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COMPREHENSIVE WATER QUALITY REPORT FOR THE LOWER MAINSTREAM OF THE GREAT MIAMI RIVER (RIVER MILE 92.5.0.9) MONTGOMERY, WARREN, BUTLER AND HAMILTON COS., OH - FINAL DRAFT DIVISION OF WASTEWATER & POLLUTION CONTROL -(REF FROM OU1, OU2 & OU5 RI REPORTS)

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Comprehensive Water Quality Report for the Lower Mainstem of the Great Miami River (River Mile 92.5-0.9) Montgomery, Warren, Butler and Hamilton Counties, Ohio

State of Ohio Environmental Protection Agency
Division of Wastewater Pollution Control
Water Quality Management Section
361 E. Broad St., Box 1049
Columbus, Ohio 43215

August 1982
(Revised September 1984)

FINAL VERSION

This Comprehensive Water Quality Report (CWQR) was prepared to identify sources of pollution, evaluate stream uses, recommend NPDES permit limitations, assess the financial impact of implementing the permit limitations, and examine the need for and benefits to be derived from the installation of advanced treatment at public wastewater treatment works.

A public hearing was held on October 24, 1983, in Dayton, Ohio, to consider this CWQR. All testimony received at that hearing concerning this report and all written comments submitted were reviewed by the Ohio EPA. Once certified by the Governor of the State of Ohio, this CWQR will be incorporated into the Great Miami Water Quality Management Plan (WQMP).

In the water quality standards used to determine NPDES permit limitations, where applicable, recommended in this report were those standards in effect at the time of this report. The Ohio EPA acknowledges that Amendments to some of those water quality standards have been proposed, and that if promulgated, the agency will use the amended standards to determine NPDES permit requirements. This report may also be amended after any revision of the Water Quality Standards has been adopted.

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Manager
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INTRODUCTION

This comprehensive water quality study was designed:

1) to determine if point source wastewater discharges and diffuse source impacts adversely affect biological condition and chemical/physical water quality in the lower mainstem of the Great Miami River (River Mile (RM) 92.5-0.9);

2) to gather data for the evaluation of stream use designations;

3) to determine wasteload allocations and National Pollutant Discharge Elimination System (NPDES) permit effluent limitations for point source discharges to the lower mainstem of the Great Miami River;

4) to assess the effect of meeting these limits on the economic condition of the affected industries and communities.

5) to assess the relationship between the expected benefits and the costs to be expended for each project.

Environmental monitoring is an important step in the management and protection of natural resources. Ideally, monitoring is the activity that directs the progression of events from problem identification and assessment, through management decisions on such issues as pollution abatement, and finally to the enforcement of environmental regulations. This comprehensive report represents the initial steps in this progression, and as such is the technical basis for water quality management decisions with regard to the lower mainstem of the Great Miami River. At the Ohio EPA Division of Wastewater Pollution Control, the application of monitoring data is primarily related to the management of the pollution abatement programs funded under the Clean Water Act. Information derived from such data must be an essential part of the construction grants management and decision making process if the expenditure of public funds for the construction of municipal sewage treatment facilities is to be justified; the valid use of monitoring data is no less important in establishing the level of treatment to be required of industrial dischargers, or in developing Best Management Practices to control nonpoint source pollution.

Water monitoring is necessary to satisfy two broad activities related to point source control programs: 1) the wasteload allocation process, and 2) the water quality standards (WQS) process (particularly the evaluation of stream uses). The comprehensive water quality report is a compilation of data, findings and conclusions, and recommendations for inclusion in the appropriate basin water quality management plan. Water quality problems in the study area are identified and quantified, and recommendations for pollution control measures are formulated. The recommendations concern primarily water quality standards, point source wasteload allocations, and National Pollutant Discharge Elimination System (NPDES) permit limitations; nonpoint source impacts on the biological condition of the receiving waters are evaluated and recommendations for reducing such impacts are made where appropriate.

This report contains a summary of findings, recommendations, and alternatives, followed by more detailed reports on the biological condition and chemical/physical water quality (Section I), the water quality modeling and wasteload allocation study (Section II), and the economic analysis (Section III).

Basin and Discharger Description

The Great Miami River is a major tributary of the Ohio River located in southwestern Ohio. It begins at Indian Lake in Logan County and flows for a distance of 170.3 miles until it joins the Ohio River just west of Cincinnati at a point 490 miles upstream from the Mississippi River. The Great Miami River has a total drainage area of 5,385 square miles, of which 3,789 square miles are in Ohio (Ohio Dept. of Natural Resources, 1960) and the remainder in eastern Indiana. Major tributaries to the river in the study area include the Stillwater River (drains 673 sq. mi.), Mad River (656 sq. mi.), Twin Creek (315 sq. mi.), Four Mile Creek (322 sq. mi.), Indian Creek (106 sq. mi.), and the Whitewater River (1483 sq. mi.). The study area included the mainstem and five major tributaries between Dayton and the Ohio River (RM 92.5 to RM 0.9).

There have been at least 84 permitted point sources of wastewater located on the lower Great Miami River mainstem and the lower 2-3 miles of tributaries since 1976. Of this total, 57 are industrial facilities, 22 are publically owned treatment works (POTW's) or semi-public facilities, 2 are federal facilities, and 3 are non-POTW municipal facilities; 18 are considered by Ohio EPA to be significant point sources. Seventy-six (76) of these facilities discharged in 1980. Besides runoff from agricultural areas throughout the basin, major nonpoint source effects in the study area include urban runoff and combined sewer overflows.

Water quality downstream from Dayton is affected by a number of point sources, the largest of which is the Dayton WWTP (RM 76.1). The largest industrial point sources in the Dayton area include the Dayton Power and Light Tait and Hutchings electrical generating stations (EGS), located at RM 77.5 and 64.3, respectively. These two facilities each have the capability to withdraw 100% of the mainstem flow for once-through cooling during critical low flow periods. Seven additional significant municipal and industrial sources are located in and downstream from Dayton.

Approximately 230-250 storm sewers located on the mainstem and lower tributaries between RM 83 and 75 carry stormwater runoff from Dayton and surrounding suburbs. The storm sewer system is separated from the sanitary system and therefore should not carry significant amounts of untreated sewage to the mainstem. Infiltration/inflow of water into the Dayton sanitary sewer system was termed "nonexcessive" and a plan for correcting what problems do exist has been formulated.

Important point sources in the Middletown and Hamilton (including Fairfield) areas are the Armco-Middletown steel making complex (RM 51.5 and via Dicks Creek, RM 47.6), Middletown WWTP (RM 48.3), and the Armco-New Miami steel mill (RM 38.7-39.3). Nine (9) additional significant municipal and industrial point sources are located in this area. Middletown has eight combined sewer overflow discharges to the mainstem between RM 52.2 and 51.0 . Thirty-one percent of the Middletown sewer system is combined. A more detailed assessment of the Middletown combined sewer system was not available, but will be included in a facilities plan for the Middletown facilities planning area

that is expected to be available sometime in 1983. A significant hazardous waste handling facility, Chem-Dyne, Inc., is located in Hamilton adjacent to the Hamilton Hydraulic Canal. Runoff from the 10 acre facility enters the Hamilton Hydraulic Canal via storm sewers approximately 0.25 miles upstream from the Great Miami River mainstem. The facility began receiving waste products in August 1974 and was closed in February 1980. Materials handled and stored generally included industrial by-products and solvents, pesticides, and compounds containing PCB's. The site has been in court receivership since mid-1981 and clean-up and recovery operations are underway.

Only two significant industrial point sources discharge into the Great Miami River mainstem downstream from the Hamilton-Fairfield area. The DOE-Feed Materials Production Center (RM 24.7) processes spent nuclear material (mostly uranium) and the Gulf Oil refinery near Hooven (RM 9.1) primarily manufactures gasoline.

Nonpoint sources in the Great Miami River Basin include runoff from agricultural, silvicultural, mining, construction and urban areas, and leachates from solid waste disposal areas and on-site disposal systems. Mining in the basin is limited to gravel dredging operations along the banks. Sediment and pollutant loadings from these dredging activities are difficult to quantify and are probably of minimal importance. Runoff from construction areas and leachates from solid waste disposal facilities and on-site disposal systems are localized.

METHODS

Chemical/physical water quality was determined at 14 locations in the lower mainstem and two (2) tributaries. Grab water samples collected during daylight hours (0745-1335) were analyzed for 23 parameters. In addition, two (2) three-day intensive surveys were conducted for the purpose of calibrating the water quality model used to establish effluent limitations. The distribution and relative abundance of the fish community was determined through the use of a boat-mounted electrofishing device at 42 mainstem locations between river mile (RM) 91.0 and RM 0.9, and seven (7) additional locations in the lower sections of the five (5) major tributaries. Benthic macroinvertebrates were sampled using modified Hester-Dendy multiple-plate artificial substrate samplers at 34 mainstem locations between RM 91.1 and RM 8.2 and four (4) locations in two (2) major tributaries. Limited bottom sediment and fish tissue collections were also made.

Recommended effluent limits were prepared for the dischargers to the lower mainstem of the Great Miami River based upon their design flows. The QUAL-II water quality simulation model (described in Section II) was used for the simulation of water quality and the allocation of loads to the various dischargers. The data used to calibrate the model for the Great Miami River mainstem was collected in two intensive field surveys in September, 1980.

Computer modeling uses several approaches for indicating the relationship between effluent and stream water quality. First, a simulation is designed to estimate the minimum effluent quality that will maintain stream water quality standards. If the calculated effluent quality is very restrictive, another simulation is made using an effluent quality associated with Advanced Waste Treatment (AWT)[a] limits. Alternatively, if the initial simulation indicates stream water quality standards can be satisfied with effluent characteristics of secondary treatment, no additional modeling is done.

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The use of AWT limits for modeling streams does not imply that the treatment is affordable or cost beneficial, nor does it preclude requiring higher levels of treatment if proven technologically feasible, affordable, and cost beneficial on an individual basis. In most instances, the Ohio EPA will require treatment more advanced than AWT only after this level of treatment is installed and operating, and subsequent biological and chemical water quality surveys indicate continued degradation.

Where a very restrictive effluent quality is indicated, model simulations are also made for effluent quality levels associated with various degrees of treatment from Secondary Treatment to Advanced Waste Treatment. These simulations provide a good indication of the instream water quality that would result from the implementation of the various treatment alternatives. In the event the highest level of required treatment proves to be beyond the economic means of the discharger, the alternatives provide a basis for establishing requirements that are economically feasible at this time along with the associated benefits and costs. The modeling results of alternative treatment levels also provide additional input for water quality management purposes such as site specific attainable water quality standards and the need for exempting a specific discharger from meeting water quality standards.

Ammonia-nitrogen (ammonia-N) loads were allocated by calculating a mass balance of the upstream and discharge ammonia-N at the points of mixing and were chosen to maintain the stream water quality standard, which is a function of temperature and pH. Conservative parameters, particularly heavy metals, were also allocated by mass balance. The QUAL-II model (SEMCOG version) was used to produce water quality simulations which are used for the allocation of biochemical oxygen demand (BOD_{20}) and dissolved oxygen (D.O.). This model can simulate both carbonaceous and nitrogenous oxygen demand.

The economic analysis was performed to determine the financial effect a treatment project on the individual users within the communities, and to assess the relationship between the costs of advanced treatment and the resulting benefits.

RESULTS

A biological and water quality survey of the lower 91.6 miles of the mainstem of the Great Miami River was conducted during June 5-October 9, 1980. The purpose of the survey was to; 1) establish baseline data on biological condition and chemical/physical water quality, 2) determine where the goals of the Clean Water Act are or are not being achieved, 3) determine the appropriate water quality use designations for the lower mainstem, 4) to identify major sources of water pollution that affect condition and water quality, and 5) to assist in the development of wasteload allocations.

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[a] Advanced Waste Treatment limits (AWT) of less than 10 mg/l $CBOD_5$, and/or 50% total nitrogen removal are technology based limitations derived from consideration of general wastewater treatment design parameters for typical Publicly Owned Treatment Works on small streams. These effluent characteristics can be maintained by use of the following train of sewage treatment unit processes; primary-secondary-nitrification-filtration.

At least 76 facilities discharged to the mainstem and lower tributaries in the study area in 1980. Of these 18 are considered to be significant point sources by the Ohio EPA. The Dayton WWTP (RM 76.1) was the largest point source in the study area in terms of BOD_5 (64%), NH_3-N (73%), and heavy metals loadings. Only the Hamilton South WTP (RM 33.9) had a larger loading of total suspended solids (57%). The next largest point sources of BOD_5 were the Middletown WWTP (RM 48.3; 10%) and Hamilton WWTP (RM 34.0; 3%). All other sources were less than 2% of the total loading each. The greatest concentration of point source loadings occurred in segment 4 (RM 76.1-71.6) and included the Dayton WWTP. Loads for BOD_5, total suspended solids, and ammonia-nitrogen have increased substantially in this segment from 1976 to 1980. Again, this increase was due primarily to the increased loading discharged by the Dayton WWTP. While the total mean third quarter (July 1-September 30) effluent flow increased from 50.6 MGD in 1976 to 60.8 MGD in 1980 (an increase of 20%), the mean BOD_5 loading increased from 2508 kg/day to 8165 kg/day (226% increase). Increases were also observed for total suspended solids (45% increase) and ammonia-nitrogen (468% increase). These increases completely overshadowed the elimination of Moraine WWTP (RM 73.7) in late 1979. Increased BOD_5 and total suspended solids loadings in segment 7 (RM 51.6-41.5) were the result of worsening effluent quality at the Middletown WWTP (RM 48.3) during 1976-1980. The BOD_5 concentration discharged by the Middletown WWTP was less than 15 mg/l on 93-100% of the days during June-September 1976-1979. In 1980, 56.5% of the daily values were greater than 15 mg/l. This worsening effluent quality coincided with the regular acceptance of industrial wastes by the Middletown WWTP in late 1979 or early 1980. Ammonia-nitrogen values, however, showed improvement through the same period, with nearly 85% of daily values less than 2 mg/l.

Chemical/physical water quality conditions in the lower mainstem Great Miami River during 1980 were typical of those observed in large rivers during higher than normal flow years. Water quality standards violations of parameters characteristic of nonpoint source runoff (total Fe, fecal coliforms) were much more frequent and widespread than for those parameters more sensitive to point source impacts (e.g., D.O., NH_3-N, temperature, cyanide, phenolics). Dividing the study area into segments of good, fair, and poor chemical/physical water quality was difficult because those parameters sensitive to point source impacts did not show distinct longitudinal differences as they have during years with lower flows. Past data indicated that exceedences of WQS for D.O., temperature, and possibly, ammonia, cyanide, and phenolics have been much more frequent during low flow years. The most severe water quality problem in the lower mainstem continues to be depressed D.O. levels which is the result of excessive loadings of oxygen demanding wastewater downstream from Dayton. Less severe problems exist downstream from Middletown and Hamilton. Unless BOD loadings are reduced in these areas, depressed D.O. levels will be a recurring problem in the lower mainstem, especially during low flow years.

The criteria most relied upon to evaluate the condition of the lower Great Miami River mainstem was the abundance, diversity, and distribution of the fish and macroinvertebrate communities. The most severe biological degradation occurred downstream from the Dayton WWTP (RM 76.1), as reflected by both the fish and macroinvertebrate communities. Another area of degradation was observed downstream from the Ohio Surburban WWTP (RM 87.4),

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although the extent and severity was much less than that observed downstream from Dayton. The fish community showed evidence of degradation between RM 74.9 and 38.2, a distance of 36.7 miles. The overall pattern of continual interruptions in recovery resulted in a net overall decline in most fish community parameters. The macroinvertebrate community in the lower half of this section did not reflect any substantial degree of degradation and was consistent with communities found in large, organically enriched warmwater rivers. The condition of the community was not, however, comparable to that found upstream from Dayton.

The apparent conflict between the condition of the macroinvertebrate and fish communities was the result of a combination factors. High flows during 1979 and 1980 evidently improved chemical water quality enough to permit the partial reestablishment of macroinvertebrate communities in the mainstem segment downstream from the Miami-Erie Canal dam (RM 62.6) to Hamilton (RM 37.2). The fish community did not show commensurate improvement in this segment apparently because avenues for repopulation from nearby refugia were blocked by dams, or there was a complete lack of repopulation epicenters (i.e. tributaries). This was especially evident in the section of the mainstem between the Middletown Hydraulic Canal dam (RM 56.7) and the Hamilton Hydraulic Canal dam (RM 41.5), where virtually no suitable refugia existed. Evidently the fish community in this section of the mainstem was reflecting past impacts during previous low flow periods (i.e., 1976, 1977). Degradation of the fish community was especially apparent in the mainstem downstream from the Armco-Middletown 001 outfall (RM 51.5), the Middletown combined sewer overflow area (RM 52.2-51.0), and the Middletown WWTP (RM 48.3). The macroinvertebrate communities did not reflect degradation to this same degree apparently because repopulation was able to occur during higher than normal flow periods (i.e., 1979, 1980). The potential for degradation during lower flows was noteworthy enough to warrant recommending further monitoring during below normal flow periods. Localized areas of impact occurred near Dayton and Hamilton.

The condition of the fish and macroinvertebrate communities outside the areas of degradation coupled with the lack of serious habitat modification illustrate the potential of the lower mainstem of the Great Miami River (RM 92.5-0.9) to support a normal and healthy aquatic community typical of that found in large warmwater rivers. The recovery of the aquatic fauna from the observed degradations with increasing distance downstream and during favorable flow periods indicated the potential for full recovery with a corresponding reduction in point source loadings.

The potential for the recovery of the lower mainstem Great Miami River fish and macroinvertebrate communities is good. Both groups have demonstrated the ability to show at least marginal improvement, primarily when chemical conditions were improved by high flows. However, the number of refuge and repopulation areas (i.e., tributaries) for fish is not exceedingly great. Upstream migration routes from tributaries and sections of the mainstem with healthly fish communities are blocked by dams at two key points, the Middletown dam (RM 51.7) and the Hamilton Hydraulic Canal Dam (RM 41.5). Neither dam pool has a suitable tributary that could act as a refuge or repopulation epicenter. Recovery in these two restricted sections will have to come from currently degraded upstream areas or within the sections themselves. However, this does not mean that recovery will not occur. Recovery will occur at a slower rate and will be more dependent on conditions

farther upstream. The remaining six (6) dams also block upstream fish movements, but the mainstem upstream from each has at least one undamaged tributary or a healthy fish community of its own.

The impact of point sources on instream chemical/physical water quality was the principle cause of the degradation of the fish and macroinvertebrate communities in the lower mainstem of the Great Miami River. Therefore, near term prospects for the recovery of these biological communities are largely dependent on the success of the programs aimed at reducing point source loadings, primarily for oxygen demanding wastes and suspended solids. Overall loadings from the Dayton WWTP must be reduced if recovery is to occur since it is by far the largest point source of wastewater in the study area. The key to ensuring full recovery downstream from Middletown is in controlling existing point source loads, better defining the apparent combined sewer overflow (CSO) problem, and determining if complex problems (i.e., possible chemical interactions, synergistic effects) exist.

The lower mainstem Great Miami River (RM 92.5-0.9), being capable of supporting reproducing populations of various fish and macroinvertebrate species, should maintain a Warmwater Habitat (WWH) use designation throughout its entire length. Impoundments, levee construction, and water diversions were not precluding factors as evidenced by good aquatic communities in the Steele and DP&L-Tait EGS dam pools. The Whitewater River between the Ohio-Indiana state line (RM 8.3) and its conflunce with the Great Miami River is also recommended for the Warmwater Habitat designation based on the resident fish community.

Using the QUAL-II model for modeling during summer critical low flow (seven day low flow with a recurrence period of once in ten years; $Q_{7,10}$), a set of mathematical discharge levels that maintained instream water quality standards was developed. Instream temperature values used in the allocations were the 75th percentile values, obtained from historical records at the USGS continuous monitors at Miamisburg (RM 67.0), Rockdale (RM 44.7), and New Baltimore (RM 21.4). As discussed in Section II, these mathematical results do not necessarily represent practical combinations of unit treatment processes. Hence several alternative treatment levels which reflect practical design constraints were evaluated to determine the extent to which water quality standards would be met instream. These alternative treatment levels, along with the length and magnitude of the resultant D.O and ammonia-nitrogen water quality standards violations, are summarized in Table 1. Dayton WWTP and Middletown WWTP are the only discharges that have significant potential for causing water quality standards violations and therefore were the only facilities included in the alternative treatment level evaluation.

Six projects in the study area were evaluated for affordability. Treatment upgradings at the Dayton, MCD North Regional, and Middletown WWTP's are not expected to pose a significant financial impact on their respective users. Insufficient information was available to make a similar assessment of the West Carrollton, MCD Franklin, and Hamilton Suburban WWTP's.

The quantifiable and nonquantifiable benefits associated with the aesthetic, recreational, and ecological values of the Great Miami River were considered to outweigh the incremental costs of advanced treatment.

Table 1. Summary of water quality modeling results showing various alternative treatment levels and the predicted instream dissolved oxygen and ammonia-N concentrations; all other discharges remained at allocated levels for all runs.

Treatment level	Dissolved oxygen		Ammonia-N	
($CBOD_{20}$/$CBOD_5$/ NH_3-N/D.O.)	Minimum average mg/l	Length of violation (miles)	Maximum mg/l	Length of violation (miles)
Segment 1: Dayton WWTP				
(MCD N. Regional WWTP @ 39.0/16.0/2.0/5.0)				
1. (15.0/6.0/1.0/6.0)	5.0	0.0	0.57[b]	0.0
2. (15.0/6.0/1.5/5.0)	4.9 (5.0)[a]	0.0	0.57	0.0
3. (20.0/8.0/2.0/5.0)	4.7 (5.0)[a]	3.0	0.57	0.0
4. (20.0/8.0/1.5/5.0)	4.8 (5.0)[a]	1.4	0.57	0.0
Segment 2: Middletown WWTP				
1.(27.2/20.0/8.0/5.0)	4.8 (5.0)[a]	0.0	0.96	0.0
2.(34.0/25.0/8.0/5.0)	4.7 (5.0)[a]	0.0	0.96	0.0
3.(40.8/30.0/5.0/5.0)	4.8 (5.0)[a]	0.0	0.88	0.0
4.(40.8/30.0/8.0/5.0)	4.6 (5.0)[a]	1.5	0.96	0.0

[a] insignificant violations of the water quality standard for D.O.
[b] maximum NH_3-N concentration occurs at RM 87.4 and is not impacted by the Dayton WWTP at these discharge levels.

DISCUSSION AND RECOMMENDATIONS

Recommendations for water quality management for the Great Miami River are influenced by the ecological value of the lower mainstem Great Miami River, AWT limits for Publically Owned Treatment Works, the financial impact of the proposed wastewater treatment plants on individual users, and the potential benefits of improved water quality. Protection of the warmwater fisheries resource in the lower mainstem of the Great Miami River through substantial reductions in point source loadings can realistically be achieved through the recommendations that follow.

Water Quality Standards

A. Final Recommendations

(1) The biotic communities present in the lower mainstem of the Great Miami River outside the area of chemical/physical water quality degradation reflect the potential of the river to support warmwater fish and macroinvertebrate populations; therefore, it is recommended

that the lower mainstem of the Great Miami River (RM 92.5-0.0) retain the Warmwater Habitat (WWH) use designation. AWT limits (8 mg/l $CBOD_5$, 2 mg/l NH_3-N) for the Dayton WWTP resulted in an insignificant projected violation of the WWH water quality standard for dissolved oxygen. Thus these limits can be conditionally certified as meeting the WWH use pending a follow up survey after these limits are being achieved.

(2) The frequency and magnitude of the projected violation downstream from the Middletown WWTP is quite small and judged to be within the margin of uncertainty of present modeling techniques. These limits can be conditionally certified as meeting the WWH use pending the results of a follow-up survey of segment 2.

(3) The proposed effluent limit for lead for the ARMCO-Middletown 001 outfall results in a minor violation of the WQS for lead. This was judged to be an insignificant violation and should be reevaluated along with other sources in the recommended follow up survey of segment 2.

(4) All effluent limits recommended in Tables 3 and 4, are certified as meeting the WWH use (Certified A) unless otherwise indicated above.

(5) The Primary Contact Recreation fecal coliform standard should be retained for the entire study area (RM 90.9 - 0.0) during the recreation season (May 1 - October 15) only. Chlorination should be minimized and closely monitored to correspond with actual wastewater flow rates to reduce the hazard to aquatic life as well as the cost of wastewater treatment, and alternatives to chlorination should be examined.

B. Recommendations for Future Studies

(1) A follow up biological and water quality survey of the entire study area during a below normal flow year is recommended after Advanced Waste Treatment (AWT) is installed and operating at the Dayton WWTP for at least one full year. There is reason to believe that the recommended limits of 8 mg/l $CBOD_5$, 2 mg/l NH_3-N at the projected effluent flow rate of 72 MGD (111.4 cfs) may not be sufficient to permit full recovery of the biological communities downstream from the Dayton WWTP during below normal flow periods. Although the projected loads represent a substantial reduction over those observed during June-September 1980 (Table 2), they are quite similar to those measured during the below normal flow period of July-September 1976. Severe biological degradation was observed in a 15 mile segment of the mainstem downstream from the Dayton WWTP during that time. The proposed effluent limits can be conditionally certified as meeting the warmwater habitat (WWH) use. Therefore, the recommended follow-up survey will be required to ascertain the adequacy of the recommended limits.

(2) Concerns raised about the possibility of complex interactions between the various toxic substances that may be present in the mainstem adjacent to and downstream from the Middletown area are an additional reason for a follow up survey. Methodologies consistent with the Ohio EPA strategy for monitoring toxic substances and evaluating their impact should be employed.

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(3) As an aid in designing future water quality modeling studies, the following points should be considered:

(a) The effect of current and anticipated improvements in treatment facilities discharging to Segment 1 on the upstream water quality available to dischargers in Segment 2.

(b) The effect of dams on reaeration.

(c) The effect of increased flows from the Middletown WWTP. At present, design flows are approximately 26 MGD (40 cfs). Modeling efforts indicate that this represents the upper limit for effluent discharge with the current effluent composition. Increases in plant flow above 26 MGD (40 cfs) will possibly change permissible loadings to the stream.

(d) The effect of the regulated withdrawal of water from the Great Miami River mainstem at the Hamilton Hydraulic Canal. Modeling efforts indicate additional flow within the mainstem would provide dilution water for the affected dischargers. However, no formal agreement currently exists between the users of the canal and the users of the mainstem. It is recommended that such an agreement be entered into to guarantee the existence of adequate dilution flow to the users of the river.

(e) The effect of algal photosynthesis and respiration on water quality within the Great Miami River mainstem.

Table 2. Comparison of 1976 and 1980 mean monthly (June-September) and third quarter (July-September) with projected BOD_5 and NH_3-N effluent loadings (kg/day) for the Dayton WWTP.

Period	MGD (cfs)	BOD_5	NH_3-N
1976 (3rd Quarter)	50.6 (78.3)	2508	497
June 1976	53.2 (82.3)	4678	1551
July 1976	50.6 (78.3)	2110	750
Aug. 1976	51.6 (79.8)	2640	442
Sept. 1976	49.5 (76.6)	2683	289
1980 (3rd Quarter)	60.8 (94.1)	8165	2824
June 1980	65.3 (101.0)	10642	3378
July 1980	62.8 (97.2)	9163	2732
Aug. 1980	63.4 (98.1)	9395	-
Sept. 1980	55.9 (86.5)	6038	-
Projected (10/2)	72.0 (111.4)	2729	546
Projected (10/1)	72.0 (111.4)	2729	273
Projected (6/1)	72.0 (111.4)	1637	273

(f) Better determination of hydraulic influences within the mainstem. The velocity/discharge and area/discharge relationships that would best serve this purpose are not yet available for all of Segment 2.

(g) Field determination of instream water quality and reaeration rates under a variety of flow conditions.

(h) Quantification and qualification of non-point source effects on the observations of stream water quality.

(4) No additional recommendations for stream uses, water quality criteria, or water quality based effluent limits should be made until the follow up surveys and report have been completed.

Recommended Effluent Limits

Recommendations for summer 30-day average NPDES limits were based on the water quality modeling described in Section II and biological and chemical water quality results described in Section I. This embodies both the technical constraints of maintaining water quality standards along with the practical constraints recommending achievable treatment trains. Table 3 summarizes the recommended CBOD, NH_3-N, and D.O. limits for major and significant point sources along the lower mainstem Great Miami River study area.

The proposed location of the New Miami WWTP is in a segment of the mainstem that is currently stressed as indicated by the biological results. As an alternative to the recommended treatment limits (Table 3) the proposed discharge by this facility should be moved to another location outside of the stressed segment.

Table 4 summarizes the recommended conservative parameter limits for all point sources along the lower mainstem Great Miami River study area that currently have NPDES limits for these substances. Section II describes the conservative wasteload allocation procedure in detail.

With reference to recommended permit limitations for dischargers to Segment 2, the following should be noted:

(1) Improvements to Dayton WWTP are currently being put on line. This facility is the major loading source in the basin; thus, these improvements will significantly impact the water quality entering Segment 2 of the GMR mainstem at Middletown. Since the wasteload allocation in Segment 2 is highly sensitive to this background water quality, the final recommendation of permit levels within Segment 2 should be reserved until the effects of Dayton's improvements are quantified.

(2) Biological and water quality surveys have identified several stress zones in Segment 2 where modeling efforts indicate either unknown influences or D.O. sags. Additional monitoring is needed to characterize these areas and the causes of these apparent degradations.

(3) Algal populations present during the summer months can dramatically affect observations of stream water quality used in model calibration and verification. To realistically account for their effects on both D.O. and the nitrogen series in Segment 2, additional data is required.

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(4) In general, there is a lack of reliable information to delineate stream water quality in Segment 2 under conditions of low flow and current discharge loadings. Data should continue to be collected to meet this need.

Therefore, it is recommended that current permit limitations for non-conservative parameters be retained for all dischargers in Segment 2. Appendix II-B (in Section II) contains present and allocated limits for all dischargers and parameters considered in water quality modeling.

A review of the State's chlorination policy is being conducted by Ohio EPA. Upon completion of this review in FFY 85, entities disinfecting with chlorine will be allocated water quality based total residual chlorine effluent limits consistent with the revised policy. The findings of the review and the recommended limits will be amended to this CWQR and reflected in their NPDES permits.

In addition winter allocations for nonconservative parameters were conducted for all entities. These results appear in Appendix C of the wasteload allocation report.

Table 3. Recommended summer 30-day average effluent concentrations for non-conservative parameters allocated to twenty-four facilities discharging to the lower mainstem Great Miami River.

Entity Name*	Recommended Permit Limitations (mg/l)			
	$CBOD_{20}$	$CBOD_5$	NH_3-N	D.O.
Segment 1:				
1 MCD N. Regional WWTP (18.56 cfs; 12.0 MGD) See Errata	39.0	16.0	2.0	5.0
2. Dayton WWTP	20.0	8.0	2.0	5.0
3. P.H. Glatfelter Inc.	88.9	37.5	2.6	5.0
4. Montgomery Co. W. Regional WWTP	28.0	10.0	2.5	6.0
5. West Carrollton WWTP	75.0	30.0	15.0	2.0
6. Interstate Folding Box	170.0	103.0	2.5	5.0
7. Miamisburg WWTP	75.0	30.0	15.0	2.0
8. River Arms Apt./Laund.	75.0	30.0	15.0	2.0
9. River Arms Apartments	75.0	30.0	15.0	2.0
10. Franklin WWTP	86.5	50.0	2.5	5.0

* All other entities were able to remain at current permit limitations.

Table 3. continued

Entity Name*	Recommended Permit Limitations(mg/l)			
	$CBOD_{20}$	$CBOD_5$	NH_3-N	D.O.
Segment 2:				
11. ARMCO-Middletown 001	-	-	3.5	5.0
12. Middletown WWTP	41.0	30.0	8.0	5.0
13. Crystal Tissue	36.0	25.0	-	5.0
14. LeSourdsville Reg. WWTP	25.0	10.0	2.5	6.0
15. Miller Brewery (proposed)	90.0	45.0	-	5.0
16. Butler Co.- Brentwood Estates	25.0	12.0	1.5	3.0
17. ARMCO - New Miami 004	-	-	5.4	5.0
ARMCO - New Miami 002	42.0	30.0	5.0	5.0
ARMCO - New Miami 001	10.2	8.8	5.6	5.0
18. New Miami WWTP (proposed)	37.5	15.0	5.0	5.0
19. Hamilton WWTP	75.0	30.0	2.5	5.0
20. Fairfield WWTP	75.0	30.0	2.5	5.0
21. Ross WWTP (proposed)	75.0	30.0	15.0	2.0
22. Procter and Gamble	60.0	30.0	-	5.0
23. DOE-Feed Materials Production Center	27.0	20.0	20.0	5.0

* All other entities were able to remain at current permit limitations.

It is recommended that the NPDES permit limitations for heavy metals be adjusted to the levels allocated in Section II (see Appendix A). The recommended limits for toxic substances (heavy metals) should be considered in the development of local limits for POTW pretreatment programs. Allocated limits for all dischargers and parameters are summarized in Appendix II-B.

Table 4. Recommended 30-day average effluent concentrations for heavy metals allocated to eight (8) facilities that discharge to the lower mainstem Great Miami River.

Facility	RM	Recommended Levels (mg/l)						
		Zn	Pb	Cr	Cu	Fe	Ni	Cd
Dayton WWTP	76.1	0.566	0.055	0.154	0.100	-	-	0.015 - see A.T
GMC-Delco #3	74.4	0.340	-	0.208	-	-	0.600	- - see p.2
GMC-Delco #2	74.2	-	-	0.040	-	-	0.120	-
Mont. Co. W. Reg. WWTP	71.5	-	0.055	-	0.200	-	-	-
DOE-Mound Lab	65.9	-	-	0.50	0.500	-	0.500	0.100
ARMCO-Middletown[1] 001 (611)	51.5	0.199	0.113[2]	-	-	-	-	-
ARMCO-New Miami 611	38.7	0.041	0.028	-	-	-	-	-
DOE-Feed Materials Prod. Center 001b and 001c	24.7	-	-	0.027	0.013	0.221	0.067	-

[1] concentrations based on an effluent flow of 11.10 MGD (17.17 cfs).
[2] results in an insignificant violation of WQS for lead

SECTION I

Intensive Biological and Water Quality Study of the Lower Mainstem of the Great Miami River

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INTRODUCTION

Biological and Water Quality Survey Program

A program of biological and water quality surveys to investigate water quality in selected rivers and streams has been conducted by the Ohio EPA since 1977. Selections are made on a priority basis within the Division of Wastewater Pollution Control during January - February preceding the July - October field season. These investigations are conducted for the purpose of addressing specific water quality issues and to serve as a mechanism for integrating surface water monitoring programs with the water quality standards, wasteload allocation, NPDES permit, and construction grants programs.

Pre-survey planning and field work is coordinated by the Water Quality Unit under the direction of the Section of Surveillance and Standards, and developed with the assistance of the Biomonitoring Unit and the appropriate District Surveillance staff. Chemical water quality simulation modeling, when included, is performed by the Water Quality Planning and Assessment Section.

All biological and water quality surveys include comprehensive chemical/physical and biological sampling. Flow, cross-sectional, kinetcic, and reaeration measurements, and time-of-travel studies are performed under the direction of the Water Quality Planning and Assessment Section when data for calibration and/or verification of the water quality model is required. All field and laboratory procedures conform to those outlined in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 1980). The following, while not an exhaustive list, are some specific examples of the purpose, use, and application of biological and water quality survey results:

- To identify, quantify, and differentiate water quality degradation and contributions from both point and nonpoint pollution sources and to assess their impact on existing or planned stream uses.
- To biologically evaluate existing water quality.
- To provide some basis for understanding and describing receiving water quality and the processes that affect that water quality.
- To determine if the Clean Water Act goal of fishable/swimmable waters is being achieved.
- To evaluate water use designations and water quality standards.
- To assess the effectiveness of surface water pollution control programs and to set priorities for their establishment or improvement.

- To provide support for the Agency's NPDES permit enforcement program.
- To identify toxic substances entering state waters and to assess their impact on existing and planned stream uses.
- To provide a partial data base for the biennial water quality inventory (305(b)) report.

Technical reports are prepared for each survey and are completed during the following year whenever possible, and are also included as a part of the next 305(b) report, which is published once every two years.

Great Miami River Mainstem - River Mile 92.5-0.9

The Great Miami River between Dayton and the Ohio River has been degraded to various degrees as the result of the discharge of wastewater from municipal and industrial point sources, and to a lesser extent by nonpoint source runoff. The mainstem has been the subject of numerous water quality and pollution abatement studies (Ohio Department of Health, 1951, 1967; Roy F. Weston, Inc. 1967; Ohio Department of Natural Resources 1971; Black and Veatch 1974; Miami Conservancy District 1974; Ohio EPA 1974; Miami Valley Regional Planning Commission 1977; Ohio-Kentucky-Indiana Regional Council of Governments 1977). The principal objective of these studies was to determine effluent limitations for point source discharges of wastewater. No fewer than 14 publications and reports are available that discuss the status of the biological communities, primarily macroinvertebrates and fish, in the lower mainstem and tributaries (Young 1967; Scott 1968, 1969a, 1969b, 1970; Conn 1971, 1972, 1973, 1977a, 1977b; Yoder and Gammon 1975; Miami Valley Regional Planning Commission 1976; Beckett et al. 1976; Beckett 1977; Gammon 1977a, 1977b). Most of these studies only considered qualitative presence/absence type data. The studies by Yoder and Gammon (1975), Gammon (1977a,b), Beckett et al. (1976), and Beckett (1977), however, included relative abundance data generated by standardized sampling procedures that provided a quantitative comparison with the results of this survey. The summary overviews provided in the 1980 Ohio EPA 305(b) report (Ohio EPA 1980a) are the most recent descriptions of water quality and biological condition in the lower Great Miami River.

This survey was initiated to develop a current and comprehensive water quality and biological data base so that the following could be accomplished:

1) determine where the goals of the Clean Water Act are or are not being achieved;
2) determine the appropriate water quality use designation(s) for the lower mainstem;
3) identify major sources of water pollution, both point and nonpoint source, that affect biological condition and water quality in the lower mainstem; and
4) establish baseline conditions in the lower mainstem in anticipation of wastewater treatment facility upgrading at major municipal point sources.

Chemical/physical water quality and biological condition (fish and macroinvertebrates) were studied in the lower 91.6 miles of the lower mainstem of the Great Miami River during the period June 5-October 9, 1980. Within the scope of this study it was possible to determine the magnitude of point and nonpoint source impacts, judge the effectiveness of existing water pollution abatement programs, and determine the potential and actual uses of the river.

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Geology

A description of the geology of the Great Miami River Basin involves a discussion of both bedrock and glacial geology. In the southern portion of the basin the bedrock consists of alternating layers of thin shale and limestone beds of the Ordovician age. These bedrock formations are exposed in the mainstem downstream from Hamilton in the form of shallow ledges. To the north, especially in the upland areas, these rocks are overlain by younger Silurian and Devonian limestone, dolomite and shale bedrocks.

The glacial geology consists of layers or mixtures of clay, silt, sand, and gravel deposited on the bedrock during three major glaciation periods. The erosion of Ohio bedrock and Canadian rocks by the movement of the glacier resulted in the formation of clay, silt, sand, and gravel which was deposited on the bedrock as the glaciers melted. Much of the sand and gravel was washed into pre-glacial or interglacial period stream valleys which are termed buried stream valleys. The upland bedrock areas were covered with glacial till (mixtures of clay, silt, sand and gravel), but with a greater proportion of clay than the buried valleys. Layers of sand and gravel also exist in the glacial till deposits.

Groundwater is obtained from both the Silurian bedrock and the glacial deposits. Devonian bedrock is a minor ground water source in the basin and Ordovician bedrock is a poor source of water (yielding less than 5 gallons per minute). Silurian bedrock in the upland areas is a significant source of groundwater yielding amounts sufficient for small public water supplies. The upland glacial till deposits contain sand and gravel deposits capable of yielding sufficient groundwater for domestic, farm, and small industrial needs.

The major goundwater resources of the basin are found in the buried valley deposits. These buried valley aquifers yield sufficient water (up to 3000 gallons per minute from some wells) for large municipalities such as Dayton and for many of the major industries of the area.

Meteorology

Generally, weather conditions in this basin as well as all southwestern Ohio are characterized by extremes and are subject to rapid change. This climate pattern is known as humid continental, where seasonal contrasts are strong and the weather highly variable. The National Weather Service at Dayton International Airport reported an average annual precipitation of 36.1 inches for 1980, which was 1.74 inches above normal.

Land Use and Population

The predominant land uses in the Great Miami River basin are agricultural and pasture land (Table 5). The upper Great Miami River subbasin is characterized by extensive agricultural land use (78%) in Logan, Shelby, and northern Miami counties. Small urban areas are found at Bellefontaine (Logan County), and Sidney (Shelby County), and smaller towns and villages are common throughout.

Table 5. Percentage of land use types by subbasin in the Great Miami River basin (data from LANDSAT via Ohio EPA PEMSO System).

Subbasin	Urban	Agriculture	Pasture	Forest	Water
Great Miami River - Headwaters to Stillwater River	4.4	78.3	8.7	7.2	0.9
Stillwater River	3.4	72.3	16.6	6.4	0.2
Mad River	5.0	61.1	14.4	18.0	0.9
Twin Creek	5.7	65.4	21.4	5.9	0.0
Four Mile Creek	12.1	52.1	28.8	3.5	0.4
Indian Creek	14.0	42.9	31.5	7.9	0.7
Whitewater River	1.7	43.2	37.4	15.6	0.3
Great Miami River - Stillwater River to Ohio River	12.4	29.7	37.3	17.6	0.8

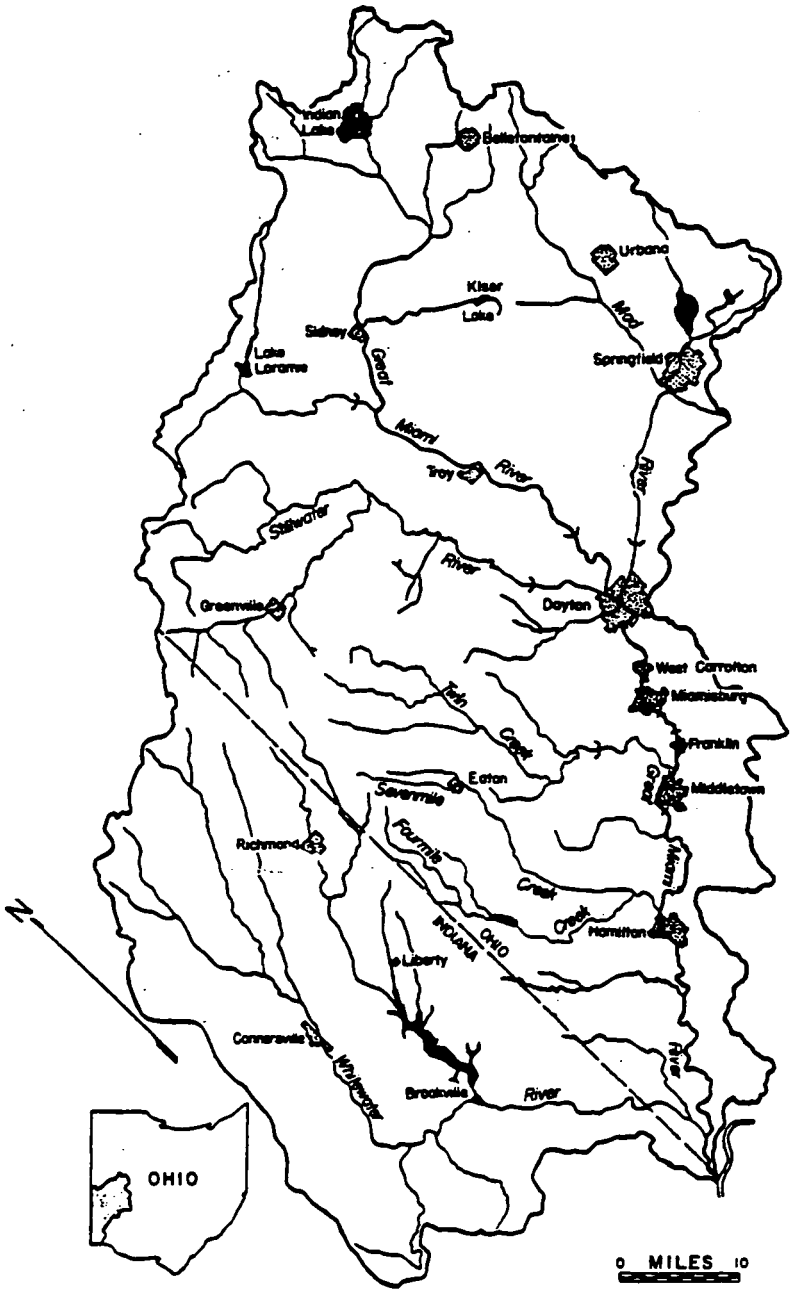
LOCATION AND DESCRIPTION

Geography

The Great Miami River is a major tributary of the Ohio River located in southwestern Ohio. It originates at Indian Lake in Logan County and flows for a distance of 170.3 miles until joining the Ohio River just west of Cincinnati at a point 490 miles upstream from the Mississippi River. The Great Miami River has a total drainage area of 5,385 square miles, of which 3,789 square miles are in Ohio (Ohio Dept. of Natural Resources, 1960) and the remainder in eastern Indiana. Major tributaries to the river in the study area include the Stillwater River (drains 673 sq. mi.), Mad River (656 sq. mi.), Twin Creek (315 sq. mi.), Four Mile Creek (322 sq. mi.), Indian Creek (106 sq. mi.), and the Whitewater River (1483 sq. mi.). The study area included the mainstem and five major tributaries between Dayton and the Ohio River (RM 92.5 to RM 0.9, Figure 1).

The majority of the Great Miami River Basin lies in the glaciated till plains division of the central lowlands physiographic province. The topography in the upper and middle portions of the basin is typified by level to gently rolling plains which are broken by the wide valleys of the major tributaries. In the lower portion, the topography progresses from rolling to hilly terrain as the river and its tributaries flow toward the Ohio River (Ohio-Kentucky-Indiana Reg. Council Govts. 1977). The Great Miami River changes from a medium sized (100-200'in width) river upstream from Dayton to a large river (gretater than 200'in width) downstream from the confluences of the Stillwater and Mad Rivers. Between RM 82.2 and 41.5 the river is impounded by nine dams of varying sizes. Only four of these dams (Steele dam, RM 82.2; Miami-Erie Canal dam, RM 62.7; Middletown Hydraulic Canal dam, RM 56.7; and Hamilton Hydraulic Canal dam, RM 41.5) create any significant pools, the largest one being approximately three miles in length. The total cumulative distance of impounded mainstem is approximately 15 miles; the remainder of the mainstem is typical of a lotic environment. The banks along the mainstem are generally tree-lined (*Acer*, *Platanus*, *Populus*, *Salix*) and include typical riparian vegetation, except where urban areas encroach on the shoreline. Grass covered earthen levees line both sides of the river in Dayton, Miamisburg, Franklin, Middletown, and Hamilton. These were constructed as part of the overall flood control program operated by the Miami Conservancy District. In spite of this encroachment the river still maintains many characteristics of a lotic environment (riffles, pools, sinuosity). Substrate in the river between Dayton and Hamilton is largely composed of gravel and rubble, but changes to predominantly bedrock and bedrock fragments downstream from Hamilton.

Figure 1. The Great Miami River basin showing major sub-basins, reservoirs, and metropolitan areas (inset map shows location within Ohio).



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Similar sized urban areas exist in and near Piqua, Troy, and Tipp City (Miami County), which are, in part, the result of an outward expansion from Dayton. The lower Great Miami River subbasin, within which the study area is located, is characterized by relatively intense urbanization (12.4%) in and near Dayton, Middletown, and Hamilton. Some of the largest population increases in the basin have occurred in the suburbs of these cities during the past decade (Table 6).

Hydrology

The hydrology of the lower Great Miami River mainstem is atypical of most large rivers in Ohio in that flow rate and volume are highly dependent on the ground water characteristics of the drainage area. Deep glacial deposits of sand and gravel in the Great Miami River valley contain considerable amounts of ground water. Low river flows are sustained by ground water discharge which results in the Great Miami River having one of the highest sustained dry weather flows in the state (Norris and Spieker 1966; Spieker 1968).

Flow controls within the Great Miami River basin consist of a unique system of five (5) retarding basins located on major tributaries and the mainstem, six (6) permanent impoundments, and flow diversions at Middletown and Hamilton. The retarding basin concept and corresponding local flood protection were developed by the Miami Conservancy District mainly in response to the devastating 1913 flood (Woodward 1920). The retarding basins, completed in the 1920's, are designed to retard the flow of water downstream once a certain discharge rate has been reached. Water is temporarily impounded within the retarding basin until flows decrease to normal base levels. This concept has the added environmental benefit of retaining the natural lotic characteristics during normal flow periods while controlling floods during high flow periods. Locations and data on each retarding basin are given in Table 7. Local flood protection consisting of channel modification, levee construction, or a combination of the two is provided for the cities of Piqua, Troy, Dayton, West Carrollton, Miamisburg, Franklin, Middletown, and Hamilton, all of which are located on the mainstem.

Permanent impoundments within the Great Miami River basin are the Clarence J. Brown Reservoir (Buck Creek) near Springfield, Acton Lake (Four Mile Creek) near Oxford, Lake Loramie (Loramie Creek) near Loramie, Kiser Lake (Mosquito Creek) in western Champaign county, Brookville Reservoir (East Fork-Whitewater River) south of Richmond, Indiana, and Indian Lake (Great Miami River) located in the extreme upper basin near Russells Point. The Clarence J. Brown Reservoir, located on Buck Creek in the Mad River basin, is intended to provide flow augmentation to the Great Miami River mainstem during low-flow periods.

Diversion of water from the Great Miami River mainstem is possible via the Middletown and Hamilton Hydraulic Canals. The most active of the two is the Hamilton Canal which is capable of diverting the entire flow of the Great Miami River during low-flow periods. Water diverted from the Great Miami River mainstem at RM 41.5 is used to run a small hydroelectric generating facility and provide non-contact cooling water for the Hamilton Municipal EGS,

Table 6. Population statistics[a] for cities, towns, and villages located within the Great Miami River basin in Ohio.

	1970 Census	1980 Census	Percent change, 1970 to 1980
GREAT-MIAMI-RIVER			
Russells Point	1,104	1,156	4.7
Degraff	1,007	1,142	13.4
Quincy	686	633	-7.7
Sidney	16,332	17,240	5.6
Ft. Loramie	744	977	31.3
Lockington	242	203	-16.1
Piqua	20,741	20,480	-1.3
Troy	17,186	19,086	11.1
Tipp City	5,090	5,595	9.9
Vandalia	10,796	13,161	21.9
Dayton	243,023	203,588	-16.2
West Carrollton	10,748	13,148	22.3
Miamisburg	14,797	15,304	3.4
Franklin	10,075	10,711	6.3
Middletown	48,767	43,719	-10.4
Trenton	5,278	6,401	21.3
Oxford	15,868	17,655	11.3
Seven Mile			
St. Clair Township	233	303	30
Wayne Township	466	538	15.5
New Miami	3,273	2,980	-9.0
Hamilton	67,865	63,189	-6.9
Fairfield	14,680	30,777	109.7
TOTAL	509,001	487,986	

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Table 6. (continued)

	1970 Census	1980 Census	Percent change, 1970 to 1980
STILLWATER RIVER			
Covington	2,575	2,610	1.4
Greenville	12,380	12,999	5.0
Pleasant Hill	1,025	1,051	2.5
West Milton	3,696	4,119	11.4
Union	3,654	5,219	42.8
Englewood	7,885	11,329	43.7
TOTAL	31,215	37,327	
MAD RIVER			
Bellefontaine	10,896	11,561	6.1
West Liberty	1,580	1,653	4.6
Urbana	11,237	10,741	-4.4
Springfield	81,941	72,563	-11.4
Fairborn	32,264	29,702	-7.9
TOTAL	137,918	126,220	

[a] 1980 Census of Population and Housing - U.S. Department of Commerce.

and then returned to the mainstem at RM 37.1. A verbal agreement between the City of Hamilton and ARMCO Steel assures a flow of at least 35 cfs over the Hamilton Hydraulic Canal dam, provided the city has adequate water for its needs. This can effectively leave 4.4 miles of the Great Miami River mainstem with little dilution water during critical low-flow periods. The Middletown Hydraulic Canal diverts water at RM 56.7 and returns it at RM 52.2. This diversion is much less active.

Water Quality Impacts

There have been at least 84 permitted point sources of wastewater located either on the lower Great Miami River mainstem or on the lower 2-3 miles of tributaries since 1976 (Figure 2). Of this total, 57 are industrial facilities, 22 are publicaly owned treatment works (POTW's) or semi-public facilities, 2 are federal facilities, and 3 are non-POTW municipal facilities; 18 are considered by Ohio EPA to be significant point sources (Table 8). Seventy-six (76) of these facilities discharged in 1980. Besides runoff from agricultural areas throughout the basin, major nonpoint source effects in the study area include urban runoff and combined sewer overflows.

Water quality downstream from Dayton is affected by a number of point sources, the largest of which is the Dayton WWTP (RM 76.1). The largest industrial point sources in the Dayton area included the Dayton Power and Light Tait and Hutchings electrical generating stations (EGS), located at RM 77.5 and 64.3, respectively. During critical low flow periods these two facilities each have the capability to withdraw 100% of the mainstem flow for once-through cooling. Seven additional significant municipal and industrial sources are located in and downstream from Dayton.

Approximately 230-250 storm sewers located on the mainstem and lower tributaries between RM 83 and 75 carry stormwater runoff from Dayton and surrounding suburbs. The storm sewer system is separated from the sanitary system and therefore should not carry significant amounts of untreated sewage to the mainstem. Infiltration/inflow of water into the Dayton sanitary sewer system was termed "nonexcessive" and a plan for correcting what problems do exist has been formulated (Black and Veatch 1981).

Important point sources in the Middletown and Hamilton (including Fairfield) areas are the ARMCO-Middletown steel making complex (RM 51.5 and via Dicks Creek, RM 47.6), Middletown WWTP (RM 48.3), and the ARMCO-New Miami steel mill (RM 38.7-39.3). Nine (9) additional significant municipal and industrial point sources are located in this area. Middletown has eight combined sewer overlow discharges to the mainstem between RM 52.2 and 51.0 (Figure 3). Thirty-one percent of the Middletown sewer system is combined. A more detailed assessment of the Middletown combined sewer system was not available, but will be included in a facilities plan for the Middletown facilities planning area that is expected to be available sometime in 1982. A significant hazardous waste handling facility, Chem-Dyne, Inc., is located in Hamilton adjacent to the Hamilton Hydraulic Canal. Runoff from the 10 acre facility entered the Hamilton Hydraulic Canal via storm sewers approximately 0.25 miles upstream from the Great Miami River mainstem. The facility began

Figure 2. Locations of major urban areas, tributaries, dams, and point sources in the lower mainstem Great Miami River study area, June-October, 1980.

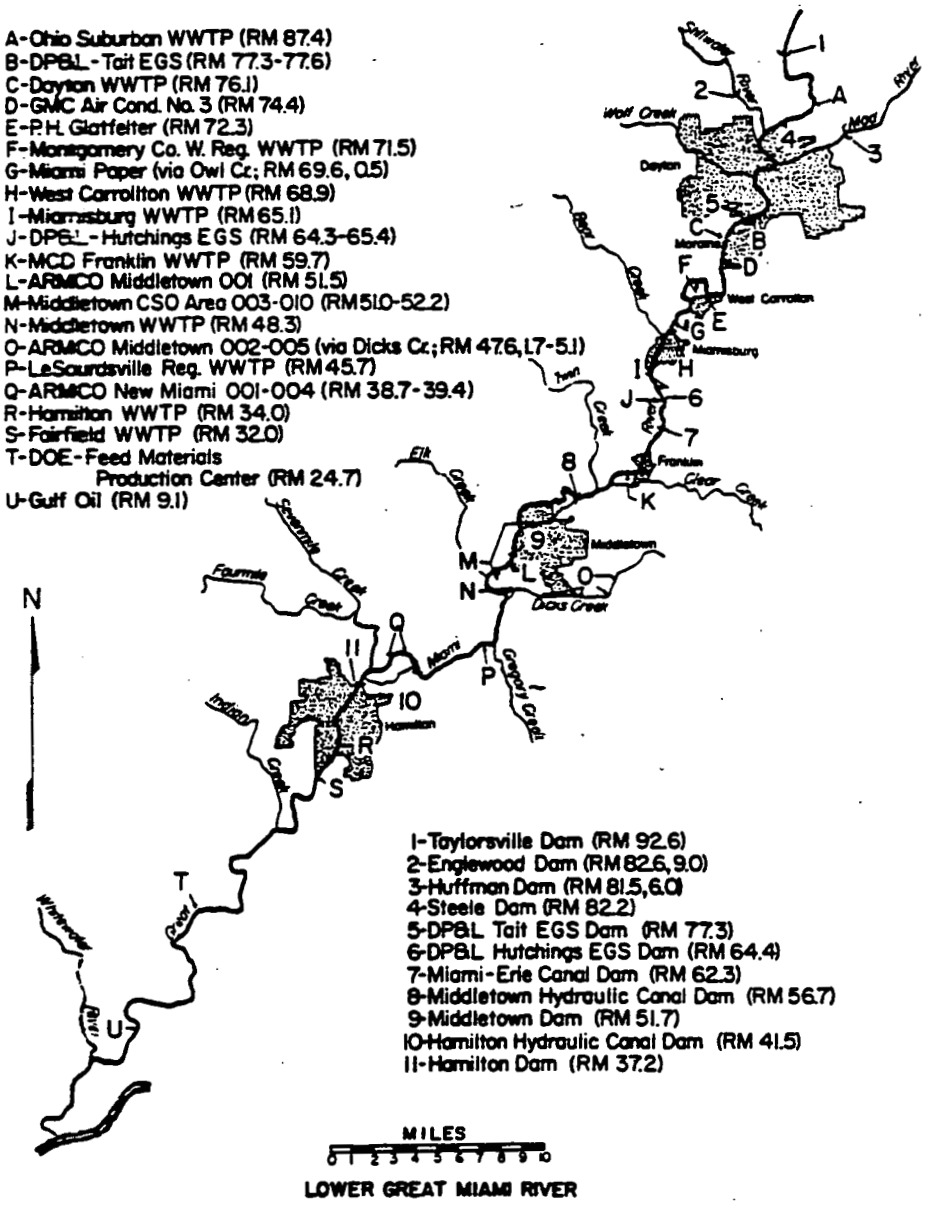

Table 7. Description and location of the five retarding basins operated and maintained by the Miami Conservancy District (data from Woodward 1920).

