ESTIMATION OF POINT SOURCE AND NONPOINT SOURCE LOADINGS IN THE MAHONING RIVER WATERSHED

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ABSTRACT

The goal of this project was to contribute the following components to the Mahoning River Watershed Inventory: evaluation of point source pollutant loading for all waste water treatment plant (WWTP) discharges; statistical summary of in-stream water quality data collected by WWTP's; and comparison of point source and nonpoint source pollutant loadings to the Mahoning River. Pollutant loading calculations were performed using NPDES data for the final effluent from each significant WWTP for the years 2000 and 2001. Means and standard deviations of measured concentrations of several water quality parameters were calculated for 2000 and 2001 separately, and for the two years combined, both upstream and downstream of each WWTP discharge. Pollutant fluxes in the Mahoning River were calculated at Leavittsburg and Lowellville using monthly monitoring data collected by Ohio EPA. These fluxes were considered to represent the sum of point and nonpoint loadings above that station. The nonpoint source loadings were calculated by subtracting the sum of point sources from the total flux for each parameter at each location.

The point/nonpoint source pollutant loadings at Leavittsburg were estimated to be: 168/46,914 kg/d for total suspended solids (TSS); 44/115 kg/d for ammonia nitrogen (AN); 386/824 kg/d for nitrite + nitrate nitrogen (NN); and 206/1,864 kg/d for 5-day CBOD. Similarly at Lowellville, point/nonpoint source pollutant loadings were estimated to be: 4,086/67,339 kg/d for TSS; 596/92 kg/d for AN; 2,506/2,339 kg/d for NN and 1,668/6,402 kg/d for 5-day CBOD. Nonpoint source controls would be required to reduce levels of TSS and CBOD in the Mahoning River.

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CHAPTER 1

INTRODUCTION

1.1 Background Information

Rivers have immense value. They are the places where most major cities develop; they provide irrigation water, industrial water, and domestic water; they provide recreation and transportation for goods, and have dozens of other uses that nearly everyone agrees are valuable (Schroeder, 2002).

The Mahoning River and its tributaries are the major providers of drinking water in the Mahoning Valley. The Mahoning River watershed, shown in Figure 1-1, covers over 1100 square miles of land in northeast Ohio and western Pennsylvania. The Mahoning River watershed occupies parts of eight counties- Columbiana (the headwaters, or starting place, of the Mahoning River), Stark, Portage, Geauga, Ashtabula, Trumbull, and Mahoning in Ohio and Lawrence in Pennsylvania. The major tributaries feeding into the Mahoning River are Eagle Creek, Mosquito Creek, West Branch, Meander Creek, Mill Creek and Yellow Creek. Dams on the river and its tributaries form several large lakes and reservoirs including Kirwan, Mosquito Creek and Meander Creek Reservoirs, and Berlin Lake. Smaller reservoirs include Evans Lake, Lake Milton, Pine Lake, McKelvey Lake, and Burgess Lake. Even smaller reservoirs include Lake Newport, Lake Cohasset, and Lake Glacier - all three in Mill Creek Park. Over 150 million gallons per day of water are withdrawn to meet the needs of the watershed's 540,000 residents and the businesses and industries that support them. The streams, lakes and adjacent land also provide many recreational opportunities, including fishing, swimming, boating, hiking, biking and bird watching (Martin, 2001).

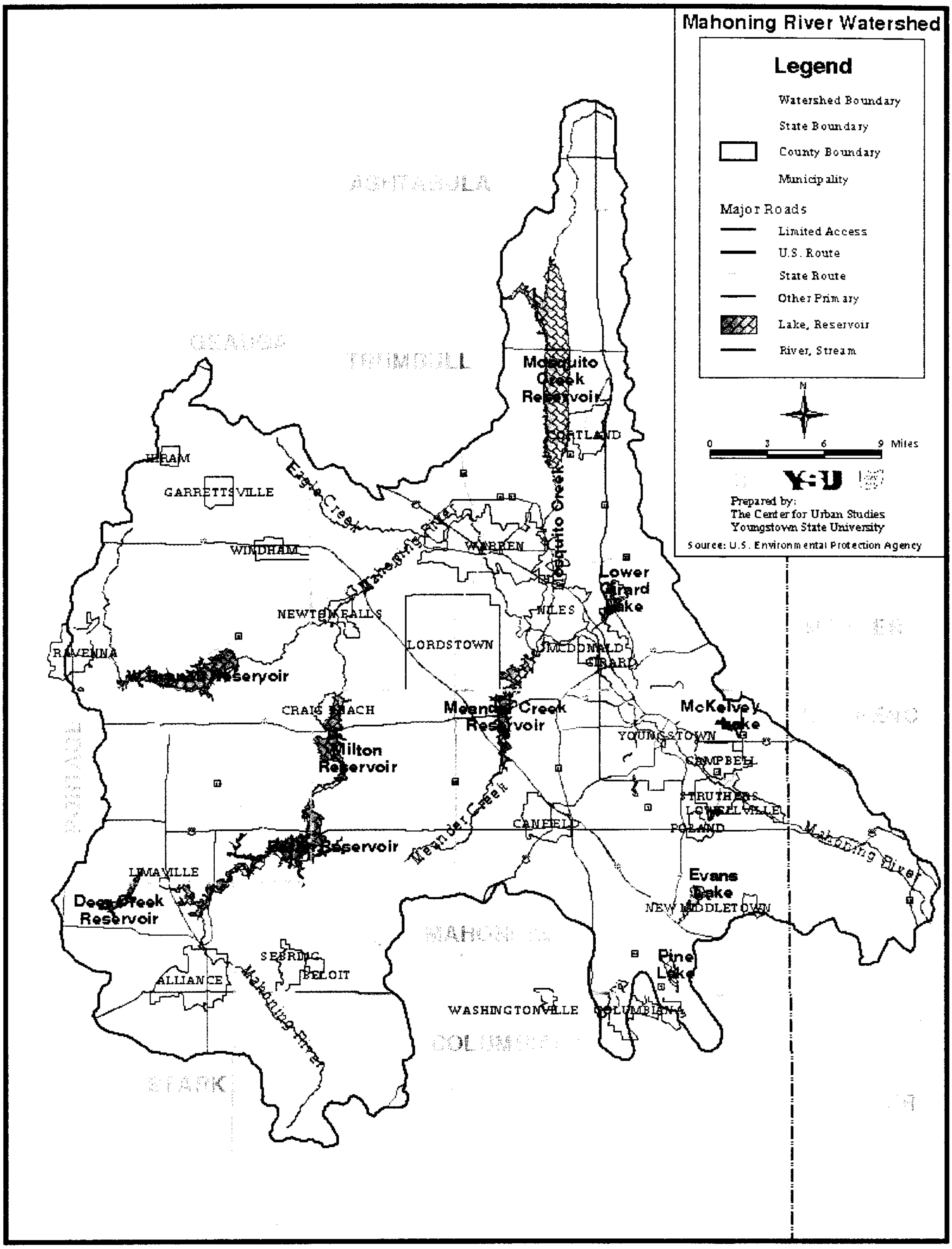


Figure 1-1 Mahoning River Watershed.

The Mahoning River was polluted during the nineteenth and twentieth centuries by two major sources- the steel industries and the human population. The lack of wastewater treatment plants along the Mahoning River until the 1960s also contributed to the river's pollution; until 1965, raw sewage from homes and businesses went directly into the river (MRC, 2002).

The lower reaches of the Mahoning River in Youngstown, Ohio, have been characterized by the Ohio Environmental Protection Agency (OEPA) as historically having poor water quality. Most wastewater treatment plants (WWTP's) in the watershed did not provide secondary sewage treatment until the late 1980's. By the late 1990's, the Mahoning River still received sewer overflow discharges from 101 locations within the city of Youngstown, Ohio. The Mahoning River in Youngstown and Mill Creek have not met biotic index criteria since the earliest published assessment by OEPA in 1980 (Stoeckel and Covert, 2002).

The industrialized section of the Mahoning River that was used by steel mills and factories includes over 30 miles of the river, starting just west of Warren in Leavittsburg and continuing southeast to Lowellville, Ohio at the border with Pennsylvania. There are 10 low-head dams in this section of the river. These dams were built by the steel industries to store water for cooling the hot steel and machinery. The cooling water, which was often over 100 °F and polluted with industrial chemicals, was discharged directly back into the river. While most of the toxins from the steel mills were washed downstream to the Beaver and Ohio Rivers, some accumulated in sediments at the bottom of the Mahoning River and behind the low-head dams. The U.S. Army Corps of Engineers estimated that there are approximately 462,000 cubic yards of contaminated riverbed sediments and an additional 286,000 cubic yards of contaminated river bank sediments (for a total of 750,000 cubic yards) spread out over the 30 miles of river (USACE, 1999). The USACE is currently developing plans to clean up this section of the Mahoning River (MRC, 2002).

The Mahoning River Consortium (MRC) is a citizen's group formed in 1996, dedicated to improving the quality of life in the Valley by promoting the wise use of the Mahoning River and its watershed. The MRC is developing a Mahoning River watershed Action Plan to serve as a blueprint for future activities and projects. The plan will identify specific water quality goals and actions to be implemented to achieve those goals. Youngstown State University is directing the planning process for the MRC. One area the group has decided to focus on is the industrial corridor of the lower Mahoning River (MRC, 2002).

The watershed planning process follows six steps recommended by the Ohio EPA (2002) in "A Guide to Developing Local Watershed Action Plans in Ohio":

1. Build public support
2. Create a watershed inventory
3. Define the problem
4. Set goals and develop solutions
5. Create an action plan
6. Implement and evaluate the plan

1.2 Study Goals

A watershed inventory is a comprehensive review of available data on the physical, chemical and biological, characteristics of the watershed on a sub-watershed basis. This includes an assessment of water quality, the human and ecological features that affect the quality of the water resource and the causes and sources of pollutants. The inventory should also identify which water bodies are high quality and should be protected (Ohio EPA, 2003). The goal of this report is to contribute the following components to the Mahoning River watershed inventory:

- Evaluation of point source pollutant loading for all waste water treatment plant (WWTP) discharges;
- Statistical summary of in-stream water quality data collected by WWTPs; and
- Comparison of point source and nonpoint source pollutant loadings to the Mahoning River.

CHAPTER 2

LITERATURE REVIEW

2.1 Point and Nonpoint Sources of Pollution

Pollutant sources are classified as point and nonpoint. Pollution originating from a single source, such as a discharge pipe from a factory or a wastewater treatment plant, is termed point source pollution. Point source pollution can be traced to the specific point where it enters the receiving water. As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge, do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states. Since its introduction in 1972, the NPDES permit program is responsible for significant improvements to our Nation's water quality (USEPA, 2003). Portions (final effluent limitations) of an NPDES permit are shown in Appendix A-1.

Nonpoint source pollution (NPS) cannot be traced to the source of pollution once it enters the river. NPS pollution does not originate from a single identifiable source, or point. NPS pollution occurs when rainfall, snow melt, or irrigation water runs over land or through the ground and picks up pollutants, and then deposits them into the river or its tributaries. Examples of NPS pollution include soil erosion from farmland and construction sites, rural and urban pesticide and fertilizer runoff, failing septic systems, animal waste, motor oil, antifreeze, and salt applied to roadways. When it rains, these pollutants are washed from the land into waterways by way of surface runoff and storm drains. Because concrete and asphalt don't absorb rainwater, runoff from urban and suburban areas is much greater than from undisturbed areas covered with vegetation (USEPA, 2001).

2.2 Description of Water Quality Parameters

2.2.1 Total Phosphorus

Phosphorus is one of the key elements necessary for growth of plants and animals. Phosphorus in elemental form is very toxic and is subject to bioaccumulation. Phosphates (PO_4^{-3}) are formed from this element. Phosphates exist in three forms: orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate. Each compound contains phosphorous in a different chemical formulation. Ortho forms are produced by natural processes and are found in sewage. Poly forms are used for treating boiler waters and in detergents. In water, they change into the ortho form. Organic phosphates are important in nature. Their occurrence may result from the breakdown of plant biomass, human and animal wastes, and organic pesticides which contain phosphates. They may exist in solution, as particles, loose fragments, or in the bodies/cells of aquatic organisms.

Rainfall can cause varying amounts of phosphates to wash from farm soils into nearby waterways. Phosphate will stimulate the growth of plankton and aquatic plants which provide food for fish. This increased growth may cause an increase in the fish population and improve the overall value of the water resources. However, if an excess of phosphate enters the waterway, dense growth of algae and aquatic plants will occur, hindering recreation and navigation in the waterway and using up large amounts of oxygen upon decomposition. This condition is known as eutrophication or overfertilization of receiving waters. The rapid growth of aquatic vegetation can cause the death and decay of aquatic life because of the decrease in dissolved oxygen levels. Phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate (Kentucky Division of Water, 2003).

2.2.2 Nitrite + Nitrate and Ammonia

Nitrogen occurs in fresh water in several forms, including dissolved molecular nitrogen (N_2), nitrate (NO_3^-), nitrite (NO_2^-), and ammonium (NH_4^+) ions, in conjunction with organic compounds such as amino acids, amines and proteins, and is continually recycled by plants and animals. The major routes of entry of nitrogen into bodies of water are municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes (including birds and fish) and discharges from car exhausts. Nitrogen-containing compounds act as nutrients in streams and rivers. Nitrogen and phosphorous are the two most common growth-limiting nutrients for algae and aquatic plants in surface waters. Nitrification reactions [$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$] in fresh water can cause oxygen depletion. Aquatic organisms depending on the supply of oxygen in the stream may die. Bacteria in water quickly convert nitrites (NO_2^-) to nitrates (NO_3^-) if oxygen is present. Nitrites can produce a serious condition in fish called "brown blood disease." Nitrites also react directly with hemoglobin in human blood and other warm-blooded animals to produce methemoglobin. Methemoglobin destroys the ability of red blood cells to transport oxygen. This condition is especially serious in babies under three months of age. It causes a condition known as Methemoglobinemia or "blue baby" disease. Water with nitrate levels exceeding 1.0 mg/L should not be used for feeding babies. Nitrite-nitrogen levels below 90 mg/L and nitrate-nitrogen levels below 0.5 mg/L seem to have no effect on warm water fish (Kentucky Division of Water, 2003).

2.2.3 Total Suspended Solids

Total suspended solids (TSS) concentrations and turbidity both indicate the amount of solids suspended in the water, whether mineral (e.g., soil particles) or organic (e.g., algae). However, the TSS test measures an actual weight of material per unit volume of water, while turbidity measures the amount of light scattered from a sample (more suspended particles cause greater scattering). High concentrations of particulate matter can cause increased sedimentation and siltation in a stream, which in turn can ruin important habitat areas for fish and other aquatic life. Suspended particles also provide attachment places for other pollutants, such as metals, nutrients and bacteria. High suspended solids or turbidity readings thus can be used as "indicators" of other potential pollutants. Land use is probably the greatest factor influencing changes in TSS or turbidity in streams. As watersheds develop, there is an increase in disturbed areas (e.g., cropland or construction sites), a decrease in vegetation, and increase in the rate of runoff. These all cause increases in erosion, particulate matter, and nutrients, which in turn promote increased algal growth. Loss of the root structure associated with vegetation due to urbanization exposes more soil to erosion, allows more runoff to form, and simultaneously reduces the watershed's ability to filter runoff before in reaches the stream (Washington State Department of Ecology, 2003).

2.2.4 Carbonaceous Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic conditions at a specified temperature (usually 20°C). BOD is typically divided into two parts - carbonaceous oxygen demand and nitrogenous oxygen demand. Carbonaceous biochemical oxygen demand (CBOD) is the result of the breakdown of organic molecules such a cellulose and sugars into carbon dioxide and water. Nitrogenous oxygen demand is the result of the breakdown of proteins. Proteins are composed of amino acids containing nitrogen. After the nitrogen is "broken off" a sugar molecule, it is usually in the form of ammonia, which is readily converted to nitrate in the environment. The conversion of ammonia to nitrate requires more than four times the amount of oxygen as the conversion of an equal amount of sugar to carbon dioxide and water. When nutrients such as nitrate and phosphate are released into the water, growth of aquatic plants is stimulated. Eventually, the increase in plant growth leads to an increase in plant decay and a greater daily variation in the dissolved oxygen level. The result is an increase in microbial populations, higher levels of BOD, and increased oxygen demand from the photosynthetic organisms during the dark hours. This results in a reduction in dissolved oxygen concentrations, especially during the early morning hours just before dawn. The major point sources, which may contribute high levels of BOD, include wastewater treatment facilities, pulp and paper mills, and meat and food processing plants. Typical nonpoint sources include agricultural runoff, urban runoff, and livestock operations. Both point and nonpoint sources can contribute significantly to the oxygen demand in a lake or stream if not properly regulated and controlled (Michigan

Department of Environmental Quality, 2003).

2.2.5 Dissolved Oxygen

Dissolved oxygen analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a byproduct of photosynthesis. When performing the dissolved oxygen test, only grab samples should be used, and the analysis should be performed immediately. Therefore, this is a field test that should be performed on site.

Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to most forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. The lower the concentration, the greater is the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills.

Total dissolved gas concentrations in water should not exceed 110 percent of saturation levels. Concentrations above this level can be harmful to aquatic life. Fish in waters containing excessive dissolved gases (especially N_2) may suffer from "gas bubble disease"; however, this is a very rare occurrence. The bubbles or emboli block the flow of blood through blood vessels causing death. Aquatic invertebrates are also affected by gas bubble disease but at levels higher than those lethal to fish (Kentucky Division of Water, 2003).

2.2.6 Water Temperature

Human activities should not change water temperatures beyond natural seasonal fluctuations. To do so could disrupt aquatic ecosystems. Acceptable temperatures are dependent on the type of stream being monitored. Lowland streams, known as "warmwater" streams which support “warmwater habitat”, are different from mountain or spring fed streams that are normally cool and support “coldwater habitat”. In a warmwater stream, temperatures should not exceed 32°C. Coldwater streams should not exceed 20°C. Often summer heat can cause fish kills in ponds because high temperatures reduce the solubility of oxygen in the water (Kentucky Division of Water, 2003).

2.2.7 pH

pH is a measure of the acidic or basic (alkaline) nature of a solution. The concentration (in moles/L) of the hydrogen ion $[H^+]$ activity in a solution determines the pH. Mathematically this is expressed as:

$$pH = - \log [H+] \qquad (2.1)$$

A pH range of 6.0 to 9.0 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates. Table 2-1 gives some special effects of pH on fish and aquatic life. The most significant environmental impact of pH involves synergistic effects. Synergy involves the combination of two or more substances which produce effects greater than their sum. This process is important in surface waters. Runoff from agricultural, domestic, and industrial areas may contain iron, aluminum, ammonia, mercury or other elements. The pH of the water will determine the toxic effects, if any, of these substances. For example, 4 mg/l of iron would not present a toxic effect at a pH of 4.8. However, as little as 0.9 mg/l of iron at a pH of 5.5 can cause fish to

Table 2-1. Limiting pH values (Kentucky Division of Water, 2003)

Minimum	Maximum	Effects
3.8	10.0	Fish eggs could be hatched, but deformed young are often produced.
4.0	10.1	Limits for the most resistant fish species.
4.1	9.5	Range tolerated by trout.
---	4.3	Carp die in five days.
4.5	9.0	Trout eggs and larvae develop normally.
4.6	9.5	Limits for perch.
---	5.0	Limits for stickleback fish.
5.0	9.0	Tolerable range for most fish.
---	8.7	Upper limit for good fishing waters.
5.4	11.4	Fish avoid waters beyond these limits.
6.0	7.2	Optimum (best) range for fish eggs.
---	1.0	Mosquito larvae are destroyed at this pH value.
3.3	4.7	Mosquito larvae live within this range.
7.5	8.4	Best range for the growth of algae.

die (Kentucky Division of Water, 2003). Synergy has special significance when considering water and wastewater treatment. The steps involved in water and wastewater treatment require specific pH levels. In order for coagulation (a treatment process) to occur, pH and alkalinity must fall within a limited range. Chlorination, a disinfecting process for drinking water, requires a pH range that is temperature dependent (Kentucky Division of Water, 2003).

