.1	conduct water sampling	Volunteers and FLMR	Ohio EPA	2005-2006	database of two sites measured
1.2.2	outreach and education	Volunteers and FLMR		2005-2006	list of landowners contacted
1.3.1	install livestock fencing and water sources	SWCD – Farm Bill	Farm Bill 2002	2007-2009	Number of feet of fence installed

EVALUATION

Long-term monitoring in the Meigs Creek Subwatershed will be coordinated by the Friends of the Lower Muskingum River (FLMR). The FLMR will rely on volunteers from the watershed group to collect water samples along the mainstem of Meigs Creek. Ten sites have been identified along the mainstem Meigs Creek as long-term monitoring stations. However, these sites can be re-located as restoration and protection activities develop. Stations will be monitored for water quality prior to project construction and continued for four years after installation. All water quality samples will be analyzed by the Ohio EPA laboratory.

In addition to monitoring the water quality, evaluation of the goals and objectives described in the management plan will be performed by the FLMR. Implementation tables displayed in the previous section will be used to track progress towards meeting the goals and objectives. Progress will be measured by tracking the indicators listed in the implementation table.

PLAN UPDATE AND DISTRIBUTION

The Lower Muskingum River Management plan will be administered and updated by the Friends of the Lower Muskingum River (FLMR). Notice that the completed final draft of the management plan will be available on the Muskingum River web site www.muskingumriver.org will distributed to the technical advisory committee, leadership review board, community group partners, agency partners, industry partners, and educational partners of the Friends of the Lower Muskingum River. In addition, the Friends of the Lower Muskingum River will announce the completion of the management plan at the monthly public meetings to encourage new stakeholder involvement. The FLMR will use the web site and public announcements to inform, educate, and involve the public in on-going outreach.

CONTACTS

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President: Ron Cremeans
Vice President: Marilyn Ortt
Vista Volunteer/Coordinator: Amber Michel

ILGARD will keep all records and documents involved in plan for future reference.

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REFERENCES

Albaugh, Douglas W. 1966. A study of the distribution of the fishes of the Meigs Creek, Ohio, watershed. Athens, OH: Ohio University Honors Thesis.

Barbour, M.T., Jeroen Gerritsen, Blaine D. Snyder and James B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish (2nd edition). <http://www.epa.gov/OWOW/monitoring/techmon.html>

Brooks, A. 1990. Restoration and enhancement of engineered river channels: Some European experiences. Regulated Rivers: Research and Management, vol. 5, p.45-56.

DeShon, J.E. 1995. *In:* Davis, W.S. and T.P. Simon, (Eds.) Biological assessment and criteria. Tools for water resource planning and decision making. Lewis Publishers, Boca Raton, Fl., pgs. 217-244.

Eddy, S. and A. Hodson. 1982. Taxonomic keys to the common animals of the north central states. Burgess Publishing Company, Minneapolis, MN.

Gierlowski-Kordesch, 2004. Ohio University, Geological Sciences. Personal Communication.

Greenvest. 2002. American Electric Power Ohio. Macroinvertebrates Community Monitoring Field Study

Kaster, G., 2004. Ohio American Electric Power. Personal Communication

Leeds, R., Larry C. Brown, Nathan L. Watermeier. 1994. Nonpoint Source Pollution: Water Primer. Ohio State University Extension Fact Sheet: AEX-465-93. <http://ohioline.osu.edu/aex-fact/0465.html>

Lickens, G. E., Bonman, F. H., Johnson, N. M., Fisher, D. W., and Peirce, R. S., 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. Ecological Monographs, vol. 40(1), p. 23-47.

McCafferty, W.P. 1983. Aquatic Entomology: The Fishermen's and Ecologists' Illustrated Guide to Insects and Their Relatives. Jones and Bartlett Publishers Boston, MA.

Megahan, W. F., 1980. Nonpoint source pollution from forestry activities in the western United States: result of recent research and research needs. In: US Forestry and Water Quality: What course in the 80s?. Proceedings of the Water Pollution Control Federation Seminar, Richmond VA, 1980, p. 92-151.

Merritt, R.W. and K.W. Cummins. 1996. An Introduction to the Aquatic Insects of North America (3rd edition). Kendall/Hunt Publishing Co., Dubuque, IA.

Mishne, D., 2003. Ohio EPA – Division of Surface Water. Personal Communication

Office of Surface Mining. 2000. A report on the cumulative off-site impacts from a large area mine in southeast Ohio. Columbus, OH.

Ohio Department of Administration Services GIS Support Center. 2004a. Digital line graphs. <http://www.geodata.gis.state.oh.us/dlg/.>

Ohio Department of Administration Services GIS Support Center. 2004b. Digit Elevation Models. <http://das.ohio.gov/ITSD/ESS/Gis/DigitalElevationModels.htm>

Ohio Department of Natural Resources, Division of Geological Survey, 2000. Open file Report 98-2: Generalized Column of Bedrock Units in Ohio.

Ohio Department of Natural Resources, Division of Wildlife, 1963. Publication W-205.

Ohio Environmental Protection Agency, Division of Surface Water. 1990. State of Ohio Nonpoint Source Assessment. Group 24

Ohio Environmental Protection Agency, Division of Surface Water. 1999. Association Between Nutrients and the Aquatic Biotia of Ohio River and Streams. Ohio EPA Technical Bulletin MAS//1999-1-1. Appendix 2.

Ohio Environmental Protection Agency, Division of Surface Water. 2003. Ohio Nonpoint Source Assessment: Hydrologic Unit Water Quality Report for Meigs Creek.

Ohio Environmental Protection Agency, Division of Surface Water. 2004. Ohio River Basin Aquatic Life and Human Health Tier I Criteria and Tier II Values contained in and developed pursuant to Chapter 3745-1 of the Ohio Administrative Code (OAC).

Ohio Environmental Protection Agency, Division of Surface Water: 2004. Ohio 2004 Integrated Water Quality Monitoring and Assessment Report: Section 305 (b) Report.
<http://www.epa.state.oh.us/dsw/tmdl/2004IntReport/final_2004IR_main_text.pdf>

Ohio Environmental Protection Agency, Division of Surface Water. 2002. Total Maximum Daily Load for the Upper Raccoon Creek, Draft Report.

Peckarsky, B., P. Fraissinet, M. Penton and D. Conklin, Jr. 1990. Freshwater macroinvertebrates of northeastern North America. Cornell University Press.

Pennak, R. 1953. Freshwater invertebrates of the United States. The Ronald Press Company, New York.

Plafkin, J., M. Barbour, K. Porter, S. Gross and R. Hughes. 1989. Rapid Bioassessment Protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency.

Preston, M., 2004. Ohio Environmental Protection Agency, Division of Groundwater. Personal Communication

Rankin, E.T. 1995. "Habitat indices in water resource quality assessment" in Davis, W.S. and T.P. Simon (Eds), Biological Assessment and Criteria. Lewis Publishers Boca Raton, FL, pgs. 181-214.

Rosgen, D.L. 1998. Field Guide for Stream Classification. Wildland Hydrology. Pagosa Springs, CO, pg. 193.

Rothwll, R. L., 1983. Erosion and sediment control at road-stream crossings (Forestry). The Forestry Chronicle, vol. 59, p 14-19.

Smith, E.P. and J.R. Voshell. 1997. Studies of benthic macroinvertebrates and fish in streams within EPA Region 3 for development of biological indicators of ecological condition. Part 1, Benthic macroinvertebrates. Report to U.S. Environmental Protection Agency. Cooperative Agreement CF821462010. EPA, Washington D.C.

Suter, G.W. and G.W. Mabrey. 1994. Toxicological benchmarks for screening of potential contaminants of concern for effects on aquatic biota on Oak Ridge Reservation, Oak Ridge, Tennessee: 1994 Revision. Publication Number ES/ER/TM-96/R1. Oak Ridge National Laboratory, Oak Ridge, TN.

Trautman, Milton B. 1957. The Fishes of Ohio. Ohio State University Press, Columbus, OH., pg 683.

United States Census Bureau, 2000. ILGARD Census Data. http://ilgard.ohiou.edu/data/index.asp

United State Environmental Protection Agency. 1996a. Nonpoint Source Factsheet: Managing Nonpoint Source Pollution from Forestry. <http://www.epa.gov/owow/nps/facts/point7.htm>

United States Environmental Protection Agency. 1996c. Report to Congress: The National Water Quality Inventory Report to Congress. US-EPA Office of Water Program Operations, Washington D.C. <http://www.epa.gov/305b/96report/index.html. >

Voshell, Jr. J. Reese. 2002. A guide to common freshwater invertebrates of North America. The McDonald and Woodward Publishing, Blacksburg, VA.

Voshell, Jr. J. Reese, 2003. Personal Communication.

Winter, Mark. 2004. WebElements. <http://www.webelements.com/.>

Yoder, C.O. and E.T. Rankin. 1995. Pp. 109-144 in Davis, W.S. and T.P. Simon, (Eds.) Biological assessment and criteria. Tools for water resource planning and decision making. Lewis Publishers, Boca Raton, FL., pgs. 109-144.

GLOSSARY

Acidic-A condition where the concentration of positively charged hydrogen ions is high and the pH is less than 7.0.

Acid Mine Drainage (AMD)- A condition formed when water reacts with the coal bedrock of underground mines. Acid concentrations in streams can kill many life forms and stunt the growth of others. Acidic water can also break down the metallic compounds of iron, sulfur, manganese, and aluminum found in nearby rock or earthen waste piles. The precipitation of iron III is responsible for the characteristic orange coloring of the water also known as "yellow-boy." Acid mine drainage is usually associated with the following characteristics:

- Low pH (high acidity)
- High metals concentrations
- Elevated sulfate levels
- Excessive sediment and siltation

Alluvium-Material deposited by rivers, which forms floodplains and deltas.

Attaining-Meeting the applicable aquatic life use designation.

Bedrock- Any solid rock exposed at the earth's surface or overlain by unconsolidated material.

Best Management Practices (BMPs)-Management practices (such as nutrient management) or structural practices (such as terraces) designed to reduce the quantities of pollutants, such as sediment, nitrogen, phosphorous, and animal wastes washed by rain and snow melt from land into nearby receiving waters, such as lakes, creeks, streams, rivers, estuaries and ground water.

Biodiversity-The variety of flora and fauna in a particular niche or ecotome. Generally, greater variety indicates a healthier environment.

Biological Criteria (Biocriteria)-A direct measure of the attainment or non-attainment of aquatic life use designations for Ohio's streams. It is based on the numbers and types of aquatic organisms inhabiting a particular stream or river sampling site.

Colluvium-Eroded sediment that accumulates at the base of a slope.

Endangered Species-A federal designation for a species population that has declined to relatively low levels: a trend that, if persists, will result in extinction.

Fecal Coliform-Bacteria that are common in the intestines and feces of both warm- and cold-blooded animals and are an indicator of possible sewage contamination.

Flocculates-Metal precipitates which build up in streams as sediment.

Full Attainment-Designation given to specific stream and river miles in which the applicable aquatic life goals and standards ("uses") are being met.

Impairment-Any type of impact that degrades the health or water quality of the creek or waterbody.

Limited Resource Water (LRW)-The stream has been irretrievably damaged to the extent that no appreciable aquatic life can be supported.

Macroinvertebrate-An environmental indicator of stream health, macro-invertebrates are crustaceans, insects (without a backbone) and worms, which assemble in semi-permanent populations. Numerous taxa of macro-invertebrates exist that are either pollutant-tolerant or pollutant-sensitive; thus they are a good indicator of water quality.

National Pollutant Discharge Elimination System-Established by the Clean Water Act of 1972, the program imposes effluent limitations and monitoring requirements on point source dischargers, which may include municipal, private and industrial sources. The NPDES permits may contain compliance schedules to ensure construction of facilities needed to achieve the required effluent limitations.

Non-attaining-Not meeting applicable aquatic life use designation.

Nonpoint Source Pollution-Water pollution that results from a variety of human land use practices, such as agriculture, surface mines, forestry, home wastewater treatment systems, construction sites, and urban yards and roadways. As a result, nonpoint source pollution is controllable by implementing land management practices that protect water quality and economic, social and political interests. These practices are often referred to as best management practices.

Nutrient Runoff-Phosphorous and nitrate bind to soils and are thereby transported with eroding soils. Synthetic fertilizers or manures applied to undeveloped cropland can wash off into streams and rivers, particularly when applied just prior to a large rain event.

Overburden-Material of any nature, consolidated or unconsolidated, that lies on top of a deposit of useful materials, ores or coal, especially those deposits that are mined from the surface by open cuts.

Partial Attainment-A designation given to specific stream and river miles in which the applicable aquatic life goals and standards ("uses") are partially being met. Indicative of some impairment.

Pebble Count- Method used to determine dominant substrate type in creek bed.

PH-Scale measurement of hydrogen ion concentration (0-14) used to designate acidity or basicity (alkalinity) of solutions or soil. A pH of 7 is neutral; values decreasing from 7 indicate increasing acidity, and values increasing from 7 indicate increasing basicity. Each unit from 7 indicates a tenfold increase over the preceding unit.

Point Source Pollution-Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fixture, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged.

Publicly Owned Treatment Works-Public water suppliers or wastewater treatment facilities.

Sedimentation-Affects water temperature, reduces aesthetic value, and causes degradation of aquatic habitat. Sources include eroding river banks and areas of disturbed soil caused by various human activities and animals.

Siltation-The filling up of a water body with water-borne sediment.

Sinuosity-The degree to which a stream channel has a meandering or straight pattern.

Stream Flow-The volume of water in a stream or riverbed varies according to the amount of rain or snowfall; it is usually greatest in the spring and lowest in the fall. Release of water from impoundments may also influence stream flow. The volume of flow affects the water body's carrying capacity. Thus, at low flows a stream would be more impacted by discharge and runoff than at high flow.

Strata-Parallel layers of sedimentary rock.

Subsidence Holes-Surface of the land that sinks due to the settling of waste piles or other areas at mine sites.

Substrate-Particles and organic matter on the stream bottom. Substrate size ranges from the finest sediments such as silt, clay, and mud, to increasingly larger particles: sand, gravel, cobble, boulders and solid bedrock.

Substrate Embeddedness-The extent to which substrate particles are surrounded or covered by fine sediment. When substrate embeddedness is high, spawning habitat is lost and macroinvertebrate populations are threatened.

Subwatershed-The watersheds of tributaries, which empty into larger streams or rivers.

Surface Water-Water bodies that are visible at the surface of the earth (as opposed to underground aquifers).

Threatened Species-A designation for a species population that is declining due to direct or indirect human impacts.

Topography-Slope of the land expressed as percent slope. The amount of slope in an area affects the likelihood that a contaminant will run off from an area or be ponded and ultimately infiltrate into the subsurface. Topography also affects soil development and often can be used to help determine the direction and gradient of ground water flow under water table conditions.

Total Maximum Daily Loads (TMDL)-Consist of wasteload allocations and load allocations. Wasteload allocations determine the amount of pollutants that can be discharged from point sources without violating water quality standards. Load allocations consider nonpoint sources of pollution. Historically, TMDLs have focused on reducing loads of pollutants from point sources.

Turbidity-Describes how the particles suspended in the water affect its clarity. It is a measure of how these particles scatter light as it passes through the water. It is an important indicator of suspended sediment and its effects on rivers.

Water Column-The width and depth of the water in the stream.

Water Quality Standards-The rules set forth in Chapter 3745-1 of the Ohio Administrative Code establish stream use designations and water quality criteria (scientifically derived ambient concentrations developed by the state) that are protective of the surface waters of the state.

Water Resource-Includes the physical, chemical and biological features of water and its stream channel, riparian corridor and invirons.

Watershed-An area of land surrounding and 'shedding' water into a stream, a river, a lake, or wetland.

APPENDICES

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APPENDIX I.A

ODOT Biological and Water Quality Survey Data

ODOT Invertebrate survey data for Cat Creek				
Taxa	Common name	Specimens seen	Specimens taken	Total
Astacidae	crayfish	5	0	5
Gammaridae	scud	0	1	1
Aeshnidae	dragonfly	0	1	1
Corixidae	water boatman	29	6	35
Gerridae	water strider	29	15	44
Mesoveliidae	water treader	0	1	1
Sialidae	alderfly	8	6	14
Dytiscidae	diving beetle	6	6	12
Haliplidae	crawling water beetle	0	6	6
Chironomidae	midge	12	6	18
Dixidae	dixa midge	0	1	1
Simuliidae	black fly	1	0	1
Gastropoda	aquatic snail	14	20	34
Sphaeriidae	fingernail clam	0	3	3

ODOT Plant Community Data for Cat Creek

type	taxa	common name
Woody vegetation	*Salix nigra*	black willow
	Salix alba	white willow
	Ulmus rubra	slippery elm
	Morus rubra	red mulberry
	Morus alba	white mulberry
	Maclura pomifera	osage orange
	Menisperum canadensae	moonseed
	Sasafras albidium	sassafras
	Plantanus occidentalis	sycamore
	Amelanchier arborea	serviceberry
	Rubus occidentalis	black raspberry
	Rubus allegheniensus	blackberry
	Alianthus altissima	tree-of-heaven
	Rhus radicans	poison ivy
	Acer sachharinium	silver maple
	Acer negundo	box-elder
	Parthenocissus quinquefolia	virginia creeper
	Vitis aestivalis	summer grape
	Vitis riparia	grape
	Fraxinus pennsylvanica	red ash
	Lonicera japonica	japanese honeysuckle
	Sambucus canadensis	common elderberry
Aquatic vegetation	*Alisma subcordatum*	water plantain
	Leersia oryzoides	rice cutgrass
	Eleocharis obtusa	common spike-rush
	Scirpus atrovirens	dark green bulrush

Upland herbs

taxa	common name	taxa	common name
Equisetum arvense	common horseta	*Solidago*	goldenrod
Bromus commutatus	brome-grass	*Erigeron annus*	daisy fleabane
Fescuta pratensis	meadow fescue	*Ambrosia trifida*	giant ragweed
Poa pratensis	blue grass	*Ambrosia artemisiifolia*	common ragweed
Dactylis glomerata	orchard grass	*Xanthium strumarium*	cocklebur
Triodia flava	purpletop	*Rudbeckia laciniata*	tall coneflower
Lolium perenne	rye grass	*Helianthus*	sunflower
Phelum pratense	timothy	*Verbesina alternifolia*	wing-stem
Phalarus arundinacea	reed canary gras	*Bidens frondosa*	beggar's ticks
Sorghum halepense	johnson grass	*Achillia millefolium*	yarrow
Carex tribuloides	sedge	*Chrysanthemum leucanthemum*	oxeye daisy
Allium vineale	wild garlic	*Arctium minus*	burdock
Hemerocallis fulva	orange day-lily	*Cirsium arvense*	canada thistle
Boehmeria cylindrica	false nettle	*Chicorium intybus*	chicory
Rumex crispus	curly dock	*Taraxacum officinale*	dandelion
Polygonum virginianum	knotweed	*Lactuca canadensis*	wild lettuce
Polygonum pennsylvainca	smartweed	*Triodanis perfoliata*	venus' looking glass
Polygonum persicaria	lady's thumb	*Eupatorium maculatum*	joe-pye-weed
Polygonum scadens	false buckwheat	*Eupatorium perfoliatum*	common boneset
Chenopodium album	common goosef		
Stellaria media	chickweed		
Saponaria officinalis	bouncing-bet		
Thalictrum polygamum	tall meadow-rue		
Lepidium virginicum	peppergrass		
Barbarea vulgaris	yellow rocket		
Trifolium repens	white clover		
Trifolium hybridium	alsike clover		
Trifolium agrarium	hop-clover		
Trifolium procumbens	low hop-clover		
Melilotus officinalis	yellow sweet clover		
Vicia	vetch		
Amphicarpaea bracteata	hog peanut		
Oxalis stricta	sourgrass		
Impatiens pallida	pale jewelweed		
Oenothera biennis	common evening-primrose		
Pastinaca Sativa	wild parsnip		
Daucus carota	wild carrot		
Lysimachia nummularia	moneywort		
Apocynum cannabinum	dogbane		
Asclepias syriaca	common milkweed		
Cynachum laeve	sandvine		
Ipomoea	morning-glory		
Convolvus sepium	bindweed		
Glechoma hederacea	ground ivy		
Lycopus sheradii	water horehound		
Solanum dulcamara	bittersweet nightshade		
Plantago rugelii	plantain		
Plantago lanceolata	english plantain		
Galium aparine	cleavers		
Dipsacus sylvestris	teasel		

ODOT Fish survey data for Cat Creek

Common name	Specimens seen	Specimens taken	Total
white sucker	61	0	61
quailback carp sucker	37	0	37
redhorse sucker	7	0	7
common carp	1	0	1
creek chub	30	0	30
emerald shiner	9	0	9
striped shiner	20	0	20
spotfin shiner	18	0	18
silverjaw minnow	1	0	1
bluntnose minnow	15	0	15
central stoneroller	20	0	20
brook silverside	14	0	14
spotted bass	1	0	1
bluegill sunfish	6	0	6
johnny darter	3	0	3

ODOT Water Quality sampling data for Cat Creek

pollutant	concentration (mg/l)
dissolved oxygen	8.1
ammonia	0.28
nitrate	0
nitrite	trace
phosphate	0.06
chloride	35
alkalinity	168
iron	0.07
sulfate	72
total hardness	268
water temperature	35 C
pH	7.7
turbidity	8.2 NTU

ODOT Invertebrate survey data for Mans Fork, Meigs Creek

Taxa	Common name	Specimens seen
Gastropoda	pouch snail	2
Decapoda	crayfish	2
Veliidae	water strider	1
Sialidae	alderfly larva	1
Diptera	midge larva	1

ODOT Fish survey data for Mans Fork, Meigs Creek

common name	Specimens seen	Specimens taken	Total
creek chub	10	2	12
striped shiner	86	2	88
silverjaw minnow	18	1	19
bluntnose minnow	14	1	15
golden redhorse	18	2	20
hog sucker	7	3	10
white sucker	2	2	4
channel catfish	1	0	1
rockbass	4	1	5
smallmouth bass	4	1	5
green sunfish	9	2	11
johnny darter	2	2	4

ODOT Water Quality sampling data for Mans Fork

pollutant	concentration (mg/l)
dissolved oxygen	6.5
ammonia	0.63
nitrate	0.02
nitrite	0.02
phosphate	0.38
chloride	88
alkalinity	137
iron	0.15
sulfate	196
total hardness	382
water temperature	18 C
pH	7.62
turbidity	7.5 NTU

ODOT Plant Community Data for Mans Fork

type	taxa	common name
Woody vegetation	*Salix nigra*	black willow
	Salix interior	sandbar willow
	Populus deltiodes	cottonwood
	Juglans nigra	black walnut
	Corylus americana	hazelnut
	Ostyra virginiana	hop-hornbeam
	Quercus alba	white oak
	Quercus velutina	black oak
	Ulmus rubra	slippery elm
	Sassafras albidium	sassafras
	Lindera benzoin	spicebush
	Hydrangea arborescens	wild hydrangea
	Plantanus occidentalus	sycamore
	Rubus occidentalis	black raspberry
	Rubus flagellaris	dewberry
	Rosa multiflora	multiflora rose
	Prunus serotina	black cherry
	Prunus virginiana	choke-cherry
	Gleditsia triacanthos	honey-locust
	Robinia pseudoacacia	black locust
	Rhus radicans	poison ivy
	Acer nigrum	black maple
	Acer rubrium	red maple
	Acer saccarinium	silver maple
	Acer negundo	box-elder
	Aesculus octandra	buckeye
	Parthenocissus quinquefolia	virginia creeper
	Vitis aestivalis	summer grape
	Fraxinus americana	white ash
	Fraxinus pennsylvanica	red ash
	Tsuga canadensis	hemlock
Aquatic vegetation	*Potamogeton crispus*	leafy pondweed
	Alisma subcordatum	water plantain
	Leersia oryzoides	rice cutgrass
	Scirpus validus	great bulrush
	Scirpus atrovirens	dark green bulrush
	Carex frankii	sedge
Upland herbs	*Equisetum arvense*	common horsetail
	Adiantum pedatum	maidenhair fern
	Polystichum acrostichoide	christmas fern
	Asplenium trichomanes	spleenwort
	Asplenium platyneuron	ebony spleenwort
	Bromus inermis	brome-grass
	Fescuta pratensis	meadow fescue
	Glyceria striata	fowl manna-grass
	Poa compressa	blue grass
	Dactylis glomerata	orchard grass