Basin Name	Lockington	Taylorsville	Englewood	Huffman	Germantown
Stream/River	Loramie Cr.	Great Miami R.	Stillwater R.	Mad R.	Twin Cr.
River Mile	119.9,2.1	92.6	82.6,9.0	81.5,6.0	57.4,10.1
Surface Area (Acres) (Spillway Level)	4160	10880	8000	9280	3520
Surface Area (Acres) (1913 Flood)	3600	9650	6350	7300	2950
Dam Height (ft.)	69	67	110.5	65	100
Days to Empty (Maximum Stage)	7	4.5	23	5	7.5

Table 8. Significant and major industrial and municipal point sources in the lower mainstem Great Miami River study area, 1980 (from Ohio EPA FY 1982 major and significant discharger lists, unless otherwise noted; information from Ohio EPA NPDES permit files).

Facility	Permit Number	Outfall Number	River Mile	Flow (MGD)	Type of Process - Effluent Characteristics
Vandalia WWTP	D612	001	94.2	2.3[a]	Municipal wastewater treatment (hydro-seives, trickling filters, Imhoff tank); receives minor amounts of industrial wastes; BOD, TSS, NH_3-N, fecal coliforms, chlorine; possible tie-in with MCD N. Reg. WWTP (1983-4?).
Ohio Suburban WWTP	S600	001	87.4	3.8[a]	Municipal wastewater treatment(trickling filters); receives pretreated plating wastes; BOD TSS, NH_3-N, fecal coliforms, chlorine; this facility to be replaced by MCD N. Reg. WWTP (1983-4?).
DP&L - Tait EGS	B103	001	77.6	204.0[a]	Once-through cooling; heat and intermittent chlorination; temperature, chlorine.
		003	77.4	*	Coal pile runoff; oil and grease, TSS
		002	77.3	1.9[a]	Ash pond and boiler blowdown; oil& grease, TSS, heavy metals (Cu, Fe).
Dayton Walther[b]	N137	001	77.3	0.69[a]	Arc furnance and dust collectors (after settling); heat, suspended solids, oil; significant violations of NPDES permit; temperature, TSS, oil & grease.
		002	77.3	0.26[a]	Once-through cooling; temperature
		003	77.2	0.05[a]	Once-through cooling; temperature.
Dayton WWTP	F600	003	77.2	c	Broadway Pump Station by-pass; untreated sewage; BOD, NH_3-N, TSS, fecal coliforms, heavy metals.
		002	76.3	c	Westwood Pump Station by-pass; untreated sewage; BOD, NH_3-N, TSS, fecal coliforms, heavy metals
		001	76.1	59.8[a]	Municipal wastewater treatment (trickling filter); receives significant industrial wastes, e.g., corn products, auto parts mfg., tire mfg., metal finishing, paper; BOD, TSS, NH_3-N, fecal coliforms, chlorine, heavy metals (Cd, Cu, Pb, Zn).
GMC Air Cond. #3	C108	001	74.4	3.45[a]	Automobile air conditioner mfg.; machining and chemical processes, non-contact cooling waters; COD, TSS, oil & grease, phosphorus, heavy metals (Fe, Cr, Zn, Ni).
P.H. Glatfelter	A104	001	72.3	4.0[a]	Deinked fine printing papers; BODNH_3-N, TSS.
Mont. Co. W. Reg. WWTP	L602	00[illegible]	71.5	20.0[a]	Municipal wastewater treatment (activated sludge, no filters); information about industrial contributors; BOD, TSS, NH_3-N, fecal coliforms, chlorine, heavy metals (Cu, Pb, Cd, Cr, Ni, Zn).

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Table 8. (continued)

Facility	Permit Number	Outfall Number	River Mile	Flow (MGD)	Type of Process - Effluent Characteristics
Miami Paper[b]	A104	001	69.6, 0.5 (Owl Cr.)	2.5[a]	Letter-press book paper mfg.; BOD, TSS, NH_3-N, Temperature.
W. Carrollton WWTP	D614	001	68.9	0.65[a]	Municipal wastewater treatment (trickling filter); no information about industrial contributors; BOD, TSS, NH_3-N, fecal coliforms, chlorine.
Miamisburg WWTP	D617	001	65.1	2.12[a]	Municipal wastewater treatment (contact stabilization); receives minor amounts of industrial wastes; raw by-passes occur at plant; BOD, TSS, NH_3-N, fecal coliforms, chlorine, heavy metals (Cd, Zn, Cu, Ni)
DP&L - Hutchings EGS	B104	002	65.4	1.7	Ash settling pond (bottom and fly ash), boiler blowdown; pH, TSS, oil & grease.
		004	64.7	*	Sanitary wastewater.
		003	64.4	0.05	Coal pile runoff; oil & grease, TSS.
		001	64.3	234	Once-through cooling; heat and intermittent chlorination; temperature, chlorine.
MCD-Franklin WWTP	D604	001	59.7	3.9[a]	Municipal wastewater treatment (activated sludge); receives significant amounts of industrial wastes, e.g., paper and pulp mill, asphalt roofing; two overflow points in Franklin under separate NPDES permit; BOD, TSS, NH_3-N, fecal coliforms, chlorine.
ARMCO-Middletown	D101	001	51.5	18.2[d]	Blast furnace wash down and scrubber (settling), non-contact cooling water, recycle blowdown (settling), coking (stripping, dephenolize), water softening sludge (settling); BOD, TSS, COD, oil & grease, NH_3-N, cyanide, phenolics, temperature, heavy metals (Fe, Cr, Zn, Pb).
Middletown WWTP	E603	001 002	48.3 48.2	18.7[a]	Municipal wastewater treatment (activated sludge); receives significant amounts of industrial wastes, e.g., steel mill (coke plant, etc.), paper mill; bypass of raw influent at plant (002); BOD, TSS, NH_3-N, fecal coliforms, chlorine, heavy metals (Cd, Cr, Cu, Pb, Hg, Ni, Zn), cyanide, phenolics, complex organics (identified).
Middletown CSO	E603	003-010	51.0-52.2	c	Overflow points from combined sewer system (31% of service area); BOD, TSS, NH_3-N, fecal coliforms, heavy metals (possible), complex organics (possible).

0000046

Table 8. (continued)

Facility	Permit Number	Outfall Number	River Mile	Flow (MGD)	Type of Process - Effluent Characteristics
ARMCO-Middletown	D101	002	47.6, 2.9 (Dicks Cr.)	1.7[a]	Non-contact cooling water from coke plant; TSS, oil & grease, cyanide, phenolics, Zn.
		003	47.6, 3.8 (Dicks Cr.)	1.4[a]	Open hearth furnace scrubber blowdown (clarifier), Basic Oxygen Furnace (clarifier), scrubber blowdown (clarifier); TSS, fluorides, Fe, Pb, Zn.
		004	47.6, 5.1, 0.2 (N. Br. Dicks Cr.)	4.3[a]	Pickling, annealing, cold rolling mill, spent pickle liquor (acid neutralization, oxidation, coagulation, clarifier); TSS, chlorides, Fe, Zn.
		005	47.6, 4.2 (Dicks Cr.)	3.9[a]	Contact cooling water from slab and hot strip mills (cooling, neutralization, coagulation, settling); TSS, oil & grease, Fe, Zn.
LeSourdsville Reg. WWTP	K611	001	45.7	1.92[a]	Municipal wastewater treatment (bio-disc, secondary settling, filters); receives significant amounts of industrial wastes, e.g., sheet steel pickling, home furnishings; BOD, TSS, NH_3-N, fecal coliforms, chlorine.
ARMCO-New Miami	D102	001	38.7	7.12[a]	Blast furnace-main sewer (settling, polymer, cooling); BOD, COD, TSS, NH_3-N, phenolics, cyanide, oil & grease, temperature, Zn, Fe.
		002	39.0	0.05[a]	Sanitary wstewater (extended aeration); BOD, TSS, NH_3-N, fecal coliforms, chlorine.
		003	39.3	0.3[a]	Non-contact cooling water; temperature.
		004	39.4	7.0[a]	Coke plant-main sewer (biological treatment system); cyanide, phenolics, NH_3-N, oil & grease, TSS, temperature.
Hamilton WWTP	E602	001	34.0	14.1[a]	Municipal wastewater treatment activated sludge); receives significant amounts of industrial wastes, e.g., paper mill, metal plating, food processing; by-passes occur at 1 lift station (031), combined sewer overflows minimal (5% of system); problems with sludge handling and disposal; BOD, TSS, NH_3-N, fecal coliforms, chlorine.
Fairfield WWTP	D603	001	32.0	4.3[a]	Municipal wastewater treatment (activated sludge, rapid sand filter); receives minor amounts of industrial wastes (industrial parks, truck washing); metered bypass at plant; BOD, TSS, NH_3-N, fecal coliforms, chlorine.

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Table 8. (continued)

Facility	Permit Number	Outfall Number	River Mile	Flow (MGD)	Type of Process - Effluent Characteristics
DOE-Feed Materials Production Center[d]	e	001	24.7	0.493	Production of purified uranium and thorium compounds; combined storm water, sewage plant, and process wastewater; BOD, TSS, NH_3-N, cyanide, chlorine, NO_3-N, heavy metals (Al, Cd, Cr, Cu, Pb).
		002		0.029	Overflow from area runoff and groundwater - goes to 001 except when runoff is heavy; TSS, oil & grease.
Gulf Oil	G100	001, 601	9.1	4.5[a]	oil refinery, gasoline (65-70%), asphalt, LPG (oil & sludge separation by primary separator, secondary separator with aeration); significant violations of NPDES permit limits 1977-1979; BOD, COD, TSS, NH_3-N, phosphorus, fluoride, chloride, phenolics, oil & grease, sulfide, Cr.

a - average annual flow reported in NPDES permit file.
b - not listed by Ohio EPA as a major or significant discharger.
c - flow variable and/or intermittent; average not available.
d - information from most recent available NPDES briefing memo; 1980 effluent volume much reduced.
e - Federal facility - no Ohio EPA permit number.
* - less than 0.1 MGD average annual flow.

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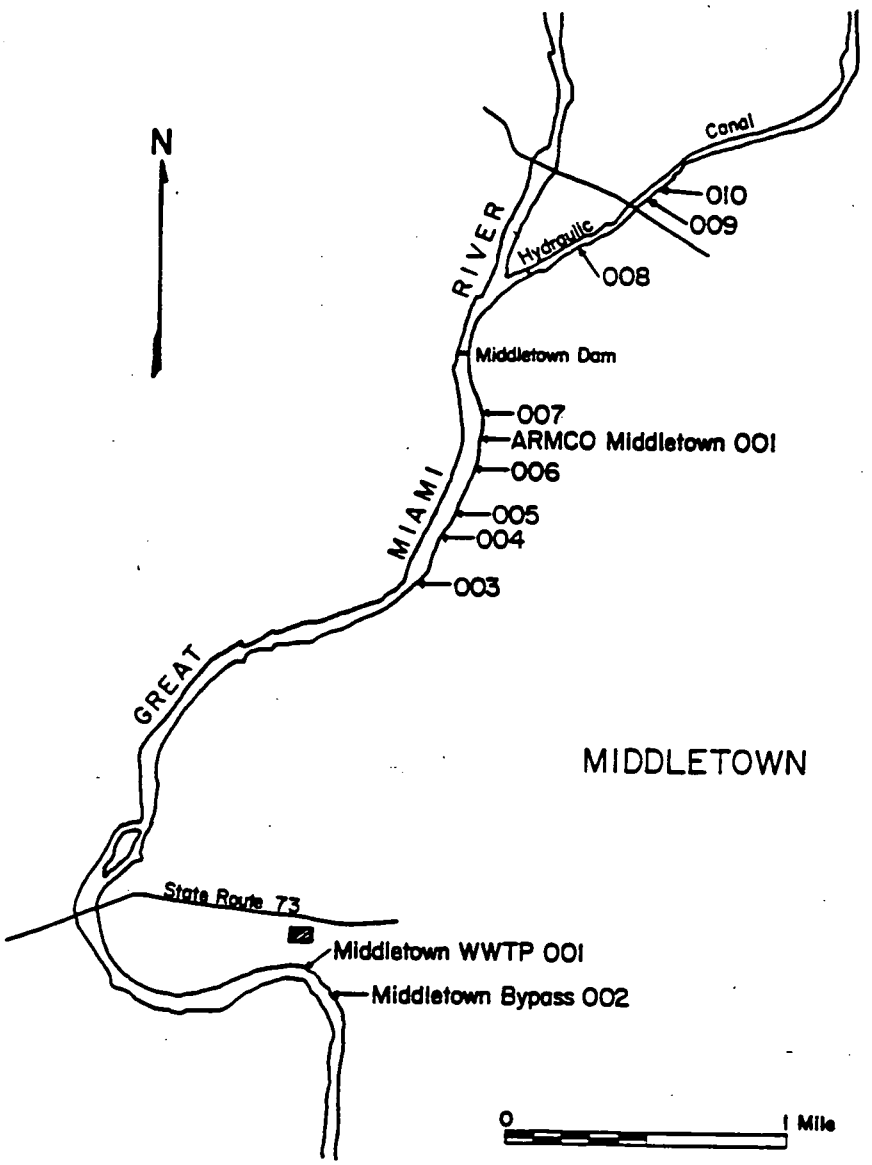
Figure 3. Great Miami River mainstem in the Middletown metropolitan area showing the locations of the Middletown WWTP outfall, Middletown combined sewer overflows, and the ARMCO-Middletown 001 outfall.



receiving waste products in August 1974 and was closed in February 1980. Materials handled and stored generally included industrial by-products and solvents, pesticides, and compounds containing PCB's. The site has been in court receivership since mid-1981 and clean-up and recovery operations are underway. Spills of toxic wastes between April 24 and September 16, 1976 were blamed for 4 fish kills that numbered at least 1,102,562 dead fish in the Great Miami River in and downstream from Hamilton (Ohio Dept. of Natural Resources, 1976; Table 9). Only two significant industrial point sources discharge into the Great Miami River mainstem downstream from the Hamilton-Fairfield area. The DOE-Feed Materials Production Center (RM 24.7) processes spent nuclear material (mostly uranium) and the Gulf Oil refinery near Hooven (RM 9.1) primarily refines gasoline.

Nonpoint sources in the Great Miami River Basin include runoff from agricultural, silvicultural, mining, construction and urban areas, and leachates from solid waste disposal areas and on-site disposal systems. Mining in the basin is limited to gravel dredging operations along the banks. Sediment and pollutant loadings from these dredging activities are difficult to quantify and are probably of minimal importance. Runoff from construction areas and leachates from solid waste disposal facilities and on-site disposal systems are generally localized (Ohio-Kentucky-Indiana Reg. Council Govts. 1977).

Urban and agricultural runoff are the two major contributors of nonpoint source loadings to the Great Miami River. Rural nonpoint sources on the lower 62 miles of the Great Miami River contributed 81% of the annual sediment load; municipalities and industries contributed 86, 77 and 64% of the BOD_5, total nitrogen and total phosphorus loadings, respectively (Ohio-Kentucky-Indiana Reg. Council Govts. 1977).

Forty-seven (47) water pollution, fish kill, and stream litter investigations were conducted by the Ohio DNR, Division of Wildlife (Ohio DNR 1970, 1971b, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980) in the study area during the period 1970-1980 (Table 9). Thirty-one (31) of these investigations accounted for from 5 to 1,849,444 dead fish per espisode. The remaining 16 investigations revealed no dead fish. No major fish kills occurred in 1980.

The largest single kills of fish occurred in 1970, 1971, and 1976 with two episodes accounting for more than one million dead fish.

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Table 9. Results of water pollution, fish kill, and stream litter investigations conducted in the study area by Ohio DNR, Division of Wildlife, during 1970-1980.

Date	Water Body (County)	Number of Wild Animals Killed	Suspected Pollutant	Operation
Aug 17, 1970	Gr. Miami River (Butler	none	oil-industrial	paper products
Sept 20, 1970	Middletown Hydraulic Canal (Butler)	812	chemical, metals	metal finishing
Sept 24, 1970	Gr. Miami River (Hamilton)	1,053	unknown	unknown
Oct 20, 1970	Gr. Miami River (Montgomery)	5,000	thermal	utilities
Oct 28, 1970	Gr. Miami River (Butler, Montgomery)	1,849,444	sodium pentachlorophenate	paper products
Nov 3, 1970	Gr. Miami River (Butler)	none	sulphuric acid	paper products
Nov 17, 1970	Gr. Miami River (Butler)	175	unknown	unknown
Dec 16, 1970	Gr. Miami River (Butler)	none	red paper dye	paper products
Dec 30, 1970	Gr. Miami River (Butler)	none	sewage, industrial wastes	manufacturing
Jan 15, 1971	Gr. Miami River (Montgomery)	7,045	heavy metals	water treatment
Feb 9, 1971	Gr. Miami River (Montgomery)	none	paper waste	paper products
Apr 27, 1971	Gr. Miami River (Butler)	124	phenol	manufacturing
May 24, 1971	Gr. Miami River (Montgomery)	100	unknown	unknown
Sept 22, 1971	Gr. Miami River (Montgomery)	111	unknown	unknown
Sept 23, 1971	Gr. Miami River (Montgomery)	6	paper waste	paper products
Oct 10, 1971	Gr. Miami River (Montgomery)	548,076	algal bloom, toxic wastes	municipal WWTP
Dec 28, 1971	Gr. Miami River (Montgomery)	21,870	unknown	unknown
Aug 23, 1972	Gr. Miami River (Montgomery)	96	oil	unknown
Oct 15, 1972	Gr. Miami River (Butler)	750	sewage	municipal WWTP
Oct 24, 1972	Gr. Miami River (Montgomery)	none	asphalt	other

Table 9. continued

Date	Water Body (County)	Number of Wild Animals Killed	Suspected Pollutant	Operation
Mar 12, 1973	Gr. Miami River (Butler)	none	paper waste	paper products
May 5, 1973	Gr. Miami River (Montgomery)	none	oil	manufacturing
July 19, 1973	Gr. Miami River (Montgomery)	81	unknown	unknown
Nov 7, 1974	Gr. Miami River (Montgomery)	none	fuel oil	trucking
Jan 28, 1975	Gr. Miami River (Montgomery)	19	hydrochloric acid	manufacturing
Feb 14, 1975	Gr. Miami River (Montgomery)	none	sewage	municipal WWTP
May 21, 1975	Gr. Miami River (Montgomery)	none	oil	manufacturing
Mar 22, 1976	Dicks Creek (Butler)	5	phenols	metal products
Apr 19, 1976	Gr. Miami River (Montgomery)	300	sewage	municipal WWTP
Apr 24, 1976	Gr. Miami River (Butler)	18,141	pesticides	waste disposal
May 27, 1976	Gr. Miami River (Butler)	none	oil	trucking
June 10, 1976	Gr. Miami River (Montgomery)	none	sewage	municipal WWTP
July 22, 1976	Gr. Miami River (Butler)	1,078,047	pesticides	waste disposal
Aug 13, 1976	Gr. Miami River (Butler)	738	pesticides	waste disposal
Sept 16, 1976	Gr. Miami River (Montgomery)	420	sewage	municipal WWTP
Sept 16, 1976	Gr. Miami River (Butler)	5,636	pesticides	waste disposal
Oct 13, 1976	Gr. Miami River (Butler)	829	cyanide, heavy metals	metal products
Nov 7, 1976	Gr. Miami River (Butler)	848	cyanide, phenol	metal products
Dec 28, 1976	Gr. Miami River (Butler)	9	unknown	unknown
Jan 3, 1977	Gr. Miami River (Montgomery)	480	unknown	unknown
July 20, 1977	Gr. Miami River (Montgomery)	600	thermal	utilities
Aug 8, 1977	Gr. Miami River (Montgomery)	54	unknown	unknown
Nov 23, 1977	Gr. Miami River (Montgomery)	none	foundry waste	manufacturing
Dec 29, 1978	Gr. Miami River (Montgomery)	13	ammonia	agricultural
July 11, 1979	Gr. Miami River (Montgomery)	none	phosphate ester	utilities
Feb 5, 1980	Gr. Miami River (Montgomery)	33	unknown	unknown
Oct 10, 1980	Gr. Miami River (Montgomery)	none	starch	food & kindred

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CHEMICAL/PHYSICAL WATER QUALITY

Graham Mitchell
Tim Staiger

Hydrology

River discharge data from two United States Geological Survey (USGS) operated gaging stations located on the mainstem at Miamisburg (RM 66.9) and Hamilton (RM 35.7) were used to characterize the river flow conditions under which this study was conducted. The gage located in Dayton was not used because of instream construction activities nearby. Mean daily discharge for the period June 1 - October 15, 1980 was compared to the average river discharge for the period of record (Fig. 4). The historical period of record spanned 46 years at Miamisburg and 65 years at Hamilton. Patterns in river discharge were generally similar at both locations and exceeded the historical average by a large margin in early June and early July. Flows were at or above the historical average during June 1-20, June 29-July 15, and August 14-21. Peak discharges measured during these periods included 28,000 cfs (June 3) and 23,400 cfs (June 30) at Miamisburg, and 29,800 cfs (June 3) and 23,500 cfs (June 30) at Hamilton. From July 7 through August 22 river discharge fluctuated just above and below the historical average, more so at Hamilton than at Miamisburg. River discharge during late August, September, and the first half of October was below average and showed little day to day fluctuation. Minimum daily flows recorded during the study were 769 cfs at Miamisburg (September 28) and 958 cfs at Hamilton (September 29).

Mean monthly river discharge at these same two locations was compared to the statistical normal for the homogeneous period of record, and total monthly precipitation measured in Dayton, for all twelve months of 1980 (Figure 5). Mean monthly discharge during the study period (June-October) was well above normal, especially during June, July, and August. The higher than normal monthly mean flows for this period were in response to higher than normal rainfall. Total monthly rainfall amounts during the remaining months of the study period were near normal which resulted in comparatively lower river discharge for that period.

Segmentation of the Study Area

The 92.5 mile study area was divided into twelve (12) segments based primarily on the position of major point sources of wastewater, tributaries, impoundments, and other physical features (Table 10). This process allows impacts from point and nonpoint sources to be evaluated in the area where the most obvious effects are expected. Previous river studies have shown the usefulness of the segmentation of lengthy study areas (Teppen and Gammon 1976; Gammon 1976; Gammon et al. 1981; Yoder et al. 1981). Study area segmentation is most useful for the evaluation of point source loading data, fish data, and macroinvertebrate data.

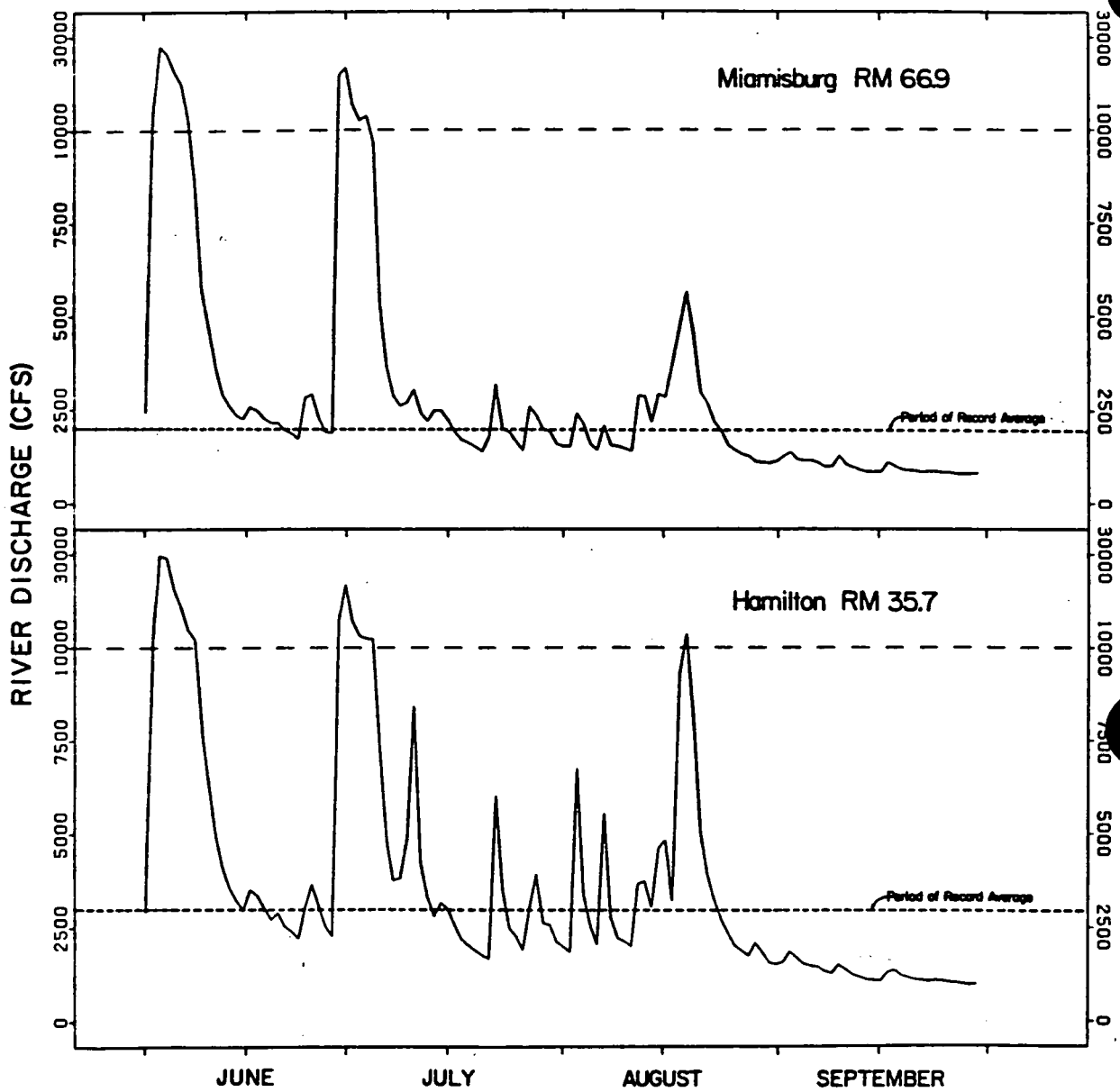

Figure 4. Flow hydrograph of the lower mainstem Great Miami River at the Miamisburg (RM 66.9) and Hamilton (RM 35.7) gaging stations during the period June 1 - September 30, 1980.

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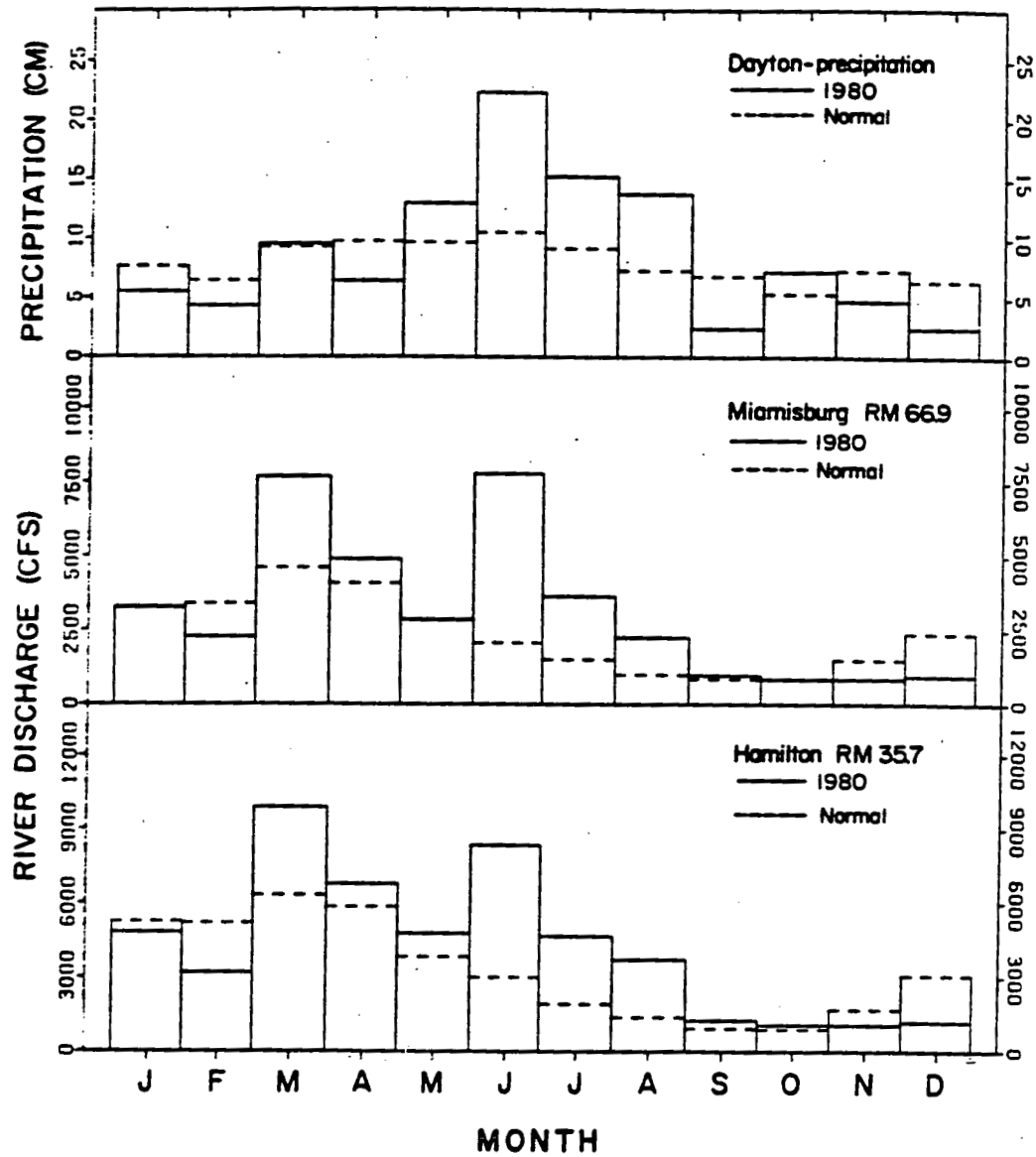

Figure 5. Comparison of monthly mean normal river discharge for the homogeneous period of record with the monthly mean river discharge observed at the Miamisburg (RM 66.9) and Hamilton (RM 35.7) gaging stations and monthly mean precipitation measured in Dayton during 1980.

Table 10. Location and description of the twelve river segments used in this study.

River Segment	Location and Description	Inclusive River Miles
1	Taylorsville Dam to upstream from Ohio Suburban WWTP.	92.6-87.5
2	Ohio Suburban WWTP to Steele Dam.	87.4-82.2
3	Downstream from Steele Dam to upstream from Dayton WWTP.	82.1-76.2
4	Dayton WWTP to upstream from Montgomery County Western Regional WWTP.	76.1-71.6
5	Montgomery County Western Regional WWTP to Miami-Erie Canal Dam.	71.5-62.7
6	Downstream from Miami-Erie Canal Dam to Middletown Dam.	62.6-51.7
7	Downstream from Middletown Dam to Hamilton Hydraulic Dam.	51.6-41.5
8	Downstream from Hamilton Hydraulic Dam to Hamilton Dam.	41.4-37.3
9	Downstream from Hamilton Dam to upstream from DOE-Feed Materials Production Center.	37.2-24.8
10	DOE-Feed Materials Production Center (FMPC) to upstream from Gulf Oil.	24.7-9.2
11	Gulf Oil to Ohio River.	9.1-0.0
12	Whitewater River mainstem downstream from Ohio-Indiana state line.	8.3-0.0

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Point Source Loadings

The lower mainstem of the Great Miami River and the lower 2-3 miles of tributaries (includes lower 8.3 miles of the Whitewater River) received point source discharges of wastewater from at least 76 facilities in 1980. There have been at least 84 permitted point sources since 1976. Of the 76 facilities still discharging in 1980, 11 had effluent flows less than 0.1 MGD and 15 did not report any data during the third quarter (July 1 - September 30). As a condition of their NPDES permit each point source entity is required to monitor its discharge for specific pollutants and report the results to Ohio EPA on a monthly basis. This data is then entered in the Liquid Effluent Analysis Processing System (LEAPS) which was developed by Ohio EPA to store and analyze monthly operating report information. Point source effluent loadings (kg/day) of 5-day biochemical oxygen demand (BOD_5), ammonia-nitrogen (NH_3-N), total suspended solids (TSS), and effluent flow (MGD) were summarized for each point source as follows:

1) Third quarter (July 1-September 30) mean effluent flow and loadings (kg/day) for each point source during 1976-1980 (Table 11);

2) Third quarter mean and maximum daily loadings (kg/day) with percent of total loadings for 41 point sources during 1980 (Table 12); and,

3) Third quarter mean loadings (kg/day) by river segment during 1976-1980 (Table 13).

In addition to these, third quarter average gross generation (MWe) and heat loads (BTU/hr.) for the Dayton Power and Light Tait and Hutchings electric generating stations (EGS) during 1964-1980 was examined. Data for flow (MGD), BOD_5 (mg/l), TSS (mg/l), and/or NH_3-N (mg/l) are generally available in most monthly operating report submittals. Reporting deficiencies by certain entities during the 1976-1980 period resulted in some missing data. Data reporting on other substances (e.g., heavy metals, cyanide, phenolics, etc.) were limited to 23 of the larger WWTP's and industries. Third quarter (1980) data for these substances were examined as well.

Although direct inferences with regard to instream water quality cannot always be made, and variations in the actual quality of the data submitted do exist, the evaluation of LEAPS data is a worthwhile effort. Perhaps the most beneficial result is the comparison of relative loadings between facilities. Those facilities with the greatest potential for impacting the receiving waters can be singled out by determining the percentage that their loading contributes compared to other facilities in the study area and noting their proximity to segments of chemical and biological degradation. Information on whether a facility is increasing or decreasing its effluent loading over a period of several years can also be gained by examining LEAPS data. This can be especially valuable when instream data (biological or chemical/physical) from two different years are being compared, as in this study.

Table II. Third quarter (July 1-September 30) mean loadings of BOD, total suspended solids (TSS), and ammonia-nitrogen (NH_3-N) for 84 dischargers located in the lower mainstem Great Miami River study area for the period 1976-1980 (facilities are arranged in order from upstream to downstream).

Facility (Outfall Number)	Permit Number	River Mile	1976 Flow MGD	1976 BOD_5	1976 TSS	1976 NH_3-N	1977 Flow MGD	1977 BOD_5	1977 TSS	1977 NH_3-N	1978 Flow MGD	1978 BOD_5	1978 TSS	1978 NH_3-N	1979 Flow MGD	1979 BOD_5	1979 TSS	1979 NH_3-N	1980 Flow MGD	1980 BOD_5	1980 TSS	1980 NH_3-N
GMC Inland Div. (002-003)	C109	95.3, 1.5	0.9	-	-	-	0.6	-	-	-	0.4	-	-	-	0.3	-	-	-	0.3	-	-	-
Vandalia WWTP (001)**	D612	94.2	1.1	148	90	77	1.1	470	124	88	1.2	353	163	84	1.4	198	117	71	2.3	322	243	134
GMC Inland Div. (001)	C109	94.1	0.2	-	18	-	0.2	-	18	-	0.2	-	15	-	0.1	-	18	-	0.1	-	6	-
Mont. Co. Incinerator (001)	N123	89.6	0.1	4	9	48	0.2	9	11	86	0.2	15	9	54	- NO DISCHARGE -				- NO DISCHARGE			
Cargill (001)	N144	89.1, 0.4	0.2	-	-	-	0.2	-	-	-	0.2	-	-	-	0.2	-	-	-	0.5	-	-	-
Miles Labs	N116	88.8	--- NO DATA ---				*	-	-	-	0.1	-	-	-	*	-	-	-	*	-	-	-
Ohio Suburban WWTP (001)**	S600	87.4	3.8	864	424	243	3.8	588	275	195	3.5	653	458	250	4.4	514	303	230	3.3	355	332	240
Sunny Acres MHP (001)	V605	87.3	*	13	36	-	*	3	6	-	*	3	8	-	*	9	7	-	*	1	3	-
GMC Delco Moraine (001)	N196	84.6	1.9	-	-	-	1.4	-	-	-	2.1	-	-	-	2.2	-	-	-	1.6	-	-	-
Price Bros. (001-002)	N162	84.1-84.5	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-
Chrysler Airtemp #2	N188	81.8	--- NO DATA ---				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -			
Alco Standard (001)	N191	81.8	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-	--- NO DATA ---			
Kruz-Kasch (001)	Q101	81.8	0.2	-	-	-	0.1	-	-	-	--- NO DATA ---				--- NO DATA ---				--- NO DATA ---			
Dayton Mfg. (001)	N136	81.5, 2.0	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-	5.0	-	-	-
Bendix Corp. (001)	N145	81.5, 1.8	0.1	-	-	-	0.1	-	-	-	0.1	-	-	-	0.6	-	-	-	0.9	-	-	-
Valley Asphalt (001-002)	J113	81.5, 1.8	- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -			
Duriron (001)	N134	81.5, 1.6	0.7	-	-	-	0.7	-	-	-	0.8	-	-	-	0.8	-	-	-	0.8	-	-	-
TRW-Globe (001)	N138	81.5, 0.7	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-
Premier Rubber (001)	N149	81.5, 0.7	--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				0.1	-	43	-
GMC Harrison Rad. (001-010)	N131	81.5, 0.3-0.6	6.1	-	-	-	5.5	-	-	-	5.4	-	-	-	2.2	-	-	-	1.7	-	-	-
GHR Foundry (001-003)	N105	81.5, 0.4-0.5	0.6	-	29	-	0.7	-	149	-	0.7	-	81	-	1.1	-	46	-	0.7	-	64	-
Hewitt Soap (001)	N132	81.5, 0.2	--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				0.1	6	6	-	--- NO DATA ---			
GMC Delco Prod. (001-008)	N199	81.5, 0.1	1.7	-	-	-	1.7	-	-	-	2.0	-	-	-	1.1	-	-	-	1.2	-	-	-
Dayton Tire (001-008)	N101	80.3, 1.2-1.4	2.0	-	46	-	2.1	-	61	-	2.1	-	57	-	1.8	-	ND	-	1.3	-	ND	-
GMC Inland Div. (001-010)	N140	80.0	0.5	-	-	-	0.5	-	-	-	0.5	-	-	-	0.4	-	-	-	0.4	-	-	-
Howard Paper (001)	N160	79.7	0.4	-	-	-	0.4	-	-	-	0.2	-	-	-	0.4	-	-	-	0.2	-	-	-
Standard Register (001)	N135	79.2	2.3	-	-	-	0.4	-	-	-	0.2	-	-	-	0.4	-	-	-	5.0	-	-	-
Natl. Cash Reg. (001, 600)	C112	79.1	2.1	-	-	-	2.1	-	-	-	3.2	-	-	-	7.7	-	-	-	--- NO DATA ---			
GMC Delco Moraine (001-003)	N130	77.5	5.4	-	-	-	5.7	-	-	-	6.2	-	-	-	5.8	-	-	-	2.7	-	-	-
DPAL - Tait EGS (002-003)	N103	77.4	1.2	-	227	-	1.5	-	705	-	0.7	-	242	-	0.6	-	423	-	3.4	-	84	-
Dayton Walther (001)	N137	77.3	6.5	-	1240	-	0.9	-	51	-	0.6	-	72	-	4.1	-	414	-	0.2	-	25	-
Dayton Bypasses (002-003)**	F600	76.3-77.2	--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				0.7	423	458	-	0.2	112	237	-
Monsanto Research (001)	N108	76.9	0.5	-	-	-	0.5	-	-	-	0.5	-	-	-	0.5	-	-	-	0.5	-	-	-
Dayton WWTP (001)**	F600	76.1	50.6	2508	7333	497	54.3	3676	11372	2933	60.0	5602	12337	2716	60.8	9383	9698	2068	60.8	8165	10621	2824
Stolle Corp.	C120	76.1	0.2	-	31	-	0.3	-	14	-	0.3	-	9	-	0.3	-	7	-	- NO DISCHARGE -			
Metallurgical Serv.	C134	75.8	*	-	-	-	*	-	-	-	*	-	-	-	--- NO DATA ---				--- NO DATA ---			
GMC Air Cond. #3 (001)**	C108	74.4	2.9	-	299	-	3.6	-	286	-	3.4	-	226	-	--- NO DATA ---				0.8	-	17	-
GMC Air Cond. #2 (001)	C107	74.2	8.4	-	185	-	8.4	-	255	-	8.2	-	251	-	5.7	-	223	-	1.5	-	39	-
Moraine WWTP (001)	K604	73.7	5.9	834	1039	316	6.0	1803	3998	364	9.0	1815	2086	484	9.0	1124	1065	305	To Mont. Co. W. Reg. WWTP			
P.H. Glatfelter (001)	A104	72.5	3.0	991	982	3	3.0	251	442	18	2.5	157	500	26	5.7	561	1102	14	3.7	299	478	59
Mont. Co. W. Reg. WWTP (001)**	L602	71.5	- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				11.0	106	129	12
Miami Paper (001)	A107	69.6, 0.5	2.5	630	438	7	2.4	57	156	19	2.5	219	247	2	2.4	282	522	4	2.2	325	934	2
W. Carrollton Parch. (001)	A110	69.6, 0.4	--- NO DATA ---				0.6	-	31	-	0.6	-	33	-	0.6	-	56	-	0.6	-	69	-
P.H. Glatfelter (003)	A104	69.6, 0.2	0.2	2	24	*	- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -			
W. Carrollton WWTP (001)**	D614	68.9	0.7	52	62	33	0.8	72	72	59	1.1	121	142	70	1.1	163	231	26	1.0	196	278	35
Dayton Sure Grip & Shore (001-002)	N109	67.9	--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---			
Interstate Folding Box (001-002)	A105	67.5, 0.1	0.1	137	725	-	0.1	133	24	-	0.1	117	29	-	0.2	109	38	-	0.2	66	32	-

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Facility (Outfall Number)	Permit Number	River Mile	1976 Flow MGD	1976 BOD_5	1976 TSS	1976 NH_3-N	1977 Flow MGD	1977 BOD_5	1977 TSS	1977 NH_3-N	1978 Flow MGD	1978 BOD_5	1978 TSS	1978 NH_3-N	1979 Flow MGD	1979 BOD_5	1979 TSS	1979 NH_3-N	1980 Flow MGD	1980 BOD_5	1980 TSS	1980 NH_3-N
NRC - Mound Lab (001)	Fed.	65.9		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---		
NRC - Mound Lab (002)	Fed.	65.1, 0.9		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---		
Miamisburg WWTP (001)**	D617	65.1	1.9	151	87	160	1.9	103	79	149	1.7	61	53	143	2.2	102	71	142	1.8	58	61	134
DP&L - Hutchings EGS (002)**	B104	64.4	0.7	-	97	-	1.4	-	970	-	0.9	-	249	-	1.4	-	525	-	1.8	-	70	-
Moraine Materials (001)	J124	61.8	12.9	-	115	-		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---		
Riverarms Laundry (001)	W602	61.1	*	*	*	-	*	*	*	-	*	*	*	-	*	*	*	-	*	*	*	-
Riverarms WWTP (001)	W600	61.0	*	*	*	-	0.1	*	*	-	*	*	*	-	*	*	*	-	*	*	*	-
MCD-Franklin WWTP (001)**	D604	59.7	2.0	171	292	128	2.3	372	340	162	3.3	439	2867	213	3.8	592	1404	151	3.9	268	605	137
Aeronca (001)	C103	52.2, 2.3	0.7	-	36	-	0.7	-	24	-	0.7	-	ND	-	0.7	-	62	-	0.7	-	10	-
Sorg Paper (001)	A108	52.2, 0.6	2.7	2700	3319	3	0.2	-	14	-	0.1	-	ND	-	0.3	-	22	-	0.4	-	37	-
ARMCO-Middletown (001)**	D101	51.5		--- NO DATA ---			18.0	671	7463	213	18.0	386	7307	150	18.0	734	4502	ND	1.0	45	123	20
Middletown Bypasses (002-010)**	E603	48.2-52.2		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---			0.7	293	717	-
Middletown WWTP (001)**	E603	48.3	11.2	257	296	142	14.9	551	645	21	15.7	247	415	21	20.8	1697	525	79	21.0	1269	460	103
Crystal Tissue (001)	A100	48.1	3.6	428	157	5	2.4	286	106	2	2.3	492	34	1	0.9	104	117	2	2.3	211	175	1
ARMCO-Middletown (002, 003, 005)**	D101	47.6, 2.5-5.1		--- NO DATA ---			2.7	-	229	-	0.9	-	75	-	2.3	-	63	-	1.2	-	120	-
Harding Jones (001)	A102	47.6, 0.8	0.9	77	59	2	0.9	43	57	1	1.0	88	60	1	1.2	62	79	1	1.2	59	54	1
Fantasy Farm	R622	46.0		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---		
LeSourdsville Village MHP (001)	Y616	45.7, 0.4	*	*	1	-	*	1	1	-	*	1	1	-	To LeSourdsville Reg. WWTP				To LeSourdsville Reg. WWTP			
LeSourdsville Lake	R643	45.7, 0.2		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---		
LeSourdsville Reg. WWTP (001)**	K611	45.7									1.0	15	17	ND	1.6	23	30	2	1.8	34	36	5
Nicolet Ind. (001)	A106	44.3	*	1	2	-	*	3	55	-	0.2	10	32	-		--- NO DATA ---				--- NO DATA ---		
Brentwood Estates (001)	G649	42.3, 1.0	*	*	*	ND	*	*	*	ND	*	*	*	ND	*	*	*	*		--- NO DATA ---		
ARMCO-New Miami (001, 002, 004)**	D102	38.7-39.3	14.5	181	1010	929	16.8	547	226	910	4.5	497	1045	1780	6.8	ND	1519	49	7.9	ND	2672	32
New Miami WWTP (001)	B623	38.4, 0.6	0.1	23	33	-	0.1	6	10	-	0.1	5	5	-		--- NO DATA ---			0.1	3	10	-
Pillsbury Co. (001)	H159	37.2, 1.3	*	*	0	-	*	*	0	*		- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -		
Hamilton Mun. EGS (609-613)	B116	37.1, 0.1-0.3	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-
Fairfield Ready Mix	J104	37.1, 0.1		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---			*	-	*	-	*	-	*	-
Hamilton Mun. EGS (002)	B116	37.1	30.8	-	17	-	*	-	17	-	*	-	15	-	*	-	0	-	*	-	0	-
Champion Int. (002-003)	A109	36.8	14.7	-	-	-	9.0	-	-	-	7.6	-	-	-	8.6	-	-	-	7.8	-	-	-
Mosler Safe #1 (001)	H186	34.3	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-
Hamilton Die Cast	H176	34.3	0.1	-	3	-	*	-	2	-	*	-	1	-	*	-	2	-	*	-	1	-
Chessie System	T101	34.3		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---				--- NO DATA ---		
Champion Int. (001)	A109	34.2	12.0	5148	3583	71	10.1	4755	4926	41		To Hamilton WWTP				To Hamilton WWTP				To Hamilton WWTP		
Mosler Safe #2 (001)	H187	34.1	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-	*	-	-	-
Hamilton WWTP (001)**	E602	34.0	6.0	984	1425	307	7.4	1093	1099	318	8.1	228	306	33	17.4	800	6712	128	17.9	367	593	16
Hamilton S. WTP (001, 002, 101)	W106	33.9	0.4	-	46069	-	0.4	-	33303	-	0.3	-	32434	-	0.2	-	27282	-	0.2	-	25308	-
Fairfield WWTP (001)**	D603	32.0	2.5	671	587	268	2.8	52	25	160	2.9	119	38	100	4.6	332	338	176	3.4	77	103	84
Procter & Gamble (001-003)	H110	26.0	1.7	2	12	-	1.1	3	6	-	1.8	5	5	-	1.7	5	5	-	1.7	6	6	-
DOE-Feed Mat. Prod. Cen. (001-002)	Fed.	24.7	0.5	4	122	139	0.6	2	42	94	0.6	6	10	56	0.8	4	26	13	0.4	4	28	13
Mobil Oil (001)	E101	20.1, 1.2	*	-	2	-	*	-	1	-	*	-	*	-	*	-	*	-	*	-	1	-
Beckman Env. (001)	Y618	12.7, 0.5	*	1	3	2	*	1	6	ND		--- NO DATA ---				--- NO DATA ---				--- NO DATA ---		
Gulf Oil (001)**	G100	9.1	0.8	136	59	32	1.4	87	32	28	1.2	109	60	15	0.6	81	38	11	1.3	55	65	14
Morrison WWTP (001)	C602	6.5, 8.2	0.6	40	34	10	0.6	44	52	27	0.6	32	74	3	0.5	63	66	8	0.7	56	27	4
Queen City Gravel (001)	J106	5.3		- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -		
E.I. DuPont	E100	0.4	1.1	-	-	-	1.6	-	-	-		- NO DISCHARGE -				- NO DISCHARGE -				- NO DISCHARGE -		

* - less than 0.1 MGD or 1 kg/day BOD_5, TSS, or NH_3-N
** - major or significant discharger; ND/NO DATA - no data available; NO DISCHARGE - no apparent discharge during the quarter

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Table 12. Maximum and third quarter (July 1-September 30) mean loadings (kg/day) of BOD_5, total suspended solids, and ammonia-nitrogen (N) discharged by 41 point sources in the lower mainstem Great Miami River study area in 1980.

Segment	Facility	Permit Number	River Mile	BOD_5 Maximum	BOD_5 Mean	BOD_5 % of Mean	Total Suspended Solids Maximum	Total Suspended Solids Mean	Total Suspended Solids % of Mean	Ammonia-N Maximum	Ammonia-N Mean	Ammonia-N % of Mean
1	Vandalia WWTP	D612	94.2	600	322	2.5	879	243	0.5	183	134	3.5
1	GMC Inland Div.	C109	94.1	-	-	-	12	6	*	-	-	-
2	Ohio Suburban WWTP	S600	87.4	1314	355	2.8	2032	332	0.7	477	240	6.2
2	Sunny Acres MHP	V605	87.3	2	1	*	17	3	*	-	-	-
3	Premier Rubber	N149	81.5, 0.7	-	-	-	115	43	0.1	-	-	-
3	GHR Foundry	N105	81.5, 0.4-0.5	-	-	-	20	14	*	-	-	-
3	DP&L - Tait EGS	B103	77.4	-	-	-	779	84	0.2	-	-	-
3	Dayton Walther	N137	77.3	-	-	-	28	25	*	-	-	-
4	Dayton Bypasses	F600	76.3-77.2	3094	112	0.9	2244	237	0.5	-	-	-
4	Datyon WWTP	F600	76.1	16593	8165	64.0	45985	10621	25.1	3681	2824	73.0
4	GMC Air Cond. #3	C108	74.4	-	-	-	33	17	*	-	-	-
4	GMC Air Cond. #2	C107	74.2	-	-	-	73	39	0.1	-	-	-
4	P.H. Glatfelter	A104	72.5	590	299	2.3	1254	478	1.1	188	59	1.5
5	Mont. Co. W. Reg. WWTP	L602	71.5	326	106	0.8	1014	129	0.3	72	12	0.3
5	Miami Paper	A107	69.6, 0.5	463	325	2.5	3064	934	2.1	13	2	*
5	W. Carrollton Parch.	A110	69.6, 0.4	-	-	-	100	69	0.2	-	-	-
5	W. Carrollton WWTP	D614	68.9	447	196	1.5	793	228	0.5	109	35	0.9
5	Int. Folding Box	A105	67.5, 0.1	92	66	0.5	51	32	*	-	-	-
5	Miamisburg WWTP	D617	65.1	116	58	0.5	139	61	0.1	180	134	3.5
5	DP&L - Hutchings EGS	B104	64.4	-	-	-	324	70	0.2	-	-	-
6	Franklin WWTP	D604	59.7	843	268	2.1	3740	605	1.3	399	137	3.5
6	Aeronca	C103	52.2, 2.3	-	-	-	47	10	*	-	-	-
6	Sorg Paper	A108	52.2, 0.6	-	-	-	40	37	0.1	-	-	-
7	ARMCO-Middletown 001	D101	51.5	88	45	0.4	442	123	0.3	48	20	0.5
7	Middletown Bypasses	E603	48.2-52.2	3616	293	2.3	15539	717	0.2	-	-	-
7	Middletown WWTP	E603	48.3	2339	1269	10.0	2467	460	1.0	553	103	2.7
7	Crystal Tissue	A100	48.1	327	211	1.7	319	175	0.4	2	1	*
7	ARMCO-Middletown	D101	47.6, 2.5-5.1	-	-	-	437	120	0.3	-	-	-
7	Harding Jones	A102	47.6, 0.8	152	59	0.5	120	54	0.1	6	1	*
7	LeSourdsville Reg. WWTP	K611	45.7	72	34	0.3	113	36	0.1	8	5	0.1
8	ARMCO-New Miami	D102	38.7-39.3	-	-	-	4149	2672	6.0	77	32	0.8
8	New Miami WWTP	B623	38.4, 0.6	9	3	*	25	10	*	-	-	-
9	Hamilton Die Cast	N176	34.3	-	-	-	1	1	*	-	-	-
9	Hamilton WWTP	E602	34.0	710	367	2.9	1919	593	1.3	49	16	0.4
9	Hamilton So. WTP	W106	33.9	-	-	-	30045	25308	56.5	-	-	-
9	Fairfield WWTP	D603	32.0	693	77	0.6	1249	103	0.2	108	84	2.2
9	Procter & Gamble	N110	26.0	11	6	*	13	6	*	-	-	-
10	DOE - F.M.P.C.	Fed.	24.7	136	4	*	136	28	*	63	13	0.3
10	Mobil Oil	E101	20.1, 1.2	-	-	-	1	1	*	-	-	-
11	Gulf Oil	G100	9.1	116	55	0.4	235	65	0.1	68	14	0.4
12	Harrison WWTP	C602	6.5, 8.2	104	56	0.4	85	27	*	6	4	0.1
	GRAND TOTALS			32853	12752	100.0		44816	100.0		3870	
	Facilities Reporting (% of total)				25	(61%)		41	(100%)		20	(49%)

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Table 13. Relative ranking of point source discharges for third quarter mean flow volume (MGD), BOD_5 (kg/day), total suspended solids (kg/day), and ammonia-nitrogen (kg/day) during 1980 (only top ten in each category are listed).

Flow (MGD; %)	BOD_5 (kg/day; %)	TSS (kg/day; %)	NH_3-N (kg/day; %)
Dayton WWTP (60.8; 37%)	Dayton WWTP (8165; 64%)	Hamilton So. WTP (25308, 53%)	Dayton WWTP (2824; 74%)
Middletown WWTP (21.8; 13%)	Middletown WWTP (1269; 10%)	Dayton WWTP (10621; 26%)	Ohio Suburban WWTP (240; 4%)
Hamilton WWTP (17.9; 11%)	Hamilton WWTP (367; 3%)	ARMCO-New Miami (2672; 6%)	Franklin WWTP (137; 4%)
Mont. Co. E. Reg. WWTP (11.0; 7%)	Ohio Suburban WWTP (355; 3%)	Miami Paper (934; 2%)	Vandalia WWTP (134; 4%)
ARMCO-New Miami (7.9; 5%)	Miami Paper (325; 3%)	Middletown Bypasses (717, 2%)	Miamisburg WWTP (134; 4%)
Franklin WWTP (3.9; 2%)	Vandalia WWTP (322; 3%)	Franklin WWTP (605; 2%)	Middletown WWTP (103; 3%)
P.H. Glatfelter (3.7; 2%)	P.H. Glatfelter (299; 2%)	Hamilton WWTP (593; 1%)	Fairfield WWTP (84; 1%)
Fairfield WWTP (3.4; 2%)	Middletown Bypasses (293; 2%)	P.H. Glatfelter (478; 1%)	P.H. Glatfelter (59; 1%)
DP&L-Tait EGS (3.4; 2%)	Franklin WWTP (268; 2%)	Middletown WWTP (460; 1%)	W. Carrollton WWTP (35; 1%)
Ohio Suburban WWTP (3.3; 2%)	Crystall Tissue (211; 2%)	Ohio Surburban WWTP (332; 1%)	ARMCO-New Miami (32; 1%)

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Table 14. Third quarter (July 1-September 30) mean point source loadings (kg/day) of BOD_5, total suspended solids (TSS), and ammonia-nitrogen (NH_3-N) to the twelve segments of the lower mainstem of the Great Miami River study area during 1976-1980.