2.2.8 Fecal Coliform

Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. They aid in the digestion of food. A specific subgroup of this collection is the fecal coliform bacteria, the most common member being *Escherichia coli*. These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste (Kentucky Division of Water, 2003).

2.3 Ohio Water Quality Standards

Ohio EPA sets standards to protect the quality of water bodies in Ohio. Water quality standards (WQS) contain two distinct elements - designated uses and numerical or narrative criteria. The agency assigns "designated uses" for the water based on the current or potential quality of the aquatic life inhabiting the water body. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. OEPA designates whether the water is or could be used for agricultural, industrial, or public water supplies. In applications of the Ohio WQS to the management of water resource issues in rivers and streams, the aquatic life use criteria frequently control the resulting protection and restoration requirements (OEPA, 2003). This is especially true in the lower Mahoning River, since it has been declared unfit for fishing and recreation purposes by the Ohio Department of Health (ODH, 1997).

Aquatic life habitats are compared to a reference site within the state that has the best known quality of aquatic habitat and are described as follows (OEPA, 2003):

- State Resource Water (SRW) - waters of high chemical and biological quality that include water bodies in state and county parks.
- Warmwater Habitat (WWH) - waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms.
- Exceptional Warmwater Habitat (EWH) - waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms as compared to a relatively pristine reference site in the state.
- Modified Warmwater Habitat (MWH) - waters that have been found by OEPA to be incapable of supporting and maintaining a balance, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat. Such modifications are of a long-lasting duration and may include stream channel modification, extensive sedimentation from abandoned mines, or permanent impoundment of free-flowing water bodies.
- Seasonal Salmonid Habitat (SSH) - rivers, streams and embayments capable of supporting the passage of salmonid fish from October through May and are large enough to support recreational fishing.
- Coldwater Habitat (CWH) - waters capable of supporting populations of coldwater fish and associated vertebrate and invertebrate organisms and plants on

an annual basis. These waters are not necessarily capable of supporting successful reproduction of salmonids.

- Limited Resource Water (LRH) - waters that have been assessed by OEPA and have been found to lack the potential resemblance of any other aquatic life habitat. Fauna are substantially degraded and recovery potential is precluded.

Ohio EPA has provided statewide water quality criteria for different chemicals for the protection of aquatic life. A mixing zone is an area downstream of a discharge point where the effluent is diluted by the receiving water and within which certain water quality standards that would otherwise be applicable may be exceeded. Setting of water quality based effluent limits is done by the criteria of "Outside Mixing Zone" where the effluent and the receiving water are reasonably well mixed. Tables have been formulated for calculating effluent limits for pollutants for WWH, EWH, MWH, SSH, CWH and LRH. These calculations are dependent on temperature and pH of water.

Ohio EPA biological criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria are the main parameters used in the monitoring and assessment of Ohio's surface water resources (OEPA, 2003).

2.4 Relevant Data from Ohio EPA Report

As part of Ohio EPA's Five-year Basin Approach for Monitoring and NPDES permitting, chemical, physical, and biological sampling was conducted in the Mahoning River basin study area during the summer and early fall of 1994. The principal objectives of this study were to (OEPA, 1994):

1) Determine the extent to which uses designated in the Ohio Water Quality Standards are or are not in attainment status;
2) Identify causes and sources associated with any non-attainment or partial attainment of uses designated in the Ohio WQS;
3) Provide information for the development of Water Quality Permit Support Documents (WQPSD's) in support of NPDES permit reassurance for selected point sources; and
4) Assess and characterize changes (trends) in biological performance and chemical/physical water quality since previous surveys (*i.e.,* 1980 and 1983) and subsequent upgrades by major municipal and industrial wastewater treatment facilities.

A summary of the status of aquatic life use attainment for all sites sampled in the Mahoning River basin study in 1994 is presented here. Note that River Mile (RM) is measured upstream from the mouth of a river or stream.

In the upper Mahoning River Mainstem from Alliance (RM 100.6) to the Leavittsburg dam (RM 45.6), only the two furthest upstream stations (RM 68 and 56.5) were in full attainment of the existing Warmwater Habitat (WWH) aquatic life use, with both the fish and macroinvertebrate community indices (IBI, MIwb, and ICI) meeting the biological criteria. Two stations (RM 70.3/70.7 and 63.6/62.7) exhibited partial attainment and nine stations exhibited non-attainment of the WWH biocriteria.

Of the 45.5 river miles evaluated in the lower Mahoning River mainstem, a total of 0.3 miles (2 sites - RM 44.3 and 39.1) were in full attainment of the existing WWH use designation, 5.8 miles (3 sites) in partial attainment, and 39.4 miles (23 sites) in non-attainment. The macroinvertebrate communities met the WWH ICI biocriterion from downstream of the Leavittsburg dam (RM 45.5) to upstream from the Dickey Run storm sewer (RM 39.1) in Warren.

Sampling results in Mahoning River mainstem tributaries showed only 2 of the 25 tributary locations in full attainment of the WWH use (Eagle Creek [RM 6.6] and Silver Creek [RM 0.8/0.9]). Two locations exhibited partial attainment (W. Br. Mahoning River [RM 0.4] and Dry Run [RM 0.6]), and the remaining 21 exhibited non-attainment (Mosquito Creek [RM 1.0/0.6], all sites in lower Meander Creek, all sites in Mill Creek and tributaries, and Yellow Creek [RM 1.0]).

Exceedances of Ohio EPA Warmwater Habitat criteria for chemical and physical water parameters (grab samples) from the Mahoning River study area during 1994 are shown in Appendix A-2 (OEPA, 1994). Fecal coliform was the major parameter exceeding standards in the upper Mahoning River and dissolved oxygen in the lower Mahoning River and its tributaries.

2.4.1 Major Point Source Discharges

The following is a general summary of information about major point source discharges which were evaluated during the 1994 Ohio EPA survey. These discharges were also the subject of this study, along with several smaller plants not described here.

- **Alliance WWTP (Beech Creek RM 0.35, Mahoning River RM 82.03)**: The city of Alliance WWTP discharges to an impounded portion of Beech Creek within the Berlin Reservoir. The discharge location corresponds to RM 0.35 of Beech Creek, which joins the Mahoning River at RM 82.03.
- **Thomas Steel Strip Corporation (Dickey Run Storm Sewer RM 1.2, Mahoning River RM 39.17)**: Thomas Steel Strip produces cold reduced steel strip, some of which is electroplated with nickel, copper, brass, or a nickel-zinc alloy. Outfall 001 discharges to the Dickey Run storm sewer at approximately RM 1.2 which, in turn, empties into the Mahoning River at RM 39.06.
- **WCI Steel Inc. (Mahoning River RM 37.15 to 35.86)**: WCI Steel is a manufacturer of flat rolled sheet and coiled steel with discharges to the Mahoning River mainstem between RM 37.0 and 35.9. The largest outfall in terms of flow and loadings is outfall 013, with an average daily flow of approximately 35 MGD. Outfall 008 is the next largest, with an average flow between 1993 and 1994 of approximately 7.0 MGD, and outfall 007 is the third largest at approximately 2.0 MGD.
- **City of Warren WWTP (Mahoning River RM 35.25)**: The Warren WWTP has a 16.0 MGD design flow and was last upgraded to advanced secondary treatment in February 1988. Treatment processes include grit removal; detritus settling tanks, extended aeration activated sludge, primary and final settling tanks,

chlorination, and post aeration with the discharge to the mainstem at river mile (RM) 35.25.

- **RMI-Niles (Mahoning River RM 33.63)**: RMI-Niles is a manufacturer of titanium alloy in slabs, billets, and sheets and has one discharge to the Mahoning River at RM 33.63. Wastewater includes non-contact cooling, process water, sanitary wastewater, and stormwater.
- **Meander Creek WWTP (Meander Creek RM 1.98, Mahoning River RM 30.27)**: The Mahoning County Meander Creek WWTP discharges to Meander Creek at RM 1.98. The Meander Creek WWTP is owned and operated by the Mahoning County Board of Commissioners. The plant was built in 1976 with treatment processes for pre-chlorination, grit removal, pure oxygen activated sludge, two stage clarification, rapid sand filtration, and ozone disinfection. Its design has a separate sewage system and the ability to remove phosphorus. Meander Creek is a small to medium size tributary (85.8 mi^2 drainage area) of the Mahoning River (RM 30.27).
- **Ohio Edison Company, Niles Plant (Mahoning River RM 30.00-29.51)**: The Ohio Edison, Niles Generating Plant (NGP) generates electric power by employing two 108 Megawatt (MW) coal fired steam generating units and one 30 MW combustion unit.
- **City of Niles WWTP (Mahoning River RM 28.86)**: The Niles WWTP discharges at RM 28.86 and was upgraded in 1988 to a secondary treatment facility. Treatment processes include grit removal, oxidation ditch with internal clarifier, and chlorine contact.

- **City of Girard WWTP (Little Squaw Creek RM 0.4, Mahoning River RM 25.28)**: The Girard WWTP was constructed in 1962 and upgraded to a secondary WWTP in 1988. The discharge is to Little Squaw Creek just upstream from the confluence with the Mahoning River at RM 25.28. Current wastewater treatment includes grit chamber, pre-aeration, primary settling, tricking filter, final clarifiers, equalization basin, and chlorine contact.
- **Boardman WWTP (Mill Creek RM 9.6, Mahoning River RM 21.63)**: The Mahoning County Boardman WWTP discharges to Mill Creek at RM 9.6. Downstream from the WWTP, Mill Creek flows through Mill Creek Park to its confluence with the Mahoning River in Youngstown (RM 21.6). Major land uses within the 78.4 square mile watershed are a mixture of suburban development, agriculture, and forested park land. The Boardman WWTP was constructed in 1962 as an activated sludge plant and upgraded in 1987 to advanced secondary treatment with nitrification, disinfection and post-aeration with a design flow of 5.0 MGD.
- **City of Youngstown WWTP (Mahoning River RM 19.43)**: The Youngstown WWTP is the largest municipal discharge to the Mahoning River (RM 19.43), with a design flow of 35.0 MGD. A primary treatment plant was built in 1957 and construction for a secondary WWTP was completed in 1988. The current treatment process includes bar screen, grit chambers, primary clarifiers, activated sludge, and trickling filters for flows up to 35.0 MGD. Flow in excess of 35 MGD bypass the aeration system and is passed through microscreens to the chlorine contact tank.

- **Campbell WWTP (Mahoning River RM 15.89)**: The Campbell WWTP was upgraded from a primary plant to a secondary WWTP in March, 1988 and discharges to the Mahoning River at RM 15.89. Treatment processes include screening and grit removal, activated sludge aeration using two oxidation ditches, secondary clarification, and chlorination.
- **Struthers WWTP (Mahoning River RM 14.32)**: The Struthers WWTP has a design flow of 6.0 MGD and discharges to the Mahoning River at RM 14.32. In March 1987 the WWTP was upgraded from primary to secondary treatment.

CHAPTER 3

METHODS AND PROCEDURES

3.1 General Description of Original Data

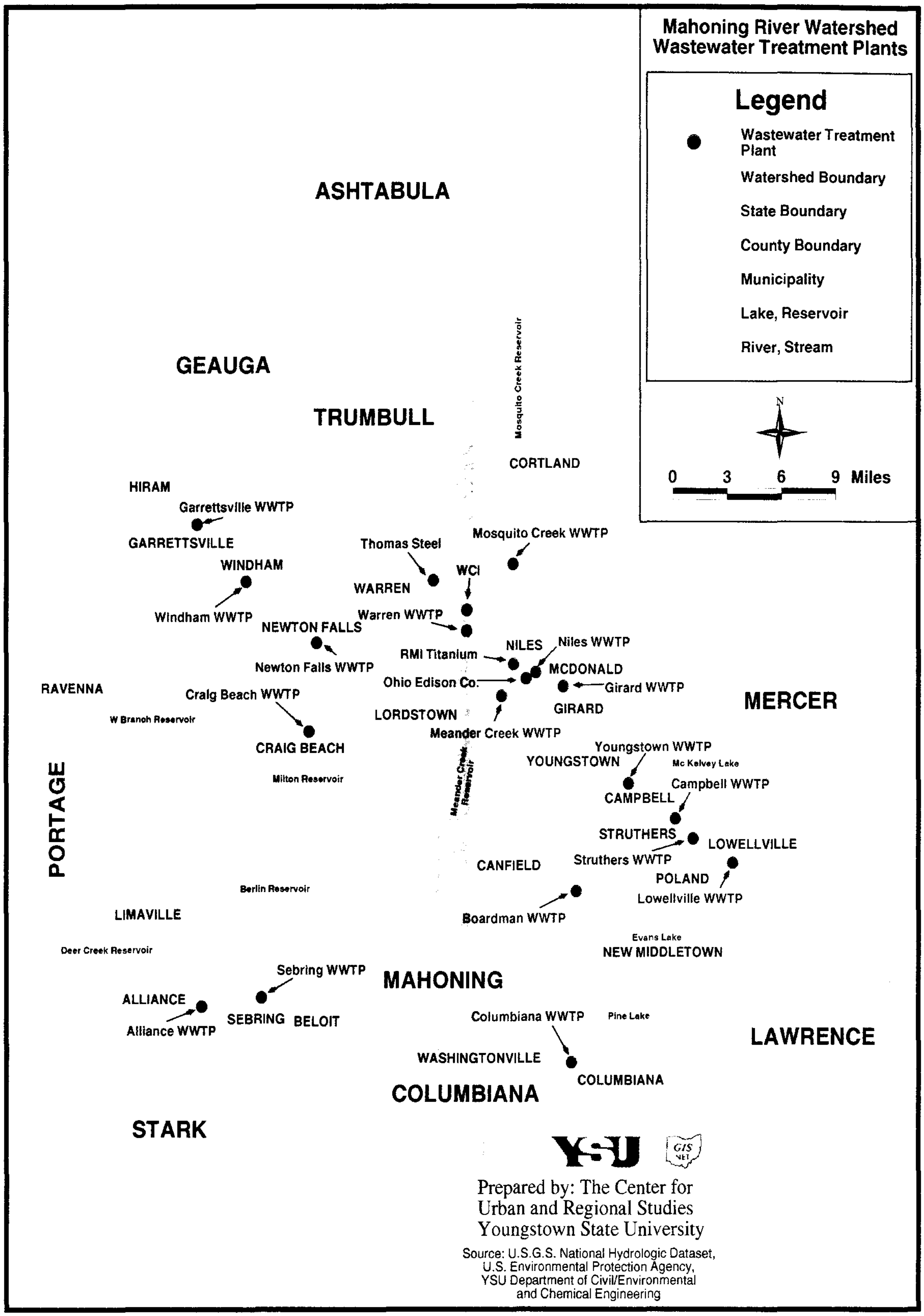
3.1.1 Sources of Data

NPDES monitoring data for the years 2000 and 2001 for 21 significant point sources, including all major wastewater treatment plants (WWTP's) and industries, (shown in Figure 3.1) were acquired from Ohio EPA. Bryan Schmucker, from the Division of Surface Water at Northeast District Office of Ohio EPA, was the key facilitator for obtaining this data. All parameters that are monitored at different monitoring stations (discharge, upstream, and downstream) by WWTP's were included in one file, resulting in 21 files.

STORET data were also obtained from Ohio EPA (Mary Ann Silagy, Central Office) for Leavittsburg and Lowellville and were used in calculating the total pollutant flux. Monthly water quality data were obtained for the years 1990-2001. STORET (short for STOrage and RETrieval) is a repository for water quality, biological, and physical data and is used by state and federal environmental agencies, universities, private citizens, and others.

3.1.2 Data File Format

All NPDES data files were in dbf (dBASE) file format. dbf is a generic database file type that allows for the transfer of data between various database programs. STORET data files were in Microsoft Excel format.



Prepared by: The Center for Urban and Regional Studies Youngstown State University

Source: U.S.G.S. National Hydrologic Dataset, U.S. Environmental Protection Agency, YSU Department of Civil/Environmental and Chemical Engineering

Figure 3.1 Point source locations in Mahoning River watershed.

3.1.3 Monitoring Stations

Commonly, NPDES data for three monitoring stations, numbered as 1, 801 and 901, were included in each .dbf file. Station 1 was the facility outfall or the final effluent from the facility. This is the station that received the most attention for the calculation of pollutant loading. Station 801 was upstream of the discharge and 901 was downstream. The numbers of parameters in the database for monitoring station 1 are much more extensive than for 801 or 901.

3.2 Data File Handling

The .dbf files were opened in Microsoft Excel and then saved as Excel files for the ease of making calculations. Special care was taken to make sure that no data were lost in the transfer. STORET data were obtained in two files – one for 1990-98 and one for 1999-2001. Separate Excel files were created for each water quality parameter by Ankur Patel, a YSU graduate student.

3.2.1 Pollutant Loading and Flux Calculation

Pollutant loadings and fluxes were calculated from the pollutant concentration and discharge or stream flow provided by the OEPA data, using Equation 3.1.

$$W = Q * C \tag{3.1}$$

Where:

W = pollutant loading or flux rate, kg/d or kg/yr

Q = stream flow rate, MGD or cfs

C = pollutant concentration, mg/L

Unit Conversions

- MGD X mg/L X 8.34 = lb/day

- lb/day X 365 or 366 days/yr X 0.4536 kg/lb = kg/yr
- cfs X mg/L X 2.446848 = kg/d

3.2.3 Assumptions and Handling of Non-Detectible Concentration

The stream flow (Q) data for the WWTP's final effluent were complete and available on a daily basis, so there were no assumptions required for this parameter. Assumptions were, however, required for the in-stream flow rates at Leavittsburg and Lowellville, for the calculation of total flux. These data were not available on a daily basis. However, average flows for each day of the year over the period of record at each station were available, and these were used for flux calculations.

In the WWTP database, several 'A' codes were listed in lieu of numeric values for water quality parameters. Some examples of 'A' codes are as follows:

AA: Below detection level
AB: Analytical data lost
AC: Plant not in operation

etc. There was nothing that could be done for any of these except for the AA code, hence the data were discarded. AA codes which had MDL (minimum detection limit) values reported were considered for further calculation. A minimum and maximum pollutant loading (or flux) was calculated. For the minimum, "AA" was replaced with zero, and for the maximum, "AA" was replaced with the MDL value for calculation.

3.3 Calculation Steps

Calculations were performed in four steps, described in the following sections.

3.3.1 WWTP Final Effluent Loadings

This step involved the pollutant loading calculations performed on each WWTP's final effluent for the years 2000 and 2001. The parameters included, based on their importance to water quality were: total phosphorus (TP), nitrite + nitrate nitrogen (NN), ammonia nitrogen (AN), total suspended solids (TSS) and 5-day CBOD. Data for TP were available for only five WWTP's. Equation 3.1 was applied to calculate pollutant loading for each date possible. The minimum and maximum loading was calculated when results fell below a known MDL. Loadings for all available dates in a given year were then averaged. Results were summarized in the form of tables, bar graphs and Arcview GIS (version 3.3) images.

3.3.2 In-Stream Data Upstream and Downstream of WWTP's

Mean and standard deviations of measured concentrations of each parameter were calculated for 2000 and 2001 separately, and for the two years combined, both upstream and downstream of each WWTP. All parameters monitored that had sufficient reliable data were included. Some were excluded due to a high percentage (more than 50%) of samples with invalid or non-detectible results. Parameters considered at upstream sites were- water temperature, dissolved oxygen (DO); pH; ammonia nitrogen, fecal coliform, total hardness (as CaCO3) and 5 day CBOD. Parameters considered at downstream sites were- all the parameters considered at upstream sites, plus total recoverable zinc, total recoverable chromium, dissolved hexavalent chromium, total recoverable nickel, total recoverable lead, total recoverable copper, total recoverable cadmium, total cyanide and total recoverable silver.