Upland herbs

taxa	common name	taxa	common name
Lolium perenna	rye grass	*Dipsachus sylvestrius*	teasel
Elymus virginicus	wild rye	*Veronia gigantia*	tall ironweed
Phelum pratense	timothy	*Eupatorium fistulosum*	joe-pye-weed
Panicum dichotomiflorum	panic-grass	*Eupatorium perfoliatum*	common boneset
Carex tribuloides	sedge	*Solidago*	goldenrod
Allium vineale	wild garlic	*Aster*	aster
Smilacina racemosa	false solomon's-sea	*Erigeron strigosus*	daisy fleabane
Pilea pumila	clearweed	*Ambrosia artemisifolia*	common ragweed
Rumex crispus	curly dock	*Xanthium strumarium*	cocklebur
Polygonum hydropiperoide	smartweed	*Silphium perfoliatum*	cup-plant
Polygonum persicaria	lady's-thumb	*Rudbeckia lanciniata*	tall coneflower
Polygonum scadens	false buckwheat	*Helianthus*	sunflower
Stelaria media	chickweed	*Verbesina alternifolia*	wing-stem
Thalictrum polygamum	tall meadow-rue	*Bidens*	bur-marigold
Anemone virginiana	thimble-flower	*Achillea millefolium*	yarrow
Thalspi arvense	pennycress	*Chrysanthemum*	
Lepidium virginicum	peppergrass	*leucanthemum*	oxeye daisy
Capsella bursa-pastoris	shepherd's-purse	*Tussilago farfara*	colt's foot
Barbarea vulgaris	yellow rocket	*Senecio aureus*	golden ragwort
Heuchera americana	alumroot	*Cirsium vulgare*	bull thistle
Aruncus dioicus	goat's beard	*Cirsium arvense*	canada thistle
Potentilla simplex	common cinquefoil	*Chicorium intybus*	chicory
Geum canadense	white avens	*Taraxacum officinale*	dandelion
Agrimonia parviflora	common agrimony	*Sonchus asper*	spiny sow-thistle
Trifolium pratense	red clover	*Latuca*	wild lettuce
Trifolium repens	white clover	*Seriocarpus asteroides*	white-topped aster
Trifolium agrarium	hop-clover	*Plantago lancerolata*	english plantain'
Melilotus officinalus	yellow sweet clover	*Galium mollugo*	cleavers
Melilotus alba	white sweet clover		
Lotus corniculatus	bird's-foot trefoil		
Desmodium	tick-trefoil		
Lathyrus latifolius	everlasting pea		
Amphicarpaea bracteata	hog-peanut		
Oxalis stricta	sourgrass		
Impatiens capensis	spotted jewelweed		
Oenothera biennis	common evening primrose		
Cryptotaenia canadensis	honewort		
Thaspium barbinode	meadow parsnip		
Dactus carota	wild carrot		
Lysimachia nummularia	moneywort		
Lysimachia ciliata	loosestrife		
Lysimachia quadrifolia	wharled loosestrife		
Apocynum			
androsaemifolium	dogbane		
Asclepius syriaca	common milkweed		
Convolvus sepium	bindweed		
Glechoma hederacea	ground ivy		
Satureja vulgaris	basil-mint		
Mentha spicata	spearmint		
Plantago rugelii	plantain		

ODOT Invertebrate survey data for Olive Green Creek

Taxa	Common name	Specimens seen
Gastropoda	pouch snail	1
Pelecypoda	fingernail clam	1
Caenidae	mayfly nymph	1
Odonata	damselfly naiad	1
Corrixidae	water boatman	1
Gerridae	water strider	1
Sialidae	alderfly larvae	1
Haliplidae	crawling water beetle	2
Hydrophilidae	water scavenger	2
Gyrinidae	whirlgig beetle	2
Chironomidae	midge larvae	1
Culicidae	mosquito larvae	1

ODOT Fish survey data for Olive Green Creek

Common name	Specimens seen
spotfin	1
carp sucker	1
spotted bass	1
bluegill sunfish	1
pumpkinseed sunfish	1

ODOT Water Quality Data for Olive Green Creek

pollutant	concentration (mg/l)
dissolved oxygen	11.7
ammonia	0.41
nitrate	2.6
nitrite	0.01
phosphate	0.32
chloride	46
alkalinity	108
iron	0.18
sulfate	112
total hardness	248
water temperature	29 C
pH	8.7
turbidity	16 NTU

ODOT Plant Community Data for Olive Green Creek

type	taxa	common name
Woody vegetation	*Salix nigra*	black willow
	Populs delitoides	cottonwood
	Jugulans nigra	black walnut
	Ulmus rubra	slippery elm
	Celtis occidentalis	hackberry
	Morus rubra	red mulberry
	Lindera benzoin	spicebush
	Plantanus occidentalis	sycamore
	Rubus occidentalis	black raspbery
	Rubus alllegheniensis	blackberry
	Rosa multiflora	multiflora rose
	Gleditsia triacanthos	honey-locust
	Rhus typhina	staghorn sumac
	Rhus radicans	poison ivy
	Acer saccharinium	silver maple
	Acer negundo	box-elder
	Aesculus glabra	buckeye
	Parthenocissus quinquefolia	virginia creeper
	Vitis aestivalis	summer grape
	Vitis riparia	grape
	Fraxinus pennsylvanica	red ash
	Lonicera japonica	japanese honeysuckle
	Sambucus canadensis	common elderberry
Aquatic vegetation	*Leersia oryzoides*	rice cutgrass
	Eleocharis obtusa	common spike-rush
	Justicia americana	water-willow
Upland herbs	*Equisetum arvense*	common horsetail
	Bromus inermis	brome-grass
	Festuca pratensis	meadow fescue
	Poa compressa	bluegrass
	Dactylis glomerata	orchard grass
	Elymus virginicus	wild rye
	Phelum pratense	timothy
	Phalaris arudinacea	reed canary grass
	Leersia virginica	white grass
	Sorghum halepense	johnson grass
	Allium vineale	wild garlic
	Allium canadense	wild onion
	Smilax herbacea	carrion-flower
	Dioscorea	wild yam
	Urtica dioica	stinging nettle
	Pilea pumila	clearweed
	Rumex crispus	curly dock
	Rumex obtusifolius	broad-leaved dock
	Polygonum aviculare	knotweed
	Polygonum persicaria	lady's thumb
	Polygonum scadens	false buckwheat

Upland herbs	*Chenopodium album*	common goosefoot
	Chenopodium ambrosiodes	mexican tea
	Phytolacca americana	pokeweed
	Thalictrum polygamum	tall meadow-rue
	Lepidium virginicum	peppergrass
	Brassica niger	mustard
	Sisymbrium officinale	hedge-mustard
	Rorippa	yellow cress
	Trifolium pratense	red clover
	Trifolium agrarium	hop-clover
	Lotus corniculatus	bird's foot
	Amphicarpaea bracteata	hog-peanut
	Oxalis stricta	sourgrass
	Impatiens capensis	spotted jewelweed
	Impatiens pallida	pale jewelweed
	Viola	violet
	Osmorhiza	sweet cicely
	Cryptotaenia canadensis	honewort
	Pastinaca sativa	wild parsnip
	Daucus carota	wild carrot
	Lysimachia nummularia	moneywort
	Apocynum androsaemifolium	dogbane
	Asclepias syriaca	common milkweed
	Convolvus sepium	bindweed
	Cuscuta gronovii	dodder
	Glechoma hederacea	ground-ivy
	Solanum carolinense	horse-nettle
	Verbascum thapsus	mullein
	Mimulus	monkey-flower
	Plantago rugelii	plantain
	Plantago lanceolata	english plantain
	Galium aparine	cleavers
	Dipsacus sylvestris	teasel
	Solidago	goldenrod
	Aster	aster
	Erigeron philadelphicus	daisy fleabane
	Ambrosia artemisiflora	common ragweed
	Xanthium strumarium	cocklebur
	Silphium perfoliatum	cup-plant
	Rudbeckia laciniata	tall coneflower
	Helianthus	sunflower
	Verbensia alternifolia	wing-stem
	Bidens	bur-marigold
	Chrysanthemum leucanthemum	oxeye daisy
	Arctium minus	burdock
	Cirsium arvense	canada thistle
	Chicorium intybus	chicory
	Taraxacum officinale	dandelion
	Lactuca	wild lettuce

APPENDIX I.B

Summary of IBI, ICI, and QHEI Scores for Lower Muskingum River and Tributary Streams

Basin	Stream	River	River Mile	Date	Type	Source	Drainage Area	IWB2	IBI
17	001	Muskingum River	2.70	07/19/1988	A	01	8045.0	7.646	34
17	001	Muskingum River	2.70	07/19/1988	N	01	8045.0	8.467	34
17	001	Muskingum River	2.70	08/24/1988	A	01	8045.0	8.010	34
17	001	Muskingum River	2.70	08/24/1988	N	01	8045.0	9.477	40
17	001	Muskingum River	2.70	09/26/1988	A	01	8045.0	8.748	30
17	001	Muskingum River	2.70	09/26/1988	N	01	8045.0	9.977	40
17	001	Muskingum River	5.60	07/20/1988	A	01	8036.0	6.939	24
17	001	Muskingum River	5.70	07/20/1988	A	01	8036.0	8.056	24
17	001	Muskingum River	5.70	08/25/1988	A	01	8036.0	8.162	34
17	001	Muskingum River	5.70	09/27/1988	A	01	8036.0	9.587	42
17	001	Muskingum River	9.30	07/15/1988	A	01	8009.0	5.922	28
17	001	Muskingum River	9.40	07/15/1988	A	01	8009.0	7.463	34
17	001	Muskingum River	9.40	08/23/1988	A	01	8009.0	8.476	30
17	001	Muskingum River	9.40	08/23/1988	N	01	8009.0	9.663	42
17	001	Muskingum River	9.40	09/28/1988	A	01	8009.0	8.854	38
17	001	Muskingum River	14.00	07/14/1988	A	01	7983.0	8.161	32
17	001	Muskingum River	14.00	08/24/1988	A	01	7983.0	9.422	38
17	001	Muskingum River	14.00	10/17/1988	A	01	7983.0	10.435	44
17	001	Muskingum River	18.50	07/14/1988	A	01	7958.0	6.967	28
17	001	Muskingum River	18.50	08/23/1988	A	01	7958.0	8.397	32
17	001	Muskingum River	18.50	10/11/1988	A	01	7958.0	8.963	32
17	001	Muskingum River	24.80	07/14/1988	A	01	7713.0	5.803	18
17	001	Muskingum River	24.80	08/23/1988	A	01	7713.0	8.093	34
17	001	Muskingum River	24.80	10/11/1988	A	01	7713.0	9.873	38
17	001	Muskingum River	26.10	09/18/1986	B	01	7711.0	8.628	38
17	001	Muskingum River	26.10	07/13/1988	A	01	7711.0	4.697	12
17	001	Muskingum River	26.10	08/22/1988	A	01	7711.0	6.772	22
17	001	Muskingum River	26.10	09/28/1988	A	01	7711.0	8.533	30
17	001	Muskingum River	28.00	10/07/1991	A	01	7626.0	8.221	34
17	001	Muskingum River	28.10	07/13/1988	A	01	7626.0	2.086	12
17	001	Muskingum River	28.10	08/22/1988	A	01	7626.0	6.037	22
17	001	Muskingum River	28.10	08/22/1988	N	01	7626.0	7.936	34
17	001	Muskingum River	28.10	09/28/1988	A	01	7626.0	6.891	34
17	001	Muskingum River	28.10	10/07/1991	A	01	7626.0	9.068	40
17	001	Muskingum River	29.00	07/13/1988	A	01	7622.0	5.834	22
17	001	Muskingum River	30.30	07/13/1988	A	01	7479.0	6.070	30
17	001	Muskingum River	30.30	08/22/1988	A	01	7479.0	8.554	32
17	001	Muskingum River	30.30	08/22/1988	N	01	7479.0	9.557	42
17	001	Muskingum River	30.30	09/28/1988	A	01	7479.0	9.238	46
17	001	Muskingum River	30.30	10/07/1991	A	01	7479.0	8.552	42
17	001	Muskingum River	33.60	07/13/1988	A	01	7470.0	7.519	30
17	001	Muskingum River	33.60	08/22/1988	A	01	7470.0	8.686	40
17	001	Muskingum River	33.60	09/28/1988	A	01	7470.0	9.236	42
17	001	Muskingum River	36.80	07/12/1988	A	01	7464.0	5.512	30
17	001	Muskingum River	36.80	08/12/1988	A	01	7464.0	8.591	34
17	001	Muskingum River	36.80	09/23/1988	A	01	7464.0	8.254	40
17	001	Muskingum River	39.50	07/12/1988	A	01	7457.0	8.144	34

Basin	Stream	River	River Mile	Date	Type	Source	Drainage Area	IWB2	IBI
17	001	Muskingum River	39.50	08/12/1988	A	01	7457.0	9.045	38
17	001	Muskingum River	39.50	09/23/1988	A	01	7457.0	9.239	38
17	001	Muskingum River	43.70	07/12/1988	A	01	7440.0	6.362	32
17	001	Muskingum River	43.70	08/11/1988	A	01	7440.0	7.298	30
17	001	Muskingum River	43.70	09/23/1988	A	01	7440.0	7.899	42
17	001	Muskingum River	48.80	07/12/1988	A	01	7422.0	7.831	38
17	001	Muskingum River	48.80	08/26/1988	A	01	7422.0	9.420	42
17	001	Muskingum River	48.80	10/07/1988	A	01	7422.0	10.178	48
17	001	Muskingum River	49.40	09/18/1986	B	01	7421.0	7.949	34
17	001	Muskingum River	49.40	08/11/1988	A	01	7421.0	7.526	30
17	001	Muskingum River	49.40	09/29/1988	A	01	7421.0	7.929	32
17	001	Muskingum River	50.90	09/03/1986	B	01	7416.0	7.235	38
17	001	Muskingum River	51.50	09/03/1986	B	01	7415.0	6.476	24
17	001	Muskingum River	51.60	08/11/1988	A	01	7415.0	7.095	28
17	001	Muskingum River	51.60	09/29/1988	A	01	7415.0	7.113	32
17	001	Muskingum River	52.50	08/11/1988	A	01	7406.0	6.865	30
17	001	Muskingum River	52.50	09/29/1988	A	01	7406.0	8.647	44
17	001	Muskingum River	52.80	09/03/1986	B	01	7406.0	5.810	20
17	001	Muskingum River	56.40	08/11/1988	A	01	7386.0	8.627	34
17	001	Muskingum River	56.40	10/07/1988	A	01	7386.0	9.998	42
17	001	Muskingum River	63.00	08/09/1988	A	01	7357.0	7.678	24
17	001	Muskingum River	63.00	08/09/1988	N	01	7357.0	9.587	40
17	001	Muskingum River	63.00	09/23/1988	A	01	7357.0	8.573	44
17	070	Olive Green Creek	2.70	08/01/1984	D	01	79.0	9.823	50
17	070	Olive Green Creek	2.70	09/26/1984	D	01	79.0	9.881	48
17	070	Olive Green Creek	2.70	10/11/1984	D	01	79.0	8.565	44
17	070	Olive Green Creek	2.70	07/29/1999	D	01	79.0	9.833	54
17	070	Olive Green Creek	18.10	07/28/1999	E	01	7.9	7.529	40
17	070	Olive Green Creek	19.50	07/28/1999	E	01	5.3	8.778	42
17	070	Olive Green Creek	21.80	07/29/1999	E	01	2.1	7.881	46
17	095	Blue Rock Creek	0.30	07/24/2002	E	05	10.1	5.080	40
17	920	Meigs Creek	0.90	10/10/1989	A	01	142.0	6.751	32
17	920	Meigs Creek	4.40	09/22/1988	D	01	118.0	6.982	42
17	920	Meigs Creek	5.20	10/23/1989	A	01	118.0	7.357	36
17	920	Meigs Creek	5.40	09/22/1988	E	01	73.0	8.344	44
17	920	Meigs Creek	7.60	10/23/1989	A	01	70.0	8.458	46
17	926	Dyes Fork	0.30	10/11/1989	E	01	45.0	6.132	38
17	926	Dyes Fork	0.90	09/22/1988	E	01	45.0	3.210	18
17	926	Dyes Fork	5.80	10/11/1989	D	01	38.0	7.052	44

Basin	Stream	River	River Mile	Year	Drainage Area	Total Taxa	Quality EPT	ICI
17	001	Muskingum River	5.60	1988	8036.0	28	3	18
17	001	Muskingum River	5.70	1988	8036.0	37	6	20
17	001	Muskingum River	18.20	1988	7960.0	32	2	14
17	001	Muskingum River	24.80	1988	7713.0	37	9	28
17	001	Muskingum River	25.60	1988	7712.0	29	1	16
17	001	Muskingum River	28.30	1988	7625.0	33	5	22
17	001	Muskingum River	31.50	1988	7477.0	37	4	22
17	001	Muskingum River	33.50	1988	7470.0	41	10	32
17	001	Muskingum River	34.30	1988	7468.0	24	2	12
17	001	Muskingum River	39.30	1988	7457.0	44	5	28
17	001	Muskingum River	43.50	1988	7440.0	39	3	22
17	001	Muskingum River	48.70	1985	7422.0	44	11	34
17	001	Muskingum River	48.90	1988	7422.0	35	9	30
17	001	Muskingum River	48.90	1990	7422.0	40	13	50
17	001	Muskingum River	49.10	1988	7422.0	29	2	10
17	001	Muskingum River	51.60	1988	7415.0	25	0	10
17	001	Muskingum River	52.30	1988	7406.0	21	1	6
17	001	Muskingum River	56.40	1988	7386.0	46	5	20
17	001	Muskingum River	62.80	1988	7357.0	34	2	26
17	070	Olive Green Creek	2.20	1984	80.0	57	12	32
17	070	Olive Green Creek	2.20	1989	80.0	66	14	28
17	070	Olive Green Creek	2.80	1999	79.0	58	12	36
17	920	Meigs Creek	2.30	1989	134.0	59	11	38
17	920	Meigs Creek	5.20	1989	118.0	60	8	42
17	920	Meigs Creek	5.40	1989	73.0	48	10	40
17	926	Dyes Fork	0.30	1989	45.0	50	5	26
17	926	Dyes Fork	2.90	1989	43.0	56	10	38

Basin	Stream	River	River Mile	Year	Drainage Area	QHEI
17	001	Muskingum River	2.70	1988	8045.0	65.5
17	001	Muskingum River	5.70	1988	8036.0	63.0
17	001	Muskingum River	9.40	1988	8009.0	69.0
17	001	Muskingum River	14.00	1988	7983.0	82.5
17	001	Muskingum River	18.50	1988	7958.0	58.0
17	001	Muskingum River	24.80	1988	7713.0	74.0
17	001	Muskingum River	26.10	1988	7711.0	63.5
17	001	Muskingum River	28.10	1988	7626.0	48.5
17	001	Muskingum River	30.30	1988	7479.0	55.0
17	001	Muskingum River	33.60	1988	7470.0	79.5
17	001	Muskingum River	36.80	1988	7464.0	61.0
17	001	Muskingum River	39.50	1988	7457.0	72.0
17	001	Muskingum River	43.70	1988	7440.0	52.5
17	001	Muskingum River	48.80	1988	7422.0	82.5
17	001	Muskingum River	49.40	1988	7421.0	65.0
17	001	Muskingum River	51.60	1988	7415.0	47.5
17	001	Muskingum River	52.50	1988	7406.0	53.5
17	001	Muskingum River	56.40	1988	7386.0	76.5
17	001	Muskingum River	63.00	1988	7357.0	60.5
17	070	Olive Green Creek	2.70	1984	79.0	84.5
17	070	Olive Green Creek	2.70	1999	79.0	73.0
17	070	Olive Green Creek	2.70	1999	79.0	68.0
17	070	Olive Green Creek	18.10	1999	7.9	69.0
17	070	Olive Green Creek	19.50	1999	5.3	63.0
17	070	Olive Green Creek	21.80	1999	2.1	68.5
17	095	Bluerock Creek	0.30	2002	10.1	52.0
17	920	Meigs Creek	0.90	1989	142.0	80.0
17	926	Dyes Fork	0.30	1989	45.0	72.5
17	926	Dyes Fork	5.80	1989	38.0	81.0

APPENDIX I.C

Summary of USGS and ORSANCO Water Quality Sampling Databases, Lower Muskingum River

Sample Number	Site Name	Collection Agency	Lattitude	Longitude	Sample Date/Time	Water Temp (C)	Barometric Pressure (mm of Hg)	Discharge Inst. Cubic Feet per Second	Gage Height (ft.)	Turbidity (NTU)	Sample Number
1	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	1/21/88 9:15	1.9	734	9820	4.76	83	1
2	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	2/18/88 9:45	2.5	740	10800	5.01	22	2
3	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	4/25/88 9:30	12.5	740	3910	2.95	4.3	3
4	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	6/2/88 9:15	24	734	1940	2.07	6.9	4
5	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	6/2/88 9:16	23.9					5
6	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	6/2/88 9:17	23.9					6
7	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	6/2/88 9:18	23.9					7
8	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	6/2/88 9:19	23.9					8
9	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	6/2/88 9:20	23.9					9
10	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	8/24/88 11:15	26	733	1410	1.74	5.5	10
11	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/28/88 12:15	7	731	5800	3.6	13	11
12	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	12/29/88 11:30	3.1	740	12100	5.36	40	12
13	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	3/7/89 9:45	3.5	744	15100	6.06	25	13
14	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	5/31/89 10:15	19.5	735	26400	8.45	27	14
15	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	6/27/89 10:30	24	736	23400	7.87	42	15
16	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	8/21/89 12:00	25	735	2000	2.1	6	16
17	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	10/18/89 12:30	14	743	1960	2.08	14	17
18	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	1/29/90 10:15	4	737	8820	4.51	13	18
19	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	3/22/90 11:00	12	738	5960	3.65	5.8	19
20	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	5/16/90 11:40	16.5	733	11600	5.24	15	20
21	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	7/11/90 11:30	24.5	738	5990	3.66	16	21
22	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	9/7/90 9:45	25	734	3160	2.65	6.1	22
23	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/26/90 10:20	4	745	8400	4.39	10	23
24	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	1/8/91 10:00	0	752	29000	8.93	39	24
25	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	3/20/91 11:00	9	752	11200	5.15	16	25
26	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	5/13/91 12:00	22.5	749	4740	3.25	4	26
27	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	7/30/91 11:35	26	749	898	1.35	41	27
28	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	8/28/91 10:30	27	756	816	1.28	1.3	28
29	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:00	5.5			1.53		29
30	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:01	5.5			1.53		30
31	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:02	5.7			1.53		31
32	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:03	5.5			1.53		32
33	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:04	5.5			1.53		33
34	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:05	5.4			1.53		34
35	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:06	5.5			1.53		35
36	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:07	5.3			1.53		36
37	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:08	5.3			1.53		37
38	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:09	5.5			1.53		38
39	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:10	5.3			1.53		39
40	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:11	5.3			1.53		40