Year	Parameter	Segment 1 92.6-87.4	Segment 2 87.3-82.2	Segment 3 82.1-76.2	Segment 4 76.1-71.6	Segment 5 71.5-62.7	Segment 6 62.6-51.7	Segment 7 51.6-41.5	Segment 8 41.4-37.2	Segment 9 37.1-24.8	Segment 10 24.7-9.1	Segment 11 9.0-0.0	Segment 12 Whitewater R.
1976	BOD_5	152	877	-	4333	972	2871	763	204	6805	5	136	40
	TSS	116	460	1542	9869	1433	3762	515	1043	51696	127	59	34
	NH_3-N	125	243	-	816	200	131	149	929	646	141	32	10
	No. Sources[a]	(4)	(4)	(17)	(8)	(6)	(6)	(5)	(2)	(10)	(3)	(2)	(1)
1977	BOD_5	479	591	-	5730	365	372	1555	553	5903	5	87	44
	TSS	153	281	966	16367	1332	378	8556	236	39378	49	32	52
	NH_3-N	174	195	-	3315	227	162	237	910	519	94	28	27
	No. Sources	(5)	(4)	(17)	(8)	(6)	(5)	(7)	(2)	(10)	(3)	(2)	(1)
1978	BOD_5	368	656	-	7574	518	439	1239	502	352	6	109	32
	TSS	187	466	452	15409	753	2867	7941	1050	32783	10	60	74
	NH_3-N	138	250	-	3226	215	213	173	1780	133	56	15	3
	No. Sources	(5)	(4)	(16)	(8)	(6)	(5)	(8)	(2)	(9)	(2)	(1)	(1)
1979	BOD_5	198	523	429	11068	656	592	2620	-	1137	4	81	63
	TSS	135	310	1347	12095	1443	1488	5316	1519	34339	26	38	66
	NH_3-N	71	230	-	2387	172	151	84	49	304	13	11	8
	No. Sources	(4)	(4)	(18)	(6)	(6)	(5)	(6)	(1)	(10)	(2)	(1)	(1)
1980	BOD_5	322	356	112	8464	751	268	1911	-	450	4	55	56
	TSS	249	335	453	11155	1573	652	1685	2682	26011	29	65	27
	NH_3-N	134	240	-	2883	183	137	130	32	100	13	14	4
	No. Sources	(4)	(4)	(16)	(5)	(7)	(5)	(6)	(2)	(10)	(2)	(1)	(1)

[a] - only facilities reporting data are included.

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Of the 84 facilities listed in Table 11 only 18 are considered by Ohio EPA to be significant point sources. During the third quarter (July 1-September 30) of 1980 the Dayton WWTP (RM 76.1) discharged the greatest mean loading of BOD_5 (8165 kg/day; 64.0%) and NH_3-N (2824 kg/day; 73.0%) in the study area (Tables 11 and 12). Only the Hamilton South water treatment plant (RM 33.9 discharged more total suspended solids (25308 kg/day; 56.5%). The next largest discharges of BOD_5; the Middletown WWTP (RM 48.3; 1269 kg/day; 10.0%) and Hamilton WWTP (RM 34.0; 367 kg/day; 2.9%), were quite small in comparison to the Dayton WWTP. The Middletown combined sewer overflow (CSO) area contributed 2% of the mean BOD_5 loading in the study area, but had maximum daily loads that exceeded those from the Middletown WWTP (Table 12). Aside from the TSS load discharged by the ARMCO-New Miami Mill (RM 38.7-39.3; 2672 kg/day; 6.0%) all other dischrges were relatively small, each comprising less than 2% of the loading in the study area. Relative rankings of the top ten discharges of wastewater flow and BOD_5, TSS, and NH_3-N loadings is given in Table 13.

During the past five years (1976-1980) there was a substantial increase in the loadings of BOD_5, TSS, and NH_3-N in segment 4 (RM 76.1-71.6) (Table 10). This increase occurred despite the phase out of the Moraine WWTP (RM 73.7) and can be attributed to the increased loading discharged by the Dayton WWTP (Table 11). While the total third quarter mean flow from the Dayton WWTP increased from 50.6 MGD in 1976 to 60.8 MGD in 1980 (an increase of 19%), the mean BOD_5 loading increased from 2508 kg/day to 8165 kg/day (an increase of 226%). Similarly large increases were observed for TSS (7333 kg/day to 10621 kg/day) and NH_3-N (497 kg/day to 2824 kg/day) between 1976 and 1980. An examination of daily effluent data for the Dayton WWTP for the period June-September 1976-1980 revealed increasing monthly mean and maximum concentrations (mg/l) of BOD_5, TSS, and NH_3-N in the final effluent (Table 15). A frequency analysis of daily BOD_5 and NH_3-N concentrations also revealed declining effluent quality from 1976 to 1980 (Table 16). The increased loads and declining effluent quality are apparently the result of Dayton accepting additional industrial contributors to the sanitary sewer system.

The only significant decrease in loadings within the study area from 1976 to 1980 took place in segment 6 (RM 62.6-51.7) and was due in large part to the elimination of the Sorg Paper 001 discharge (RM 52.2, 0.6). Overall increases in BOD_5 and TSS loadings, but decreases in NH_3-N were indicated in segments 7 (RM 51.6-41.5) and 8 (RM 41.4-37.2). However, the evaluation was hampered by missing data, especially BOD_5 and NH_3-N. In segment 7 (RM 51.6-41.5) the most consistent loading increases took place at the Middletown WWTP (RM 48.3), particularly for BOD_5 (257 kg/day to 1269 kg/day; Table 11). An examination of daily effluent data, similar to that performed for the Dayton WWTP, was also made for the Middletown WWTP final effluent (Tables 16 and 17). Monthly mean and maximum flow (MGD), BOD_5 (mg/l) and TSS (mg/l) values increased through the 1976-1980 period, especially in 1980 (Table 17). Ammonia-N (mg/l) concentrations, however, showed a slight decrease. The frequency analysis was perhaps the most revealing, showing 93-100% of the

Table 15. Mean (±SD) maximum and minimum flow (MGD), BOD_5 (mg/l), TSS (mg/l), and NH_3-N (mg/l) recorded during June-September 1976-1980 for the Dayton WTP final effluent.

	1976				1977				1978				1979				1980			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
Flow (MGD)																				
Mean	53.2	50.6	51.6	49.5	52.1	51.8	56.3	55.0	59.8	56.1	62.2	58.6	51.6	51.7	70.4	60.2	65.3	62.8	63.4	55.9
±SD	±7.8	±5.9	±6.4	±6.3	±4.1	±6.4	±5.3	±6.0	±5.8	±4.6	±8.4	±5.5	±7.5	±10.5	±15.5	±11.4	±13.3	±8.8	±9.4	±7.9
Max.	74.7	58.2	83.8	59.1	56.8	61.3	70.2	67.1	72.7	64.4	87.7	69.5	73.0	70.0	105.9	104.1	96.8	82.3	86.8	75.2
Min.	36.7	37.9	38.7	36.7	42.3	39.1	46.3	42.3	49.7	46.0	49.1	43.3	36.9	27.2	47.7	46.6	46.5	46.4	47.3	41.6
n	30	31	31	30	30	31	31	30	30	31	31	30	30	31	31	30	30	31	31	30
BOD_5 (mg/l)																				
Mean	23.2	11.0	13.5	14.3	40.7	18.9	16.0	18.1	32.5	17.9	28.1	28.3	50.9	52.8	39.3	32.7	43.0	38.5	39.1	28.5
±SD	±9.7	±4.0	±5.3	±3.1	±6.6	±7.0	±4.3	±5.5	±13.5	±4.6	±9.1	±11.3	±17.7	±13.5	±11.9	±7.5	±13.7	±10.9	±10.4	±7.0
Max.	45	21	30	22	55	32	24	38	65	33	48	62	90	75	69	52	76	60	63	41
Min.	12	5	6	9	28	8	7	8	16	10	15	13	27	26	19	20	24	17	20	17
n	28	31	30	30	30	29	31	27	30	31	30	28	16	31	30	30	26	26	30	30
TSS (mg/l)																				
Mean	58.5	39.0	37.3	37.9	89.9	71.6	53.8	38.2	38.8	57.6	60.1	46.0	62.3	46.7	39.3	36.4	46.0	63.5	46.1	30.1
±SD	±31.3	±10.8	±7.8	±10.6	±19.3	±23.2	±12.0	±9.1	±11.3	±28.3	±22.5	±12.4	±60.2	±53.4	±18.9	±23.3	±18.6	±40.9	±21.4	±14.9
Max.	156	57	55	58	144	118	90	58	78	162	130	68	350	238	74	126	92	188	90	64
Min.	20	19	22	9	63	42	27	15	26	29	34	25	12	2	8	6	22	9	15	6
n	28	31	31	30	30	29	30	27	30	31	29	28	29	31	29	30	27	26	29	30
NH_3-N (mg/l)																				
Mean	7.69	3.91	2.26	1.54	14.87	16.93	14.27	10.35	19.60	18.24	10.34	7.93	15.43	9.86	7.67	9.82	13.65	11.44	-	-
±SD	±1.25	±1.67	±1.01	±0.96	±4.40	±2.88	±3.22	±2.77	±2.17	±4.70	±2.48	±1.86	±2.57	±2.78	±4.03	±4.27	±3.96	±2.76	-	-
Max.	10.07	6.71	3.91	4.47	33.59	22.39	19.59	16.23	22.39	31.35	15.67	12.87	23.51	14.00	15.11	17.35	19.05	15.69	-	-
Min.	5.03	1.67	0.27	0.55	9.51	12.31	8.39	4.47	13.91	11.19	5.59	5.59	11.75	5.03	1.15	1.67	7.27	6.19	-	-
n	28	31	31	29	30	29	30	20	28	21	30	28	29	31	30	29	27	9	-	-

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Table 16. Frequency analysis of BOD_5 (mg/l) and NH_3-N (mg/l) concentrations measured for the Dayton WWTP and Middletown WWTP final effluents during June-September 1976-1980.

Dayton WWTP 001 (F600) - RM 76.1

BOD_5	1976	1977	1978	1979	1980	NH_3-N	1976	1977	1978	1979	1980[a]
0- 1.9	-	-	-	-	-	0- 0.99	8.6	-	-	-	-
2- 4.9	-	-	-	-	-	1- 1.99	21.6	-	-	1.7	-
5- 9.9	19.7	4.5	-	-	-	2- 2.99	23.3	-	-	0.8	-
10-14.9	39.3	18.3	6.8	-	-	3- 4.99	16.4	0.8	-	5.9	-
15-19.9	23.1	28.7	23.9	0.9	3.6	5- 6.99	12.9	-	10.3	17.8	2.9
20-24.9	10.1	15.7	23.9	5.8	13.6	7- 8.99	15.5	5.1	18.1	12.7	22.9
25-29.9	2.6	7.0	15.4	11.5	15.5	9-10.99	1.7	7.6	6.9	7.8	2.9
30-39.9	2.6	13.0	17.9	30.8	28.2	11-12.99	-	24.6	12.1	21.2	22.9
40-49.9	2.6	10.4	9.4	23.1	25.5	13-14.99	-	19.5	8.6	14.4	8.4
50-59.9	-	2.4	1.7	12.5	10.9	15-19.99	-	36.4	24.1	16.9	40.0
60	-	-	1.0	15.4	2.7	20	-	6.0		0.8	-
n	117	115	117	104	110	n	116	118	116	118	35

Middletown WWTP 001 (E603) - RM 48.3

BOD_5	1976	1977	1978	1979	1980	NH_3-N	1976	1977	1978	1979	1980
0- 1.9	27.5	-	12.2	1.3	-	0- 0.99	42.5	74.7	74.7	42.9	50.6
2- 4.9	37.5	7.4	45.1	21.1	1.2	1- 1.99	12.5	12.0	6.3	20.2	34.1
5- 9.9	28.8	42.0	32.9	34.2	17.6	2- 2.99	13.8	-	8.9	14.3	9.4
10-14.9	3.7	44.4	9.8	40.8	24.7	3- 4.99	12.5	1.2	3.8	8.3	4.7
15-19.9	2.5	6.2	-	2.6	25.9	5- 6.99	7.5	4.8	3.8	10.7	1.2
20-24.9	-	-	-	-	28.2	7- 8.99	1.3	2.4	2.5	3.6	-
25-29.9	-	-	-	-	1.2	9-10.99	5.0	3.7	-	-	-
30-39.9	-	-	-	-	1.2	11-12.99	3.6	-	-	-	-
40-49.9	-	-	-	-	-	13-14.99	1.3	1.2	-	-	-
50-59.9	-	-	-	-	-	15-19.99	-	-	-	-	-
60	-	-	-	-	-	20	-	-	-	-	-
n	80	81	82	76	85	n	80	83	79	84	85

[a] - limited number of samples (mostly June-July)

daily BOD_5 values to be less than 15 mg/l from 1976 to 1979 (Table 16). By comparison, only 43.5% of the daily BOD_5 values were less than 15 mg/l in 1980, an indication of declining effluent quality. NH_3-N values, showed slight improvement during 1976-1980 with 84.7% of the daily measurements less than 2 mg/l. The reduction in BOD_5 effluent quality (and corresponding increased loading) may be the result of increased industrial contributions to the Middletown WWTP. The acceptance of approximately 0.5 MGD of coke plant wastes[a] from the ARMCO-Middletown facility was evident in the cyanide and phenolic effluent data measured at the Middletown WWTP in 1980 (Table 17). Approximately 3.5 MGD of paperboard wastes are also discharged to the Middletown WWTP from several paper making facilities. A portion of these wastes receive petereatment prior to being discharged to the Middletown sanitary sewer. Overall, but inconsistent decreases in third quarter loadings for all substances took place in the ARMCO-Middletown 001 effluent (RM 51.5) especially between 1979 and 1980 (Table 11). Monthly mean (+ standard deviation), maximum, and minimum flow (MGD), BOD_5 (mg/l), TSS (mg/l), NH_3-N (mg/l), cyanide (ug/l), phenolics (ug/l), and zinc (ug/l) values for the period June-September 1977-1980 were examined to provide a more detailed evaluation (Table 18). The 1980 results were difficult to evaluate because the monitoring location of the 001 effluent was changed to three internal locations (611, 612, 613) tributary to 001. According to LEAPS, only locations 612 and 613 were sampled during June, July, and September 1980. The data base for August appeared incomplete and was not used. No data was found for NH_3-N, cyanide, and phenolics in 1979. Aside from these difficulties some patterns were evident. Effluent flow volume (estimated), BOD_5, TSS, cyanide, phenolics, and zinc all showed an overall decrease between 1977 and 1980, although some trends were quite erratic. Decreases in monthly mean cyanide and phenolics from 1977 and 1978 and zinc from 1977 to 1979 were substantial. The high NH_3-N and cyanide concentrations measured in June 1980 are departures from the observed pattern of overall decrease, but the loading to the Great Miami River was still comparatively small. Variations about the mean as indicated by the standard deviation, maximum, and minimum values was quite substantial for cyanide and zinc. Standard deviations were often times 50% of the mean and several times exceeded the mean. Based on weekly sampling (4-5 samples/month) it is difficult to determine whether process or sampling variability was the dominant factor. Steel production, based on tons of steel shipped, for the ARMCO-Middletown works during the period examined (1977-1980) showed a steady decline from 553,000 tons (July-September) in 1977 to 336,000 tons in 1980. The 1980 figure was the lowest during the period 1970-1980 (Table 19). This decrease in production coincides with improving 001 effluent quality, but new treatment facilities were also installed during the period of improvement.

In segment 8 (RM 41.4-37.2) TSS loadings increased during 1976-1980, primarily the result of increased loadings from the ARMCO-New Miami facility 004 effluent (RM 38.7). Ammonia-N loadings, however, have decreased substantially, apparently the result of new treatment facilities. Production at the ARMCO-New Miami facility is parallel with the ARMCO-Middletown facility and was reflected in the steel production data in Table 19. The trend in

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[a] information from industrial users report in NPDES permit files.

Table 17. Mean (±SD) maximum and minimum flow (MGD), BOD_5 (mg/l), TSS (mg/l), NH_3-N (mg/l), cyanide (mg/l), and phenolics (ug/l) recorded during June-September 1976-1980 for the Middletown WWTP final effluent.

	1976				1977				1978				1979				1980			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
Flow (MGD)																				
Mean	10.8	10.5	11.5	11.7	15.2	15.9	14.9	13.7	16.5	14.2	17.0	16.1	19.1	19.7	20.7	22.1	21.9	22.7	23.7	18.8
±SD	±1.3	±1.1	±1.8	±1.6	±1.9	±1.8	±2.5	±2.2	±1.7	±2.0	±4.3	±1.0	±2.4	±1.8	±1.5	±2.8	±1.5	±2.5	±2.3	±2.2
Max.	15.0	12.9	19.9	15.3	19.2	21.2	24.3	17.9	20.4	18.6	37.6	18.7	21.9	22.9	23.7	32.9	24.4	26.9	27.0	22.1
Min.	8.6	8.5	9.0	7.7	10.1	13.4	11.3	8.2	12.5	11.0	13.5	13.8	13.7	16.5	18.1	17.4	19.2	17.5	16.9	14.7
n	30	31	31	30	30	31	31	30	30	31	31	30	30	31	31	30	30	31	31	30
BOD_5 (mg/l)																				
Mean	1.9	2.1	8.4	7.1	7.7	10.9	10.4	8.5	6.8	4.0	3.9	3.8	12.6	7.9	6.6	6.1	16.6	12.7	18.5	14.8
±SD	±1.5	±1.1	±4.1	±5.1	±3.7	±3.3	±2.5	±3.3	±3.9	±2.4	±2.4	±2.8	±1.8	±2.5	±3.5	±3.2	±5.4	±5.6	±4.1	±5.4
Max.	6	4	18	18	16	18	17	16	14	11	9	9	18	14	12	13	30	23	24	23
Min.	1	1	1	1	2	5	6	3	2	1	1	1	10	4	1	3	8	4	12	5
n	22	19	23	21	22	17	23	20	21	21	23	19	20	18	22	18	22	22	19	22
TSS (mg/l)																				
Mean	5.9	3.3	6.8	9.1	9.2	12.0	12.7	10.8	7.4	9.0	4.3	7.2	5.9	7.9	4.9	7.3	9.9	3.7	5.2	8.0
±SD	±4.1	±1.9	±7.0	±19.2	±8.2	±7.6	±7.2	±7.5	±3.9	±8.0	±4.9	±5.5	±5.6	±6.6	±4.9	±6.1	±11.7	±3.8	±5.6	±6.8
Max.	16	8	31	88	31	32	31	32	16	31	23	24	24	24	22	21	54	17	25	23
Min.	2	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
n	22	20	23	21	22	20	23	20	21	21	23	19	20	22	22	19	22	22	19	22
NH_3-N (mg/l)																				
Mean	1.10	3.21	1.74	4.88	4.02	0.46	0.17	0.56	3.20	0.29	0.39	0.38	5.30	1.55	1.04	0.45	1.15	0.96	1.60	1.17
±SD	±1.21	±2.35	±2.81	±4.73	±4.34	±0.77	±0.27	±0.54	±2.40	±0.39	±0.32	±0.32	±1.87	±0.83	±0.92	±0.43	±1.10	±1.27	±1.32	±0.54
Max.	5.00	9.09	13.09	12.69	13.39	3.50	1.09	1.64	7.79	2.00	1.00	1.09	8.59	3.39	2.79	1.39	4.79	4.50	6.59	2.39
Min.	0.09	0.29	0.09	0.59	0.04	0.04	0.04	0.04	0.19	0.04	0.04	0.04	1.59	0.25	0.04	0.03	0.09	0.08	0.29	0.39
n	22	20	23	20	22	20	22	19	20	21	21	17	20	22	22	20	22	22	19	22
Cyanide (ug/l)																				
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	5	-	10
±SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	±9	±3	-	±7
Max.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	13	-	25
Min.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	1
n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	16	-	16
Phenolics (ug/l)																				
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-	-
±SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	±12	-	-	-
Max.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-	-	-
Min.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	-	-	-

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Table 18. Mean (±SD) maximum and minimum flow (MGD), BOD_5 (mg/l), TSS (mg/l), NH_3-N (mg/l), cyanide (mg/l), phenolics (ug/l) and zinc (ug/l) recorded during June-September 1977-1980 for the ARMCO-Middletown 001 effluent.

	1977				1978				1979				1980			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June[a]	July[b]	Aug.	Sept.[b]
001 - Flow (MGD)																
Mean	-	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	0.2	0.4	-	1.7
±SD	-	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0.2	±0.2	-	±0.3
Max.	-	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	0.7	0.7	-	2.4
Min.	-	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	0	0.1	-	0.5
n	-	4	5	4	5	4	5	4	4	5	4	4	30	31	-	30
001 - BOD_5 (mg/l)																
Mean	24.3	8.5	12.6	7.8	6.8	4.8	8.8	3.8	6.3	13.4	6.3	12.0	12.0	11.5	-	8.4
±SD	±11.2	±6.6	±6.3	±2.6	±8.6	±5.5	±2.1	±4.3	±4.9	±15.7	±4.3	±8.5	±0	±5.4	-	±2.9
Max.	39	15	23	10	21	10	12	8	11	38	9	24	12	18	-	16
Min.	14	7	7	5	6	9	7	7	5	11	7	4	12	5	-	5
n	5	4	5	4	5	4	5	4	4	5	4	4	3	4	-	5
001 - TSS (mg/l)																
Mean	105.0	72.5	138.2	110.8	97.4	103.5	65.2	151.8	61.5	54.0	117.5	29.8	52.5	8.4	-	38.8
±SD	±24.3	±16.7	±74.3	±42.3	±26.3	±41.8	±20.1	±148.6	±20.9	±13.4	±61.0	±11.3	±40.3	±2.9	-	±33.6
Max.	130	87	261	173	119	160	93	374	81	75	191	37	105	12	-	178
Min.	74	49	75	79	61	60	40	62	41	40	63	13	17	4	-	8
n	5	4	5	4	5	4	5	4	4	5	4	4	4	5	-	5
001 - NH_3-N (mg/l)																
Mean	8.85	3.42	3.16	2.79	2.78	1.86	2.88	1.58	-	-	-	-	21.67	0.47	-	6.84
±SD	±6.06	±1.11	±1.44	±1.04	±0.64	±0.10	±0.85	±0.22	-	-	-	-	±7.33	±0.07	-	±2.33
Max.	13.87	4.81	5.09	4.14	3.79	2.00	4.39	1.89	-	-	-	-	29.60	0.55	-	10.27
Min.	1.25	2.09	1.23	1.71	2.13	1.75	2.33	1.36	-	-	-	-	12.17	0.39	-	4.60
n	5	4	5	4	5	4	5	4	-	-	-	-	4	5	-	5
001 - Cyanide (ug/l)																
Mean	500	100	800	390	20	20	40	10	-	-	-	-	2150	32	-	250
±SD	±220	±80	±1120	±200	±10	±0	±50	±0	-	-	-	-	±2090	±44	-	±215
Max.	720	210	2770	550	30	20	140	20	-	-	-	-	5150	105	-	535
Min.	250	30	90	80	10	10	0	0	-	-	-	-	300	0	-	25
n	5	4	5	4	5	4	5	4	-	-	-	-	4	5	-	5

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Table 18 continued.

	1977				1978				1979				1980			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June[a]	July[b]	Aug.	Sept.[b]
001 - Phenolics (ug/l)																
Mean	2207	656	1254	36	100	13	198	11	-	-	-	-	19	-	-	35
+SD	+352	+352	+1376	+12	+77	+4	+382	+9	-	-	-	-	+9	-	-	+60
Max.	2700	860	3000	47	212	17	880	21	-	-	-	-	29	-	-	142
Min.	1863	130	18	21	18	8	11	10	-	-	-	-	10	-	-	4
n	5	4	5	4	5	4	5	4	-	-	-	-	4	-	-	5
001 - Zinc (ug/l)																
Mean	1117	461	372	1101	1148	846	507	1205	259	486	517	281	289	241	-	1814
+SD	+787	+273	+309	+763	+792	+566	+446	+999	+116	+198	+400	+198	+143	+245	-	+1087
Max	2500	830	825	2223	2500	1500	1240	2500	415	634	1092	565	418	663	-	2850
Min	645	180	7	517	466	167	168	270	134	150	175	108	135	55	-	263
n	5	4	5	4	5	4	5	4	4	5	4	4	3	5	-	5

[a] - data from monitoring station 612 only.
[b] - data from monitoring station 612 and 613 only.

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Table 19. Steel production (based on tons shipped) for the ARMCO Steel-Middletown Works, 1970-1980. (data supplied by ARMCO, May 18, 1982).

Year	Tons of Steel Shipped	
	July 1 - Sept. 30	Year
1970	377,000	1,736,000
1971	391,000	1,787,000
1972	498,000	2,031,000
1973	574,000	2,309,000
1974	478,000	2,192,000
1975	467,000	1,673,000
1976	500,000	1,942,000
1977	553,000	2,142,000
1978	527,000	2,078,000
1979	456,000	1,836,000
1980	366,000	1,608,000

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BOD_5 loadings for the ARMCO-New Miami facility was difficult to ascertain since this parameter was not reported in 1979 or 1980. The Hamilton South WTP (RM 33.9) was by far the largest contributer of TSS in the study area, even though third quarter mean loadings declined between 1976 and 1980. In the remaining segments effluent flow volume and loadings of BOD_5, TSS, and NH_3-N showed little change (segments 1, 5, 10, and 12) or slight decreases (segments 2, 3, 9, 11) during 1976-1980.

Of the 23 facilities that monitored for heavy metals, cyanide, and phenolics, the Dayton WWTP (by virtue of its comparatively large effluent flow) contributed the highest loadings of heavy metals (total Pb, Zn, Cd, Cu, Cr, and Ni) in the study area (Table 20). Other sources contributing in excess of one (1) kg/day of one or more heavy metals were the Ohio Suburban WWTP (total Zn), DP&L-Tait EGS (total Fe, Cu), Montgomery County Western Regional WWTP (total Pb, Zn, Cu), Franklin WWTP (total Zn), ARMCO-Middletown 001 and 004 (total Fe, Zn), Middletown WWTP (total Pb, Zn, Cd, Ni), and Fairfield WWTP (total Zn, Cu, Ni). Only a few facilities monitored cyanide and phenolics. The Middletown WWTP contributed the largest cyanide load which was nearly 5 times that produced by the ARMCO-Middletown 001 effluent. The sources of heavy metals and other toxic compounds present in municipal WWTP effluents mainly come from two sources, urban nonpoint runoff and industrial contributors.

Although certain substances can come from both sources heavy metals such as Fe, Zn, Pb, and possibly Cd and Cu, are primarily from urban nonpoint runoff. The remaining metals (Ni, Cr, Cr^{+6}, Cd, Cu), cyanide, phenolics, and complex organic compounds generally are the result of industrial processes (e.g., electroplating, manufacturing, steel making, etc.). For example a 1981 survey of toxic pollutants discharged to the Middletown WWTP[b] revealed the presence of 33 priority pollutants of which 22 were complex organic compounds (including cyanide and phenols) and 11 were heavy metals (Sb, As, Be, Cd, Cu, Cr, Pb, Hg, Ni, Se, Ag, Zn). Further sampling of the Middletown WWTP, CSO area, industrial effluents, and the receiving stream (water column, fish tissue, sediments) is needed to ascertain the impact of these complex compounds on water quality and biological condition in the lower mainstem Great Miami River.

A facility not listed in Table 11, the Monsanto Mound Laboratory (RM 65.9), periodically discharges low-level radioactive wastes containing 10-200 uCi of plutonium (^{238}Pu) to the lower mainstem Great Miami River (Muller et al. 1977). These discharges contain less than 5 dpm (disintegrations/minute)/ml of ^{238}Pu, occur 2-3 times per week, and generally last for 1.5 hours. The studies, conducted in 1975, determined that in most cases more than 90% of the plutonium was associated with suspended solids and that most of it ended up in river sediments within 6 miles (10km) of the discharge. The effects of this discharge on water quality or aquatic life are not known at this time.

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[b] Summary of analytical data provided by the City of Middletown.

Table 20. Third quarter (July 1-September 30) mean loadings (kg/day) and concentrations (ug/l) of heavy metals, cyanide, and phenolics from 23 point sources where these substances were monitored during 1980 (concentrations appear in parentheses under loadings).

Facility (Outfall Number)	Permit Number	River Mile	Flow MGD	Fe-T	Pb-T	Zn-T	Cd-T	Cu-T	Cr-T	Cr^{+6}	Ni-T	As-T	CN-T	Phenols	Al-T
Vandalia WWTP (001)	D612	94.2	2.33	-	0.092 (10)	0.804 (90)	0.265 (31)	0.374 (42)	0.387 (44)	-	0.139 (15)	-	-	-	-
GMC - Inland Div. (001)	C109	94.1	0.08	-	-	0.156 (449)	-	-	0.001 (4)	-	-	-	-	-	-
Ohio Suburban WWTP (001)	S600	87.4	3.30	-	0.263 (20)	8.010 (690)	0.012 (1)	0.981 (77)	0.046 (4)	-	0.244 (21)	-	-	-	-
DP&L - Tait EGS (002)	B103	77.3	3.37	8.792 (644)	-	-	-	1.422 (104)	-	-	-	0.330 (24)	-	-	-
Dayton WWTP (001)	F600	76.1	60.75	-	15.585 (64)	69.292 (285)	1.392 (6)	45.311 (186)	72.853 (303)	-	25.406 (105)	-	-	-	-
GMC Air Cond. #3 (001)	C108	74.4	0.80	0.400 (163)	-	0.104 (34)	-	-	0.047 (16)	0 (0)	0.025 (10)	-	-	-	-
GMC Air Cond. #2 (001)	C107	74.2	1.53	0.887 (182)	-	-	-	-	0.078 (16)	0.019 (1)	0.122 (25)	-	-	-	0.994 (200)
Mont. Co. W. Reg. WWTP (001)	L602	71.5	10.99	-	1.603 (37)	6.795 (138)	0.118 (3)	1.984 (45)	0.923 (19)	-	0.549 (13)	-	-	-	-
W. Carrollton WWTP (001)	D614	68.9	0.96	-	0.137 (33)	0.326 (80)	0.019 (5)	0.283 (72)	0.103 (26)	-	0.083 (20)	-	-	-	-
Miamisburg WWTP (001)	D617	65.1	1.83	-	0 (0)	0.183 (21)	0 (0)	0.183 (21)	0 (0)	-	0.122 (14)	-	-	-	-
DP&L - Hutchings EGS (002)	B104	65.4	1.83	2.035 (343)	-	-	-	0.456 (79)	-	-	-	0.160 (32)	-	-	-
Franklin WWTP (001)	D604	59.7	3.94	-	0.466 (32)	1.214 (78)	0.060 (4)	0.367 (25)	0.203 (14)	-	0.402 (27)	-	-	-	-
Aeronca (001)	C103	52.2, 2.3	0.650	-	-	-	-	-	-	0.291 (118)	0.376 (153)	-	-	0.062 (25)	-
ARMCO-Middletown (001)	D101	51.5	1.00	1.101 (290)	0.129 (34)	6.928 (1828)	-	-	-	0.022 (6)	-	-	1.284 (339)	0.065 (17)	-
Middletown WWTP (001)	E603	48.3	21.79	-	1.550 (18)	7.165 (91)	1.157 (13)	0.669 (8)	0.792 (10)	-	1.310 (16)	-	5.913 (81)	0 (0)	-
ARMCO-Middletown (005)	D101	47.6, 4.2	0.85	-	-	0.113 (28)	-	-	-	-	-	-	-	-	-
ARMCO-Middletown (004)	D101	47.6,5.1, 0.2	1.92	3.399 (467)	0.699 (10)	3.385 (465)	-	-	-	-	-	-	-	-	-
LeSourdsville Reg. WWTP[a]	K611	45.7	1.86	-	0.162 (19)	0.842 (96)	0.189 (28)	0.217 (31)	0.345 (53)	-	0.350 (53)	-	-	-	-
ARMCO-New Miami (004)	D102	39.4	7.80	-	-	-	-	-	-	-	-	-	1.415 (57)	0.619 (22)	-
Hamilton WWTP (001)	E602	34.0	17.88	-	0.527 (9)	0.527 (9)	0.059 (1)	0 (0)	0.821 (14)	-	0 (0)	-	-	-	-
Fairfield WWTP (001)	D603	32.0	3.43	-	0.537 (53)	1.171 (96)	0.132 (14)	1.504 (118)	0.326 (34)	-	1.181 (103)	-	-	-	-
DOE - National Lead (001)	Fed.	24.7	0.43	0.155 (95)	-	-	-	-	-	0.028 (17)	-	-	-	-	-
Gulf Oil (001, 601)	G100	9.1	2.82	-	-	-	-	-	0 (0)	0 (0)	-	-	-	0.088 (9)	-

[a] - annual data reported; third quarter metals data not available.

000022

Instream Water Quality

Methods

Chemical/physical water quality sampling in the lower mainstem Great Miami River during June 5 - October 9, 1980 consisted of the weekly collection of grab samples from 14 locations in the study area and two three-day intensive surveys during September 3-5 (RM 91.1 to 52.6) and September 16-18, 1980 (RM 52.6 to 14.9). The purpose of the weekly grab sampling effort was to establish baseline chemical/physical water quality conditions primarily in support of the fish and macroinvertebrate sampling. The purpose of the two three-day intensive surveys was to provide data for the calibration of the water quality model used to establish effluent limitations. All field and laboratory methods followed those outlined in the Ohio EPA Manual of Surveillance Methods and Quality Assurance Practices (Ohio EPA 1980b).

Grab water samples were collected during daylight hours (0745 - 1335) at 12 locations in the Great Miami River mainstem (RM 92.5 to 5.6) and two (2) locations in the lower sections of the Stillwater River (RM 82.6, 0.3) and Mad River (RM 81.5, 0.2) between June 5 and October 9, 1980 (Fig. 6). Samples were collected once each week, whenever possible, except when very high river flows persisted in early June. All analyses except phenolics and cyanide were performed at the Ohio EPA Laboratory; phenolics and cyanide analyses were conducted at the Ohio Department of Health Laboratory, also located in Columbus. Dissolved oxygen (D.O., mg/l) and temperature (^{o}C) were measured in the field with a YSI model 57 Oxygen Meter. pH (S.U.) was measured in the field with an Orion Model 399A meter; however, problems with field pH probes necessitated measuring pH in the laboratory.

Samples collected during the two three-day intensive surveys were composited over a 24 hour period. The grab sampling method just described or a Manning/ISCO automatic sampler were used. Laboratory analyses for all parameters except the heavy metals were conducted by Howard Laboratories in Dayton. All phenolics data collected during the September 3-5 and September 16-18 intensive surveys and all cyanide data collected during the September 16-18 intensive survey were not used because of quality assurance problems in the laboratory. All other methods used in the three-day surveys were the same as those described for the weekly sampling. The results of a brief, two-day survey by the U.S. EPA, Region V-Eastern District Office are also included (U.S. EPA 1982).

Results and Discussion

Chemical/physical water quality was monitored weekly via grab samples at 14 locations and by continuous water quality recorders operated by the USGS at four locations and the Ohio River Valley Sanitation Commission (ORSANCO) at one location (Fig. 6). Composite samples were collected during the periods September 3-5 and 16-18 for the purpose of model calibration. Data from this sampling effort was used where sampling locations coincided with the weekly monitoring stations Analyses were run for twenty-three (23) parameters during the weekly sampling part of the survey (Table 21). Water quality standards[c] (WQS) violations for certain parameters, especially dissolved oxygen, have occurred with some regularity in certain segments of the lower mainstem Great Miami River (Ohio EPA 1976, 1980a). Such violations generally increase in frequency during periods of relatively low flow. However, river flows during this study were well above normal during June, July, and August and slightly above normal in September and October (Fig. 5). Extreme peak flows occurred in early June and July (Fig. 4; Table 22).

Mean flow for the period July 1-September 30, 1980 was the third highest recorded since 1971. These flow conditions resulted in very few or reduced violations of parameters related to point sources (i.e., D.O., NH_3-N, cyanide, phenolics, etc.), but increased violations of others, especially those related to nonpoint source runoff (i.e., total iron, fecal coliforms).

Third quarter dissolved oxygen (July 1-September 30), temperature (June 16-September 15), and flow (July 1-September 30) data from the five continuous water quality and four flow recorders were compared for the period 1971-1980 (Table 19). The percentage of days in which at least one hourly D.O. value was less than 4 mg/l and at least one hourly temperature exceeded 31.7°C (89°F) was calculated for the five continuous monitor locations for the period 1971-1980. A simple linear correlation (r) was performed by comparing the percentage of violations for D.O. with the third quarter mean flow. This analysis was not performed for temperature because of the comparatively low frequency of WQS violations.

The daily minimum D.O. standard of 4 mg/l was violated on 10 of 91 days (11%) that the monitor was operating between July 1 and September 30, 1980, at the Linden Ave. location in Miamisburg (RM 67.0) (Table 23). Additionally, the 5 mg/l average D.O. standard was violated on two consecutive days in September 1980 (Fig. 7). Except for a minimal number of violations (2%) of the 4 mg/l minimum D.O standard at the Lost Bridge monitor (RM 5.6), no violations of either the 4 mg/l minimum or 5 mg/l average D.O. standard were observed at the other monitors in 1980.

000074

Figure 6. Locations of 14 weekly chemical/physical water quality sampling locations, 14 bottom sediment sampling locations, 5 flow gages, and 5 continuous water quality monitors in the lower mainstem Great Miami River study area, June 5 - October 9, 1980.

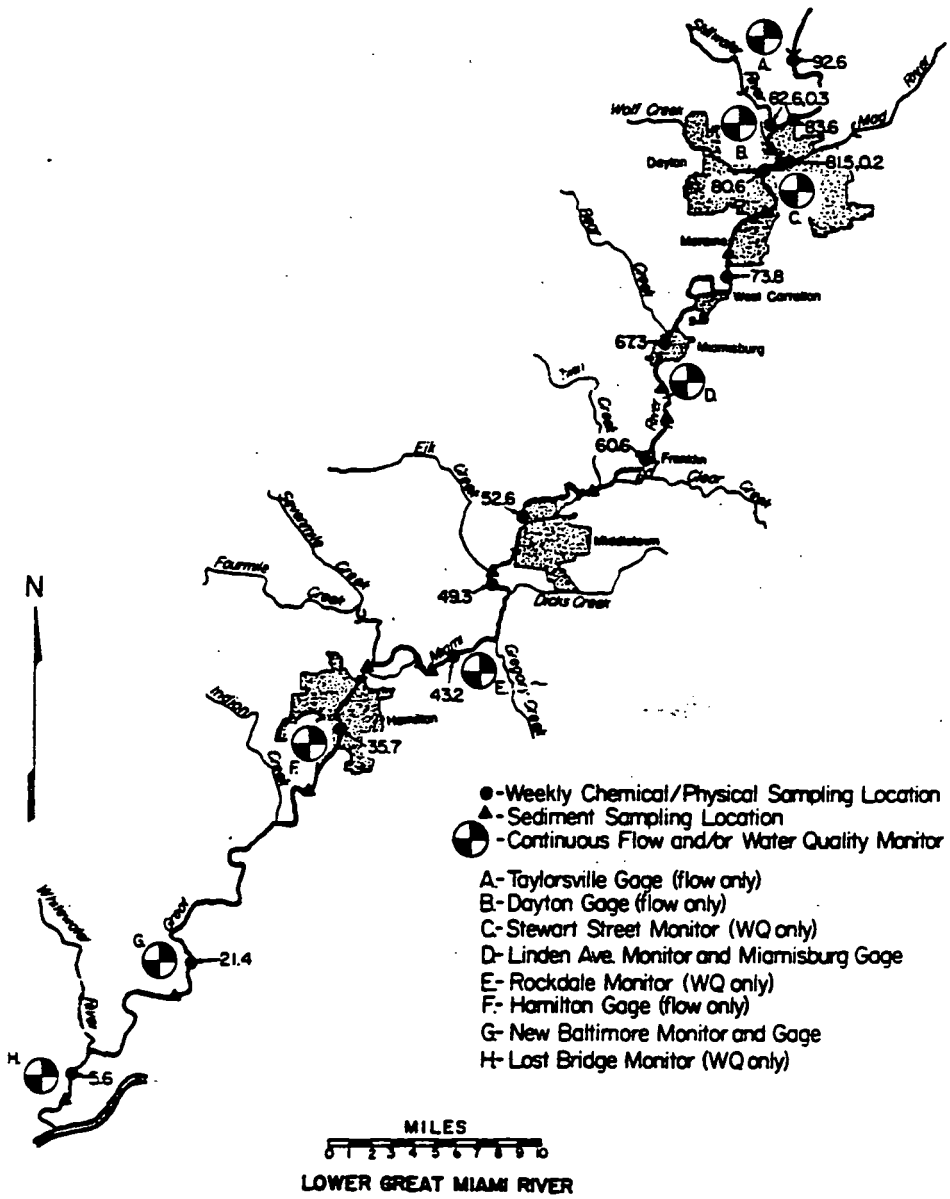

Table 21. Chemical/physical water quality parameters monitored by Ohio EPA in the lower mainstem Great Miami River during June 5-October 9, 1980.

Dissolved Oxygen (field)	Fecal Coliforms
pH (field)	Hardness
Temperature (field)	Total Iron (Fe-T)
Conductivity (lab)	Total Lead (Pb-T)
Total Suspended Solids (TSS)	Total Zinc (Zn-T)
Chemical Oxygen Demand (COD)	Total Copper (Cu-T)
5-day Biochemical Oxygen Demand (BOD_5)	Total Cadmium (Cd-T)
Ammonia-nitrogen (NH_3-N)	Total Nickel (Ni-T)
Nitrate-nitrogen (NO_3-N)	Total Chromium (Cr-T)
Nitrite-nitrogen (NO_2-N)	Total Cyanide
Total Kjeldahl Nitrogen (TKN)	Total Phenolics
Total Phosphorus (P-T)	

000076

Table 22. Daily flow (cfs) measured at four USGS flow gaging stations on the lower mainstem Great Miami River on the days chemical/physical grab water samples were collected, June 5-October 9, 1980.

Date	Taylorsville Dam - RM 92.6	Monument Ave. (Dayton) - RM 80.7	Miamisburg - RM 67.3	Hamilton - RM 35.6
June 5	11,100	20,000	22,700	22,500
June 10	1,540	3,000	4,710	6,270
June 19	527	1,580	2,160	2,170
June 26	657	1,720	2,300	3,090
July 1	3,240	13,200	15,400	15,600
July 8	681	2,180	2,620	3,810
July 17	439	1,310	1,710	2,180
July 22	355	1,780	3,170	6,020
August 4	235	1,780	2,140	3,370
August 12	723	2,970	2,880	3,670
August 21	686	2,280	2,990	5,050
August 28	217	1,020	1,270	1,740
September 3	228	1,150	1,380	1,850
September 4	218	982	1,190	1,680
September 5	218	1,200	1,150	1,520
September 16	166	721	859	1,070
September 17	172	762	1,110	1,290
September 18	175	794	1,010	1,360
September 25	132	665	840	1,070
October 1	113	628	821	995
October 4	133	660	812	958
October 9	130	632	787	967

Daily maximum and minimum D.O. concentrations were markedly influenced by flow variations during 1980 (Fig. 7). The difference between daily maximum and minimum D.O. concentrations were generally less than 1-2 mg/l during peak flow periods (early-mid June, early July, mid-late August). When flows declined to near base levels, especially during September and October, the daily fluctuation between maximum and minimum increased, some days as much as 8-10 mg/l. These daily fluctuations reflect the influence that algal photosynthesis and respiration have on D.O. concentrations. This phenomenon was not unique to conditions during the 1970's. An earlier survey by the Ohio Dept. of Health (1967) revealed equally large diel fluctuations in the mainstem D.O. upstream from Dayton. High flows tend to eliminate these wide diel fluctuations by diluting the effect of algal photosynthesis and respiration. Increased loadings of oxygen demanding substances tend to decrease mean, maximum, and minimum D.O. concentrations collectively as was evidenced during September at the Linden Ave. location (RM 67.0). Daytime grab samples collected weekly at 14 locations, as expected, revealed no violations of the 4 mg/l D.O. standard at this location. Concentrations were generally similar to the daily average and maximum values observed at the continuous monitors (Table 24; Fig. 7). The longitudinal trend in daytime D.O. concentrations, especially the minimums, reflected the inputs of substantial BOD loadings in the Dayton area and possibly additive BOD inputs in the Middletown and Hamilton areas (Fig. 8). The sections of the lower mainstem downstream from the Dayton WWTP (RM 75- 70), adjacent to and downstream from Miamisburg (RM 70-60), adjacent to and downstream from Middletown (RM 50-40), and downstream from Hamilton (RM 34-16) have typically been the D.O. "sag" areas where concentrations frequently decreased to 0-2 mg/l during low and even normal flow periods during the summer and fall months (Ohio Dept. of Health 1951, 1967).

Violations of the 4 mg/l minimum D.O standard have been more frequent in past years reaching as high as 80% at the Linden Ave. monitor (RM 67.0) in 1977. The frequency of days with D.O. readings less than 4 mg/l showed the greatest decrease at the Linden Ave. (RM 67.0), Rockdale (RM 44.7), and New Baltimore (RM 21.4) locations since 1976 and 1977. The simple linear correlation analysis showed that this decline was apparently in response to annual flow changes rather than reductions in point source BOD loadings. The relationship between D.O. violations and flow was highly correlated for the Linden Ave (P less than 0.05) location, and mildly correlated at the Rockdale (P less than 0.10) and New Baltimore (P less than 0.10) locations. Total segment BOD_5 loadings from point sources located upstream from the Linden Ave. and Rockdale monitors showed an overall increase since 1976, especially in the mainstem segment downstream from Dayton (Segment 4, RM 76.1-71.6) (Table 14). The frequency of D.O. concentrations less than 4 mg/l is expected to be similarly high during future low flow periods under these BOD loadings.

Table 23. Percent of days during July 1-September 30, 1971-1980, in which at least one hourly dissolved oxygen value was less than 4 mg/l and during June 16-September 15, 1971-1980 that hourly temperature exceeded 31.7°C (89F) at five continuous monitors located along the lower mainstem Great Miami River.

	Stewart Str. (Dayton) - RM 78.1[a]			Linden Ave. (Miamisburg) - RM 67.0[a]			Rockdale - - RM 44.7[b]			New Baltimore - - RM 21.4[b]			Lost Bridge (Elizabethtown) - RM 5.6[c]		
Year	% Days D.O. 4 mg/l	% Days Temp. 31.7°C	Mean Flow (cfs)	% Days D.O. 4 mg/l	% Days Temp. 31.7°C	Mean Flow (cfs)	% Days D.O. 4 mg/l	% Days Temp. 31.7°C	Mean Flow (cfs)	% Days D.O. 4 mg/l	% Days Temp. 31.7°C	Mean[d] Flow (cfs)	% Days D.O. 4 mg/l	% Days Temp. 31.7°C	Mean Flow (cfs)
1971	46	0	513	83	1	661	86	3	820	93	0	820	1	0	-
1972	16	0	1016	74	0	1159	86	5	1205	86	0	1205	9	0	-
1973	0	0	2623	9	1	2877	2	0	3611	34	0	3611	0	0	-
1974	3	0	872	48	0	1089	8	0	1626	34	0	1626	0	0	-
1975	0	0	1328	10	0	1549	23	0	1763	29	3	1763	0	0	-
1976	26	0	531	60	0	691	25	1	890	20	0	890	11	0	-
1977	74	31	322	80	3	485	29	15	644	67	22	644	8	0	-
1978	1	0	891	60	8	1092	8	0	1613	1	4	1613	0	0	-
1979	10	0	3533	5	0	4161	0	0	5128	2	0	5128	0	0	-
1980	0	0	1853	11	4	2291	0	0	3201	0	0	3201	2	0	-
	Mean flow vs. % Days D.O. 4 mg/l, $r = 0.525$			Mean flow vs. % Days D.O. 4 mg/l, $r = 0.830$**			Mean flow vs. % Days D.O. 4 mg/l, $r = 0.590$*			Mean flow vs. % Days D.O. 4 mg/l, $r = 0.580$*					

a - monitor operated by Miami Conservancy District through June 30, 1977, and thereafter by the United States Geological Survey.
b - monitor operated by United States Geological Survey, 1971-1980.
c - monitor operated by Ohio River Valley Sanitation Commission.
d - flow data from gaging station located at RM 35.7 in Hamilton.
* - P 0.10 (90% confidence), r 0.10(8) = 0.549
** - P 0.05 (95% confidence), r 0.05(8) = 0.632

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Table #4 Mean (± standard deviation), maximum, and minimum values for 23 chemical/physical water quality parameters measured weekly at 14 locations in the lower mainstem Great Miami River study area, June 5 - October 9, 1980.

RM - Location		D.O.[a] mg/l	pH S.U.	Temp. °C	Cond. 25°C umohs	TSS mg/l	COD mg/l	BOD_5 mg/l	NH_3-N mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	Fecal coli. #/100ml
Great Miami River														
RM 92.6 - Taylorsville Dam														
SC 610050														
	mean	7.5	7.8	20.5	609	82	21	3.2	0.17	3.68	0.06	1.25	0.45	2632
	±SD	(1.2)	(0.3)	(3.3)	(117)	(63)	(9.3)	(1.1)	(0.19)	(1.96)	(0.06)	(0.42)	(0.16)	(3246)
	min	4.9	7.2	15.0	370	22	12	1.8	0.02	0.04	0.02	0.8	0.23	170
	max	9.4	8.2	25.0	770	234	43	5.7	0.19	8.00	0.24	2.3	0.71	11000
	n	14	15	16	15	16	16	14	16	16	15	16	16	13
Great Miami River														
RM 83.6 - Keowee Str. (Dayton)														
SC 600310														
	mean	7.2	7.9	22.4	616	74	24	4.3	0.26	3.25	0.09	1.70	0.47	8346
	±SD	(0.7)	(0.3)	(2.8)	(140)	(82)	(13)	(1.8)	(0.35)	(2.05)	(0.05)	(0.99)	(0.15)	(15704)
	min	6.2	7.2	18.0	350	22	12	1.7	0.06	0.05	0.05	0.7	0.25	800
	max	8.8	8.2	26.0	830	295	57	7.5	1.63	8.00	0.24	5.5	0.71	56000
	n	15	16	16	13	16	16	16	19	16	16	19	19	12
Stillwater River														
RM 82.6, 0.3 - Triangle Park (Dayton)														
SC 600120														
	mean	7.9	7.9	22.1	573	144	26	4.0	0.11	3.03	0.07	1.37	0.42	2848
	±SD	(1.0)	(0.3)	(2.9)	(178)	(177)	(14)	(3.5)	(0.20)	(2.03)	(0.10)	(0.69)	(0.26)	(3041)
	min	6.6	7.4	17.0	210	12	8	1.2	0.00	0.24	0.01	0.7	0.22	230
	max	9.6	8.2	25.8	790	710	64	14	0.82	2.03	0.01	3.1	1.14	10000
	n	15	13	17	14	17	17	17	17	14	14	17	17	11
Mad River														
RM 81.5, 0.2 - Webster Str. (Dayton)														
SC 610150														
	mean	8.8	7.9	20.4	581	141	24	3.0	0.27	2.87	0.08	1.09	0.38	21320
	±SD	(0.9)	(0.2)	(2.4)	(156)	(188)	(19)	(1.5)	(0.70)	(1.50)	(0.06)	(0.71)	(0.23)	(28179)
	min	7.4	7.4	16.2	310	4	4	1.2	0.01	0.01	0.04	0.4	0.18	1200
	max	11.2	8.2	23.8	750	532	75	6.3	0.70	7.40	0.25	2.4	0.79	75000
	n	15	15	16	13	16	16	16	16	16	13	16	16	10
Great Miami River														
RM 80.6 - Monument Ave. (Dayton)														
SC 610060														
	mean	8.2	7.9	21.4	582	129	22	3.1	0.14	2.99	0.07	1.36	0.41	16357
	±SD	(0.7)	(0.3)	(3.0)	(168)	(175)	(12)	(1.0)	(0.28)	(1.42)	(0.04)	(0.76)	(0.21)	(23708)
	min	7.4	7.3	15.0	230	26	2	1.6	0.00	0.03	0.04	0.6	0.25	85
	max	10.0	8.4	25.1	790	703	48	6.0	1.22	5.44	0.19	3.2	1.09	70000
	n	16	16	17	13	16	17	17	17	14	14	17	17	13

000080

Table 24 continued.

RM - Location		D.O.[a] mg/l	pH S.U.	Temp. °C	Cond. 25°C umohs	TSS mg/l	COD mg/l	BOD_5 mg/l	NH_3-N mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	Fecal coli. #/100ml
Great Miami River RM 73.8 - Sellars Rd. (West Carrollton) SC 610130														
	mean	7.8	7.9	23.3	614	106	25	6.5	0.72	2.91	0.12	1.97	0.55	12396
	±SD	(0.8)	(0.2)	(2.6)	(151)	(120)	(10)	(2.3)	(0.41)	(1.59)	(0.05)	(0.57)	(0.14)	(26468)
	min	6.2	7.6	18.0	330	16	6	3.0	0.14	0.01	0.07	1.1	0.34	850
	max	9.8	8.1	26.9	870	466	49	10	1.40	7.10	0.22	3.7	0.86	100000
	n	16	17	17	14	17	17	17	20	17	17	20	20	13
Great Miami River RM 66.9 - Linden Ave. (Miamisburg) SC 600150														
	mean	7.1	7.8	23.2	632	112	28	5.9	0.63	3.16	0.22	2.01	0.65	31935
	±SD	(0.9)	(0.2)	(2.8)	(164)	(139)	(9)	(2.5)	(0.70)	(1.65)	(0.11)	(0.67)	(0.19)	(26541)
	min	5.8	7.6	17.8	340	25	14	2.8	0.08	0.04	0.10	1.2	0.36	4700
	max	9.2	8.1	28.0	880	587	47	12	3.05	7.00	0.46	3.6	1.00	72000
	n	17	14	18	14	18	18	18	21	18	18	21	21	13
Great Miami River RM 60.6 - State Route 123 (Franklin) SC 610120														
	mean	7.3	7.8	25.1	649	132	31	5.2	0.33	3.37	0.21	1.69	0.59	29466
	±SD	(0.9)	(0.2)	(3.0)	(168)	(172)	(17)	(1.7)	(0.16)	(1.65)	(0.07)	(0.44)	(0.15)	(36764)
	min	6.0	7.4	19.5	350	27	12	3.1	0.14	0.14	0.10	1.1	0.38	230
	max	8.9	8.0	29.8	920	738	86	9.4	0.82	7.20	0.34	2.6	0.87	100000
	n	17	13	17	14	17	17	17	16	13	14	16	16	11
Great Miami River RM 52.6 - State Route 122 (Middletown) SC 610110														
	mean	7.9	7.9	23.9	617	156	32	4.6	0.20	3.20	0.17	1.72	0.57	22833
	±SD	(0.7)	(0.2)	(2.8)	(169)	(153)	(15)	(1.2)	(0.19)	(1.68)	(0.07)	(0.64)	(0.19)	(33016)
	min	6.8	7.3	19.5	320	37	14	7.3	0.01	0.17	0.05	0.8	0.10	800
	max	9.5	8.2	29.5	900	600	64	9.5	0.82	7.30	0.30	3.1	1.01	100000
	n	16	18	16	13	19	19	19	22	16	16	22	22	9
Great Miami River RM 49.3 - State Route 73 (Middletown) SC 600330														
	mean	8.1	7.7	23.8	631	166	30	4.9	0.20	3.34	0.16	1.57	0.62	25849
	±SD	(0.8)	(0.5)	(3.0)	(167)	(181)	(12)	(1.9)	(0.15)	(1.53)	(0.06)	(0.55)	(0.18)	(36886)
	min	7.0	6.3	19.5	330	43	10	2.2	0.01	0.04	0.07	0.9	0.35	340
	max	10.1	8.2	29.5	920	615	55	10.2	0.57	7.30	0.23	2.9	1.02	100000
	n	16	13	16	13	16	16	16	19	17	16	19	19	11

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Table 24 continued.