3.3.3 Pollutant Fluxes from STORET Data

STORET data only included the pollutant concentrations at Leavittsburg and Lowellville and did not include the stream flow rate. The stream flow rate was assumed to equal the average for the given date in record history at the USGS gauging station at Leavittsburg or Lowellville. Equation 3.1 was used to calculate pollutant flux in the river. The parameters considered were the same as for WWTP discharges.

3.3.4 Comparison of Point Source Vs Nonpoint Source Loadings

The pollutant fluxes calculated at Leavittsburg and Lowellville were considered to represent the sum of point and nonpoint source loading above that station. All the WWTP loadings upstream of each location were summed to estimate the total point source loadings for each parameter. The nonpoint source loadings were calculated by subtracting the sum of point sources from the total flux in the river for each parameter at each location. All pollutants were assumed to behave conservatively (i.e. no loss or gain due to in-stream processes).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Wastewater Discharge Data

4.1.1 Loading Ranges by Parameter

An example of the pollutant loading calculations performed on wastewater discharge data for each parameter is shown in Table 4-1 (for total phosphorus).

Estimates of minimum and maximum wastewater discharge loadings for 2000 and 2001 of total phosphorus (TP), nitrite + nitrate nitrogen (NN), ammonia nitrogen (AN), total suspended solids (TSS) and 5-day CBOD are summarized in Tables 4-2 through 4-6, respectively.

4.1.2 Summary of Best Estimates

Summaries of best estimates (average of minimum and maximum) for 2000 and 2001, and two-year averages, are presented in Tables 4-7 through 4-9, respectively. Table 4-9 also gives the percentages of total point source loading contributed by each discharger for a given pollutant. TP percentages were not included in the table because most WWTP's discharge phosphorus, but do not measure TP concentration. So, the summation of loading for the four WWTP's that do measure TP would underestimate total point source phosphorus loading. Graphs of the best estimates showing a comparison between 2000 and 2001 loadings for TP, NN, AN, TSS and 5-day CBOD are presented in Figures 4-1 through 4-4, respectively. ArcView GIS maps showing average loading for 2000 and 2001 (combined data set) in kg/yr for the same five parameters are presented in Figures 4-5 through 4-8.

Table 4-1. An example of the pollutant loading calculations performed on wastewater discharge data for total phosphorus at the Boardman WWTP for the year 2000.

Date	Flow Rate	Total	Phosphorus	ACODE	MDL	TP	Load
	MGD	mg/l	mg/l			kg/d	kg/d
		For Min	For Max			Min	Max
1/1/2000	4.6	0.26	0.26			4.52	4.52
1/10/2000	6.7	0.20	0.20			5.07	5.07
1/18/2000	5.4	0.11	0.11			2.25	2.25
1/24/2000	4.5	0.17	0.17			2.89	2.89
1/31/2000	5.0	0.27	0.27			5.11	5.11
2/7/2000	5.1	0.00	0.20	AA	0.2	0.00	3.86
2/14/2000	10.2	0.00	0.20	AA	0.2	0.00	7.72
2/22/2000	8.0	0.00	0.20	AA	0.2	0.00	6.05
2/28/2000	7.6	0.00	0.20	AA	0.2	0.00	5.75
3/6/2000	5.4	0.12	0.12			2.45	2.45
3/13/2000	5.4	0.19	0.19			3.88	3.88
3/20/2000	6.8	0.17	0.17			4.37	4.37
3/27/2000	6.1	0.26	0.26			6.00	6.00
4/3/2000	20.3	0.34	0.34			26.11	26.11
4/10/2000	8.2	0.28	0.28			8.69	8.69
4/17/2000	6.9	0.10	0.10			2.61	2.61
4/24/2000	6.0	0.29	0.29			6.58	6.58
5/1/2000	6.8	0.31	0.31			7.97	7.97
5/8/2000	6.0	0.32	0.32			7.26	7.26
5/15/2000	5.5	0.21	0.21			4.37	4.37
5/22/2000	6.5	0.21	0.21			5.16	5.16
5/30/2000	7.4	0.21	0.21			5.88	5.88
6/5/2000	7.6	0.00	0.20	AA	0.2	0.00	5.75
6/12/2000	8.7	0.00	0.20	AA	0.2	0.00	6.58
6/19/2000	6.1	0.19	0.19			4.38	4.38
6/26/2000	6.0	0.26	0.26			5.90	5.90
7/3/2000	12.0	0.33	0.33			14.98	14.98
7/10/2000	6.1	0.38	0.38			8.77	8.77
7/17/2000	6.7	0.22	0.22			5.58	5.58
7/24/2000	5.8	0.20	0.20			4.39	4.39
7/31/2000	5.5	0.29	0.29			6.03	6.03
8/7/2000	7.5	0.24	0.24			6.81	6.81

8/14/2000	5.5	0.41	0.41			8.53	8.53
8/21/2000	5.3	0.55	0.55			11.03	11.03
8/28/2000	5.4	0.43	0.43			8.78	8.78
9/5/2000	5.1	0.50	0.50			9.65	9.65
9/11/2000	5.7	0.35	0.35			7.55	7.55
9/18/2000	5.2	0.80	0.80			15.74	15.74
9/25/2000	5.5	0.41	0.41			8.53	8.53
10/2/2000	5.1	0.57	0.57			11.00	11.00
10/9/2000	5.6	0.56	0.56			11.86	11.86
10/16/2000	5.2	0.46	0.46			9.05	9.05
10/23/2000	5.1	0.53	0.53			10.23	10.23
10/30/2000	5.1	0.44	0.44			8.49	8.49
11/6/2000	5.1	0.38	0.38			7.33	7.33
11/13/2000	5.1	0.41	0.41			7.91	7.91
11/20/2000	5.2	0.47	0.47			9.25	9.25
11/27/2000	6.2	0.34	0.34			7.97	7.97
12/4/2000	5.5	0.40	0.40			8.32	8.32
12/11/2000	7.5	0.35	0.35			9.93	9.93
12/19/2000	6.2	0.28	0.28			6.57	6.57
12/27/2000	5.3	0.16	0.16			3.21	3.21
					Ave=	6.71	7.40
					kg/yr	2456.07	2707.43

Table 4-2. Estimates of minimum and maximum point source loading rates for total phosphorus.

Facility	2000 Min Load (kg/yr)	2000 Max Load (kg/yr)	2001 Min Load (kg/yr)	2001 Max Load (kg/yr)
Alliance WWTP	2456	2707	2366	2954
Boardman WWTP	13089	13089	5392	5392
Columbiana WWTP	2108	2108	2975	2975
Meander Crk WWTP	7027	7027	2274	2274

Table 4-3. Estimates of minimum and maximum point source loading rates for total suspended solids.

Facility	2000 Min Load (kg/yr)	2000 Max Load (kg/yr)	2001 Min Load (kg/yr)	2001 Max Load (kg/yr)
Alliance WWTP	39436	39436	41368	41368
Boardman WWTP	8784	8784	14260	14260
Campbell WWTP	27536	27536	17105	17105
Columbiana WWTP	13785	17803	21558	26982
CraigBeach WWTP	1055	1055	1772	1772
Garrettsville WWTP	3784	3784	3355	3355
Girard WWTP	69251	69251	75943	75943
Lowellville WWTP	4104	4104	3070	3070
Meander Crk WWTP	30082	30082	25848	25848
Mosquito Crk WWTP	25860	25905	29840	29840
Newton Falls WWTP	6932	6932	8633	8633
Niles WWTP	62136	62136	58143	58143
OhioEdNiles-S2	52268	52268	70260	70260
RmiTitanium	5105	5243	4215	5966
Sebring WWTP	7513	7513	7053	7053
Struthers WWTP	166304	166304	153903	153903
ThomasSteel	24320	24320	25307	25307
Warren WWTP	129669	129669	74589	74589
WCI-S8	166275	167024	113957	118345
WCI-S603	41747	42197	28934	28934
WCI-S602	66223	72479	14284	28550
WCI-S13	321618	362917	236209	386296
Windham WWTP	610	832	522	945
Youngstown WWTP	306257	306257	379254	379254

Table 4-4. Estimates of minimum and maximum point source loading rates for ammonia nitrogen.

Facility	2000 Min Load (kg/yr)	2000 Max Load (kg/yr)	2001 Min Load (kg/yr)	2001 Max Load (kg/yr)
Alliance WWTP	4046	4369	3995	4152
Boardman WWTP	964	964	486	486
Campbell WWTP	16932	16932	9766	9766
Columbiana WWTP	1098	1100	1499	1499
Craig Beach WWTP	56	56	253	253
Garrettsville WWTP	127	127	163	163
Girard WWTP	6886	6886	7746	7746
Lowellville WWTP	641	641	1660	1660
MeanderCrk WWTP	11187	11187	5714	5714
Mosquito Crk WWTP	2361	2361	2657	2657
NewtonFalls WWTP	11204	11204	10525	10525
Niles WWTP	9576	9576	12444	12444
OhioEdNiles-S2	15880	15880	17034	17034
Rmi Titanium	336	336	285	287
Sebring WWTP	514	514	664	664
Struthers WWTP	60659	60659	61480	61480
Warren WWTP	31502	31504	18604	18604
WCI-S804	26155	26744	19110	20956
WCI-S13	12208	12283	20432	20702
Windham WWTP	45	45	30	30
Youngstown WWTP	31688	32024	26655	26655

Table 4-5. Estimates of point source loading rates for nitrite + nitrate nitrogen.

Facility	2000[1] Load (kg/yr)	2001[1] Load (kg/yr)
Alliance WWTP	101598	113906
Boardman WWTP	86186	96880
Campbell WWTP	8385	3995
Columbiana WWTP	7384	12027
CraigBeach WWTP	4239	3721
Garrettsville WWTP	6662	6162
Girard WWTP	54871	40692
Lowellville WWTP	5535	3930
Meander Crk WWTP	32127	42073
Mosquito Crk WWTP	57697	56287
Newton Falls WWTP	3449	6180
Niles WWTP	64228	82488
Sebring WWTP	13934	10564
Struthers WWTP	36503	35146
Warren WWTP	170967	174593
Windham WWTP	5526	5800
Youngstown WWTP	347674	409589

1- The min. and the max. loading estimates were the same since no records with AA codes had MDL values listed.

Table 4-6. Estimates of minimum and maximum point source loading rates for 5-day CBOD.

Facility	2000 Min Load (kg/yr)	2000 Max Load (kg/yr)	2001 Min Load (kg/yr)	2001 Max Load (kg/yr)
Alliance WWTP	22467	22467	90068	90068
Boardman WWTP	18952	18952	25038	25038
Campbell WWTP	6355	6355	5978	5978
Columbiana WWTP	9130	10050	9206	11214
Craig Beach WWTP	1345	1345	1362	1362
Garrettsville WWTP	2022	2022	1838	1838
Girard WWTP	43043	43043	63439	63439
Lowellville WWTP	1712	1712	1796	1796
Meander Crk WWTP	14933	15997	7746	9713
Mosquito Crk WWTP	10321	10469	11113	11204
Newton Falls WWTP	9729	9729	12275	12275
Niles WWTP	70039	70039	62081	62081
Rmi Titanium		3545	1294	3101
Sebring WWTP	3871	3871	3547	3547
Struthers WWTP	107343	107343	175149	175149
Warren WWTP	88638	88638	61889	61889
Windham WWTP	1021	1042	1047	1160
Youngstown WWTP	198599	200218	217267	217267

Table 4-7. Best estimates of point source loadings for the year 2000 in kg/yr.

Facility	TP	TSS	Ammonia Nitrogen	Nitrite + Nitrate Nitrogen	CBOD (5 day)
Alliance WWTP	2582	39436	4207	101598	22467
Boardman WWTP	13089	8784	964	86186	18952
Campbell WWTP		27536	16932	8385	6355
Columbiana WWTP	2108	15794	1099	7384	9590
CraigBeach WWTP		1055	56	4239	1345
Garrettsville WWTP		3784	127	6662	2022
Girard WWTP		69251	6886	54871	43043
Lowellville WWTP		4104	641	5535	1712
Meander Crk WWTP	7027	30082	11187	32127	15465
Mosquito Crk WWTP		25882	2361	57697	10395
Newton Falls WWTP		6932	11204	3449	9729
Niles WWTP		62136	9576	64228	70039
OhioEdNiles-S2		52268	15880		
Rmi Titanium		5174	336		1772
Sebring WWTP		7513	514	13934	3871
Struthers WWTP		166304	60659	36503	107343
Thomas Steel		24320			
Warren WWTP		129669	31503	170967	88638
WCI-S804			26450		
WCI-S8		166650			
WCI-S603		41972			
WCI-S602		69351			
WCI-S13		342267	12245		
Windham WWTP		721	45	5526	1032
Youngstown WWTP		306257	31856	347674	199409

Table 4-8. Best estimates of point source loadings for the year 2001 in kg/yr.

Facility	TP	TSS	Ammonia Nitrogen	Nitrite + Nitrate Nitrogen	CBOD (5 day)
Alliance WWTP	2660	41368	4074	113906	90068
Boardman WWTP	5392	14260	486	96880	25038
Campbell WWTP		17105	9766	3995	5978
Columbiana WWTP	2975	24270	1499	12027	10210
Craig Beach WWTP		1772	253	3721	1362
Garrettsville WWTP		3355	163	6162	1838
Girard WWTP		75943	7746	40692	63439
Lowellville WWTP		3070	1660	3930	1796
Meander Crk WWTP	2274	25848	5714	42073	8729
Mosquito Crk WWTP		29840	2657	56287	11159
Newton Falls WWTP		8633	10525	6180	12275
Niles WWTP		58143	12444	82488	62081
OhioEdNiles-S2		70260	17034		
Rmi Titanium		5091	286		2198
Sebring WWTP		7053	664	10564	3547
Struthers WWTP		153903	61480	35146	175149
Thomas Steel		25307			
Warren WWTP		74589	18604	174593	61889
WCI-S804			20033		
WCI-S8		116151			
WCI-S603		28934			
WCI-S602		21417			
WCI-S13		311253	20567		
Windham WWTP		734	30	5800	1104
Youngstown WWTP		379254	26655	409589	217267

Table 4-9. Averages of best estimates of point source loading for the years 2000 and 2001 in kg/yr, with percentages of total point source loading contributed by each discharger.

Facility		TP	TSS	%	Ammonia	%	Nitrite + Nitrate Nitrogen	%	CBOD (5 day)	%
Alliance WWTP	All	2,621	40,402	3	4,140	2	107,752	10	56,267	8
Boardman WWTP	Boa	9,240	11,522	1	725	0.31	91,533	9	21,995	3
Campbell WWTP	Cam		22,321	1	13,349	6	6,190	1	6,166	1
Columbiana WWTP	Col	2,541	20,032	1	1,299	1	9,705	1	9,900	1
Craig Beach WWTP	Cra		1,414	0	154	0.07	3,980	0.4	1,353	0.2
Garrettsville WWTP	Gar		3,570	0	145	0.06	6,412	1	1,930	0.3
Girard WWTP	Gir		72,597	5	7,316	3	47,781	5	53,241	8
Lowellville WWTP	Low		3,587	0.2	1,151	0.49	4,732	0	1,754	0.3
Meander Crk WWTP	Mea	4,650	27,965	2	8,450	4	37,100	4	12,097	2
Mosquito Crk WWTP	Mos		27,861	2	2,509	1	56,992	5	10,777	2
Newton Falls WWTP	New		7,783	1	10,865	5	4,815	0.5	11,002	2
Niles WWTP	Nil		60,140	4	11,010	5	73,358	7	66,060	10
OhioEdNiles-S2	OhN		61,264	4	16,457	7				
Rmi Titanium	Rmi		5,132	0	311	0.13			1,985	0.3
Sebring WWTP	Seb		7,283	0	589	0.25	12,249	1	3,709	1
Struthers WWTP	Str		160,104	10	61,069	26	35,824	3	141,246	21
Thomas Steel	Tho		24,813	2						
Warren WWTP	War		102,129	7	25,054	11	172,780	16	75,264	11
WCI-S804	WCI-S804				23,241	10				
WCI-S8	WCI-S8		141,401	9						
WCI-S603	WCI-S603		35,453	2						
WCI-S602	WCI-S602		45,384	3						
WCI-S13	WCI-S13		326,760	21	16,406	7				
Windham WWTP	Win		728	0	38	0.02	5,663	1	1,068	0.2
Youngstown WWTP	You		342,756	22	29,255	13	378,631	36	208,338	30
Sum=			1,552,398		233,534		1,055,498		684,151	

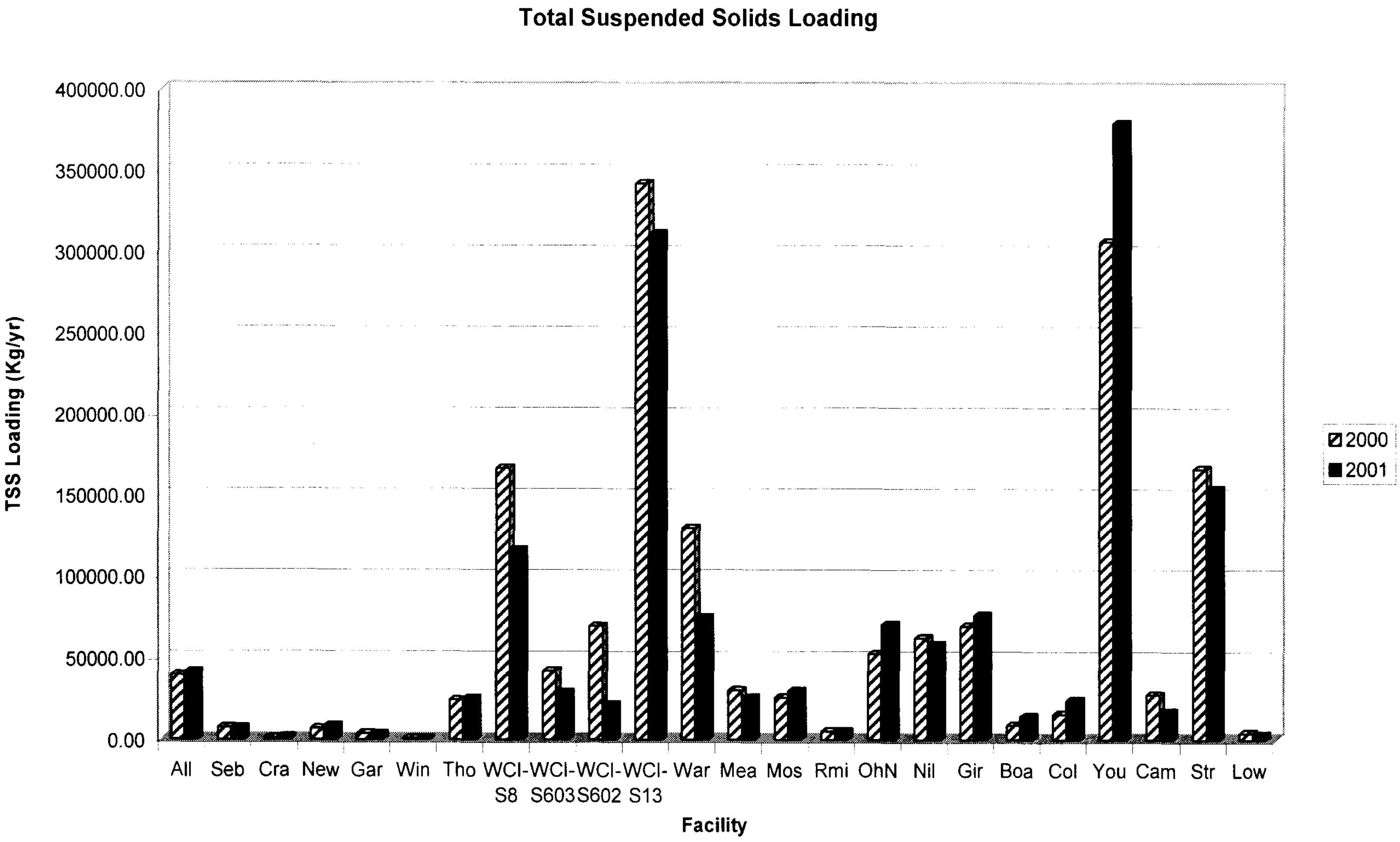


Figure 4-1. Comparison of best estimates of TSS loadings for 2000 and 2001.