Sample Number	Site Name	Collection Agency	Lattitude	Longitude	Sample Date/Time	Temperature Water (deg C)	Barometric Pressure (mm of Hg)	Discharge Inst. Cubic Feet per Second	Gage Height (ft.)	Turbidity (NTU)	Sample Number
41	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:12	5.4			1.53		41
42	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:13	5.2			1.53		42
43	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 10:14	5.3			1.53		43
44	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 11:15	5.3			1.53		44
45	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 11:16	5.2			1.53		45
46	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 11:17	5.2			1.53		46
47	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 11:18	5.3			1.53		47
48	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 11:19	5.3			1.53		48
49	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 11:20	5.2			1.53		49
50	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/91 11:21	5.4			1.53		50
51	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/1991 11:22	5.3			1.53		51
52	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/1991 11:23	5.3			1.53		52
53	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	11/14/1991 11:45	5.3	752	1750	1.96	2.5	53
54	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	1/9/1992 11:15	5.5	745	1650	1.9	4.9	54
55	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	5/28/1992 11:10	19.7	755	2710	2.46	6.5	55
56	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	7/6/1992 11:45	26.2	749	2160	2.19	2.9	56
57	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	9/1/1992 10:30	20	756	8860	4.52	14	57
58	MCCONNELSVILLE OH	USGS	39°38'42"	81°51'00"	10/29/1994 0:00						58
59	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	9/30/1985 16:30	17.5		2.6			59
60	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	6/23/1986 13:30	26.5		19			60
61	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	10/21/1986 11:15	9		7.4			61
62	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	7/22/1987 9:00	25.5		9.1			62
63	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	10/27/1987 16:45	9.5		1.9			63
64	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	6/6/1988 15:30	21.5		18			64
65	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	10/5/1988 9:45	12		0.99			65
66	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	8/14/1989 14:30	22		25			66
67	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	10/16/1989 11:15	16		34			67
68	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	9/5/1990 13:20	22.5					68
69	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	6/11/1991 9:30	21.5		4.3			69
70	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	8/26/1991 16:30	25.5		3.5			70
71	MEIGS C NR BEVERLY OH	USGS	39°36'00"	81°42'42"	10/23/1991 14:00	13.5		2.2			71
72	WA-3 NR. BEVERLY	USGS	39°32'41"	81°35'35"	6/12/1997 10:32	13					72
73	BALD EAGLE RN NR STOCKPORT OH	USGS	39°33'33"	81°47'54"	10/31/1991 17:25	13.5		0.06			73
74	DYES F NR UNIONVILLE OH	USGS	39°37'54"	81°43'17"	10/31/1991 16:25	14.5		1.3			74
75	MEIGS C (31-2) NR MEIGS OH	USGS	39°41'30"	81°45'07"	10/31/1991 15:00	15		0.01			75
76	MU 56 J SWARTZ AT GAYSPORT OH	USGS	39°48'25"	81°53'30"	9/24/1991 18:00	15					76
77	MO9 STREAM NR CHANDLERSVILLE OH	USGS	39°48'39"	81°46'30"	7/23/1986 16:00	30.5					77
78	MO9 STREAM NR CHANDLERSVILLE OH	USGS	39°48'39"	81°46'30"	10/29/1986 10:30	16					78
79	MO9 STREAM NR CHANDLERSVILLE OH	USGS	39°48'39"	81°46'30"	5/28/1987 10:15	21.5					79
80	STREAM NR CHANDLERSVILLE OH	USGS	39°48'39"	81°46'30"	11/18/1987 12:00	9					80

Sample Number	Site Name	Collection Agency	Lattitude	Longitude	Sample Date/Time	Temperature Water (deg C)	Barometric Pressure (mm of Hg)	Discharge Inst. Cubic Feet per Second	Gage Height (ft.)	Turbidity (NTU)	Sample Number
81	MO9 STREAM NR CHANDLERSVILLE OH	USGS	39°48'39"	81°46'30"	8/9/1988 8:30	19.5					81
82	MO9 STREAM NR CHANDLERSVILLE OH	USGS	39°48'39"	81°46'30"	7/13/1989 11:15	21	733				82
83	M09 P14-1	USGS	39°48'51"	81°46'28"	7/23/1986 13:00	17					83
84	M09 P14-1	USGS	39°48'51"	81°46'28"	10/29/1986 9:00	14					84
85	M09 P14-1	USGS	39°48'51"	81°46'28"	5/27/1987 14:30	14.5					85
86	M09 P14-1	USGS	39°48'51"	81°46'28"	11/18/1987 10:45	12					86
87	M09 P14-1	USGS	39°48'51"	81°46'28"	8/9/1988 9:00	14.5					87
88	M09 P14-1	USGS	39°48'51"	81°46'28"	7/13/1989 9:00	14	733				88
89	MU-121 MO9 P8-1	USGS	39°48'52"	81°46'20"	7/24/1986 11:00	14.5					89
90	MU-121 MO9 P8-1	USGS	39°48'52"	81°46'20"	11/4/1986 15:00	14					90
91	MU-121 MO9 P8-1	USGS	39°48'52"	81°46'20"	5/28/1987 11:30	14.5					91
92	MU-121 MO9 P8-1	USGS	39°48'52"	81°46'20"	11/18/1987 11:00	12					92
93	MU-121 MO9 P8-1	USGS	39°48'52"	81°46'20"	8/8/1988 15:00	14					93
94	MU-121 MO9 P8-1	USGS	39°48'52"	81°46'20"	7/12/1989 15:45	14.5	729				94
95	MU-122 MO9 P9-2	USGS	39°48'52"	81°46'20"	7/24/1986 11:45	12.5					95
96	MU-122 MO9 P9-2	USGS	39°48'52"	81°46'20"	11/4/1986 13:40	12					96
97	MU-122 MO9 P9-2	USGS	39°48'52"	81°46'20"	5/28/1987 13:00	14					97
98	MU-122 MO9 P9-2	USGS	39°48'52"	81°46'20"	11/18/1987 10:00	12					98
99	MU-122 MO9 P9-2	USGS	39°48'52"	81°46'20"	8/9/1988 11:00	13.5					99
100	MU-122 MO9 P9-2	USGS	39°48'52"	81°46'20"	7/13/1989 12:45	14	733				100
101	M09 P12-1	USGS	39°48'58"	81°46'28"	7/23/1986 14:00	18					101
102	M09 P12-1	USGS	39°48'58"	81°46'28"	11/4/1986 11:30	14.1					102
103	M09 P12-1	USGS	39°48'58"	81°46'28"	5/27/1987 12:30	18					103
104	M09 P12-1	USGS	39°48'58"	81°46'28"	8/8/1988 13:00	15					104
105	M09 P12-1	USGS	39°48'58"	81°46'28"	7/12/1989 16:30	24	729				105
106	MU 55 F THORNTON NR GAYSPORT OH	USGS	39°49'09"	81°53'28"	9/24/1991 16:20	16	1028				106
107	BRUSH C NR PHILO OH	USGS	39°51'20"	81°59'07"	10/31/1991 11:40	15	1028	0.53			107

Specific Conduct-ance (us/cm)	Oxygen, Dissolved (mg/l)	pH Water Whole Units Field (standard units)	pH Whole Lab (standard units)	ANC Water Unfltrd. Fet Field (mg/l as CaC03)	Bicarbonate Water Dis It Field mg/l as HCO3	Nitrogen, Ammonia Dissolved (mg/l as N)	Nitrogen, Ammonia Total (mg/l as N)	Nitrogen, Nitrite Dissolved (mg/l as N)	Nitrogen, Nitrite Total (mg/l as N)	Nitrogen, Ammonia and Organic Total (mg/l as N)	Sample Number
625	12.6	7.7	7.8	106		0.4	0.39	0.03		1.1	1
560	13.9	7.9	7.9	96		0.23	0.27	0.01		0.9	2
685	10.2	8.7	8.3	134		0.01	0.02	0.02		0.9	3
686	8.6	8.3	8.4	115		0.02	0.03	0.03		0.3	4
687	8.6	8.3									5
684	8.7	8.4									6
686	8.6	8.4									7
686	8.6	8.3									8
687	8.7	8.3									9
830	6.9	7.8	7.7	134		0.29	0.29	0.05		0.8	10
551	10.9	7.5	7.8	198	242	0.06	0.07	0.02		0.7	11
535	13.2	7.9	7.7	81	100	0.13	0.13	0.02		0.9	12
527	15	6.7	7.8	93	117	0.08	0.09	0.02		0.5	13
386	9.9	7.8	7.6	90	110	0.06	0.04	0.02		0.9	14
417	7.2	7.9	7.8	85	105	0.03	0.03	0.03		0.4	15
750	5.2	8.3	7.9	125	149	0.13	0.13	0.02		0.6	16
820	8.2	8.2	7.9	148	183	0.05	0.07	0.02		0.5	17
590	11	7.9	7.9	99	120	0.09	0.1	0.02		0.6	18
670	11.7	8.3	8.3	122	148	0.02	< .01	0.01		0.4	19
520	8.8	8	7.9	105	127	0.06	0.1	0.03		0.9	20
660	8.9	8.6	8.2	123	145	0.01	0.02	0.02		1.1	21
610	8.2	8.4	8.3	134	164	0.04	0.05	0.01		0.6	22
603	9.2	8.3	8	122	149	0.07	0.04	0.02	0.01	0.4	23
364	13.3	7.9	7.6	73	88	0.09	0.1	0.01	0.03	0.5	24
570	12.4	8	8	110	134	0.01	0.05	< .010	0.01	0.4	25
682	10.5	8.8	8.6	140	139	0.02	0.02	0.02	0.02	0.9	26
893	4.2	7.9	7.8	95	120	0.25	0.25	0.03	0.03	0.8	27
770	5.9	8.2	8.1	120	146	0.02	< .01	0.02	0.03	1	28
1020	12.1	8.4									29
1010	12.3	8.3									30
1000	12.4	8.2									31
994	12	8.6									32
987	12	8.5									33
983	12	8.5									34
993	12.5	8.6									35
967	12.6	8.5									36
973	12.8	8.4									37
970	12.4	8.6									38
966	12.2	8.6									39
960	12.2	8.5									40

Specific Conductance (us/cm)	Oxygen, Dissolved (mg/l)	pH Water Whole Units Field (standard units)	pH Whole Lab (standard units)	ANC Water Unfltrd. Fet Field (mg/l as CaC03)	Bicarbonate Water Dis It Field mg/l as HCO3	Nitrogen, Ammonia Dissolved (mg/l as N)	Nitrogen, Ammonia Total (mg/l as N)	Nitrogen, Nitrite Dissolved (mg/l as N)	Nitrogen, Nitrite Total (mg/l as N)	Nitrogen, Ammonia and Organic Total (mg/l as N)	Sample Number
964	12.2	8.6									41
959	12.3	8.6									42
956	13	8.5									43
952	11.8	8.7									44
954	11.7	8.7									45
948	11.5	8.7									46
950	11.8	8.7									47
950	11.8	8.6									48
947	11.9	8.6									49
942	11.7	8.7									50
942	11.6	8.7									51
942											52
965	12.4	8.2	7.9	183	221	0.02	0.03	0.02	0.02	0.6	53
850	11.4	7.7	7.6	140	171	0.11	0.12	0.03	0.03	0.9	54
637	9.2	8.1	7.8	109	132	0.02	0.02	0.02	0.02	0.4	55
715	3.8	7.8	7.5	124	150	0.25	0.26	0.03	0.03	0.8	56
408	8.7	7.7	7.6	88	104	0.06	0.06	0.03	0.03	0.4	57
957		7.3									58
650		8	7.7	134							59
1200		7.7		145							60
1400		7.7		163							61
1250		8.1		131							62
2100		7.8		144							63
1300		8.1		172							64
2250		7.9		128							65
1300		7.8		180							66
1230		8.1		100							67
1100		7.8		175							68
1600		8.2		166							69
1300		8.3		35							70
2100		7.7		167							71
625	0.7	7.2	7.5	220		< .015		< .010			72
690		8		292							73
2400		8.1		202							74
1200		8.1		247							75
740	3.4	7.1	7.7	220							76
2000		8.1	7.8	206							77
2200		7.8	7.7	225							78
1850		7.8	7.8	243							79
2380		7.5	8.1	238							80

Specific Conductance (us/cm)	Oxygen, Dissolved (mg/l)	pH Water Whole Units Field (standard units)	pH Whole Lab (standard units)	ANC Water Unfltrd. Fet Field (mg/l as CaC03)	Bicarbonate Water Dis It Field mg/l as HCO3	Nitrogen, Ammonia Dissolved (mg/l as N)	Nitrogen, Ammonia Total (mg/l as N)	Nitrogen, Nitrite Dissolved (mg/l as N)	Nitrogen, Nitrite Total (mg/l as N)	Nitrogen, Ammonia and Organic Total (mg/l as N)	Sample Number
2150		7.7	7.6	245							81
2720	5.8	7.8	7.8	257							82
1520	0	6.7	7	969							83
1510		6.7	6.9	992							84
1100		6.8	6.7	1120							85
1430		6.7	7.1	872							86
1180		6.5	6.8	700							87
1380	0.4	6.4	6.6	826							88
1520	0	6.7	7.1	395							89
1830		6.7	6.8	510							90
1300		6.8	6.8	404							91
1450		6.9	6.6	558							92
1500		6.8	6.9	420							93
2400	0.2	6.5	6.7	467							94
800		7.4	7.8	463							95
919		7.3	7.5	347							96
905		7.5	7.5	363							97
1000		6.9	7.7	364							98
840		7.4	7.5	330							99
810	0.5	7.5	7.5	305							100
4530	0.4	6.6	7	610							101
4340		6.9	6.8	554							102
4100		6.7	6.7	581							103
4050		6.6	6.7	535							104
5080	0.4	6.4	6.7	578							105
430	3.2	7.5	7.8	182							106
2100		3.5									107

Nitrogen, NO2 and NO3 Dissolved (mg/l as N)	Phosphorus Total (mg/l as P)	Phosphorus Dissolved (mg/l as P)	Orthophosphate, Dissolved (mg/l as P)	Calcium, Dissolved (mg/l as Ca)	Magnesium, Dissolved (mg/l as Mg)	Sodium, Dissolved (mg/l as Na)	Potasium, Dissolved (mg/l as K)	Chloride, Dissolved (mg/l as Cl)	Sulfate Dissoved (mg/l as SO4)	Fluoride, Dissolved (mg/l as F)	Sample Number
1.7	0.11	0.03	< .010	66	20	31	5.2	49	130	0.3	1
2.2	0.14	0.03	0.02	59	18	26	4.2	44	98	0.2	2
1.2	0.07	0.02	< .010	70	21	27	3	47	130	0.2	3
0.5	0.05	0.02	< .010	71	24	35	4.3	51	150	0.3	4
											5
											6
											7
											8
											9
0.52	0.11	0.06	0.03	72	24	50	6.4	83	170	0.3	10
2.7	0.12	0.04	0.03	62	20	23	4.1	35	100	0.2	11
1.4	0.16	0.02	0.02	55	18	27	3.3	44	100	0.2	12
2	0.11	0.01	0.01	54	17	23	3.3	39	92	0.2	13
1.9	0.07	0.12	0.04	44	13	11	3.5	16	70	0.1	14
1.6	0.06	0.04	0.03	49	14	12	3.5	18	74	0.2	15
0.51	0.06	0.03	0.01	71	26	44	5.7	62	160	0.3	16
1.5	0.12	0.05	0.05	84	26	41	5.1	65	160	0.3	17
2.3	0.08	0.02	0.02	61	18	21	3.4	34	120	0.1	18
1.3	0.04	< .010	< .010	71	22	29	4	48	130	0.2	19
2.1	0.05	0.03	0.02	56	17	20	3.8	32	87	0.2	20
0.8	0.11	0.03	< .010	71	24	33	4.6	49	140	0.1	21
1.2	0.05	0.03	0.01	79	23	33	5.3	51	120	0.2	22
1.3	0.08	0.02	0.01	68	21	23	3.6	34	120	0.3	23
1.4	0.13	0.02	0.02	40	12	11	3.7	20	71	0.2	24
1.6	0.04	0.01	< .010	60	18	19	2.7	34	110	0.2	25
0.88	0.06	< .010	0.01	72	22	26	3.1	41	130	0.2	26
0.22	0.08	0.03	< .010	71	28	51	6	76	160	0.2	27
0.45	0.1	0.03	< .010	70	27	57	6.1	86	170	0.4	28
											29
											30
											31
											32
											33
											34
											35
											36
											37
											38
											39
											40

Nitrogen, NO2 and NO3 Dissolved (mg/l as N)	Phosphorus Total (mg/l as P)	Phosphorus Dissolved (mg/l as P)	Orthophosphate, Dissolved (mg/l as P)	Calcium, Dissolved (mg/l as Ca)	Magnesium, Dissolved (mg/l as Mg)	Sodium, Dissolved (mg/l as Na)	Potasium, Dissolved (mg/l as K)	Chloride, Dissolved (mg/l as Cl)	Sulfate Dissoved (mg/l as SO4)	Fluoride, Dissolved (mg/l as F)	Sample Number
											41
											42
											43
											44
											45
											46
											47
											48
											49
											50
											51
											52
2.2	0.12	0.05	0.04	93	29	67	7.9	100	160	0.3	53
2.2	0.16	0.06	0.05	90	27	44	4.6	65	190	0.4	54
0.42	0.06	0.03	< .010	62	21	32	4.2	54	130	0.3	55
0.72	0.06	0.04	0.02	64	23	42	5.8	76	130	0.3	56
1.2	0.08	0.05	0.04	43	12	16	4.7	25	71	0.2	57
				116	15	55	4.1	162	143	0.4	58
									130		59
									490		60
									630		61
									550		62
									990		63
									570		64
									1100		65
									570		66
									500		67
									470		68
									360		69
								15	920		70
									1100		71
7.99	< .010		< .010	103	19.5	8					72
									47		73
									1200		74
									470		75
				82	18	42	3.1	87	43		76
				350	140	20	2.4	2.2	1200		77
				350	150	15	2.1	3	1300		78
				370	140	14	1.6	11	1200		79
				350	140	14	3.2	12	1400		80

Nitrogen, NO2 and NO3 Dissolved (mg/l as N)	Phosphorus Total (mg/l as P)	Phosphorus Dissolved (mg/l as P)	Orthophosphate, Dissolved (mg/l as P)	Calcium, Dissolved (mg/l as Ca)	Magnesium, Dissolved (mg/l as Mg)	Sodium, Dissolved (mg/l as Na)	Potasium, Dissolved (mg/l as K)	Chloride, Dissolved (mg/l as Cl)	Sulfate Dissoved (mg/l as SO4)	Fluoride, Dissolved (mg/l as F)	Sample Number
				420	180	15	2	2.5	1500		81
				470	190	10	1.7	1	1700		82
				240	61	18	1.1	11	13		83
				230	58	13	1.1	5.7	9.3		84
				250	58	13	1	11	8.5		85
				230	56	14	1.1	5.1	54		86
				200	54	15	1	4	100		87
				210	54	14	0.9	3.8	45		88
				280	53	6.2	2.2	2.6	560		89
				370	64	8.3	2.2	2.7	840		90
				330	55	6.5	2.2	2	700		91
				230	58	8.2	3.1	2.5	350		92
				260	53	6.5	2.3	2	500		93
				490	77	8.4	2	1.2	1100		94
				62	25	88	2.3	2.8	130		95
				55	22	140	2.2	5.3	160		96
				55	21	120	2.4	2.6	130		97
				54	21	140	2.4	6	170		98
				55	24	100	2.2	3.4	150		99
				44	19	120	2	1.9	160		100
				520	560	57	9.6	5.5	2900		101
				550	590	56	9.7	4.6	3000		102
				530	470	47	9.2	11	2900		103
				580	490	44	9.4	2.2	2800		104
				560	650	41	8.9	0.6	3500		105
				63	15	5.9	0.7	4.8	43		106
									1100		107

Silica, Dissolved (mg/l as SiO2)	Arsenic Dissolved (ug/l as As)	Barium, Dissoved (ug/l as Ba)	Berylium, Dissolved (ug/l as Be)	Cadmium Dissolved (ug/l as CD)	Chromium, Dissolved (ug/l as Cr)	Cobalt, Dissolved (ug/l as Co)	Copper Dissolved (ug/l as Cu)	Iron, Dissolved (ug/l as Fe)	lead, Dissolved (ug/l as Pb)	Manganese, Dissolved (ug/l as Mn)	Molybdenum, Dissolved (ug/l as Mo)	Sample Number
6	< 1.0	39	< .50	< 1.00	< 1.0	< 3.00	22	20	8	630	< 10.0	1
7.6												2
3	1	41	< .50	< 1.00	< 1.0	< 3.00	2	M	< 5.00	110	< 10.0	3
0.2	< 1.0	50	< .50	< 1.00	< 1.0	< 3.00	4	M	< 5.00	12	< 10.0	4
												5
												6
												7
												8
												9
3.3												10
7.6	1	44	< .50	< 1.00	< 1.0	< 3.00	10	20	< 5.00	150	< 10.0	11
6	< 1.0	38	< .50	< 1.00	< 1.0	< 3.00	6	40	< 5.00	220	< 10.0	12
5.6												13
7.8	1	34	< .50	< 1.00	< 1.0	< 3.00	12	50	1	21	< 10.0	14
8.3	1	39	< .50	< 1.00	< 1.0	< 3.00	9	30	1	5	< 10.0	15
1.4												16
5	< 1.0	51	< .50	1	< 1.0	< 3.00	4	10	< 1.00	93	< 10.0	17
7.4	< 1.0	38	< .50	< 1.00	< 1.0	< 3.00	< 10.0	10	< 10.0	120	< 10.0	18
4.9												19
6.2	1	42	< .50	< 1.00	1	< 3.00	20	30	1	11	< 10.0	20
2.2	< 1.0	51	< .50	1	< 1.0	< 3.00	5	M	1	3	< 10.0	21
7.2												22
6.2	< 1.0	44	< .50	< 1.00	< 1.0	< 3.00	2	110	< 1.00	89	< 10.0	23
7.3	< 1.0	29	< .50	1	< 1.0	< 3.00	2	140	2	62	< 10.0	24
6.2												25
3.4	< 1.0	47	< .50	< 1.00	< 1.0	< 3.00	2	20	< 1.00	41	< 10.0	26
0.4	< 1.0	66	< .50	1	< 1.0	< 3.00	2	100	< 1.00	52	10	27
1.7												28
												29
												30
												31
												32
												33
												34
												35
												36
												37
												38
												39
												40

Silica, Dissolved (mg/l as SiO2)	Arsenic Dissolved (ug/l as As)	Barium, Dissoved (ug/l as Ba)	Berylium, Dissolved (ug/l as Be)	Cadmium Dissolved (ug/l as CD)	Chromium, Dissolved (ug/l as Cr)	Cobalt, Dissolved (ug/l as Co)	Copper Dissolved (ug/l as Cu)	Iron, Dissolved (ug/l as Fe)	lead, Dissolved (ug/l as Pb)	Manganese, Dissolved (ug/l as Mn)	Molybdenum, Dissolved (ug/l as Mo)	Sample Number
												41
												42
												43
												44
												45
												46
												47
												48
												49
												50
												51
												52
3.4		56				< 3.00		20		130	< 10.0	53
5.2		46				< 3.00		20		290	< 10.0	54
M		46				< 3.00		M		11	< 10.0	55
1.8		50				< 3.00		30		62	< 10.0	56
7.6												57
9.4												58
								80		380		59
								60		30		60
								20		80		61
								30		30		62
								20		70		63
								20		40		64
								40		50		65
								120		40		66
								30		30		67
								20		20		68
								110		30		69
								< 10		20		70
								< 10		100		71
12.4		95.3	0.53	1.02	< 5.0	< 3.00	< 10.0	< 3	11.2	< 1.0	< 10.0	72
								< 10		20		73
								10		50		74
								< 10		100		75
9.4								< 3		60		76
								30		1900		77
								< 10		1800		78
								20		580		79
								40		320		80

Silica, Dissolved (mg/l as SiO2)	Arsenic Dissolved (ug/l as As)	Barium, Dissoved (ug/l as Ba)	Berylium, Dissolved (ug/l as Be)	Cadmium Dissolved (ug/l as CD)	Chromium, Dissolved (ug/l as Cr)	Cobalt, Dissolved (ug/l as Co)	Copper Dissolved (ug/l as Cu)	Iron, Dissolved (ug/l as Fe)	lead, Dissolved (ug/l as Pb)	Manganese, Dissolved (ug/l as Mn)	Molybdenum, Dissolved (ug/l as Mo)	Sample Number
								30		2400		81
								50		480		82
								35000		3300		83
								32000		3100		84
								41000		3300		85
								29000		3000		86
								3900		2500		87
								22000		2400		88
								9300		1300		89
								M		1200		90
								M		930		91
								20000		990		92
								9700		970		93
								30		2700		94
								20		74		95
								M		75		96
								20		96		97
								10		80		98
								20		71		99
								20		52		100
								1700		2100		101
								600		1500		102
								1400		1900		103
								940		1700		104
								690		1100		105
10								20		10		106
								1900		9300		107