RM - Location		D.O.[a] mg/l	pH S.U.	Temp. °C	Cond. 25°C umohs	TSS mg/l	COD mg/l	BOD_5 mg/l	NH_3-N mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	Fecal coli. #/100ml
Great Miami River														
RM 43.2 - Liberty-Fairfield Rd.														
SC 610090														
	mean	7.8	7.8	23.3	636	168	29	4.7	0.21	3.41	0.15	1.62	0.64	37885
	±SD	(0.9)	(0.3)	(3.2)	(177)	(212)	(10)	(1.6)	(0.21)	(1.59)	(0.07)	(0.50)	(0.19)	(44533)
	min	6.6	7.4	19.0	310	2	11	2.8	0.04	0.03	0.09	0.8	0.37	230
	max	9.8	8.3	29.5	900	765	47	8.1	0.87	7.30	0.29	2.6	1.10	130000
	n	16	12	16	12	15	16	16	16	15	13	16	16	11
Great Miami River														
RM 35.7 - State Route 128 (Hamilton)														
SC 600270														
	mean	8.6	7.9	23.2	629	344	35	4.5	0.25	3.27	0.13	2.00	0.72	27920
	±SD	(1.3)	(0.3)	(2.6)	(203)	(749)	(30)	(1.5)	(0.47)	(1.58)	(0.05)	(1.50)	(0.60)	(36220)
	min	6.8	7.2	19.5	320	38	10	2.5	0.01	0.07	0.05	0.9	0.35	200
	max	11.7	8.5	29.5	920	3062	140	7.3	2.02	7.20	0.24	7.4	2.92	100000
	n	17	17	17	13	16	17	17	17	17	14	17	17	10
Great Miami River														
RM 21.4 - River Rd. (New Baltimore)														
SC 600030														
	mean	8.1	8.0	22.9	605	204	34	4.2	0.15	3.39	0.08	1.63	0.60	16009
	±SD	(1.5)	(0.3)	(2.9)	(154)	(203)	(13)	(1.5)	(0.33)	(1.42)	(0.07)	(0.64)	(0.23)	(13596)
	min	6.5	7.5	18.2	350	48	12	2.2	0.00	1.75	0.02	0.8	0.34	110
	max	11.6	8.4	28.8	830	740	53	7.2	1.43	7.40	0.23	2.8	1.20	43000
	n	18	18	18	14	18	18	18	18	18	15	18	18	12
Great Miami River														
RM 5.6 - Lost Bridge (Elizabethtown)														
SC 600300														
	mean	8.0	7.7	23.2	589	251	32	4.1	0.16	3.04	0.07	1.71	0.63	13680
	±SD	(1.0)	(0.4)	(3.1)	(153)	(304)	(16)	(1.5)	(0.39)	(1.84)	(0.06)	(0.72)	(0.39)	(28215)
	min	6.3	6.8	19.0	340	58	10	2.0	0.00	0.02	0.02	0.8	0.31	110
	max	9.6	8.3	28.3	800	988	60	6.7	1.43	7.40	0.22	3.1	1.50	100000
	n	13	13	13	13	13	13	13	13	13	13	13	13	12

0000082

Table 24 continued.

Location - RM		Hardness mg/l	Fe-T ug/l	Pb-T ug/l	Zn-T ug/l	Cu-T ug/l	Cd-T ug/l	Ni-T ug/l	Cr-T ug/l	Cyanide ug/l	Phenolics ug/l
Great Miami River											
RM 92.6 - Taylorsville Dam											
SC 610050											
	mean	337	2371	6	21	9	1	46	52	-	4
	±SD	(62)	(2814)	(2)	(15)	(6)	(1)	(15)	(25)	-	(2)
	min	201	590	5K	10	5K	1K	40K	30K	5K	2K
	max	430	10040	10	60	30	5	100	120	10K	8
	n	16	16	16	16	16	16	16	16	15	15
Great Miami River											
RM 83.6 - Keowee Str. (Dayton)											
SC 600310											
	mean	324	2081	6	18	8	1	42	51	-	4
	±SD	(59)	(3089)	(2)	(14)	(4)	(0)	(8)	(31)	-	(1)
	min	195	480	4	5K	4	1K	40K	40K	5K	2
	max	397	10590	14	55	15	1	70	160	10	6
	n	16	16	16	16	16	16	16	16	13	13
Stillwater River											
RM 82.6, 0.3 - Triangle Park (Dayton)											
SC 600120											
	mean	327	4254	6	25	9	1	48	55	-	6
	±SD	(83)	(5844)	(4)	(27)	(7)	(1)	(20)	(26)	-	(9)
	min	117	740	5K	5K	5K	1K	40K	30K	5K	2K
	max	423	21720	21	95	30	5	100	120	10K	36
	n	17	17	17	17	17	17	17	17	13	13
Mad River											
RM 81.5, 0.2 - Webster Str. (Dayton)											
SC 610150											
	mean	356	3304	11	29	9	1	53	52	-	3
	±SD	(68)	(4177)	(10)	(25)	(5)	(0)	(35)	(19)	-	(1)
	min	204	250	5K	5K	5K	1K	40K	40K	5K	2K
	max	425	11790	36	80	20	1	160	100	10K	5
	n	16	16	16	16	16	16	16	16	13	13
Great Miami River											
RM 80.6 - Monument Ave. (Dayton)											
SC 610060											
	mean	332	3617	10	29	9	1	42	48	-	4
	±SD	(70)	(5127)	(9)	(28)	(4)	(0)	(7)	(17)	-	(3)
	min	137	440	5K	5K	5K	1K	40K	40K	5K	2K
	max	412	20980	34	90	20	1	60	100	10K	11
	n	17	17	17	17	17	17	17	17	14	14
Great Miami River											
RM 73.8 - Sellars Rd. (West Carrollton)											
SC 610130											
	mean	344	2998	8	34	13	1	45	44	-	4
	±SD	(83)	(4038)	(5)	(17)	(6)	(0)	(13)	(10)	-	(3)
	min	171	390	5K	10	5	1K	40K	40K	5K	2K
	max	565	15780	17	70	28	1	90	80	10K	12
	n	17	17	17	17	17	17	17	17	14	14

000083

6399

Table 24 continued.

Location - RM		Hardness mg/l	Fe-T ug/l	Pb-T ug/l	Zn-T ug/l	Cu-T ug/l	Cd-T ug/l	Ni-T ug/l	Cr-T ug/l	Cyanide ug/l	Phenolics ug/l
Great Miami River											
RM 66.9 - Linden Ave. (Miamisburg)											
SC 600150											
	mean	324	3212	10	41	13	1	43	48	11	5
	±SD	(66)	(4463)	(8)	(27)	(4)	(0)	(10)	(19)	(5)	(2)
	min	180	270	5K	10	5K	1K	40K	40K	5K	2K
	max	410	17530	28	105	20	1	80	100	28	9
	n	18	18	18	18	18	17	18	18	14	14
Great Miami River											
RM 60.6 - State Route 123 (Middletown)											
SC 610120											
	mean	332	3382	9	36	12	1	43	48	-	5
	±SD	(61)	(4699)	(8)	(26)	(6)	(0)	(7)	(9)	-	(3)
	min	188	350	5K	10	5K	1K	40K	40K	5K	2K
	max	408	18220	30	90	25	1	90	60	10K	10
	n	17	17	17	17	17	17	17	17	14	13
Great Miami River											
RM 52.6 - State Route 122 (Middletown)											
SC 610110											
	mean	322	3711	9	38	13	1	44	51	10	3
	±SD	(53)	(4562)	(6)	(25)	(6)	(0)	(16)	(16)	(1)	(2)
	min	198	620	5K	15	5K	1K	40K	40K	7	2K
	max	404	17520	28	85	30	1	110	80	10	5
	n	19	19	19	19	19	19	19	19	13	13
Great Miami River											
RM 49.3 - State Route 73 (Middletown)											
SC 600330											
	mean	327	4015	10	41	13	-	44	46	10	4
	±SD	(60)	(4973)	(6)	(27)	(5)	-	(13)	(13)	(1)	(2)
	min	190	730	5K	20	10K	1K	40K	40K	5K	2K
	max	406	17970	27	115	30	1K	90	80	10	10
	n	16	16	15	16	16	16	16	16	13	13
Great Miami River											
RM 43.2 - Liberty-Fairfield Rd.											
SC 610090											
	mean	336	3819	9	43	11	1	43	45	-	5
	±SD	(60)	(4907)	(7)	(21)	(5)	(0)	(13)	(4)	-	(3)
	min	193	500	5K	20	5K	1K	40K	40K	5K	2
	max	408	18360	26	90	20	1	90	120	10K	12
	n	16	16	16	16	16	16	16	16	13	13

000084

Table 24 continued.

Location - RM		Hardness mg/l	Fe-T ug/l	Pb-T ug/l	Zn-T ug/l	Cu-T ug/l	Cd-T ug/l	Ni-T ug/l	Cr-T ug/l	Cyanide ug/l	Phenolics ug/l
Great Miami River RM 35.7 - State Route 128 (Hamilton) SC 600270											
	mean	352	5333	12	52	13	1	46	46	-	5
	±SD	(60)	(9332)	(14)	(51)	(12)	(1)	(17)	(16)	-	(4)
	min	243	780	5K	20	5K	1K	40K	40K	5K	2K
	max	456	38150	63	230	55	4	100	100	10K	15
	n	16	16	16	16	16	16	16	16	12	12
Great Miami River RM 21.4 - River Rd. (New Baltimore) SC 600030											
	mean	340	4344	9	47	12	1	43	44	-	6
	±SD	(58)	(5347)	(7)	(24)	(5)	(0)	(8)	(8)	-	(7)
	min	202	600	5K	20	5K	1K	40K	40K	5K	2K
	max	414	20240	24	100	25	1	70	70	10K	25
	n	18	18	18	18	18	18	18	18	15	14
Great Miami River RM 5.6 - Lost Bridge (Elizabethtown) SC 600300											
	mean	326	6104	11	46	13	1	42	48	-	5
	±SD	(51)	(7061)	(9)	(33)	(8)	(0)	(6)	(17)	-	(4)
	min	204	880	5K	15	5K	1K	40K	40K	5K	2K
	max	398	21380	34	110	30	1	60	100	10K	14
	n	13	13	13	13	13	13	13	13	13	13

000085

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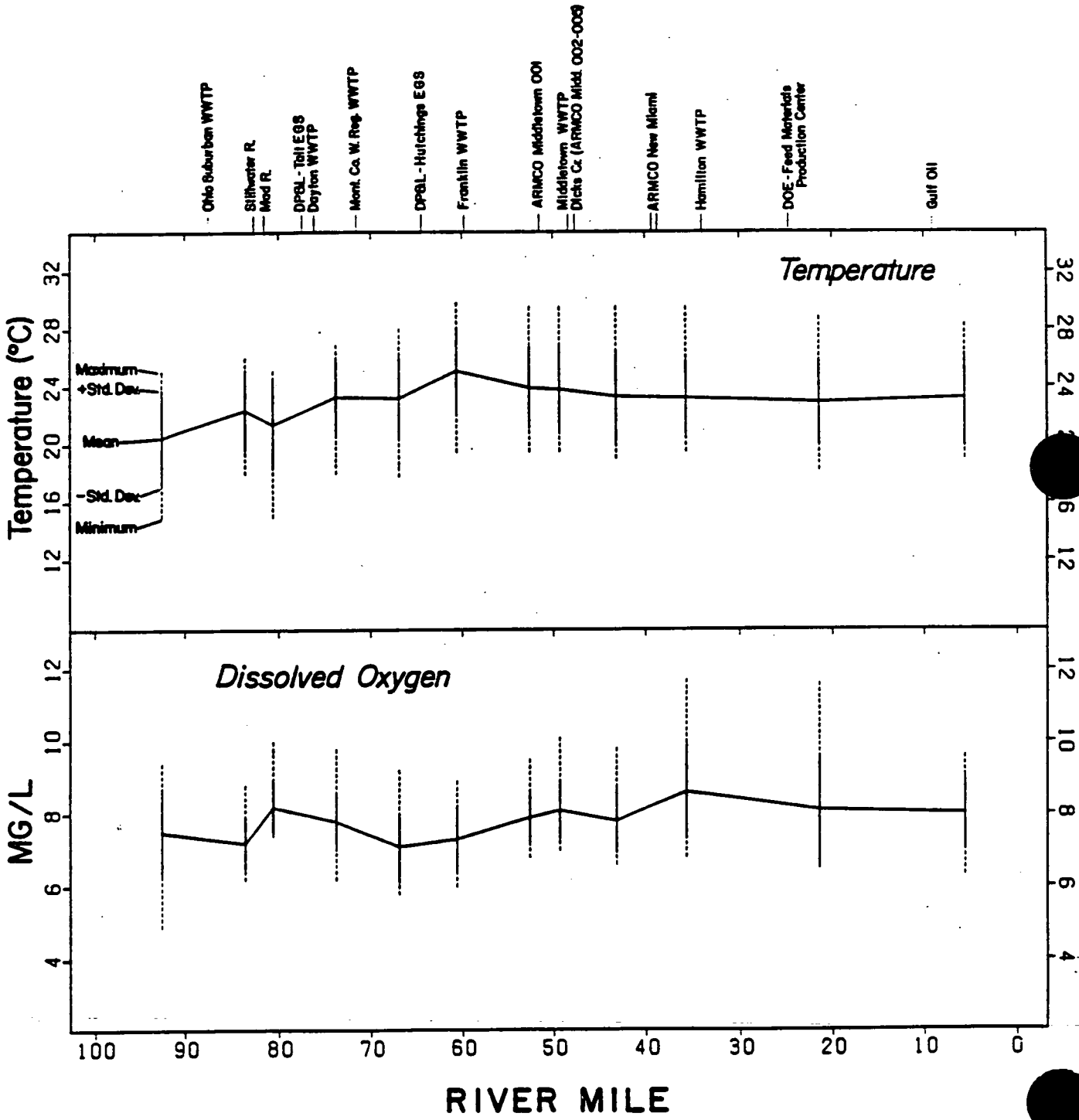
Fig. 7. Longitudinal profiles of mean (±SD), maximum, and minimum dissolved oxygen (mg/l) and temperature (°C) measured at 12 locations in the lower mainstem Great Miami River, June 5 - October 9, 1980.



000086

The frequency of D.O. violations recorded at the Stewart Street monitor (RM 78.6) was highest during the three lowest flow years (1971, 1976, and 1977) and was nearly equal to the frequency observed for the Linden Ave. (RM 67.0) monitor in 1977 (Table 24). Consideration of these results alone could be misleading as to the magnitude and cause of the D.O. concentrations less than 4 mg/l at each location. A frequency analysis of daily minimum and average D.O. concentrations measured at the four continuous monitors was performed in order to determine the magnitude of the violations at each monitor during 1977, a year with a high number of D.O. WQS violations and the lowest average flows during 1971-1980. The analysis was performed by examining minimum hourly and daily average D.O. concentrations for the period July 1-September 30, 1977 and determining the percent occurrence at 1 mg/l intervals (Table 25). Minimum D.O. concentrations at the Stewart Street monitor (RM 78.6) fell below 1 mg/l 7% of the time compared to 26% of the time at Linden Ave. (RM 67.0), which is downstream from the largest point source of wastewater in the study area. Although the total percentage of minimum readings less than 4 mg/l was nearly the same at both locations the magnitude of the violations was less severe at the Stewart Street monitor. The magnitude of the violations was also less severe at the Rockdale (RM 44.7) and New Baltimore (RM 21.4) monitors. Perhaps the best indication of daily D.O. conditions in the mainstem segments adjacent to the four monitors is obtained by examining the frequency analysis for daily average D.O. concentrations. Only 9% of the daily averages at the Stewart Street monitor (RM 78.6) were less than the WQS (daily average) of 5 mg/l and none were less than 4 mg/l. This contrasted sharply with the Linden Ave. location (RM 67.0) where 61% of the daily average readings were less than 5 mg/l and some (8%) less than 1 mg/l. Daily average D.O. concentrations were generally higher at the Rockdale (84% greater than 5 mg/l) and New Baltimore (68% greater than 5 mg/l) monitors, but were more indicative of an oxygen depletion problem than the Stewart Street monitor. This analysis revealed that the severity and magnitude of both minimum and daily average D.O. WQS violations were more serious at the Linden Ave. location (RM 67.0), than at the other three locations.

The situation at Stewart Street (RM 78.6) appears to be entirely related to algal induced diel D.O. fluctuations. D.O. concentrations below 4 mg/l would be expected to be more frequent during low flow years since the algal populations would be more concentrated. The low frequency or lack of readings less than 4 mg/l during higher flow years is likely due to the effects of dilution and scouring of periphytic algal communities. The situation at Linden Ave. (RM 67.0) also involved diel fluctuations due to algal photosynthesis and respiration, but daily averages less than 1-3 mg/l indicated relatively long periods of low D.O. levels caused by the high

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c Unless otherwise indicated, Warmwater Habitat (WWH) criteria and the Primary Contact Recreation fecal coliform criterion (Rule 3745-1 of the Ohio Administrative Code) are the applicable water quality standards (WQS) throughout this report.

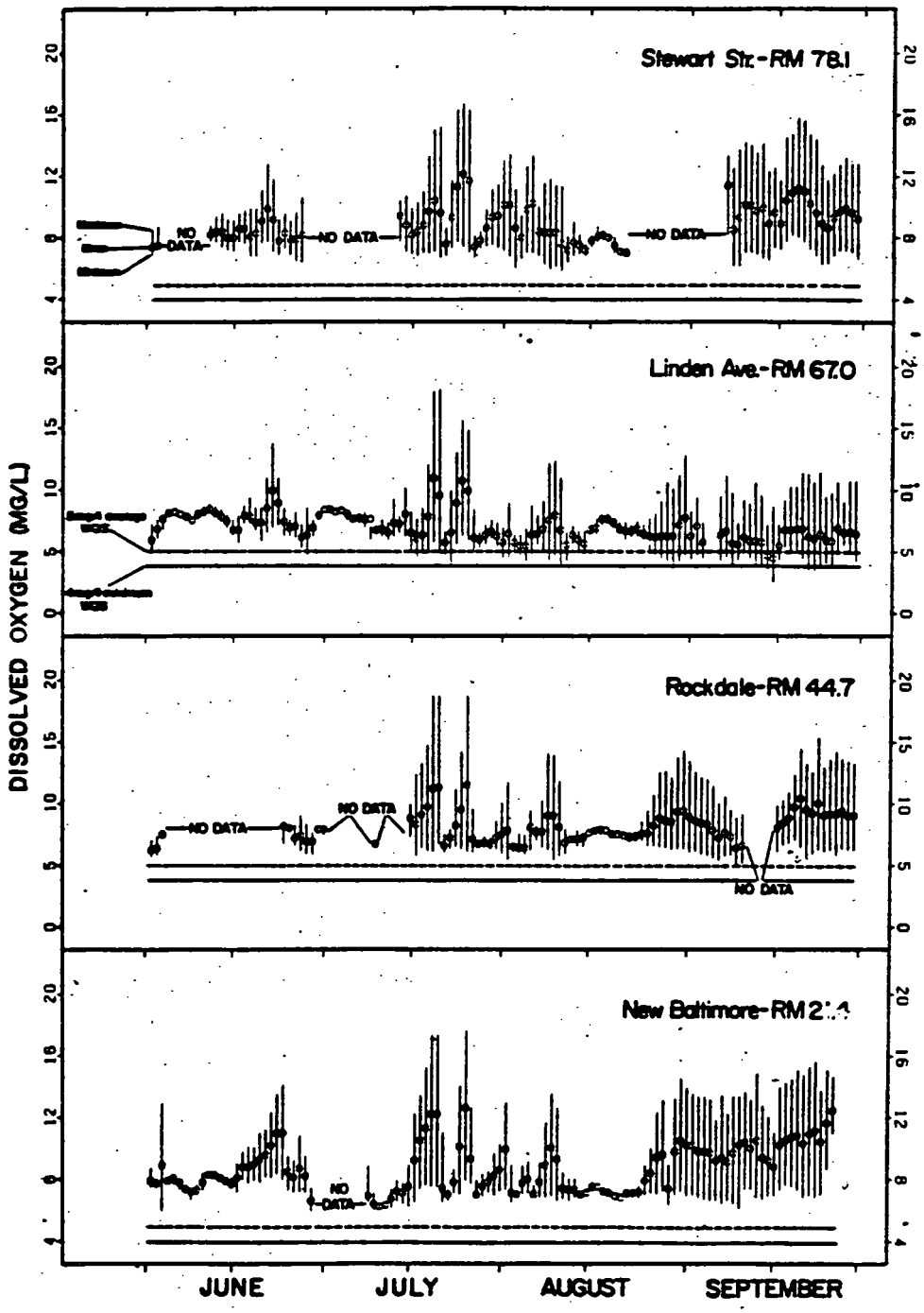

Fig. 8. Daily mean, maximum, and minimum dissolved oxygen (mg/l) measured continuously at four locations in the lower mainstem Great Miami River during June 1 - September 30, 1980.

000088

Table 25. Frequency analysis of daily minimum and average dissolved oxygen concentrations measured continuously at four locations on the lower mainstem Great Miami River, July 1-September 30, 1977 (numbers in parentheses are the number of monitoring days).

Minimum D.O. - 1977

	4.0	3.0-3.9	2.0-2.9	1.0-1.9	0-0.9
Stewart Str. (RM 78.6)	26% (12)	23% (10)	30% (13)	14% (6)	7% (3)
Linden Ave. (RM 67.0)	20% (16)	8% (7)	16% (13)	30% (23)	26% (21)
Rockdale (RM 44.7)	71% (64)	13% (9)	14% (13)	2% (2)	0% (0)
New Baltimore (RM 21.4)	33% (30)	38% (35)	27% (14)	2% (2)	0% (0)

Average D.O. - 1977

	5.0	4.0-4.9	3.0-3.9	2.0-2.9	1.0-1.9	0-0.9
Stewart Str. (RM 78.6)	91% (40)	9% (4)	0% (0)	0% (0)	0% (0)	0% (0)
Linden Ave. (RM 67.0)	39% (31)	6% (5)	21% (17)	18% (14)	8% (6)	8% (7)
Rockdale (RM 44.7)	84% (76)	7% (6)	8% (7)	1% (1)	0% (0)	0% (0)
New Baltimore (RM 21.4)	68% (52)	21% (16)	6% (5)	1% (1)	4% (3)	0% (0)

concentration of oxygen demanding substances. The results observed for the Rockdale (RM 44.7) and New Baltimore (RM 21.4) monitors also indicated the influence of algal activity much the same that was observed at Stewart Street. Although hourly results were not examined, the situation at the Lost Bridge monitor (RM 5.6) appeared to be similar to that observed at Stewart Street, except for a much lower frequency of violation of the 4 mg/l minimum WQS.

The maximum temperature WQS (31.7°C or 89°F for the period June 15-September 16) was exceeded on 4 of 91 days (4%) at the Linden Ave. monitor (RM 67.0) during 1980 (Table 24). No exceedences of the maximum WQS were observed at the four remaining locations. Daily mean, maximum and minimum temperatures at the Stewart Street, Linden Ave., Rockdale, and New Baltimore monitors exhibited comparable patterns through early August (Fig. 9). Episodes of sharp decreases occurred during peak flow periods. Temperatures, as expected, declined sharply during late September. The fluctuation of maximum and minimum values around the mean were generally consistent (on the order of 2-4°C). No violation of the period (June 16-September 15) average temperature WQS of 29.3°C (85°F) was observed, but two daily average values at the Linden Ave. monitor exceeded this value. Grab daytime temperature measurements taken weekly at 14 locations in the study area revealed no violations of the 31.7°C (89°F) maximum (Table 24). The longitudinal temperature trend downstream through the study area reflected a steady increase in the mean temperature downstream from Dayton (23.3-25.1°C) to RM 60.6 in Franklin (Table 24; Fig. 8). A brief increase was noted at RM 60.6 which is 3.7 miles downstream from the DP&L Hutchings EGS (RM 64.3). Both the highest mean (25.1°C) and highest maximum (29.8°C) temperatures during the study were measured at this location. Mean temperature then decreased at RM 52.6 (23.9°C) and remained fairly constant throughout the remainder of the study area (22.9-23.8°C). Maximum values also increased downstream from Dayton (26.9-29.8°C), but remained above 29°C through RM 35.7 and above 28°C in the remainder of the study area. The expected trend in a large river is for a gradual warming downstream. The results of the 1980 sampling revealed a mild thermal enrichment in the Dayton area that persisted at least to Franklin (RM 60.6), and perhaps to Hamilton (RM 35.7). The DP&L Hutchings EGS (RM 64.3) had a detectable, but minor impact on instream temperatures. However, under the combination of extreme meteorological conditions, high plant load (MWe), and low river flow (less than 1000cfs) the impact on instream temperatures could be significant (WAPORA 1977) causing violations of the Ohio water quality standards for temperature for 5-10 miles downstream.

The frequency of daily maximum temperatures in excess of the 31.7°C standard increased during low flow years, especially 1976 and 1977. Major point sources of heat in the study area could be responsible for some of the observed high values. Heat loads from two of these sources, the DP&L-Tait EGS (RM 78.6) and Hutchings EGS (RM 64.3), have shown an overall, but erratic decline during the past 17 years (Table 26). The high frequency oftemperature violations at the Stewart Street monitor (RM 78.6) during 1977 may be an indication that ambient temperatures in the mainstem may exceed the 31.7°C (89°F) WQS; however, physical problems experienced with the pumping

000090

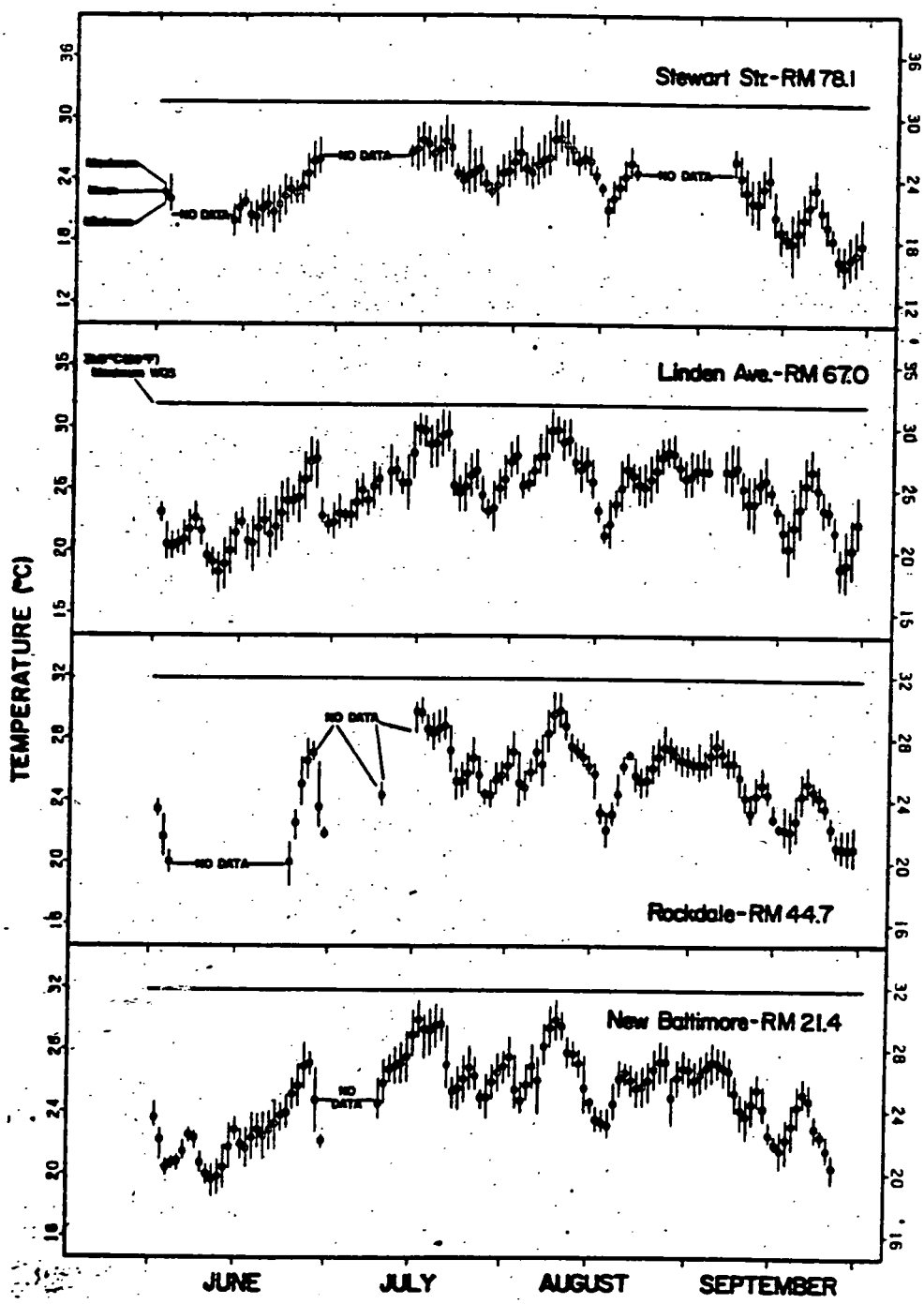

Figure 9. Daily mean, maximum, and minimum temperature (°C) measured continuously at four locations in the lower mainstem Great Miami River, June 1 - September 30, 1980.

apparatus at that monitor may have been responsible for these high readings (Max Katzenbach, USGS, personnel communication). No WQS violations were observed at this location during any other year between 1971 and 1980 (Table 20).

Mean (±SD), maximum, and minimum concentrations of BOD_5, COD, ammonia-nitrogen (NH_3-N), nitrate-nitrogen (NO_3-N), total phosphorus, total iron (Fe-T), and total zinc (Zn-T) measured weekly at 12 mainstem and two tributary sampling locations were plotted by river mile to demonstrate longitudinal trends (Figs. 10 and 11).

Mean BOD_5 concentrations in the study area ranged from 3.0-5.9 mg/l (Table 24; Fig. 10). After increasing slightly between RM 92.6 and RM 83.6, mean BOD_5 decreased sharply at RM 80.6, possibly reflecting dilution from the Stillwater (RM 82.6) and Mad (RM 81.5) Rivers. At the two locations (RM 73.8 and 66.9) downstream from the heaviest concentration of BOD_5 sources values increased to their highest levels in the study area (5.5 and 5.9 mg/l). Mean concentrations then decreased slowly, but steadily through the remainder of the study area but remained higher (4.1-5.2 mg/l) than levels upstream from Dayton (3.1-4.3 mg/l). The highest maximum values (8-14 mg/l) were recorded in September and October during the lowest flows encountered during the study, largely at sampling locations downstream from the Dayton metropolitan area (RM 73.8, 66.9, and 60.6).

Mean COD concentrations ranged from 21-35 mg/l and only roughly paralleled the longitudinal trend in BOD_5 (Table 24; Fig. 10). The overall trend for COD, unlike BOD_5, was a general, although slight, increase downstream. A high COD value of 140 mg/l measured on July 22 at RM 35.7 was nearly twice the next highest recorded maximum.

Mean NH_3-N concentrations ranged from 0.11-0.72 mg/l in the study area (Table 24; Fig. 10). The highest mean concentration of 0.72 mg/l occurred at RM 73.8 downstream from the Dayton WWTP (RM 76.1). The highest single value of 3.05 mg/l occurred at RM 66.9 on October 9; this location together with RM 73.8 had the most single values in excess of 0.8 mg/l. Other single high concentrations were recorded at RM 83.6 (1.63 mg/l), the Mad River (RM 81.5, 0.2; 2.86 mg/l), RM 21.4 (1.43 mg/l), and RM 5.6 (1.43 mg/l). All of these single high values occurred on the same date, August 12. Although NH_3-N concentrations were somewhat lower in 1980 than during past low flow years the general longitudinal trend in the lower mainstem has remained relatively unchanged from previous years (Ohio EPA 1976).

Mean NO_3-N and total phosphorus concentrations showed very little variation from upstream to downstream (Table 24; Fig. 11). Mean NO_3-N concentrations ranged from 2.87-3.68 mg/l and showed no longitudinal trend. Maximum values were consistently much higher than the mean at all sampling locations reaching the 6-8 mg/l range. Most of the highest single NO_3-N values were measuredin early June during the very high flows that occurred during that period. Mean total phosphorus concentrations ranged from 0.38-0.72 mg/l and increased slightly downstream. Except for a single high value of 2.92 mg/l measured at RM 35.7, maximum concentrations were generally in the range of 0.7-1.2 mg/l.

Table 26. Third quarter (July 1-September 30) average gross electric generation (MWe) and heat rejection rates (BTU/hr.) for the Dayton Power & Light - Tait and Hutchings electric generating stations (EGS), 1964-1980 (data supplied by Dayton Power & Light Co., April 3, 1981).

	Tait EGS (RM 77.6)		Hutchings EGS (RM 64.3)	
Year	Gross Generation (MWe)	Heat Rejection Rate (BTU/hr x 10)	Gross Generation (MWe)	Heat Rejection Rate (BTU/hr x 10
1964	266	1.208	205	1.030
1965	295	1.381	247	1.237
1966	274	1.280	248	1.237
1967	250	1.157	210	1.030
1968	307	1.519	309	1.503
1969	265	1.323	240	1.220
1970	299	1.505	278	1.353
1971	232	1.203	222	1.080
1972	137	0.707	187	0.927
1973	204	1.046	207	1.047
1974	90	0.501	194	0.987
1975	122	0.545	118	0.613
1976	118	0.583	114	0.597
1977	102	0.557	168	0.860
1978	153	0.771	113	0.617
1979	80	0.424	135	0.717
1980	139	0.764	172	0.927

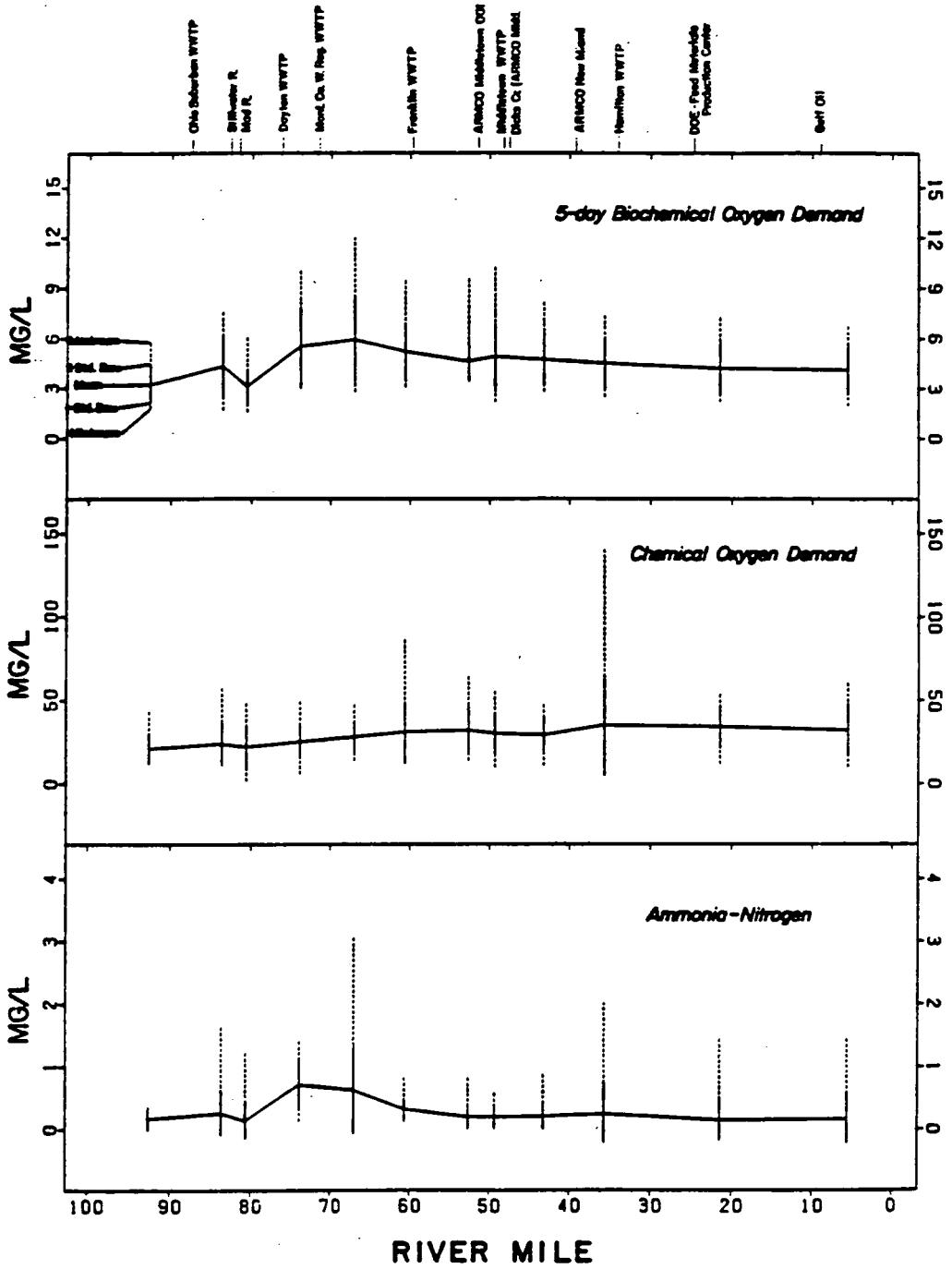

Figure 10. Longitudinal profiles of mean (+SD), maximum, and minimum 5-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and ammonia-nitrogen (NH_3-N) measured at 12 locations in the lower mainstem Great Miami River, June 5 - October 9, 1980.

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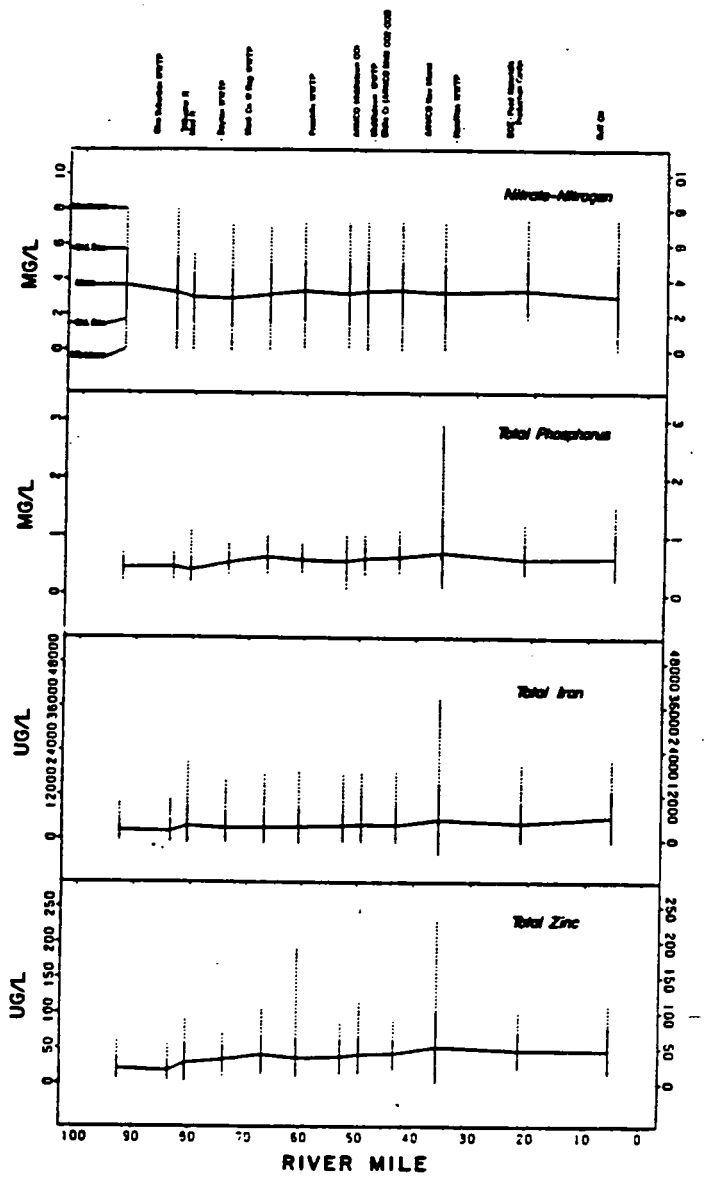

Figure 11. Longitudinal profiles of mean (+SD), maximum, and minimum nitrate-nitrogen (NO_3-N), total phosphorus (T-P), total iron (Fe), and total zinc (Zn) measured at 12 locations in the lower mainstem Great Miami River during June 5 - October 9, 1980.

Total iron (Fe) and zinc (Zn) were the only two metals that were appreciably above detectable limits throughout the study area (Table 24; Fig. 11). Total iron concentrations were consistently greater than 500-1000 ug/l ranging from 8000-20000 ug/l during high flows. During normal flows iron concentrations were usually less than 1000 ug/l. High total iron concentrations have been observed during high flow periods in other Ohio streams (Altfater et al. 1980; Yoder et al. 1981) and are generally associated with high total suspended solids concentrations. Mean total zinc concentrations ranged from 18-52 ug/l and generally increased downstream. Most individual values were above the detection limit of 5 ug/l (97%) (Table 24) ranging from 10-30 ug/l upstream from Dayton (RM 92.6-81.5) and 20-50 ug/l in the remainder of the mainstem (RM 80.6-5.6). Maximum concentratins in the range of 70-100 ug/l were measured at each sampling location. The highest value of 230 ug/l was measured at RM 35.7 on July 22 which corresponded to the very high COD value of 140 mg/l.

The two most frequently violated water quality standards during 1980 were for fecal coliforms (71%) and total iron (64%) (Table 27). Fecal coliform counts were generally less than 2000/100 ml upstream from Dayton, but commonly ranged from 12000-38000/100 ml in and downstream from Dayton with single counts up to 70000/100 ml during normal flows. High flow samples frequently had fecal coliforms too numerous to count (TNTC; greater than 100000/100 ml). WQS violations of six additional parameters occurred at a much lower frequency (Table 27).

Six of the seven heavy metal parameters analyzed for during the survey occurred in detectable concentrations in 8-97% of the samples (Table 28). Total iron was detectable in 100% of the samples, as it is in all Ohio surface waters, and therefore was not included in Table 28.

Exceedences of the detection limit for total cadmium (1 ug/l), chromium (30 ug/l) and nickel (40 ug/l) were slight and scattered throughout the study area. Exceedences of the total lead detection limit (5 ug/l) were more frequent downstream from Dayton (31-76%) than upstream (19-25%), apparently the result of urban nonpoint source runoff. The frequency of total Cu concentrations above the detection limit (5 ug/l) was also greater downstream from Dayton (68-94%) than upstream (47-56%). This trend is apparently due to the influence of urban impacts including municipal WWTP effluents.

Two parameters of interest in the lower study area (primarily because they are common constitutents of steel making process effluents) were cyanide and phenolics. During 1980 cyanide was nearly always at or below the 5-10 ug/l detection limit. Only one violation of the Warmwater Habitat (WWH) WQS of 25 ug/l was observed at RM 66.9 (28 ug/l). Phenolic compound concentrations were consistently less than 10 ug/l in the study area except for a few individual values ranging from 11-36 ug/l. Neither parameter showed any meaningful longitudinal trend in the mainstem. However, WQS violations of these two parameters in the mainstem have been more frequent during low flow years (Ohio EPA 1980a).

Table 27. Water quality standards violations/total samples observed during June 5-October 9, 1980 in the lower mainstem Great Miami River (RM 92.6-5.6)

River Mile - Location	Fecal coliforms (2000/100 ml)[a]	Total Iron - Fe-T (1000 ug/l)	Ammonia-N NH_3-N (0.05 mg/l as NH_3)[b]	Phenolics (10 ug/l)	Total Zinc Zn-T (variable)[c]	Total Lead Pb-T (30 ug/l)	Total Cyanide CN-T (25 ug/l)	Total Chromium Cr-T (100 ug/l)
RM 92.6 - Taylorsville Dam	5/12	9/15	0/15	0/15	0/15	0/15	0/15	0/15
RM 83.6 - Keowee Str. (Dayton)	6/12	6/16	1/16	0/13	0/16	0/16	0/13	0/16
RM 82.6, 0.3 - Stillwater R. (Dayton)	5/11	16/16	0/16	1/13	1/16	0/16	0/13	0/16
RM 81.5, 0.2 - Mad R. (Dayton)	7/10	9/16	1/16	0/13	0/16	2/16	0/13	0/16
RM 80.7 - Monument Ave. (Dayton)	8/13	10/17	0/17	1/14	0/17	1/17	0/14	0/17
RM 73.8 - Sellars Rd. (West Carrollton)	11/13	11/17	0/17	1/14	0/17	0/17	0/14	0/17
RM 66.9 - Linden Ave. (Miamisburg)	13/13	11/18	0/18	0/15	0/18	0/18	1/15	0/18
RM 60.6 - State Route 123 (Franklin)	10/11	12/17	0/16	0/13	1/17	0/17	0/14	0/17
RM 52.6 - State Route 122 (Middletown)	8/9	10/19	0/19	0/13	0/19	0/19	0/13	0/19
RM 49.3 - State Route 73 (Middletown)	9/11	10/16	0/16	0/13	0/16	0/16	0/13	0/16
RM 43.2 - Liberty Fairfield Rd.	10/11	10/16	0/16	1/13	0/16	0/16	0/13	1/16
RM 35.7 - State Route 128 (Hamilton)	7/10	12/17	1/17	1/12	0/17	1/17	0/12	0/17
RM 21.4 - River Road (New Baltimore)	8/12	11/18	1/18	2/14	0/18	0/18	0/15	0/18
RM 5.6 - Lost Bridge (Elizabethtown)	6/12	11/13	0/13	1/13	0/13	0/13	0/13	0/13
Totals (%)	113/160 (71%)	148/231 (64%)	4/230 (2%)	8/188 (4%)	1/215 (1%)	3/231 (1%)	1/190 (1%)	1/231 (1%)

a - based on the primary recreation standard, 2000/100 ml.
b - water quality standard varies according to temperature and pH.
c - water quality standard varies according to water hardness as mg/l $CaCO_3$.

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Table 28. Number of samples above quantifiable detection limits/total samples for six heavy metal parameters at 14 locations in the lower mainstem Great Miami River (RM 92.6-5.6), June 5-October 9, 1980 (lowest detectable concentration in ug/l is given in parentheses for each parameter).

River Mile - Location	Total Cadmium (1)	Total Chromium (40)	Total Copper (5)	Total Lead (5)	Total Nickel (40)	Total Zinc (5)
RM 92.6 - Taylorsville Dam	1/15	7/15	7/15	4/15	4/15	15/15
RM 83.6 - Keowee Str. (Dayton)	2/16	7/16	8/16	3/16	2/16	15/16
RM 82.6, 0.3 - Stillwater R. (Dayton)	1/16	6/16	9/16	4/16	4/16	15/16
RM 81.5, 0.2 - Mad R. (Dayton)	1/16	7/16	8/16	7/16	4/16	14/16
RM 80.7 - Monument Ave. (Dayton)	2/17	4/17	12/17	7/17	4/17	16/17
RM 73.8 - Sellars Road (West Carrollton)	2/17	4/17	16/17	8/17	6/17	17/17
RM 66.9 - Linden Ave. (Miamisburg)	2/18	7/18	15/18	9/18	5/18	18/18
RM 60.6 - State Route 123 (Franklin)	2/17	9/17	16/17	13/17	6/17	17/17
RM 52.6 - State Route 122 (Middletown)	2/19	7/19	13/19	10/19	5/19	18/19
RM 49.3 - State Route 73 (Middletown)	0/16	4/16	15/16	10/16	3/16	16/16
RM 43.2 - Liberty-Fairfield Rd.	1/16	2/16	14/16	5/16	3/16	16/16
RM 35.7 - State Route 128 (Hamilton)	2/17	4/17	13/17	9/17	2/17	17/17
RM 21.5 - River Road (New Baltimore)	1/18	5/18	15/18	8/14	4/18	18/18
RM 5.6 - Lost Bridge (Elizabethtown)	2/13	3/13	9/13	6/13	2/13	13/13
Totals (%)	19/231 (8%)	76/231 (33%)	170/231 (74%)	103/227 (45%)	54/231 (23%)	225/231 (97%)

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The remaining parameters generally followed expected trends (Table 24). Conductivity (25°C) generally remained at 500-700 umhos/cm^2, except during high flows (250-350 umhos/cm^2). Hardness was also affected by high flow dilution influence decreasing to 200-300 mg/l from the normal 300-400 mg/l range. Total suspended solids followed a reverse pattern ranging from 100-500 mg/l during high flows and 20-60 mg/l during normal flow conditions. Nitrite-nitrogen (NO_2-N) generally followed the pattern of slight increases downstream from the major point sources of organic loading (Dayton WWTP) while total Kjeldahl nitrogen showed an overall increase through the study area. During June and July, pH (S.U.) ranged from 7-8 but reflected the influence of algal photosythesis with several readings greater than 8 in August and September.

The results of chemical/physical sampling conducted by the U.S. EPA, Region V-Eastern District Office (U.S. EPA 1982) during September 24-25, 1980 at four locations between Middletown (RM 52.4) and Hamilton (RM 35.7) was also examined (Table 29). Ten of the 28 parameters included in Table 29 were not sampled for during this survey and one of the four sampling locations included Dicks Creek (RM 47.6). The results of the U.S. EPA-EDO survey were consistent with those of this survey for coincidentally monitored parameters. Of those parameters unique to the U.S. EPA-EDO survey only mercury (Hg) violated water quality standards. Concentrations throughout the sampling area were remarkably similar (0.3-0.4 ug/l), however. The presence of detectable concentrations of CN, chromium, copper, arsenic, zinc, pentachlorophenol, and bis (2-ethylhexyl) phthalate were noteworthy. The elevated concentrations of arsenic (2.1 ug/l) and zinc (192 ug/l) were attributed to the ARMCO-Middletown steelmaking operations which discharge ot Dicks Creek (002-005) (U.S. EPA 1982).

Chemical/physical water quality conditions in the lower mainstem Great Miami River during 1980 were typical of those observed during higher than normal flow years. Water quality standards violations of parameters characteristic of nonpoint source runoff (total Fe, fecal coliforms) were much more frequent and widespread than for those parameters more sensitive to point source impacts (e.g., D.O., NH_3-N, temperature, cyanide, phenolics). Dividing the study area into segments of good, fair, and poor chemical/physical water quality was difficult because those parameters sensitive to point source impacts did not show distinct longitudinal differences as they have during years with lower flows. Past data indicated that exceedences of WQS for D.O., temperature, and possibly, ammonia, cyanide, and phenolics have been much more frequent during low flow years (Ohio EPA 1976, 1980a). The most severe water quality problem in the lower mainstem continues to be depressed D.O. levels which is the result of excessive loadings of oxygen demanding wastewater in and downstream from Dayton. Less severe problems exist downstream from Middletown and Hamilton. Unless BOD loadings are reduced in these areas, depressed D.O. levels will be a recurring problem in the lower mainstem, especially during low flow years.

Table 29. Results of chemical/physical sampling conducted by U.S. EPA, Region V. Eastern District Office in the lower mainstem Great Miami River during September 24-25, 1980 (U.S. EPA 1982) (K indicates concentration less than).

Sampling Location	River Mile	Temp. (°C)	pH S.U.	BOD_5 mg/l	COD mg/l	TDS mg/l	TSS mg/l	Chloride mg/l	CN-T ug/l	Phenolics ug/l	Phenol ug/l	Penta-chloro-phenol ug/l	Hg-T ug/l	bis (2-ethylhexyl) phthalate
Gr. Miami R. - St. Rt. 122	52.6	21.0	8.2	7.0	39	492	37	62	8	2K	1.5	N.D.	0.4*	2.8
Dicks Cr. - dst. ARMCO 002-005	47.6, 0.2	20.5	7.9	4.0	28	928	15	260	10	2K	1.6	N.D.	0.4*	3.0
Gr. Miami R. - dst. Dicks Cr.	47.4	22.0	8.2	5.0	34	529	37	74	8	2K	1.3	N.D.	0.3*	2.4
Gr. Miami R. - St. Rt. 128	35.7	22.0	8.5	3.0	32	511	52	67	5	2K	1.3	1.5	0.3*	2.8

Sampling Location	Hardness[a] mg/l	Al-T ug/l	As-T ug/l	Ba-T ug/l	Be-T ug/l	B-T ug/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Mn-T ug/l	Ni-T ug/l	Ag-T ug/l	Zn-T ug/l
Gr. Miami R. - St. Rt. 122	350	813	2K	108	1K	150	2K	34	7	1050*	30K	74	30K	3K	50K
Dicks Cr. - dst. ARMCO 002-005	492	240	2.1	200	1K	326	2K	38	8	847	30K	145	30K	3K	192
Gr. Miami R. - dst. Dicks Cr.	355	794	2K	101	1K	80K	2K	34	7	1060*	30K	84	30K	3K	50K
Gr. Miami R. - St. Rt. 128	362	908	2K	110	1K	80K	2K	30	7	1220*	30K	96	30K	3K	50K

N.D. - not detected in sample.
a - Hardness calculated from Mg and Ca values; Ca x 2.497 + Mg x 4.116.
* - Violates Ohio water quality standard for warmwater habitat.

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Sediment Chemistry

Methods

Sediment samples were collected from 14 locations in the lower mainstem Great Miami River between RM 81.4 and 4.0 during October 7-21, 1980 (Fig. 6). Fourteen (14) parameters were analyzed for (Table 30). Some of the bottom sediment samples were collected from a boat using an Ekman Dredge while others were taken by wading into the river and scooping sediment into a 1 liter glass pesticide jar. One sample was collected from a concrete block that was being used to hold a periphytometer in place (RM 59.7), on which sediment had accumulated over a period of two weeks (October 7-21). All sediment analyses were performed at the Ohio Department of Health Laboratory in Columbus.

Results and Discussion

Bottom sediment deposits in the lower mainstem Great Miami River were difficult to find, even in the dam pools. This was possibly due to the preceding high flows in June and early July or minimal deposition caused by other factors.

Longitudinal trends were erratic, especially for nitrate + nitrite-nitrogen (NO_3+NO_2-N), total phosphorus, and ortho phosphorus. Several extremely high values were observed, especially for NO_3+NO_2-N. Concentrations (ug/g) of heavy metals were quite low overall, but generally increased downstream. The highest overall concentration of metals were from the sample collected from a concrete block at RM 59.7. Total cadmium (Cd), copper (Cu), chromium (Cr), iron (Fe), nickel (Ni) and zinc (Zn) concentrations were high between RM 64.2 and 48.5. Total lead (Pb) values were highest in Dayton and then decreased to near upstream levels by RM 19.6. Total mercury (Hg) levels were highest between RM 80.9 and RM 41.4. Both cyanide and phenolics values were very low throughout the study area.

The occurrence of total iron, lead, NO_3+NO_2-N, TKN, and phosphorus was most likely the result of nonpoint source runoff. Several of the heavy metals occurred in both municipal WWTP and industrial effluents. Dam pools along the

mainstem may act as settling areas for certain of the heavy metals which are commonly bound to settlable solids (Wilber et al. 1980). This phenomenon was illustrated by the sample collected from a concrete block at RM 59.7 on which sediment had been allowed to collect over a two week period Several metal parameters either peaked or began to peak at the DP&L - Hutchings EGS sampling location (RM 64.2) which is the first dam pool downstream from the major point sources in the Dayton metropolitan area. Other high values were observed for the sample collected at RM 59.7. Conversely, concentrations generally showed a decline downstream from the Hamilton sampling location (RM 36.6), which was the most downstream dam pool in the study area. Additional sediment samples were collected at three locations between Middletown and Hamilton by U.S. EPA-EDO (U.S. EPA 1982). Analytical results for 38 parameters are presented in Table 31. Of the eight heavy metals parameters common to both the U.S. EPA-EDO study (Table 31) and this study, somewhat higher concentrations were found by this study (Table 30). In the U.S. EPA-EDO study 23 parameters showed distinct increases from the most upstream location (RM 52.6) through the most downstream location (RM 35.7), while seven showed distinct decreases. The remaining 8 parameters were variable. Several of the parameters that exhibited increases from upstream to downstream are generally associated with industrial processes (heavy metals) and steel making operations (chrysene, benzo(a)pyrene, and trichloromethane) (U.S. EPA 1982).

Even though sediment deposits were not extensive the data derived from sediment samples can be a valuable indication of past discharges and chemical/physical water quality. Many substances not detected by water column monitoring show up in the sediments indicating an association with suspended solids. Harmful contaminants present in the sediments can exert negative influences via direct and indirect interaction with the aquatic biota (direct uptake, food chain, etc.) or through resuspension during higher flow. Dam pools can act as sinks for contaminants attached to sediments during low river flows as demonstrated by Muller et al. (1977). The data in Tables 30 and 31 indicate the presence of several contaminants that were either not monitored for or detected in the chemical/physical water quality sampling data.

Fish Tissue

Methods

Fish for tissue analysis were collected by both the Ohio EPA and U.S. EPA-EDO. Samples were collected during 1977, 1978, 1979, and 1980 by the Ohio EPA using the boat electrofishing method. Samples were collected in 1980 by U.S. EPA-EDO with baited trotlines. Carp (*Cyprinus carpio*) and channel catfish (*Ictalurus punctatus*) were used most frequently, however other species were included at certain locations (Table 32). Fish were prepared in the field according to procedures outlined in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 1980). All of the results are for multiple species, whole body composites, except for the 1977 samples which were fillet composites. Samples collected in 1977 were analyzed for chlorinated hydrocarbons (pesticides and PCBs) by gas chromatography at the Ohio Department of Agriculture laboratory in Reynoldsburg, Ohio (Ohio EPA 1977, unpublished). The remaining samples were analyzed by gas chromatography/mass spectroscopy at the U.S. EPA-Environmental Research Laboratory at Duluth, Minnesota using procedures described in Veith et al. (1981). The types and number of parameters analyzed varied from year to year; polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) were analyzed for in nearly every sample.

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Table 30. Results of bottom sediment sampling conducted at 14 locations in the lower mainstem Great Miami River (RM 81.4-4.0), October 7-21, 1980 (all numbers expressed as ug/g dry weight).