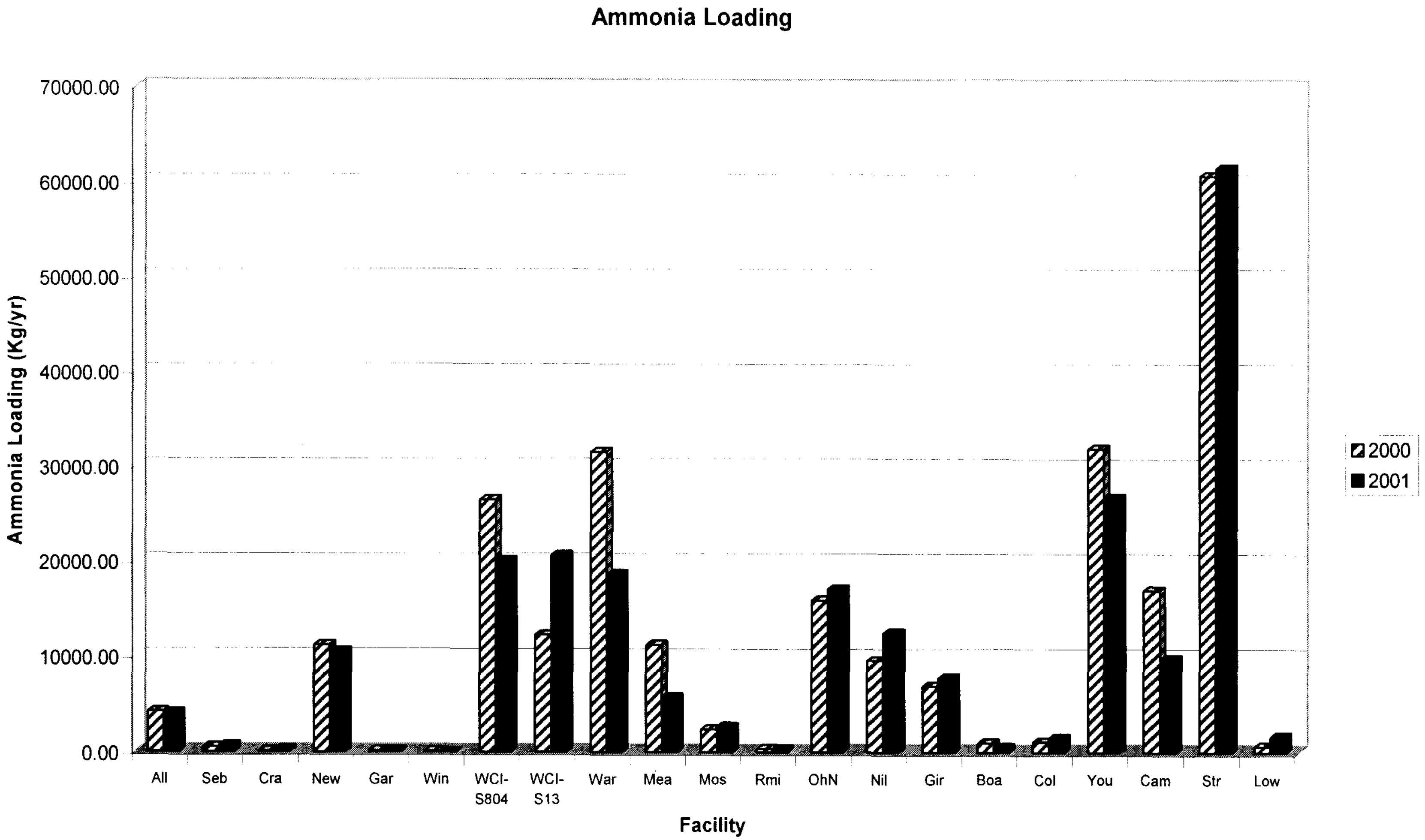


Figure 4-2. Comparison of best estimates of ammonia nitrogen loadings for 2000 and 2001.

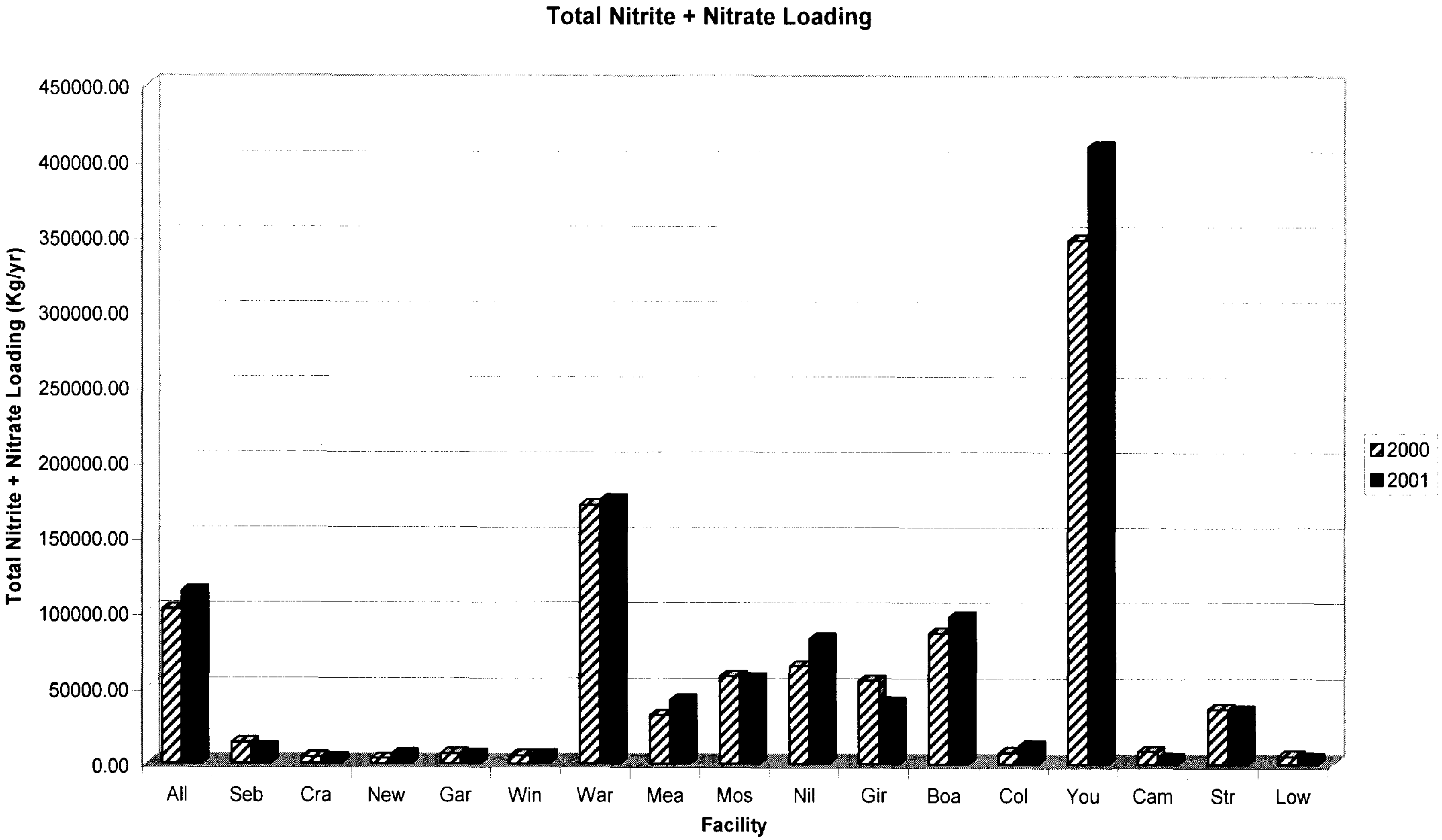


Figure 4-3. Comparison of best estimates of nitrite + nitrate nitrogen loadings for 2000 and 2001.

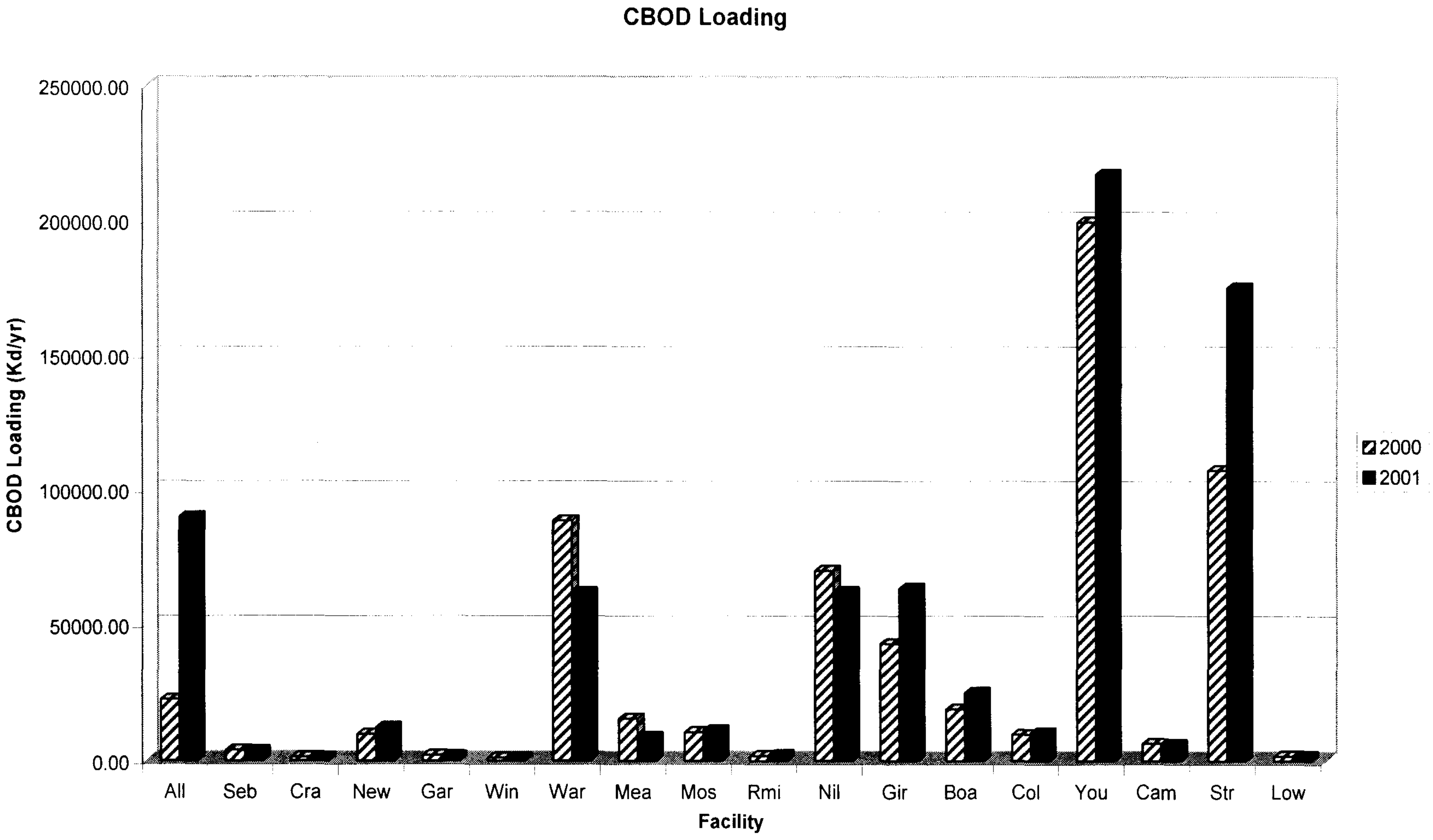
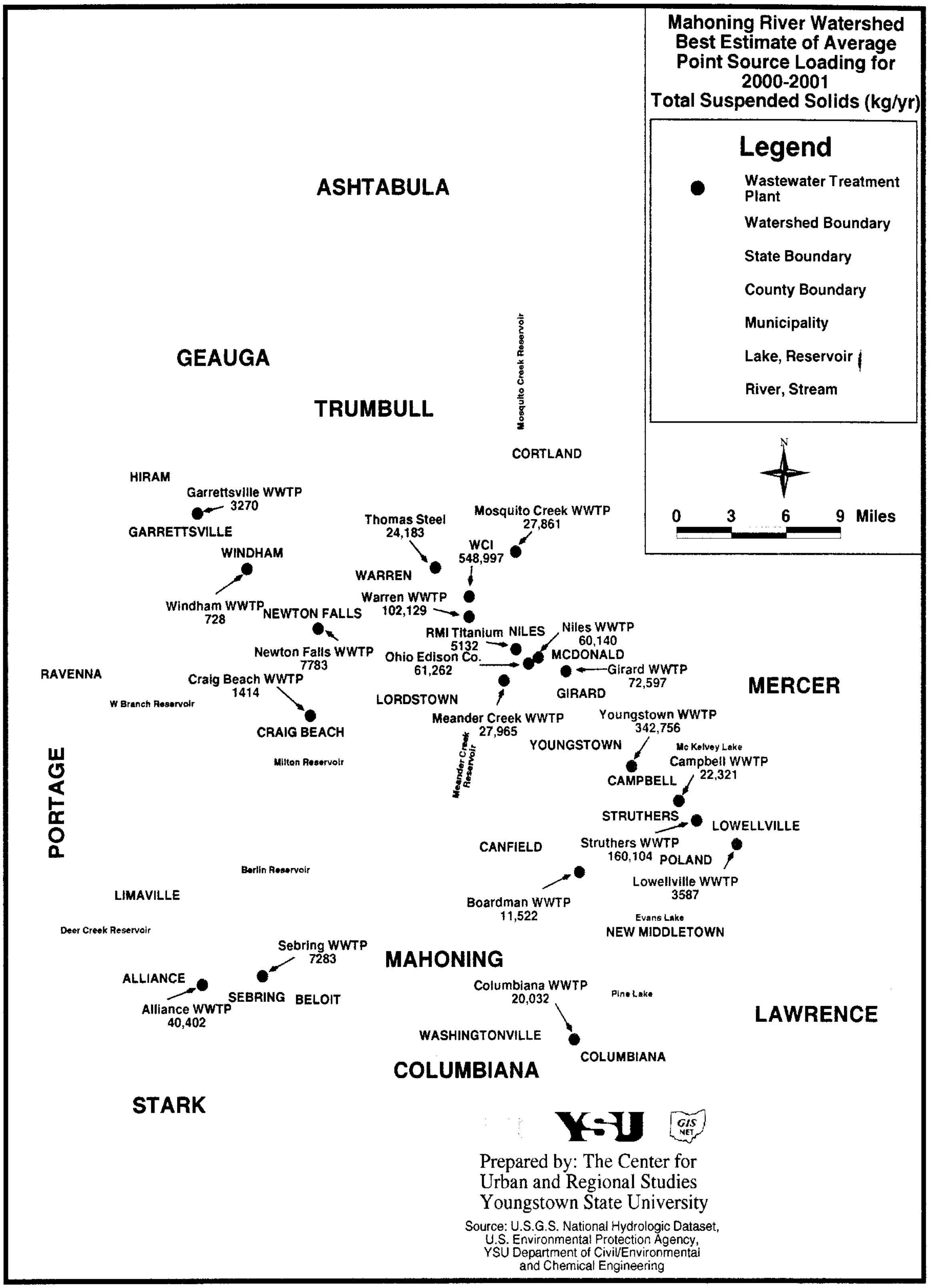


Figure 4-4. Comparison of best estimates of 5 day CBOD loadings for 2000 and 2001.



Prepared by: The Center for
Urban and Regional Studies
Youngstown State University

Source: U.S.G.S. National Hydrologic Dataset,
U.S. Environmental Protection Agency,
YSU Department of Civil/Environmental
and Chemical Engineering

Figure 4-5. ArcView GIS map showing average loading of total suspended solids for 2000 and 2001 in kg/yr.

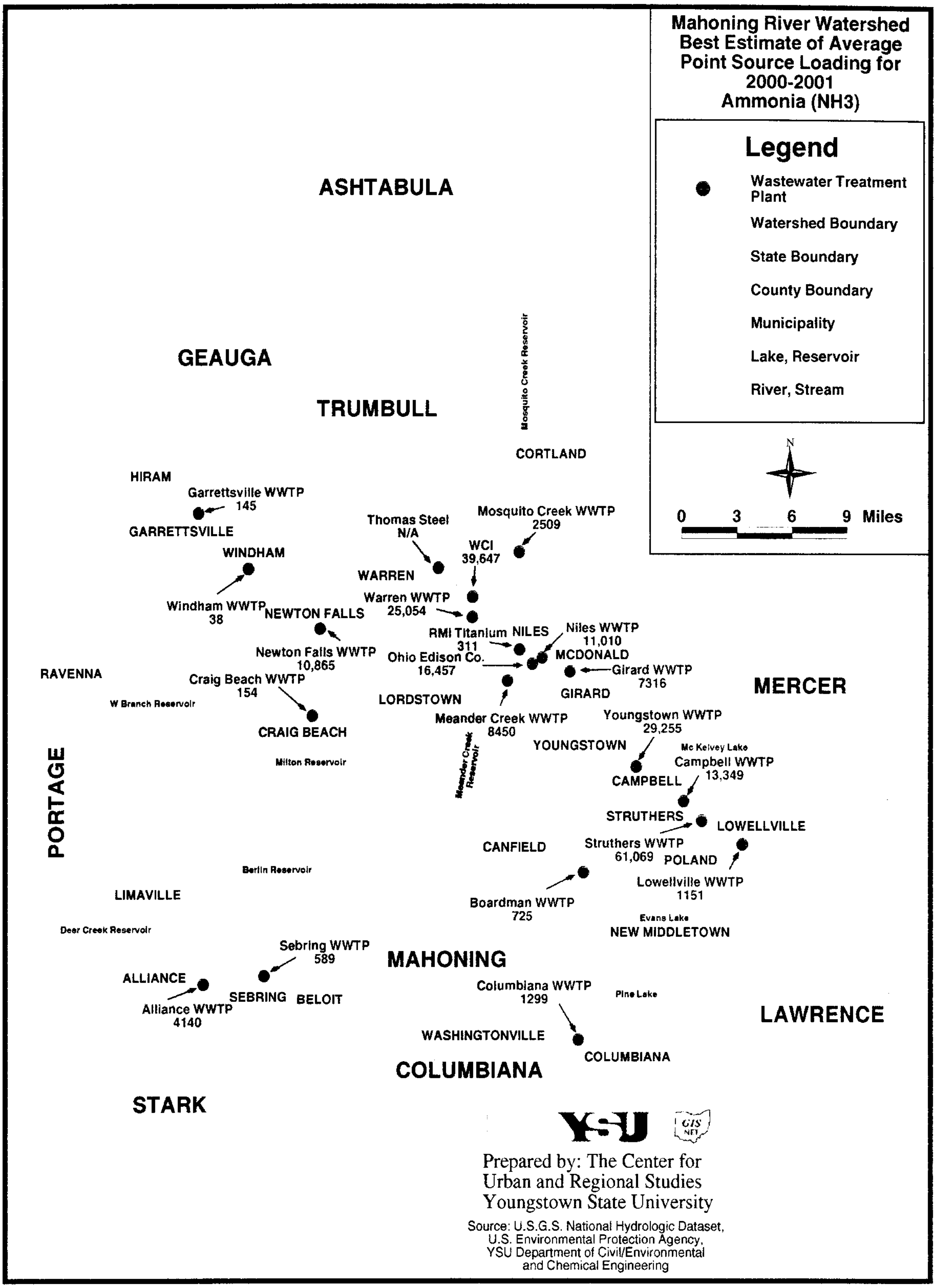
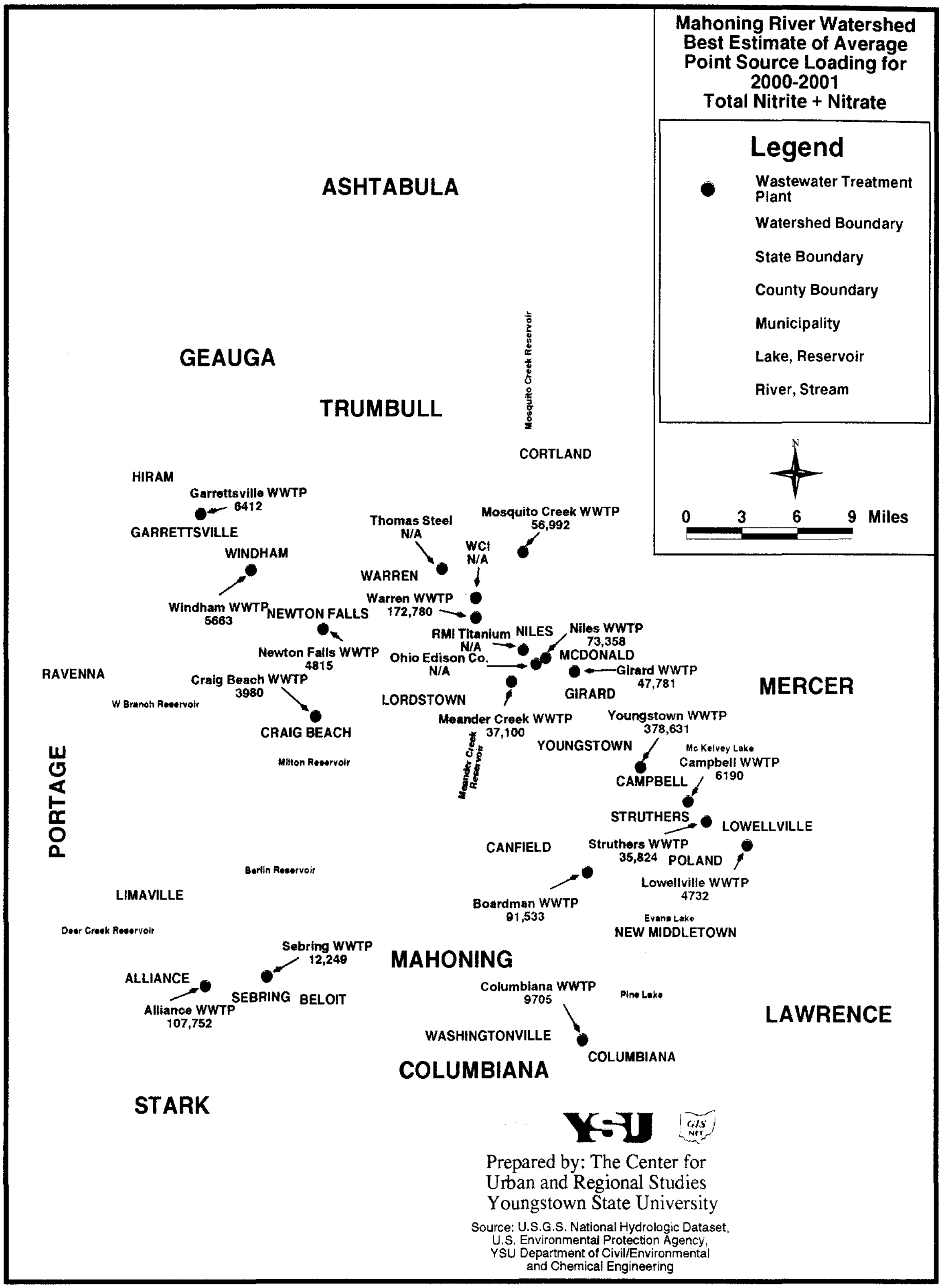