Silver, Dissolved (ug/l as Ag)	Strontium, Dissolved (ug/l as Sr)	Vanadium, Dissolved (ug/l as V)	Zinc, Dissolved (ug/l as Zn)	Aluminum, Dissolved (ug/l as Al0	Lithium Dissolved (ug/l as Li	Selenium, Dissolved (ug/l as Se)	Coliform Fecal, 0.7 UM-MF (cols./100 ml)	Fecal strep, KF Strp. MF, Water (Col./100 ml)	Alkalinity Wat Dis Tot It Field (mg/l as CaCO3)	Sample Number
< 1.0	240	< 6.0	13	20	8	< 1.0	1800	E 15000		1
							E 1400	E 7500		2
< 1.0	260	< 6.0	< 3	60	10	< 1.0	50	E 24		3
< 1.0	300	< 6.0	4	40	15	< 1.0	40	40		4
										5
										6
										7
										8
										9
							1600	1600		10
1	270	< 6.0	8	20	10	< 1.0	450	110	198	11
1	280	< 6.0	27	40	9	< 1.0	3200	M --	82	12
							1100	4300	96	13
< 1.0	170	< 6.0	11	40	7	< 1.0	370	370	90	14
< 1.0	190	< 6.0	8	30	6	< 1.0	420	820	86	15
							55	< 10000	126	16
< 1.0	310	< 6.0	12	30	13	< 1.0	E 39	E 780	150	17
< 1.0	270	< 6.0	5	20	7	< 1.0	E 550	E 290	98	18
							E 180	E 27	121	19
< 1.0	250	< 6.0	42	30	8	< 1.0	E 200	E 210	104	20
< 1.0	320	< 6.0	21	40	12	< 1.0	1	E 160	126	21
							E 42	E 24	133	22
< 1.0	290	< 6.0	4	30	11	< 1.0	800	280	122	23
< 1.0	160	< 6.0	12	80	7	< 1.0	780	1600	72	24
							200	210	110	25
< 1.0	280	< 6.0	8	50	11	< 1.0	E 15	E 4	150	26
< 1.0	310	< 6.0	11	20	14	< 1.0	140	E 7	98	27
							E 7	170	120	28
										29
										30
										31
										32
										33
										34
										35
										36
										37
										38
										39
										40

Silver, Dissolved (ug/l as Ag)	Strontium, Dissolved (ug/l as Sr)	Vanadium, Dissolved (ug/l as V)	Zinc, Dissolved (ug/l as Zn)	Aluminum, Dissolved (ug/l as Al0	Lithium Dissolved (ug/l as Li	Selenium, Dissolved (ug/l as Se)	Coliform Fecal, 0.7 UM-MF (cols./100 ml)	Fecal strep, KF Strp. MF, Water (Col./100 ml)	Alkalinity Wat Dis Tot It Field (mg/l as CaCO3)	Sample Number
										41
										42
										43
										44
										45
										46
										47
										48
										49
										50
										51
										52
< 1.0	320	< 6.0		30	15	< 1.0	120	E 7	183	53
< 1.0	350	< 6.0		30	11	< 1.0	660	73	140	54
< 1.0	290	< 6.0		40	7	< 1.0	E 14	E 2	109	55
< 1.0	310	< 6.0		20	9	< 1.0	70	E 22	123	56
							360	540	85	57
										58
				< 100						59
				30						60
				< 10						61
				10						62
				< 10						63
				10						64
				30						65
				90						66
				30						67
				10						68
				40						69
				20						70
				< 10						71
< 1.0	168	< 6.0	5		6.4				222	72
				< 10						73
				< 10						74
				< 10						75
				10						76
				< 10						77
				10						78
				10						79
				< 10						80

Silver, Dissolved (ug/l as Ag)	Strontium, Dissolved (ug/l as Sr)	Vanadium, Dissolved (ug/l as V)	Zinc, Dissolved (ug/l as Zn)	Aluminum, Dissolved (ug/l as Al0	Lithium Dissolved (ug/l as Li	Selenium, Dissolved (ug/l as Se)	Coliform Fecal, 0.7 UM-MF (cols./100 ml)	Fecal strep, KF Strp. MF, Water (Col./100 ml)	Alkalinity Wat Dis Tot It Field (mg/l as CaCO3)	Sample Number
				20						81
				< 10						82
				< 10						83
				10						84
				< 10						85
				< 10						86
				20						87
				20						88
				< 10						89
				< 10						90
				10						91
				< 10						92
				20						93
				< 10						94
				< 10						95
				30						96
				< 10						97
				< 10						98
				20						99
				< 10						100
				20						101
				20						102
				10						103
				20						104
				< 10						105
				20						106
				12000						107

Solids, Residue at 180 deg. C Dissolved (mg/l)	Phosphours, Ortho Total (mg/l as P)	Sediment, Suspended (mg/l)	Specific Conductance Lab (us/cm)	ANC Unfltrd TIT Lab (mg/l as CaCO3)	ANC Unfltrd Carbonate It-Field (mg/l as CaCO3)	Bicarbonate It-Fld (mg/l as HCO3)	Carbonate It-Fld (mg/l as CO3)
376		132	630	105	127	127	0
342		50	564	99	0	117	0
390		21	644	117	12	142	12
430		19	691	117	114	139	0
498		14	814	126	134	164	0
350		24	558	105			
337		97	543	92			
299		52	532	176			
228		78	375	81			
235		121	409	92			
456		14	762	119			
495		27	808	149			
338		42	550	96			
429		18	632	115		148	
300		67	500	101			
439		62	687	113			
428		45	678	154			
360	0.04	18	603	120	122	149	0
229	0.04	55	363	73	72	88	0
314	0.02	27	536	110			
374	0.02	48	617	129			
487	< .010	15	814	118			
493	0.02	22	817	123			

Solids, Residue at 180 deg. C Dissolved (mg/l)	Phosphours, Ortho Total (mg/l as P)	Sediment, Suspended (mg/l)	Specific Conductance Lab (us/cm)	ANC Unfltrd TIT Lab (mg/l as CaCO3)	ANC Unfltrd Carbonate It-Field (mg/l as CaCO3)	Bicarbonate It-Fld (mg/l as HCO3)	Carbonate It-Fld (mg/l as CO3)
575	0.06	9	959	183			
511	0.08	15	839	140			
371	0.01	25	639	109			
436	0.03	10	713	123			
235	0.07	39	409	92			
583							
			654				
					133		0
			667				
418			754	229			
1960			2130				
1980			2190				
2000			2210				
2220			2340				

Solids, Residue at 180 deg. C Dissolved (mg/l)	Phosphours, Ortho Total (mg/l as P)	Sediment, Suspended (mg/l)	Specific Conductance Lab (us/cm)	ANC Unfltrd TIT Lab (mg/l as CaCO3)	ANC Unfltrd Carbonate It-Field (mg/l as CaCO3)	Bicarbonate It-Fld (mg/l as HCO3)	Carbonate It-Fld (mg/l as CO3)
2290			2380				
2650			2640		259	316	0
750			1440				
833			1290				
918			1470				
858			1370				
846			1320				
806			1340		844	1030	0
1230			1500				
1310			1850				
1350			1670				
990			1510				
1170			1480				
2060			2270		462	564	0
519			809				
614			909				
553			916				
620			987				
551			900				
519			835		305	372	0
4780			4430				
4610			4220				
4650			4290				
4390			4200				
5410			4860		582	710	0
245			434	181			

APPENDIX I.D

Macroinvertebrate Taxa Collected at the Sampling Sites

Taxa Name	River	Date	Quantity	Quality	Reference
Ablabesmyia janta	Olive Green Creek	1999	8		
Ablabesmyia mallochi	Meigs Creek	1989	94+		
	Muskingum River	1988	187		
	Olive Green Creek	1989	74+		
Ablabesmyia rhamphe group	Dyes Fork	1989	15		X
	Muskingum River	1988	2338+		
	Olive Green Creek	1984	113		X
Acroneuria frisoni	Dyes Fork	1989	20+		X
	Meigs Creek	1989	15+		X
	Olive Green Creek	84/89/99	10+		X
Agnetina capitata complex	Muskingum River	1985	1		
Ancyronyx variegata	Olive Green Creek	1989	1		X
Argia sp	Dyes Fork	1989	1		X
	Meigs Creek	1989	12+		X
	Muskingum River	1988	275+		
	Olive Green Creek	1984/1999	7+		X
Atrichopogon websteri	Dyes Fork	1989	8		X
Baetidae	Meigs Creek	1989	8		
Baetis sp	Meigs Creek	1989	39+		X
	Muskingum River	85/88/90	290+		X
Caenis sp	Dyes Fork	1989	57+		X
	Meigs Creek	1989	308		X
	Muskingum River	85/88	6187+		
	Olive Green Creek	84/89/99	277+		X
Centroptilum sp or Procloeon sp (formerly Cloeon)	Olive Green Creek	1989	13+		X
Ceratopogonidae	Dyes Fork	1989	32		X
	Meigs Creek	1989	12		
	Olive Green Creek	1984	2		X
Ceratopsyche morosa group	Muskingum River	1990	3		
Cheumatopsyche sp	Dyes Fork	1989	72+		X
	Meigs Creek	1989	213+		X
	Muskingum River	85/88/90	2123+		
	Olive Green Creek	1989	7+		X
Chimarra obscura	Meigs Creek	1989	46+		X
Chironomus (C.) decorus group	Olive Green Creek	1984	50		X
Chironomus (C.) sp	Olive Green Creek	1999	4+		
Cipangopaludina japonica	Muskingum River	1988	2+		
Cladotanytarsus species group A	Dyes Fork	1989	60		X
Cladotanytarsus vanderwulpi group Type 4	Meigs Creek	1989	19		
Coelotanypus sp	Muskingum River	1988	21		
Coenagrionidae	Muskingum River	1988	1+		
Conchapelopia sp	Meigs Creek	1989	70+		X
Corbicula fluminea	Dyes Fork	1989	26+		X
	Muskingum River	85/88/90	87+		
	Olive Green Creek	89/99	2+		X
Cordylophora lacustris	Dyes Fork	1989	2		X
	Meigs Creek	1989	1		
	Muskingum River	85/88	5		
Corydalus cornutus	Dyes Fork	1989	1+		X
	Meigs Creek	1989	5+		X
	Muskingum River	1988	4+		
Corynoneura "celeripes"	Meigs Creek	1989	16		X
Corynoneura lobata	Meigs Creek	1989	263		X
	Muskingum River	1988	145		
	Olive Green Creek	89/99	30		X
Corynoneura sp	Olive Green Creek	1984	12		X

Taxa Name	River	Date	Quantity	Quality	Reference
Crangonyx sp	Muskingum River	1988	1+		
Cricotopus (C.) bicinctus	Dyes Fork	1989	54+		X
	Muskingum River	1989	56		
	Olive Green Creek	1989	19		X
Cricotopus (C.) sp	Dyes Fork	1989	78+		
	Meigs Creek	1989	375+		X
	Muskingum River	1988	429		
Cricotopus (C.) tremulus group	Meigs Creek	1989	304+		X
Cyrnellus fraternus	Dyes Fork	1989	9		X
	Muskingum River	85/88	11478+		
	Olive Green Creek	1984	3		X
Dicrotendipes lucifer	Muskingum River	85/88	7837+		
	Olive Green Creek	84/99	277		X
Dicrotendipes modestus	Muskingum River	1988	361		
Dicrotendipes neomodestus	Dyes Fork	1989	9		
	Meigs Creek	1989	85		
	Muskingum River	85/88	1027+		
	Olive Green Creek	84/88/99	299+		X
Dicrotendipes simpsoni	Muskingum River	1988	6332+		
Dicrotendipes sp	Muskingum River	1988	202		
Dineutus sp	Muskingum River	1988	14+		
Dubiraphia sp	Dyes Fork	1989	18+		X
Dubiraphia vittata group	Dyes Fork	1989	29+		
	Meigs Creek	1989	9+		
	Olive Green Creek	1984	2		X
Elimia sp	Dyes Fork	1989			
	Meigs Creek	1989	5+		
	Muskingum River	85/88/90	164+		
	Olive Green Creek	1999	3+		
Empididae	Dyes Fork	1989	594+		X
	Meigs Creek	1989	900+		X
	Muskingum River	85/90	365+		
	Olive Green Creek	84/89/99	51+		X
Eurylophella sp	Olive Green Creek	1999	4		
Ferrissia sp	Meigs Creek	1989	1		
	Muskingum River	85/88	1		
	Olive Green Creek	84/89/99	12+		X
Fredericella indica	Muskingum River	1988	1		
Glyptotendipes (G.) sp	Muskingum River	85/88	180767+		
	Olive Green Creek	1984	134		X
Glyptotendipes (Trichotendipes) amplus	Muskingum River	1988	183+		
Hayesomyia senata or Thienemannimyia norena	Dyes Fork	1989	190		X
	Meigs Creek	1989	646		X
	Muskingum River	85/88/90	982+		
Helichus sp	Olive Green Creek	1984	1		X
Heptagenia flavescens	Muskingum River	1990	2		
Hexagenia sp	Muskingum River	1988	1+		
Hyalella azteca	Muskingum River	1988	17+		
Hyalinella punctata	Muskingum River	85/88	21+		
Hydra sp	Dyes Fork	1989	1		X
	Muskingum River	1988	368		
	Olive Green Creek	89/99	13		X
Hydracarina	Dyes Fork	1989	8		X
Hydropsyche bidens	Muskingum River	1988	750		
Hydropsyche dicantha	Dyes Fork	1989	12		
	Meigs Creek	1989	2+		
Hydropsyche orris	Muskingum River	85/88/90	24529+		
Hydropsyche simulans	Meigs Creek	1989	18+		

Taxa Name	River	Date	Quantity	Quality	Reference
	Muskingum River	88/90	35		
Hydroptila sp	Dyes Fork	1989	9		
	Meigs Creek	1989	6+		
	Muskingum River	1988	164+		
	Olive Green Creek	84/99	7+		X
Hydroptilidae	Dyes Fork	1989	30+		X
	Muskingum River	1985	5+		
Isonychia sp	Muskingum River	1990	6+		
Labrundinia pilosella	Meigs Creek	1989	16		
	Olive Green Creek	1999	2		
Labrundinia sp	Olive Green Creek	1984	12		X
Laevapex fuscus	Muskingum River	1988	128		
Leucrocuta sp	Olive Green Creek	1989	2+		X
Lophopodella carteri	Muskingum River	1988	1130+		
Macronychus glabratus	Dyes Fork	1989	90+		X
	Meigs Creek	1989	8+		
	Muskingum River	88/90	15+		
	Olive Green Creek	84/99	2		X
Macrostemum zebratum	Muskingum River	1990	13		
Menetus (Micromenetus) dilatatus	Muskingum River	1988	26		
	Olive Green Creek	1989	48		
Microtendipes pedellus group	Olive Green Creek	89/99	23		X
Nanocladius (N.) crassicornus (old)	Meigs Creek	1989	16		
	Muskingum River	1988	551+		
Nanocladius (N.) distinctus	Meigs Creek	1989	16		
	Muskingum River	85/88	3873+		
Neotrichia sp	Meigs Creek	1989	8		
Neureclipsis sp	Dyes Fork	1989	21+		X
	Meigs Creek	1989	18+		
	Muskingum River	85/88/90	56+		
Nigronia fasciatus	Meigs Creek	1989	1		
Nigronia serricornis	Olive Green Creek	1989	2+		X
Nilotanypus fimbriatus	Meigs Creek	1989	51		X
Nilothauma sp	Olive Green Creek	84/99	29		X
Nyctiophylax sp	Olive Green Creek	1999	2		
Oecetis sp	Muskingum River	1988	16+		
Oligochaeta	Dyes Fork	1989	18		
	Meigs Creek	1989	14		X
	Muskingum River	85/88/90	14189+		
	Olive Green Creek	1984	4+		
Parachironomus carinatus	Muskingum River	1988	21		
Parachironomus frequens	Muskingum River	1988	1356+		
Parachironomus pectinatellae	Muskingum River	1988	591+		
Parachironomus sp	Muskingum River	1988	101		
Parakiefferiella n.sp 1	Dyes Fork	1989	32		X
Parakiefferiella n.sp 2	Dyes Fork	1989	166+		X
	Meigs Creek	1989	179+		
Paralauterborniella nigrohalteralis	Dyes Fork	1989	24		X
Parametriocnemus sp	Meigs Creek	1989	19		
Paratanytarsus sp	Meigs Creek	1989	19		
	Olive Green Creek	1999	8		
Paratendipes albimanus or P. duplicatus	Olive Green Creek	89/99	43+		X
Pectinatella magnifica	Muskingum River	88/90	64+		
Phaenopsectra obediens group	Meigs Creek	1989	35		X
	Olive Green Creek	84/89	183+		X
Physella sp	Meigs Creek	1989	20+		
	Muskingum River	1988	175+		
Placobdella sp	Muskingum River	1988	1		

Taxa Name	River	Date	Quantity	Quality	Reference
Plumatella sp	Dyes Fork	1989	1+		X
	Muskingum River	88/90	116+		
Polycentropus sp	Muskingum River	1985	4+		
	Olive Green Creek	84/89/99	8		X
Polypedilum (P.) fallax group	Dyes Fork	1989	56		X
	Meigs Creek	1989	310+		X
	Olive Green Creek	84/89/99	191		X
Polypedilum (P.) illinoense	Meigs Creek	1989	16+		
Polypedilum (Tripodura) scalaenum group	Dyes Fork	1989	112		X
	Meigs Creek	1989	279		X
	Muskingum River	1985	45		
	Olive Green Creek	84/89	116+		X
Polypedilum (Uresipedilum) flavum	Meigs Creek	1989	54+		X
	Muskingum River	85/88/90	6829+		
	Olive Green Creek	1999	4+		
Potamyia flava	Muskingum River	85/88/90	5675+		
Procladius sp	Muskingum River	1988	21+		
	Olive Green Creek	84/89	25		X
Procloeon sp (formerly in Centroptilum)	Muskingum River	1988	1		
Pseudochironomus sp	Meigs Creek	1989	19		
	Olive Green Creek	1984	12		X
Rheocricotopus (Psilocricotopus) robacki	Dyes Fork	1989	316+		X
	Meigs Creek	1989	482		X
Rheotanytarsus pellucidus	Dyes Fork	1989	60		X
	Meigs Creek	1989	1		
Rheotanytarsus sp	Dyes Fork	1989	9+		
	Meigs Creek	1989	2766+		X
	Muskingum River	85/88/90	25461+		
Sialis sp	Dyes Fork	1989	1+		X
	Olive Green Creek	84/99	2		X
Simulium sp	Dyes Fork	1989	8+		
	Meigs Creek	1989	1+		
	Muskingum River	1990	70+		
Somatochlora sp	Muskingum River	1988	1+		
Sphaerium sp	Muskingum River	88/90	2+		
	Olive Green Creek	84/89/99	2		X
Stenacron sp	Meigs Creek	1989	57+		X
	Muskingum River	85/88/90	293+		
	Olive Green Creek	84/89/99	86+		X
Stenelmis sp	Dyes Fork	1989	30		
	Meigs Creek	1989	74+		X
	Muskingum River	85/88/90	883+		
	Olive Green Creek	84/89/99	14+		X
Stenonema exiguum	Muskingum River	1990	101+		
Stenonema femoratum	Olive Green Creek	1999	64+		
Stenonema mexicanum integrum	Muskingum River	85/88/90	226+		
Stenonema pulchellum	Muskingum River	1985	4		
Stenonema terminatum	Muskingum River	85/88/90	511+		
Stenonema tripunctatum	Meigs Creek	1989	22+		X
	Olive Green Creek	84/89	23		X
Tanytarsus curticornis group	Meigs Creek	1989	19		
Tanytarsus glabrescens group	Dyes Fork	1989	503		X
	Meigs Creek	1989	2578		X
	Muskingum River	1988	48		
	Olive Green Creek	84/89	383+		X
Tanytarsus glabrescens group sp 7	Olive Green Creek	1999	12		
Tanytarsus guerlus group	Dyes Fork	1989	84		X
	Meigs Creek	1989	136		X

Taxa Name	River	Date	Quantity	Quality	Reference
	Olive Green Creek	84/89/99	147+		X
Tanytarsus sp	Meigs Creek	1989	148		X
	Olive Green Creek	84/88/99	69		X
Tanytarsus Type 1	Meigs Creek	1989	19		
Telopelopia okoboji	Meigs Creek	1989	35+		X
Thienemanniella lobapodema	Dyes Fork	1989	32+		X
	Meigs Creek	1989	152		X
Thienemanniella xena	Meigs Creek	1989	16		X
Thienemannimyia group	Olive Green Creek	1884	38+		X
Tribelos fuscicorne	Dyes Fork	1989	9		
	Meigs Creek	1989	35		X
	Olive Green Creek	1999	69		
Tribelos jucundum	Dyes Fork	1989	15		X
	Olive Green Creek	1999	34		X
Tricorythodes sp	Dyes Fork	1989	90+		X
	Meigs Creek	1989	168+		X
	Muskingum River	85/88/90	372+		
	Olive Green Creek	1984	4+		X
Turbellaria	Muskingum River	85/88/90	2332+		
Tvetenia discoloripes group	Muskingum River	1990	924+		
Unionidae	Muskingum River	1988	1		
Urnatella gracilis	Meigs Creek	1989	1		X
	Muskingum River	85/88	8+		

APPENDIX I.E

Rare, Threatened, and Endangered Species List, ODNR-DNAP

	Feature ID	Species Name	Species Common Name	Last Observance	State Status	Federal Status
1	724	MOXOSTOMA CARINATUM	RIVER REDHORSE	1976-12	SC	
2	744	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1971-10	T	
3	782	CRYPTOBRANCHUS ALLEGANIENSIS	EASTERN HELLBENDER	4/29/1962	E	
4	1038	NOTROPIS AMBLOPS	BIGEYE CHUB	1965-07	N	
5	1368	PLETHOBASUS CYPHYUS	SHEEPNOSE	1977-03	E	
6	1444	CYPROGENIA STEGARIA	FANSHELL	1973-09	E	LE
7	1496	QUERCUS ALBA	WHITE OAK	1974-11		
8	1688	HIODON ALOSOIDES	GOLDEYE	1971-09	E	
9	2028	POTAMILUS OHIENSIS	PINK PAPERSHELL	1969-10	N	
10	2194	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1980-08	T	
11	2200	PLATANUS OCCIDENTALIS	AMERICAN SYCAMORE	1974-11		
12	2272	LAMPSILIS OVATA	POCKETBOOK	1966-06	E	
13	2342	SIMPSONAIAS AMBIGUA	SALAMANDER MUSSEL	1967-01	SC	
14	2754	CYPROGENIA STEGARIA	FANSHELL	1962-05	E	LE
15	2824	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1962-07	T	
16	3032	LAMPSILIS OVATA	POCKETBOOK	1965-09	E	
17	3126	GREAT BLUE HERON COLONY		1986-07		
18	3136	PANICUM LAXIFLORUM	PALE GREEN PANIC GRASS	1963-07	P	
19	3172	FUSCONAIA MACULATA MACULATA	LONG-SOLID	1973-09	E	
20	3248	ELLIPSARIA LINEOLATA	BUTTERFLY	1980-09	E	
21	3416	ACCIPITER STRIATUS	SHARP-SHINNED HAWK	1984-07	SC	
22	3672	ICHTHYOMYZON BDELLIUM	OHIO LAMPREY	1965-02	E	
23	3802	EPIOBLASMA TRIQUETRA	SNUFFBOX	1980-10	E	
24	3910	APALONE MUTICA	SMOOTH SOFTSHELL	1964-08	N	
25	4006	PLETHOBASUS CYPHYUS	SHEEPNOSE	1969-10	E	
26	4026	HIODON TERGISUS	MOONEYE	1977-03	N	
27	4258	HIODON TERGISUS	MOONEYE	1977	N	
28	4318	GOMPHUS NOTATUS	ELUSIVE CLUBTAIL	9/8/1994	N	
29	4322	TURKEY VULTURE ROOST		1974-04		
30	4394	POTAMILUS OHIENSIS	PINK PAPERSHELL	1983-06	N	
31	4430	SIMPSONAIAS AMBIGUA	SALAMANDER MUSSEL	1969-10	SC	
32	4448	HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	2000-06	E	LT
33	4500	GREAT BLUE HERON COLONY		1984-05		
34	4796	NOTROPIS BUCHANANI	GHOST SHINER	1977	N	
35	4878	POTAMILUS OHIENSIS	PINK PAPERSHELL	1962-07	N	
36	5266	OPSOPOEODUS EMILIAE	PUGNOSE MINNOW	1977	E	
37	5306	CIRCUS CYANEUS	NORTHERN HARRIER	1983	E	
38	5368	LAMPSILIS OVATA	POCKETBOOK	1973-08	E	
39	5414	EASTERN WHITE PINE	PINUS STROBUS	1/1/1989		
40	5484	SELAGINELLA RUPESTRIS	ROCK SPIKE-MOSS	1951-07	X	
41	5536	LAMPSILIS ABRUPTA	PINK MUCKET	6/22/1966	E	LE
42	5662	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1983-08	SC	
43	5762	MIXED EMERGENT MARSH		4/14/1994		
44	5878	POTAMILUS OHIENSIS	PINK PAPERSHELL	1980-09	N	
45	6018	QUADRULA CYLINDRICA CYLINDRICA	RABBITSFOOT	1980-05	E	
46	6244	CARDAMINE DISSECTA	NARROW-LEAVED TOOTHWORT	1988-05	P	
47	6320	MOLLUSK BED		1992-10		
48	6322	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	7/13/1988	SC	
49	6424	PLEUROBEMA RUBRUM	PYRAMID PIGTOE	1992-10	E	
50	6634	MIXED MESOPHYTIC FOREST		1983-09		
51	6638	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1988-09	N	
52	6700	HIODON TERGISUS	MOONEYE	1988-09	N	
53	6776	NOTROPIS BUCHANANI	GHOST SHINER	1983-09	N	
54	6858	CRYPTOBRANCHUS ALLEGANIENSIS	EASTERN HELLBENDER	1988-07	E	
55	6990	HIODON TERGISUS	MOONEYE	1988-09	N	
56	7042	CYPROGENIA STEGARIA	FANSHELL	10/30/1992	E	LE