River Mile - Location	Date	Total Kjeldahl Nitrogen	Nitrate + Nitrite - Nitrogen	Total Phosphorus	Ortho Phosphorus	Total Cyanide	Phenolics	Cadmium	Copper	Chromium	Iron	Lead	Mercury	Nickel	Zinc
RM 82.4 - Ust. Steele Dam (Dayton)	10/07/80	296	6	135	14	-	-	3.10	6.5	6.5	4030	21.7	0.045	12.4	26.4
RM 81.9 - Ust. Monument Ave. Dam (Dayton)	10/21/80	1510	27000	599	30	10	3	1.42	52.8	19.0	10600	135.0	0.282	17.8	200.0
RM 77.8 - Ust. DP&L-Tait EGS Dam (Dayton)	10/08/80	1080	6	233	16	-	2	1.07	43.1	26.5	10500	1460.0	0.177	21.3	108.0
RM 73.8 - Sellers Road (West Carrollton)	10/07/80	750	5	347	46	-	10	0.37	21.8	33.6	10400	34.9	0.200	24.9	85.6
RM 65.2 - Ust DP&L-Hutchings Dam (Miamisburg)	10/08/80	1900	5	1680	76	-	4	4.67	97.0	104.0	14300	210.0	0.340	72.6	324.0
RM 62.8 - Ust. Miami-Erie Canal Dam (Chataqua)	10/08/80	1830	11	981	38	-	6	6.14	63.2	66.0	13100	77.9	0.180	39.4	201.0
RM 60.6 - Dst. St. Rt. 123 (Franklin)	10/21/80	3090	345000	1970	208	-	-	4.43	168.0	139.0	18200	113.0	0.345	56.4	385.0
RM 57.8 - Ust. Middletown Hydraulic Canal Dam	10/08/80	1240	5	945	59	-	3	5.45	55.4	57.6	12300	69.8	0.165	34.9	177.0
RM 49.5 - Ust. St. Rt. 73 (Middletown)	10/16/80	3440	388000	1420	128	10	3	3.29	109.0	81.4	22200	78.2	0.299	65.8	350.0
RM 42.4 - Ust. Hamilton Hydraulic Canal Dam	10/08/80	1810	5	1060	46	10	4	1.63	36.9	41.1	16800	47.6	0.154	32.7	189.0
RM 37.6 - Ust. Hamilton Dam (Hamilton)	10/16/80	1510	76900	908	54	10	3	3.99	18.4	21.6	13000	25.5	0.075	20.0	83.4
RM 30.4 - American Materials R.R. Bridge	10/16/80	2400	41900	1070	124	10	4	3.25	33.6	29.8	12500	54.2	0.114	37.9	148.0
RM 20.6 - Welch Sand & Gravel R.R Bridge	10/16/80	1350	5	805	49	10	3	1.22	23.9	20.4	9930	24.3	0.062	29.2	104.0
RM 4.0 - Dst. Lost Bridge (Elizabethtown)	10/16/80	1760	55100	859	55	10	2	1.16	20.5	22.8	13500	25.1	0.070	23.3	87.9

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Table 31. Results of sediment sampling conducted in the lower mainstem Great Miami River study area by U.S. EPA, Region V-Eastern District Office during September 24-25, 1980 (U.S. EPA 1982) (K indicates concentration less than).

Parameter (units)	Great Miami River - Location RM 52.6	RM 47.4	RM 35.7
Aluminum (mg/kg)	2200	8800	6700
Arsenic (mg/kg)	2K	3.4	7.7
Barium (mg/kg)	23	97	100
Beryllium (mg/kg)	0.2	0.6	0.5
Boron (mg/kg)	8K	8K	8K
Cadmium (mg/kg)[a]	0.2K	1	2
Chromium (mg/kg)[a]	24	27	37
Copper (mg/kg)[a]	10	23	29
Iron (mg/kg)[a]	4900	16000	16000
Lead (mg/kg)[a]	19	44	72
Manganese (mg/kg)	160	280	300
Nickel (mg/kg)[a]	6	15	17
Silver (mg/kg)	0.3K	0.7	0.8
Zinc (mg/kg)[a]	32	73	220
Mercury (mg/kg)[a]	0.3	0.1	0.5
Phenol (ug/kg)	20	21	N.D.
fluoroanthene (ug/kg)	220	180	320
bis(2-ethylhexyl)phthalate (ug/kg)	240	110	180
di-n-butylphthalate (ug/kg)	56	40	41
di-n-octyl phthalate (ug/kg)	16	N.D.	N.D.
diethyl phthalate (ug/kg)	56	33	29
benzo(a)anthracene/chrysene (ug/kg)	230	300	350
benzo(a)pyrene (ug/kg)	250	340	380
3,4-benzofluoranthene benzo(k)fluoranthene (ug/kg)	260	250	380
acenapthylene (ug/kg)	N.D.	12	N.D.
anthracene/phenanthrene (ug/kg)	180	130	220
benzo(ghi)perylene (ug/kg)	88	97	130
fluorene (ug/kg)	16	N.D.	N.D.
dibenzo (a,h) anthracene (ug/kg)	N.D.	N.D.	31
indeno (1,2,3-d) pyrene (ug/kg)	63	67	120
pyrene (ug/kg)	200	290	320
PCB-1254 (ug/kg)	170	88	N.D.
trichloromethane (ug/kg)	500	1700	1600
1,2-dichloroethane (ug/kg)	4.2	4.1	8.5
bromodichloromethane (ug/kg)	5.0	5.3	8.8
trichloroethene (ug/kg)	2.6	2.8	3.8
tetrachloroethene (ug/kg)	2.7	1.1	0.64
1,2-dibromoethene (ug/kg)	0.25	0.36	0.41

N.D. - not detected.
a - parameter overlaps with Ohio EPA sediment sampling (Table 30).

Table 32. Summary of fish tissue contamination data for fish collected in the lower mainstem Great Miami River study area during 1977-1980. All collections were made by Ohio EPA unless noted otherwise; all values are reported as ug/kg.

Location (Year)	River Mile	Species (Number)	Lipid	PCB's 1242	PCB's 1248	PCB's 1254	PCB's 1264	Total PCB	DDT	DDE	Aldrin	Dieldrin	TDE	Endrin	Methoxy-chlor	Lindane	Toxa-phene
GMR-Ust. Dayton (1980)[a]	89.2	Carp, bullhead,Cent.(?)	6.5	N.D	N.D	640	430	1070	-	-	-	-	-	-	-	-	-
GMR-Miamisburg (1978)[a]	67.9	Carp, goldfish (5)	-	2000	-	5180	-	7180	450	240	-	-	-	-	-	-	-
GMR-Miamisburg (1980)[a]	67.9	Carp, Green sunfish (?)	8.0	N.D	N.D.	1600	580	2180	-	-	-	-	-	-	-	-	-
GMR-Middletown (1980)[b,c]	52.6	Carp (2)	-	-	-	-	1400	-	-	-	-	-	-	-	-	-	-
GMR-Trenton (1980)[a]	48.4	Carp, Bass (?)	4.5	N.D.	1600	1400	550	3550	-	-	-	-	-	-	-	-	-
GMR-Trenton (1980)[a]	45.9	Carp, ChanCat, Gr Sun(?)	4.0	750	1400	4800	1600	8550	-	-	-	-	-	-	-	-	-
GMR-Hamilton (1980)[a]	36.9	Carp (?)	6.5	N.D.	1700	3600	700	6000	-	-	-	-	-	-	-	-	-
GMR-Hamilton (1980)[b,c]	35.7	Carp (1)	-	-	-	-	1500	-	-	-	-	-	-	-	-	-	-
GMR-Dst. Hamilton (1979)[a]	32.9	Carp (2)	-	3340	10	3320	-	6670	-	130	-	-	-	-	-	-	-
GMR-Dst. Hamilton (1980)[a]	32.9	Carp (?)	5.0	N.D.	N.D	1400	720	2120	-	-	-	-	-	-	-	-	-
GMR-New Baltimore (1980)[b,c]	21.5	Channel catfish (1)	-	-	-	-	700	-	-	-	-	-	-	-	-	-	-
GMR-Hooven (1980)[a]	7.4	Carp, Channel catfish	14.0	N.D.	1300	3100	1700	6100	-	-	-	-	-	-	-	-	-
GMR-Elizabethtown (1977)[d]	4.0	Chan catfish-fillets (5)	-	-	-	-	-	5740	N.D.	35	N.D.	N.D.	N.D.	N.D.	N.D	N.D	-
GMR-Elizabethtown (1978)[a]	4.0	Carp, Chan. catfish (4)	-	780	8590	-	-	9370	660	-	-	-	-	-	-	-	-

Location (Year)	River Mile	Species (Number)	% Lipid	Mirex	Chlor-dane	Mona-chlor	Oxych-lordane	Hepta-chlor	Hept. Epoxide	HCB	PCDD	PCDF	Phenol	bis(2ethyl hexyl phthalate	di-n-butyl phthalate
GMR-Ust. Dayton (1980)[a]	89.2	Carp, bullhead,Cent.(?)	-	-	-	-	-	-		7.1	-	-	-	-	-
GMR-Miamisburg (1978)[a]	67.9	Carp, goldfish (5)	-	-	40	-	0.5	11	0.5	13	-	-	-	-	-
GMR-Miamisburg (1980)[a]	67.9	Carp, Green sunfish (?)	8.0	-	--	-	-	-	-	N.D.	N.D.	N.D.	-	-	-
GMR-Middletown (1980)[b,c]	52.6	Carp (2)	-	-	-	-	-	-	-	-	-	-	87	170	N.D.
GMR-Trenton (1980)[a]	48.4	Carp, Bass (?)	-	-	-	-	-	-	-	3.2	N.D.	N.D.	-	-	-
GMR-Trenton (1980)[a]	45.9	Carp, ChanCat, Gr Sun(?)	4.0	-	-	-	-	-	-	5.3	N.D.	N.D.	-	-	-
GMR-Hamilton (1980)[a]	36.9	Carp (?)	6.5	-	-	4	-	-	-	3.2	N.D.	N.D.	-	-	-
GMR-Hamilton (1980)[b,c]	35.7	Carp (1)	-	-	-	-	-	-	-	-	-	-	66	N.D.	58
GMR-Dst. Hamilton (1979)[a]	32.9	Carp (2)	-	-	195	143	-	-	-	5.0	-	--	-	--	-
GMR-Dst. Hamilton (1980)[a]	32.9	Carp (?)	5.0	-	-	-	-	-	-	N.D.	18	XX	-	-	-
GMR-New Baltimore (1980)[b,c]	21.5	Channel catfish (1)	-	-	-	-	-	-	-	-	-	-	64	190	-
GMR-Hooven (1980)[a]	7.4	Carp, Channel catfish	14.0	-	-	-	-	-	-	22	17	2	-	-	-
GMR-Elizabethtown (1977)[d]	4.0	Chan catfish-fillets (5)	-	N.D.	-	-	-	N.D.	N.D.	17	-	-	-	-	-
GMR-Elizabethtown (1978)[a]	4.0	Carp, Chan. catfish (4)	-	-	68	-	0.5	0.5	0.5	13	-	-	-	-	-

a - sample analysis by U.S. EPA-ERL, Duluth (GC/MS).
b - sample analysis by U.S. EPA-EDO contractor (GC/MS).
c - sample collected by U.S. EPA-EDO.
d - sample analysis by Ohio Dept. of Agriculture (GC).
XX - detected, not quantified.

000105

6399

Results and Discussion

The results of the fish tissue analyses are being used here to demonstrate the relative presence or absence of certain organic compounds that were not analyzed for in the chemical/physical water quality sampling. The results should not be used to determine the suitability of a particular species for human consumption. Fish, however, are quite suitable for determining the presence and relative quantity of most organic compounds in aquatic environments.

Of the two compounds that were most consistently analyzed for both PCB and HCB generally increased at the locations downstream from Dayton. Total PCB levels measured at RM 89.2 upstream from Dayton were just over 1000 ug/kg, but values throughout the remainder of the study area were well above this value. The highest levels measured were 8550 ug/kg at RM 45.9, downstream from Middletown, and 9370 ug/kg at RM 4.0 near the month. Values in the 3000-6000 ug/kg range were measured between these locations. HCB levels were highest in the lower section of the study area reaching 22 ug/kg at RM 7.4 and slightly less (13 and 17 ug/kg) at RM 4.0. Except for a value of 13 ug/kg at RM 67.9 downstream from Dayton the remaining samples were less than 10 ug/kg. The potential sources of these compounds were not determined.

Polychlorinated dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF) were detected in fish at RM 32.9 and RM 7.4, but were below detectable limits at four upstream locations between RM 67.9 and RM 36.9. The potential sources of these compounds was not determined.

The remaining compounds were either not detected or were not analyzed for at enough locations to discern any possible patterns of accumulation.

000106

DISTRIBUTION AND ABUNDANCE OF FISHES

Marc A. Smith

This section is concerned with one of the major components of the aquatic community, the fish. Fish are a conspicuous part of the aquatic biota and can be one of the most sensistive indicators of environmental quality (Smith 1971). They complete their entire life cycle in the water, they are the end product of most aquatic food webs and since their biomass is dependent on the primary and secondary productivity of the aquatic community they integrate community response. However, fish have received considerably less attention than other groups of aquatic organisms in stream and river surveys despite the fact that the literature contains much information about their life history and environmental requirements (Doudoroff and Warren 1957; Gammon 1976). Many investigators feel that fish are too mobile and difficult to capture to be of any practical use in water monitoring. However, most stream and many large river species are actually sedentary, especially during the summer months (Gerking 1953, 1959; Funk 1954, 1970). Recent advances in sampling techniques have made their capture and study a relatively easy task.

The objective of this part of the study was to evaluate the condition of the fish community in a 91 mile (146.4 km) segment of the Great Miami River, as reflected by distribution and relative abundance patterns, and to establish a baseline against which future trends can be compared.

Methods

The distribution and relative abundance of fishes in a 91 mile (146.4 km) study area of the Great Miami River (RM 91.0 to RM 0.0) and five (5) major tributaries was determined through the use of a boat mounted electrofishing device. Alternating current (240 VAC) produced by a 4500 watt gasoline powered alternator was rectified to direct current (336 to 672 VDC) by a Smith-Root type VI-A electrofishing unit set at 8 amperes and 60 pulses/second. The current was then passed through an electrode array mounted on a 16 foot john boat similar to that described by Frankenberger (1960). Pulsed direct current has been shown to be the most effective, single method for sampling fish populations over extended distances in rivers (Vincent 1971; Gammon 1976). Sampling zones were approximately 0.5 km (0.31 miles) in length and were located along the shoreline on the outside of gradual bends in the river, as recommended by Gammon (1973, 1976). Forty-two (42) of the 49 sampling zones were located in the lower mainstem of the Great Miami River; the remaining zones were located in five (5) major tributaries (Figure 12). Sampling zones used to assess changes in the composition, diversity and abundance of the fish community were chosen based upon the locations of major pollutional influences, dams, impoundments and tributary confluences. Sampling zone lengths were measured with a Ranging 620 optical range finder and confirmed on U.S. Geological Survey (USGS) 7-1/2 minute topographic maps.

0001077

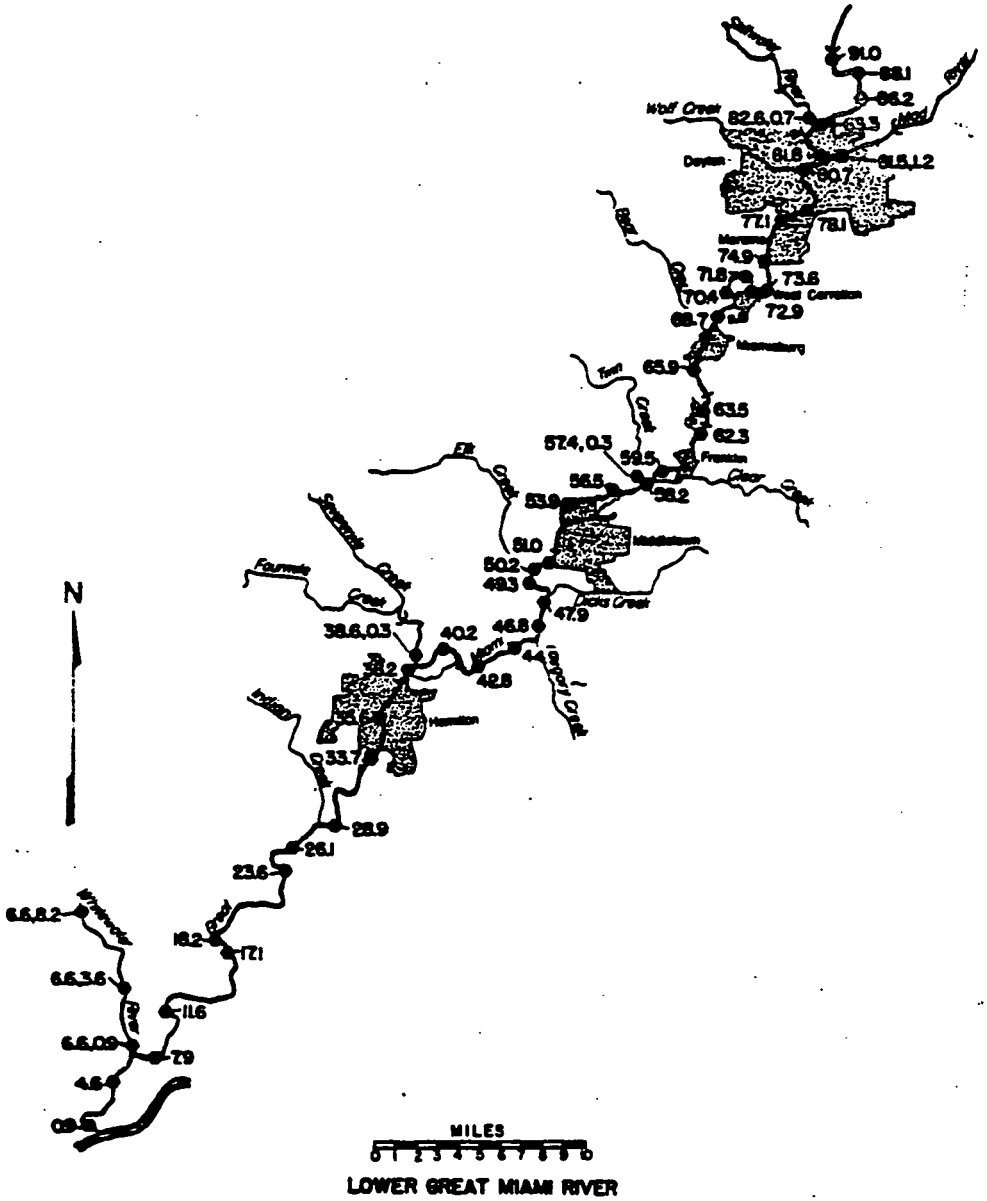

Figure 12. Locations of fish sampling zones in the lower mainstem Great Miami River study area, July 9 - October 7, 1980.

Three sequential downstream sampling passes were made through each sampling zone from July 9 through October 7, 1980. This sampling time was chosen because river discharge is generally low, pollutional stresses are potentially high and fish communities are seasonally stable and sedentary. Each zone was electrofished from upstream to downstream following the shoreline and submerged cover as closely as possible. Water depth was measured at approximately 10 locations in each zone and a mean depth (cm) recorded. Captured fish were placed in an onboard holding tank. The catch was identified to species, weighed to the nearest gram, measured (total length) to the nearest millimeter, examined for external lesions, tumors, parasites, or eroded fins, and then released. Individual fish requiring laboratory identification were preserved in a 10 percent solution of borax buffered formalin. All identifications were made with the aid of keys available in Trautman (1957). Scientific nomenclature used is consistent with that recommended by the American Fisheries Society (Robins et al. 1980).

Electrofishing catches are often reported as catch per unit time. However, catch rates reported as numbers and weights per unit distance in rivers where current is spatially and temporally variable are more desirable (Gammon 1976). Therefore, relative abundance in this study was reported as numbers and weight (kg) of fish per kilometer. A detailed assessment of these methods and the rationale for their application to rivers and streams is available in Gammon (1976) and Ohio EPA (1980b).

Raw catch data from each sampling zone were compiled in sequence and entered into the Fish Information System (FINS), which was developed by the Ohio EPA to store and analyze fish relative abundance data. Analytical programs were used to compute the following statistics: numbers/km, kg/km, number of species/zone, cumulative number of species/zone, Shannon diversity (H) based on numbers and weights (Shannon 1948), a composite index (Gammon 1976), percent similarity (Whittaker 1975), a square root transformation of the percent similarity formula (F), and percent species composition by numbers and weights. The percentage of external anomalies (lesions, tumors, parasites, and eroded fins) was also calculated. The computational formulae for the Shannon index, composite index, and square root transformation of percent similarity are given in Table 33.

Dissolved oxygen (mg/l) and temperature (^{o}C) were measured at each sampling location with a YSI Model 54 oxygen meter following the procedures outlined in Ohio EPA (1980b).

Table 33. Computational formulae for the Shannon diversity index (H), the composite index, and percent similarity.

Shannon Diversity Index

$$\bar{H} = -\sum \frac{(n_i)}{N} \log_e \frac{(n_i)}{N}$$

where;
n_i = relative numbers or weight of the ith species
N = total number or weight of the sample

Composite Index

$$I_{WB} = 0.5 \log_e N + 0.5 \log_e B + \bar{H}\,(\text{no.}) + \bar{H}\,(\text{wt.})$$

where;
N = relative numbers of all species
B = relative weight of all species
$\bar{H}$ (no.) = Shannon index based on relative numbers
$\bar{H}$ (wt.) = Shannon index based on relative weight

Modified Percent Similarity (F)

$$PS = \sum \min\left(\frac{\sqrt{n_a}}{\sum\sqrt{n_a}} \text{ or } \frac{\sqrt{n_b}}{\sum\sqrt{n_b}}\right)$$

where;
n_a = number or weight of fish per km of a given species in sample a;
n_b = number or weight per km of the same species in sample b;
and all summations are over all species.

000110

Results

Species Inventory

A total of 16,215 individual fish representing 64 species and 6 hybrids were collected in 49 sampling zones (Table 27); 42 were located in the lower mainstem Great Miami River and seven (7) were located in the lower reaches of five (5) tributaries. The five most abundant species comprised more than 64% of the total numbers. Carp (*Cyprinus carpio*) and gizzard shad (*Dorosoma cepedianum*), the two most abundant species, accounted for over 34% of the catch by number; carp dominated biomass and accounted for more than 67% of the total weight (Table 34).

A total of 106 species and 6 hybrids have been recorded at one or more locations in the 91 mile (146.4 km) study area during 1900-1978 (Trautman 1957, 1981). Distributional records from two periods, 1900 to 1955 and 1955 to 1978, were compared to the results of this study (Table 35). The criterion used to assess possible changes in distribution and abundance was the number of locations at which a species was collected. Such a comparison has value, but it also has some significant limitations. Therefore, these comparisons must be used with caution. The three most important limitations in assessing trends with these data are; 1) the difference in the length of time over which the records were compiled (i.e., 55, 23 and 1 year(s), respectively), 2) the number of collections made during each period (27, 7, and 49 locations, respectively), and 3) the variations in sampling equipment used in generating these data. Many of the trends observed when comparing the periods of record are attributable to one or more of the following factors; sampling gear selectivity, habitats sampled, sampling effort, and/or chance.

Forty-four (44) of the 106 species found during 1900-1978 were not encountered in 1980. Thirty-three (33) of these 44 species were rare even during the 1900-1955 and 1955-1978 periods and the probability of missing them due to chance alone was high (Table 36). Twenty-seven (27) of the 44 species were missed most likely due to sampling gear selectivity and/or habitats not sampled (i.e., riffle, mid-channel areas). Eight (8) species that were collected in 1980 occurred in low numbers for this same reason. Twenty-eight (28) of the 108 recorded species were observed only during the 1900-1955 period, six (6) were unique to the 1955-1978 period, and two (2) were observed only during 1980. These results compare well with those obtained in a similar analysis of the mainstem Scioto River fish community (Yoder *et al*. 1981).

The disparity in the number of locations between the 1900-1955 period (27), 1955-1978 period (7), and the 1980 survey (49) makes trend assessments of species decline/increase difficult at best. Several species appeared to exhibit genuine declines in distribution and abundance, but sampling gear selectivity and habitats not sampled could not be ruled out as additional contibuting factors. Other species were rare even during the 1900-1955 and 1955-1978 periods and there is reason to believe that several have been extirpated from the study area (Trautman 1981). The trend for several species indicated substantial increases in both distribution and abundance,

Table 34. Overall composition of the fish community as determined by electrofishing in a 91 mile (146.5 km) segment of the lower mainstem of the Great Miami River and the lower portions of five tributaries[a]

Common Name	Scientific Name	Mean No/Km	% by Numbers	Mean Kg/Km	% By Weight
Common Carp	Cyprinus carpio	50.65	21.84	42.066	69.43
Gizzard shad	Dorosoma cepedianum	32.78	14.13	3.001	4.95
Green sunfish	Lepomis cyanellus	25.23	10.88	0.977	1.61
Spotfin shiner	Notropis spilopterus	23.79	10.26	0.080	0.13
Longear sunfish	Lepomis megalotis	18.29	7.89	0.531	0.88
Golden redhorse	Moxostoma erythrurum	12.30	5.30	3.409	5.63
Bluegill	Lepomis macrochirus	7.26	3.13	0.183	0.30
Goldfish	Carassius auratus	6.07	2.62	1.088	1.80
Golden shiner	Notemigonus crysoleucas	5.18	2.23	0.164	0.27
White sucker	Castostomus commersoni	4.90	2.11	0.774	1.28
Northern hog sucker	Hypentelium nigricans	4.04	1.74	0.603	0.99
Smallmouth bass	Micropterus dolomieui	3.55	1.53	0.680	1.12
Black redhorse	Moxostoma duquesnei	3.40	1.47	0.906	1.49
Emerald shiner	Notropis atherinoides	3.20	1.38	0.008	0.01
White crappie	Pomoxis annularis	3.16	1.36	0.199	0.33
Rock bass	Ambloplites rupestris	3.11	1.34	0.250	0.41
Striped shiner	Notropis chrysocephalus	2.83	1.22	0.053	0.09
Channel catfish	Ictalurus punctatus	2.31	1.00	1.124	1.86
River carpsucker	Carpiodes carpio	2.21	0.96	1.238	2.04
Spotted sucker	Minytrema melanops	1.87	0.80	0.418	0.69
Largemouth bass	Micropterus salmoides	1.60	0.69	0.308	0.51
Freshwater drum	Aplodinotus grunniens	1.45	0.62	0.397	0.66
Common carp x goldfish		1.38	0.59	0.492	0.81
Bluntnose minnow	Pimephales notatus	1.27	0.55	0.004	0.01
Silver shiner	Notropis photogenis	1.25	0.54	0.007	0.01
Black crappie	Pomoxis nigromaculatus	1.09	0.47	0.075	0.12
Quillback carpsucker	Carpiodes cyprinus	1.07	0.46	0.383	0.63
Highfin carpsucker	Carpiodes velifer	0.77	0.33	0.254	0.42
Orangespotted sunfish	Lepomis humilis	0.77	0.33	0.007	0.01
Central stomeroller minnow	Campostoma anomalum	0.68	0.29	0.006	0.01
White bass	Morone chrysops	0.67	0.29	0.120	0.20
Skipjack herring	Alosa chrysochloris	0.45	0.19	0.002	0.00
Green x Bluegill sunfish		0.35	0.15	0.018	0.03
Smallmouth buffalo	Ictiobus bubalus	0.31	0.13	0.211	0.35

[a] Species are ranked by numerical abundance

000112

Table 34. (Continued).

Common Name	Scientific Name	Mean No/Km	% by Numbers	Mean Kg/Km	% By Weight
Silver redhorse	Moxostoma anisurum	0.29	0.13	0.120	0.20
Sauger	Stizostedion canadense	0.26	0.11	0.073	0.12
Shorthead redhorse	Moxostoma macrolepidotum	0.24	0.10	0.074	0.12
Pumpkinseed sunfish	Lepomis gibbosus	0.17	0.07	0.004	0.01
Longnose gar	Lepisosteus osseus	0.15	0.07	0.035	0.06
Creek chub	Semotilus atromaculatus	0.15	0.07	0.004	0.01
Suckermouth minnow	Phenacobius mirabilis	0.15	0.07	0.001	0.00
Green x Orangespot sunfish		0.15	0.07	0.004	0.01
Yellow bullhead	Ictalurus natalis	0.13	0.05	0.078	0.05
Sand shiner	Notropis stramineus	0.11	0.05	0.000	0.00
Spotted bass	Micropterus salmoides	0.10	0.04	0.008	0.01
Green x Longear sunfish		0.08	0.04	0.004	0.01
Yellow perch	Perca flavescens	0.08	0.04	0.001	0.00
Northern pike	Esox lucius	0.07	0.03	0.034	0.06
Grass pickerel	Esox americanus	0.06	0.02	0.004	0.01
Flathead catfish	Pylodictus olivaris	0.06	0.02	0.068	0.11
Black buffalo	Ictiobus niger	0.04	0.02	0.028	0.05
Brown bullhead	Ictalurus nebulosus	0.04	0.02	0.006	0.01
Black bullhead	Ictalurus melas	0.04	0.02	0.008	0.01
River redhorse	Moxostoma carinatum	0.03	0.01	0.033	0.06
Silver chub	Hybopsis storeriana	0.03	0.01	0.000	0.00
Stonecat madtom	Noturus flavus	0.03	0.01	0.001	0.00
Green sunfish x Pumpkinseed		0.03	0.01	0.001	0.00
Bowfin	Amia calva	0.01	0.01	0.006	0.01
Mooneye	Hiodon tergisus	0.01	0.01	0.003	0.00
Riverchub	Nocomis micropogon	0.01	0.01	0.000	0.00
Rosyface shiner	Notropis rubellus	0.01	0.01	0.000	0.00
Rosyfin shiner	Notropis ardens	0.01	0.01	0.000	0.00
Mimic shiner	Notropis volucellus	0.01	0.01	0.000	0.00
Fathead minnow	Pimephales promelas	0.01	0.01	0.000	0.00
Tadpole madtom	Noturus gyrinus	0.01	0.01	0.000	0.00
Warmouth	Lepomis gulosus	0.01	0.01	0.001	0.00
Walleye	Stizostedion vitreum	0.01	0.01	0.003	0.00
Logperch	Percina caprodes	0.01	0.01	0.000	0.00
Greenside darter	Etheostoma blennioides	0.01	0.01	0.000	0.00

Total Distance Fished - 72.75 Km
Total Number of Species - 58 (plus 6 hybrids)

[a] Species are ranked by numerical abundance

Table 35. Checklist of fishes occurring in the lower mainstem Great Miami River and the lower sections of major tributaries during the periods 1900-1955, 1955-1978, and July-October, 1980, from river mile 91 - 0. The number of locations and general distribution of each species within the study area is given.

Species	Trautman (1957) 1900-1955 (27)[a]	Trautman (1979 ms.) 1955-1978(7)[a]	Ohio EPA July-October 1980(49)[a]
Ohio lamprey (*Ichthyomyzon bdellium*)	2 (RM 10-0)	-	-
Lake sturgeon (*Acipenser fulvescens*)	2 (mouth, Whitewater R.)	-	-
Shovelnose sturgeon (*Scaphirhynchus platorynchus*)	1 (mouth)	-	-
Paddlefish (*Polyodon spathula*)	2 (RM 15, mouth)	1 (mouth)	-
Longnose gar (*Lepisosteus osseus*)	3 (RM 15, mouth, Whitewater R.)	1 (mouth)	6 (RM 37-0, Whitewater R.)
Bowfin (*Amia calva*)	-	1 (RM 82)	1 (RM 80.7)
American eel (*Anguilla rostrata*)	1 (mouth)	1 (RM 82)	-
Skipjack herring (*Alosa chrysochloris*)	3 (mouth, Whitewater R., RM 40)	-	4 (RM 9-0)
Alewife (*Alosa pseudoharengus*)		1 (mouth or Ohio R.?)	-
Gizzard shad (*Dorosoma cepedianum*)	7 (Warren[b], Butler, Hamilton Counties, WMR[c])	2 (RM 90-82	49 (ubiquitous)
Goldeye (*Hiodon alosoides*)	-	1 (mouth)	-
Mooneye (*Hiodon tergisus*)	-	-	1 (RM 35.6)
Grass pickerel (*Esox americanus*)	-	1 (RM 90)	2 (RM 87-76)
Northern pike (*Esox lucius*)	1 (RM 55)	-	2 (RM 90, Mad R.)
Muskellunge (*Esox masquinongy*)	1 (mouth)	1 (mouth)	-
Common carp (*Cyprinus carpio*)	13 (ubiquitous)	3 (RM 90, Mad R., WMR)	49 (ubiquitous)
Goldfish (*Carassius auratus*)	-	3 (RM 90, SMR, Mad R.)	31 (RM 82-0
Golden shiner (*Notemigonus crysoleucas*)	8 (Montgomery, Warren, Butler Co.)	3 (mouth, SMR, Mad R.)	20 (RM 91-37)
River chub (*Nocomis micropogon*)	3 (WMR, Mad R., RM 90)	-	1 (Fourmile Creek)
Silver chub (*Hybopsis storeriana*)	7 (Butler Co., Whitewater R.)	1 (mouth)	1 (RM 0.9)
Bigeye chub (*Hybopsis amblops*)	17 (ubiquitous, prior 1938)	-	-
Streamlined chub (*Hybopsis dissimilis*)	1 (Stillwater R., prior 1900)	-	-
Gravel chub (*Hybopsis x-punctata*)	4 (Whitewater R., RM 26, SMR)	-	-
Speckled chub (*Hybopsis aestivalis*)	-	1 (mouth)	-
Blacknose dace (*Rhinichthys atratulus*)	4 (WMR, Indian Cr., Mad R., RM 90)	-	-
Creek chub (*Semotilus atromaculatus*)	15 (ubiquitous)	4 (mouth, SMR, RM 90)	5 (RM 76-52)
Tonguetied minnow (*Exoglossum laurae*)	2 (Stillwater R., Mad R.)	-	-
Suckermouth minnow (*Phenacobius mirabilis*)	6 (RM 40-0, Whitewater R.)	-	-
So. redbelly dace (*Phoxinus erythrogaster*)	2 (RM 40, 90)	1 (RM 90)	-
Emerald shiner (*Notropis atherinoides*)	7 (RM 40-0, Whitewater R.)	2 (mouth, SMR)	13 (RM 37-0, Twin Cr.)
Silver shiner (*Notropis photogenis*)	9 (all counties, Whitewater R.)	2 (Stillwater, Mad R.)	9 (scattered, tribs.)
Rosyface shiner (*Notropis rubellus*)	9 (RM 90-85, SMR,TC,IC,WMR, RM 40)	-	1 (Fourmile Cr.)
Rosefin shiner (*Notropis ardens*)	7 (Warren, Butler, Hamilton Co., tribs.)	-	1 (RM 88)
River shiner (*Notropis blennius*)	2 (RM 5-0)	1 (mouth)	-
Bigeye shiner (*Notropis boops*)	1 (Stillwater R., prior 1900)	-	-
Steelcolor shiner (*Notropis whipplei*)	2 (Whitewater R.)	-	-
Spotfin shiner (*Notropis spilopterus*)	10 (all counties, tribs.)	1 (mouth)	39 (ubiquitous)
Sand shiner (*Notropis stramineus*)	10 (all counties, tribs.)	1 (RM 90)	3 (RM 91, 63-42)
Mimic shiner (*Notropis volucellus*)	9 (Butler, Montgomery Co.)	1 (mouth)	1 (Fourmile Creek)
Ghost shiner (*Notropis buchanani*)	1 (mouth)	-	-

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Table 35. (Continued)

Species	Trautman (1957) 1900-1955 (27)[a]	Trautman (1979 ms.) 1955-1978(7)[a]	Ohio EPA July-October 1980(49)[a]
Silverjaw minnow (Ericymba buccata)	14 (all counties, tribs.)	1 (mouth)	-
Fathead minnow (Pimephales promelas)	11 (all counties, 1901-1938)	1 (mouth)	1 (RM 45)
Bluntnose minnow (Pimephales notatus)	18 (ubiquitous)	1 (mouth)	21 (RM 91-9)
Central stoneroller (Campostoma anomalum)	12 (all counties, tribs.)	3 (mouth, WMR, RM 90)	6 (RM 91-42)
Blue sucker (Cycleptus elongatus)	1 (mouth)	-	-
Bigmouth buffalo (Ictiobus cyprinellus)	1 (mouth)	-	-
Black buffalo (Ictiobus niger)	1 (mouth)	1 (mouth)	2 (RM 37-0)
Smallmouth buffalo (Ictiobus bubalus)	2 (mouth, RM 30)	1 (mouth)	9 (RM 37-0)
Quillback (Carpiodes cyprinus)	8 (Butler, Hamilton Co.)	3 (mouth, WMR, Mad R.)	28 (ubiquitous)
River carpsucker (Carpiodes carpio)	4 (Hamilton Co.)	1 (mouth)	18 (RM 82-72, 37-0, WMR)
Highfin carpsucker (Carpiodes velifer)	4 (Hamilton Co.)	2 (mouth, WMR)	19 (RM 91-76, 37-0, WMR)
Silver redhorse (Moxostoma anisurum)	4 (mouth, Whitewater R.)	-	6 (RM 9-0, WMR)
Black redhorse (Moxostoma duquesnei)	1 (RM 90)	3 (mouth, RM 82, Mad R.)	5 (RM 87-82, WMR)
Golden redhorse (Moxostoma erythrurum)	10 (Hamilton, Butler, Montgomery Co.)	3 (mouth, RM 82, Mad R.)	36 (ubiquitous, absent RM 72-63)
Shorthead redhorse (Moxostoma macrolepidotum)	3 (mouth, Whitewater R.)	2 (mouth, RM 82)	6 (RM 82-72, 9-0, WMR)
River redhorse (Moxostoma carinatum)	3 (mouth, Whitewater R.)	-	1 (Whitewater R.)
Northern hog sucker (Hypentelium nigricans)	8 (Hamilton, Butler Co., RM 90)	3 (mouth, RM 90, Mad R.)	10 (scattered, most RM 91-63)
White sucker (Catostomus commersoni)	13 (all counties, tribs.)	2 (mouth, RM 90)	27 (RM 91-37)
Spotted sucker (Minytrema melanops)	-	3 (mouth, SMR, Mad R.)	27 (RM 91-37)
Creek chubsucker (Erimyzon oblongus)	1 (Stillwater R., 1)	-	-
Blue catfish (Ictalurus furcatus)	1 (mouth)	-	-
Channel catfish (Ictalurus punctatus)	8 (Hamilton, Butler, Warren Co.)	2 (RM 90, Stillwater R.)	28 (ubiquitous)
White catfish (Ictalurus catus)	-	1 (mouth)	-
Yellow bullhead (Ictalurus natalis)	5 (Hamilton, Butler Co., 1901-1937)	2 (mouth, Mad R.)	7 (RM 72-25)
Brown bullhead (Ictalurus nebulosus)	-	1 (mouth)	2 (Stillwater R., RM 45)
Black bullhead (Ictalurus melas)	9 (all counties)	2 (mouth, Mad R.)	2 (RM 66, 36)
Flathead catfish (Pylodictis olivaris)	1 (mouth)	1 (mouth)	4 (RM 45, 25-0)
Stonecat (Noturus flavus)	6 (mouth, WMR, Warren Co.)	1 (Mad R.)	1 (Mad R.)
Northern madtom (Noturus stigmosus)	1 (Whitewater R.)	-	-
Brindled madtom (Noturus miurus)	2 (Whitewater R.)	-	-
Tadpole madtom (Noturus gyrinus)	-	-	1 (RM 83)
Troutperch (Percopsis omiscomaycus)	7 (Hamilton, Butler Co.)	-	-
Burbot (Lota lota)	-	1 (RM 82)	-
Brook silverside (Labidesthes sicculus)	1 (RM 90)	-	-
White bass (Morone chrysops)	2 (mouth, Whitewater R.)	1 (mouth)	13 (RM 91-82, 37-0)
White crappie (Pomoxis annularis)	6 (Hamilton, Butler, Warren Co., Mad R.)	1 (mouth)	1 (Stillwater R.)
Black crappie (Pomoxis nigromaculatus)	1 (Mad R.)	1 (Mad R.)	30 (RM 91-9)
Rock bass (Ambloplites rupestris)	10 (all counties)	3 (mouth, RM 90, Mad R.)	20 (RM 91-52, 36)
Smallmouth bass (Micropterus dolomieui)	12 (ubiquitous)	2 (mouth, Mad R.)	30 (RM 91-9, WMR)
Spotted bass (Micropterus punctulatus)	5 (RM 15-0, Whitewater R.)	1 (mouth)	2 (RM 9-0, WMR)
Largemouth bass (Micropterus salmoides)	1 (Mad R.)	3 (mouth, WMR, Mad R.)	26 (RM 87-9)
Warmouth (Lepomis gulosus)	-	1 (mouth)	1 (RM 8)
Green sunfish (Lepomis cyanellus)	12 (ubiquitous)	4 (RM 90, Stillwater, Mad R., Bear Cr.)	40 (RM 91-0

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Table 35. (Continued)

Species	Trautman (1957) 1900-1956 (27)[a]	Trautman (1979 ms.) 1956-1978(7)[a]	Ohio EPA July-October 1980(49)[a]
Bluegill (Lepomis macrochirus)	4 (Hamilton Co., Mad R.)	4 (RM 90, Mad R., Paddys Run, WMR)	41 (RM 91-0)
Orangespotted sunfish (Lepomis humilis)	3 (RM 90, Whitewater R.)	1 (Mad R.)	2 (Stillwater, Mad R.)
Longear sunfish (Lepomis megalotis)	7 (Hamilton, Butler Co., RM 90)	4 (mouth, WMR, Mad R., RM 82)	45 (ubiquitous)
Redear sunfish (Lepomis microlophus)	-	1 (Warren Co.)	-
Pumpkinseed (Lepomis gibbosus)	-	2 (mouth, Mad R.)	6 (RM 72-37)
Sauger (Stizostedion canadense)	1 (mouth)	1 (mouth, RM 40)	9 (RM 37-0)
Walleye (Stizostedion vitreum)	2 (mouth, Whitewater R.	-	1 (Whitewater R.)
Yellow perch (Perca flavescens)	1 (RM 5)	-	3 (RM 91-72)
Blackside darter (Percina maculata)	4 (Hamilton, Butler Co.)	-	-
Slenderhead darter (Percina phoxocephala)	4 (RM 5, Whitewater R., RM 55)	-	-
River darter (Percina shumardi)	1 (mouth)	1 (mouth)	-
Channel darter (Percina copelandi)	1 (RM 5)	-	-
Logperch (Percina caprodes)	6 (RM 30-0, 90)	2 (mouth, RM 90)	1 (RM 34)
E. sand darter (Ammocrypta pellucida)	3 (Whitewater R.)	-	-
Johnny darter (Etheostoma nigrum)	8 (all counties)	-	-
Greenside darter (Etheostoma blennioides)	11 (all counties, tribs.)	-	1 (Mad R.)
Banded darter (Etheostoma zonale)	6 (Hamilton, Butler Co., Mad R.	-	-
Variegate darter (Etheostoma variatum)	6 (all counties)	-	-
Bluebreast darter (Etheostoma camurum)	1 (Stillwater R., prior 1900)	-	-
Rainbow darter (Etheostoma caeruleum)	5 (Whitewater R., RM 30-20, Wolf Cr.)	-	-
Orangethroat darter (Etheostoma spectabile)	6 (tribs. - all counties)	-	-
Fantail darter (Etheostoma flabellare)	3 (RM 90-85, 30)	-	-
Least darter (Etheostoma microperca)	1 (RM 82)	-	-
Freshwater drum (Aplodinotus grunniens)	2 (RM 5-0)	1 (mouth)	13 (RM 37-0, WMR)
Total Number of Species	93	64	64
New Species Added	-	13	1
Cumulative Species - 108			

a - number of locations sampled in study area.
b - Hamilton Co. RM 26.3 - 0
Butler Co. RM 56.6 - 26.3
Warren Co. RM 62.7 - 56.6
Montgomery Co. RM 93.5 - 62.7
c - WMR, Whitewater River
SWR, Stillwater River
TC, Twin Creek
IC, Indian Creek

Table 36. Fish species observed in the lower mainstem of the Great Miami River during 1900-1978, but not collected during July - October 1980, with possible reasons for their absence.

Common Name	Scientific Name	Rare 1900-1978	Present 1900-1955 Only	Present 1955-1978 Only	Gear Selectivity/Habitats Not Sampled
Ohio lamprey	Ichthyomyzon bdellium	X	X	-	-
Paddlefish	Polyodon spathula	X	-	-	-
Lake sturgeon	Acipenser fulvescens	X	X	-	-
Shovelnose sturgeon	Scaphirhynchus platyrynchus	X	-	-	-
Alewife	Alosa pseudoharengus	X	-	X	-
Muskellunge	Esox masquinongy	X	-	-	-
Goldeye	Hiodon alosoides	X	-	X	-
Blue sucker	Cycleptus elongatus	X	X	-	-
Bigmouth buffalo	Ictiobus cyprinellus	X	X	-	-
Creek chubsucker	Erimyzon oblongus	X	X	-	-
Bigeye chub	Hybopsis amblops	-	X	-	X
Streamline chub	Hybopsis dissimilis	X	X	-	X
Gravel chub	Hybopsis x-punctata	X	X	-	X
Speckled chub	Hybopsis aestivalis	X	-	X	X
Blacknose dace	Rhinichthys atratulus	X	-	-	X
Tonguetied chub	Exoglossum laurae	X	X	-	X
So. redbelly dace	Phoxinus erythrogaster	X	-	-	X
River shiner	Notropis blennius	X	-	-	X
Bigeye shiner	Notropis boops	X	X	-	X
Steelcolor shiner	Notropis whipplei	X	X	-	-
Ghost Shiner	Notropis buchanani	X	X	-	X
Siverjaw minnow	Ericymba buccata	-	-	-	X
Blue catfish	Ictalurus furcatus	X	X	-	-
Northern madtom	Noturus stigmosus	X	X	-	X
Brindled madtom	Noturus miurus	X	X	-	X
White catfish	Ictalurus catus	X	-	X	-
American eel	Anguilla rostrata	X	-	-	-
Burbot	Lota lota	X	-	X	-
Trout-perch	Percopsis omiscomaycus	-	X	-	X
Brook silverside	Labidesthes sicculus	X	X	-	-
Redear sunfish	Lepomis microlophus	X	-	X	-
Blackside darter	Percina maculata	-	X	-	X
Slenderhead darter	Percina phoxocephala	-	X	-	X
River darter	Percina shumardi	X	-	-	X
Channel darter	Percina copelandi	X	X	-	X
E. sand darter	Ammocrypta pellucida	X	X	-	X
Johnny Darter	Etheostoma nigrum	-	-	-	X
Banded darter	Etheostoma zonale	-	X	-	X
Variegate darter	Etheostoma variatum	-	X	-	X
Rainbow darter	Etheostoma caeruleum	-	X	-	X
Orangethroat daretr	Etheostoma spectabile	-	X	-	X
Bluebreast darter	Etheostoma camurum	X	X	-	X
Fantail darter	Etheostoma flabellare	-	X	-	X
Least darter	Etheostoma microperca	X	X	-	X
Totals		33	28	6	27

but these trends too must be viewed with caution. An assessment of new species occurrences and range expansions since the 1900-1955 period revealed 10 new species (2 by the 1980 survey) and apparent distribution increases by 25 (Table 37). The range expansions of only four (4) of these 25 species was judged to be genuine. The apparent increased distribution of the remaining 20 species was more likely the result of the intensive sampling of the 1980 Ohio EPA survey. The reasons for the new occurrences of five (5) of the 10 new species were stocking, inadvertent releases, and/or more efficient sampling techniques, but were undetermined for the remaining five (Table 37).

Community Composition

Any meaningful assessment of the biological condition of an extended reach of a river or stream must also include relative abundance analyses that show the longitudinal changes in the fish community. Two such analyses, modified percent similarity (Whittaker 1975) and relative composition based on numbers and weight, were used to assess changes in the lower mainstem Great Miami River fish community.

Zone by zone comparisons were made using the modified percent similarity (F) formulas. A similarity matrix (Figure 13) was constructed to reveal areas of similar and dissimilar community composition. Locations with identical composition have values of 100 and those with no similarity at all have values of 0. Comparisons with values of 65 or greater were regarded as having strong resemblance, a criterion used previously by Hanson (1955), Hurd (1961), Beckett (1977), Gammon and Reidy (1981), and Yoder *et al*. (1981).

Trends in community composition were reported as percent by numbers and percent by weight, and were examined to determine changes in composition between the eleven previously described river segments. To simplify this analysis thirteen species groups were selected based upon similarities in ecological roles, taxonomy, environmental requirements, and distributional patterns (Table 38).

The similarity matrix (Fig. 13) indicated where linear (numerical) changes in community composition occurred, while segmental analysis of composition based upon relative numbers and weights showed where qualitative and quantitative changes in composition occurred (Figs. 14 and 15). The boundaries of clusters of similar zones in the similarity matrix generally occurred at or very near segment boundaries (Table 10), which were selected based largely upon the locations of major point source dischargers of wastewater. The expected trend in the similarity matrix downstream would be for a continuous overlap between clusters of similar ($F \geq 65$) zones. Interruptions in the expected trend signify possible perturbations to community structure.

The similarity matrix (Fig. 13) revealed fairly distinct areas or clusters of strong similarity ($F \geq 65$) and dissimilarity ($F < 65$). Overlapping clusters of similar zones were also evident, and indicated longitudinal transitions in fish community composition. This was particularly evident in the lower mainstem between RM 71.8 and RM 40.2. Two clusterings of similar zones occurred between the Taylorsville Dam and the Stillwater River

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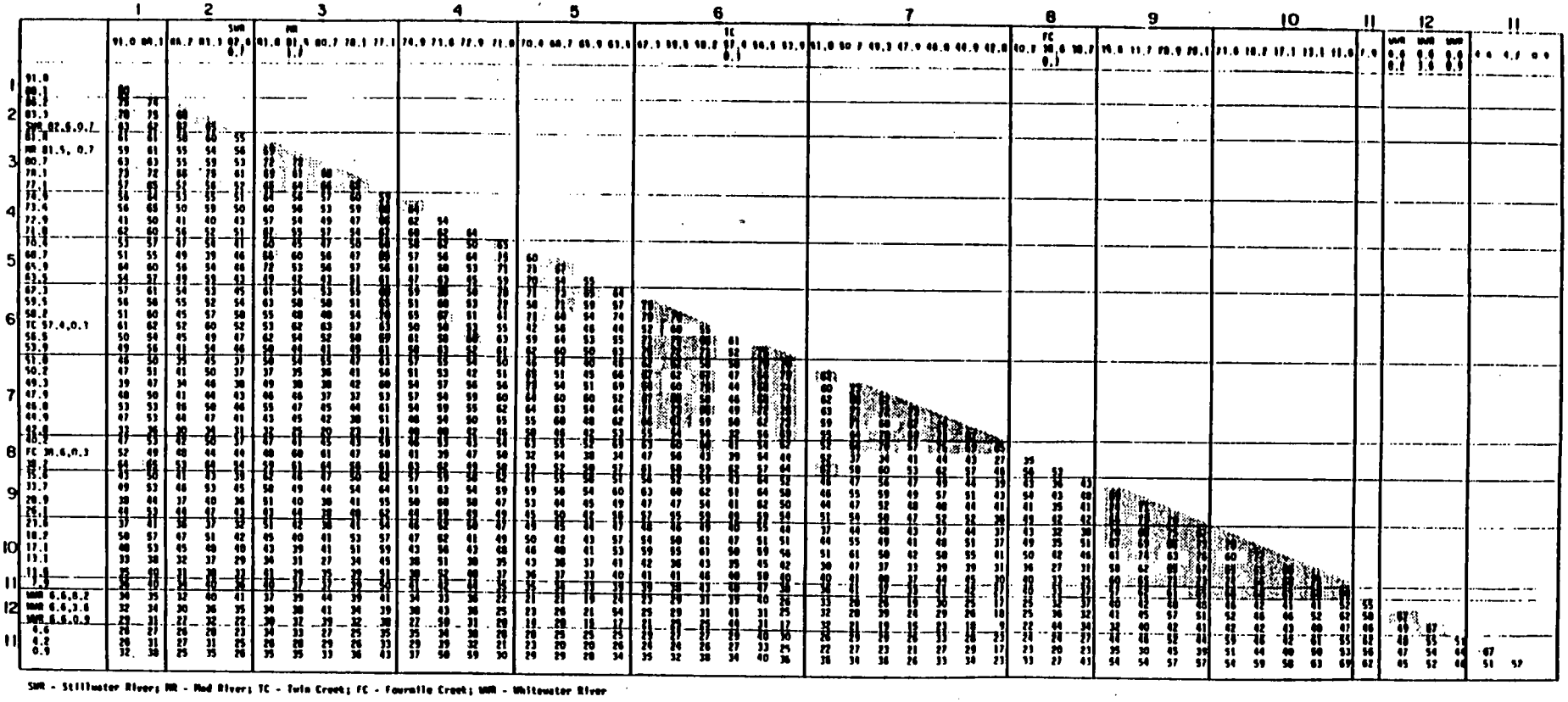
Table 37. New occurrences and range expansions of fish species in the 91 mile (146.5 km) study area since Trautman (1957), with possible explanations for their appearance or range expansion.

Common Name	Scientific Name	Trautman (1981) 1955-1978	Ohio EPA July-October 1980	Reason for Occurrence
Bowfin	*Amia calva*	X	X	A
Mooneye	*Hiodon tergisus*	-	X	A
Grass pickerel	*Esox americanus*	X	X	A
Common carp	*Cyprinus carpio*	XX	X	C,D
Goldfish	*Carassius auratus*	X	X	C,D
Golden shiner	*Notemigonus crysoleucas*	XX	X	C
Emerald shiner	*Notropis atherinoides*	XX	X	C
Spotfin shiner	*Notropis spilopterus*	XX	X	C
Quillback carpsucker	*Carpiodes cyprinus*	XX	X	C
Highfin carpsucker	*Carpiodes velifer*	XX	X	C
River carpsucker	*Carpiodes carpio*	XX	X	C
Golden redhorse	*Moxostoma erythrurum*	XX	X	C
Spotted sucker	*Minytrema melanops*	X	X	C
Channel catfish	*Ictalurus punctatus*	XX	X	C
Tadpole Madtom	*Noturus gyrinus*	-	X	A
Burbot	*Lota lota*	X	-	B
White bass	*Morone chrysops*	XX	X	C
Black crappie	*Pomoxis nigromaculatus*	XX	X	C,D
Rock bass	*Ambloplites rupesrtis*	XX	X	C
Smallmouth bass	*Micropterus dolomieui*	XX	X	C
Largemouth bass	*Micropterus salmoides*	XX	X	C
Green sunfish	*Lepomis cyanellus*	XX	X	C
Bluegill	*Lepomis macrochirus*	XX	X	C
Longear sunfish	*Lepomis megalotis*	XX	X	C
Warmouth	*Lepomis gulosus*	X	X	A
Redear sunfish	*Lepomis microlophus*	X	-	B
Pumpkinseed sunfish	*Lepomis gibbosus*	X	X	C,D
Sauger	*Stizostedion canadense*	XX	X	C
Freshwater drum	*Aplodinotus grunniens*	XX	X	C

A. Undetermined.
B. Stocking or inadvertant release.
C. Range increase due to increased sampling efficiency and/or sampling intensity, 1980 only.
D. Range increase judged to be genuine.
X. Observed during 1955-1978 period only.
XX. Observed during both 1900-1955 and 1955-1978 periods.

Table 38: Species group designations used to assess community composition patterns in the lower mainstem of the Great Miami River and five major tributaries.

Group	Species (Genera)
GS	Gizzard shad (*Dorosoma*)
G	Carp - Goldfish (*Cyprinus*, *Carrasius*)
R	Round-bodied Catostomidae (*Moxostoma*, *Hypentelium*, *Minytrema*, *Catostomus*)
C	Deep-bodied Catostomidae (*Carpiodes*, *Ictiobus*)
M	Minnow - Chubs (*Semotilus*, *Pimephales*, *Hybopsis*, *Nocomis*, *Phenacobius*, *Campostoma*)
N	Shiners (*Notropis*, *Notemigonus*)
B	Bass - Crappies (*Micropterus*, *Ambloplites*, *Pomoxis*)
S	Sunfishes (*Lepomis*)
F	Catfishes - Drum (*Ictalurus*, *Pylodictis*, *Aplodinotus*)
V	Sauger - Walleye (*Stizostedion*)
W	White Bass - Skipjack - Goldeye - Mooneye (*Morone*, *Alosa*, *Hiodon*)
L	Gars (*Lepisosteus*)
O	Other species not included above.



SWR - Stillwater River; MR - Mad River; TC - Twin Creek; FC - Fourmile Creek; WWR - Whitewater River

Figure 13. Similarity matrix, based on the modified percent similarity formula (F), used to assess compositional similarity of the fish community in the lower mainstem Great Miami River study area, July 9 - October 7, 1980 (lines delineate segment boundaries; zones are arranged in sequence from upstream to downstream; shaded areas indicate similar locations, F ≥ 65).

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Figure 14. Composition of the fish community in the lower mainstem Great Miami River based on numbers, July 9 - October 7, 1980. Species group symbols are those given in Table 38. The size of each circle is proportional to the mean density of fish (numbers/km) in each segment.