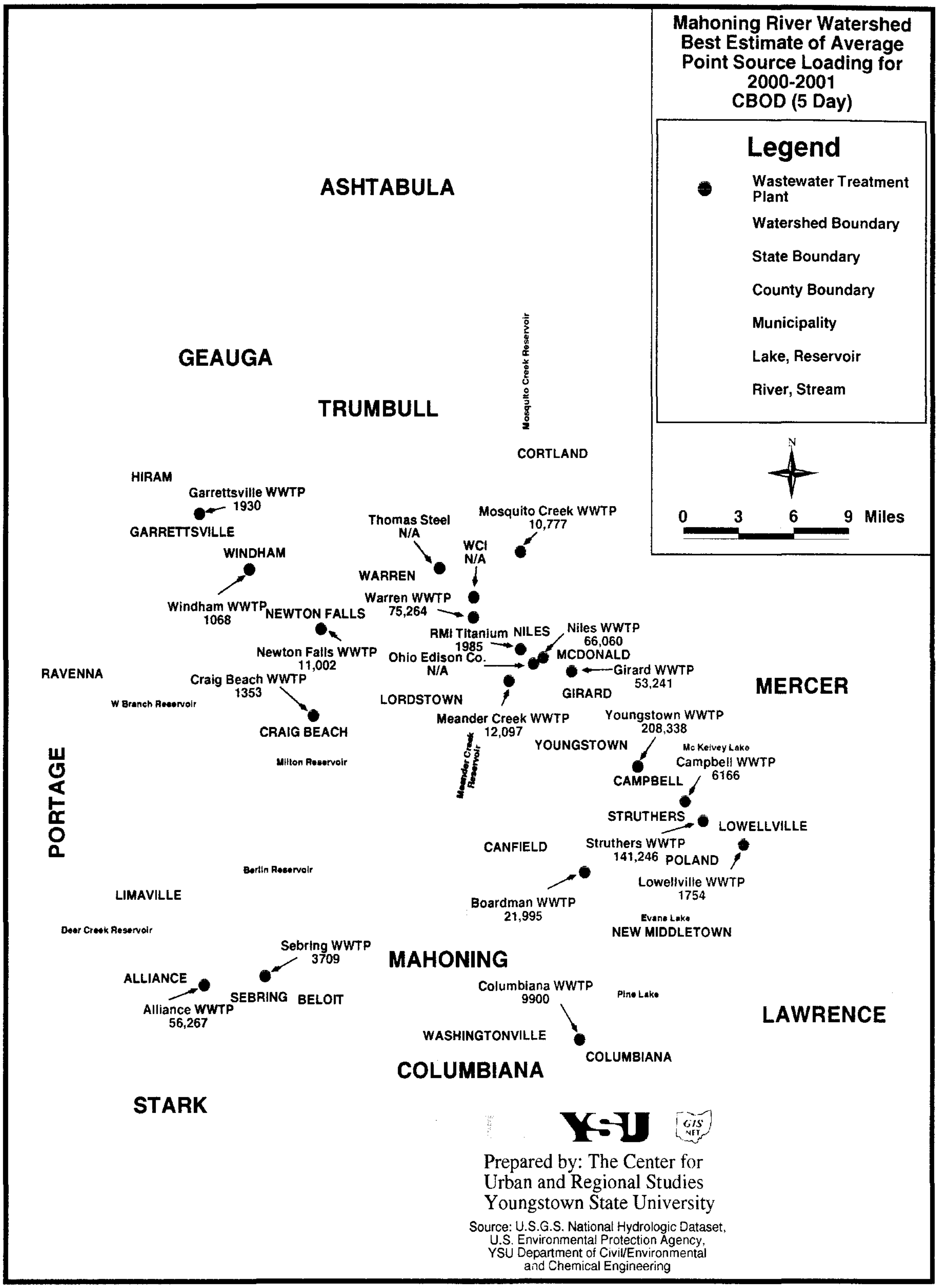
Figure 4-6. ArcView GIS map showing average loading of ammonia nitrogen for 2000 and 2001 in kg/yr.


Mahoning River Watershed Best Estimate of Average Point Source Loading for 2000-2001 Total Nitrite + Nitrate

Prepared by: The Center for Urban and Regional Studies Youngstown State University

Source: U.S.G.S. National Hydrologic Dataset, U.S. Environmental Protection Agency, YSU Department of Civil/Environmental and Chemical Engineering

Figure 4-7. ArcView GIS map showing average loading of nitrite + nitrate nitrogen for 2000 and 2001 in kg/yr for.



Prepared by: The Center for
Urban and Regional Studies
Youngstown State University

Source: U.S.G.S. National Hydrologic Dataset,
U.S. Environmental Protection Agency,
YSU Department of Civil/Environmental
and Chemical Engineering

Figure 4-8. ArcView GIS map showing average loading of 5 day CBOD for 2000 and 2001 in kg/yr.

4.1.3 Discussion

As expected, the largest loadings were observed in WWTPs of Youngstown, Struthers, Girard, Warren, Niles and WCI. Youngstown WWTP contributed 22% of the TSS loading, 13% of ammonia, 36% of NN, and 30% of 5-day CBOD loading from point sources. Struthers WWTP contributed 10% of TSS, 26% of AN and 21% of 5-day CBOD loading to the Mahoning River. WCI steel contributed 35% of TSS loading from point sources. Warren WWTP contributed 11% of AN, 16% of NN and 11% of 5-day CBOD. All other contributions were 10% or less. While several other small WWTP's (e.g. package plants) and industries also discharge wastewater to the Mahoning River, the loadings are not significant compared with those evaluated in this study.

NPDES monitoring data for TP were available for only five WWTP's. TP should be monitored in all WWTP's, if possible. Monitoring TP would make it possible to calculate both the total point source loading and the nonpoint source loading for TP.

There was not a large difference (and in many cases, no difference) between the minimum and maximum loading, since there were very few AA codes with MDL (minimum detection limit) values reported.

No set pattern was observed for the loading difference between 2000 and 2001 for the various WWTP's and parameters. The number of cases where 2001 loading exceeded 2000 loading was roughly equal to the number of times 2000 exceeded 2001. Commonly, the difference was less than 10% between the two years. Greater differences for CBOD and ammonia nitrogen may be due to periodic problems with biological treatment processes. According to the t-test, loading differences between 2000 and 2001 are most significant for 5-day CBOD. The difference for CBOD are not statistically significant at the p = 0.05 level, but are significant at the p = 0.20 level. So, the probability is less than 20% that observation differences are due to random variations alone.

The Ohio Edison, Niles generating plant withdraws water from the Mahoning River and uses it as cooling water and then returns it back, without treating it. So, a portion of the pollutant loadings that were calculated for Ohio Edison may well have been taken originally from the river itself.

4.2 In-Stream Monitoring by Dischargers

4.2.1 Summary of Data

An example of pollutant mean concentration calculations for dissolved oxygen downstream of Boardman WWTP, based on NPDES monitoring data, is given in Appendix Table A-3. Results for all parameters measured upstream and downstream of WWTP's - water temperature, pH, ammonia nitrogen, fecal coliforms, total hardness (as CaCO3), 5-day CBOD, total recoverable zinc, total recoverable chromium, dissolved hexavalent chromium, total recoverable nickel, total recoverable lead, total recoverable copper, total recoverable cadmium, total cyanide and total recoverable silver - are summarized in Appendix Tables A-4 through A-24. The WWH criteria are shown for comparison in appendix table A-25.

As an example, results of calculations for dissolved oxygen upstream and downstream of discharges are presented in Table 4-10 and 4-11, respectively. A plot of dissolved oxygen concentration versus River Mile, based on these data, is presented in Figure 4-9.

Table 4-10. Dissolved oxygen concentrations measured upstream of point source discharges, in mg/L.

Facility	RM[1]	N[2]	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	10	9.14	11	10.4	9.8	1.9
Boardman WWTP	21.63[3]	12	9.4	12	9.0	9.2	2.5
Campbell WWTP	15.89	12	9.3	12	8.93	9.1	2.0
Columbiana WWTP	21.63[3]	20	10.3	12	10.3	10.3	2.6
CraigBeach WWTP		11	9.4	11	9.6	9.5	0.95
Garrettsville WWTP		12	11.9	12	12.3	12.1	2.6
Girard WWTP	25.28	12	10.8	12	11.4	11	2.2
Lowellville WWTP	12.22	12	9.1	12	9.1	9.1	2
Meander Crk WWTP	30.27[4]	12	8.1	11	7.6	7.8	2.2
Mosquito Crk WWTP	30.25[5]	11	11.0	11	10.2	10.6	1.5
Newton Falls WWTP	56.85	12	10.0	12	9.4	9.7	2.5
Niles WWTP	28.86	12	6.7	12	6.7	6.7	0.26
Sebring WWTP		18	10.5	11	9.3	10	2.8
Struthers WWTP	14.32	12	8.6	12	8.4	8.5	1.9
Warren WWTP	35.25	12	9.8	12	9.8	9.8	1.9
Windham WWTP		12	11.0	12	10.4	10.7	2.4
Youngstown WWTP	19.43	12	8.3	12	8.4	8.3	2.4

1- RM= River Mile.
2- N= Number of observations.
3- Location where Mill Creek enters Mahoning River.
4- Location where Meander Creek enters Mahoning River.
5- Location where Mosquito Creek enters Mahoning River.

Table 4-11. Dissolved oxygen concentrations measured downstream of point source discharges, in mg/L.

Facility	RM[1]	N[2]	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	9.93	11	10.62	10.26	2.27
Boardman WWTP	21.63[3]	12	8.8	12	9.3	9.1	2.1
Campbell WWTP	15.89	12	9.49	12	9.03	9.26	1.99
Columbiana WWTP	21.63[3]	20	9.73	12	8.98	9.44	1.59
CraigBeach WWTP		11	9.1	12	9.8	9.4	1.01
Garrettsville WWTP		12	11.5	12	11.9	11.7	2.8
Girard WWTP	25.28	12	8.7	12	9.1	8.9	1.7
Lowellville WWTP	12.22	12	9.6	12	8.8	9.2	2.23
Meander Crk WWTP	30.27[4]	12	7.9	4	9.4	8.3	1.6
Mosquito Crk WWTP	30.25[5]	11	11.2	12	10.5	10.8	1.6
Newton Falls WWTP	56.85	12	10.0	12	9.4	9.7	2.61
Niles WWTP	28.86	12	6.79	12	6.79	6.79	0.24
Sebring WWTP		21	9.9	12	9.2	9.6	2.4
Struthers WWTP	14.32	12	8.88	12	8.62	8.75	2.03
Warren WWTP	35.25	12	9.49	12	9.35	9.42	2.01
Windham WWTP		12	18.5	12	10.4	14.5	19.14
Youngstown WWTP	19.43	12	8.64	12	8.58	8.61	2.29

1- RM= River Mile.
2- N= Number of observations.
3- Location where Mill Creek enters Mahoning River.
4- Location where Meander Creek enters Mahoning River.
5- Location where Mosquito Creek enters Mahoning River.

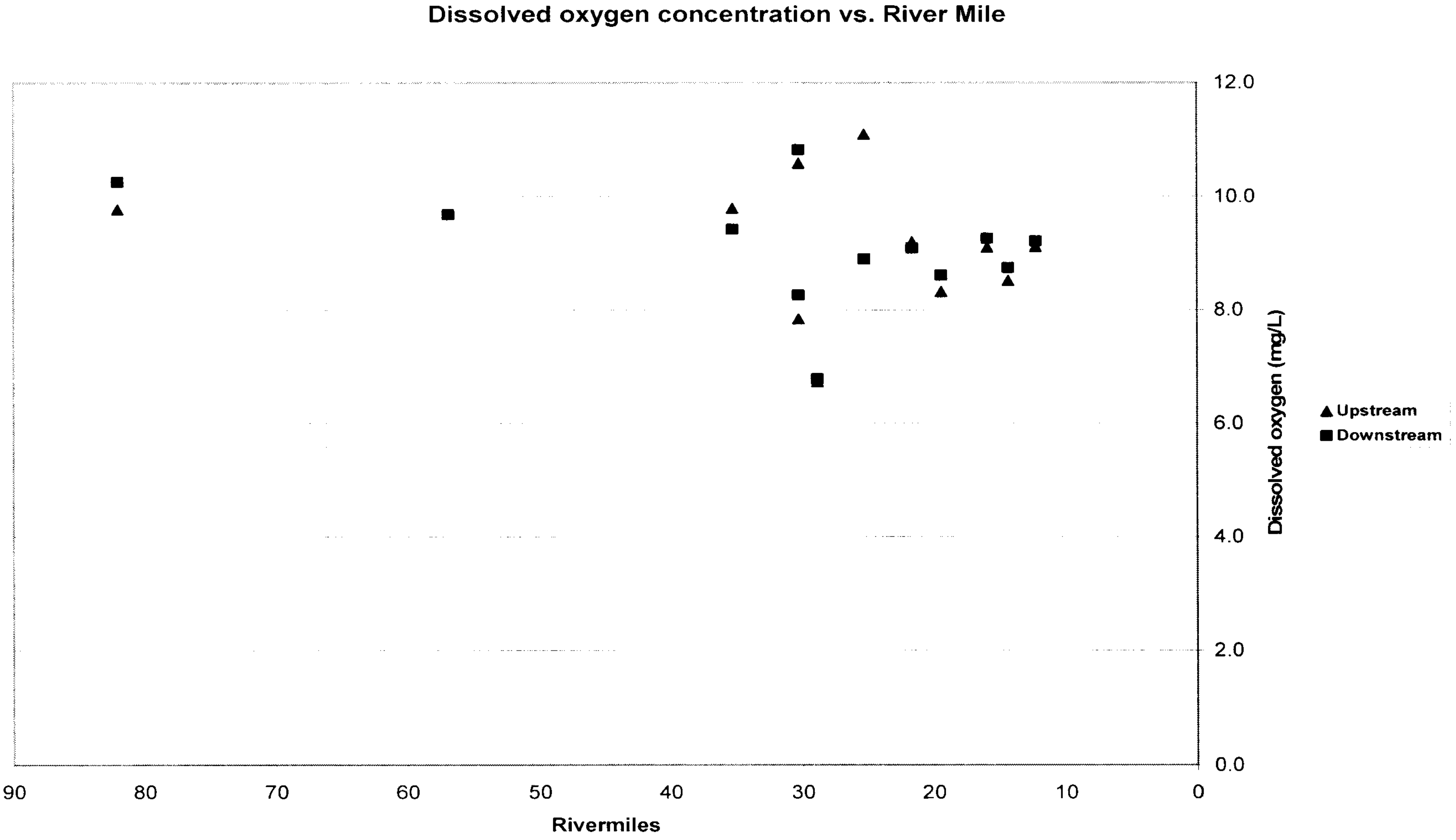


Figure 4-9. Mean dissolved oxygen concentration for 2000 and 2001 vs. River Mile in the Mahoning River, from NPDES monitoring data, upstream and downstream of WWTP discharges.

4.2.2 Discussion

For WWTP's where upstream and downstream average dissolved oxygen concentration could be compared, half showed downstream concentration averages higher than the upstream, and for the other half, upstream was higher. Normally, downstream dissolved oxygen are expected to be lower, since WWTP discharges are often low in D.O. For cases where downstream dissolved oxygen was higher, the results indicate that those WWTP discharges are well aerated. Based on the t-test for paired observations, the difference between the upstream and downstream average dissolved oxygen concentrations are not statistically significant ($p > 0.80$ for zero difference).

While dissolved oxygen concentrations decline slightly as water flows downstream, levels in the river seem to be within acceptable limits (WWH criteria > 4.0 mg/L) for aquatic life. Only one location had a combined mean below 7.0 mg/L. This was near the Niles WWTP discharge around RM 30. However, the values presented are averages and include both summer and winter values. There might be times in the summer when dissolved oxygen is much lower than the average.

4.3 Estimates of Point and Nonpoint Source Loadings

An example of pollutant flux calculations performed on STORET data is shown in Appendix Table A-25, for CBOD at Leavittsburg.

Final estimates of point and nonpoint source loading at Leavittsburg and Lowellville are presented in Tables 4-12 and 4-13, respectively.

Pie graphs depicting the percentages of point vs. nonpoint source loadings for each parameter are presented in Figures 4-10 through 4-17.

Table 4-12. Estimated point and nonpoint source loadings at Leavittsburg.