	Feature ID	Species Name	Species Common Name	Last Observance	State Status	Federal Status
57	7144	MOLLUSK BED		1992-10		
58	7438	MIXED MESOPHYTIC FOREST		1994-04		
59	7678	PLEUROBEMA SINTOXIA	ROUND PIGTOE	1992-10	SC	
60	7814	LIGUMIA RECTA	BLACK SANDSHELL	1962-08	T	
61	7930	CRYPTOBRANCHUS ALLEGANIENSIS	EASTERN HELLBENDER	1976	E	
62	8020	PEDESTAL ROCK		1993-01		
63	8060	NATURAL BRIDGE OR ARCH		1977		
64	8278	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1986-09	N	
65	8344	APALONE MUTICA	SMOOTH SOFTSHELL	1980-07	N	
66	8418	EPIOBLASMA TRIQUETRA	SNUFFBOX	10/1/1980	E	
67	8490	JUGLANS CINEREA	BUTTERNUT	11/8/2000	P	
68	8562	OAK-HICKORY FOREST		9/14/1983		
69	8640	EPIOBLASMA TRIQUETRA	SNUFFBOX	1962-07	E	
70	8702	CYCLONAIAS TUBERCULATA	PURPLE WARTYBACK	8/10/1979	SC	
71	8776	OAK-MAPLE FOREST		1984-08		
72	8820	LAMPSILIS OVATA	POCKETBOOK	1979-07	E	
73	8958	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1977-06	T	
74	8998	CYSTOPTERIS TENNESSEENSIS	TENNESSEE BLADDER FERN	1982-06	P	
75	9034	CRYPTOBRANCHUS ALLEGANIENSIS	EASTERN HELLBENDER	1982-09	E	
76	9070	PENSTEMON PALLIDUS	DOWNY WHITE BEARD-TONGUE	1988-05	T	
77	9148	PLEUROBEMA SINTOXIA	ROUND PIGTOE	10/30/1992	SC	
78	9166	ELLIPSARIA LINEOLATA	BUTTERFLY	1980-10	E	
79	9406	ASIMINA TRILOBA	PAW PAW	1/1/1989		
80	9456	NOTURUS ELEUTHERUS	MOUNTAIN MADTOM	1987-11	E	
81	9536	LAMPSILIS ABRUPTA	PINK MUCKET	1981-08	E	LE
82	9588	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1980-09	T	
83	9662	CYCLONAIAS TUBERCULATA	PURPLE WARTYBACK	1961-09	SC	
84	9836	LIGUMIA RECTA	BLACK SANDSHELL	1962-08	T	
85	10034	HEMLOCK-HARDWOOD FOREST		6/27/1983		
86	10062	HIODON TERGISUS	MOONEYE	9/28/1988	N	
87	10080	MIXED MESOPHYTIC FOREST		1983-07		
88	10084	MOLLUSK BED		1992-10		
89	10152	WATER-WILLOW RIVERINE COMMUNITY		9/6/1984		
90	10548	CARYA TOMENTOSA	MOCKERNUT HICKORY	7/1/1997		
91	10822	HIODON TERGISUS	MOONEYE	1988-10	N	
92	10848	MOXOSTOMA CARINATUM	RIVER REDHORSE	1988-10	SC	
93	11050	NOTROPIS BUCHANANI	GHOST SHINER	1983-10	N	
94	11262	HIODON TERGISUS	MOONEYE	1988-09	N	
95	11370	ELLIPSARIA LINEOLATA	BUTTERFLY	1992-10	E	
96	11592	CHRYSOGONUM VIRGINIANUM	GOLDEN-KNEES	4/24/1997	T	
97	11702	NOTURUS STIGMOSUS	NORTHERN MADTOM	1987-12	E	
98	11798	CARDAMINE DISSECTA	NARROW-LEAVED TOOTHWORT	1988-05	P	
99	11846	TRUNCILLA TRUNCATA	DEERTOE	1992-10	SC	
100	11912	MIXED MESOPHYTIC FOREST		1984-07		
101	11954	NOTURUS ELEUTHERUS	MOUNTAIN MADTOM	1991-10	E	
102	12194	NOTURUS ELEUTHERUS	MOUNTAIN MADTOM	10/26/1992	E	
103	12300	CARDAMINE DISSECTA	NARROW-LEAVED TOOTHWORT	1988-05	P	
104	12316	CHRYSOGONUM VIRGINIANUM	GOLDEN-KNEES	1988-05	T	
105	12406	MOXOSTOMA CARINATUM	RIVER REDHORSE	1988-09	SC	
106	12408	MOXOSTOMA CARINATUM	RIVER REDHORSE	1988-09	SC	
107	12468	HIODON TERGISUS	MOONEYE	1988-08	N	
108	12478	LILIUM SUPERBUM	TURK'S-CAP LILY	1995-08	P	
109	12822	MOLLUSK BED		1992-10		
110	12834	NOTROPIS BUCHANANI	GHOST SHINER	1988-08	N	
111	13140	MIXED MESOPHYTIC FOREST		4/14/1994		
112	13490	FLOODPLAIN FOREST		11/1/1982		
113	13512	VILLOSA FABALIS	RAYED BEAN	1980-05	E	
114	13638	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1987-11	SC	

	Feature ID	Species Name	Species Common Name	Last Observance	State Status	Federal Status
115	13756	MOLLUSK BED		10/30/1992		
116	13864	FUSCONAIA MACULATA MACULATA	LONG-SOLID	1980-09	E	
117	13894	MOLLUSK BED		1992-10		
118	13904	MIXED MESOPHYTIC FOREST		1984-04		
119	14112	CARDAMINE DISSECTA	NARROW-LEAVED TOOTHWORT	1988-05	P	
120	14458	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1980-07	T	
121	14508	GREAT BLUE HERON COLONY		1990-03		
122	14730	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1987-10	SC	
123	14732	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1983-10	SC	
124	15396	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1991-10	N	
125	15710	MOLLUSK BED		1987-06		
126	16026	MIXED MESOPHYTIC FOREST		1982-10		
127	16136	OAK-MAPLE FOREST		11/23/1994		
128	16288	PLEUROBEMA RUBRUM	PYRAMID PIGTOE	1992-10	E	
129	16580	SCAPHIOPUS HOLBROOKII	EASTERN SPADEFOOT	6/21/2001	E	
130	16656	BEECH-SUGAR MAPLE FOREST		1988-09		
131	16818	CIRCUS CYANEUS	NORTHERN HARRIER	6/6/2000	E	
132	16860	PLEUROBEMA PLENUM	ROUGH PIGTOE	1992-10	X	LE
133	16912	MEGALONAIAS NERVOSA	WASHBOARD	10/30/1992	E	
134	16958	ANODONTA GRANDIS CORPULENTA	STOUT FLOATER	1980-09	N	
135	17004	PEDESTAL ROCK		1993-01		
136	17152	ETHEOSTOMA TIPPECANOE	TIPPECANOE DARTER	1991-10	T	
137	17186	MOXOSTOMA CARINATUM	RIVER REDHORSE	1988-10	SC	
138	17902	NOTURUS STIGMOSUS	NORTHERN MADTOM	11/5/1987	E	
139	18170	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1980-07	SC	
140	18528	SCAPHIOPUS HOLBROOKII	EASTERN SPADEFOOT	6/21/2001	E	
141	18692	FUSCONAIA MACULATA MACULATA	LONG-SOLID	1980-06	E	
142	18836	MIXED EMERGENT MARSH		1983-08		
143	18860	NOTURUS ELEUTHERUS	MOUNTAIN MADTOM	1987-12	E	
144	18890	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1980-09	T	
145	19060	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1983-07	SC	
146	19084	MIXED MESOPHYTIC FOREST		1994-04		
147	19196	LIGUMIA RECTA	BLACK SANDSHELL	1980-06	T	
148	19198	CYSTOPTERIS TENNESSEENSIS	TENNESSEE BLADDER FERN	1982-09	P	
149	19252	BEECH-SUGAR MAPLE FOREST		1983-06		
150	19368	POTAMILUS OHIENSIS	PINK PAPERSHELL	1977-06	N	
151	19482	PLEUROBEMA RUBRUM	PYRAMID PIGTOE	1979-09	E	
152	19790	PERCINA SHUMARDI	RIVER DARTER	1987-11	T	
153	19974	CHRYSOGONUM VIRGINIANUM	GOLDEN-KNEES	1987-05	T	
154	20002	CYCLONAIAS TUBERCULATA	PURPLE WARTYBACK	1980-09	SC	
155	20092	ACCIPITER STRIATUS	SHARP-SHINNED HAWK	1986-08	SC	
156	20250	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1987-09	N	
157	20420	LIGUMIA RECTA	BLACK SANDSHELL	1969-09	T	
158	20430	MOXOSTOMA CARINATUM	RIVER REDHORSE	1983-08	SC	
159	20486	HIODON TERGISUS	MOONEYE	1988-09	N	
160	20526	MOLLUSK BED		1987-09		
161	20528	MOLLUSK BED		1987-09		
162	20558	PERCINA COPELANDI	CHANNEL DARTER	1987-12	T	
163	20672	ELLIPTIO CRASSIDENS	ELEPHANT-EAR	10/30/1992	E	
164	20910	EPIOBLASMA TRIQUETRA	SNUFFBOX	1980-06	E	
165	20976	NOTROPIS AMBLOPS	BIGEYE CHUB	1987-10	N	
166	21008	MEGALONAIAS NERVOSA	WASHBOARD	10/30/1992	E	
167	21554	MOLLUSK BED		1987-09		
168	21876	HIODON TERGISUS	MOONEYE	1988-10	N	
169	21936	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	12/8/1994	SC	
170	22008	CYCLONAIAS TUBERCULATA	PURPLE WARTYBACK	1979-09	SC	
171	22110	PLEUROBEMA PLENUM	ROUGH PIGTOE	1992-10	X	LE
172	22678	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1988-07	N	

	Feature ID	Species Name	Species Common Name	Last Observance	State Status	Federal Status
173	22912	MIXED MESOPHYTIC FOREST		1984-08		
174	22920	NOTURUS STIGMOSUS	NORTHERN MADTOM	1983-10	E	
175	23030	EPIOBLASMA TRIQUETRA	SNUFFBOX	1979-08	E	
176	23134	NOTURUS ELEUTHERUS	MOUNTAIN MADTOM	1984-11	E	
177	23178	MOLLUSK BED		1987-09		
178	23286	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	5/19/1994	SC	
179	23990	POTAMILUS OHIENSIS	PINK PAPERSHELL	1980-07	N	
180	24036	VILLOSA FABALIS	RAYED BEAN	1979-09	E	
181	24062	CHRYSOGONUM VIRGINIANUM	GOLDEN-KNEES	1991-05	T	
182	24134	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1983-08	SC	
183	24144	NOTURUS ELEUTHERUS	MOUNTAIN MADTOM	11/5/1987	E	
184	24330	MOXOSTOMA CARINATUM	RIVER REDHORSE	8/22/1988	SC	
185	24386	JUGLANS CINEREA	BUTTERNUT	11/8/2000	P	
186	24398	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	5/24/1994	SC	
187	24400	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	8/31/1994	SC	
188	24754	NOTURUS STIGMOSUS	NORTHERN MADTOM	1984-11	E	
189	24874	PLETHOBASUS CYPHYUS	SHEEPNOSE	1979-08	E	
190	25000	PLETHOBASUS CYPHYUS	SHEEPNOSE	1962-08	E	
191	25074	CARDAMINE DISSECTA	NARROW-LEAVED TOOTHWORT	1988-05	P	
192	25124	GREAT BLUE HERON COLONY		1990-03		
193	25134	CHRYSOGONUM VIRGINIANUM	GOLDEN-KNEES	5/31/1989	T	
194	25204	NON-CALCAREOUS CLIFF COMMUNITY		10/20/1982		
195	25266	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	10/26/1992	SC	
196	25272	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1987-09	SC	
197	25298	ELLIPSARIA LINEOLATA	BUTTERFLY	10/30/1992	E	
198	25330	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1980-06	T	
199	25332	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1980-07	T	
200	25342	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1988-09	N	
201	25360	NOTROPIS AMBLOPS	BIGEYE CHUB	8/22/1994	N	
202	25408	CYPROGENIA STEGARIA	FANSHELL	1993-10	E	LE
203	25412	CYCLONAIAS TUBERCULATA	PURPLE WARTYBACK	10/30/1992	SC	
204	25432	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1993-10	T	
205	25438	FUSCONAIA MACULATA MACULATA	LONG-SOLID	1992-10	E	
206	25442	ELLIPSARIA LINEOLATA	BUTTERFLY	1993-10	E	
207	25472	PLEUROBEMA CORDATUM	OHIO PIGTOE	1992-10	E	
208	25478	QUADRULA METANEVRA	MONKEYFACE	1992-10	E	
209	25486	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1992-10	T	
210	25494	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	10/30/1992	T	
211	25508	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1992-10	T	
212	25520	FUSCONAIA MACULATA MACULATA	LONG-SOLID	1980-09	E	
213	25532	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	10/7/1988	N	
214	25564	PLEUROBEMA SINTOXIA	ROUND PIGTOE	10/30/1992	SC	
215	25568	NOTROPIS AMBLOPS	BIGEYE CHUB	4/14/1992	N	
216	25588	CYCLONAIAS TUBERCULATA	PURPLE WARTYBACK	1980-06	SC	
217	25600	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1980-09	T	
218	25602	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	11/5/1987	N	
219	25604	EPIOBLASMA TRIQUETRA	SNUFFBOX	1980-06	E	
220	25632	POTAMILUS OHIENSIS	PINK PAPERSHELL	1992-10	N	
221	25646	LIGUMIA RECTA	BLACK SANDSHELL	1979-08	T	
222	25648	LIGUMIA RECTA	BLACK SANDSHELL	5/2/1980	T	
223	25656	PLEUROBEMA SINTOXIA	ROUND PIGTOE	1992-10	SC	
224	25668	FUSCONAIA MACULATA MACULATA	LONG-SOLID	1992-10	E	
225	25686	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1988-09	N	
226	25704	PLEUROBEMA RUBRUM	PYRAMID PIGTOE	10/30/1992	E	
227	25720	SCAPHIOPUS HOLBROOKII	EASTERN SPADEFOOT	6/21/2001	E	
228	25742	POTAMILUS OHIENSIS	PINK PAPERSHELL	1992-10	N	
229	25746	NOTROPIS BUCHANANI	GHOST SHINER	8/22/1988	N	
230	25758	FUSCONAIA MACULATA MACULATA	LONG-SOLID	1992-10	E	

	Feature ID	Species Name	Species Common Name	Last Observance	State Status	Federal Status
231	25782	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	10/11/1988	N	
232	25796	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	1988-10	N	
233	25810	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1988-09	SC	
234	25814	EPIOBLASMA TRIQUETRA	SNUFFBOX	1980-07	E	
235	25824	CYPROGENIA STEGARIA	FANSHELL	1992-10	E	LE
236	25838	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1987-09	SC	
237	25842	ELLIPSARIA LINEOLATA	BUTTERFLY	1992-10	E	
238	25848	TRUNCILLA DONACIFORMIS	FAWNSFOOT	10/30/1992	T	
239	25854	MEGALONAIAS NERVOSA	WASHBOARD	10/30/1992	E	
240	25864	POTAMILUS OHIENSIS	PINK PAPERSHELL	10/30/1992	N	
241	25896	PLETHOBASUS CYPHYUS	SHEEPNOSE	10/7/1980	E	
242	25898	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1980-07	T	
243	25908	NOTROPIS BUCHANANI	GHOST SHINER	1988-08	N	
244	25920	LAMPSILIS ABRUPTA	PINK MUCKET	1981-08	E	LE
245	25930	PLEUROBEMA CORDATUM	OHIO PIGTOE	1992-10	E	
246	25964	POTAMILUS OHIENSIS	PINK PAPERSHELL	1981-08	N	
247	25972	PLEUROBEMA CORDATUM	OHIO PIGTOE	1980-09	E	
248	25984	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1993-10	T	
249	25988	HIODON ALOSOIDES	GOLDEYE	1971-09	E	
250	26038	MOXOSTOMA CARINATUM	RIVER REDHORSE	1988-09	SC	
251	26042	OBLIQUARIA REFLEXA	THREEHORN WARTYBACK	1992-10	T	
252	26106	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1987-09	SC	
253	26110	QUADRULA METANEVRA	MONKEYFACE	1993-10	E	
254	26112	FUSCONAIA MACULATA MACULATA	LONG-SOLID	10/30/1992	E	
255	26118	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1977-05	T	
256	26132	PLEUROBEMA CORDATUM	OHIO PIGTOE	1992-10	E	
257	26138	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	7/12/1988	N	
258	26158	PLETHOBASUS CYPHYUS	SHEEPNOSE	1992-10	E	
259	26162	POTAMILUS OHIENSIS	PINK PAPERSHELL	1992-10	N	
260	26192	EPIOBLASMA TRIQUETRA	SNUFFBOX	5/2/1980	E	
261	26226	AMMOCRYPTA PELLUCIDA	EASTERN SAND DARTER	1983-08	SC	
262	26254	POTAMILUS OHIENSIS	PINK PAPERSHELL	9/6/1987	N	
263	26258	ERIMYSTAX DISSIMILIS	STREAMLINE CHUB	10/13/1988	N	
264	26268	PLEUROBEMA CORDATUM	OHIO PIGTOE	10/30/1992	E	
265	26274	PLETHOBASUS CYPHYUS	SHEEPNOSE	1992-10	E	
266	26284	LIGUMIA RECTA	BLACK SANDSHELL	1987-09	T	
267	26330	TRUNCILLA DONACIFORMIS	FAWNSFOOT	1992-10	T	

APPENDIX I.F

Friends of the Lower Muskingum River
Code of Regulations

Approved December 5, 2002
CODE OF REGULATIONS

OF

FRIENDS OF LOWER MUSKINGUM RIVER

ARTICLE I

The Corporation

Section 1.01. Name and Organizational Structure. Friends of Lower Muskingum River (herein after the "Corporation") is a nonprofit corporation organized and existing under the Ohio Nonprofit Corporation Law.

Section 1.02. Location. The place in Ohio where the principal office of the Corporation is to be located is City of Marietta, Washington County, Ohio.

Section 1.03. Purposes. The purposes for which the Corporation is formed are exclusively for charitable, educational or scientific purposes, including, for such purposes, the making of distributions to organizations that qualify as exempt organizations under Section 501 (c) 3 of the Internal Revenue Code of 1986, as amended (or corresponding provisions of any future United States internal revenue law) (the "Code").

The purpose of the corporation is to improve the water quality and natural habitat of the Lower Muskingum River watershed and promote appropriate, improved recreational and economic development within it.

To accomplish this purpose, the Corporation, among other things, will:

1. educate the public concerning the need for and methods of improving water quality, pollution and stream bank stabilization.
2. monitor water quality, develop a land use inventory, identify contaminant sources, and take steps to improve water quality.
3. acquire or hold land as a land trust and otherwise assist in the conservation or preservation of natural or open areas, and, in addition, encourage developers to include areas of greenspace in their developed areas
4. educate the public concerning the conservation and preservation of natural areas and open spaces, and the best management practices for agriculture, commercial, industrial, residential and recreational uses of watershed properties
5. establish cooperative relationships with other organizations and agencies sharing common goals.

ARTICLE II

Membership

Section 2.01. Membership in the Corporation shall be open to all individuals, organizations, and corporations in sympathy with the purposes of Friends of the Lower Muskingum River.

Individuals can become members upon payment of annual dues, which shall be $10.00 initially, and thereafter the annual dues shall be determined and adjusted by the Board. Upon payment of the minimum annual dues, an individual shall be entitled to membership in the Corporation and shall be entitled to one and only one vote, regardless of the amount of money contributed by such individual to the Corporation in excess of the minimum dues.

Organizations or corporations can become members upon payment of a minimum of $100.00 initially, and thereafter the annual dues for non-individual members may be determined by and adjusted by the Board. Upon payment of the minimum annual dues, an organization or corporation shall be entitled to membership in the corporation and shall be entitled to one and only one vote, regardless of any contribution of payments to the Corporation in excess of the minimum dues.

Section 2.02 Government. The government of the Corporation shall be vested in a Board of Directors, which such Board is to have any and all powers conferred upon it by Chapter 1702 of the Ohio Revised Code.

Section 2.03. Annual Meeting. This Corporation shall hold its annual membership meeting in October to elect officers and Directors, to receive various reports, and to transact such other and further business as may come before the membership.

In general, the membership will meet monthly at a time and place designated by the President.

Section 2.04. Quorum The voting members present at any meeting of the general membership shall constitute a quorum for such meeting, provided that no action required by law to be authorized or taken by a specified proportion or number of the voting members may be authorized or taken by a lesser proportion or number. The affirmative vote of a majority of the voting members present at which a quorum is present shall be necessary for the authorization or taking of any action voted upon by the members.

For extraordinary corporate transactions (such as sales of substantially all of the assets, merger, amendment to the Articles, dissolution, etc.) or for the adoption or amendment of a Code of Regulations, an affirmative vote in favor of the proposal by a majority of the members present and voting is required.

Section 2.05. Notice of Meeting of Membership. Notice of the place, date and time of each meeting of the Membership shall be given to each member not more than thirty-one (31) days nor fewer than two (2) days before the date of the meeting. The date of notification and the day of the meeting shall not count as a day for the purpose of notification. Any notice referred to in this Section 2.05 may be given by any reasonable means and need not specify the purpose of the meeting, except that if an amendment to the Articles of Incorporation or these Regulations is proposed a copy of such proposed amendment shall accompany said notice, and except with respect to a proposed action to elect or remove a Director or officer.

The giving of notice shall be deemed to be waived by any Member who shall attend and participate in such meeting, other than to protest the lack of proper notice at or prior to such meeting, and

may be waived, in writing by any Member either before, at or after such meeting. Such writing shall be filed with or entered upon the records of the meeting.

ARTICLE III

Directors

Section 3.01. Power and Authority of Directors. Except as otherwise provided by law, the Articles of Incorporation or these Regulations, all of the authority of the Corporation shall be exercised by the board of Directors. The Directors serving hereunder shall have the power, authority and responsibilities of and shall perform the functions provided for Directors under the Ohio Non-profit corporation law. The Directors shall be, for purposes of any statute or rule of law relating to corporations, members of the Corporation and shall have all rights and privileges of members.

Section 3.02. Provisions Relating to Directors.

A. Number. The initial Board of Directors shall be composed of five members. The number of Directors may be established by the Board of Directors from time to time, but shall never be less than three (3) nor greater than fifteen (15).

B. Term and Election. Each director designated in the Articles of Incorporation shall be deemed to be elected as such as of the time of filing the Articles of Incorporation to serve until his or her replacement is elected at the first annual meeting of the Membership. At the first election, Directors shall be elected into three (3) classes: Class I Directors, Class II Directors and Class III Directors. The initial Class I Directors shall serve for a one (1) year term, the initial Class II Directors shall serve for a two (2) year term and the initial Class III Directors shall serve for a three (3) year term. Thereafter, all Directors shall serve for terms of three (3) years each or until his or her successor is duly elected and qualified. Directors may be reelected.