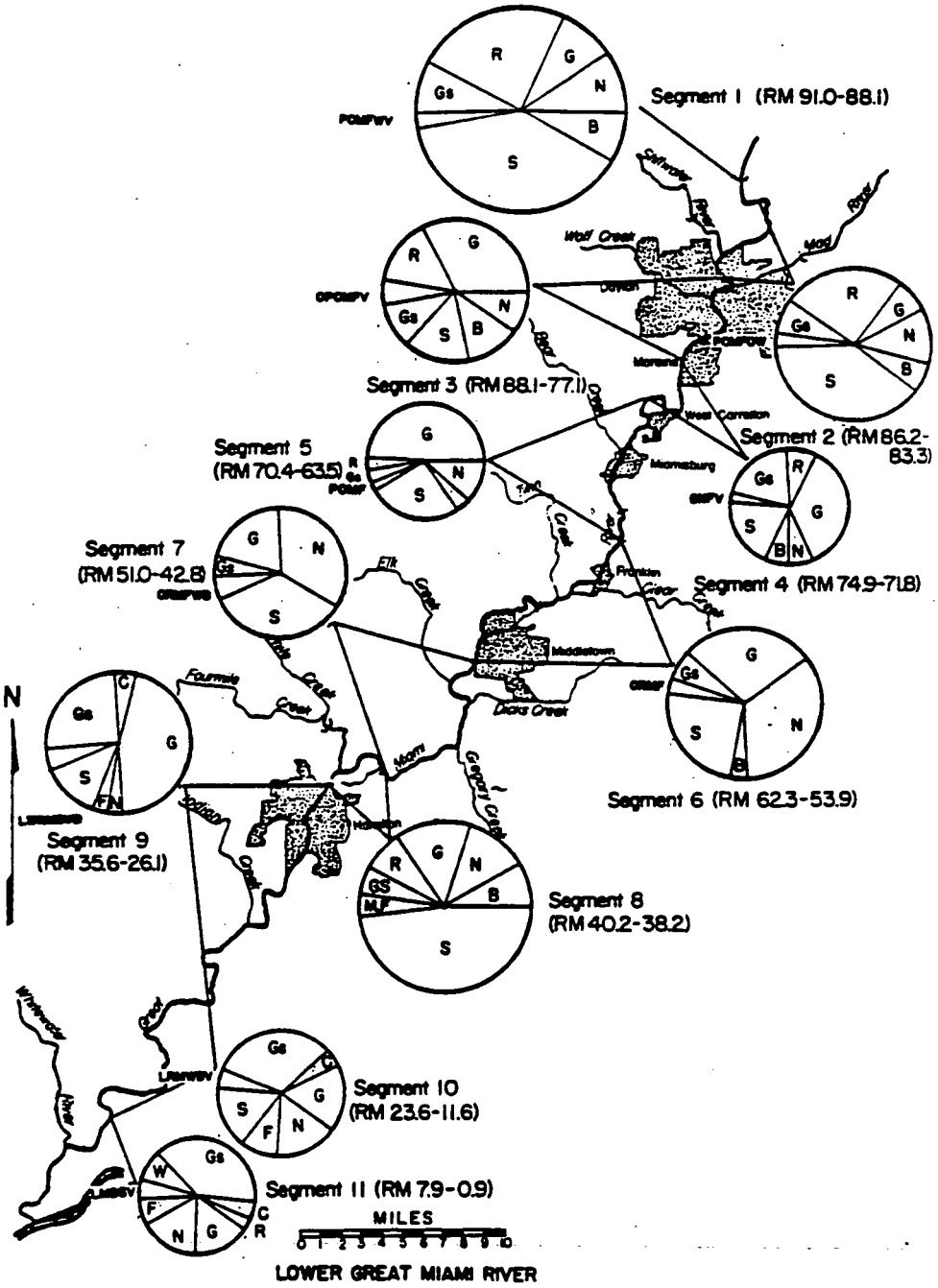

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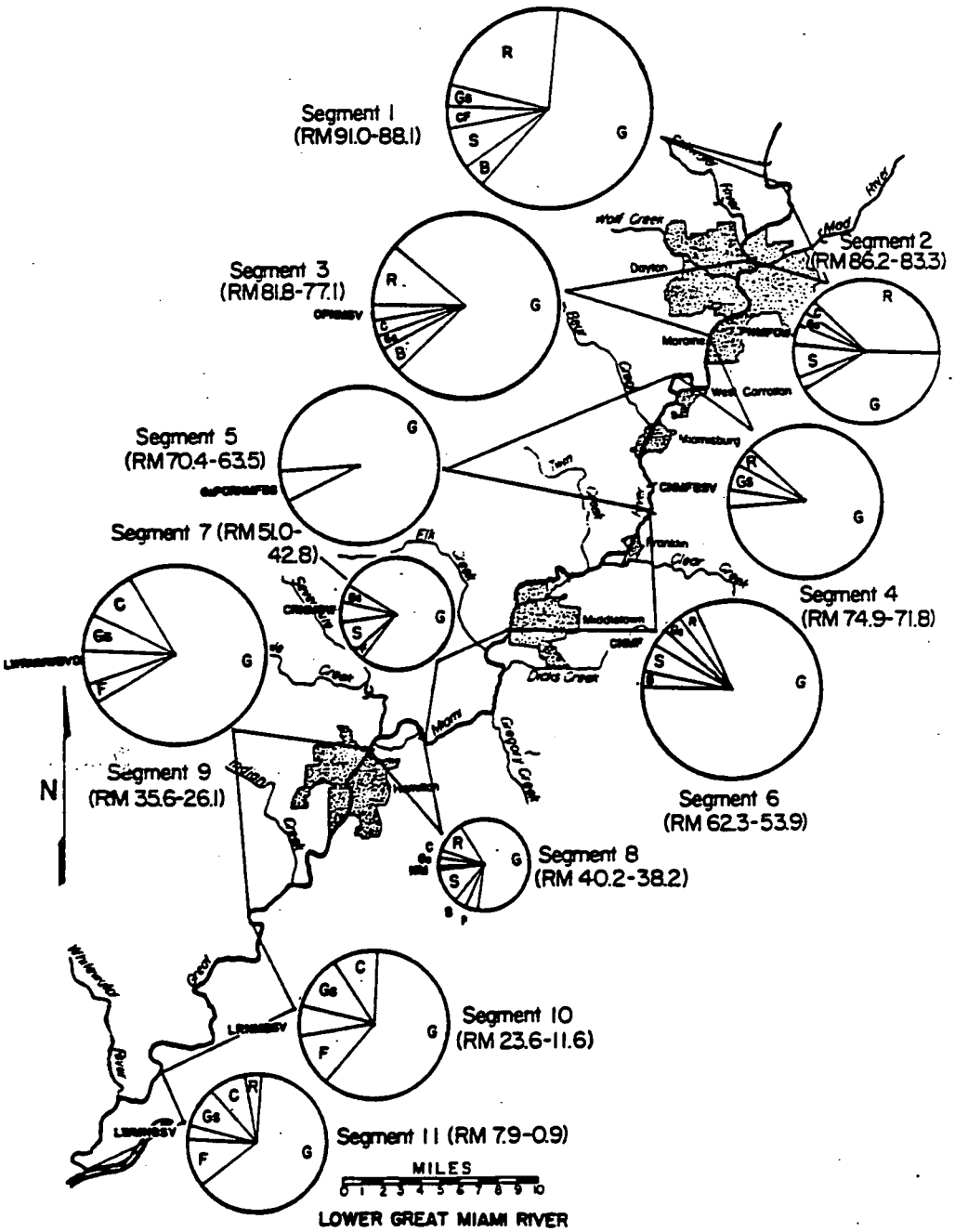
Figure 15. Composition of the fish community in the lower mainstem Great Miami River based on weight, July 9 - October 7, 1980. Species group symbols are those given in Table 31. The size of each circle is proportional to the mean biomass (kg/km) in each segment.



(RM 91.0 - 82.6), and between the Steele Dam and just upstream from the Dayton WWTP (RM 81.8 - 77.1). These two clusterings included all of segments 1 (RM 92.6 to RM 87.4), 2 (RM 87.3 to RM 82.2) and 3 (RM 82.1 to RM 76.2). The fish community in segments 1 and 2 was dominated numerically by round bodied Catostomidae (R) and sunfish (S) groups, with significant contributions from the shiners (N), bass-crappie (B), gizzard shad (GS), and carp-goldfish (G) groups (Figure 14). This association was quite similar to the smallmouth bass-rock bass-redhorse community described by Funk (1970) as being typical of middle size streams throughout the midwest United States. The numerical composition of fish in segment 3 shifted towards the carp-goldfish group (G), with the round-bodied Catostomidae (R), sunfish (S), shiners (N), bass-crappie (B), and gizzard shad (GS) groups still of major importance. Round-bodied Catostomidae (R) and carp-goldfish (G) groups dominated the biomass in all three segments (Figure 15). Three of the four segments having the highest density (numbers/km) and two of the three segments having the greatest biomass (kg/km) recorded during this study were found between RM 91.0 and RM 77.1 (Table 39).

A short stretch of the lower mainstem (RM 74.9 to RM 72.0) immediately downstream from the Dayton WWTP (RM 76.1) was dissimilar from all other zones in the study area. This represented an interruption in the expected downstream trend which was indicative of a major change in water quality.

Two overlapping clusters of similar zones (RM 71.8 to RM 40.2) were found upstream from the Montgomery Western Regional WWTP (RM 71.5) to immediately downstream from the Hamilton Hydraulic Canal Dam (RM 41.5). Segments 5 (RM 71.5 to RM 62.7), 6 (RM 62.6 to RM 51.7), 7 (RM 51.6 to RM 41.5) and small portions of two other segments (4 and 8) were included. The area of overlap occurred between RM 62.3 and Twin Creek (RM 57.4). The only major tributaries in this area, Twin Creek (RM 57.6) and Four Mile Creek (RM 38.6), were not similar to any other zone in the study area. Both streams had excellent water quality which, in part, contributed to their dissimilarity as compared to adjacent mainstem zones. The only river zone (RM 51.0) in this area which was dissimilar from all other adjacent mainstem zones was located immediately downstream from the ARMCO-Middletown 001 discharge (RM 51.5). This area is heavily impacted by WWTP's, a combined sewer overflow (CSO) area, and industries, is impounded by four dams, and has few areas for refuge and repopulation of the fish community (i.e., tributaries, non-degraded upstream areas). Shiners (N), sunfish (S) and the carp-goldfish groups (G) dominated numerically. Carp-goldfish (G) dominated the biomass comprising over 93% of the total in segment 5. This association was similar to that described by Funk (1970) as being more typical of turbid, low gradient plains type rivers.

The next cluster of similar zones (RM 35.6 to RM 7.9) was very distinct and extended downstream from the Hamilton Dam (RM 37.2) to RM 7.6, just downstream from Gulf Oil (RM 9.1). The river is free-flowing between the Hamilton Dam and the Ohio River which may be one explanation for the consistent degree of similarity. Gizzard shad (GS) and carp-goldfish (G) were numerically dominant in segment 9 (RM 37.1 to RM 24.8); carp-goldfish (G) and deep-bodied Catostomidae (C) dominated in terms of biomass. The first appearance of species from groups L (longnose gar) and V (sauger, walleye), which are

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Table 39: Mean community indices (± S.E.) for eleven mainstem segments of the 91 mile (146.4 km) study area based on electrofishing results (June - October 1980)

Segment (Location)	N	Composite Index	Number/Km	Kg/Km	Number of Species
1 (RM 92.6 to RM 87.4)	6	9.30 (±0.07)	525.3 (±38.6)	103.2 (±20.1)	20.0 (±1.3)
2 (RM 87.3 to RM 82.2)	6	8.23 (±0.21)	286.0 (±28.4)	52.9 (±4.2)	13.8 (±0.9)
3 (RM 82.1 to RM 76.2)	13	7.87 (±0.67)	246.3 (±35.8)	79.5 (±17.0)	13.5 (±2.1)
4 (RM 76.1 to RM 71.6)	12	6.84 (±0.18)	159.6 (±21.5)	60.8 (±11.5)	11.8 (±0.8)
5 (RM 71.5 to RM 62.7)	12	6.82 (±0.20)	167.5 (±28.9)	63.1 (±15.5)	11.7 (±1.0)
6 (RM 62.6 to RM 51.7)	15	7.27 (±0.21)	250.8 (±32.0)	41.7 (±6.5)	11.8 (±0.7)
7 (RM 51.6 to RM 41.5)	21	6.62 (±0.24)	203.9 (±25.4)	31.3 (±6.8)	9.8 (±0.7)
8 (RM 41.4 to RM 37.2)	5	7.14 (±0.40)	126.8 (±12.4)	19.7 (±2.4)	13.0 (±1.6)
9 (RM 37.1 to RM 24.8)	12	7.73 (±0.12)	248.5 (±39.6)	75.4 (±17.1)	14.7 (±0.7)
10 (RM 24.7 to RM 9.1)	14	7.90 (±0.16)	185.0 (±23.6)	48.8 (±7.7)	13.7 (±0.9)
11 (RM 9.0 to RM 0.0)	9	7.16 (±0.26)	148.9 (±33.4)	42.5 (±5.1)	11.7 (±1.1)
12 (Whitewater River, RM 8.3 - 0.0)	8	7.97 (±0.15)	228.9 (±62.3)	63.5 (±15.4)	12.9 (±0.6)

characteristic of large river habitats occurred in this segment. In segment 10 (RM 24.7 to RM 9.1) numerical dominance of the fish community was shared by five species groups (i.e, shiners (N), sunfish (S), catfish-drum (F), gizzard shad (GS), and carp-goldfish (G)). Carp-goldfish (G), catfish-drum (F), gizzard shad (GS) and deep-bodied Catostomidae (C) dominated in terms of biomass. The fish community in segment 11 (RM 9.1 - 0.0) continued to reflect the shift towards a large river fish community.

There were very few similar zones downstream from the Great Miami River-Whitewater River confluence (RM 6.6) due primarily to changes in habitat. The flow of the Great Miami River is increased approximately 30% by the inflow of the Whitewater River (Ohio-Kentucky-Indiana Reg. Council Govts. 1977). The Ohio River also backs up the Great Miami River for approximately 5 miles, giving this segment the semi-lentic characteristics of a large, slow moving river (i.e., broad gradual bends, high cut banks, silt and sediment deposits, and high turbidity). The resulting fish community was distinctly different from the one observed in upstream segments.

Of the five tributaries that were sampled only the Stillwater and Mad Rivers showed any similarity to adjacent mainstem sampling zones. Two mainstem zones (RM 86.2 and RM 83.3) immediately upstream from the mouth of the Stillwater-Great Miami River confluence (RM 82.6) were similar to the Stillwater River (RM 82.6, 0.7). Both the Stillwater River sampling location and the adjacent mainstem sampling location (RM 83.3) are within the impoundment effect of the Steele Dam (RM 82.2). The mainstem sampling location at RM 86.2 was 1.2 miles downstream from the Ohio Suburban WWTP (RM 87.5) and had a less diverse fish community characteristic of an impoundment. The inflow of Mad River was reflected in the fish community immediately downstream from its confluence (RM 80.7). The composition of this mainstem zone (RM 80.7) was similar to that found in the Mad River (RM 81.5, 1.2). Aside from these instances, the remaining tributaries of the lower mainstem Great Miami River were much different than the adjacent mainstem in terms of community structure. Most tributaries were predominated numerically by the round-bodied Catostomidae (R) and carp-goldfish (G) groups, with the sunfish (S), bass-crappie (B), and shiners (N) also prominent Groups R and G dominated the biomass (Table 40). This association resembles that found in the mainstem upstream from the Dayton WWTP.

The Whitewater River fish community exhibited a striking contrast with that of the adjacent mainstem. The round-bodied Catostomidae (R) along with gizzard shad (GS) dominated numerically, and together with carp-goldfish (G) dominated the biomass (Table 40). Group R was much less prominent in the mainstem zones of segments 10 and 11. The compositional difference between the two areas was primarily due to habitat, but was also attributable to water quality. The differences in the amount of point source loadings received by the two rivers was quite large, the Whitewater receiving only minimal loadings from the Harrison WWTP (RM 6.6, 8.2).

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Table 40. Composition of lower mainstem Great Miami River tributaries by numbers and weight during July-October, 1980.

Tributary - Gr. Miami RM	Mean No./km	Percent by Numbers												
		G	C	M	N	GS	S	B	R	F	V	W	L	O
Stillwater R. - 82.6	286.7	14.9	0.8	-	0.2	0.6	42.3	15.6	25.4	0.2	-	-	-	-
Mad R. - 81.5	283.3	26.6	1.4	2.6	6.6	9.4	13.2	14.4	24.0	-	0.7	-	-	1.1
Twin Cr. - 57.4	286.7	5.5	0.6	0.9	16.6	13.1	17.7	5.8	39.5	0.3	-	-	-	-
Fourmile Cr. - 38.6	272.0	1.5	0.4	3.2	16.0	3.0	12.0	9.5	54.2	0.2	-	-	-	-
Whitewater R. - 6.6	228.9	7.8	7.3	3.0	7.9	45.2	0.7	2.2	22.8	2.7	0.2	-	0.1	-

Tributary - Gr. Miami RM	Mean Kg/km	Percent by Weight												
		G	C	M	N	GS	S	B	R	F	V	W	L	O
Stillwater R. - 82.6	77.29	56.8	1.0	-	*	0.2	4.3	7.1	30.4	0.1	-	-	-	-
Mad R. - 81.5	85.46	70.2	1.2	0.1	0.5	1.9	1.2	5.0	17.9	-	*	-	-	1.9
Twin Cr. - 57.4	34.97	21.8	2.3	*	0.7	10.6	3.5	8.6	51.8	0.7	-	-	-	-
Fourmile Cr. - 38.6	36.42	7.1	1.2	0.1	0.5	3.3	2.6	8.3	76.4	0.5	-	-	-	-
Whitewater R. - 6.6	63.46	44.2	9.9	*	0.1	16.6	0.1	1.1	23.1	4.6	0.1	-	0.1	-

Community Diversity and Abundance

In addition to determining longitudinal trends in community composition several measures of community diversity and abundance were used. Community abundance was expressed in terms of numbers/km (density) and kg/km (biomass) and diversity was expressed as the mean number of species/zone and the cumulative species/zone. The Shannon index ($\bar{H}$) was calculated based on numbers and weights, but was not used alone as an evaluation of fish community diversity. The composite index (Gammon 1976), which incorporates density, biomass, and diversity via the Shannon index ($\bar{H}$), was used as an overall evaluation of the relative condition of the fish community along the length of the lower mainstem. This index has been shown to reflect the general condition of the fish community more satisfactorily than any of the other evaluations or indices to which it has been compared (Gammon 1976; Gammon *et al*. 1981; Yoder *et al*. 1980, 1981).

Mean values (+ SE) were plotted against river mile for the composite index (Fig. 16), and for density, biomass, mean number of species/zone, and cumulative species/zone (Fig. 17). Each of these five indices have a certain degree of inherent variability most of which is the result of sampling error and biological variability. Gammon (1976) evaluated the potential variability of three of these indices and found the coefficient of variation to be lowest for the composite index (9.3%) and highest for density and biomass (25.6-46.1%). These factors were taken into account while evaluating longitudinal trends in the lower mainstem.

Mean composite index values were highest in the study area upstream from the Ohio Suburban WWTP, ranging from 9.19 (RM 91.0) to 9.41 (RM 88.1)(Fig. 16). This was the only time mean composite index values consistently greater than 9.0 were recorded in the study area. The mean composite index decreased to 7.99 (RM 86.2) 1.2 miles downstream from the Ohio Suburban WWTP (RM 87.4), increased slightly through RM 81.8, and then quickly recovered to 9.26 at RM 80.7 in downtown Dayton. Downstream from this location the trend in composite index values was one of sharp decline, especially downstream from the Dayton WWTP (RM 76.1). One of the lowest composite index values recorded in the study area (6.12) occurred at RM 72.9 which corresponded to an area of both measured and predicted low dissolved oxygen.

The mean composite index exhibited a repeating pattern of decline and recovery between RM 72.9 to RM 38.2 (i.e., downstream from the Dayton metropolitan area to just upstream from the Hamilton Dam, RM 37.2), but remained at levels between 5.71 and 7.81, well below those observed upstream from and in Dayton. Standard error (S.E.) values were considerably greater than those observed in the upstream zones which can also be an indication of an intermittently stressed environment.

The greatest depressions in the composite index occurred between RM 74.9 and 70.4, RM 68.7 and RM 63.5, RM 59.5 and RM 53.9, RM 51.0 and RM 47.9, and RM 44.9 and RM 42.8. Recovery of the fish community (as evidenced by increasing composite index values) was continually interrupted throughout this section of the mainstem. This situation is typical of large rivers that have concentrations of point source discharges located at varying distances along the mainstem.

Figure 16. Longitudinal trend of the mean (±SE) composite index in the lower mainstem Great Miami River study area, July 9 - October 7, 1980. Lines and shaded areas indicate boundaries and overlap between biological criteria classes described in Table 41 (dots represent tributary location values).

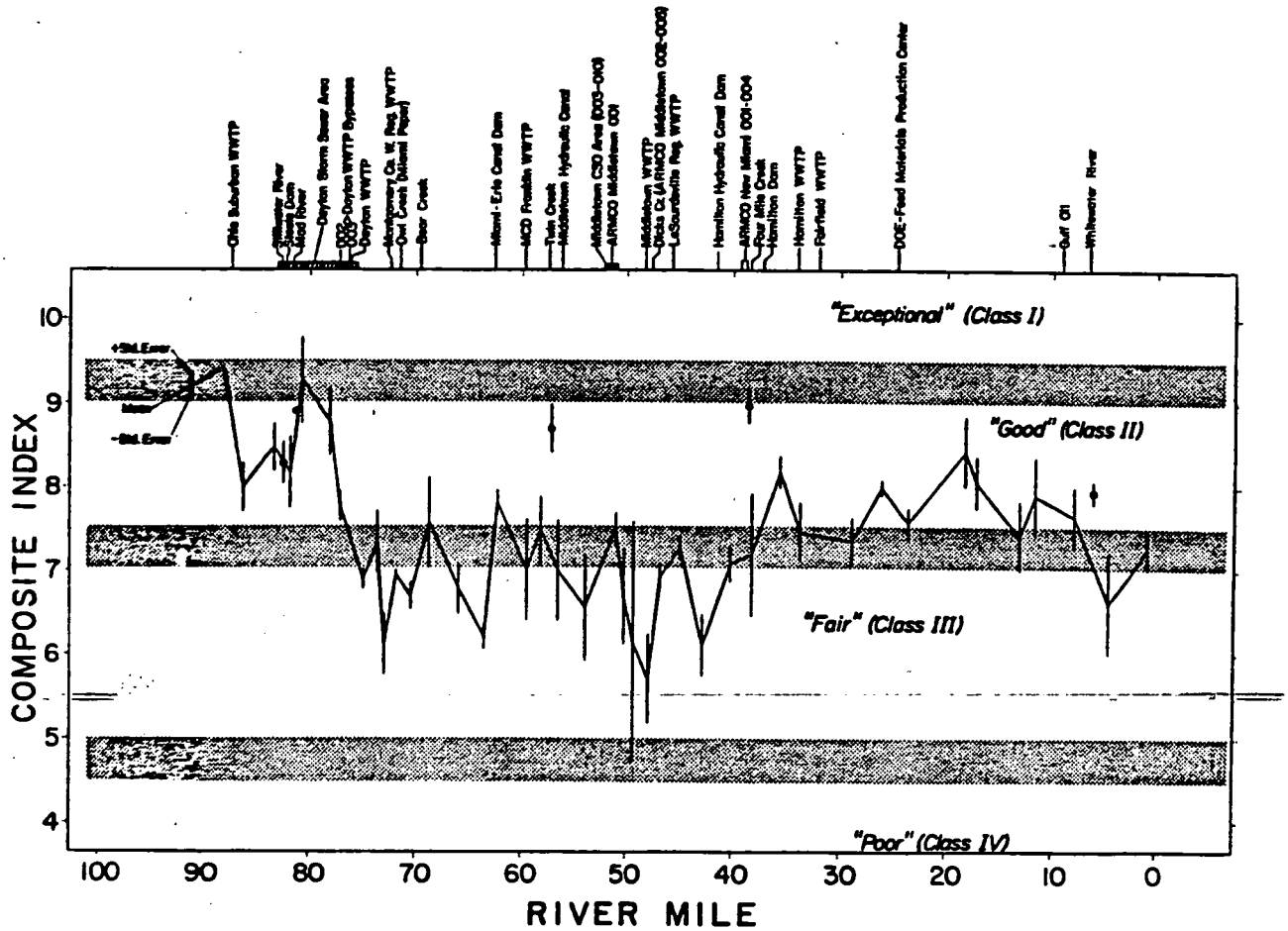
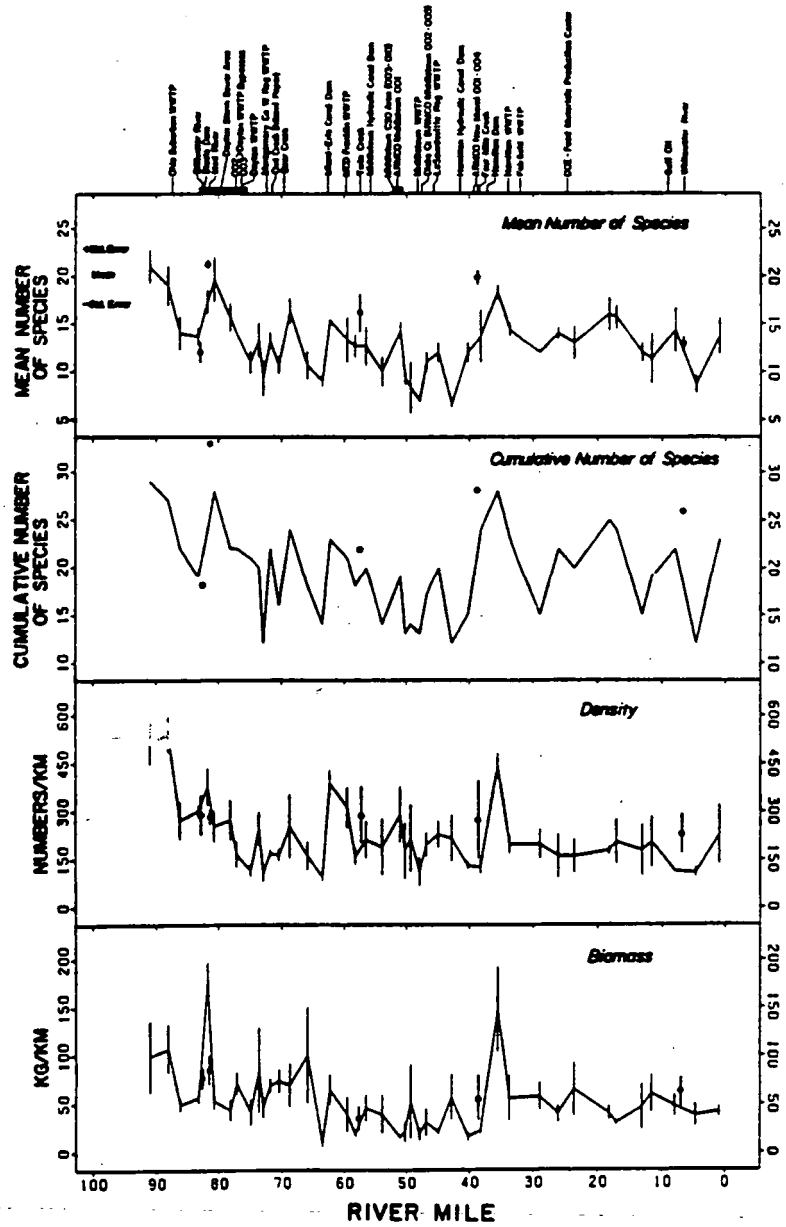


Figure 17. Longitudinal trend of mean (+SE) number of species/zone, cumulative number of species/zone, density (numbers/km), and biomass (kg/km) in the lower mainstem Great Miami River study area, July 9 - October 7, 1980 (dots represent tributary location values).



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The composite index gradually increased to above 8.0 for the first time in 42.5 miles downstream from the Hamilton Dam (RM 37.2). An interruption in this recovery occurred downstream from the Hamilton WWTP (RM 34.0) at RM 33.7 and 28.9. The recovery trend resumed reaching a high value of 8.42 at RM 18.2. Although this was less than the values observed upstream from Dayton it does show that the lower section of the Great Miami River mainstem is capable of supporting a well-balanced, healthy fish community. From this point on however, there was a steady decline through the next 13.6 miles, the lowest value being 6.61 at RM 4.6. A slight increase was observed at RM 0.9.

Mean composite index values measured in the five tributaries were generally higher than those observed in the adjacent mainstem. The values observed in the Mad (8.92), Stillwater (8.28), and Whitewater (7.64-8.33) Rivers were 0.2-0.4 units higher than those observed in adjacent mainstem zones. The values measured in Twin Creek (8.73) and Four Mile Creek (9.00) were substantially higher than the adjacent mainstem on the the order of 1.5-2.0 composite index units.

The community parameters of mean number of species/zone and cumulative number of species/zone closely resembled the longitudinal pattern of the composite index (Fig. 17). As with the composite index the highest mean number of species/zone and cumulative species/ zone occurred at RM 91.0 (21.0 and 29), RM 88.1 (19.0 and 27), RM 80.7 (19.7 and 28), and RM 35.6 (18.3 and 28). These were the only mainstem locations where 25 or more species were collected in 1980. Low values for each index occurred at RM 72.9 (9.3 and 12), RM 63.5 (9.0 and 14), RM 47.9 (7.0 and 13), RM 42.8 (6.7 and 12), and RM 4.6 (8.7 and 12). All of these locations (except RM 4.6) were directly influenced by major point sources of wastewater. The reduction in mean number of species/zone and cumulative species/zone between the high and low locations ranged from 48-68%. In the tributary locations both indices again followed the pattern of the composite index with two exceptions. The highest mean number of species/zone and cumulative species /zone in the study area occurred in Mad River (21.3 and 33) which was higher than adjacent mainstem zones. The Stillwater River had slightly lower values than adjacent mainstem zones and substantially lower than other tributaries. This was due primarily to the partially impounded nature of the lower one mile of the Stillwater River.

Mean density (numbers/km) and biomass (kg/km) followed roughly similar patterns and only very generally resembled the composite index trend. These were the two most variable indices used with standard errors being 30-50% of the mean. Density declined from more than 500 fish/km upstream from Dayton (RM 91.0 and 88.1) to 250-300 fish/km between RM 86.2 and 78.1. The decline continued through RM 63.5 with all except two locations having less than 200 fish /km. A temporary recovery to more than 300 fish/km at RM 62.3 and RM 59.5 was found, and mean values returned to the 100-150 fish/km range through RM 38.2. A sharp increase to more than 400 fish/km at RM 35.6 downstream from

the Hamilton Dam (RM 37.2) was again followed by a decrease to less than 200-210 fish/km. Tributary densities were only slightly higher than the values observed in the adjacent mainstem. Biomass (kg/km) was greatly influenced by the presence of large species such as common carp, carpsuckers (Carpiodes), and buffalo (Ictiobus), and increased in some of the stressed river segments due to the abundance of these pollution tolerant species. Like density, biomass also showed large increases immediately downstream from dams because of the large numbers of fish that were usually concentrated in these areas. Of all the parameters tested, biomass was the least useful for measuring fish community health and well-being.

Discussion

The use of diversity and relative abundance data to determine the general "health" or "well-being" of fish communities, and to assess the quality of the environment (habitat and water quality) which they inhabit, is based on the premise that unstressed segments support a greater variety and abundance of fish than do stressed segments in the same river or stream. This has been verified in several fish community studies (Gammon 1976; WAPORA 1978; Gammon et al. 1981; and Yoder et al. 1981) and confirms the potential that this concept and attendant methodologies have for use as a tool to monitor environmental quality, to measure the effectiveness of water pollution control programs, and to determine attainment of Clean Water Act goals. Stream and river surveys using the composite index have shown a positive correlation between the index and environmental quality. The following three ranges of environmental quality based upon the composite index were reported for the East Fork-White River (Indiana) (WAPORA 1978): 0 to 3.5, degraded; 3.5 to 7.0, degraded to recovery; and greater than 7.0, healthy. The Ohio EPA, as part of its effort to establish attainable use criteria and determine attainment of Clean Water Act goals, has developed a similar method employing the composite index and narrative biological criteria which were used to evaluate the condition of the lower mainstem of the Great Miami River based on data collected during July 9 - October 7, 1980 (Table 41).

The Influence of Various Factors on the Distribution and Abundance of Fishes in the Study Area

The presence of permanent, large populations of different fish species is generally considered to be the result of a combination of many favorable factors (Trautman 1942). Factors which account for variations in the distribution and abundance of fishes in streams and rivers include, but are not limited to, stream order, instream cover, stream morphology, depth, flow, substrate, gradient and water quality. Perturbations to the physical and/or chemical quality of a river or stream usually result in varying degrees of stress to one or more fish species. Species that fail to adjust to these stresses will be reduced in numbers or be eliminated via mortality, lowered reproductive success, and/or avoidance. The subsequent absence or reduced numbers of species results in decreased community diversity and abundance, and is reflected by an association of predominately stress tolerant species.

Table 41. Ohio EPA biological criteria (fish) for determining water quality use designations and attainment of Clean Water Act (CWA) goals (November 1980).

	- - - - - -MEETS CWA GOALS - - - - - - - - - -		- - - - -DOES NOT MEET CWA GOALS - - - - -	
Evaluation Class[a] Category	"Exceptional" Class I (EWH)	"Good" Class II (WWH)	"Fair" Class III	"Poor" Class IV
1.	Exceptional, or unusual assemblage of species	Usual association of expected species	Some expected species absent, or in very low abundance	Most expected species absent
2.	Sensitive species abundant	Sensitive species present	Sensitive species absent, or in very low abundance	Sensitive species absent
3.	Exceptionally high diversity	High diversity	Declining diversity	Low diversity
4.	Composite index 9.0 - 9.5	Composite index 7.0 - 7.5, 9.0 - 9.5	Composite index 4.5 - 5.0, 7.0 - 7.5	Composite index 4.5 - 5.0
5.	Outstanding recreational fishery		Tolerant species increasing, beginning to dominate	Tolerant species dominate
6.	Rare, endangered, or threatened species present			

[a] Conditions: Categories 1, 2, 3 and 4 (if data is available) must be met and 5 or 6 must also be met in order to be designated in that particular class.

Pollution affects fish communities in one of two ways; either by the elimination of some species, occasionally accompanied by an increase in the remaining species, or by the replacement of the normal aquatic community by another community better adapted to the new ecological conditions (Hynes 1970). Further studies have shown that increased organic loadings affect the fish community by first reducing the number of species, then reducing the total weight, and finally reducing the number of individuals (Larimore and Smith 1963).

Pronounced negative effects on the lower mainstem Great Miami River fish community were observed during July-October 1980. These effects were primarily the result of changes in water quality attributable to point sources of wastewater. Additional, but less serious effects were attributed to both point and nonpoint sources. Other factors that affected the fish community included river discharge, tributaries, dams, and changes in habitat. Of all the various impacts on water quality point sources are the most obvious. Their outfalls are readily detected and their discharge effects can usually be determined. A total of 76 point sources located along the 91 mile (146.4 km) study area had active discharges during 1980.

Several tributaries were identified as being particularly important to the maintenance of the overall integrity of the fauna in the lower mainstem Great Miami River. Several studies of river fish communities have indicated the importance of tributaries to mainstem fish communities as refuge areas and sources for repopulation (Gammon et al. 1981; Gammon and Reidy 1981; Yoder et al. 1981). During years of normal and above normal flow, mainstem sampling locations in stressed river segments usually have fish communities similar to those found in the lower sections of adjacent tributaries. During years of below normal and low flow the mainstem fish communities are depressed whereas tributary communities remain stable or even increase (Gammon and Reidy 1981). The 1980 flow in the lower mainstem Great Miami River was above normal and trends in the fish community generally followed the patterns observed by Gammon and Reidy (1981). In addition, several dams were also important to localized segments. The immediate areas (i.e., within one mile) downstream from dams can serve as refugia for fish because the water is well oxygenated, deposition of harmful substances is minimal, time exposure to toxic substances is brief, and good cover is usually available. Large dams are also effective barriers to upstream fish movements and therefore can act as congregation areas for fish. Often times diversity and abundance immediately downstream from dams in stressed areas can be equal to that found in relatively unstressed upstream segments (Yoder et al. 1981).

In a large section of the mainstem between RM 74.9 and 38.2 the fish community was depressed as compared to flanking areas. The overall pattern in this section was one of repeated interruptions in recovery from degradation which resulted in a net overall decline in the relative density and diversity of the fish community. Mean composite index values (with three exceptions) were below 7.5, diversity in terms of number of species and densities were comparatively low, and the community was dominated by pollution tolerant species (e.g., carp, goldfish, certain sunfish species). According to the

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biological criteria presented in Table 41 this 36.7 mile long segment was rated "fair" (Class III) which indicated that Clean Water Act goals were not being met. The composite index criterion of 7.5 was used because 1980 was an above normal flow year (as was 1979). Of the three individual zones with mean values at or exceeding the 7.5 criterion, two (RM 62.3; 7.81 and RM 51.0; 7.50) were immediately downstream from dams. The remaining zone (RM 68.7; 7.57) was immediately upstream from Bear Creek which harbors a healthy fish community (Ohio EPA 1982). The composite index value of 7.47 measured at RM 58.2, just upstream from Twin Creek, was noteworthy since it was nearly at the 7.5 level. Like Bear Creek, Twin Creek also harbored a relatively healthy and diverse fish community.

There were five (5) major depressions of the fish community within the 36.7 mile long section of the lower mainstem Great Miami River where point source discharges had a major negative impact on the fish community; 1) RM 74.9 to RM 70.4, immediately downstream from the Dayton WWTP, 2) RM 68.7 to 63.5, downstream from the Dayton metropolitan area including Moraine, West Carrollton, and Miamisburg, 3) RM 59.5 to 53.9, downstream from Franklin, 4) RM 51.0 to 47.9, which includes ARMCO-Middletown 001, the Middletown CSO area, and the Middletown WWTP, and 5) RM 44.9 to RM 42.8, downstream from the Middletown metropolitan area.

The depression between RM 74.9 and RM 70.4 corresponded with the river segment having the highest point source pollutant loadings in the study area. The major point source discharge to this segment was the Dayton WWTP (RM 76.1), which was the largest point source in the study area, contributing 64.0% of the BOD_5, 25.1% of the total suspended solids, and 73.0% of the NH_3-N loading to the entire lower mainstem Great Miami River. Several smaller point sources and the Dayton storm sewer system (urban nonpoint runoff) were located within or just upstream from this area. The trend in the community indices closely resembled the depletion and recovery of both the measured and predicted D.O. profile downstream from the Dayton WWTP.

A very sharp decrease in community parameters between RM 78.1 and RM 77.1 was attributed to a series of apparently localized impacts within this brief section of the mainstem. The sampling location at RM 77.1 was located immediately downstream from the Dayton Walther outfall (RM 77.3) and the Dayton WWTP 002 bypass (RM 77.2) and was subjected to the direct impacts of each. Dayton Walther has had significant NPDES permit violations during the past several years (Ohio EPA, NPDES permit file). Several storm sewer outfalls were also present at points adjacent to the 0.5 km sampling zone. Visual evidence of impacts were present in the form of a highly visible oil sheen, floating solids, and debris. One large storm sewer outfall located at RM 77.0 (approximate) had a very heavy oil sheen covering the water that was backed up into the sewer conduit by the mainstem river. These direct impacts apparently degraded the fish community in this zone as compared with upstream locations. Community diversity and abundance were, however, higher than levels found in the downstream segments.

The apparent recovery noted at RM 68.7 may well be due to the proximity of this sampling location with a major tributary, Bear Creek (RM 67.6). The second major depression that followed between RM 68.7 and 63.5 almost appeared to be a continuation of the previous depression. Gammon (1977b) observed the fish community to be substantially depressed throughout the entire segment between RM 74.9 and 63.5 during 1976, the second lowest flow year between 1970 and 1980. The mainstem is impounded twice in this section (RM 62.6 and 64.4) and this combined with upstream BOD loadings apparently served to depress the fish community. A mild thermal enrichment also occurred in this section of the lower mainstem, but the tolerant fauna currently present was apparently able to withstand the heat loads being discharged. The recovery in the fish community that occurred downstream from the Miami-Erie Canal dam (RM 62.6) at RM 62.3 is a common occurrence in stressed segments of impounded rivers. Although community diversity and abundance downstream from the Miami-Erie Canal dam was the highest of any mainstem location between RM 74.9 and 38.2 it was still well below that measured in the upstream segments.

The fish community downstream from the Middletown Hydraulic Canal dam (RM 56.7) did not show the characteristic increase in diversity and abundance that is usually observed. Included among the possible reasons for this are past water diversions via the Middletown Hydraulic Canal, the almost total restriction of fish to a five mile section of river between the Middletown dam (RM 51.7) and Middletown Hydraulic Canal dam, and the complete lack of any significant tributaries to serve as refuge areas and sources for repopulation. These factors combined with the cumulative effects of upstream point source loadings and the impoundment caused by the Middletown Dam create poor conditions for the maintenance of a healthy fish community.

Although some local recovery was noted community parameters downstream from the ARMCO-Middletown 001 outfall (RM 51.5) were still well below those observed upstream from and in Dayton. At this point the mainstem returned to the more natural pool-large riffle habitat which continued downstream to the impoundment caused by the Hamilton Hydraulic Canal dam (RM 41.5). The comparatively large standard error measured at RM 49.3 indicated highly variable instream conditions associated with intermittent inputs of deleterious substances. On the first and third sampling dates (July 29 and September 30) the composite index was 7.45 and 7.70, respectively; 11 species were observed on both occasions. On the second sampling date (August 19) the composite index was 3.29 and only 3 species were observed. Possible sampling error was considered, but was later ruled out as a principal cause for this low value.

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The major potential impacts in the mainstem between RM 51.7 and 47.9 were the ARMCO-Middletown Works 001 outfall (RM 51.5), eight combined sewer overflow (CSO) outfalls (003-010) from Middletown (RM 51.7-51.0), and the Middletown WWTP final effluent (001) and bypass (002) outfalls (RM 48.3-48.2). The characteristic constituents of the effluents of each include oxygen demanding substances, ammonia, heavy metals (primarily Zn), cyanide, and phenolics. In addition, approximately 20 additional complex organic compounds were detected in the Middletown sanitary sewage system which, under certain conditions, could enter the mainstem via the WWTP or the CSO system. The impact observed at RM 49.3 at least corresponds in location and type of impact (i.e., intermittent) to the eight CSO outfalls located 0.7-1.4 miles upstream. A similar type of coincidental pattern was observed by Altfater et al. (1981) in the Sandusky River adjacent to the CSO area in Bucyrus, Ohio. Visual evidences of impact were present downstream from RM 51.0 in the form of an oil mark on the banks and overhanging vegetation indicating past "spills". The flow hydrograph for the USGS gage at Hamilton (RM 35.7) indicated a relatively sharp increase in flow on August 19, a good indication that a significant runoff event took place just prior to that date. The degradation observed at RM 47.9 was more indicative of an acute toxic impact associated with the Middletown WWTP (RM 48.3), but effects from the described upstream impacts could not be ruled out. The toxicity of several of the substances present in the discharges located in this area can be increased by the presence of other substances or by higher temperatures and low D.O. The toxicity of cyanide and ammonia together, for example, is greatly increased even at levels at which each alone would be relatively harmless (Doudoroff 1976). Certainly the potential for these interactions is present, but the observed degradation cannot be attributed to any one source, substance, or a combination of either without further monitoring. Static bioassays have been conducted on the Middletown WWTP effluent, but little acute toxicity was found, at least on the dates that the tests were performed (Ohio EPA, NPDES permit file).

Another factor that may have contributed to the observed degradation between RM 51.0 and 47.9 is the almost total lack of refugia or opportunity for recruitment from nearby tributaries. The only significant tributary in this segment of river is Dicks Creek (RM 47.6) which has been degraded by discharges from the ARMCO-Middletown Works (Ohio EPA 1976, 1980b). The Hamilton Hydraulic Canal dam (RM 41.5) prevents any movement of fish from downstream into this 10 mile section of river. Therefore any repopulation of this section must come from upstream areas which are currently degraded. Griswold et al. (1982) attributed the lack of complete fish community recovery in an unchannelized section of the Little Auglaize River (northwest Ohio) following a period of severe drought to the lack of adjacent refuge areas and blockage of reinvading fish by a low head dam. The macroinvertebrate fauna at the same location, however, recovered to pre-drought levels within one year. A downstream channelized section in the Little Auglaize River that had uninhibited access to adjoining streams was repopulated to pre-drought levels within one year. These results are consistent with the set of circumstances prevalent in the study area between the Middletown Hydraulic Canal (RM 56.7) and Hamilton Hydraulic Canal (RM 41.5) dams.

The brief recovery of the fish community that occurred through RM 44.9 was again followed by a decline in community parameters at RM 42.8 in the Hamilton Hydraulic Canal dam pool. Again, this decline was attributable to the combined effects of impoundment (i.e., low reaeration) and upstream pollutant loadings in the Middletown area. From RM 42.8 through RM 38.2 the fish community steadily improved as evidenced by the composite index and number of species.

The recovery of all community parameters at RM 35.6 returned community values to their highest levels in 39.3 miles, but still below those observed in and upstream from Dayton. The relative density of fish at RM 35.6 approached levels observed upstream from Dayton and was 2-3 times that observed at adjacent mainstem locations. The improvement occurred in spite of the presence of two major dams (RM 41.5 and 37.2), the ARMCO-New Miami Works (RM 38.7-39.3), and the diversion of mainstem flow via the Hamilton Hydraulic Canal (RM 41.5), and the occurrence of massive fish kills in this area during 1976. The relatively large standard error measured at RM 38.2, just downstream from the confluence with Four Mile Creek (RM 38.4), is perhaps indicative of temporarily adverse conditions much the same as that observed at RM 49.3 near Middletown. The Hamilton dam (RM 37.2) is the first barrier to upstream fish movement in the lower mainstem and as such restricted the occurrence of many typical large river species (e.g., smallmouth buffalo, longnose gar, sauger, mooneye, skipjack herring, etc., Funk 1970) to the lower 37.2 miles of the mainstem. In contrast, the mainstem of the Scioto River is dam free for the lower 129.8 miles and many of these typical large river fishes occur well upstream from the Ohio River (Yoder et al. 1981). The addition of these species to the fish fauna should serve to increase community diversity and abundance, as was observed at RM 35.6.

The minor decline in the fish community at RM 33.7 and 28.9, downstream from the Hamilton WWTP (RM 34.0), Hamilton South WTP (RM 33.9), and Fairfield WWTP (RM 32.0), was brief and was an indication that these point sources exerted a relatively minor impact. The recovery trend initiated at RM 35.6 resumed at RM 26.1 and continued through RM 18.2 where the composite index reached its highest point since RM 78.1, nearly 60 miles upstream. This demonstrated that the lower mainstem is capable of supporting a healthy and diverse fish fauna typical of large river systems.

Several factors together may have contributed to the decline that took place between RM 18.2 and 4.9. An instream sand and gravel operation located just upstream from RM 18.2 caused a visual increase in turbidity and siltation, but this influence was localized. The Gulf Oil discharge at RM 9.1 may have been a factor since a slight, but visible oil sheen was noticed downstream to RM 7.9. This facility also has had a record of significant NPDES permit limit violations in the past (Ohio EPA, NPDES permit file), but loadings reported for all substances in 1980 appeared to be minimal. The mainstem also underwent a change in habitat from a pool-large riffle system with a sand-gravel-rubble substrate to a series of long pools and bedrock ledges with a rubble-boulder-bedrock substrate. Downstream from the confluence with the Whitewater River (RM 6.6), the character of the mainstem again changed to a large, slow moving river with very large outside bends, high cut earthen banks, and a fine substrate of sand-gravel and silt. Sediment deposits were

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more extensive in the lower 5 miles of the mainstem than in any other section upstream. The lower 5 miles are also backed up by the Ohio River, the exact number of miles being dependent on the stage height of the impounded river. This latter effect has resulted in a reduction in habitat complexity and apparently contributed to the decline in community abundance and diversity observed at RM 4.9. A similar decline in community parameters in the lower 10-15 miles of the mainstem Scioto River was also correlated with similar changes in habitat (Yoder et al. 1981). Possible secondary effects from upstream loadings (i.e., diel D.O. variations, nutrient enrichment, etc.) cannot be ruled out as an additional contributing factor. The normal or expected downstream trend in fish community diversity is one of steady increase via species addition (Burton and Odum 1945; Sheldon 1968; Jenkins and Freeman 1972; Whiteside and McNatt 1972; Cashner and Brown 1977). Funk (1970) attributed this pattern to the increasing complexity of habitat with distance downstream. However, this pattern has been documented only in streams as high as 4th or 5th order. Vannote et al. (1980) hypothesized that overall aquatic community diversity in lotic environments increases through orders 3-5, but then decreases as stream order increases further. The lower mainstem Great Miami River reaches order 7 or 8 in this section and may well be reflecting the trend hypothesized by Vannote et al. (1980).

The lower 8.3 miles of the Whitewater River contained a fairly diverse assemblage of fishes typical of medium to large sized rivers, but somewhat less than what was expected. Extreme flow variations caused by the controlled releases at the Brookville Reservoir (located some 30 miles upstream) may have been responsible for a slight depression of the fish community. Composite index values were higher than those found in the adjacent mainstem Great Miami River and this difference was due in part to the different levels of impact to which each was subjected. The habitat of the Whitewater River is not strikingly different from the mainstem Great Miami River upstream from RM 5.0, but contains several species (i.e., Moxostoma) typical of large rivers that the mainstem lacks in abundance. It should not, however, be used as a direct comparison with the lower mainstem downstream from RM 5.0 since the habitats between the two are somewhat different.

Sublethal Stress Indicator: External Anomalies

The relative incidence of external anomalies such as tumors, lesions, eroded fins, and parasites on all fish was assessed in the 91 mile study area as a possible indication of sublethal stress. Pippy and Hare (1969) observed external ulcers (or lesions) and eroded fins on Atlantic salmon (Salmo salar) and white suckers (Catostomus commersoni) in the Miramichi River (New Brunswick). They concluded that an increase in copper and zinc levels, and temperature, enhanced the production of an epizootic (Aeromonas liquefaciens) which was blamed for the abnormalities and some mortalities. Larimore and Smith (1963) observed similar deformities (eroded fins) in certain polluted Illinois streams and hypothesized that embryonic development of the fish was affected by toxic substances. Yoder et al. (1981) observed the highest frequency of external anomalies in a segment of the mainstem Scioto River that

received primarily urban nonpoint runoff and combined sewer overflows. Berra and Au (1981) observed an overall affliction rate of 0.26% among the fish community in Cedar Fork Creek in north central Ohio which was estimated to be a normal, background condition. These results appear to be applicable to the results observed in the study area (Table 42) because of the resemblance of the abnormalities (lesions, eroded fins) and the environmental conditions.

The frequency of external anomalies among individual fish (all species combined) ranged from a low of 0.5% at RM 17.1 to a high of 24.8% at RM 65.9. The frequency of occurrence in the five major tributaries was generally less than 4%. The longitudinal pattern in the frequency of external anomalies was correlated with major sources (both point and nonpoint) of potential stress in the study area. An increase from upstream rates measured at RM 91.0 (3.2%) and RM 88.1 (1.5%) was observed at RM 86.2 (5.5%) and RM 83.3 (11.1%), both of which are downstream from the Ohio Suburban WWTP (RM 87.4). The frequency of occurrence showed an overall increase in segment 3 (9.4%) with high values of 14.2% and 10.5% at RM 81.8 and 78.1, respectively. This segment is directly affected by inputs from the nearly 250 storm sewer outfalls that carry urban nonpoint source runoff and industrial process wastes from the Dayton metropolitan area. The rate of external anomalies declined in segment 4 (5.9%) with individual location frequencies ranging from 4.0 to 8.2%. Both the highest segment (15.3%) and individual location (24.8%; RM 65.9 and 21.1%; RM 70.4) frequencies occurred in segment 5 which is downstream from the Dayton metropolitan area, which was the largest concentration of point sources and urbanization in the study area. After declining somewhat through segments 6 (5.5%) and 7 (4.3%), the frequency of external anomalies increased to 17.9% at RM 40.2. This location is immediately upstream from the ARMCO-New Miami discharges (RM 38.7-39.3), but it was subjected to runoff from the steel making complex and recirculation of the mainstem during low flow periods. A visible oil sheen was present at this location during the last two sampling passes and river flow was relatively low. The frequency declined through the remainder of the study area, but most values were higher than those observed upstream from Dayton.

These results agree well with the degradation observed in terms of fish community structure (composition, abundance, diversity) downstream from the Ohio Suburban WWTP and the Dayton metropolitan area. The frequency of external anomalies in the other sections of the mainstem that had structurally degraded fish communities was generally higher than the apparent background rate of 1 to 3%, but not to the extent of the aforementioned areas. The comparatively high frequency of external anomalies observed in the segment adjacent to downtown Dayton (RM 81.8 to 77.1) seemingly conflicted with the "good" (Class II) rating that this segment received based on structural criteria (Table 41). However, the comparatively large standard errors and declining trends observed throughout this segment were suggestive that some stress was present. This situation parallels that observed in a mainstem segment of the Scioto River that was subjected to similar urban impacts (Yoder et al. 1981). The production of the ubiquitous epizootic (Aeromonas) is evidently enhanced by such conditions and by a lowered resistance of the individual fish due to environmental stress (Sniezko 1962).

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Table 42: Incidence (% occurrence) of external lesions, tumors, eroded fins, and parasites in fish (all species) in the lower mainstem Great Miami River study area during July-October 1980.

Segment	River Mile	Percent Affected	Segment Average	Segment	River Mile	Percent Affected	Segment Average
1	91.0	3.2	2.4	7	51.0	7.0	
1	88.1	1.5		7	50.2	1.3	
				7	49.3	3.5	
2	86.2	5.5	8.3	7	47.9	6.7	4.3
2	83.3	11.1		7	46.8	3.6	
				7	44.9	4.8	
Stillwater River	82.6, 0.7	3.7	-	7	42.8	3.0	
3	81.8	14.2		8	40.2	17.9	11.0
3	80.7	7.9	9.4	8	38.2	4.1	
3	78.1	10.5					
3	77.1	4.7		Four Mile Cr.	38.4, 0.3	4.4	-
Mad River	81.5, 1.2	4.2	-	9	35.6	8.3	
				9	33.7	2.0	3.5
4	74.9	8.2		9	28.9	2.6	
4	73.6	4.0	5.9	9	26.1	1.2	
4	72.9	7.3					
4	71.8	4.1		10	23.6	6.0	
				10	18.2	2.4	2.8
5	70.4	21.1		10	17.1	0.5	
5	68.7	7.6	15.3	10	11.6	2.5	
5	65.9	24.8					
5	63.5	7.6		11	7.9	5.7	
				11	4.2	2.2	3.8
6	62.3	6.3		11	0.9	3.4	
6	59.5	8.8					
6	58.2	4.0	5.5	12[a]	6.6,8.2	2.4	
				12[a]	6.6,3.6	0.7	3.5
6	56.5	7.2		12[a]	6.6,0.9	7.3	
6	53.9	3.6					
Twin Cr.	57.4, 0.3	2.8	-				

[a] Whitewater River

Comparison With Previous Surveys

Previous surveys of the fish community in the study area consist of efforts by Scott (1968, 1969a) and Conn (1973), both of the Miami Conservancy District (MCD). These studies generally documented good fish communities upstream from Dayton, marginally stressed communities in Dayton, and degraded communities downstream from Dayton, Middletown, and Hamilton. Two later surveys by Yoder and Gammon (1975) and Gammon (1977b) of the mainstem between Dayton and Franklin considered relative abundance type data using methods similar to those used in the 1980 survey.

Yoder and Gammon (1975) sampled nine locations in June and November, 1974 and seven locations in July, 1975, all in the mainstem between RM 89 and RM 63. Their sampling method was the same as that used by Ohio EPA in 1980, except that sampling zones were shorter (0.2-0.3 km) and each was fished only once or twice. Gammon (1977b) sampled 21 locations between RM 89 and RM 58 during June-September, 1976 which included two locations each in the lower Stillwater and Mad Rivers. The sampling method used was a battery powered electrofishing unit fished from a 10' john boat in a manner similar to that used by Ohio EPA in 1980. The results of both surveys were compared to the 1980 results, but with qualification because of the differences in sampling coverage and gear used.

Generally, the results of both previous surveys agreed with those of the 1980 Ohio EPA survey. The mainstem fish community was diverse and abundant upstream from Dayton and was predominated by redhorse (Moxostoma), smallmouth bass, rock bass, and longear sunfish in 1974, 1975, and 1976 (Yoder and Gammon 1975; Gammon 1977b). Composite index values based on short distances (0.2-0.3 km) and one pass ranged from 7-8 in 1974 and 1975, which was less than the 9-9.5 range observed in 1980. Gammon (1977b) found healthy fish communities of a similar composition in 1976. The most diverse and abundant assemblage of fish was found in the lower 3 miles of the Stillwater River. The different sampling method used in 1976 made direct comparisons of community indices (i.e., composite index, density, biomass) with those of the 1980 survey inadvisable. The relative longitudinal trend observed in 1976, however, was different than that found in this segment of the mainstem in 1980. The 1976 results did not reveal the decline observed in 1980 downstream from the Ohio Suburban WWTP.

Both the 1974-75 and 1976 studies showed the first indications of possible environmental stress adjacent to downtown Dayton between RM 82 and 77. The increasing numerical importance of common carp, white sucker, and gizzard shad along with composite index values in the 4-6 range were observed during 1974-75. Gammon (1977b) observed evidence of intermittent stress in this area, especially during June, 1976 when community parameters were substantially lower than those observed upstream from Dayton. Although recovery was noted throughout the remaining summer months, pollution tolerant species such as common carp, goldfish, and white sucker increased in abundance. The highest diversity in the segment was found immediately downstream from the Steele dam (RM 82.2). These results, with few exceptions, basically agree with the observations of the 1980 survey.