Parameter	Mass flux in river (kg/d)	Total upstream point sources (kg/d)	Non-point source Loading (kg/d)	Non-point source Loading (kg/yr)
CBOD5	2,071	206	1,864	680,466
TSS	47,081	168	46,914	17,123,448
AN	159	44	115	42,091
NN	1,210	386	824	300,746

Table 4-13. Estimated point and nonpoint source loadings at Lowellville.

Parameter	Mass flux in river (kg/d)	Total upstream point sources (kg/d)	Non-point source Loading (kg/d)	Non-point source Loading (kg/yr)
CBOD5	8,070	1,668	6,402	2,336,569
TSS	71,425	4,086	67,339	24,578,891
AN	688	596	92	33,464
NN	4,845	2,506	2,339	853,793

Figure 4-10. Comparison of Point vs. Nonpoint Loading for CBOD5 at Leavittsburg.

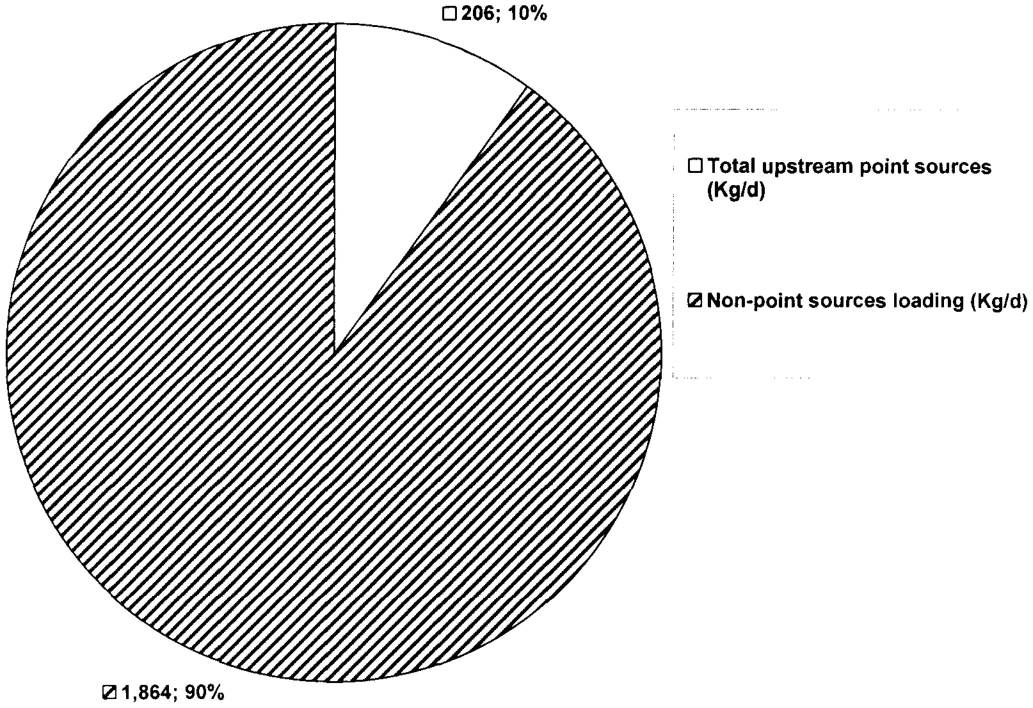


Figure 4-11. Comparison of Point vs. Nonpoint Loading for TSS at Leavittsburg.

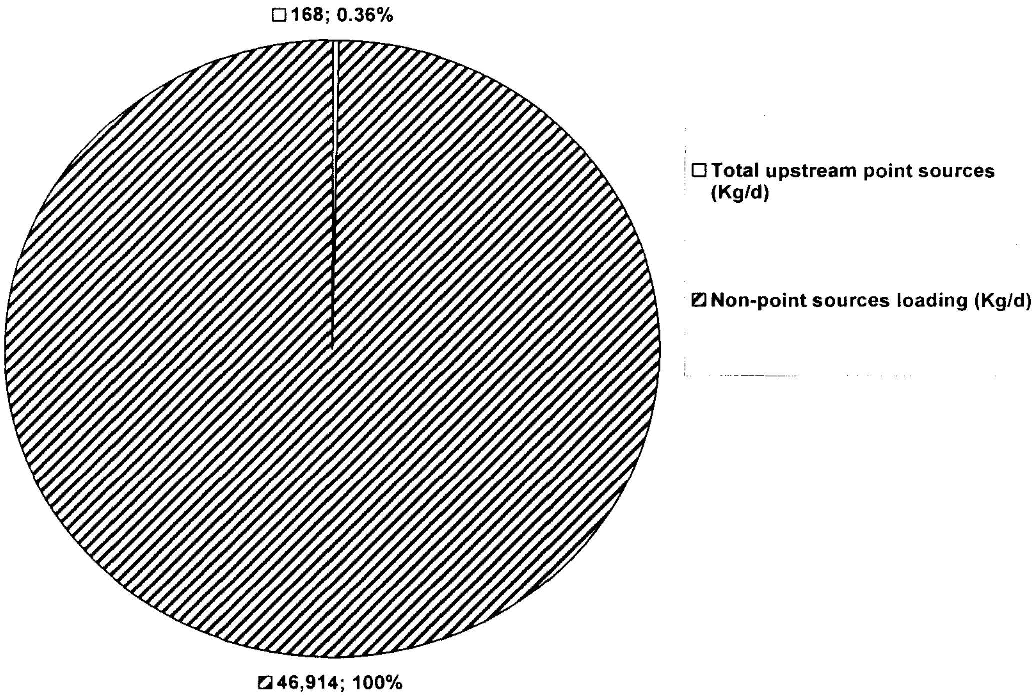


Figure 4-12. Comparison of Point vs. Nonpoint Loading for ammonia nitrogen at Leavittsburg.

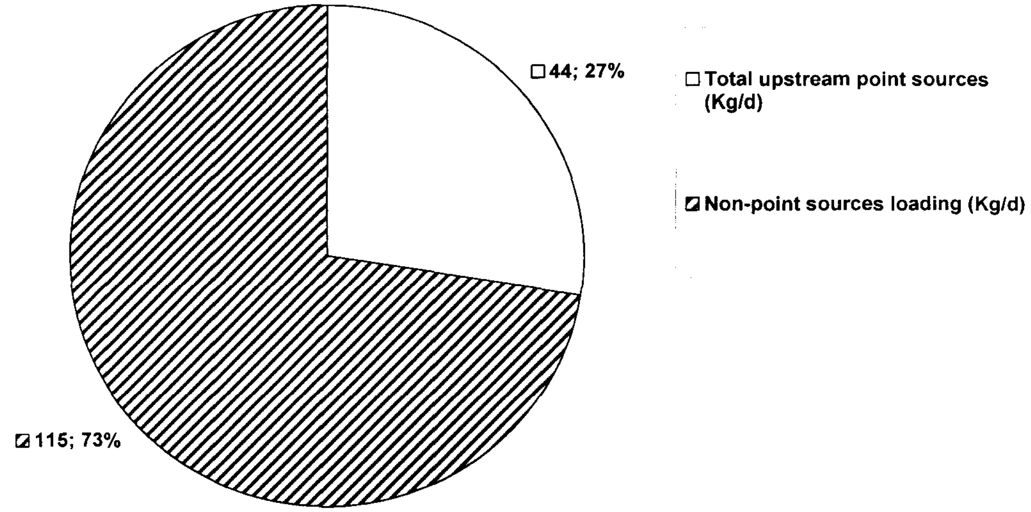


Figure 4-13. Comparison of Point vs. Nonpoint Loading for nitrite + nitrate nitrogen at Leavittsburg.

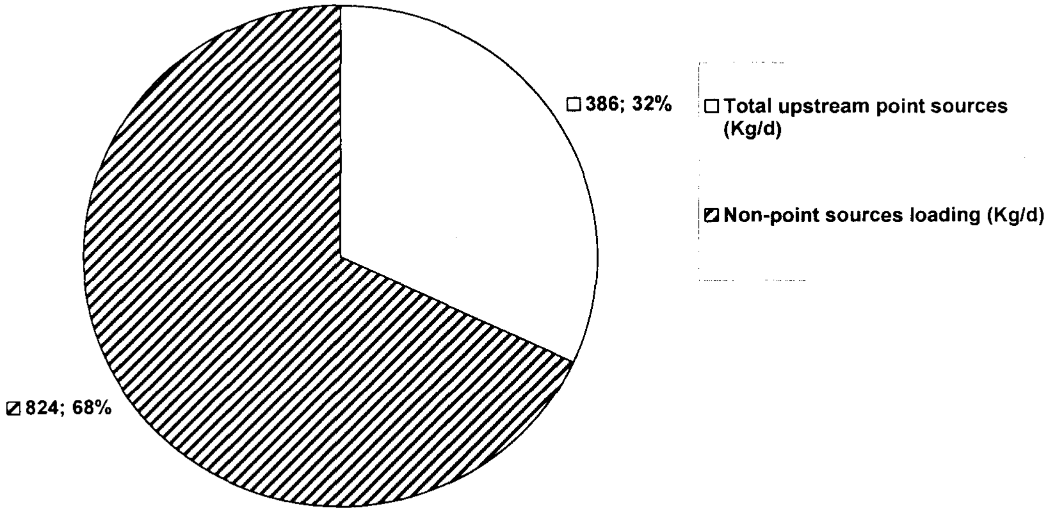


Figure 4-14 Comparison of Point vs. Nonpoint Loading for CBOD5 at Lowellville.

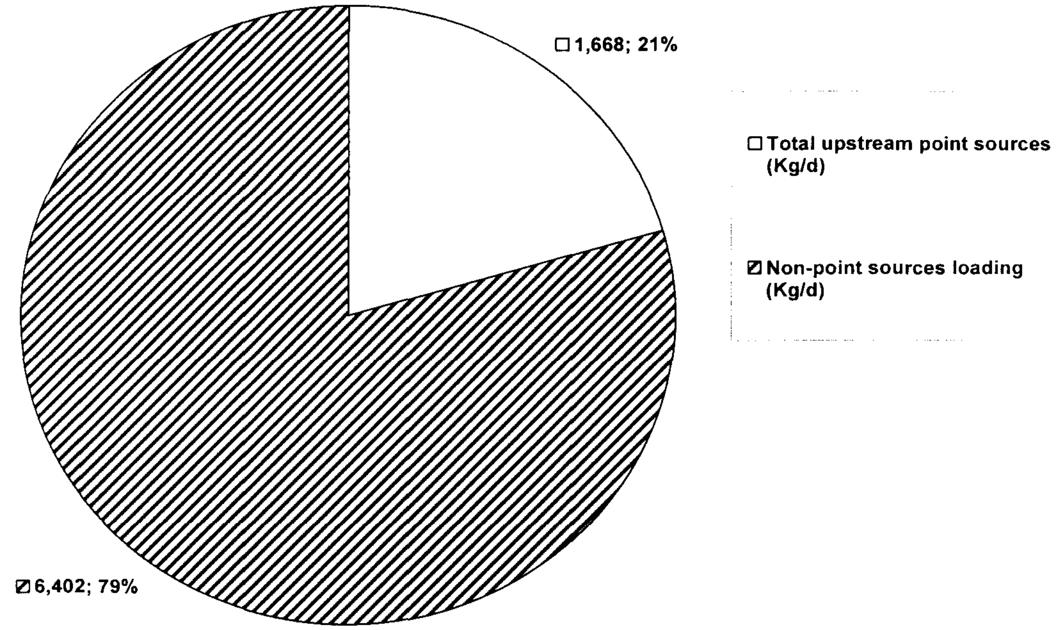


Figure 4-15 Comparison of Point vs. Nonpoint Loading for TSS at Lowellville.

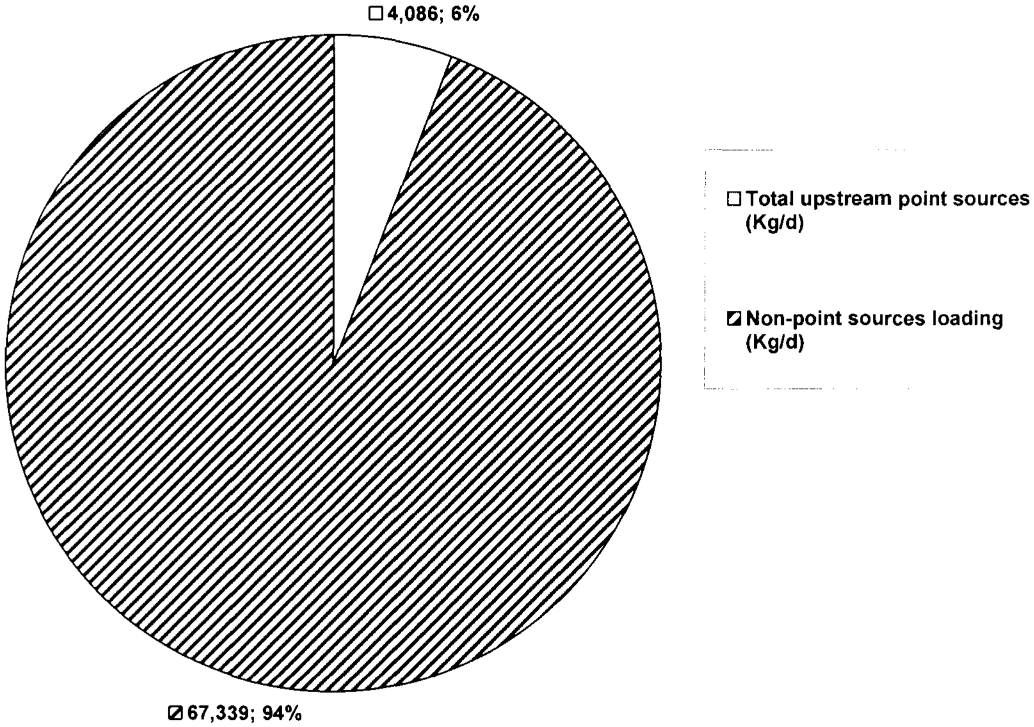


Figure 4-16. Comparison of Point vs. Nonpoint Loading for ammonia nitrogen at Lowellville.

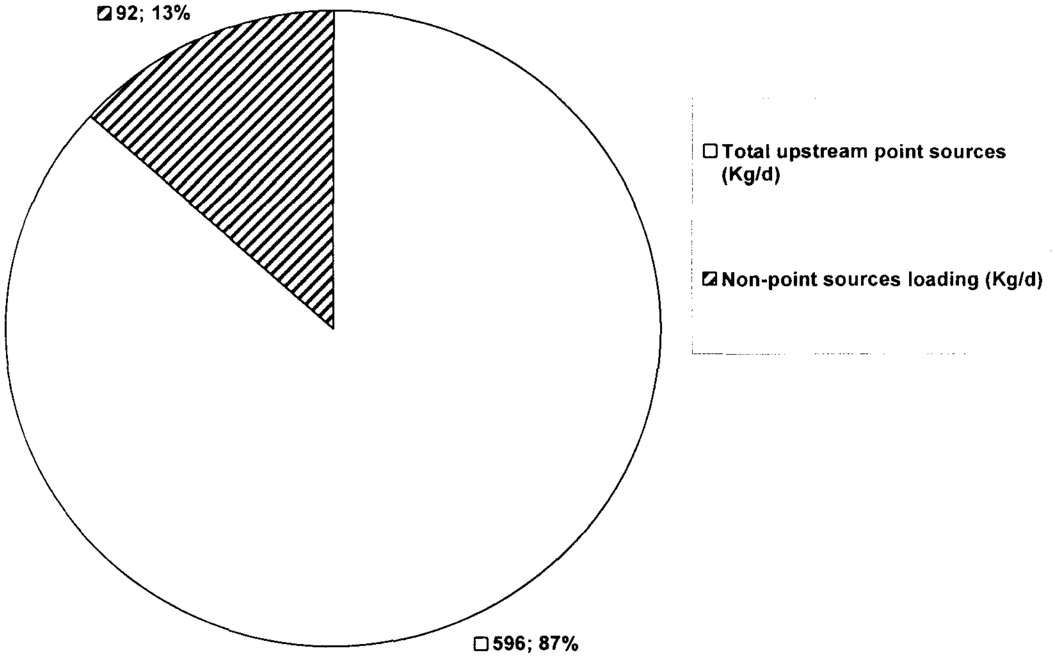
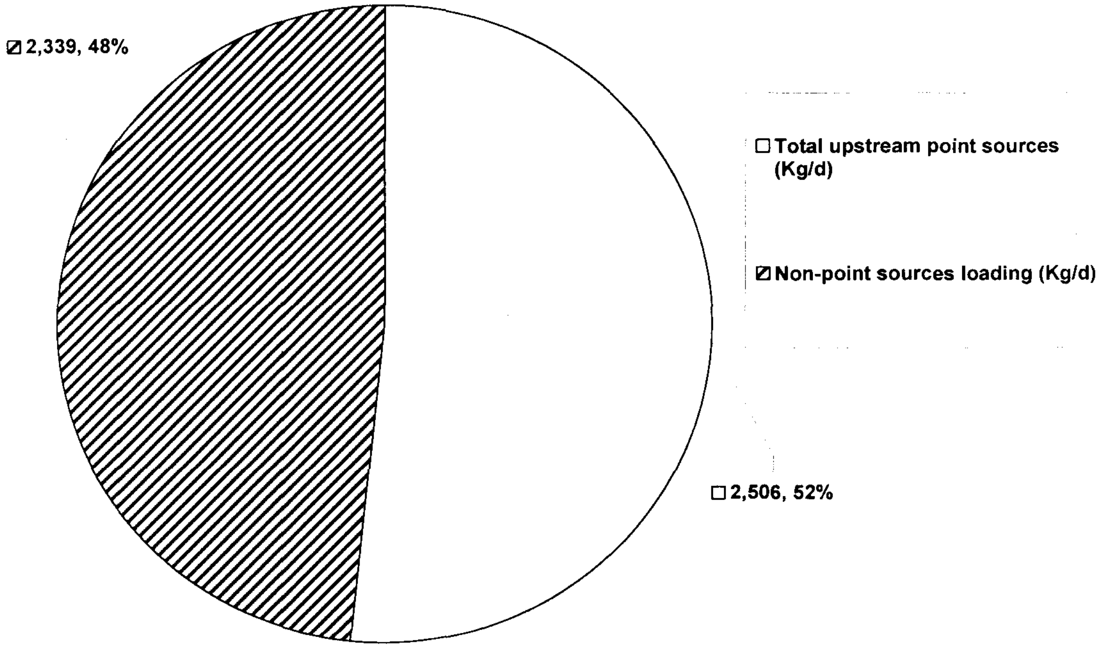


Figure 4-17. Comparison of Point vs. Nonpoint Loading for nitrite + nitrate nitrogen at Lowellville.



4.3.1 Discussion

Nonpoint sources were much higher than point source at Leavittsburg for all parameters. This is expected because most WWTP's above Leavittsburg are small. For AN and NN, point sources account for a significant fraction (>25%) of the total loading.

At Lowellville, point sources were greater than nonpoint sources for AN and NN, but nonpoint sources were greater than point sources for CBOD and TSS.

Management programs to reduce TSS loading should focus on nonpoint sources. Reductions in CBOD, AN and NN loading can be accomplished by a combination of point source and nonpoint source controls.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusions

5.1.1 Scope of Work

The goal of this project was to contribute to the Mahoning River Watershed Inventory. In a four step calculation process, point source and nonpoint source pollutant loadings were estimated for the watershed.

1. Pollutant loading calculations were performed using NPDES data for the final effluent from each significant WWTP for the years 2000 and 2001. The parameters included total phosphorus (TP), nitrite + nitrate nitrogen (NN), ammonia nitrogen (AN), total suspended solids and 5-day CBOD, based on their importance to water quality.
2. Means and standard deviations of measured concentrations of several water quality parameters were calculated for 2000 and 2001 separately, and for the two years combined, both upstream and downstream of each WWTP discharge. All parameters monitored that had sufficient reliable data were included.
3. Pollutant fluxes in the Mahoning River were calculated at Leavittsburg and Lowellville using monthly monitoring data collected by Ohio EPA. These fluxes were considered to represent the sum of point and nonpoint loadings above that station.
4. The nonpoint source loadings were calculated by subtracting the sum of point sources from the total flux for each parameter at each location.