The election of Directors shall be made at the annual meeting of the Membership, or if action is not then taken, or if there is a vacancy, the election may be made at any regular or special meeting of the Membership for which notice is given as provided in Section 3.04.
Vacancies arising on the Board of Directors or in any office of the Corporation shall be filled by appointment made by the remaining members of the Board.

C. Resignations and Removal. Any Director, by notice in writing to the Board of Directors, may resign at any time. Except as otherwise provided in these Regulations, any Director may be removed from office with or without cause by a majority vote of the whole number of Directors.

Section 3.03. Quorum and Voting.

A. Quorum. Except as otherwise provided in these Regulations, a majority of the Directors then in office shall constitute a quorum for the transactions of business at any meeting of the Directors.

B. Voting. Except as otherwise provided in these Regulations, each Director then in office shall have one (1) vote, and the vote of a majority of the Directors present at a meeting at which a quorum is present shall constitute the action of the Board of Directors.

Section 3.04. Notice of Meeting of Board of Directors. Notice of the place, date and time of each meeting of the Board of Directors shall be given to each Director not more than thirty-one (31) days nor fewer than two (2) days before the date of the meeting. The date of notification and the day of the meeting shall not count as a day for the purpose of notification. Any notice referred to in this Section 3.04 may be given by any reasonable means and need not specify the purpose of the meeting, except that if an amendment to the Articles of Incorporation or these Regulations is proposed a copy of such proposed amendment shall accompany said notice, and except with respect to a proposed action to elect or remove a Director or Officer. The giving of notice shall be deemed to be waived by any Director who shall attend and participate in such meeting, other than to protest the lack of proper notice at or prior to such meeting, and may be waived, in writing, by any Director either before, at or after such meeting. Such writing shall be filed with or entered upon the records of the meeting.

Section 3.05. Meeting of Directors.

A. Regular Meetings. Regular meetings of the Directors, including the annual meeting, shall be at such place (within or without the State of Ohio), date and time as may be fixed by the Board of Directors or by the President as authorized by the Board.

B. Special Meetings. Special meetings of the Board of Directors may be called by the President or by two (2) Directors who deliver a written request to the Secretary for the calling of a meeting at least five (5) business days prior to the minimum notice period (as provided in Section 3.04) for the meeting to be called.

Section 3.06 Action Without Meeting. Any action which might be taken at any meeting of the Board of Directors may be taken without such meeting by a writing or writings signed by all of the members of the Board. The writing or writings evidencing such action taken without a meeting shall be filed with the Secretary of the Corporation and inserted by him or her in the permanent records relating to meetings of the Board of Directors.

ARTICLE IV

Committees

Section 4.01. Committees. The Board of Directors may from time to time create committees consisting of one (1) or more Directors and appoint the members thereof. The Board of Directors may prescribe or limit the powers and duties of any committee.

Section 4.02. Committee Limitations. Each committee shall serve at the pleasure of the Board of Directors, shall act only in the intervals between meetings of the Board or in making reports to the Board and shall be subject to the control and direction of the Board. Except as otherwise provided by law, or these Regulations, each committee shall act by a majority vote of the whole number of its members.

Section 4.03. Action Without Meeting. Any action which might be taken at any meeting of any committee may be taken without such meeting by a writing or writings signed by all of the members of such committee. The writing or writings evidencing such action taken without a meeting shall be filed with the Chair of such committee and inserted by him or her in the permanent records relating to meetings of the committee.

ARTICLE V

Officers

Section 5.01. Election. The Officers of the Corporation shall consist of a President, a Vice-President, a Secretary, a Treasurer and such other Officers as the Directors may from time to time designate. Election of Officers shall take place at each annual meeting of the Board of Directors or, if action is not taken then or if there is a vacancy, at any regular meeting or special meeting for which notice is given as provided in Section 3.04. The same individual may be elected to more than one (1) office. All Officers shall be elected by the Board of Directors by a majority vote for a one (1) year term.

Section 5.02. President. The President shall preside at all meetings of the Board of Directors and Membership. The President shall, subject to the direction of the Board of Directors, have general supervision, direction and control of the business and Officers of the Corporation. The President shall be an ex officio member of all committees. The President shall have the general powers and duties usually vested in the chief executive officer of a nonprofit corporation under the laws of the State of Ohio and shall have such other powers and duties as may be prescribed by the Board of Directors.

Section 5.03. Vice-President. The Vice-President shall in the absence or disability of the President, perform all duties of the President, and, when so acting, shall have the powers and be subject to the restrictions on the President. The Vice-President shall have such other powers and shall perform such other duties as from time to time may be prescribed by the Board of Directors.

Section 5.04. Secretary. The Secretary shall keep the minutes of the proceedings of the Board of Directors, shall be the custodian of all books, records, papers and property of the Corporation and shall perform such other administrative duties as shall be necessary or desirable to carry out the purposes of the Corporation. He or she shall have such other duties as may be established by the President with the consent of the Board of Directors.

Section 5.05. Treasurer. The Treasurer shall be the chief financial officer of the Corporation and shall perform such other administrative duties as shall be necessary or desirable to carry

out the purposes of the Corporation. He or she shall have such other duties as may be established by the President with the consent of the Board of Directors.

ARTICLE VI

Indemnification and Insurance

Section 6.01. Mandatory Indemnification. The Corporation shall indemnify any Officer or Director of the Corporation who was or is a party or is threatened to be made a party to any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative or investigative (including, without limitation, any action threatened or instituted by or in the right of the Corporation), by reason of the fact that he or she is or was a Director, Officer, employee, agent or volunteer of the Corporation, or is or was serving at the request of the Corporation as a director, trustee, officer, employee, agent or volunteer of another corporation (domestic or foreign, nonprofit or for profit), partnership, joint venture, trust or other enterprise, against expenses (including, without limitation, attorney's fees, filing fees, court reporters' fees and transcript costs), judgments, fines and amounts paid in settlement actually and reasonably incurred by him or her in connection with such action, suit or proceeding if he or she acted in good faith and in a manner he or she reasonably believed to be in or not opposed to the best interests of the Corporation, and with respect to any criminal action or proceeding, he or she had no reasonable cause to believe his or her conduct was unlawful. A person claiming indemnification under this Section 6.01 shall be presumed, in respect of any act or omission giving rise to such claim for indemnification, to have acted in good faith and in a manner he she reasonably believed to be in or not opposed to the best interests of the Corporation, and with respect to any criminal matter, to have had no reasonable cause to believe his or her conduct was unlawful, and the termination of any action, suit or proceeding by judgment, order, settlement or conviction, or upon a plea of nolo contendere or its equivalent shall not, of itself, rebut such presumption.

Section 6.02 Court-Approved Indemnification. Anything contained in these Regulations or elsewhere to the contrary notwithstanding:

A. the Corporation shall not indemnify any Officer or Director of the Corporation who was a party to any completed action or suit instituted by or in the right of the Corporation to procure a judgment in its favor by reason of the fact he or she is or was a Director, Officer, employee, agent or volunteer of the Corporation, or is or was serving at the request of the Corporation as a director, trustee, officer, employee, agent or volunteer of another corporation (domestic or foreign, nonprofit or for profit), partnership, joint venture, trust or other enterprise, in respect of any claim, issue or matter asserted in such action or suit as to which he or she shall have been adjudged to be liable for acting with reckless disregard for the best interests of the Corporation or misconduct (other than negligence) in the performance of his or her duties to the Corporation unless and only to the extent that the Court of Common Pleas of Washington County, Ohio, or the court in which such action or suit was brought shall determine upon application that, despite such adjudication of liability, and in view of all the circumstances of the case, he or

she is fairly and reasonably entitled to such indemnity as such Court of Common Pleas or such other court shall deem proper; and

B. the Corporation shall promptly make any such unpaid indemnification as is determined by a court to be proper as contemplated by this Section 6.02.

Section 6.03. Indemnification for Expenses. Anything contained in these Regulations or elsewhere to the contrary notwithstanding, to the extent that an Officer or Director of the Corporation has been successful on the merits or otherwise in defense of any action, suit or proceeding referred to in Section 6.01, or in defense of any claim, issue or matter therein, he or she shall be promptly indemnified by the Corporation against expenses (including, without limitation, attorneys' fees, filing fees, court reporters' fees and transcript costs) actually and reasonably incurred by him or her in connection therewith.

Section 6.04 Determination Required. Any indemnification required under Section 6.01 and not precluded under Section 6.02 shall be made by the Corporation only upon a determination that such indemnification of the Officer or Director is proper under the circumstances because he or she has met the applicable standard of conduct set forth in Section 6.01. Such determination may be made only:

A. by a majority vote of a quorum of Directors of the Corporation who were not or are not parties to, or threatened with, any such action, suit or proceeding;

B. if such a quorum is not obtainable or if a majority of a quorum of disinterested Directors so directs, in a written opinion by independent legal counsel other than an attorney retained previously by the Corporation, or a firm having associated with it an attorney, who has been retained by or who has performed services for the Corporation, or any person to be indemnified, within the past five (5) years; or

C. by the Court of Common Pleas of Washington County, Ohio or (if the Corporation is a party thereto) the court in which such action, suit or proceeding was brought, if any.

Any such determination may be made by a court under division (c) of this Section 6.04 at any time (including, without limitation, any time before, during or after the time when any such determination may be requested of be under consideration by or have been denied or disregarded by the disinterested Directors under division (A) or by independent legal counsel under division (B) of this Section 6.04) No decision for any reason to deny any such determination, by the disinterested Directors under division (A) or by independent legal counsel under division (B) of this Section 6.04 shall be evidence in rebuttal of the presumption recited in Section 6.01. Any determination made by the disinterested Directors under division (A) or by independent legal counsel under division (b) of this Section 6.04 to make indemnification in respect of any claim, issue or matter asserted in an action or suit threatened or brought by or in the right of the Corporation shall be promptly communicated to the person who threatened or brought such action or suit, and within ten (10) days after receipt of such notification such person shall have the right to petition the Court of Common Pleas of Washington county, Ohio, or the court in which such action or suit was brought, if any, to review the reasonableness of such determination.

Section 6.05. Advances for Expenses. Expenses (including, without limitation, attorneys' fees, filing fees, court reporters' fees and transcript costs) incurred in defending any action, suit or proceeding referred to in Section 6.01 shall be paid by the Corporation in advance of the final disposition of such action, suit or proceeding to or on behalf of the Officer or Director promptly as such expenses are incurred by him or her, but only if such Officer or Director shall first agree, in writing, to repay all amounts so paid in respect of any claim, issue or other matter asserted in such action, suit or proceeding in defense of which he or she shall not have been successful on the merits or otherwise:

A. if it shall ultimately be determined a provided in Section 6.04 that he or she is not entitled to be indemnified by the Corporation as provided under Section 6.01; or

B. if, in respect of any claim, issue or other matter asserted by or in the right of the Corporation in such action or suit, he or she shall have been adjudged to be liable for acting with reckless disregard for the best interests of the Corporation or misconduct (other than negligence) in the performance of his or her duties to the Corporation, unless and only to the extent that the Court of Common Pleas of Washington county, Ohio, or the court in which such action or suit was brought, shall determine upon application that, despite such adjudication of liability, and in view of all the circumstances, he or she fairly and reasonably entitled to all or part of such indemnification.

Section 6.06. Insurance. The Corporation may purchase and maintain insurance or furnish similar protection, including but not limited to trust funds, letters of credit or self-insurance, on behalf of any person who is or was a Director, Officer, employee, agent or volunteer of the Corporation, or is or was serving at the request of the Corporation as a director, trustee, officer, employee, agent or volunteer of another corporation (domestic or foreign, nonprofit or for profit), partnership, joint venture, trust or other enterprise, against any liability asserted against him or her and incurred by him or her in any such capacity, or arising out of his or her status as such, whether or not the Corporation would have the obligation or the power to indemnify him or her against such liability under the provisions of the ARTICLE VI. Insurance may be purchased from or maintained with a person in whom the Corporation has a financial interest.

APPENDIX II.A

Water quality data Meigs Creek

Appendix II A
Water Quality Data

ILGARD ID	Date Collected	Conductivity	pH	Total Suspended Solids	Total Solids	Al	Ba	Ca	Cr	Cu	Hardness Total	Fe	Mn	Mg	Ni	K	Na	Sr	Zn
		umhos/cm	s.u.	mg/L	mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	mg/L	µg/L	µg/L
MF-00-55	4/18/2004	504	8.23 *	<5	318	<200	59	68	<30	<10	240	108	17	12	<40	2	9	312	<10
MF-10-20	4/18/2004	726	8.17*	8	498	<200	68	107	<30	<10	378	282	27	46	<40	<2	11	429	<10
MF-00-75	4/18/2004	558	8.44*	7	362	<200	66	81	<30	<10	289	357	21	30	<40	<2	11	402	11
MF-11-01	4/18/2004	497	8.44*	<5	306	<200	64	68	<30	<10	236	188	16	17	<40	2	10	307	<10
MF-00-45	4/18/2004	478	8.44*	<5	292	<200	60	67	<30	<10	237	95	17	16	<40	2	10	302	<10
BS-00-05	4/18/2004	618	8.42*	<5	408	<200	62	94	<30	<10	325	122	22	25	<40	2	7	381	<10
MF-00-30	4/18/2004	499	8.55*	<5	320	<200	64	75	<30	<10	261	112	18	21	<40	2	9	334	<10
MF-00-25	4/18/2004	492	8.64*	<5	318	<200	60	71	<30	<10	247	116	17	18	<40	2	9	315	<10
MF-00-10	4/18/2004	506	8.59*	<5	318	<200	63	72	<30	<10	250	140	17	26	<40	2	9	325	<10
MC-00-36	4/18/2004	753	8.29*	5	532	<200	64	102	<30	<10	386	227	32	66	<40	2	14	610	<10
OR-00-11	4/19/2004	446	8.38*	<5	272	<200	52	63	<30	<10	227	<50	17	<10	<40	<2	7	311	<10
OR-00-10	4/19/2004	447	8.44*	<5	272	<200	56	66	<30	<10	239	74	18	<10	<40	<2	7	330	<10
OR-00-01	4/19/2004	459	8.41*	<5	278	<200	56	66	<30	<10	235	59	17	<10	<40	<2	7	329	<10
DF-00-30	4/19/2004	1520	8.25*	14	1250	<200	32	173	<30	<10	737	342	74	141	<40	2	76	1690	<10
BI-00-01	4/19/2004	2180	8.21*	<5	1840	<200	<15	189	<30	<10	842	<50	90	101	<40	3	231	2940	<10
BL-00-70	4/19/2004	4090	7.13	<5	3350	<200	<15	199	<30	<10	1010	<50	125	<10	<40	8	686	6670	<10
TR-00-01	4/19/2004	1590	8.4	5	1290	<200	18	170	<30	<10	721	151	72	335	<40	4	112	2060	<10
RE-00-03	4/19/2004	850	8.22	39	666	492	37	132	<30	<10	474	1100	35	334	<40	2	10	700	<10
BF-00-35	4/19/2004	2120	8.15	40	1880	362	26	241	<30	<10	1100	804	120	292	<40	4	128	2570	<10
HR-00-50	4/19/2004	953	8.16	5	732	<200	27	133	<30	<10	534	167	49	180	<40	<2	7	923	<10
MF-00-03	4/19/2004	776	8.22	67	614	<200	68	110	<30	<10	410	322	33	74	<40	2	10	618	<10
MC-00-25	4/19/2004	770	8.18	11	540	<200	69	109	<30	<10	412	287	34	76	<40	2	15	658	<10
MC-00-20	4/19/2004	781	8.34	<5	548	<200	69	106	<30	<10	400	218	33	54	<40	2	19	657	<10
DF-00-01	4/19/2004	1520	8.29	20	1250	254	37	177	<30	<10	759	591	77	156	<40	3	82	1790	<10
MC-00-16	4/19/2004	1160	8.34	9	896	<200	53	140	<30	<10	576	341	55	90	<40	2	49	1210	<10
MC-00-13	4/19/2004	1120	8.39	9	852	<200	53	134	<30	<10	545	332	51	79	<40	2	46	1130	<10
MS-00-01	4/28/2004	492	8.23*	<5	304	<200	64	63	<30	<10	219	<50	15	10	<40	2	13	284	<10
MC-00-83	4/28/2004	485	8.23*	<5	300	<200	60	61	<30	<10	222	<50	17	15	<40	2	10	299	<10
MC-00-88	4/28/2004	388	8.15*	<5	240	<200	52	45	<30	<10	166	<50	13	<10	<40	2	8	211	<10
MC-00-78	4/28/2004	494	8.32*	<5	314	<200	55	60	<30	<10	220	<50	17	12	<40	2	9	292	<10
MC-00-77	4/28/2004	791	8.38*	<5	548	<200	51	82	<30	<10	328	88	30	16	<40	2	37	639	<10

Appendix II A
Water Quality Data

ILGARD ID	Date Collected	Conductivity	pH	Total Suspended Solids	Total Solids	Al	Ba	Ca	Cr	Cu	Hardness Total	Fe	Mn	Mg	Ni	K	Na	Sr	Zn
GF-00-01	4/28/2004	1090	8.46*	<5	804	<200	47	104	<30	<10	437	<50	43	13	<40	2	65	995	<10
GF-02-01	4/28/2004	1410	8.31*	<5	1120	<200	36	148	<30	<10	654	<50	69	45	<40	2	65	1560	<10
GF-00-70	4/28/2004	1210	8.41*	<5	846	<200	56	88	<30	<10	352	88	32	17	<40	2	122	949	<10
MC-00-70	4/28/2004	758	8.39*	<5	538	<200	54	77	<30	<10	303	234	27	30	<40	2	35	584	<10
RR-00-01	4/28/2004	687	8.5*	<5	480	<200	64	94	<30	<10	350	97	28	15	<40	<2	9	463	<10
MC-00-67	4/28/2004	722	8.45*	<5	492	<200	59	82	<30	<10	316	100	27	26	<40	2	33	571	<10
MC-00-65	4/28/2004	729	8.49*	<5	500	<200	61	80	<30	<10	307	63	26	25	<40	2	34	556	<10
MC-00-60	4/28/2004	814	8.39*	<5	570	<200	60	90	<30	<10	348	101	30	51	<40	2	33	610	<10
MC-00-40	4/28/2004	843	8.28*	<5	608	<200	59	100	<30	<10	390	168	34	100	<40	2	24	685	<10
BR-00-01	4/28/2004	891	8.26*	10	672	<200	72	134	<30	<10	475	329	34	51	<40	<2	7	576	<10
FM-00-70	4/28/2004	485	8.44*	<5	292	<200	62	69	<30	<10	230	123	14	53	<40	<2	6	305	<10
MC-00-03	4/29/2004	1240	8.26*	11	964	<200	57	135	<30	<10	555	353	53	77	<40	2	61	1180	<10
MC-00-08	4/29/2004	1250	8.23*	13	976	227	56	140	<30	<10	580	470	56	85	<40	2	61	1240	<10
PR-00-03	4/29/2004	520	8.29*	<5	320	<200	55	70	<30	<10	253	<50	19	<10	<40	<2	10	366	<10
FM-00-05	4/29/2004	510	8.31*	<5	306	<200	69	73	<30	<10	252	<50	17	11	<40	<2	7	369	<10
PR-00-50	4/29/2004	474	8.46*	<5	282	<200	50	63	<30	<10	223	76	16	14	<40	<2	10	301	<10
FM-02-01	4/29/2004	522	8.31*	11	322	<200	58	73	<30	<10	252	109	17	11	<40	<2	8	369	<10
FM-00-25	4/29/2004	506	8.29*	<5	180	<200	77	80	<30	<10	274	<50	18	13	<40	<2	7	405	<10
FM-00-30	4/29/2004	505	8.35*	<5	304	<200	78	80	<30	<10	274	<50	18	11	<40	<2	7	386	<10
FM-00-55	4/29/2004	521	8.3*	<5	318	<200	87	85	<30	<10	286	95	18	33	<40	<2	7	391	<10
MC-00-03	7/30/2003 9	1380	8.2		1120	250	66	151	<30	<10	632	446	62	61	<40	3	77	1360	<10
MC-00-40	7/30/2003 1	891	8.13		652	<200	83	116	<30	<10	438	353	36	155	<40	2	26	690	<10
MC-00-16	7/30/2003 1	1520	8.22		1560	403	58	167	<30	<10	709	675	71	99	<40	3	89	1530	<10
MC-00-13	7/30/2003 1	1480	8.2		1240	514	61	160	<30	<10	680	775	68	100	<40	3	87	1490	<10
MC-00-77	7/30/2003 1	1050	8.36		792	<200	66	99	<30	<10	408	65	39	12	<40	3	75	835	<10
MC-00-36	7/30/2003 1	884	8.14		652	<200	82	116	<30	<10	442	399	37	86	<40	2	22	692	<10
MC-00-08	7/30/2003 1	1440	8.18		1200	562	63	154	<30	<10	652	802	65	87	<40	3	83	1440	<10
MC-00-83	7/30/2003 3	497	7.99		310	<200	79	64	<30	<10	226	<50	16	<10	<40	4	12	306	<10
BR-00-01	8/13/2003 9	884	7.98	24	672	436	94	135	<30	<10	469	716	32	107	<40	2	9	559	<10
BI-00-01	8/12/2003 9	2590	8.16	<5	2200	<200	16	166	<30	<10	822	54	99	74	<40	4	366	3440	<10
BL-00-70	8/12/2003 1	3880	7.2	<5	3210	<200	<15	192	<30	<10	1060	<50	141	<10	<40	7	704	7520	<10
BS-00-05	8/13/2003 1	724	8.24	<5	510	<200	81	108	<30	<10	377	132	26	18	<40	3	8	434	<10

Appendix II A
Water Quality Data

ILGARD ID	Date Collected	Conductivity	pH	Total Suspended Solids	Total Solids	Al	Ba	Ca	Cr	Cu	Hardness Total	Fe	Mn	Mg	Ni	K	Na	Sr	Zn
BF-00-35	8/12/2003 1	2030	8.22	7	1790	<200	28	194	<30	<10	925	192	115	162	<40	4	138	2110	<10
DF-00-30	8/12/2003 2	1630	8.31	12	1380	<200	34	158	<30	<10	716	311	78	82	<40	3	102	1760	<10
DF-00-01	7/30/2003 1	1780	8.2		702	487	40	190	<30	<10	828	871	86	151	<40	3	117	1910	<10
FM-00-05	7/30/2003 1	536	8.28		334	<200	82	77	<30	<10	270	146	19	22	<40	2	9	408	<10
FM-00-55	8/13/2003 5	542	8.36	15	344	306	118	84	<30	<10	284	466	18	58	<40	3	8	384	<10
GF-00-70	8/13/2003 2	2270	8.46	7	1670	<200	42	88	<30	<10	434	149	52	48	<40	3	370	1500	<10
GF-00-01	7/30/2003 2	1250	8.48		982	<200	60	111	<30	<10	475	<50	48	<10	<40	3	100	1040	<10
HR-00-50	8/12/2003 1	966	8.1	<5	770	<200	38	124	<30	<10	528	193	53	130	<40	2	8	944	<10
MF-00-55	8/13/2003 1	686	8.29	5	472	<200	92	95	<30	<10	340	120	25	29	<40	3	12	438	<10
MF-00-30	8/13/2003 9	643	8.12	12	448	<200	87	92	<30	<10	320	411	22	46	<40	3	9	385	<10
MF-00-03	7/30/2003 1	930	8.22		660	<200	80	127	<30	<10	490	212	42	79	<40	3	15	761	<10
MF-00-10	8/13/2003 9	626	8.05	28	442	515	94	90	<30	<10	311	815	21	120	<40	3	10	383	<10
MF-00-75	8/13/2003 1	735	8.18	36	552	<200	92	100	<30	<10	365	398	28	37	<40	4	14	524	<10
MF-00-75	8/13/2003 1	734	8.18	34	540	<200	93	100	<30	<10	365	327	28	31	<40	4	14	526	<10
OR-00-10	7/30/2003 1	536	8.33		1280	<200	70	79	<30	<10	280	153	20	10	<40	2	8	389	<10
PR-00-03	7/30/2003 1	577	8.25		362	<200	69	80	<30	<10	290	162	22	28	<40	2	12	436	<10
RE-00-03	8/12/2003 1	963	7.95	11	742	<200	44	140	<30	<10	514	358	40	207	<40	2	14	776	<10
TR-00-01	8/12/2003 1	1890	8.29	12	1600	<200	20	156	<30	<10	740	98	85	140	<40	5	163	2390	<10