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Downstream from the Dayton WWTP (RM 76.1) community parameters declined sharply and the community was predominated by stress tolerant species (i.e., common carp, goldfish, and their hybrids). Composite index values in 1974 and 1975 ranged from 3.3-6.5 between RM 72 and RM 63, although the presence of clean water species such as hog sucker (Hypentelium nigricans) and smallmouth bass was noted in July, 1975 following a period of unusually high river flow. In 1976 Gammon (1977b) found the section of the mainstem between RM 76 and RM 62 to be the most degraded in the 31 mile long study area. Density decreased 3-4 times compared to upstream and no fish were present at two sampling locations on two dates near Miamisburg (RM 67). Of the fish that were collected in this segment most were small, young fish. The fish community was predominated almost totally by common carp, goldfish, and their hybrids, with a small percentage of white sucker. The trend in the composite index was highly correlated with the longitudinal pattern of minimum D.O. concentrations in this segment. Downstream from the Miami-Erie Canal dam (RM 62.3) near Chautaqua community parameters showed improvement, but catches were still dominated by common carp and goldfish with green sunfish and longear sunfish becoming more numerous. The recovery reached its highest point at the most downstream sampling location (RM 58.9), but was not considered to be complete. Overall, the fish community was rated excellent upstream from Dayton (RM 89-82), good to fair in Dayton (RM 81-77), fair and mostly poor downstream from Dayton (RM 76-59), and fair at the last sampling location (RM 58.9) (Gammon 1980).

At first glance it would appear that there has been some improvement in the mainstem fish community between RM 76 and 62 from 1976 to 1980. This segment was rated "fair" (Class III) by the 1980 survey and at least partial recovery within the segment was noted. Gammon (1977b, 1980) rated most of this segment as "poor" (corresponding to Ohio EPA Class IV) with two locations on two dates having no fish; however the flow regimes during the two surveys were quite different.

River discharge is an important factor in determining and controlling water quality in flowing water environments. Annual and seasonal variations in river discharge occur somewhat regularly and are a primary determinant of pollutant concentrations in the water column. Under generally constant loading conditions pollutant concentrations are highest under the lowest flows and vice versa. Low flow periods are the times of greatest concern, hence water quality based effluent limits are established to meet water quality standards during these periods. Because river discharge has such an important effect on pollutant concentrations, it is very influential in determining the composition, distribution, and abundance of river fish communities.

The mean third quarter (July-September) flow during 1976 at Miamisburg (RM 67.0) was 691 cfs which was 30% of the flow during the same period in 1980 (2291 cfs). The mean flow measured in 1976 was the second lowest between 1970 and 1980 whereas the 1980 mean flow was the third highest (Table 23). In addition, the flow during the two months preceding the June-September, 1976 sampling period was well below normal (USGS 1977). In contrast, the flows during the months preceding the July-October, 1980 survey were well above normal as was the preceding year of 1979 (USGS 1980). Total point source pollutant loadings to this segment (RM 76.1-62.7) showed an increase between

1976 and 1980. Total BOD_5, TSS, and NH_3-N all increased by 1.73, 1.13, and 3.02 times between 1976 and 1980, respectively. There was, however, a loading reduction between 1979 and 1980 which was due to the phase out of the Moraine WWTP (RM 73.7) and the start up of the new Montgomery County Western Regional WWTP (RM 71.5) in late 1979. During the 1976 to 1980 period the Dayton WWTP (RM 76.1) increased its mean third quarter BOD_5 load from 2508 kg/day to 8165 kg/day (a 226% increase) while effluent volume increased only 19% (50.6 to 60.8 MGD). These increases completely overshadowed the apparrent improvements brought about through the elimination of the Moraine WWTP and addition of the Montgomery County Western Regional WWTP. Under the 1980 loadings and with flow conditions similar to those observed in 1976 the degradation to the mainstem fish community in this segment (RM 76-62) would be equivalent to or more severe than that observed by Gammon (1977b) in 1976.

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BENTHIC MACROINVERTEBRATES

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Benthic macroinvertebrates have been widely used in recent years in pollution studies involving flowing waters. The group has a number of characteristics that make them useful as indicators of water quality. They form permanent or semi-permanent stream communities, are less transient than fish, are less sporadic in occurrence than microorganisms, and usually occur in statistically significant numbers even in small streams. Species composition and community structure of the benthos are determined by environmental factors that have existed throughout the life span of the organisms. Consequently, most types of pollution, whether long or short term in exposure, can alter the existing community structure. The nature and magnitude of the community alteration depend upon the nature and severity of the environmental change.

Methods

Thirty-eight stations were established in the lower mainstem Great Miami River in the summer of 1980 to evaluate water quality by monitoring the existing benthic macroinvertebrate communities. Two stations each were located in the lower Mad River and the Stillwater River while 34 were located on the Great Miami mainstem (Figure 18). Station locations and descriptions can be found in Appendix C.

The primary sampling equipment used for collection of benthos consisted of modified Hester-Dendy multiple-plate artificial substrate samplers (Hester and Dendy, 1962). The samplers were constructed of 1/8 inch tempered hardboard cut into three inch square plates and one inch square spacers. A total of eight plates and twelve spacers were used for each sampler. The plates and spacers were placed on a 1/4 inch eyebolt so that there were three single spaces, three double spaces, and one triple space between the plates. The total surface area of each sampler, excluding the eyebolt, was 145.6 square inches.

Five samplers were exposed at each station for a seven week period spanning July 7 to September 3, 1980. Installation of the samplers on the stream substrate was accomplished by securing the five samplers to a concrete construction block which served to anchor them in place and prevent their contact with the natural substrate. The samplers were placed in runs rather than pools or riffles and an attempt was made to establish stations in as similar an ecological situation as possible.

Retrieval of the samplers consisted of cutting them from the block and placing them in one quart plastic containers while still submersed. Care was taken to avoid jolting the samplers and thereby dislodging any organisms. Formalin was then added to approximate a ten percent solution. All samplers were transported to the laboratory for subsequent analysis.

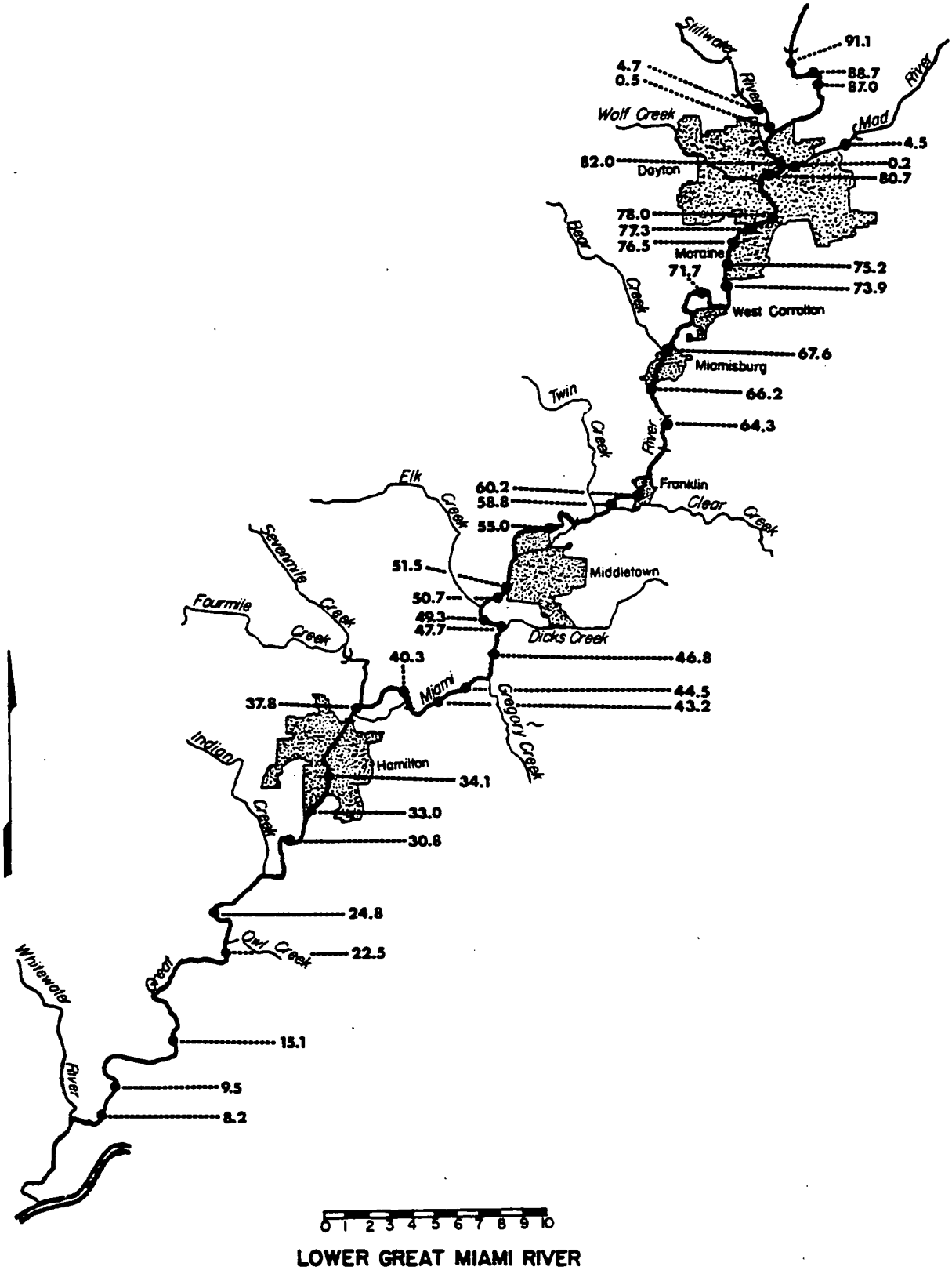

Figure 18. Sampling locations for benthic macroinvertebrates in the lower mainstem Great Miami River, July - September, 1980.

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Qualitative samples from the natural substrate were collected at the time of retrieval of the multiple-plates. Dip net samples were taken in a river segment approximately 20 yards long in the area where the samplers were exposed. The qualitative sampling continued until, by gross examination, no new taxa were being collected.

The multiple-plates were dismantled in the laboratory and the colonizing organisms were screened from the debris using number 30 (0.600 mm openings) and number 40 (0.425 mm openings) U.S. Standard Testing Sieves. Larger organisms were hand picked from the number 30 screen and preserved in 70 percent alcohol. The smaller number 40 screen material was washed into a separate jar containing 70 percent alcohol.

Identifications and counts were made using dissecting and compound microscopes. Where identification of large numbers of organisms was impractical, a Folsom sample splitter was used to obtain a subsample. Unidentifiable early instar nymphs and larvae collected in the number 40 screen were counted under magnification and their numbers extrapolated into the identified taxa of their respective major groups. Identifications were made using keys and illustrations from the following taxonomic guides: Beck and Beck (1966), Brown (1972), Burch (1973), Burks (1953), Edmunds et al. (1976), Frison (1935), Harman and Berg (1971), Hilsenhoff (1970), Hobbs (1972), Holsinger (1972), Klemm (1972), Lewis (1974), Merritt and Cummins (1978), Pennak (1978), Roback (1957), Ross (1944), Usinger (1956), Walker (1958), Walker and Corbet (1975), Ward and Whipple (1959), Wiggins (1977), and Williams (1972). Dipterans of the family Chironomidae were prepared for identification following the methods described by Mason (1973).

After the samples were identified and quantified, a species diversity index ($\bar{d}$) was calculated for each station using the modified Shannon formula (1948):

$$\bar{d} = - \sum_{i=1}^{s} \frac{n_i}{n} \log_2 \frac{n_i}{n}$$

where: "n_i" is the number of individuals in the ith taxa,
"n" is the total number of individuals, and
"s" is the total number of taxa.

Coefficients of similarity based on prominence values assigned to each taxa were also calculated. These values were calculated by multiplying the density of a taxon by the square root of its frequency (Beals 1961; Burlington 1962). The prominence value made possible a comparison of the stations on the basis of a single number which considered both frequency and density. Using the prominence values, the coefficient of similarity (c) between two stations was calculated employing Van Horn's equation (Van Horn 1950) modified from the general formula described by Gleason (1920):

$$c = \frac{2W}{a + b}$$

where: a is the sum of the prominence values of all of the taxa at one station,
b is the sum of the prominence values of all of the taxa at the other station, and
W is the sum of the prominence values of all of the taxa of one station which it has in common with the other station. The lower of the two resulting values of W was used in the equation.

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The Use of Benthic Macroinvertebrates in Water Quality Evaluations

Water quality evaluations using benthic macroinvertebrates were based on the thesis that characteristic assemblages of these organisms occur in waters of varying physical and chemical properties. In streams of high water quality and suitable habitat, a stable, well balanced benthic community usually exists. The organisms in these areas are usually predominated by the more pollution sensitive groups such as stoneflies, mayflies, and caddisflies. The more tolerant groups such as oligochaetes, pulmonate snails, and many dipterans are often represented by a few species in low numbers. When the water quality is adversely impacted, the sensitive groups will decline in number or be eliminated and pollution tolerant groups that are present may greatly expand in number. All types of organisms may be absent if extreme toxic conditions exist.

The number of benthic taxa present in a given stream segment is as important as the composition of the benthic community in determining water quality. Previous water quality investigations in Ohio streams have indicated that the number of taxa colonizing modified Hester-Dendy multiple-plate samplers range from 3 in grossly polluted areas to over 40 in very high water quality stream segments (DeShon, et al. 1980). The number of taxa is usually not less than 30 in high quality areas and not more than 20 in degraded areas.

Water quality indices commonly used with macroinvertebrate collections include those based on mathematical functions of diversity and similarity in benthic communities. The Shannon diversity index is a function of the number of taxa, the total number of individuals, and the distribution of those individuals among the taxa. Unlike some diversity indices, $\bar{d}$ distinguishes taxa of different abundance. The index strongly reflects population imbalances that may not be readily apparent in the tabulated data. A minimum of 100 organisms is needed to calculate this index. Previous investigations of Ohio streams have revealed a range of index values from a low of less than 0.01 in a grossly polluted area to 4.12 in a stream exhibiting very good water quality (DeShon et al. 1980). Wilhm (1970) reported that clean streams often have $\bar{d}$ values between 3 and 4.

The coefficient of similarity compares benthic communities from two different areas. The communities can be from stream stations on the same river or from different rivers. Uniformity of habitat and sampling technique must be maintained for the coefficient to be valid. The coefficient of similarity measures the extent to which two communities resemble each other biologically. The coefficient is determined by using either qualitative or quantitative data. Coefficients employing qualitative data are based on the presence or absence of taxa at each site as well as those taxa the two stations have in common. Coefficients based on quantitative data use the same concept but employ the numerical data collected. A coefficient ranges from 0.0 (complete dissimilarity) to 1.0 (complete similarity). A value greater than or equal to 0.65 has been generally accepted as indicating high similarity between samples (Hanson 1955; Hurd 1961; Beckett 1977).

Previous Benthic Investigations in the Lower Great Miami River

A large amount of biological data has been collected from the lower Great Miami River basin in the past two decades with particular emphasis on the benthic community.

The Miami Conservancy District has been quite active in maintaining an ongoing benthic monitoring program in the basin (Scott 1968, 1969b; Conn 1971, 1972, 1973, 1977a, 1977b). In these studies, qualitative benthic data were collected and then analyzed using the Biotic Index (BI) developed by Beck (1954). This index consisted of assigning benthic organisms to three classes of tolerance: intolerant, intermediate, and tolerant. A numerical score (the Biotic Index) was then obtained by adding the number of types of intermediate organisms to twice the number of types of intolerant organisms. High Biotic Index values indicated good water quality. A value of 10 was considered the minimum value and designated marginally good water conditions.

Although these data were not directly applicable to this quantitative study, some general conclusions on past water quality in the basin were made. Scott (1968, 1969b) presented data collected in 1966 and 1969, respectively. Based on the Biotic Index, water quality in the lower Great Miami mainstem for a 60 mile stretch downstream from Dayton to New Baltimore (RM 80.2 - 21.4) was poor. All index values were below 10 except for two 1969 values, one (BI = 17) collected at RM 77.4 and the other (BI = 16) at RM 55.0. Upstream from RM 80.2 and downstream from RM 21.4, water quality was good (all BI's greater than 10). Conn (1973) presented data collected from the same stations in 1972. Again, poor water quality was found from Dayton (RM 80.2) to Hamilton (RM 34.0) with the same two exceptions at RM 77.4 (BI = 15) and RM 55.0 (BI = 13).

Conn (1977a,b) sampled five sites on the lower mainstem in 1977. These stations were not the same as those sampled in previous years, but many were located near the original sites. He also sampled stations on the Mad River and the Stillwater River and compared the results with those collected in 1972 from the Mad River (Conn 1972) and in 1971 from the Stillwater River (Conn 1971). Water quality in the lower Great Miami River mainstem remained comparable to previous years with marginally good water quality upstream from RM 77.3 (BI = 11) and subsequent degradation for long distances downstream (all BI's less than 10). Water quality improved only in the extreme lower reaches of the river near RM 5.7 (BI = 10). Water quality in the Stillwater River downstream from RM 27.7 to the confluence with the Great Miami River was apparently degraded to some degree between 1971 and 1977. Biotic Index values from two stations in that segment decreased from highs of 47 and 36 in 1971 to lows of 16 and 20, respectively, in 1977. Although these lower values were still considered indicative of good water quality, the decreases were considered significant. Water quality in the Mad River apparently improved at a station near the mouth (RM 1.6) and remained the same at two stations farther upstream (RM 6.0 and RM 10.0) between 1972 and 1977. Biotic Index values for both years were greater than 10 at all three sites.

A study of much greater comparative importance was undertaken in 1976 on the lower Great Miami River, the Stillwater River, and the Mad River (Beckett et al. 1976; Beckett 1977). Fourteen stations were established on the three rivers and were sampled in June, August, and September. The sampling equipment used was a multiple-plate artificial substrate sampler of the modified Hester-Dendy type. Six samplers were exposed to colonization at each site for a six or seven week period. Shannon diversity indices were calculated as well as coefficients of similarity based on a qualitative technique. A summary of the benthic data collected in August can be found in Table 43. Beckett concluded that stations on the Stillwater River (RM 4.7) and the Mad River (RM 3.7) along with the two farthest upstream stations on the Great Miami River (RM 91.1 and RM 77.8) had relatively good water quality although all but the station at RM 77.8 seemed to show some pollutional stress. Poor water quality was encountered in the Great Miami River downstream from the Dayton Power and Light Tait EGS (RM 77.1) to the end of the study area at RM 57.4. The degradation was attributed to dissolved oxygen sags due to high biological and chemical oxygen demands caused by the numerous industrial and wastewater treatment plant effluents along this segment of the river. Some recovery occurred towards the end of the study area, but water quality never returned to the level observed at RM 77.8.

More detailed August data from Beckett (1977) were included where applicable in the following pages evaluating the 1980 Ohio EPA information. Caution was taken in making direct comparisons between the two sets of data because of some differences in methodology. Some of the stations used by Beckett (1977) were located in the mixing zones of major WWTP's while those in this study were placed at least one mile downstream. Site selection in general was somewhat different. Many Beckett sites were located in pooled areas with little or no detectable current while stations in this study were located in runs with good current.

Also included where applicable were summary data (i.e., number of taxa, diversity index, composition) collected from the lower Great Miami River basin since 1976 by the Biomonitoring Section of the Ohio Environmental Protection Agency (OEPA). These data were collected from National Ambient Water Quality Monitoring Network (NAWQMN) sites as well as various State of Ohio fixed pollution monitoring stations. Data collection and analysis were consistent with the methodology used in this report. Stations were located on the Great Miami mainstem at river miles 87.1, 67.7, and 22.1, on the Mad River at river mile 9.9, and on the Stillwater River at river mile 1.9. Tabulated data from these stations can be found in reference document three of Ohio EPA (1980a).

Benthic Macroinvertebrate Survey in the Lower Great Miami River, Summer, 1980

The biological criteria used to evaluate water quality at the stations established in the lower Great Miami River Basin were: (1) the types of benthic macroinvertebrates present, (2) the number of benthic taxa colonizing the artificial substrate samplers, (3) the diversity index, $\bar{d}$, modified from Shannon (1948), and (4) the coefficient of similarity, c, described by Beals (1961) and Burlington (1962). A summary of the benthic data collected from the lower Great Miami River basin can be found in Table 44. Tabulated data for each station can be found in Appendix C, Tables C-1 through C-8.

Table 43. Summary of benthic data collected on artifical substrate samplers from the Great Miami River mainstem, June 21 to August 9, 1976 (modified from Beckett *et al*. 1976)

River Mile	No. Organisms/Ft^2	Taxa	Diversity Index
Mad River			
3.7	103	25	3.00
Stillwater River			
4.7	36	18	2.78
Great Miami River			
91.1	175	20	3.22
77.8	113	27	3.12
77.1	107	11	1.72
75.8	134	5	0.48
73.7	171	10	1.87
72.4	57	17	2.66
67.8	79	9	0.98
65.0	181	17	2.28
64.6	89	20	2.70
64.3	76	12	1.60
62.5	171	16	2.37
57.4	88	17	2.35

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Table 44. Summary of benthic data collected on artificial substrate samplers from the Great Miami River mainstem and two tributaries, July-September, 1980

River Mile	No. Organisms/Ft.^{2}	No. Taxa	Diversity Index
Stillwater River			
4.7	1117	19	2.04
0.5	299	28	2.23
Mad River			
4.5	892	31	3.02
0.2	209	31	3.57
Great Miami River			
91.1	433	34	3.44
88.7	1190	18	2.65
87.0	1082	24	2.80
82.0	769	31	3.40
80.7	469	32	3.65
78.0	472	28	3.57
77.3	293	28	3.40
76.5	313	26	3.34
75.2	375	24	3.33
73.9	1307	28	3.31
71.7	1631	23	2.18
67.6	1091	31	3.30
66.2	251	24	3.33
64.3	479	24	3.59
60.2	2192	19	2.65
58.8	580	27	3.58
55.0	857	29	3.61
51.5	845	31	3.99
50.7	987	29	3.27
49.3	654	29	3.62
47.7	332	26	3.41
46.8	920	26	3.68
44.5	912	34	3.73
43.2	1738	24	2.65
40.3	425	26	3.62
37.8	232	25	2.99
34.1	375	31	3.82
33.0	397	30	3.91
30.8		18[a]	
24.8		13[a]	
22.5		26[a]	
15.1	847	27	3.10
9.5	711	22	3.09
8.2		22[a]	

[a] Number of qualitative taxa; quantitative data not available.

Quantitative and qualitative data were collected at 34 of the 38 stations. At four stations, artificial substrates were lost and only qualitative samples were taken. For purposes of facilitating presentation of the data, the 34 stations on the lower Great Miami mainstem were divided among the 11 river segments. The boundaries of these segments were delineated by the presence of major dams and/or significant dischargers. In the following discussion of the benthic data, some of these segments were combined in order to provide a sufficient number of sampling stations for an accurate segment evaluation (Table 45). Discussions of the stations located on the Stillwater River and the Mad River were included with the discussions of the stations in Segments 1-2, the location where both rivers join the lower Great Miami mainstem.

Segments 1-2

Segments 1-2 (RM 92.6 - RM 80.1) consisted of the segment of the Great Miami mainstem from the Taylorsville Dam to a few miles downstream from the Steele Dam in downtown Dayton. Five stations were located in these segments at RM 91.1, 88.7, 87.0, 82.0, and 80.7 (Figure 18). Also included in these segments were stations at RM 0.5 and 4.7 on the Stillwater River (confluence with Great Miami River at RM 82.6) and RM 0.2 and 4.5 on the Mad River (RM 81.5). Known discharges to these segments included effluent from the Ohio Suburban WWTP (RM 87.4 and nearly 250 storm sewer outfalls in the downtown Dayton area. No known significant dischargers were located near the sites on the Stillwater River, but several small industrial sources discharged to the lower Mad River.

Thirty-five (35) taxa were collected from the artificial substrates located at the two stations on the Stillwater River (Appendix C, Table C-1). Predominant taxa at both stations included the mayfly Stenonema and the caddisflies Cheumatopsyche and Symphitopsyche, while oligochaetes and chironomids were present in low numbers. Nineteen taxa were collected at RM 4.7 and 28 taxa were collected at RM 0.5 and diversity indices were 2.04 and 2.23, respectively (Table 44). The above values seemed to indicate some degradation of water quality at RM 4.7 as was also indicated by previous investigations (Conn 1977; Beckett 1977). Beckett (1977) reported 18 taxa collected and a diversity index of 2.78 at his station at river mile 4.7 (Table 43). This apparent degradation at Station 4.7 appeared to have been of recent origin since Conn's survey in 1971 reported good water quality throughout the river. The reason for the poor water quality was unknown, although nonpoint source pollution was a possibility due to increased residential development along this segment of the river. Water quality in the Stillwater River seemed to improve to some degree near the confluence with the Great Miami River. The fixed station monitoring conducted in 1976 and 1977 by the OEPA Biomonitoring Unit at RM 1.9 collected benthic communities comprised of 29 and 23 taxa with diversity indices of 3.33 and 3.27, respectively. This was in reasonable agreement with the 1980 values of 28 taxa and a diversity index of 2.23 at RM 0.5. The low diversity index was caused by a large number of mayflies of the genus Stenonema which comprised 53 % of the sample.

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Table 45. Stream segment delineations on the lower mainstem of the Great Miami River for the thirty-four benthic stations.

Segments	Description of Segment	Inclusive River Miles
1-2	Taylorsville Dam to downstream from Steele Dam.	92.6 - 80.1
3-4	Downstream from Steele Dam to upstream from Montgomery County Western Regional WWTP.	80.0 - 71.6
5	Montgomery County Western Regional WWTP to Miami-Erie Canal Dam.	71.5 - 62.7
6	Downstream from Miami-Erie Dam to Middletown Dam.	62.6 - 51.7
7	Downstream from Middletown Dam to Hamilton Hydraulic Dam.	51.6 - 41.5
8-9	Downstream from Hamilton Hydraulic Dam to DOE - Feed Materials Production Center.	41.4 - 24.8
10-11	DOE-Feed Materials Production Center to Ohio River	24.7 - 0.0

Forty-four (44) taxa were collected from the artificial substrates located at the two stations on the Mad River (Appendix C, Table C-1). Thirty-one taxa were collected at each site and diversity indices were 3.02 at RM 4.5 and 3.57 at RM 0.2 (Table 44). Predominant organisms included the mayflies Stenonema and Baetis and the caddisflies Cheumatopsyche and Symphitopsyche. Oligochaetes and chironomids were present in moderate numbers. The above criteria indicated good water quality at both sites, in agreement with the evaluations made by Conn 1977 and, to some degree, Beckett 1977. Beckett (1977) reported values of 25 taxa and a diversity index of 3.00 at his station at RM 3.7 (Table 43). Fixed station monitoring in 1977 by the OEPA Biomonitoring Unit at RM 9.9 also indicated good water quality with 31 taxa collected and a diversity index of 3.48.

Fifty-four (54) taxa were collected from the artificial substrates located at the five stations within Segments 1-2 of the Great Miami mainstem (Appendix C, Table C-2). Numbers of taxa ranged from 34 at RM 91.1 to 18 at RM 87.7, while diversity indices ranged from 3.65 at RM 80.7 to 2.65 at RM 88.7 (Table 44). Percent composition by numbers of the major benthic groups at each station are presented in Figure 19. Coefficients of similarity among the five stations and their relationships with the significiant dischargers are illustrated in Figure 20.

The farthest upstream site, RM 91.1, showed good water quality reflected by a community with a large number of taxa (34), a high diversity index (3.44), and a relatively even numerical and taxonomic distribution of the three major benthic groups: mayflies, caddisflies, and chironomids.

The benthic community at RM 88.7, the next downstream station, indicated degradation of water quality had occurred upstream from this point. The number of taxa decreased significantly to 18, the diversity index decreased to 2.65, the number of organisms per square foot almost tripled (433 to 1190), and a definite shift in dominance from many taxa of mayflies in moderate numbers to large populations of a few taxa of caddisflies and chironomids occurred. The apparent cause of this degradation was the Cargill Co. which processes corn to syrup, molasses, and other by-products. Approximately 100,000 gallons of cooling water per day were released to a small ditch that entered the Great Miami River by way of an oxbow channel located at RM 89.1. The problem was caused by the runoff of spilled syrups from the tank loading area into the effluent ditch. The resultant effluent had BOD_5 values ranging from 15 to 50 mg/l. Sewage fungus was noticeable in both the ditch and the oxbow channel. Biochemical oxygen demands at the above levels were sufficient to cause the degradation of water quality and subsequent change in the benthic community at the RM 88.7 station, which was located near the confluence of the oxbow channel and the mainstem.

Figure 19. Percent composition by numbers of the benthic macroinvertebrate community collected on artificial substrates at the stations located within segments 1 and 2 of the lower mainstem Great Miami River, July-September, 1980.

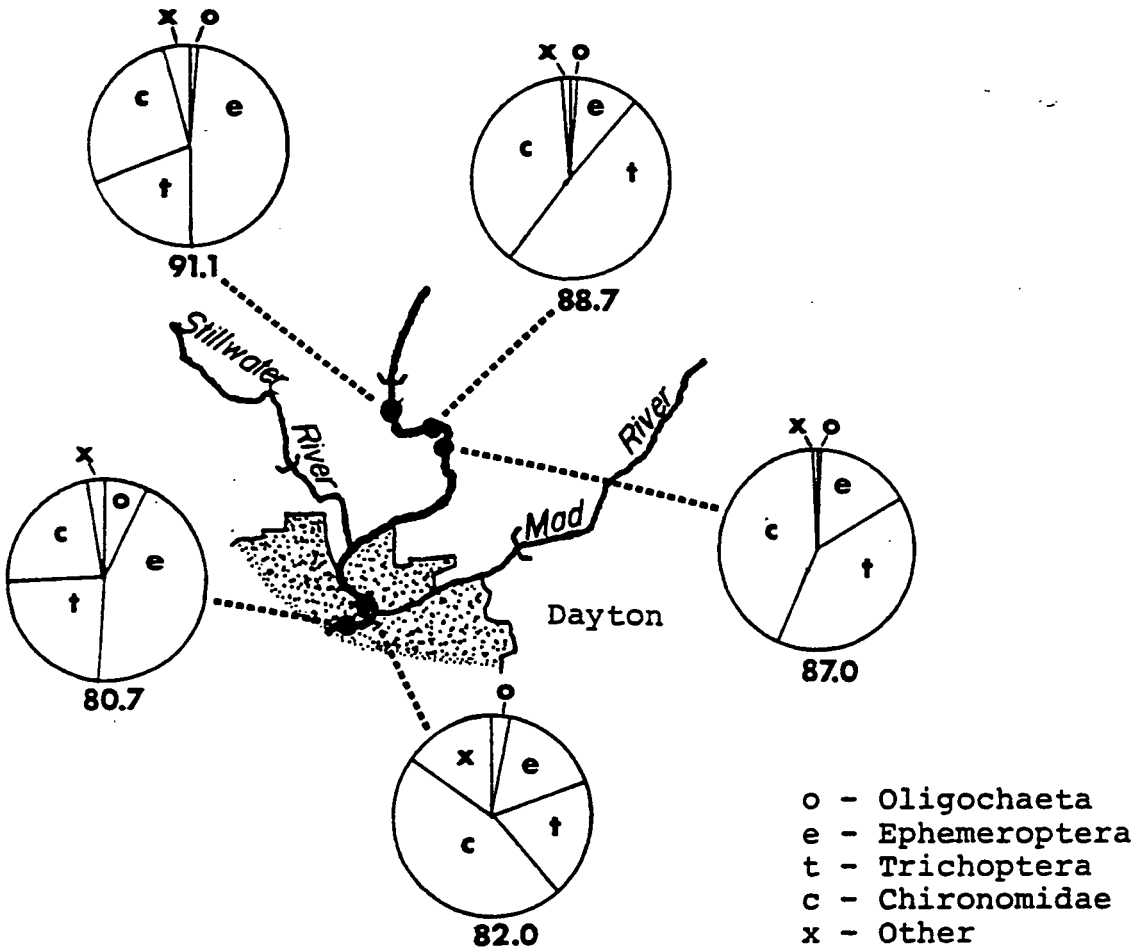
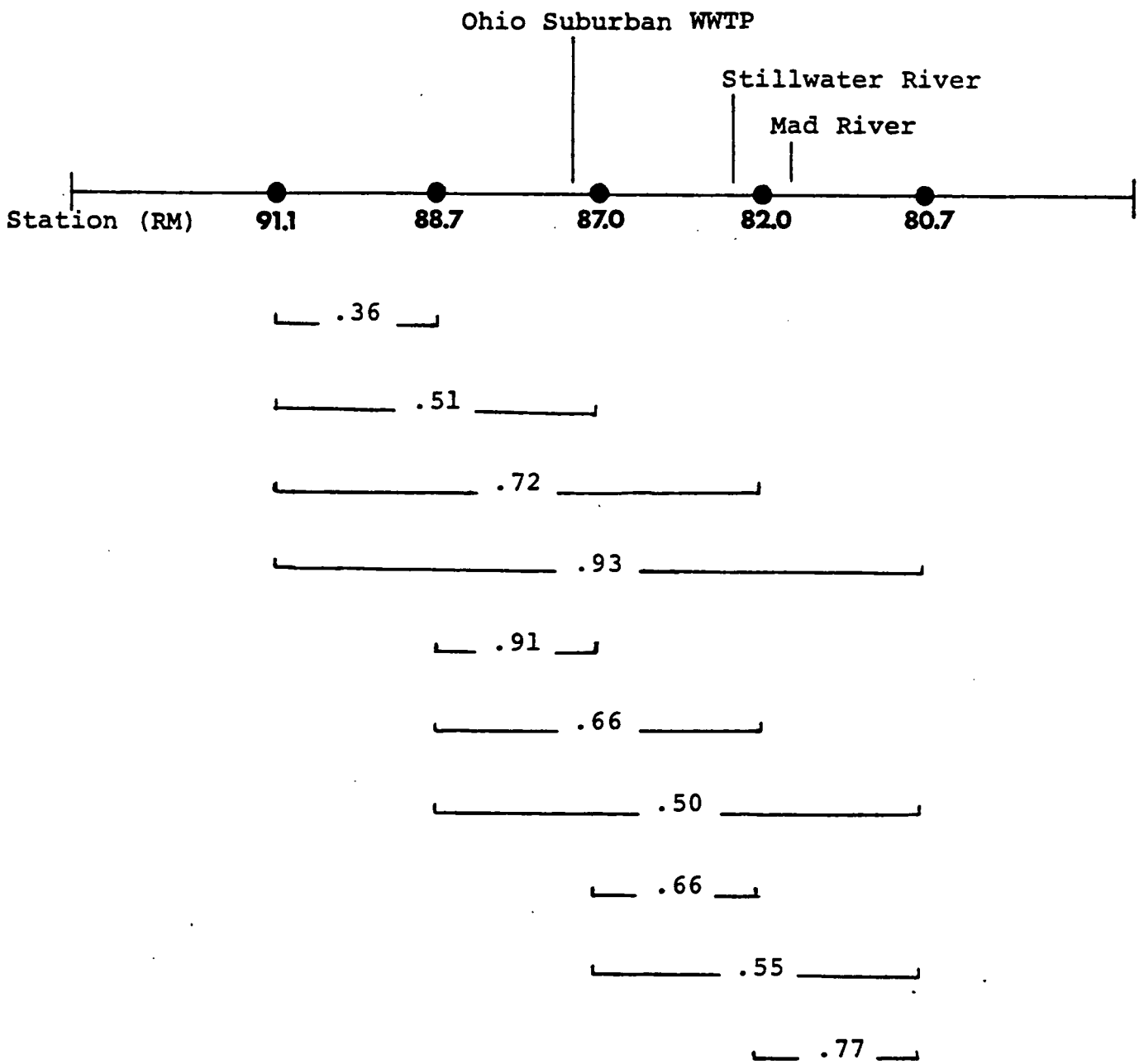


Figure 20. Coefficients of similarity for stations within segments 1 and 2 of the lower mainstem Great Miami River study area with relative locations of point source discharges.



000158

The station at RM 87.0 was located approximately 0.5 mile downstream from the Ohio Suburban WWTP outfall. Number of taxa (24), number of organisms per square foot (1082), diversity index (2.80), and percent composition of the major groups were not appreciably different from Station 88.7. There was little or no change in water quality at this site. However, this represented a substantial reduction when compared to the RM 91.1 station which was considered to be more indicative of upstream water quality than RM 88.7.

Recovery in Segments 1-2 of the Great Miami mainstem to water quality levels similar to RM 91.1 gradually occurred downstream from RM 87.0. The benthic communities at the last two stations in these segments, RM 82.0 and RM 80.7, showed marked increases in numbers of taxa (31 and 32, respectively) and diversity indices (3.40 and 3.65, respectively). The number of organisms per square foot decreased and a more favorable percent composition of mayflies, caddisflies, and chironomids, indicative of clean water conditions, was reached by RM 80.7. The effect of the Stillwater River, the Mad River, and storm sewer overflows in downtown Dayton were considered to have had a negligible impact on the Great Miami River benthic communities.

Coefficients of similarity (Figure 20) between the five stations supported the evaluation of water quality degradation at RM 88.7 and eventual recovery by RM 80.7. High coefficients of similarity (0.65) were found between RM 91.1, 82.0, and 80.7 which were considered to have had good water quality. Low coefficients (0.65) were found when these were compared with RM 88.7 and 87.0, both of which had poor water quality. Similarly, a high coefficient was found between RM 88.7 and 87.0.

Previous data had shown this segment of the mainstem upstream from Dayton to have had fairly good water quality (Beckett, 1977; Conn, 1977, 1973; Scott, 1969, 1968). However, annual NAWQMN data collected at RM 87.1 by the OEPA Biomonitoring Unit between 1976 and 1979 did indicate moderately degraded water quality downstream from the Ohio Suburban WWTP. In those four years, numbers of taxa collected ranged from 17 in 1967 to 28 in 1978 and diversity indices ranged from 2.01 in 1979 to 3.02 in 1978.

Segments 3-4

Segments 3-4 (RM 80.0 - RM 71.6) consisted of the segment of the Great Miami mainstem downstream from the downtown Dayton area to upstream from the Montgomery County Western Regional WWTP. Six stations were located in these segments at RM 78.0, 77.3, 76.5 75.2, 73.9, and 71.7 (Figure 18). There were numerous significant dischargers along these segments including the Dayton Power and Light Tait EGS (RM 77.4), GMC-Delco Moraine (RM 77.5), Dayton WWTP (RM 76.1), GMC Air Conditioning Plant #3 (RM 74.4) and Plant #2 (RM 74.2), and P.H. Glatfelter (RM 72.5).

Fifty-eight (58) taxa were collected from the artificial substrates located at the six stations within segments 3-4 of the lower Great Miami mainstem (Appendix C, Table C-3). Numbers of benthic taxa ranged from 28 at RM 78.0, 77.3, and 73.9 to 23 at RM 71.7. Diversity indices ranged from 3.57 at RM 78.0 to 2.18 at RM 71.7 (Table 44). Percent composition by numbers of the major benthic groups at each station are presented in Figure 21. Coefficients of similarity among the six stations and their relationships with the significant dischargers are illustrated in Figure 22.

The clean water conditions found in the downtown Dayton area of Segments 1-2 continued in the stations in segments 3-4 upstream from the Dayton WWTP. Stations 77.3 and 76.5 exhibited benthic communities with characteristics typical of good water quality. The numbers of taxa at each site (28 at RM 77.3 and 26 at RM 76.5) along with the diversity indices (3.40 at RM 77.3 and 3.34 at RM 76.5) reflected healthy and diverse communities. The benthic composition at each site also reflected good water quality. Mayflies and caddisflies predominated at each station while chironomids were present in only moderate numbers.

With a large number of taxa (28) and a high diversity index (3.57), the benthic community at RM 78.0 seemed to have characteristics similar to RM 77.3 and 76.5 downstream. However, the composition of the community at this site was predominated by chironomids. These chironomids, however, were represented by many taxa with moderate numbers of individuals, as opposed to only a few taxa in large numbers such as occurred in the poor water quality conditions observed at RM 88.7 in Segment 1. The RM 78.0 sampling station was located in the DP&L - Tait EGS dam pool where water flow was restricted. This was in marked contrast to the other nearby stations that were located in areas with good flow. The benthic community under these conditions was expected to be different and characterized by taxa capable of thriving under the existing conditions. Most chironomids are well adapted to living in all aquatic habitats but often exist exceptionally well in quiet water areas (Pennak 1978). On the other hand, mayflies and caddisflies of the dominant types found in this survey (mainly those of the mayfly family Heptageniidae and the caddisfly family Hydropsychidae) have a much greater preference for running water habitats (Mackey and Wiggins 1979; Pennak 1978; Wiggins 1977; Edmunds et al. 1976). Neither of these groups, particularly the hydropsychids, were present in numbers comparable to those found at neighboring stations. With this in mind and taking into consideration the large number of taxa and high diversity index, the benthic community at RM 78.0 probably reflected fairly good water quality, much like the immediate upstream and downstream stations. There were no indications of water quality problems resulting from the discharges from the DP&L Tait EGS or GMC-Delco Moraine facility.

Benthic communities at the three stations downstream from the Dayton WWTP indicated declining water quality. While numbers of taxa remained relatively unchanged from the upstream stations, diversity indices decreased to 2.18 and numbers of organisms per square foot increased to 1631 by RM 71.7. However, it was the changing composition of the benthic communities that best reflected the deteriorating water quality from RM 76.5 upstream from the Dayton WWTP to

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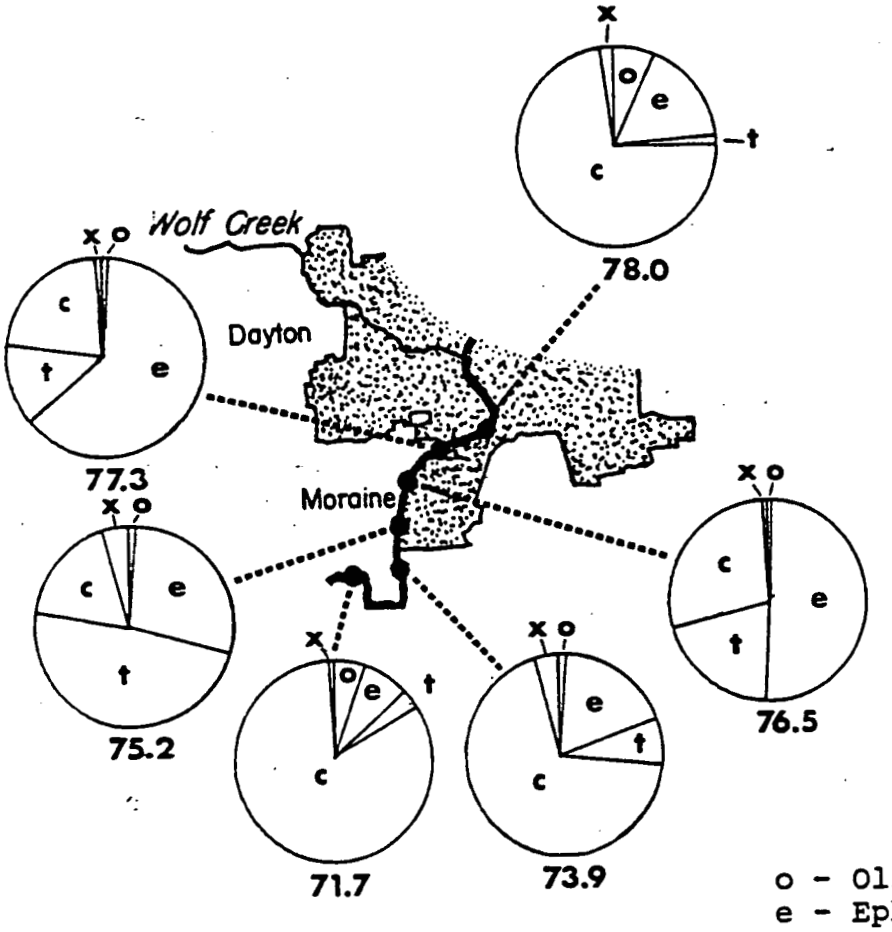
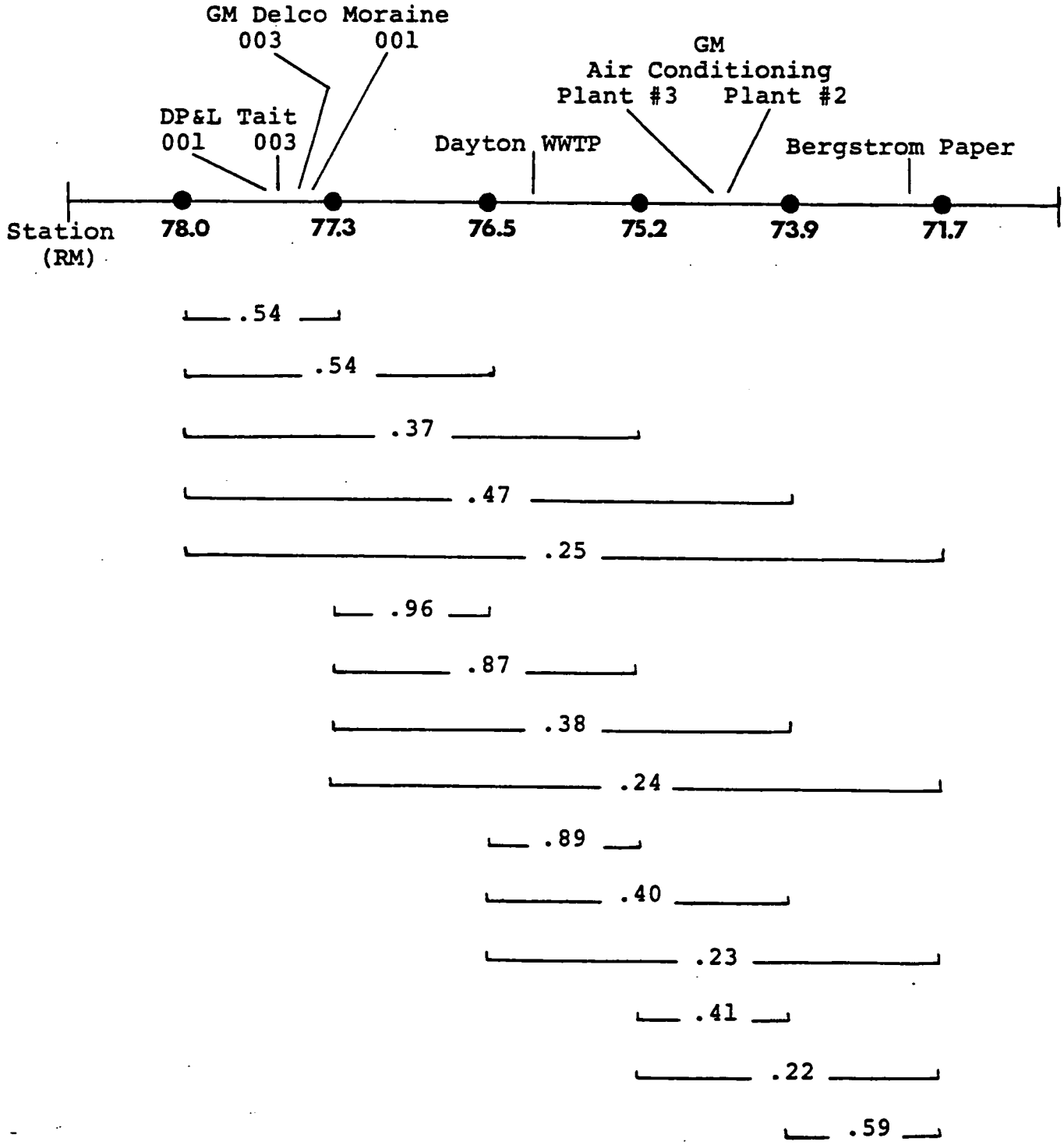
Figure 21. Percent composition by numbers of the benthic macroinvertebrate community collected on artificial substrates at the stations located within segments 3 and 4 of the lower mainstem Great Miami River, July-September, 1980.



o - Oligochaeta
e - Ephemeroptera
t - Trichoptera
c - Chironomidae
x - Other

Figure 22. Coefficients of similarity for stations within segments 3 and 4 of the lower mainstem Great Miami River study area with relative locations of point source discharges.



000162

RM 71.7 downstream from P.H. Glatfelter (RM 72.5). Thirteen taxa of mayflies and caddisflies in moderate numbers populated RM 76.5 while three taxa of caddisflies predominated at RM 75.2, three chironomid taxa predominated at RM 73.9, and one chironomid taxa predominated at RM 71.7. At RM 75.2, individuals of the taxa Cheumatopsyche, Symphitopsyche, and Hydropsyche orris comprised 44 % of the 24 taxa. These three taxa of caddisflies are common in swift large warmwater rivers with a high silt load and a high concentration of suspended organic substances (Schuster and Etnier 1978; Ross 1944). Mason et al. (1971) considered these three taxa to be intermediate in their pollution tolerance and frequently associated with moderate levels of organic contamination. Their occurrence downstream from the Dayton WWTP as the predominant portion of the benthic community indicated the presence of high organic loadings in an environment capable of supporting the large populations.

Further downstream at RM 73.9, continued degradation of the water quality was indicated by the appearance of a benthic community predominated by three chironomid taxa. Polypedilum (Polypedilum) illinoense, a species of Cricotopus, and a species in the Calopsectra Rheotanytarsus group comprised nearly 60 % of a community consisting of 28 taxa. The seven chironomid taxa present made up 70 % of the community. By RM 71.7, six chironomid taxa out of a total of 23 constituted 83 % of the community with Polypedilum (Polypedilum) illinoense alone making up 62 % of the individuals. Oligochaetes also became more apparent in the benthic composition with densities reaching 75 individuals per square foot.

Coefficients of similarity for segments 3-4 (Figure 22) supported the other criteria in showing substantial changes in the composition of the benthic community from RM 77.3 to RM 71.7. The three sites with good to moderate water quality (RM 77.3, 76.5, and 75.2) all had high coefficients when compared to each other and low coefficients when compared to RM 73.9 and 71.7. Also, the atypical nature of the benthic community at RM 78.0 was further substantiated by the fact that similarities were poor between this site and the other stations in the segment.

The poor water quality observed at RM 71.7 appeared to be the result of a cumulative effect of numerous discharges to the Great Miami River along this 8.5 mile segment. The Dayton WWTP was by far the largest point source located in this segment as it discharged 64.0% of the BOD_5, 25.1% of the total suspended solids, and 73.0% of the ammonia-nitrogen in the entire study area. The data collected in segments 3-4 supported the water quality evaluations made by all other investigators since 1966 (Beckett 1977; Conn 1973, 1977; Scott 1968, 1969). Of the five stations sampled by Beckett (1977) that were located in these segments (Table 43), three were located in areas closely comparable to those in this survey. His station at RM 77.8 with 27 taxa and 3.12 diversity index compared well with the 28 taxa and 3.57 diversity index found at RM 78.0. However, at the two other similar Beckett stations at RM 77.1 and 73.7, there were substantial differences in the values found compared to those from RM 77.3 and 73.9 in this survey. At RM 73.9, the values observed were much higher than those of Beckett (1977) at RM 73.7, but the

same water quality evaluation was made. In the case of Beckett's site at RM 77.1 and RM 77.3, a completely different evaluation of water quality was reached. Since both stations were located downstream from the DP&L-Tait EGS, the differences in the benthic communities collected during each survey may have been the result of varying effects of the thermal discharge that was modified by the hydrological conditions present at the time of sampling.

Segment 5

Segment 5 (RM 71.5 - RM 62.7) consisted of the segment of the Great Miami mainstem from the Montgomery County Western Regional WWTP to the Miami-Erie Canal Dam. Three stations were located in this segment at RM 67.6, 66.2, and 64.3 (Figure 18). Significant dischargers to this segment included the Montgomery County Western Regional WWTP (RM 71.5), two industrial discharges on Owl Creek (RM 69.6), West Carrollton WWTP (RM 68.9), Interstate Folding Box (RM 67.5), Miamisburg WWTP (RM 65.1), and the DP&L-Hutchings EGS (RM 64.4).

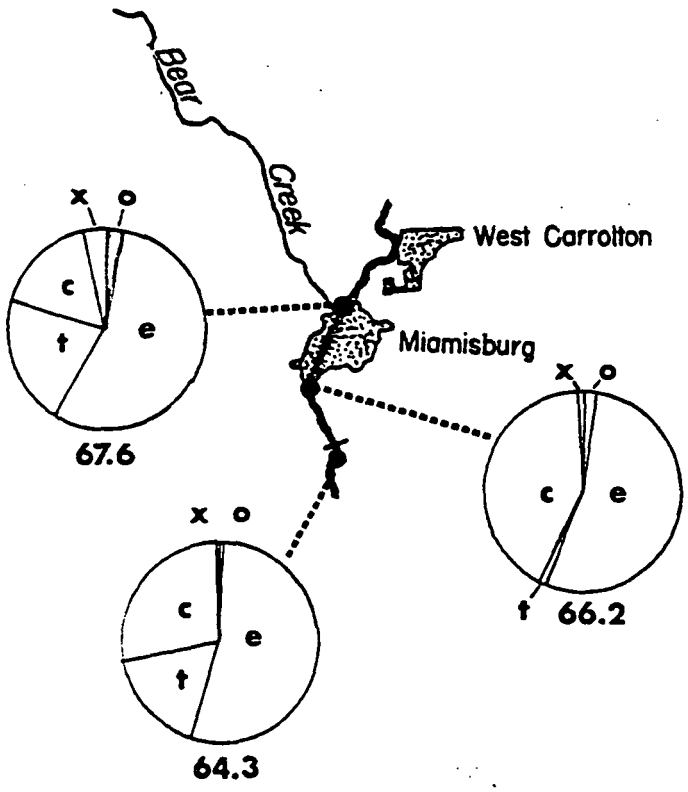
Forty (40) taxa were collected from the artificial substrates located at the three stations within Segment 5 of the lower Great Miami mainstem (Appendix C, Table C-4). Thirty-one taxa were collected from RM 67.6 and 24 each at RM 66.2 and 64.3. Diversity indices ranged from 3.59 at RM 64.3 to 3.30 at RM 67.6 (Table 44). Percent composition by numbers of the major benthic groups at each station are presented in Figure 23. Coefficients of similarity among the three stations and their relationships with the significant dischargers are illustrated in Figure 24. Included in Figure 24 for purposes of comparison are two stations from Segments 3-4.

This segment reflected a general trend towards recovery from the poor water quality conditions found at the upstream stations at RM 73.9 and 71.7. In the four mile segment between RM 71.7 and 67.6, the benthic community improved to a considerable degree. Number of taxa increased from 23 to 31 and the diversity index rose from 2.18 to 3.30. A favorable change in the benthic composition also occurred. Sixteen taxa of mayflies and caddisflies comprising 77 % of the individuals at RM 67.6 replaced the overwhelming abundance of chironomids found at RM 71.7. However, organic enrichment was still evident due to the high number of organisms per square foot (1091) and the presence of large numbers of the caddisfly Hydropsyche orris and the mayfly Baetis, both of which have a wide range of tolerance to various inorganic and organic chemical substances (Hart and Fuller, 1974).

At RM 66.2 and 64.3, numbers of taxa declined to 24 at each site while diversity indices increased slightly. Number of organisms per square foot decreased substantially at each site to more moderate levels. Benthic composition remained much the same at each station with the exception of the decline of caddisflies at RM 66.2. The reason for this decline was unknown. The possiblity of a major water quality problem was considered remote because of the presence of a large and diverse mayfly population, generally considered more sensitive to changes in water quality.