5.1.2 Results and Conclusion

For the point sources, the largest loadings were observed in WWTPs of Youngstown, Struthers, Girard, Warren, Niles and WCI. For example, Youngstown WWTP accounted for 36% of the point source loading of nitrite + nitrate nitrogen, 22% of the TSS, 30% of the 5-day CBOD, and 13% of the point source ammonia nitrogen loading. Similarly, Struthers WWTP was the source for 21% of the 5 day CBOD, and 26% of ammonia nitrogen loading from point sources. Discharges from WCI Steel, Inc. contributed 35% of the total point source loading of TSS. It can be concluded that these are the major contributors to the point source loading.

In the comparison of point versus nonpoint source loadings at Leavittsburg, as was expected, nonpoint sources were much higher than the point source loadings. At Lowellville, nonpoint source loadings were larger for TSS and CBOD; point source loadings were higher for ammonia and nitrite + nitrate nitrogen.

5.2 Recommendations

Non-detectible concentrations in the data sets cause some uncertainty in the loading calculation. In most cases, there was not a large difference between the minimum and maximum loading calculated. However, the uncertainty could be reduced if MDL (minimum detection limit) values are reported consistently when non-detectible concentrations are obtained.

NPDES monitoring data for TP were available for only five WWTP's. TP should be monitored in all WWTP's, if possible. Although the major contributors for TP come from the nonpoint sources, monitoring TP would make it possible to estimate both the total point source loading and the nonpoint source loading for TP.

Studies that contribute to the watershed inventory should be continued. Data from these and other programs should be analyzed in the future to refine the estimates of point source and nonpoint source pollutant loadings. Management programs should be monitored and improved to protect the Mahoning River and its tributaries.

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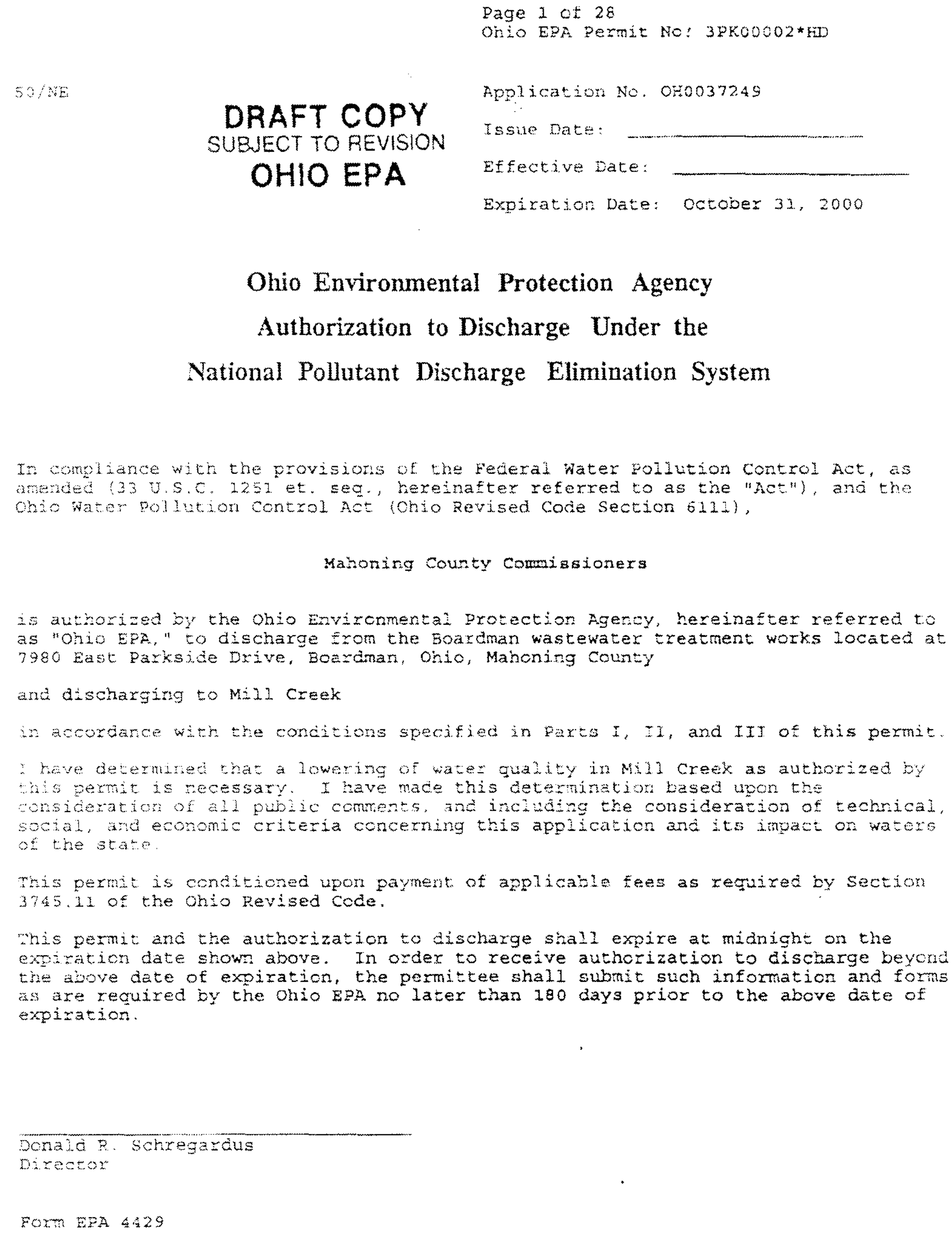
APPENDIX

Figure A-1 Portions (final effluent limitations) of an NPDES permit.



Page 1 of 28
Ohio EPA Permit No: 3PK00002*HD

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DRAFT COPY
SUBJECT TO REVISION
OHIO EPA

Application No. OH0037249

Issue Date: ________________

Effective Date: ________________

Expiration Date: October 31, 2000

Ohio Environmental Protection Agency
Authorization to Discharge Under the
National Pollutant Discharge Elimination System

In compliance with the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251 et. seq., hereinafter referred to as the "Act"), and the Ohio Water Pollution Control Act (Ohio Revised Code Section 6111),

Mahoning County Commissioners

is authorized by the Ohio Environmental Protection Agency, hereinafter referred to as "Ohio EPA," to discharge from the Boardman wastewater treatment works located at 7980 East Parkside Drive, Boardman, Ohio, Mahoning County

and discharging to Mill Creek

in accordance with the conditions specified in Parts I, II, and III of this permit.

I have determined that a lowering of water quality in Mill Creek as authorized by this permit is necessary. I have made this determination based upon the consideration of all public comments, and including the consideration of technical, social, and economic criteria concerning this application and its impact on waters of the state.

This permit is conditioned upon payment of applicable fees as required by Section 3745.11 of the Ohio Revised Code.

This permit and the authorization to discharge shall expire at midnight on the expiration date shown above. In order to receive authorization to discharge beyond the above date of expiration, the permittee shall submit such information and forms as are required by the Ohio EPA no later than 180 days prior to the above date of expiration.

Donald R. Schregardus
Director

Form EPA 4429

Part I, A. - **FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS**

1. During the period beginning on the date that the improved wastewater treatment works are to attain operational level as specified in Item I, C.1 in the Schedule of Compliance and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements from outfall 3PK00002001. See Part II, **OTHER REQUIREMENTS**, for locations of effluent sampling.

EFFLUENT CHARACTERISTIC			DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
			Concentration Specified Units		Loading* kg/day			
Reporting Code	Units	Parameter	30 day	7 day	30 day	7 day	Meas. Freq.	Sample Type
00010	°C	Water Temperature	-	-	-	-	Daily	Continuous Max.
00530	mg/l	Total Suspended Solids	12	18	229	343	3/Week	Composite
00556	mg/l	Oil and Grease	Not to exceed 10 at any time				1/2 Weeks	Grab
00610	mg/l	Nitrogen, Ammonia (NH_3)						
		(summer)	1.5	2.25	28	43	3/Week	Composite
		(winter)	-	-	-	-	3/Week	Composite
00665	mg/l	Phosphorus, Total (P)	1.0	1.5	19	29	1/Week	Composite
31616	#/100ml	Fecal Coliform (Summer Only)	1000	2000	-	-	3/Week	Grab
50050	MGD	Flow Rate	-	-	-	-	Daily	Continuous
80082	mg/l	$CBOD_5$	10	15	189	284	3/Week	Composite

2. The pH (Reporting Code 00400) shall not be less than 6.5 S.U. nor greater than 9.0 S.U. and shall be monitored daily by multiple grab sample.

3. If the entity uses chlorine for disinfection, the Chlorine Residual (Reporting Code 50060) shall be maintained at a level not to exceed 0.024 mg/l and shall be monitored daily by multiple grab sample. (Summer only)**

4. The Dissolved Oxygen (Reporting Code 00300) shall be maintained at a level of not less than 6.0 mg/l and shall be monitored daily by multiple grab sample.

* The average effluent loading limitations are established using the following flow value: 5.0 MGD.

** See Part II, Items H and I.

Part I, A. - FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning on the date that the improved wastewater treatment works are to attain operational level as specified in Item I, C.4 in the Schedule of Compliance and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements from outfall 3PK00002001. See Part II, **OTHER REQUIREMENTS**, for locations of effluent sampling.

EFFLUENT CHARACTERISTIC			DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
			Concentration Specified Units		Loading* kg/day			
Reporting Code	Units	Parameter	30 day	Daily Max.	30 day	Daily Max.	Meas. Freq.	Sample Type
00335	mg/l	COD	-	-	-	-	1/Month	Composite
00625	mg/l	Nitrogen, Total Kjeldahl	-	-	-	-	1/Month	Composite
00630	mg/l	Nitrogen, Nitrite + Nitrate	-	-	-	-	1/Month	Composite
01079	µg/l	Silver, Total Recoverable	-	-	-	-	1/Month	Composite(1)
01094	µg/l	Zinc, Total Recoverable	233	334	4.42	6.36	1/Month	Composite(1)
01118	µg/l	Chromium, Total Recoverable	106	483	2.01	9.21	1/Month	Composite(1)
01220	µg/l	Chromium, Dissolved Hexavalent	13	24	0.25	0.46	1/Month	Grab(2)
39100	µg/l	Bis(2-Ethylhexyl) phthalate	-	-	-	-	Quarterly	Grab
34506	µg/l	1,1,1-Trichloroethane	-	-	-	-	Quarterly	Grab
61425	TUa	Acute Toxicity, <u>Ceriodaphnia</u> <u>dubia</u>	-	-	-	-	1/Month	See Part II, R
61426	TUc	Chronic Toxicity, <u>Ceriodaphnia</u> <u>dubia</u>	-	-	-	-	Quarterly	See Part II, R
61427	TUa	Acute Toxicity, <u>Pimephales</u> <u>promelas</u>	-	-	-	-	1/Month	See Part II, R
61428	TUc	Chronic Toxicity, <u>Pimephales</u> <u>promelas</u>	-	-	-	-	Quarterly	See Part II, R
99989	µg/l	Copper, Total Recoverable	38	60	0.72	1.14	1/Month	Composite(1)
99984	µg/l	Nickel, Total Recoverable	-	-	-	-	1/Month	Composite(1)
99988	µg/l	Lead, Total Recoverable	31	483	0.59	9.2	1/Month	Composite(1)
99990	µg/l	Cadmium, Total Recoverable	2.4	17	0.05	0.32	1/Month	Composite(1)
99993	µg/l	Mercury, Total(3)	.017	1.4	0.0003	0.027	1/Month	Composite(1)
99995	mg/l	Cyanide, Free(4)	.011	.048	0.21	0.91	1/Month	Grab(2)

* The average effluent loading limitations are established using the following flow value: 5.0 MGD.

(1) See Part II, Item L.

(2) See Part II, Item M.

(3) See Part II, Items I and P.

(4) See Part II, Items I and Q.

Table A-2. Exceedances of OEPA Warmwater Habitat criteria for chemical and physical water parameters (grab samples) from the Mahoning River study area during 1994.

Stream	River Mile	Parameter (value)
Upper Mahoning River		
	93.23	F. Coliform (2500◊ ◊ , 2700◊ ◊), Dissolved Oxygen ((2.76‡‡)
	88.33	F. Coliform (2300◊ ◊)
	47.35	F. Coliform (1500◊)
Lower Mahoning River		
	45.51	Aldrin (0.002#)
	41.5	F. Coliform (2200◊ ◊ , 15000◊ ◊ ◊)
	38.9	F. Coliform (1100◊)
	38.23	F. Coliform (1060◊)
	30.8	Dissolved Oxygen (0.78‡‡)
	29.03	Temperature (30.5*,31.0*)
	28.63	Temperature (30.5*,3.6*)
	26.43	Temperature (30.5*)
	25.16	Temperature (29.7*)
	23.43	Temperature (29.8*)
	21.73	F. Coliform (3900◊ ◊)
	21.14	Dissolved Oxygen (3.8‡‡)
	19.43	T-Lead (12*)
	15.53	T-Lead (22*), F. Coliform (8400◊ ◊ ◊ , 20000◊ ◊ ◊)
	12.42	F. Coliform (2200◊ ◊ , 10000◊ ◊ ◊)
	7.1	F. Coliform (6800◊ ◊ ◊)
Meander Creek		
	2.0	Dissolved Oxygen (4.5‡)
	1.8	Dissolved Oxygen (3.6‡‡), T-Lead (21*)
	0.8	Dissolved Oxygen (2.4‡‡, 3.5‡‡,3.8‡‡)
Mill Creek		
	11.3	Dissolved Oxygen (2.84‡‡)
	10.1	Dissolved Oxygen (3.4‡‡)
	9.5	Dissolved Oxygen (4.8‡,4.8‡),Ammonia-N (1.77*,2.05*,2.81*)
	7.8	Dissolved Oxygen (1.7‡‡,1.3‡‡,0.6‡‡,4.5‡,4,4.1‡),Ammonia-N (1.73,4.5,1.88)
	7.7	Dissolved Oxygen (1.33‡‡)
	5.9	Dissolved Oxygen (3.36‡‡)
	5.4	Dissolved Oxygen (3.7‡‡, 2.78‡‡, 2.7‡‡, 1.2‡‡) Ammonia-N (2.39*, 3.38*), T-Lead (13*)

Stream	River Mile	Parameter (value)
	5.1	Dissolved Oxygen (3.8‡‡)
	2.6	Dissolved Oxygen (3.7‡‡, 3.9‡‡)
	0.8	Dissolved Oxygen (4.9‡,1.99‡‡), pH(9.07*,9.2*)
	0.1	T-Lead (31*)
Anderson Run		
	0.2	Dissolved Oxygen (3.3)*, T-Lead (14*)
Indian Run		
	0.3	Dissolved Oxygen (4.5)*, T-Lead (11*, 12*)

* Exceedences of numerical criteria for prevention of chronic toxicity (Chronic Aquatic Concentration [CAC]).
** Exceedence of numerical criteria for prevention of acute toxicity (Acute Aquatic Concentration [AAC]).
# Exceedence of numerical criteria for human health 30-day average.
‡ Exceedence of the average Warmwater habitat dissolved oxygen (D.O.) criterion (5.0 mg/l).
‡‡ Exceedence of the minimum warmwater habitat dissolved oxygen (D.O.) criterion (4.0 mg/l).
◊ Exceedence of the average Primary Contact Recreation criterion (fecal coliform 1000/100 ml; E. coli 126/100 ml).
◊◊ exceedence of the maximum Primary Contact Recreation criterion (fecal coliform 2000/100 ml; E. coli 298/100 ml).
◊◊◊ exceedence of the maximum Secondary Contact Recreation criterion (fecal coliform 5000/100 ml; E. coli 576/100 ml).

Table A-3. An example of pollutant mean concentration calculations performed for dissolved oxygen downstream of Boardman WWTP.

	Date	Dissolved Oxygen (mg/L)	RM[1]	N[2]	Combined Mean	Standard Deviation
1	1/5/2000	10.8	9.6	12	9.1	2.1
2	2/1/2000	7.6				
3	3/1/2000	7.4				
4	4/5/2000	9.5				
5	5/3/2000	9.1				
6	6/1/2000	9.4				
7	7/3/2000	7.1				
8	8/1/2000	6.6				
9	9/5/2000	7.5				
10	10/2/2000	8.8				
11	11/1/2000	9.2				
12	12/1/2000	12.2				
	Ave =	8.8				
1	1/2/2001	12.2		12		
2	2/1/2001	12.7				
3	3/1/2001	13.4				
4	4/2/2001	11.1				
5	5/1/2001	8.5				
6	6/1/2001	8.2				
7	7/2/2001	5.6				
8	8/1/2001	7.3				
9	9/5/2001	7.3				
10	10/1/2001	9.0				
11	11/1/2001	8.6				
12	12/3/2001	8.0				
	Ave =	9.3				

1= RM- River Mile

2= N- Number of observations.

Table A-4. Results of water temperature (^oC) monitoring upstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	10	15.6	11	13.4	14.4	6.3
Boardman WWTP	21.63	12	14.9	12	13.6	14.3	6.0
Campbell WWTP	15.89	12	14.3	12	14.6	14.5	7.6
Columbiana WWTP		20	13.9	12	14.0	13.9	5.4
CraigBeach WWTP		11	16.3	11	15	15.7	6.9
Garrettsville WWTP		12	11.3	12	11.1	11.2	7.4
Girard WWTP	25.28	12	12	12	10	11	6.8
Lowellville WWTP	12.22	12	17	12	15	16	7.4
Meander Crk WWTP	30.27	12	16.3	11	15.9	16.1	5.1
Mosquito Crk WWTP	30.25	11	12	11	13	12.5	7.9
Newton Falls WWTP	56.85	12	13.5	12	13.8	13.7	7.2
Niles WWTP	28.86	12	16	12	12	14	8.8
Sebring WWTP		18	8.6	11	13.5	10.5	6.7
Struthers WWTP	14.32	12	16.2	12	15.5	15.9	7.0
Warren WWTP	35.25	12	13.2	12	12.8	13	7.2
Windham WWTP		12	12.6	12	12.3	12.5	6.2
Youngstown WWTP	19.43	12	16.8	12	16.3	16.58	7.1

Table A-5. Results of pH (S.U.) monitoring upstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	10	7.848	11	8.043	7.950	0.35
Boardman WWTP	21.63	12	7.399	12	7.277	7.338	0.21
Campbell WWTP	15.89	12	7.299	12	7.389	7.344	0.15
Columbiana WWTP		19	7.973	12	8.092	8.019	0.22
Craig Beach WWTP		11	7.464	10	7.220	7.348	0.2
Garrettsville WWTP		12	8.267	12	8.292	8.279	0.31
Girard WWTP	25.28	12	8.252	12	8.287	8.269	0.14
Lowellville WWTP	12.22	12	7.323	12	7.604	7.463	0.6
Meande rCrk WWTP	30.27	12	7.588	11	7.764	7.672	0.34
Mosquito Crk WWTP	30.25	11	7.377	11	7.336	7.357	0.11
NewtonFalls WWTP	56.85	12	7.528	12	7.434	7.481	0.37
Niles WWTP	28.86	12	6.852	12	6.792	6.822	0.08
Sebring WWTP		18	7.383	11	7.509	7.431	0.18
Struthers WWTP	14.32	12	7.624	12	7.683	7.654	0.76
Warren WWTP	35.25	12	7.833	12	7.983	7.908	0.22
Windham WWTP		12	7.533	12	7.324	7.428	0.39
Youngstown WWTP	19.43	12	7.658	12	7.592	7.625	0.18