Appendix II A
Water Quality Data

ILGARD ID	As	Cd	Pb	Se	Turbidity	Acidity	Alkalinity	Chloride	NH3	Nitrate+ nitrite	Sulfate	TKN	Total P
	µg/L	µg/L	µg/L	µg/L	ntu	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MF-00-55	<2	<0.20	<2.0	<2.0	2.47*	<5	174	12.3	<0.050	<0.10	71.9	0.31	<0.010
MF-10-20	<2	<0.20	<2.0	<2.0	4.92*	<5	230	11.6	<0.050	<0.10	142	0.21	0.035
MF-00-75	<2	<0.20	<2.0	<2.0	3.88*	<5	202	16.8	<0.050	<0.10	74.9	0.26	0.019
MF-11-01	<2	<0.20	<2.0	<2.0	2.54*	<5	190	17.7	<0.050	<0.10	48.2	0.24	<0.010
MF-00-45	<2	<0.20	<2.0	<2.0	2.02*	<5	168	12.7	<0.050	<0.10	63.9	<0.20	<0.010
BS-00-05	<2	<0.20	<2.0	<2.0	3.12*	<5	202	<5	<0.050	<0.10	124	0.22	0.016
MF-00-30	<2	<0.20	<2.0	<2.0	2.63*	<5	175	9.5	<0.050	<0.10	76.4	0.24	<0.010
MF-00-25	<2	<0.20	<2.0	<2.0	2.78*	<5	172	9.2	<0.050	<0.10	70.5	0.21	0.036
MF-00-10	<2	<0.20	<2.0	<2.0	2.04*	<5	183	10.1	<0.050	<0.10	68.4	<0.20	0.117
MC-00-36	<2	<0.20	<2.0	<2.0	2.56*	<5	196	8	<0.050	<0.10	187	<0.20	0.823
OR-00-11	<2	<0.20	<2.0	<2.0	1.84	<5	184	<5	<0.050	<0.10	54.6	<0.20	0.016
OR-00-10	<2	<0.20	<2.0	<2.0	2.5	<5	184	<5	<0.050	<0.10	53.7	<0.20	0.011
OR-00-01	<2	<0.20	<2.0	<2.0	2.55	<5	192	<5	<0.050	<0.10	55	<0.20	0.02
DF-00-30	<2	<0.20	<2.0	<2.0	4.02	<5	219	<5	<0.050	0.14	663	0.21	0.061
BI-00-01	<2	<0.20	<2.0	<2.0	1.32	<5	275	<5	<0.050	<0.10	995	0.21	0.126
BL-00-70	<2	<0.20	<2.0	2.2	<1	<5	621	8.9	<0.050	6.67	1960	0.21	0.016
TR-00-01	<2	<0.20	<2.0	<2.0	2.17	<5	237	<5	<0.050	0.19	686	0.29	0.048
RE-00-03	<2	<0.20	<2.0	<2.0	11.2	<5	1181	<5	<0.050	<0.10	299	0.21	0.082
BF-00-35	<2	<0.20	<2.0	<2.0	10.1	<5	250	7.8	<0.050	<0.10	1020	0.26	0.024
HR-00-50	<2	<0.20	<2.0	<2.0	2.88	<5	186	<5	<0.050	<0.10	355	0.22	<0.010
MF-00-03	<2	<0.20	<2.0	<2.0	6.24	<5	201	<5	<0.050	<0.10	222	0.29	0.056
MC-00-25	<2	<0.20	<2.0	<2.0	5.2	<5	197	6.4	<0.050	<0.10	223	<0.20	0.053
MC-00-20	<2	<0.20	<2.0	<2.0	4.68	<5	199	6.8	<0.050	<0.10	224	0.21	<0.010
DF-00-01	<2	<0.20	<2.0	<2.0	7.84	<5	219	5	<0.050	0.18	667	0.31	0.01
MC-00-16	<2	<0.20	<2.0	<2.0	5.73	<5	212	5.6	<0.050	<0.10	434	0.28	0.027
MC-00-13	<2	<0.20	<2.0	<2.0	5.7	<5	210	6.1	<0.050	<0.10	417	0.28	0.019
MS-00-01	<2	<0.20	<2.0	<2.0	1.22*	<5	170	23.5	<0.050*	<0.10*	56.2	<0.2*	<0.01*
MC-00-83	<2	<0.20	<2.0	<2.0	1.3*	<5	158	12.5	<0.050*	<0.10*	79.8	<0.2*	<0.01*
MC-00-88	<2	<0.20	<2.0	<2.0	1.55*	<5	133	9.4	<0.050*	<0.10*	122	<0.2*	<0.01*
MC-00-78	<2	<0.20	<2.0	<2.0	<1*	<5	155	11.4	<0.050*	<0.10*	91.9	<0.2*	<0.01*
MC-00-77	<2	<0.20	<2.0	<2.0	1.22	<5	186	10.3	<0.050*	<0.10*	243	<0.2*	<0.01*

Appendix II A
Water Quality Data

ILGARD ID	As	Cd	Pb	Se	Turbidity	Acidity	Alkalinity	Chloride	NH3	Nitrate+ nitrite	Sulfate	TKN	Total P
GF-00-01	<2	<0.20	<2.0	<2.0	1.33	<5	218	9.3	<0.050*	<0.10*	380	0.26*	<0.01*
GF-02-01	<2	<0.20	<2.0	<2.0	<1	<5	219	7.2	<0.050*	<0.10*	638	0.33*	0.01*
GF-00-70	<2	<0.20	<2.0	<2.0	1.26	<5	280	15.9	<0.050*	0.65*	359	0.23*	<0.01*
MC-00-70	<2	<0.20	<2.0	<2.0	4	<5	182	10.5	<0.050*	<0.10*	224	0.29*	<0.01*
RR-00-01	<2	<0.20	<2.0	<2.0	2.28	<5	196	7.8	<0.050*	<0.10*	182	0.35*	0.01*
MC-00-67	<2	<0.20	<2.0	<2.0	1.3	<5	186	9.7	<0.050*	<0.10*	200	0.27*	0.019*
MC-00-65	<2	<0.20	<2.0	<2.0	1.7	<5	194	9.5	<0.050*	<0.10*	176	0.22*	<0.01*
MC-00-60	<2	<0.20	8.4	<2.0	1.85	<5	200	8.8	<0.050*	<0.10*	234	<0.2*	<0.01*
MC-00-40	<2	<0.20	<2.0	<2.0	1.31	<5	206	8.1	<0.050*	<0.10*	261	<0.2*	0.011*
BR-00-01	<2	<0.20	<2.0	<2.0	6.18	<5	235	<5	<0.050*	<0.10*	294	<0.2*	0.051*
FM-00-70	<2	<0.20	<2.0	<2.0	2.37	<5	209	10	<0.050*	<0.10*	42.2	<0.2*	<0.01*
MC-00-03	<2	<0.20	<2.0	<2.0	2.74	<5	226	9.9	<0.050*	0.15*	458	0.22*	<0.01*
MC-00-08	<2	<0.20	<2.0	<2.0	3.4	<5	226	9.3	<0.050*	0.11*	470	0.22*	0.02*
PR-00-03	<2	<0.20	<2.0	<2.0	1.2	<5	230	10.2	<0.050*	<0.10*	54.4	<0.2*	<0.01*
FM-00-05	<2	<0.20	<2.0	<2.0	1.33	<5	230	10.2	<0.050*	<0.10*	37.4	0.33*	<0.01*
PR-00-50	<2	<0.20	<2.0	<2.0	2.03	<5	204	11.3	<0.050*	<0.10*	40.6	0.29*	0.035*
FM-02-01	<2	<0.20	<2.0	<2.0	1.51	<5	236	12.9	<0.050*	<0.10*	35.9	<0.2*	0.105*
FM-00-25	<2	<0.20	<2.0	<2.0	1.34	<5	231	9.4	<0.050*	<0.10*	36.4	<0.2*	0.02*
FM-00-30	<2	<0.20	<2.0	<2.0	1.56	<5	228	9.8	<0.050*	<0.10*	37.5	<0.2*	<0.01*
FM-00-55	<2	<0.20	<2.0	<2.0	1.82	<5	235	11.4	<0.050*	<0.10*	37.1	<0.2*	0.014*
MC-00-03	<2.0	<.20	<2.0	<2.0	13.5	<5.0	227		<.050	0.15	513	0.24	0.058
MC-00-40	<2.0	<.20	<2.0	<2.0	10.5	<5.0	228		<.050	<.10	243	0.39	0.043
MC-00-16	<2.0	<.20	<2.0	<2.0	16.3	<5.0	196		<.050	0.12	635	0.29	0.035
MC-00-13	<2.0	<.20	<2.0	<2.0	19.8	<5.0	222		<.050	0.13	584	<.20	0.041
MC-00-77	<2.0	<.20	<2.0	<2.0	1.65	<5.0	222		<.050	0.16	324	0.2	0.075
MC-00-36	<2.0	<.20	<2.0	<2.0	9.16	<5.0	212		<.050	<.10	245	<.20	0.11
MC-00-08	<2.0	<.20	<2.0	<2.0	21.1	<5.0	231		<.050	0.13	562	<.20	0.037
MC-00-83	<2.0	<.20	<2.0	<2.0	1.27	<5.0	170		<.050	0.53	57.8	0.26	0.022
BR-00-01	<2.0	<.20	<2.0	<2.0	22.9	<5.0	228	5.3	<0.05	<.10	229	0.51	0.036
BI-00-01	2.4	<.20	<2.0	<2.0	2.08	<5.0	300	<5.0	<0.05	<.10	1140	0.36	<0.010
BL-00-70	<2.0	<.20	<2.0	<2.0	<1.00	<5.0	591	10	<0.05	4	1690	<.20	0.014
BS-00-05	<2.0	<.20	<2.0	<2.0	3.65	<5.0	193	5.8	<0.05	<.10	166	0.33	0.01

Appendix II A
Water Quality Data

ILGARD ID	As	Cd	Pb	Se	Turbidity	Acidity	Alkalinity	Chloride	NH3	Nitrate+ nitrite	Sulfate	TKN	Total P
BF-00-35	<2.0	<.20	<2.0	<2.0	2.67	<5.0	196	9.7	<0.05	<.10	986	0.29	<0.010
DF-00-30	<2.0	<.20	<2.0	<2.0	4.81	<5.0	206	7.8	<0.05	<.10	678	0.28	0.01
DF-00-01	<2.0	<.20	<2.0	<2.0	20.5	<5.0	214		<.050	0.11	807	0.21	0.047
FM-00-05	<2.0	<.20	<2.0	<2.0	4.08	<5.0	210		<.050	<.10	37.8	<.20	0.025
FM-00-55	<2.0	<.20	<2.0	<2.0	10.6	<5.0	208	14.3	<0.05	<.10	33.3	0.25	0.021
GF-00-70	<2.0	<.20	<2.0	<2.0	4.04	<5.0	307	36.5	<0.05	0.82	866	0.32	0.016
GF-00-01	<2.0	<.20	<2.0	<2.0	1.08	<5.0	221		<.050	<.10	448	<.20	0.021
HR-00-50	<2.0	<.20	<2.0	<2.0	2.59	<5.0	164	5.8	<0.05	<.10	365	0.28	<0.010
MF-00-55	<2.0	<.20	<2.0	<2.0	4.42	<5.0	188	15	<0.05	<.10	135	0.31	<0.010
MF-00-30	<2.0	<.20	<2.0	<2.0	11.3	<5.0	180	9.4	<0.05	<.10	125	0.27	0.048
MF-00-03	<2.0	<.20	<2.0	<2.0	5.72	<5.0	221		<.050	<.10	276	<.20	0.441
MF-00-10	<2.0	<.20	<2.0	<2.0	23.7	<5.0	183	11.8	<0.05	<.10	108	0.3	0.03
MF-00-75	<2.0	<.20	<2.0	<2.0	28.6	<5.0	215	20.6	<0.05	0.19	124	0.63	0.023
MF-00-75	<2.0	<.20	<2.0	<2.0	25.3	<5.0	216	20.5	<0.05	0.19	126	0.61	0.033
OR-00-10	<2.0	<.20	<2.0	<2.0	3.24	<5.0	232		<.050	<.10	55.8	<.20	0.023
PR-00-03	<2.0	<.20	<2.0	<2.0	4.14	<5.0	237		<.050	<.10	42.3	<.20	<0.010
RE-00-03	<2.0	<.20	<2.0	<2.0	8.06	<5.0	197	6.8	<0.05	<.10	328	0.34	<0.010
TR-00-01	2	<.20	<2.0	<2.0	5.7	<5.0	246	<5.0	<0.05	<.10	838	0.54	0.053

APPENDIX II.B

Biological data Meigs Creek

Stream: HORSE RUN 9/21/2003
ILGARD ID: HR-00-50

Metric	Value	MAIS Value
% 5 Dominant Taxa	88.64	1
Modified HBI	4.58	1
% Haptobenthos	81.14	1
EPT Index	4.00	1
# Ephemeropera	1.00	1
% Ephemeroptera	6.29	1
SDI	0.80	1
# Intolerant Taxa	8.00	1
% Scrapers	17.65	2
	Total	10

Biological Condition Category
Poor

Taxon	Total	Kick	Dip
BAETIDAE	31	30	1
HYDROPSYCHIDAE	164	158	6
PHILOPOTAMIDAE	105	103	2
PHRYGANEIDAE	1		1
ELMIDAE	87	82	5
CORYDALIDAE	5	5	
AESHNIDAE	5	1	4
CALOPTERYGIDAE	7	1	6
COENAGRIONIDAE	2	2	
TIPULIDAE	33	30	3
CHIRONOMIDAE	1		1
TABANIDAE	1		1
VELIIDAE	2		2
GAMMARIDAE	1	1	
CAMBARIDAE	1	1	
PLANORBIDAE	1	1	
CORBICULIDAE	48	40	8
TOTALS	**495**	**455**	**40**

Stream: GUYST FORK 9/17/2003
ILGARD ID: GF-00-08

Taxon	Total	Kick	Dip
HEPTAGENIIDAE	2	2	
PERLIDAE	9	6	3
HYDROPSYCHIDAE	291	264	27
PHILOPOTAMIDAE	30	27	3
DYTISCIDAE	5		5
HYDROPHILIDAE	1		1
DRYOPIDAE	1		1
ELMIDAE	66	63	3
STAPHYLINIDAE	1		1
CORYDALIDAE	1		1
GOMPHIDAE	1		1
AESHNIDAE	5	1	4
CALOPTERYGIDAE	9	1	8
COENAGRIONIDAE	2		2
TIPULIDAE	3	3	
SIMULIIDAE	10	10	
CHIRONOMIDAE	21	19	2
GERRIDAE	2		2
VELIIDAE	13	1	12
CAMBARIDAE	8		8
SPHAERIIDAE	1		1
TOTALS	**482**	**397**	**85**

Metric	Value	MAIS Value
% 5 Dominant Taxa	90.15	1
Modified HBI	5.32	1
% Haptobenthos	89.51	2
EPT Index	4.00	1
# Ephemeropera	1.00	1
% Ephemeroptera	0.43	1
SDI	0.59	0
# Intolerant Taxa	11.00	2
% Scrapers	14.78	2
	Total	11
Biological Condition Category		**Poor**

Appendix IIB
Biological Data

Stream: FOURMILE RUN 9/20/2003
ILGARD ID: FM-00-55

Metric	Value	MAIS Value
% 5 Dominant Taxa	83.84	1
Modified HBI	5.17	1
% Haptobenthos	85.48	2
EPT Index	6.00	1
# Ephemeropera	3.00	1
% Ephemeroptera	6.32	1
SDI	0.69	1
# Intolerant Taxa	9.00	1
% Scrapers	26.00	2
	Total	11

Biological Condition Category
Poor

Taxon	**Total**	**Kick**	**Dip**
HEPTAGENIIDAE	13	13	
ISONYCHIIDAE	3	3	
BAETIDAE	11	11	
PERLIDAE	12	12	
LEUCTRIDAE	1	1	
HYDROPSYCHIDAE	214	214	
DYTISCIDAE	3		3
HYDROPHILIDAE	2		2
ELMIDAE	98	98	
SIALIDAE	1		1
CORYDALIDAE	12	12	
CALOPTERYGIDAE	1		1
TIPULIDAE	13	12	1
CHIRONOMIDAE	16	15	1
MUSCIDAE	1	1	
VELIIDAE	1		1
CORIXIDAE	2		2
GAMMARIDAE	1	1	
CAMBARIDAE	17	14	3
PHYSIDAE	6	4	2
SPHAERIIDAE	1	1	
CORBICULIDAE	1		1
TOTALS	**430**	**412**	**18**

Stream: MANS FORK 9/20/2003
ILGARD ID: MF-00-75

Taxon	**Total**	**Kick**	**Dip**
HEPTAGENIIDAE	52	51	1
BAETIDAE	10	10	
PERLIDAE	11	10	1
HYDROPSYCHIDAE	144	144	
PHILOPOTAMIDAE	18	18	
DYTISCIDAE	1		1
HYDROPHILIDAE	1	1	
ELMIDAE	19	19	
CORYDALIDAE	5	5	
TIPULIDAE	10	10	
SIMULIIDAE	1	1	
CHIRONOMIDAE	10	9	1
STRATIOMYIIDAE	1	1	
GERRIDAE	2	1	1
VELIIDAE	14	1	13
GAMMARIDAE	1	1	
CAMBARIDAE	9	8	1
PHYSIDAE	2	2	
TOTALS	**311**	**292**	**19**

Metric	Value	MAIS Value
% 5 Dominant Taxa	83.73	1
Modified HBI	4.80	1
% Haptobenthos	88.47	2
EPT Index	5.00	1
# Ephemeropera	2.00	1
% Ephemeroptera	21.02	2
SDI	0.72	1
# Intolerant Taxa	8.00	1
% Scrapers	24.07	2
	Total	12

Biological Condition Category
Good

Appendix IIB
Biological Data

Stream: ONION RUN REP #2 9/21/2003
ILGARD ID: OR-00-10

Metric	Value	MAIS Value
% 5 Dominant Taxa	82.63	1
Modified HBI	5.22	1
% Haptobenthos	90.53	2
EPT Index	7.00	1
# Ephemeropera	3.00	1
% Ephemeroptera	13.68	1
SDI	0.72	1
# Intolerant Taxa	11.00	2
% Scrapers	10.00	1
	Total	11

Biological Condition Category
Poor

Taxon	Total	Kick	Dip
HEPTAGENIIDAE	3	2	1
ISONYCHIIDAE	3	3	
BAETIDAE	20	20	
PERLIDAE	4	2	2
NEMOURIDAE	1	1	
HYDROPSYCHIDAE	96	96	
PHILOPOTAMIDAE	11	11	
HALIPLIDAE	1		1
ELMIDAE	16	14	2
CORYDALIDAE	3	3	
GOMPHIDAE	1		1
TIPULIDAE	2	2	
SIMULIIDAE	14	14	
CHIRONOMIDAE	10	10	
GAMMARIDAE	1		1
CAMBARIDAE	4	1	3
TOTALS	**190**	**179**	**11**

Stream: ONION RUN REP # 1 9/21/2003
ILGARD ID: OR-00-10

Taxon	Total	Kick	Dip
HEPTAGENIIDAE	2	2	
ISONYCHIIDAE	10	10	
BAETIDAE	21	21	
PERLIDAE	4	4	
PERLODIDAE	2	2	
NEMOURIDAE	2	2	
HYDROPSYCHIDAE	111	111	
PHILOPOTAMIDAE	36	36	
PSEPHENIDAE	1		1
ELMIDAE	17	15	2
CORYDALIDAE	11	11	
TIPULIDAE	5	4	1
SIMULIIDAE	22	22	
CHIRONOMIDAE	18	18	
GERRIDAE	1		1
VELIIDAE	1		1
CAMBARIDAE	3	2	1
T0TALS	**267**	**260**	**7**

Metric	Value	MAIS Value
% 5 Dominant Taxa	78.49	2
Modified HBI	4.89	1
% Haptobenthos	90.19	2
EPT Index	8.00	2
# Ephemeropera	3.00	1
% Ephemeroptera	12.45	1
SDI	0.78	1
# Intolerant Taxa	12.00	2
% Scrapers	7.55	1
	Total	13

Biological Condition Category
Good

Appendix IIB
Biologial Data

Stream: BORDER SCHOOL TRIBUTARY 9/20/2003
ILGARD ID: BS-00-05

Metric	Value	MAIS Value
% 5 Dominant Taxa	92.41	1
Modified HBI	5.32	1
% Haptobenthos	81.34	1
EPT Index	6.00	1
# Ephemeropera	4.00	2
% Ephemeroptera	20.39	2
SDI	0.66	0
# Intolerant Taxa	8.00	1
% Scrapers	21.48	2
	Total	11

Biological Condition Category
Poor

Taxon	Total	Kick	Dip
HEPTAGENIIDAE	69	65	4
ISONYCHIIDAE	1	1	
BAETIDAE	21	21	
CAENIDAE	3		3
PERLIDAE	2	2	
HYDROPSYCHIDAE	252	248	4
HALIPLIDAE	1		1
HYDROPHILIDAE	2	2	
DRYOPIDAE	1	1	
ELMIDAE	29	29	
TIPULIDAE	12	12	
CHIRONOMIDAE	55	55	
TABANIDAE	2	2	
GERRIDAE	3		3
VELIIDAE	4		4
CAMBARIDAE	7	5	2
PHYSIDAE	3	3	
LYMNAEIDAE	1	1	
TOTALS	**468**	**447**	**21**

Stream: MEIGS CREEK 9/17/2003
ILGARD ID: MC-00-77

Taxon	Total	Kick	Dip
HEPTAGENIIDAE	19	8	11
ISONYCHIIDAE	1	1	
BAETIDAE	72	58	14
CAENIDAE	3		3
HYDROPSYCHIDAE	214	211	3
PHILOPOTAMIDAE	56	52	4
HALIPLIDAE	1		1
GYRINIDAE	3		3
DRYOPIDAE	1	1	
ELMIDAE	22	19	3
STAPHYLINIDAE	1	1	
AESHNIDAE	4		4
CALOPTERYGIDAE	14	4	10
COENAGRIONIDAE	20		20
TIPULIDAE	9	9	
DIXIDAE	1		1
CULICIDAE	9		9
SIMULIIDAE	25	25	
CHIRONOMIDAE	58	49	9
DOLICHOPODIDAE	1	1	
EMPIDIDAE	1	1	
GERRIDAE	7		7
VELIIDAE	4		4
GAMMARIDAE	1		1
CAMBARIDAE	3		3
TOTALS	**550**	**440**	**110**

Metric	Value	MAIS Value
% 5 Dominant Taxa	78.85	2
Modified HBI	5.36	1
% Haptobenthos	81.26	1
EPT Index	6.00	1
# Ephemeropera	4.00	2
% Ephemeroptera	17.63	1
SDI	0.80	1
# Intolerant Taxa	12.00	2
% Scrapers	7.79	1
	Total	12

Biological Condition Category
Good

Appendix IIB
Biological Data

Stream: PERRY RUN 9/21/2003
ILGARD ID: PR-00-03

Metric	Value	MAIS Value
% 5 Dominant Taxa	78.26	2
Modified HBI	5.22	1
% Haptobenthos	78.26	1
EPT Index	9.00	2
# Ephemeropera	4.00	2
% Ephemeroptera	16.52	1
SDI	0.81	1
# Intolerant Taxa	13.00	2
% Scrapers	19.78	2
	Total	14

Biological Condition Category
Good

Taxon	Total	Kick	Dip
HEPTAGENIIDAE	25	25	
ISONYCHIIDAE	3	3	
BAETIDAE	47	47	
CAENIDAE	1		1
PERLIDAE	3	3	
CHLOROPERLIDAE	3	3	
LEUCTRIDAE	1	1	
HYDROPSYCHIDAE	176	174	2
PHILOPOTAMIDAE	7	7	
DYTISCIDAE	7		7
PSEPHENIDAE	2	2	
DRYOPIDAE	7	3	4
ELMIDAE	57	55	2
CORYDALIDAE	1	1	
TIPULIDAE	13	13	
SIMULIIDAE	11	11	
CHIRONOMIDAE	55	55	
GERRIDAE	1		1
GAMMARIDAE	17	17	
CAMBARIDAE	21	14	7
LYMNAEIDAE	1	1	
CLASS OLIGOCHAETA	2	2	
TOTALS	**461**	**437**	**24**