Table A-6. Results of ammonia nitrogen (in mg/L) monitoring upstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	10	0.26	(Min)	11	0.33	0.297	0.302
			0.30	(Max)		0.36	0.33	0.27
Boardman WWTP	21.63	11	0.1036		12	0.1017	0.1026	0.0410
Campbell WWTP	15.89	11	0.395		12	0.214	0.3	0.37
Columbiana WWTP		19	0.2161	(Min)	12	0.12	0.18	0.28
			0.2176	(Max)		0.12	0.18	0.27
CraigBeach WWTP		10	0.08		11	0.04	0.06	0.04
Garrettsville WWTP		4	0.08		3	0.03	0.06	0.07
Girard WWTP	25.28	12	0.1048		12	0.0631	0.0839	0.119
Lowellville WWTP	12.22	5	0.45		4	0.42	0.44	0.18
Meander Crk WWTP	30.27	12	0.18		11	0.15	0.16	0.14
Mosquito Crk WWTP	30.25	11	0.18		11	0.23	0.2	0.11
NewtonFalls WWTP	56.85	4	0.14		4	0.19	0.16	0.11
Niles WWTP	28.86	12	0.127		12	0.129	0.128	0.007
Sebring WWTP		18	0.55		11	0.56	0.55	0.36
Struthers WWTP	14.32	12	0.32		12	0.43	0.378	0.24
Warren WWTP	35.25	12	0.0775	(Min)	12	0.0775	0.0775	0.08
			0.081	(Max)		0.0792	0.08	0.082
Windham WWTP		4	0.28		4	0.08	0.18	0.17
Youngstown WWTP	19.43	12	0.43		12	0.36	0.4	0.18

Table A-7. Results of fecal coliform (in #/100 ml) monitoring upstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	6	395	6	593	494	487
Boardman WWTP	21.63	6	726	4	888	791	871
Campbell WWTP	15.89	6	505	4	325	433	428
Columbiana WWTP		6	655	6	1460	1058	1159
Garrettsville WWTP		2	235	2	341	288	66
Girard WWTP	25.28	6	664.4	6	360.6	512	344
Lowellville WWTP	12.22	2	1388	2	275	831	758
Meander Crk WWTP	30.27	2	2400	3	467	1240	1911
Mosquito Crk WWTP	30.25	6	379	6	296	337	204
Newton Falls WWTP	56.85	6	213	6	126	166	107
Niles WWTP	28.86	6	1674	6	1675	1675	224
Sebring WWTP		8	2272	6	4092	3052	3748
Struthers WWTP	14.32	6	3492	6	2117	2804	4671
Warren WWTP	35.25	6	188	6	110	149	157
Windham WWTP		2	590	1	3960	1713	1949
Youngstown WWTP	19.43	6	618	5	149	405	743

Table A-8. Results of total hardness (mg/L as $CaCO_3$) monitoring upstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Lowellville WWTP	12.22	4	150.05				
MeanderCrk WWTP	30.27	11	158	11	208	183.1	46.5
Struthers WWTP	14.32	12	169.5	12	170.9	170	33

Table A-9. Results of 5-day CBOD (mg/L) monitoring upstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Boardman WWTP	21.63	2	2.2		2	2.6	2.4	0.33
Columbiana WWTP		7	1.7	(Min)				
			2.5	(Max)				
Sebring WWTP	4.1	9	1.93					

Table A-10. Results of water temperature (°C) monitoring downstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	13.7	11	13.4	13.5	6.9
Boardman WWTP	21.63	12	16.2	12	14.4	15.3	5.43
Campbell WWTP	15.89	12	14.5	12	14.7	14.6	7.8
Columbiana WWTP		20	15.1	12	15.2	15.13	4.62
CraigBeach WWTP		11	16	12	14	14.95	6.2
Garrettsville WWTP		12	11.3	12	11.1	11.2	7.3
Girard WWTP	25.28	12	13.8	12	12.75	13.3	5.7
Lowellville WWTP	12.22	12	17	12	15	16	7.58
Meander Crk WWTP	30.27	12		10		16.4	4.2
Mosquito Crk WWTP	30.25	11	12.7	12	12.9	12.8	7.5
NewtonFalls WWTP	56.85	12	13.2	12	13.6	13.4	7.5
Niles WWTP	28.86	12	16	12	12	13.7	8.84
Sebring WWTP		21	9.5	12	13.8	11.1	6.21
Struthers WWTP	14.32	12	15.7	12	15.3	15.5	7.53

Warren WWTP	35.25	12	13.83	12	14.17	14	7.21
Windham WWTP		12	14.5	12	12.4	13.5	7.48
Youngstown WWTP	19.43	12	16.2	12	15.8	16	7

Table A-11. Results of pH (S.U.) monitoring downstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	7.84	11	8.05	7.94	0.31
Boardman WWTP	21.63		XX	2	7.08		
Campbell WWTP	15.89	12	7.27	12	7.39	7.33	0.16
Columbiana WWTP		19	7.78	12	8.20	7.94	0.86
CraigBeach WWTP		11	7.7	12	7.3	7.5	0.71
Garrettsville WWTP		12	8.16	12	8.23	8.19	0.28
Girard WWTP	25.28	12	7.795	12	7.78	7.79	0.18
Lowellville WWTP	12.22	12	7.3	12	7.8	7.6	0.77
Mosquito Crk WWTP	30.25	11	7.43	12	7.38	7.4	0.13
NewtonFalls WWTP	56.85	12	7.63	12	7.54	7.59	0.38
Niles WWTP	28.86	12	6.75	12	6.786	6.77	0.197
Sebring WWTP		21	7.23	12	7.43	7.3	0.26
Struthers WWTP	14.32	12	7.64	12	7.62	7.63	0.21
Warren WWTP	35.25	12	7.83	12	8.02	7.93	0.25
Windham WWTP		12	7.53	12	7.41	7.47	0.25
Youngstown WWTP	19.43	12	7.73	12	7.66	7.696	0.152

Table A-12. Results of ammonia nitrogen (in mg/L) monitoring downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	0.18	(Min)	11	0.24	0.21	0.2
			0.21	(Max)		0.26	0.23	0.17
Boardman WWTP	21.63	11	0.1109		11	0.1145	0.1127	0.0533
Campbell WWTP	15.89	11	0.328		12	0.225	0.275	0.226
Columbiana WWTP		19	0.3315	(Min)	12	0.22	0.286	0.395
			0.3331	(Max)		0.22	0.287	0.394
CraigBeach WWTP		9	0.14		12	0.09	0.11	0.09
Garrettsville WWTP		4	0.08		3	0.04	0.06	0.063
Girard WWTP	25.28	12	0.801		12	1.419	1.11	1.19
Lowellville WWTP	12.22	4	0.24		4	0.30	0.27	0.08
Mosquito Crk WWTP	30.25	11	0.25		12	0.31	0.28	0.13
NewtonFalls WWTP	56.85	4	0.18		4	0.15	0.16	0.07
Niles WWTP	28.86	12	0.13		11	0.24	0.18	0.249
Sebring WWTP		21	1.14		12	0.74	0.993	0.721
Struthers WWTP	14.32	12	0.39		12	0.42	0.41	0.17
Warren WWTP	35.25	12	0.1383	(Min)	12	0.12	0.129	0.172
			0.1408	(Max)		0.1208	0.131	0.171
Windham WWTP		4	0.21		4	0.07	0.14	0.11
Youngstown WWTP	19.43	8	0.4		12	0.295	0.337	0.16

Table A-13. Results of total hardness (mg/L as $CaCO_3$) monitoring downstream of WWTP discharges.

RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation	RM
Alliance WWTP	82.03	12	220	11	258	238	63.3
Boardman WWTP	21.63	12	226	12	276	251	75.3
Columbiana WWTP		8	244	11	221	231	26.1
Garrettsville WWTP		4	167	4	219	193	52.1
Lowellville WWTP	12.22	4	167.8	4	182.8	175.3	24.42
Mosquito Crk WWTP	30.25	11	125	12	123	124	16.9
Niles WWTP	28.86	12	148	12	120	134	39
Sebring WWTP		9	336	12	319	326	74
Struthers WWTP	14.32	12	168.6	12	177.8	173.2	30.3
Warren WWTP	35.25	12	150	12	168	159	23.32
Windham WWTP		4	169	4	177	173	48.55
Youngstown WWTP	19.43	12	177	12	199	188	26.39

Table A-14. Results of fecal coliform (in #/100 ml) monitoring downstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	6	212	6	577	394	487
Boardman WWTP	21.63	6	509	6	235	372	431
Campbell WWTP	15.89	6	480	6	198	339	331
Columbiana WWTP		6	703	6	1098	901	857
CraigBeach WWTP		2	55	3	40	46	38
Garrettsville WWTP		2	230	2	313	271	70.5

Girard WWTP	25.28	6	1962.7	6	293.7	1128	2834
Lowellville WWTP	12.22	2	1338	3	332	734	822
Mosquito Crk WWTP	30.25	6	420	6	314	367	249
NewtonFalls WWTP	56.85	6	223	6	134	175	129
Niles WWTP	28.86	6	1722	6	1923	1823	345
Sebring WWTP		6	4408	6	3610	4009	3445.2
Struthers WWTP	14.32	6	3271	6	1070	2170	4494
Warren WWTP	35.25	6	115	6	88	102	70.43
Windham WWTP		2	440	2	430	435	134
Youngstown WWTP	19.43	6	2673	5	6698	4502	8785

Table A-15. Results of total recoverable zinc (μg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	27.3	(Min)	11	13.4	20.6	34.1
			37.3	(Max)		31.5	34.5	31.2
Boardman WWTP	21.63	12	60.1		12	34.7	47.4	30.7
Girard WWTP	25.28	5	40.8		9	38.7	39.4	8.44
Lowellville WWTP	12.22	4	25		4	21	22.6	7.6
Mosquito Crk WWTP	30.25	11	19.3	(Min)	12	20.1	19.696	10.818
				(Max)		20.2	19.74	10.74
Sebring WWTP		9	149.4		12	395.7	290.1	371.6
Struthers WWTP	14.32	12	19.8	(Min)	12	19.5	19.66	7.77
				(Max)		20.08	19.95	7.09
Warren WWTP	35.25	12	19.4		12	12.9	16.2	12.5
Youngstown WWTP	19.43	12	41		12	50	45	58.44

Table A-16. Results of total recoverable chromium (µg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	1.4	(Min)	11	0	0.73	3.5
			5.8	(Max)		4.82	5.335	5.34
Boardman WWTP	21.63	7	53			XX		
Lowellville WWTP	12.22	4	0.95	(Max)				
			1.40	(Min)				
Mosquito Crk WWTP	30.25	11	0	(Min)	11	0.364	0.182	0.501
			1	(Max)		1.455	1.227	0.869
Struthers WWTP	14.32	12	1.62	(Min)	12	1.64	1.63	1.07
			1.70	(Max)		1.77	1.74	0.93
Youngstown WWTP	19.43	10	66.7		10	3.7	35.2	60.31

Table A-17. Results of dissolved hexavalent chromium (µg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	14.4	(Min)	11	0	7.5	22.2
			33.2	(Max)		25.0	29.3	15.03
Boardman WWTP	21.63	7	12.6		9	8.2	10.1	12.9
Warren WWTP	35.25	12	1.7	(Min)	12	1.3	1.46	1.474
			2.5	(Max)		2.8	2.63	1.31

Table A-18. Results of total recoverable nickel (μg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	23	(Min)	10	3	13.89	31.9
			33	(Max)		13	24.2	30
Boardman WWTP	21.63	2	53		1	38.7	48.2	11.5
Lowellville WWTP	12.22	4	5		1	4.7	4.97	1.4
Mosquito Crk WWTP	30.25	11	1.6	(Min)	11	6.1	3.86	9.99
				(Max)		6.5	4.1	9.909
Sebring WWTP		3	46.7		3	32.5	39.6	8.98
Struthers WWTP	14.32	11	4.57		12	4.52	4.54	1.03
Warren WWTP	35.25	12	2	(Min)	12	1.8	1.92	5.48
			10.33	(Max)		11	10.67	2.55

Table A-19. Results of total recoverable lead (μg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Boardman WWTP	21.63	2	2.5		8	3	2.9	1.4
Girard WWTP	25.28	1	20		2	18	18.3	7.64
Lowellville WWTP	12.22	4	3.65	(Max)	4	1.67	2.66	1.93
				(Min)		1.82	2.73	1.82
Mosquito Crk WWTP	30.25	11	0.273	(Min)	11	7.2	3.73	8.34
			1	(Max)		7.6	4.32	8.07
Sebring WWTP		5	13.77		7	10.46	11.84	7.19
Struthers WWTP	14.32	11	4.01	(Min)	12	3.18	3.58	4.01

			4.07	(Max)			3.72	4.04
Warren WWTP	35.25	12	4.1	(Min)	12	2.6	3.4	2.1
			4.3	(Max)		3.1	3.7	1.6
Youngstown WWTP	19.43	6	41.5		9	10.7	23.04	19.7

Table A-20. Results of total recoverable copper (μg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Alliance WWTP	82.03	12	27.4	(Min)	10	1	15.4	40.4
			34.5	(Max)		9.6	23.2	38.3
Boardman WWTP	21.63	6	14		5	16	14.6	3.98
Girard WWTP	25.28	2	6.7		5	8.9	8.3	6.3
Lowellville WWTP	12.22	4	5.33		3	4.92	5.15	1.77
Mosquito Crk WWTP	30.25	11	4.45	(Min)	11	3.82	4.14	2.36
				(Max)		3.91	4.18	2.28
Sebring WWTP		6	98.0		7	32.6	62.7	68.25
Struthers WWTP	14.32	11	4.88		12	4.90	4.89	2.16
Youngstown WWTP	19.43	11	15		11	7	11.1	11.26

Table A-21. Results of total recoverable silver (μg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean	N	2001 Mean	Combined Mean	Standard Deviation
Youngstown WWTP	19.43	6	3	2	3.85	3.21	2.17

Table A-22. Results of total recoverable cadmium (µg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Boardman WWTP	21.63	5	10.2		6	0.1	4.72	8.7
Girard WWTP	25.28	8	0.394		2	0.64	0.443	0.22
Lowellville WWTP	12.22	4	0.24	(Max)	4	0.06	0.15	0.16
				(Min)		0.09	0.17	0.15
Mosquito Crk WWTP	30.25	11	0	(Min)	11	0.07	0.036	0.13
			0.18	(Max)		0.24	0.21	0.095
Struthers WWTP	14.32	11	0.128	(Min)	11	0.053	0.0903	0.185
			0.153	(Max)		0.092	0.122	0.171
Warren WWTP	35.25	12	0.6	(Min)	12	0.8	0.7	0.7042
			0.7	(Max)		1	0.8542	0.561
Youngstown WWTP	19.43	5	7.4					

Table A-23. Results of total cyanide (µg/L) monitoring Downstream of WWTP discharges.

Facility	RM	N	2000 Mean		N	2001 Mean	Combined Mean	Standard Deviation
Girard WWTP	25.28	1	0.011		2	0.021	0.017	0.0110
Warren WWTP	35.25	12	0.0053	(Min)	12	0.0037	0.0045	0.0054
			0.0073	(Max)		0.0066	0.007	0.0035

Table A-24. Results of 5-day CBOD (mg/L) monitoring downstream of WWTP discharges.

Facility	RM	N	2000 Mean	
Columbiana WWTP		8	4.1	(Min)
			4.4	(Max)
Sebring WWTP	4.1	12	2.98	

Table A-25. Selected Warmwater Habitat Criteria

Parameter	OMZM[1]	Details
Water Temperature	52-82 °F	Allowable Daily Maximum Varies by month
Dissolved Oxygen (DO)	4.0 mg/l	
pH	6.5-9.0	
Ammonia Nitrogen	13.0 mg/l for pH below 7.8 at any temperature	pH and Temperature dependent
Total Recoverable Zinc	220 µg/l at hardness of 200 mg/l ($CaCO_3$)	Depends on water hardness
Total Recoverable Chromium	3200 µg/l at hardness of 200 mg/l ($CaCO_3$)	Depends on water hardness
Dissolved hexavalent Chromium	1000 µg/l at hardness of 200 mg/l ($CaCO_3$)	Depends on water hardness
Total Recoverable Nickel	840 µg/l at hardness of 200 mg/l ($CaCO_3$)	Depends on water hardness
Total Recoverable Lead	300 µg/l at hardness of 200 mg/l ($CaCO_3$)	Depends on water hardness
Total Recoverable Copper	27 µg/l at hardness of 200 mg/l ($CaCO_3$)	Depends on water hardness
Total Recoverable Cadmium	9.9 µg/l at hardness of 200 mg/l ($CaCO_3$)	Depends on water hardness
Total Cyanide	46 µg/l	

1- Outside of Mixing Zone

Table A-26. An example of calculations performed on Leavittsburg data for calculating total flux.

	602280	pcode	00310	Flow Rate	BOD Loading
begindate	pname	value	rmk	cfs	Kg/d
900426	BOD 5 DAY MG/L	2.1		241	1238
900627	BOD 5 DAY MG/L	1.1		292	786
900829	BOD 5 DAY MG/L	1.5		404	1483
910221	BOD 5 DAY MG/L	1.3		2360	7507
980622	BOD 5 DAY MG/L	2	K	263	1287
980722	BOD 5 DAY MG/L	2	K	348	1703
980818	BOD 5 DAY MG/L	2	K	304	1488
980929	BOD 5 DAY MG/L	2.1		358	1840
981027	BOD 5 DAY MG/L	2		199	974
981117	BOD 5 DAY MG/L	2	K	215	1052
20-Jan-99	BOD 5 DAY MG/L	4.6		1040	11706
24-Feb-99	BOD 5 DAY MG/L	2	K	297	1453
30-Mar-99	BOD 5 DAY MG/L	2.3		194	1092
26-Apr-99	BOD 5 DAY MG/L	2	K	426	2085
10-May-99	BOD 5 DAY MG/L	2	K	257	1258
28-Jun-99	BOD 5 DAY MG/L	2	K	302	1478
19-Jul-99	BOD 5 DAY MG/L	2	K	287	1404
18-Aug-99	BOD 5 DAY MG/L	2	K	277	1356
30-Sep-99	BOD 5 DAY MG/L	2	K	301	1473
21-Oct-99	BOD 5 DAY MG/L	2	K	181	886
01-Nov-99	BOD 5 DAY MG/L	2	K	173	847
13-Dec-99	BOD 5 DAY MG/L	2	K	215	1052
12-Jan-00	BOD 5 DAY MG/L	2	K	551	2696
23-Feb-00	BOD 5 DAY MG/L	2		1040	5089
22-Mar-00	BOD 5 DAY MG/L	2	K	464	2271
24-Apr-00	BOD 5 DAY MG/L	2		560	2740
25-May-00	BOD 5 DAY MG/L	2.6		638	4059
15-Jun-00	BOD 5 DAY MG/L	2	K	661	3235
11-Jul-00	BOD 5 DAY MG/L	3.1		515	3906
07-Aug-00	BOD 5 DAY MG/L	2.1		671	3448
18-Sep-00	BOD 5 DAY MG/L	2	K	261	1277
19-Oct-00	BOD 5 DAY MG/L	2	K	355	1737
20-Nov-00	BOD 5 DAY MG/L	2	K	195	954
24-Jan-01	BOD 5 DAY MG/L	2	K	238	1165
26-Feb-01	BOD 5 DAY MG/L	2	K	370	1811

20-Mar-01	BOD 5 DAY MG/L	2	K	250	1223
30-Apr-01	BOD 5 DAY MG/L	4		249	2437
14-May-01	BOD 5 DAY MG/L	2	K	270	1321
12-Jun-01	BOD 5 DAY MG/L	2	K	330	1615
11-Jul-01	BOD 5 DAY MG/L	2	K	287	1404
15-Aug-01	BOD 5 DAY MG/L	2	K	267	1307
17-Sep-01	BOD 5 DAY MG/L	2	K	231	1130
02-Oct-01	BOD 5 DAY MG/L	2	K	202	989
06-Nov-01	BOD 5 DAY MG/L	2	K	155	759
04-Dec-01	BOD 5 DAY MG/L	2	K	237	1160
	Average	2.11		Average (kg/d)	**2071**
				in kg/yr	**755794**
	Standard deviation			SD (kg/d)	1947
				SD (kg/yr)	710582