Stream: MIEGS CREEK 9/17/2003
ILGARD ID: MC-00-83

Taxon	Total	Kick	Dip
HEPTAGENIIDAE	56	43	13
ISONYCHIIDAE	1	1	
BAETIDAE	183	143	40
CAENIDAE	8	1	7
PERLIDAE	1		1
HYDROPSYCHIDAE	218	156	62
PHILOPOTAMIDAE	88	65	23
DYTISCIDAE	4		4
GYRINIDAE	2	2	
PSEPHENIDAE	1	1	
ELMIDAE	15	6	9
LIBELLULIDAE	1		1
CALOPTERYGIDAE	8	1	7
COENAGRIONIDAE	32		32
TIPULIDAE	36	34	2
DIXIDAE	5		5
CULICIDAE	3		3
SIMULIIDAE	50	26	24
CHIRONOMIDAE	131	102	29
GERRIDAE	7		7
VELIIDAE	13	5	8
GAMMARIDAE	6		6
CAMBARIDAE	1	1	
PHYSIDAE	21	7	14
CLASS HIRUDINEA	1	1	
TOTALS	**892**	**595**	**297**

Metric	Value	MAIS Value
% 5 Dominant Taxa	77.52	2
Modified HBI	5.23	1
% Haptobenthos	75.23	1
EPT Index	7.00	1
# Ephemeropera	4.00	2
% Ephemeroptera	28.44	2
SDI	0.85	2
# Intolerant Taxa	10.00	2
% Scrapers	8.26	1
	Total	14

Biological Condition Category **Good**

Appendix IIB
Biological Data

Stream: MANS FORK 9/20/2003
ILGARD ID: MF-00-55

Metric	Value	MAIS Value
% 5 Dominant Taxa	87.99	1
Modified HBI	4.73	1
% Haptobenthos	88.47	2
EPT Index	7.00	1
# Ephemeropera	4.00	2
% Ephemeroptera	37.99	2
SDI	0.75	1
# Intolerant Taxa	12.00	2
% Scrapers	37.66	2
	Total	14

Biological Condition Category
Good

Taxon	**Total**	**Kick**	**Dip**
HEPTAGENIIDAE	169	168	1
ISONYCHIIDAE	17	17	
BAETIDAE	46	46	
CAENIDAE	2	2	
PERLIDAE	2	2	
HYDROPSYCHIDAE	242	242	
PHILOPOTAMIDAE	3	3	
DYTISCIDAE	1		1
PSEPHENIDAE	1	1	
DRYOPIDAE	2	1	1
ELMIDAE	60	60	
CORYDALIDAE	1	1	
AESHNIDAE	1		1
TIPULIDAE	18	18	
CULICIDAE	1	1	
SIMULIIDAE	1	1	
CHIRONOMIDAE	25	25	
TABANIDAE	3	3	
GERRIDAE	2	1	1
ASELLIDAE	1	1	
CAMBARIDAE	14	11	3
PHYSIDAE	5	3	2
LYMNAEIDAE	1	1	
TOTALS	**618**	**608**	**10**

Stream: FOURMILE RUN 9/20/2003
ILGARD ID: FM-00-05

Taxon	**Total**	**Kick**	**Dip**
HEPTAGENIIDAE	6	6	
ISONYCHIIDAE	6	5	1
BAETIDAE	9	9	
CAENIDAE	2		2
PERLIDAE	3	3	
HYDROPSYCHIDAE	28	26	2
PHILOPOTAMIDAE	3	3	
DRYOPIDAE	2	1	1
ELMIDAE	20	19	1
CORYDALIDAE	10	10	
TIPULIDAE	7	7	
CHIRONOMIDAE	3	3	
TABANIDAE	1	1	
MUSCIDAE	1	1	
BELOSTOMATIDAE	1		1
GERRIDAE	1		1
VELIIDAE	4	4	
ASELLIDAE	2	2	
GAMMARIDAE	1		1
CAMBARIDAE	11	6	5
PHYSIDAE	1		1
TOTALS	**122**	**106**	**16**

Metric	Value	MAIS Value
% 5 Dominant Taxa	67.24	2
Modified HBI	4.79	1
% Haptobenthos	75.86	1
EPT Index	7.00	1
# Ephemeropera	4.00	2
% Ephemeroptera	19.83	2
SDI	0.89	2
# Intolerant Taxa	10.00	2
% Scrapers	24.14	2
	Total	15

Biological Condition Category
Good

APPENDIX II.C

Best management practices

Table 1
Agricultural BMPs

Best Management Practice	Environmental Degradation				USDA Funding Opporunities						
	Wildlife Habitat Loss	Hillside Erosion	Nutrient Runoff	Stream-bank Erosion	CRP	CSP	EQIP	FLEP	GRP	WHIP	WRP
Compost Facilities			X			X	X				
Contour Buffer Strips		X	X		X	X	X				
Conservation Tillage		X			X	X	X				
Cover Crops		X	X		X	X	X				
Field Borders		X	X		X	X	X				
Forested Riparian Buffers	X		X	X	X	X	X	X		X	
Grass Filterstrips				X	X	X	X	X		X	
Grassland Restoration	X				X	X	X	X	X	X	X
Grassed Conservation Buffers	X	X	X		X	X	X				
Grassed Waterways		X	X	X	X	X	X				
Lagoons			X			X	X				
Livestock Exclusion (Fencing)				X	X	X	X	X		X	
Manure Spreading			X			X	X				
Nutrient Management			X		X	X	X				
Rotational Grazing	X				X	X	X	X	X	X	X
Stream Habitat Improvement	X				X	X	X	X	X	X	X
Streambank Protection				X	X	X	X	X		X	
Terrace farming		X	X		X	X	X				
Waste Storage Structures			X			X	X				
Watering Facilities				X	X	X	X	X		X	
Wetland Restoration	X				X	X	X	X	X	X	X

CRP = Conservation Reserve Program

CSP = Conservation Security Program

EQIP = Environmental Quality Incentives Program

FLEP = Forest Land Enhancement Program

GRP = Grassland Reserve Program

WHIP = Wildlife Habitat Incentive Program

WRP = Wetland Reserve Program

Table 2
Forestry BMPs

Best Management Practice	Environmental Degradation				USDA Funding Opportunities				
	Wildlife Habitat Loss	Forest Fragmentation	High Density New Growth	Degraded Stream Quality	CRP	EQIP	FLEP	FLP	FSP
Controlling Invasive Plants	X	X		X	X	X	X	X	X
Prescribed Burning			X		X	X	X	X	X
Removal of Organic Debris	X			X					
Riparian Forests	X			X					
Thinning			X		X	X	X	X	X
Tree Planting	X	X		X	X	X	X	X	X

CRP = Conservation Reserve Program
EQIP = Environmental Quality Incentives Program
FLEP = Forest Land Enhancement Program
FLP = Forest Legacy Program
FSP = Forest Stewardship Program

Streamways as Riparian Corridors

Original Article Provided by: Mike Greenlee
Summarized by: Bill Carlson (10/5/2004)

Streamways is a principle being used to determine the size and nature of riparian corridors. Today, there are numerous methods used to determine the appropriate sizes of riparian corridors and floodplains for individual streams. When determining the size of a riparian corridor, such factors as the nature and amplitude of meanders, gradient, drainage area, and dynamic nature of streams must be considered. The Streamways method accommodates these factors and can be applied in an equation that uses a relationship of belt width and stream drainage area (DA). The equation used is: $W_{streamway} = 83 * (DA)^{0.43}$. On average, this equation will yield a streamway, or riparian corridor, that is 6 to 7 times the bank full width of the stream. Streams are unique; ergo, information involving the physical and temporal characteristics of the stream will allow for a better prediction.

Orphan Well Plugging Program
ODNR DMRM
Summarized by: Bill Carlson (10/5/2004)

Orphaned oil and natural gas wells can be a threat to public health, a landowner's safety, and the natural environment. The Ohio Department of Natural Resources' Division of Mineral Resources Management operates the Orphan Well Program. This program was created in 1977 in response to the large number of oil and natural gas wells that were improperly abandoned. State law requires that well owners plug their wells after production ceases, but in many cases this did not occur. It is then the choice of the landowners to rectify the situation by locating orphaned wells and contacting the Division of Mineral Resources Management (DMRM) to seek assistance.

DMRM must establish that a well is abandoned with no legal owner and that the State has forfeited the owner's surety bond. In most cases, DMRM will award the well plugging contract to the lowest qualified bidder. Once a well is determined to be orphaned, a landowner may apply to DMRM for funding through three available programs.

When a well begins to leak and poses a risk to public health, the Emergency Services Program will fund the well plugging. The Traditional Program is used to plug wells for common landowners according to priority and geographic location. In some cases, funds are provided to landowners, or landowners are reimbursed, for using approved contractors to plug their orphaned wells. This program is referred to as the Landowner Grant Program.

APPENDIX II.D

Funding sources

Abandoned Mine Land, Erosion, Sedimentation, Stream Debris, Stream Bank Stabilization and Wastewater Treatment

Acorn Foundation

Overview: Established in 1978, the Acorn Foundation supports projects dedicated to building a sustainable future for the planet and to restoring a healthy global environment. The Acorn Foundation is particularly interested in small and innovative community-based projects that: preserve and restore habitats supporting biological diversity and wildlife; advocate for environmental justice, particularly in low-income and indigenous communities; and prevent or remedy toxic pollution.

Deadline: January 15th and June 15th for Spring and Fall grant making meetings respectively. Decisions usually take at least 6 months from date of submittal.

Eligibility: Non-profit organizations. Most Acorn Foundation grants are made in North America, though occasional grants are made in Latin America.

Assistance Provided: Grants range from $5,000 to $10,000.

Contact:
Common Council Foundation
1221 Preservation Park Way
Oakland, California 94612- 1206
Phone: (510) 834-2995
Fax: (510) 834-2998
e-mail: ccounsel@igc.org
http://www.commoncounsel.org/index.html

Appalachian Regional Commission

Overview: The Appalachian Regional Commission (ARC) awards grants to qualified individuals and organizations for research and projects that enhance the quality of life for communities of the Appalachian Region. ARC undertakes projects that address their five goals: developing a knowledgeable and skilled population, strengthening the region's physical infrastructure, building local and regional capacity, creating a dynamic economic base and fostering healthy people.

Eligibility: Program grants are awarded to state or local agencies and governmental entities, local governing boards, and nonprofit organizations. Organizations must first apply to the program manager in their respective states.

Contact:
Assistant Director
Governor's Office of Appalachia
77 South High Street, 28th Floor
P.O. Box 1001
Columbus, OH 43216-1001
(614) 644-9228
http://www.arc.gov/

Challenge Grants for Conservation - The National Fish and Wildlife Foundation

Overview: The Foundation awards challenge grants to projects that: Address priority actions promoting fish and wildlife conservation and the habitats on which they depend; work proactively to involve other conservation and community interests; leverage Foundation provided funding; and evaluate project outcomes. The Foundation makes strategic investments in conservation projects, especially those that address one or more of the following priorities: Habitat protection and restoration on private lands; sustainable communities through conservation; and conservation education.

Assistance Provided**:** The Foundation awards challenge grants: each dollar awarded by the Foundation must be matched with one non-federal dollar or goods and services of equal value. However, the Foundation strives to increase resources directed to conservation and encourages applicants to achieve at least a 2:1 ratio of $2 raised in non-federal funds, goods, or services for every dollar awarded by the Foundation.

The funds awarded by the Foundation are matching funds. The Foundation's matching funds are federal funds provided to the Foundation by annual Congressional appropriations and agreements with federal agencies. Grants typically range from $10,000 to $150,000 based upon need.

Deadlines: June 1st and October 1st for grant requests over $5,000. Small grant requests are perpetual.

Eligibility: Federal, tribal, state, and local governments, educational institutions, and non-profit organizations.

Contact:

National Fish and Wildlife Foundation
1 Federal Drive
Ft. Snelling, MN 55111
(612) 713-5173
Director: Donn Waage

National Office

National Fish and Wildlife Foundation
1120 Connecticut Avenue, NW, Suite 900
Washington, DC 20036
Phone: (202) 857-0166
Fax: (202) 857-0162

Clean Ohio Fund

Overview: The Clean Ohio Fund is landmark legislation to fund preserving open space and farmland, brownfield cleanup, recreational trails and improve public health. The fund, known as Issue One, was passed in November of 2000. Abandoned mine lands have been classified as brownfields in the past and may qualify for these funds.

Contact:

http://www.dnr.state.oh.us/cleanohiofund/default.htm

Clean Water Action Plan Fund

Overview: The purpose of this fund is to restore streams, riparian areas and wetlands resulting in direct and measurable water quality improvements.

Contact: U.S. Fish and Wildlife Service

Conservation Works of Improvement

Overview: Soil and Water Conservation Districts and county commissioners are eligible for grants up to 50% of the project cost for natural resource protection projects involving multiple landowners. Projects include wetlands development, storm water management, mitigation for agricultural drainage.

Contact:
Kevin Elder
Ohio Department of Natural Resources
Division of Soil and Water Conservation
(614) 265-6617

Five Star Challenge Restoration Grants
Overview: The purpose of this program is to provide modest financial assistance to support community-based wetland and riparian restoration projects that build diverse partnerships and foster local natural source stewardship.
Contact: U.S. Fish and Wildlife Service

Ford Motor Company
Overview: As a corporate citizen of the world, Ford Motor Company believes that concern for the environment is vital to developing products for the marketplace. Ford Motor Company continues its strategy of keeping environment as its second priority after education. Ford supports a number of organizations that advance environmental education, research and conservation.
Deadlines: Requests for support are accepted and reviewed throughout the year. There are no application deadlines.
Contact:
Ford Motor Company Fund
One American Road
P.O. Box 1899
Dearborn, MI 48126-1899
Phone: 888-313-0102

The J.C. Downing Foundation
Overview: The foundation supports innovative efforts and original projects that offer far-reaching gains and widespread results in the area of, but not limited to environmental research and preservation.
Deadline: Perpetual
Eligibility: The Foundation awards grants to qualified nonprofit organizations with explicit, identifiable needs. There are no restrictions based on geography. The Foundation supports local, national, and international programs. Applications from the Southern California area may be given preferential consideration, but applications from other geographical areas will not be excluded.
Assistance Provided: There are no restrictions on grant amounts. Typical awards are between $5,000 and $50,000. The J.C. Downing Foundation issues project grants, not general support grants.
Contact:
http://www.jcdowning.org/

National Fish and Wildlife Foundation: Five Star Restoration Challenge Grants
Overview: The Five-Star Restoration Program provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural source stewardship through education, outreach, and training activities.
Deadline: postmarked by 02-Mar-02
Assistance: Average grant is $10,000. Awards are between $5,000 and $20,000.
Eligibility: Open to any public or private entity

Contact:
Tom Kelsch
National Fish and Wildlife Foundation
1120 Connecticut Avenue NW Suite 900
Washington, D.C. 20036
Phone: (202) 857-0166
Fax: (202) 857-0162
Internet: http://nfwf.org/programs/5star-rfp.htm

ODNR, Division of Mineral Resources Management
Federally Funded Abandoned Mine Land Program
Overview: Federal excise taxes on coal are returned to the State of Ohio for reclamation of abandoned mine land sites that adversely affect the public's health and safety.
State Abandoned Mine Land Program
Overview: State excise taxes on coal and industrial minerals are dedicated to reclamation projects that improve water quality in impacted streams. Priority is given to leveraging these funds with other partners.

ODNR Nonpoint Source Watershed Projects
Overview: Funds provided to help implement programs and projects, which protect or improve natural functions of water resources. Projects generally provide cost sharing to landowners or managers to apply nonpoint source pollution control policies.
Assistance Provided: Grants are usually funded in the $30,000-50,000 range.
Eligibility: SWCDs or other local agencies in cooperation with SWCDs.
Deadline: March 1 each year
Contact:
Jill Evans, 614-265-6637

Office of Surface Mining (OSM), Reclamation and Enforcement
Appalachian Clean Streams Initiative
Overview: The mission of the ACSI is to facilitate and coordinate citizens groups, university researchers, the coal industry, corporations, the environmental community, and local, state, and federal government agencies that are involved in cleaning up streams polluted by acid mine drainage. OSM provides funds for ACSI projects on an annual basis.
Direct Grants to Watershed Groups
Overview: A grant process for directly funding citizen watershed groups efforts to restore acid mine drainage impacted streams on a project basis.

Ohio Division of Wildlife: Wildlife Diversity Grant Program
Overview: The priorities for Wildlife Diversity grant program include research, surveys (biological or sociological), management, preservation, law enforcement, education, and land acquisition. Funding is a maximum of $5,000 for one year. Two public presentations focusing on the project highlights are required of grant recipients.
Eligibility: Both individuals and organizations.
Deadline: December of each year
Contact:
Kendra Wecker
614-265-7043
1840 Belcher Drive, Building G
Columbus, OH 43224-1329

Phone: 614-265-6300
Fax: 614-262-1143

Ohio EPA 319 Program

Overview: Under the Clean Water Act (CWA) the EPA was directed to control water pollution from point and nonpoint source pollution. As a result, funding was appropriated to support the Ohio Nonpoint Source Management Program that protects and/or corrects problems associated with nonpoint source pollution and water resources. Ohio EPA Ohio NPS Programs emphasize education, technical assistance, financial incentives and voluntary actions rather than regulatory mandates or permits. The Ohio NPS Program is based upon innovation and voluntary compliance and involves a multitude of local, state, and federal agencies working toward a common water quality goal.

Contact:
Julio Perez, (614)-644-2874

Ohio Water and Sewer Rotary Commission

Overview: To provide interest-free loans to pay that portion of the cost of a sewer or drinking water line extension project, which otherwise would have been paid by assessments on agricultural land.

Contact:
Ohio Water and Sewer Rotary Commission
Department of Development
P.O. Box 1001
Columbus OH 43266-1001
(614) 466-2285

Partners for Fish and Wildlife Program

Overview: This program assists private landowners by providing technical and financial assistance to establish self-sustaining native habitats.

Contact:
United States Fish and Wildlife Service

Rural Hardship Grant Program

Overview: Hardship grants are designed to assist communities that cannot afford the full costs of the loans offered by the Clean Water State Revolving Fund. Under this program, the USEPA awards grants to states, which in turn provide assistance to disadvantaged communities smaller than 3,000 people. These grants were intended to complement the funds offered by the CWSRF so that, by using a combination of funding sources, any community, despite its economic status, can meet its wastewater disposal needs. In addition to assisting with the development of infrastructure, these funds can also be used to provide training, education and technical assistance on the operation and maintenance of onsite systems.

Sustainable Agriculture Research and Education

Overview: The purpose of the Sustainable Agriculture Research and Education (SARE) Program is to facilitate and increase scientific investigation and education to reduce the use of chemical pesticides; to mitigate run-off, fertilizers, and toxic materials in agricultural production; to improve management of on-farm resources used to enhance productivity and competitiveness; to promote crop, livestock, and enterprise diversification; to facilitate the research of agricultural production systems located in areas that possess various soil, climatic, and physical characteristics; to study farms that have been to be managed using farm practices that optimize the use of on-farm resources and conservation practices; and to promote partnerships among

farmers, nonprofit organizations, agribusiness, and public and private research and extension institutions.
Application Deadline: Pre-proposal – Mid-July, Proposal- Mid-September. See Internet site for regional deadlines http://www.sare.org/htdocs/docs/other.html
Eligibility: Land-grant colleges or universities, other universities, state agricultural experiment stations, State cooperative extension services, nonprofit organizations, individuals with demonstrable expertise, and federal or state governmental entities. Producers are eligible for a separate small grants program.
Assistance Provided: Project grants (cooperative agreements). Funding is available through Chapter 1 (research and education) and Chapter 3 (field personnel training) of the Farm Bill.
Contact:
vberton@wam.umd.edu
http://www.sare.org/

Village Capital Improvement Fund (VCIF)
Overview: Jointly administered by the Ohio Environmental Protection Agency and Ohio Water Development, the purpose of VCIF is to aid Ohio villages with financing preliminary engineering plans, detailed engineering plans, feasibility studies, and legal costs incurred for planning phases of wastewater and/or public drinking water facilities. VCIF is a partially interest-free loan program.
Contact:
VCIF Coordinator, Sharon Williamson
Division of Environmental and Financial Assistance
Ohio Environmental Protection Agency
P.O. Box 1049
Columbus OH 43216-1049
(614) 644-3637
www.epa.state.oh.us/defa/vcif.html

Water Pollution Control Loan Fund
Overview: Loans made for wastewater systems. Projects are funded based upon readiness to proceed and priority.
Contact:
Water Pollution Control Loan Fund
Ohio EPA
Division of Environmental and Financial Assistance
P.O. Box 1049
Columbus OH 43216-1049
(614) 644-2832
www.epa.state.oh.us/defa/defamain.html

Water Quality Special Research Grants Program
Overview: This program teams the Cooperative State Research Education Extension Service (CSREES) with multiple federal agencies. The program is targeted directly to the identification and resolution of agriculture-related degradation of water quality. Eligible proposals will provide watershed-based information that can be used to assess sources of water quality impairment in targeted watersheds; develop and/or recommend options for continued improvement of water quality in targeted watersheds; and evaluate the relative costs and benefits associated with cleanup to all responsible sectors (e.g., farming, processing, urban runoff, municipal waste treatments). The program favors proposals that have a clear problem statement and are place-based. In addition, preference is given to projects that coordinate targeted research, education,

and cooperative extension activities to minimize any adverse impacts that agricultural, forest, and range management practices, food and agricultural product processing, and/or livestock production systems might have on the nation's water quality.
Application Deadline: Perpetual
Eligibility: State/local governments and academic/nonprofit institutions located in the United States are eligible for EPA, National Science Foundation, and USDA funding. Profit-making firms and federal agencies are eligible for USDA funding.
Contact:
U.S. Department of Agriculture
Cooperative State Research, Education and
Extension Service
Ag Box 2201, Washington, DC 20250-2201
(202) 401-5971
mhorton@reeusda.gov
http://www.reeusda.gov

Water and Sanitary Sewer Program
Overview: Provides grants to small, needy communities in rural areas to help them comply with Environmental Protection Agency mandates.
Contact:
Office of Housing and Community Partnerships (OHCP)
Ohio Department of Development
(614) 466-2285
Or (800)-848-130

Water and Waste Disposal Systems for Rural Communities
Overview: This program provides monies to provide basic human amenities, alleviate health hazards and promote the orderly growth of the rural areas of the nation by meeting the need for new and improved rural water and waste disposal facilities. Funds may be used for the installation, repair, improvement, or expansion of a rural water facility including costs of distribution lines and well pumping facilities. Funds also support the installation, repair, improvement, or expansion of a rural waste disposal facility, including the collection and treatment of sanitary waste stream, storm water, and solid wastes.
Application Deadline: Perpetual
Eligibility: Municipalities, counties, and other political subdivisions of a state (such as districts), and authorities, associations, cooperatives, non-profit corporations, and federally recognized Indian tribes
Assistance Provided: Project grants (617 grants awarded in FY98, ranging from $3,000 to $4.1 million) Direct loans (774 loans awarded in FY98, ranging from $5,000 to 7.3 million) Guaranteed/insured loans (9 guaranteed/insured loans awarded in FY98)
Contact:
U.S. Department of Agriculture
Rural Utilities Service,
Water and Environmental Programs
1400 Independence Avenue, SW, Washington, DC
(202) 690-2670
http://www.usda.gov/rus/water/programs.htm

Water and Waste Disposal Loans and Grants

Overview: The U.S.D.A. Rural Utilities Service offers loans and grants to assist rural communities with their waste management needs. Funds are designed to aid local residents by reducing the costs of waste and wastewater disposal to a more affordable level. Public bodies and not for profit corporations are eligible. Projects must be serving unincorporated areas or incorporated communities with populations of less than 10,000. Applicants must be unable to finance project through conventional sources.

Contact:

Water and Waste Disposal Loans and Grants
Rural Development
US Department of Agriculture
200 N High St, Room 507
Columbus OH 43215
(614) 255-2500