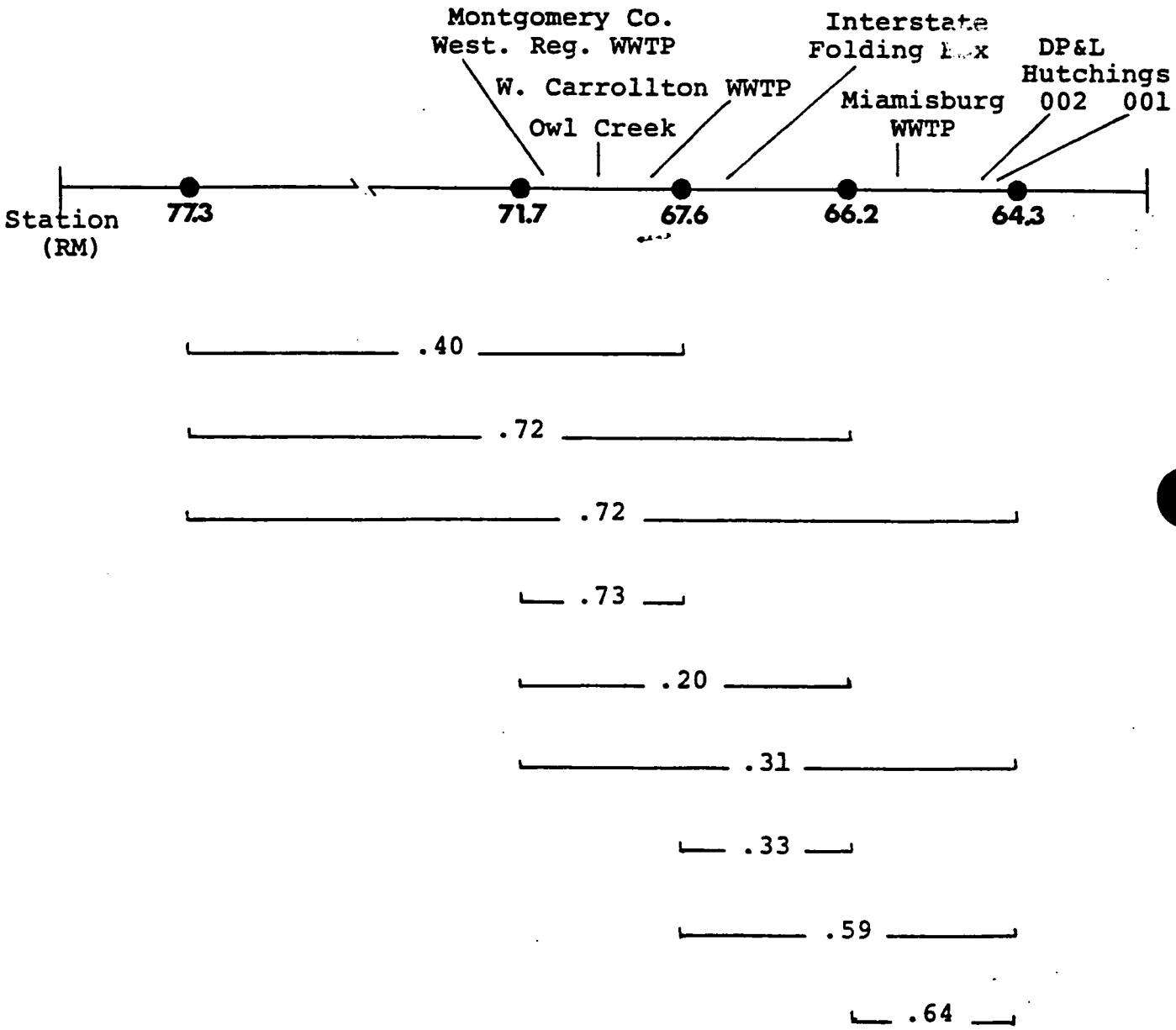
000164

Figure 23. Percent composition by numbers of the benthic macroinvertebrate community collected on artificial substrates at the stations located within segment 5 of the lower mainstem Great Miami River, July-September, 1980.



o - Oligochaeta
e - Ephemeroptera
t - Trichoptera
c - Chironomidae
x - Other

Figure 24. Coefficients of similarity for stations within segment 5 of the lower mainstem Great Miami River study area with relative locations of point source discharges.



000166

Coefficients of similarity in this segment also reflected the changing benthic composition and the trend towards recovery of water quality to levels approaching the quality found upstream from the Dayton WWTP (Figure 24). The results observed at RM 66.2 and 64.3 compared well with RM 77.3, a station of good water quality upstream from the Dayton WWTP. On the other hand, a high coefficient existed between RM 67.6 and the degraded station at RM 71.7, thus reflecting the continued moderate degradation in water quality at RM 67.6. Similarly, the two downstream stations in this segment compared fairly well with each other but not at all with RM 67.6.

The above criteria indicated little or no discernible impact on water quality by the dischargers in this segment. Recovery to those water quality levels observed upstream from the Dayton WWTP seemed to occur to some degree at each station with fairly good water quality indicated by the benthic community at RM 64.3. Previous investigators (Scott 1968, 1969b; Conn 1973, 1977a,b) concluded that poor water quality existed throughout this segment with eventual recovery occurring farther downstream. Beckett (1977), however, did indicate that some recovery was reached in this segment. At his stations at RM 67.8, 65.0, and 64.6 (Table 43), numbers of taxa and diversity indices increased from 9 and 0.98 at RM 67.8 to 20 and 2.70 at RM 64.6. At RM 64.3 downstream from the DP&L-Hutchings EGS, water quality again seemed to decline with the number of taxa and the diversity index decreasing to 12 and 1.60. This degradation of water quality was not noticeable in the benthic data from RM 64.3 in this survey. NAWQMN data collected at RM 67.7 in 1976 and 1977 by the OEPA Biomonitoring Unit produced results quite similar to those of Beckett (1977) at the same site. Thirteen taxa with a diversity index of 1.27 were collected in 1976 and 12 taxa with a diversity index of 2.86 were collected in 1977. Only one taxon of mayflies and no caddisflies were found in the two years. These values, indicating severe degradation, were quite different from the data collected in this survey at RM 67.6, where the presence of 16 taxa of mayflies and caddisflies indicated a significant improvement in the benthic community.

Segment 6

Segment 6 (RM 62.6 - RM 51.7) consisted of the segment of the Great Miami mainstem between the Miami-Erie Canal Dam and the Middletown Dam. Three stations were located in this segment at RM 60.2, 58.8, and 55.0 (Figure 18). The Franklin WWTP (RM 59.7) was the only significant discharger in this segment.

Thirty-six (36) taxa were collected from the artifical substrates located at the three stations within segment 6 of the lower Great Miami mainstem (Appendix C, Table C-5). Numbers of benthic taxa and diversity indices ranged from 19 and 2.65 at RM 60.2 to 29 and 3.61 at RM 55.0 (Table 44). Percent composition by numbers of the major benthic groups at each station are presented in Figure 25. Coefficients of similarity among the three stations and their relationships with the Franklin WWTP are illustrated in Figure 26.

Both sampling locations at RM 58.8 and 55.0, located downstream from the Franklin WWTP, had benthic communities characteristic of fairly good water quality. Numbers of taxa and diversity indices were high at each station. However, the large percentage of caddisflies of the family Hydropsychidae in the benthic community at each site (48% at RM 58.8 and 40% at RM 55.0) indicated moderate organic enrichment along this segment of the river (Figure 25). This was even more evident at RM 60.2 where caddisflies composed 67 % of the 2200 individuals collected per square foot. The two hydropsychid caddisflies Hydropsyche orris and H. bidens alone accounted for 60 % of the benthic community. Schuster and Etnier (1978) reported populations of these two species with such enormous numbers that individual larval retreats and pupal cases were literally stacked on top of one another. These large populations were thought to be caused by the high concentration of suspended organic matter in the rivers where they occurred. Fremling (1960) reported large nuisance populations of Hydropsyche orris under similar conditions in the organically enriched Mississippi River. With such large numbers of these two caddisflies at RM 60.2, habitat availability may have been greatly reduced, thus accounting for the low number of taxa collected (19) and the moderate diversity index (2.65).

Coefficients of similarity from this segment reflected the imbalance of caddisflies in the benthic community, especially at RM 60.2 (Figure 26). A high coefficient (0.77) existed between RM 58.8 and 55.0 while neither of these stations compared well with RM 60.2.

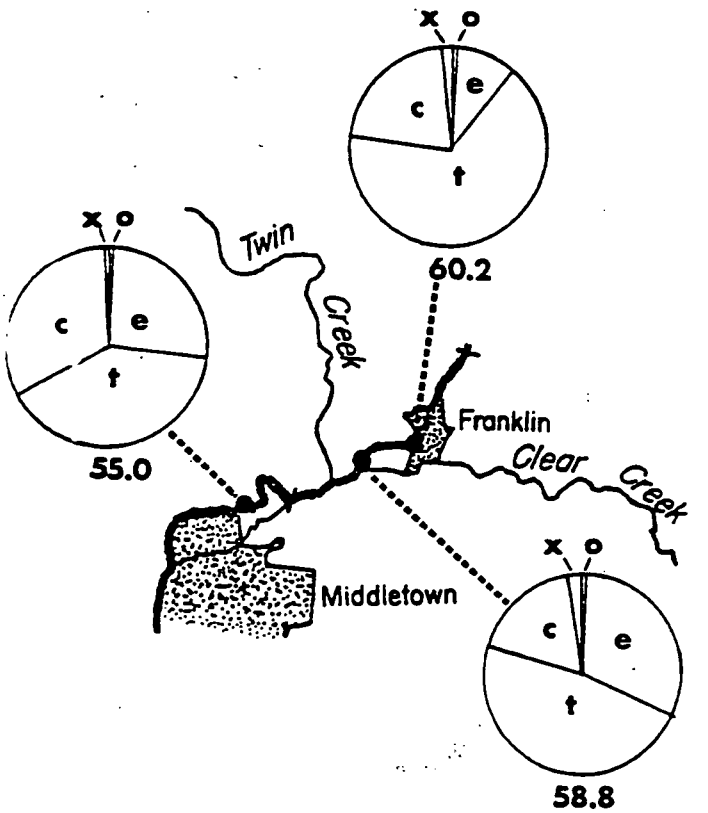
There was no discernible impact on the benthic community by the Franklin WWTP. The moderate organic enrichment throughout the segment resulted in large populations of caddisflies in an otherwise diverse benthic community. As in Segment 5, water quality was greatly improved over the quality found downstream from the Dayton WWTP but did not attain those levels observed farther upstream. Historically, this segment of the river was the first area downstream from the Dayton WWTP where water quality improved to some degree. Both Scott (1969) and Conn (1973) reported marginally good Biotic Index values at their stations near RM 55.0. Beckett (1977) collected 17 benthic taxa with a diversity index of 2.35 at his farthest downstream station at RM 57.4 (Table 43). This indicated a definite improvement in water quality in this area, but it was still noticeably degraded when compared to his stations in the Dayton area above RM 77.8.

Segment 7

Segment 7 (RM 51.6 - RM 41.5) consisted of the segment of the lower Great Miami mainstem from the Middletown Dam to the Hamilton Hydraulic Canal Dam. Seven stations were located in this segment at RM 51.5, 50.7, 49.3, 47.7, 46.8, 44.5, and 43.2 (Figure 18). Significant dischargers in this segment included ARMCO-Middletown 001 (RM 51.5), the Middletown CSO area (RM 52.2-51.0), Middletown WWTP (RM 48.3), Crystal Tissue (RM 48.1), ARMCO-Middletown 002-005 via Dicks Creek (RM 47.6), and Lesourdsville Regional WWTP (RM 45.7). Baseline data was also collected near river mile 44.3 in the area of the expected outfall of the future Miller Brewery.

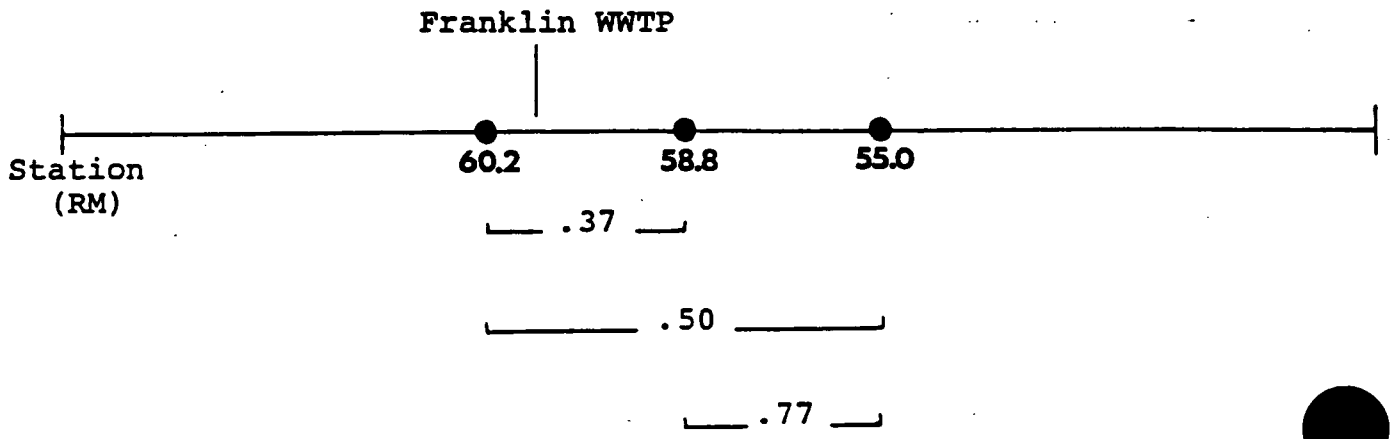
000168

Figure 25. Percent composition by numbers of the benthic macroinvertebrate community collected on artificial substrates at the stations located within segment 6 of the lower mainstem Great Miami River, July-September, 1980.



o - Oligochaeta
e - Ephemeroptera
t - Trichoptera
c - Chironomidae
x - Other

Figure 26. Coefficients of similarity for stations within segment 5 of the lower mainstem Great Miami River study area with relative locations of point source discharges.



000170

Forty-nine (49) taxa were collected from the artificial substrates located at the seven stations within Segment 7 of the Great Miami mainstem (Appendix C, Table C-6). Numbers of benthic taxa collected and diversity indices ranged from 31 and 3.99 at RM 51.5 to 24 and 2.65 at RM 43.2 (Table 44). Percent composition by numbers of the major benthic groups at each station are presented in Figure 27. Coefficients of similarity among the seven stations and their relationships with the significant dischargers are illustrated in Figure 28.

Stations in this 10 mile segment were characterized by remarkable similarities in their benthic composition. With only a few exceptions, eight taxa of mayflies, five taxa of caddisflies, and four taxa of chironomids were present at all seven stations. These 17 taxa made up 90 % or more of the individuals collected at each site. Distributions of the 13 taxa of mayflies and caddisflies predominated at all stations except RM 50.7 downstream from ARMCO-Middletown 001 where chironomids composed nearly 50 % of the individuals collected. However, the number of taxa collected (29), the diversity index (3.27), and coefficients of similarity with other stations did not indicate a major water quality problem at this station.

As would be expected, coefficients of similarity also indicated high similarities between the benthic communities of each station. These coefficients were the highest calculated from the Great Miami River with many greater than 0.80. The only poor station comparisons were those involving RM 47.7 and RM 43.2. At the time of collection, it was noticed that the artificial substrates at RM 47.7 had been partially filled in by small rocks and other debris. The resulting loss of surface area available for colonization was apparent in the decreased numbers of organisms collected, especially when compared to the numbers collected at nearby stations. Since the coefficient was directly related to the density of organisms, it was not surprising that some poor coefficients resulted between RM 47.7 and the other stations in the segment. The low coefficients involving RM 43.2 were a result of an exceptionally large population of the caddisfly *Hydropsyche orris*. As at RM 60.2, the large numbers of this caddisfly was thought to have reduced habitat availability to other less competitive benthic organisms. This was reflected in the number of taxa collected (24) and the diversity index (2.65), both of which were the lowest in the segment. Favorable habitat characteristics and the availability of large amounts of organic debris made this station conducive to the proliferation of this caddisfly. There were no indications of a water quality problem.

The above criteria indicated good water quality throughout this segment. There was no apparent degradation downstream from any of the dischargers. Water quality in this segment had recovered to levels supporting populous and diverse benthic communities characteristic of large, swift, and moderately organically enriched warmwater rivers. The evaluation was a marked improvement over those evaluations made previously (as recently as 1977) by personnel of the Miami Conservancy District (Scott 1968, 1969; Conn 1973, 1977).

Figure 27. Percent composition by numbers of the benthic macroinvertebrate community collected on artificial substrates at the stations located within segment 7 of the lower mainstem Great Miami River, July-September, 1980.

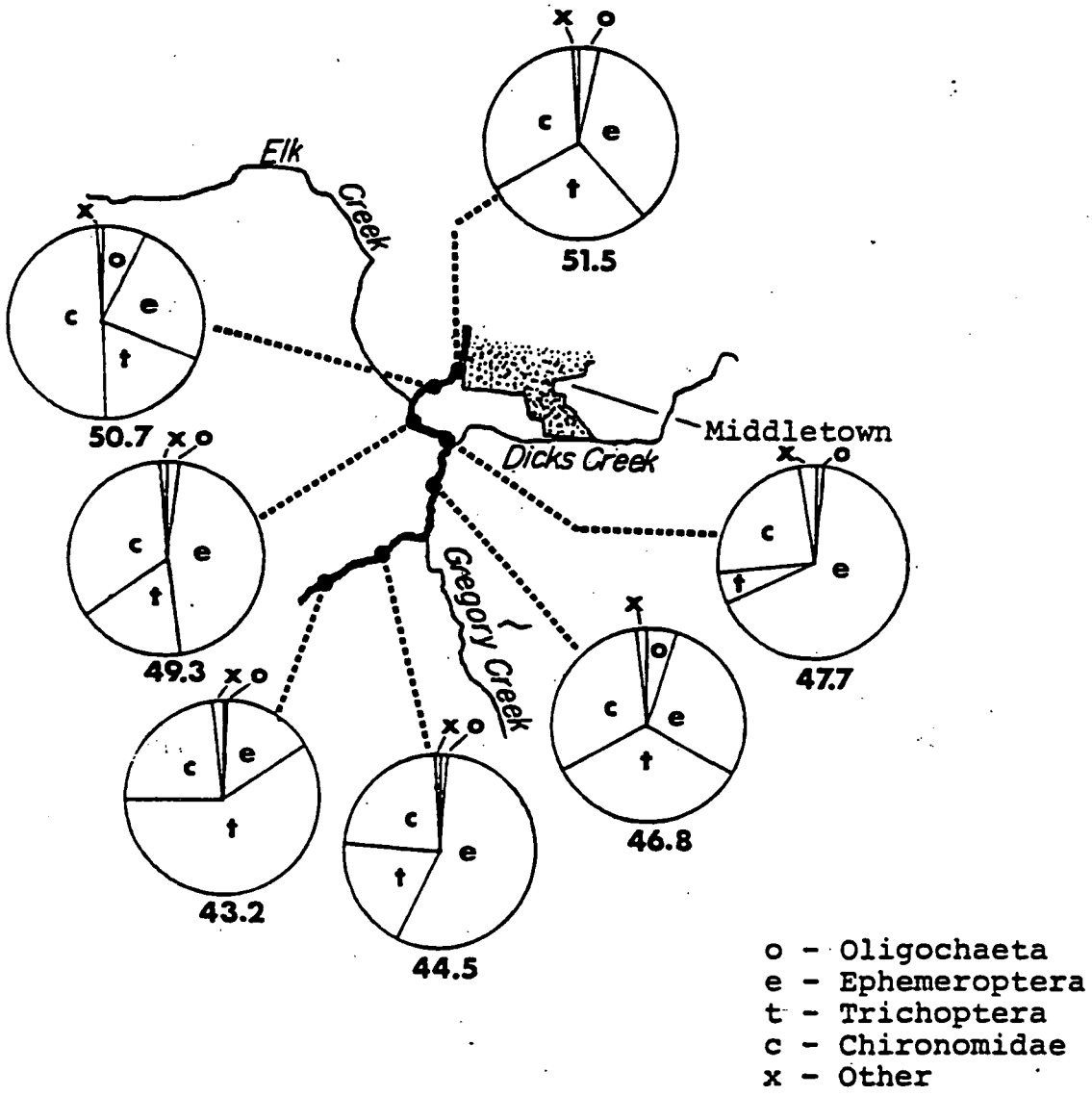


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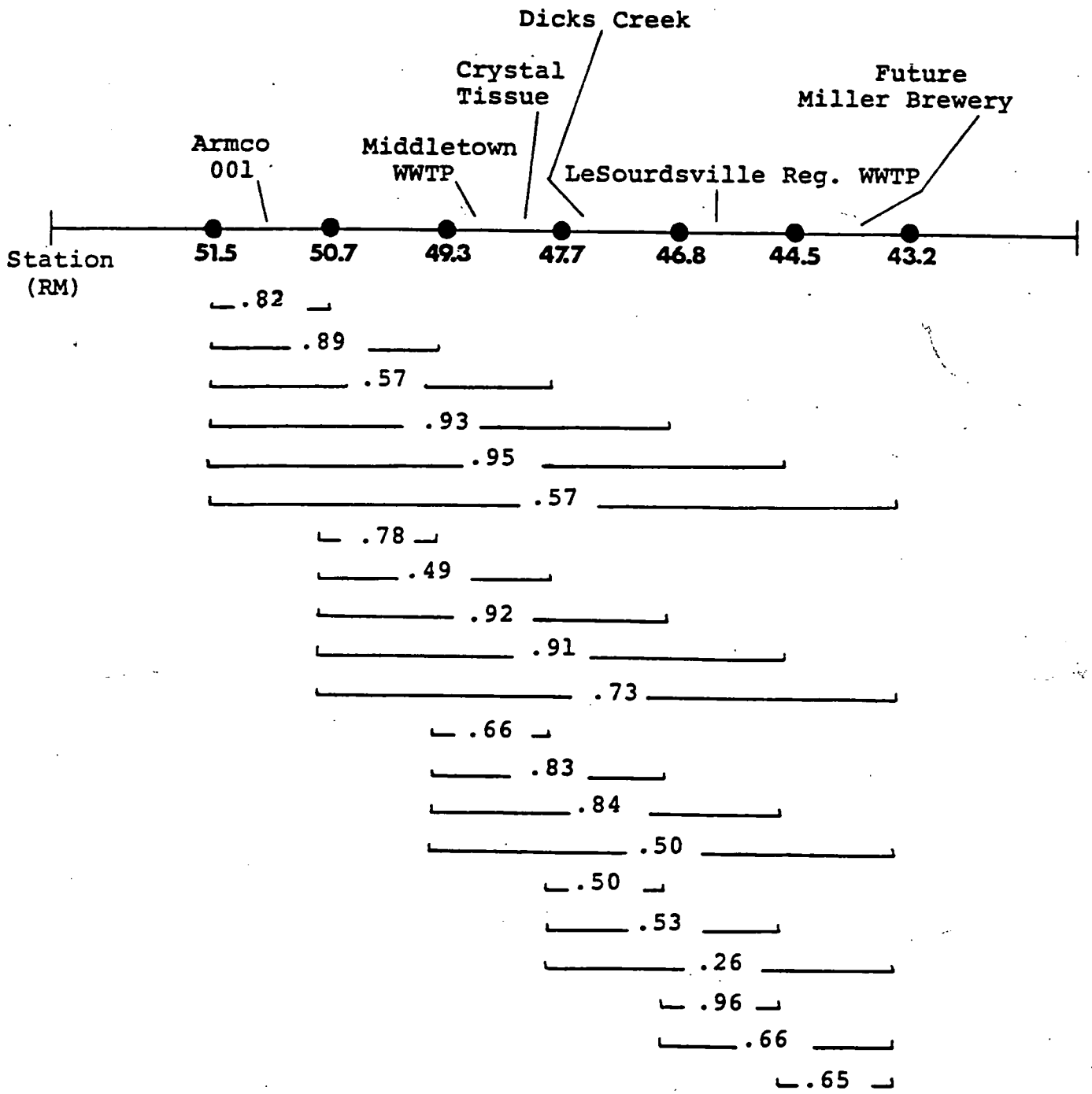
Figure 28. Coefficients of similarity for stations within segment 5 of the lower mainstem Great Miami River study area with relative locations of point source discharges.



Segments 8-9

Segments 8-9 (RM 41.4 - RM 24.8) consisted of the segment of the Great Miami mainstem from the Hamilton Hydraulic Canal Dam to the DOE - Feed Materials Production Center. Five stations were located in these segments at RM 40.3, 37.8, 34.1, 33.0, and 30.8 (Figure 18). Qualitative data only was collected at RM 30.8. Known significant dischargers to these segments included ARMCO - New Miami (RM 38.7 and RM 39.3), Hamilton WWTP (RM 34.0), and Fairfield WWTP (RM 32.0).

Forty-seven (47) taxa were collected from the artificial substrates located at the four quantitative stations within Segments 8-9 of the Great Miami mainstem (Appendix C, Table C-7). Numbers of taxa collected and diversity indices ranged from 25 and 2.99 at RM 37.8 to 31 at RM 34.1 and 3.91 at RM 33.0 (Table 44). Percent composition by numbers of the major benthic groups at each station except Station 30.8 are presented in Figure 29. Coefficients of similarity among the four quantitative stations and their relationships with the significant dischargers are illustrated in Figure 30.

Both RM 40.3 and 37.8 were located in an area of the Great Miami River downstream from the Hamilton Hydraulic Canal Dam where low flows often occur due to water diversions. Twenty-six (26) taxa with a diversity index of 3.62 were collected at RM 40.3 while 25 taxa with a diversity index of 2.99 were collected at RM 37.8. At both stations, benthic communities were predominated by mayflies (52% of the individuals at RM 40.3 and 76% at RM 37.8). The noticeable lack of hydropsychid caddisflies at RM 37.8 was caused by the location of the site in an area of sluggish flow upstream from the Hamilton Dam (RM 37.2). Conditions here were similar to those encountered at RM 78.0 in the DP&L-Tait EGS dam pool. The above criteria indicated good water quality in this low flow area. There were no indications of an adverse effect on the benthic community at RM 37.8 downstream from ARMCO-New Miami (RM 38.7-39.3).

The sampling station at RM 34.1 was located downstream from the confluence of the Hamilton Hydraulic Canal (RM 37.2) and several small point sources. Thirty-one benthic taxa with a diversity index of 3.82 were collected from the artificial substrates at this site. Although the number of taxa and diversity index were both high, chironomids constituted the dominant portion of the benthic community (9 taxa composing 43 % of the individuals). Oligochaetes and the gastropod genera Physa and Ferrissia were also more noticeable components of the community at this site (Figure 29). These chironomids, oligochaetes, and gastropods, known to be common under grossly polluted conditions (Hart and Fuller, 1974), comprised nearly 75% of the individuals collected at RM 34.1. On-site observations of suspended solids in the water, the presence of sewage fungus covering the natural substrate, and oil and grease permeating the artificial substrates confirmed the existence of a localized water quality problem in this area. There was the possibility that this site was located quite close to or within the mixing zone of the discharge from a storm sewer at RM 34.3. This situation could have resulted in the presence of the large numbers of pollution associated organisms. However, the presence of diverse populations of mayflies and caddisflies seemed to preclude an evaluation of grossly polluted water quality.

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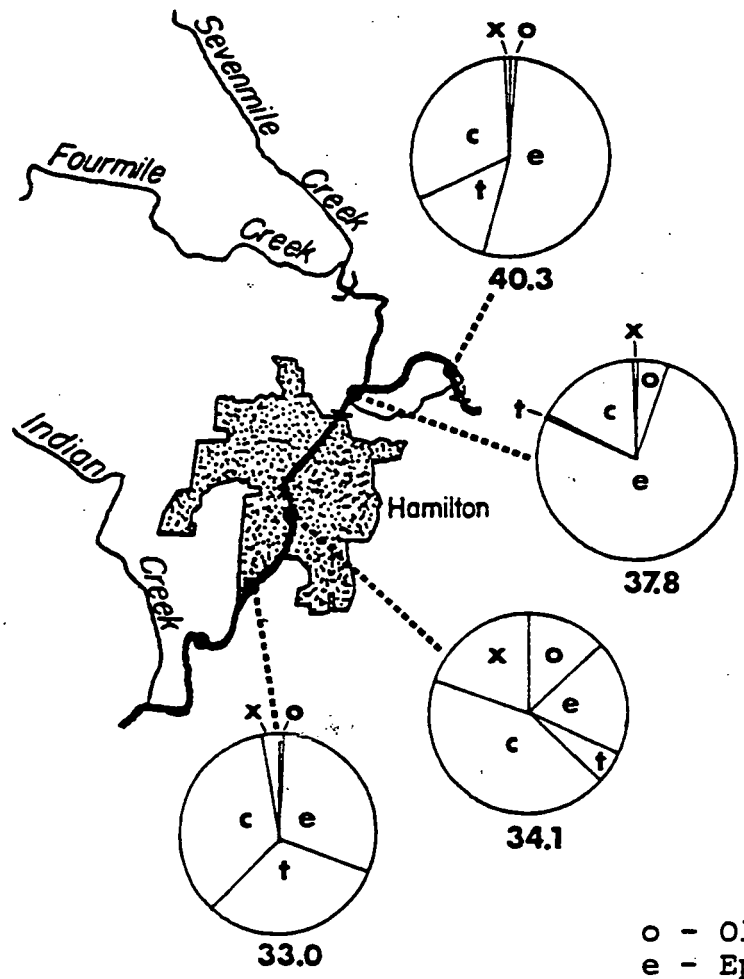
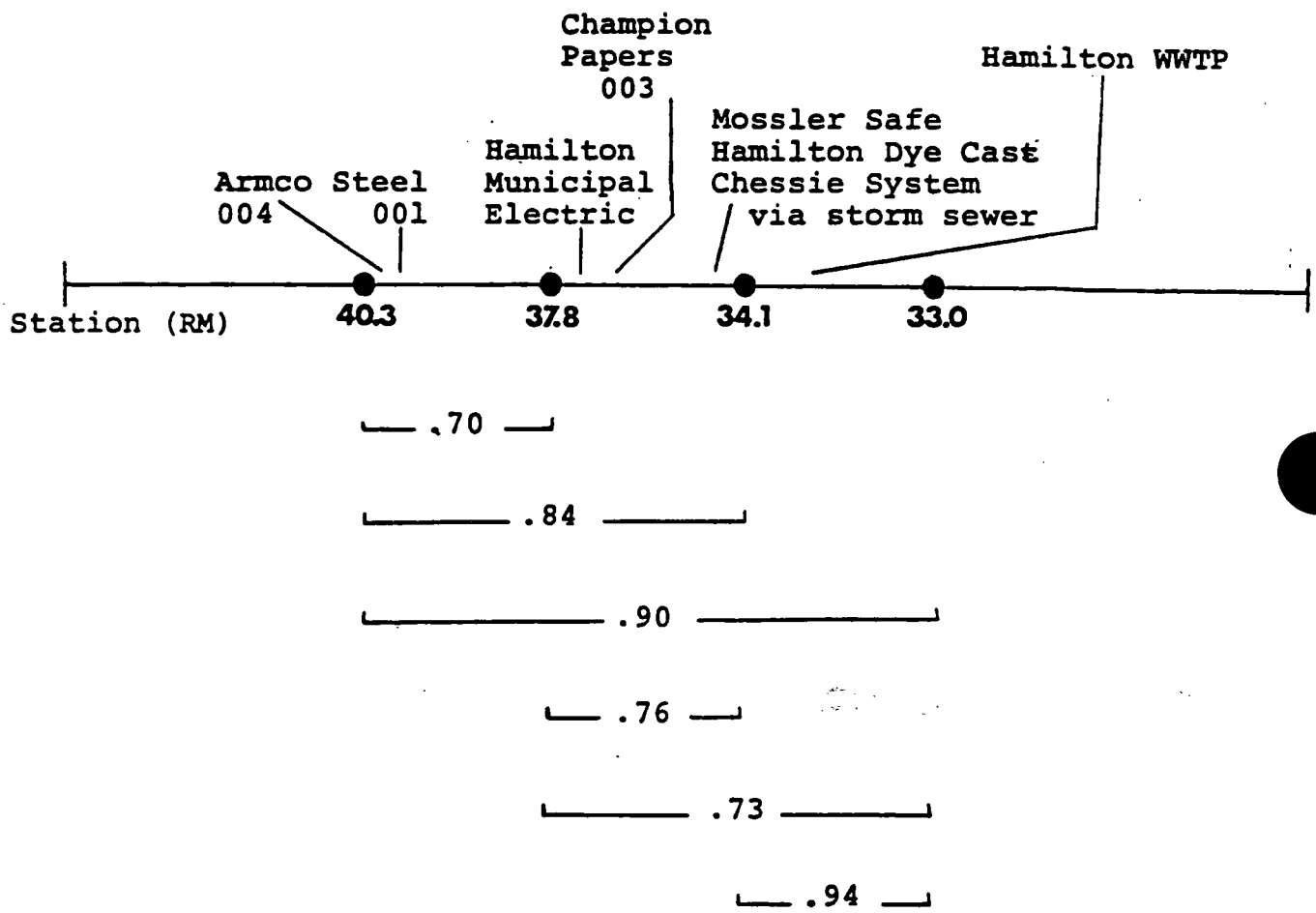
Figure 29. Percent composition by numbers of the benthic macroinvertebrate community collected on artificial substrates at the stations located within segments 8 and 9 of the lower mainstem Great Miami River, July-September, 1980.



o - Oligochaeta
e - Ephemeroptera
t - Trichoptera
c - Chironomidae
x - Other

Figure 30. Coefficients of similarity for stations within segments 8 and 9 of the lower mainstem Great Miami River study area with relative locations of point source discharges.



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The benthic community appeared to recover by RM 33.0. Number of taxa (30) and the diversity index (3.91) remained much the same as at RM 34.1, but the community was composed of 21 taxa of mayflies, caddisflies, and chironomids in nearly equal abundance (Figure 29). Numbers of oligochaetes and gastropods were greatly reduced. There was no noticeable effect on water quality by the Hamilton WWTP.

The qualitative data collected at RM 30.8 was limited in its usefulness in discerning any further positive or negative changes in water quality by the Fairfield WWTP. Eighteen qualitative taxa were collected at Station 30.8 compared to 19 qualitative taxa at RM 33.0. The taxa were nearly identical at each site and thus seemed indicative of little change in water quality below the discharger.

Coefficients of similarity in Segments 8-9 did not reflect the change in benthic composition at RM 34.1 (Figure 30). All values were greater than 0.65 between all four stations. The insensitivity of this coefficient to the change at RM 34.1 was thought to be caused by the relative constancy of the mayfly, caddisfly, and chironomid taxa that were present at nearly all the stations in the Great Miami River. With the coefficient directly affected by the frequency of a taxon at the quantitative stations, those taxa occurring at nearly all the sites would have had a much more dramatic effect on the coefficient than those taxa found at only a few sites. At Station 34.1, the impact of the large numbers of individuals of the genera Physa and Ferrisa on the coefficient was minimal because the frequency of the two taxa at all 34 stations was low. This problem was inherent in this coefficient of similarity when a large number of stations were involved that were consistently predominated by the same taxa. The change in benthic composition in areas with minimal degradation was not always reflected in the coefficient if many of the dominant taxa were present at the stations in the degraded area. This masking effect seemed to be present at RM 34.1 and further indicated that the degradation was highly localized.

Overall water quality through Segments 8-9 was good except for the localized area upstream from RM 34.1 where some degradation was apparent. The source of this problem appeared to emanate from the storm sewer outfall located at RM 34.3. Both Scott (1967, 1968) and Conn (1973, 1977a,b) evaluated the entire segment as having poor water quality. However, the Biotic Index values that they calculated showed a general increasing trend through these segments until the Hamilton Dam (RM 37.2) where downstream values dropped sharply. Both Scott (1969) and Conn (1973) reported Biotic Index values of 0 at RM 34.1 just upstream from the Hamilton WWTP.

Segments 10-11

Segments 10-11 (RM 24.8 - RM 0.0) consisted of the segment of the Great Miami mainstem from the DOE - Feed Materials Production Center to the confluence with the Ohio River. Five stations were located in these segments at RM 24.8, 22.5, 15.1, 9.5 and 8.2 (Figure 18). Qualitative data only were collected at RM 24.8, 22.5, and 8.2. Known significant dischargers to these segments included DOE-Feed Materials Production Center (RM 24.7) and Gulf Oil Refinery (RM 9.1).

Twenty-eight (28) taxa were collected from the artificial substrates located at the two quantitative stations within Segments 10-11 of the Great Miami mainstem (Appendix C, Table C-8). Numbers of taxa collected and diversity indices were 27 and 3.10 at RM 15.1 and 22 and 3.09 at RM 9.5 (Table 44). Percent composition by numbers of the major benthic groups at the two stations are presented in Figure 31. As at many of the upstream stations, caddisflies predominated the benthic communities at both sites, composing 57 % of the individuals collected at Station 15.1 and 66 % of the individuals collected at RM 9.5. Both stations were heavily populated by individuals of the genera Hydropsyche orris and H. simulans. Mayflies were well represented at RM 15.1 and to a lesser extent at RM 9.5 while chironomids were equally abundant at each site. Oligochaetes were present in low numbers. The coefficient of similarity between RM 15.1 and RM 9.5 was greater than 0.90 indicating excellent similarity. The diverse benthic communities were very similar to those collected at upstream sites and were indicative of fairly good water quality in a large warmwater river with a swift current and substantial organic enrichment.

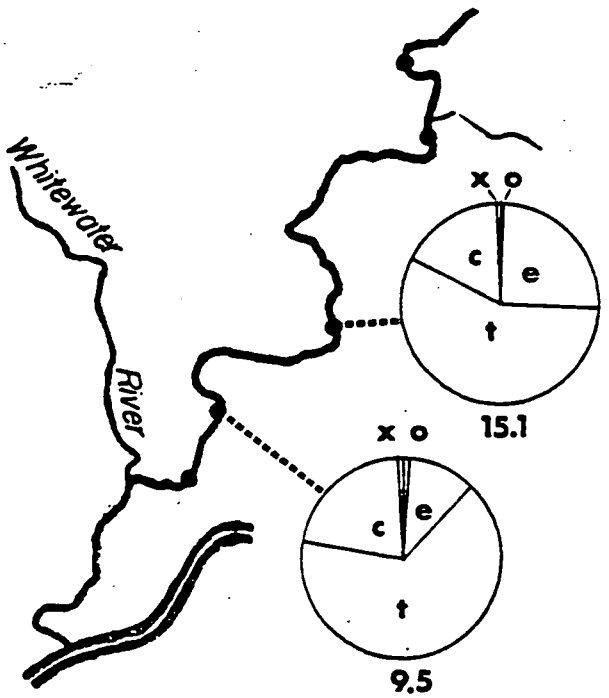
The qualitative taxa collected at RM 24.8, 22.5, and 8.2 were limited in their usefulness in evaluating water quality. The numbers of taxa collected were quite consistent at all three sites and compared well with those quantitative and qualitative taxa collected at RM 15.1 and 9.5. This seemed to indicate little change in the benthic composition throughout this segment and no apparent deleterious effect on water quality by the dischargers.

Previous data compiled by the Miami Conservancy District in the 1960's indicated a general increasing trend in biotic diversity and water quality through Segments 10-11, with good water quality occurring by RM 10.0 (Scott, 1968 and 1969). NAWQMN data collected in 1976 and 1977 by the OEPA Biomonitoring Unit at RM 22.1 indicated fair water quality at this site. Fifteen taxa with a diversity index of 2.51 were collected in 1976 and 20 taxa with a diversity index of 2.47 were collected in 1977. Chironomids, caddisflies, and oligochaetes predominated the benthic communities both years with mayflies noticeably lacking as an important component. There was no current quantitative data available to compare with these values although the presence of a diverse group of mayflies in the qualitative sample at RM 22.5 seemed to indicate higher diversity in the benthic community as well as improved water quality.

Summary

Biological monitoring with benthic macroinvertebrates in the lower Great Miami River basin in the summer of 1980 indicated three major areas of water quality problems. The first of these was located north of Dayton downstream from the Ohio Surburan WWTP (RM 87.5) and a heretofore unidentified, but localized runoff problem from the nearby Cargill Co. (RM 89.1). Recovery gradually occurred downstream from RM 87.0 with complete recovery indicated at RM 80.7, approximately 7 miles downstream from the impacts.

Figure 31. Percent composition by numbers of the benthic macroinvertebrate community collected on artificial substrates at the stations located within segments 10 and 11 of the lower mainstem Great Miami River, July-September, 1980.



o - Oligochaeta
e - Ephemeroptera
t - Trichoptera
c - Chironomidae
x - Other

The second problem area was located downstream from the Dayton WWTP (RM 76.1) where macroinvertebrate sampling indicated gradual deterioration in water quality. Poorest conditions were found at RM 71.7, most likely the culmination of effects from numerous upstream discharges. Recovery in water quality appeared to occur by RM 64.3, immediately downstream from Miamisburg and approximately 12 miles downstream from the initial degradation.

The third problem area was confined to a small river segment within the City of Hamilton. The most likely source of the degradation was a storm sewer carrying industrial discharges and railroad yard runoff (RM 34.3). The impact was noticeable but not considered severe, with recovery occurring within one mile downstream.

Insufficient macroinvertebrate data were available for an adequate water quality evaluation in the lower 25 miles of the river. Data that were collected, however, did not indicate any severe problem.

A comparison of this survey with previous surveys in the basin indicated that problem areas have remained consistent over the past 15 years. However, the severity of the problem appears to have lessened to some degree in recent years. The flow differences noted between 1976 and 1980 could very well be responsible for the apparent improvement. The survey of Beckett (1977) was conducted under a mean summer flow 30% of that encountered in 1980. Additionally, overall loadings in the Dayton area (especially the Dayton WWTP) increased between 1976 and 1980. These observations indicate that the improvement noted between 1976 and 1980 was probably due to higher flows rather than real improvements in water quality.

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DISCUSSION:
ENVIRONMENTAL DEGRADATION AND STREAM USE ANALYSIS

Existing Degradation of the Aquatic Environment

Modification of the aquatic environment in the study area was evidenced in the form of both natural channel and habitat modification and perturbations to chemical/physical water quality caused by point sources of wastewater, and to a much lesser extent by nonpoint sources (mostly urban runoff). The impact of point sources on chemical/physical water quality and subsequent negative effects on the aquatic biota (fish and macroinvertebrates) were by far the most detrimental effects. Modifications to the natural river channel by impoundment and flood protection levees had a relatively minor impact. Urban nonpoint source runoff in the Dayton area was also minor in its relative effect on the aquatic biota.

At least 76 facilities discharged to the mainstem and lower tributaries in the study area in 1980. Of this total, 18 are considered to be significant point sources by the Ohio EPA. The Dayton WWTP (RM 76.1) was the largest point source in the study area in terms of BOD_5 (64%), NH_3-N (73%), and heavy metals loadings. Only the Hamilton South WTP (RM 33.9) had a larger loading of total suspended solids (57%). The next largest point sources of BOD_5 were the Middletown WWTP (RM 48.3; 10%) and Hamilton WWTP (RM 34.0; 3%). All other sources were each less than 2% of the total loading. The greatest concentration of point source loadings occurred in segment 4 (RM 76.1-71.6) and included the Dayton WWTP. Loadings of BOD_5, total suspended solids, and ammonia-nitrogen have increased substantially in this segment from 1976 to 1980. Again, this increase was due primarily to the increased loading discharged by the Dayton WWTP. While the total mean third quarter (July 1-September 30) effluent flow increased from 50.6 MGD in 1976 to 60.8 MGD in 1980 (an increase of 20%), the mean BOD_5 loading increased from 2508 kg/day to 8165 kg/day (226% increase). Increases were also observed for total suspended solids (45% increase) and ammonia-nitrogen (468% increase). These increases completely overshadowed the elimination of Moraine WWTP (RM 73.7) in late 1979. Worsening effluent quality for both BOD_5 and ammonia-nitrogen was evident for the Dayton WWTP between 1976 and 1980. Daily BOD_5 concentrations during June-September 1976 were less than 20 mg/l during 82% of the time. By 1980, daily BOD_5 values were greater than 25 mg/l during 83% of the time, and daily values greater than 30-40 mg/l were common. The trend for ammonia-nitrogen followed a similar pattern. Increased BOD_5 and total suspended solids loadings in segment 7 (RM 51.6-41.5) were the result of worsening effluent quality at the Middletown WWTP (RM 48.3) during 1976-1980. The BOD_5 concentration discharged by the Middletown WWTP was less than 15 mg/l on 93-100% of the days during June-September 1976-1979. In 1980, 56.5% of the daily values were greater than 15 mg/l. This worsening effluent quality coincided with the regular acceptance of industrial wastes by the Middletown WWTP in late 1979 or early 1980. Ammonia-nitrogen values, however, showed improvement through the same period, with nearly 85% of daily values less than 2 mg/l.

Chemical/physical water quality conditions in the lower mainstem Great Miami River during 1980 were typical of those observed in large rivers during higher than normal flow years. Water quality standards violations of parameters characteristic of nonpoint source runoff (total Fe, fecal coliforms) were much more frequent and widespread than for those parameters more sensitive to point source impacts (e.g., D.O., NH_3-N, temperature, cyanide, phenolics). Dividing the study area into segments of good, fair, and poor chemical/physical water quality was difficult because those parameters sensitive to point source impacts did not show distinct longitudinal differences as they have during years with lower flows. Past data indicated that exceedences of WQS for D.O., temperature, and possibly, ammonia, cyanide, and phenolics have been much more frequent during low flow years (Ohio EPA 1976, 1980b). The most severe water quality problem in the lower mainstem continues to be depressed D.O. levels which is the result of excessive loadings of oxygen demanding wastewater downstream from Dayton. Less severe problems exist downstream from Middletown and Hamilton. Unless BOD loadings are reduced in these areas, depressed D.O. levels will be a recurring problem in the lower mainstem especially during low flow years.

Bottom sediments in the mainstem were not severely contaminated and extensive sediment deposits were difficult to find. This was likely due to scouring effects of the high flows that preceded the June-October 1980 study period. Heavy metal concentrations were highest downstream from Dayton, but were not indicative of any acute or widespread problem. Fish tissue analyses showed PCB and HCB to increase in the lower sections of the mainstem.

Clean Water Act Goals

The most relied upon criteria for evaluating the condition of the lower Great Miami River mainstem was the abundance, diversity, and distribution of the fish and macroinvertebrate communities. The most severe biological degradation occurred downstream from the Dayton WWTP (RM 76.1), as reflected by both the fish and macroinvertebrate communities. Another area of degradation was observed downstream from the Ohio Surburban WWTP (RM 87.4) although the extent and severity was much less than that observed downstream from Dayton. The fish community showed evidence of degradation between RM 74.9 and 38.2, a distance of 36.7 miles. The overall pattern of continual interruptions in recovery resulted in a net overall decline in most fish community parameters. The macroinvertebrate community in the lower half of this section did not reflect any substantial degree of degradation and was consistent with communities found in large, organically enriched warmwater rivers. The condition of the community was not, however, comparable to that found upstream from Dayton.

The apparent conflict between the condition of the macroinvertebrate and fish communities was the result of a combination of factors. High flows during 1979 and 1980 evidently improved chemical water quality enough to permit the partial reestablishment of macroinvertebrate communities in the mainstem segment downstream from the Miami-Erie Canal dam (RM 62.6) to Hamilton (RM 37.2). The fish community did not show commensurate improvement in this segment apparently because avenues for repopulation from nearby refugia were blocked by dams, or there was a lack of repopulation epicenters

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(i.e. tributaries) altogether. This was especially evident in the section of the mainstem between the Middletown Hydraulic Canal dam (RM 56.7) and the Hamilton Hydraulic Canal dam (RM 41.5), where virtually no suitable refugia existed. Evidently the fish community in this section of the mainstem was reflecting past impacts during previous low flow periods (i.e., 1976, 1977). Degradation of the fish community was especially apparent in the mainstem downstream from the ARMCO-Middletown 001 outfall (RM 51.5), the Middletown combined sewer overflow area (RM 52.2-51.0), and the Middletown WWTP (RM 48.3). The macroinvertebrate communities did not reflect degradation to this same degree apparently because repopulation was possible during higher than normal flow periods (i.e., 1979, 1980).

Localized areas of impact occurred near Dayton and Hamilton. Runoff from the Cargill facility (RM 89.1, 0.4) upstream from the Ohio Suburban WWTP (RM 87.4) apparently caused a reduction in the macroinvertebrate community observed at RM 88.7. The impact was evidently limited in extent, as the fish community 0.6 miles downstream (RM 88.1) was indicative of excellent environmental quality. The combination of urban runoff and industrial sources in the Dayton area apparently stressed the fish community to some, extent as indicated by the frequency of external anomalies on fish and fish community trends through downtown Dayton (RM 81.8-77.1). However, the condition of the macroinvertebrate community and the structural evaluation of the fish community indicated good water and environmental quality overall. The degradation of the macroinvertebrate community at RM 34.1 was attributed to the close proximity of the sampling location to a storm sewer outfall that carried industrial wastes and combined sewer overflows. The impact was not apparent at the next downstream sampling location. A mild reduction in the fish community occurred downstream from the Hamilton WWTP (RM 34.0), Hamilton South WTP (RM 33.9), and Fairfield WWTP (RM 32.0).

Dicks Creek (RM 47.6) was not sampled in the 1980 survey, but past chemical/physical data (Ohio EPA 1976, 1980a) indicated substantial water quality degradation. A biological and water quality evaluation of this stream is needed to more accurately determine the severity and extent of degradation and to properly determine stream uses and water quality standards.

Previous evaluations of the lower mainstem Great Miami River have rated water quality as poor from the Dayton WWTP to the Ohio River (Ohio EPA 1980a), although some recovery has been noted in the lower 5-10 miles (Ohio EPA 1976). These evaluations considered chemical/physical data only and relied on sampling conducted during both lower than normal and above normal flow years. A rating of fair water quality was given to the mainstem upstream from and in Dayton. Based on the results of the 1980 survey, the current condition of the mainstem is rated as follows:

1) Taylorsville Dam to upstream from the Ohio Suburban WWTP (RM 92.6-87.5) - GOOD: this segment contained excellent assemblages of fish and macroinvertebrates.

2) Ohio Suburban WWTP to the Steele dam (RM 87.4-82.2) - FAIR: although fish and macroinvertebrate communities were within the general condition considered to be "good", longitudinal trends indicated a moderate degradation.

3) Downstream from the Steele dam to upstream from the Dayton WWTP (RM 82.1-76.2) - GOOD: this segment contained good assemblages of fish and macroinvertebrates, although some marginal stress to the fish community was evident.

4) Dayton WWTP to the Miami-Erie Canal dam (RM 76.1-62.6) - POOR: the most extensive biological degradation was observed in this segment as was the greatest concentration of point source loadings; although the condition of the biological communities was rated "fair", the impacts observed during 1976 under lower than normal flow conditions at reduced loadings as compared to 1980 resulted in a poor rating.

5) Downstream from the Miami-Erie Canal dam to the Hamilton dam (RM 62.5-37.2) - FAIR: the lack of suitable refugia and scarcity of repopulation epicenters contributed to the observed degradation of the fish community; the ability of this segment to show some degree of improvement resulted in a fair rating.

6) Downstream from the Hamilton dam to the Ohio River (RM 37.1-0.0) - GOOD: both the fish and macroinvertebrate communities exhibited patterns of diversity and abundance generally consistent with large, organically enriched warmwater rivers; however, some minor stresses were noted, however.

The evaluation of the lower mainstem Great Miami River based on biological condition observed in 1980 differed from previous evaluations based on chemical/physical data alone (Ohio EPA 1980a). A similar result was obtained by Yoder et al. (1981) in a similar comparison for the mainstem Scioto River. Biological communities, being subjected to all of the long term chemical and physical conditions within the water column, better reflect the true condition of the aquatic environment.

Chemical/physical data represent instream water quality conditions only at the time of sampling and thus are subject to short-term environmental variations. Therefore evaluations based primarily on the aquatic biota should produce the most realistic indication of the condition of the aquatic environment and whether or not the goals of the Clean Water Act are being met. The collection of chemical/physical data is necessary not only to characterize the prevailing water quality conditions, but also to quantify instream reaction kinetics over short periods of time. This information is used to calibrate and verify the mathematical water quality models that are used to project future water quality and individual point source loads. In addition modeling results should provide interpretive insight into the biological evaluation and visa versa. The result is a combined definition of the existing biological condition, which is based on biological data (usually fish and macroinvertebrates), with the calibration and verification of the water quality model based on chemical/physical data. The two are interrelated in that they define complimentary facets of the same process and thus provide valuable insight into understanding the water body in question.

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APPENDIX A
Physical/Chemical Data

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The potential for the recovery of the lower mainstem Great Miami River fish and macroinvertebrate communities is good. Both groups have demonstrated the ability to show at least marginal improvement, primarily when chemical conditions were improved by high flows. However, the number of refuge and repopulation areas (i.e., tributaries) for fish is not exceedingly great. Upstream migration routes from tributaries and sections of the mainstem with healthy fish communities are blocked by dams at two key points, the Middletown dam (RM 51.7) and the Hamilton Hydraulic Canal Dam (RM 41.5). Neither dam pool has a suitable tributary that could act as a refuge or repopulation epicenter. Recovery in these two restricted sections will have to come from currently degraded upstream areas or within the sections themselves. However, this does not mean that recovery will not occur. Recovery will occur at a slower rate and will be more dependent on conditions farther upstream. The remaining six (6) dams also block upstream fish movements, but the mainstem upstream from each has at least one undamaged tributary or a healthy fish community of its own.

Other impounded sections of the mainstem have at least one relatively undamaged tributary or upstream area from which repopulation can occur. Because of their importance to the lower mainstem, these tributaries (i.e., Stillwater River, Mad River, Bear Creek, Twin Creek, Four Mile Creek) should receive a high degree of protection commensurate with their importance to the lower mainstem Great Miami River.

Residual effects that might preclude the full recovery of the lower mainstem biological communities were not readily apparent (i.e., no significant bottom sediment contamination or habitat alterations). Sludge deposits downstream from Dayton have been more prevalent during low flow periods (Gammon 1977b). However, these are attributable to solids loadings from major point sources of wastewater and should diminish as point source loadings decrease. Existing discharges of once-through cooling water (DP&L-Tait and Hutchings EGS) could preclude full recovery of the fish community under certain operating conditions. Their current impact is slight primarily because the tolerant fauna can withstand the heat loads discharged by these two facilities. Also the discharged heat loads have been decreasing, especially for the Tait EGS (RM 77.4). However, problems may be encountered downstream from the Hutchings EGS (RM 64.4) during summer low flow (less than 1000 cfs) periods. Thermal modeling predictions indicate that temperatures could exceed 30-32C for at least 10 miles downstream (WAPORA 1977). These conditions could deter the reestablishment of thermally sensitive species that are currently absent due primarily to impacts from wastewater discharges located upstream.

The impact of point sources on instream chemical/physical water quality was the principal reason for the degradation of the fish and macroinvertebrate communities in the lower mainstem of the Great Miami River. Therefore, near term prospects for the recovery of these biological communities are largely dependent on the success of the programs aimed at reducing point source loadings, primarily for oxygen demanding wastes and suspended solids. Overall loadings from the Dayton WWTP must be reduced if recovery is to occur since it is by far the largest point source of wastewater in the study area. The key to ensuring full recovery downstream from Middletown is in controlling existing point source loads, better defining the apparent combined sewer overflow (CSO) problem, and determining if complex problems (i.e., possible chemical interactions, synergistic effects) exist.

Water Use Designations

The condition of the fish and macroinvertebrate communities outside the areas of degradation coupled with the lack of serious biological impacts resulting from habitat modification illustrate the potential of the lower mainstem of the Great Miami River (RM 92.5-0.0) to support a normal and healthy aquatic community typical of that found in large warmwater rivers. The recovery of the aquatic fauna from the observed degradations with increasing distance downstream and during favorable flow periods indicated the potential for full recovery with a corresponding reduction in point source loadings.

The lower mainstem Great Miami River (RM 92.5-0.0), being capable of supporting reproducing populations of various fish and macroinvertebrate species, should maintain a Warmwater Habitat (WWH) use designation throughout its entire length. Impoundments, levee construction, and water diversions were not precluding factors as evidenced by good aquatic communities in the Steele and DP&L-Tait EGS dam pools. The Whitewater River between the Ohio-Indiana state line (RM 8.3) and its confluence with the Great Miami River is also recommended for the Warmwater Habitat designation based on the resident fish community.

The lower mainstem Great Miami River has the capability of supporting a significant sport and recreational fishery. The opportunity for this use should substantially increase with improved water quality. Other beneficial uses of the lower mainstem include pleasure boating, water skiing, and canoeing. Pleasure boating and water skiing are restricted to the 2-3 miles upstream from the Steele dam (RM 82.2), Middletown Hydraulic Canal dam (RM 56.7), Hamilton Hydraulic Canal dam (RM 41.5), and the Hamilton dam (RM 37.2). Both activities also take place in the last 3 miles of the lower mainstem (RM 3.0-0.0). Canoeing is possible throughout the entire mainstem. Therefore the high potential for full human body contact during the summer recreation season (May 1-October 15) suggests that the Primary Contact Recreation fecal coliform standard is appropriate throughout the lower mainstem. The influence of these water body contact recreation standards on effluent chlorination requirements should be consistent with the current Ohio EPA chlorination policy.

Evidence of Water Quality Improvements

Past water quality (Ohio Dept. Health 1951, 1967) and biological (Scott 1968, 1969a,b; Conn 1973) evaluations of the lower mainstem of the Great Miami River have revealed substantial degradation. The principal problem has been low dissolved oxygen due to high loadings of oxygen demanding substances discharged primarily from municipal wastewater treatment plants. Biological degradation in the mid and late 1960's occurred from Dayton downstream to New Baltimore. These conditions have certainly improved overall, but degradation in certain segments still persists.

The current areas of concern remain the segment downstream from the Dayton WWTP and the segment adjacent to and downstream from Middletown. The data collected in 1980, when compared to similar data bases from 1976, appeared to show substantial improvement downstream from Dayton. This was, however, mostly the result of the higher than normal flows during 1979 and 1980. Point source loadings of BOD_5 from the Dayton WWTP have more than doubled since 1976 and would certainly result in biological degradation at least as severe as that observed by Gammon (1977b) and Beckett (1977) in 1976 under the lower than normal flow conditions that prevailed that year. Thus the situation downstream from Dayton has essentially deteriorated since 1976.

Some improvements in point source load reductions have taken place in other parts of the study area since 1976. A significant decrease in BOD_5 and total suspended solids loadings took place in segment 6 (RM 62.6-51.7) which was due to the elimination of the Sorg Paper 001 discharge. The overall decrease in mean BOD_5 loadings to segment 8 (RM 37.1-24.8) was attributed to the elimination of the 10 MGD Champion International 001 outfall. This waste has been diverted to the Hamilton WWTP and apparently resulted in improved D.O. levels downstream from Hamilton.. ARMCO-Middletown 001 (RM 51.5) showed decreases in all measured parameters (BOD_5, ammonia-nitrogen, cyanide, zinc, phenolics) during 1976-1980, although effluent quality was highly variable. This improvement corresponded to a decline in steel production at the ARMCO-Middletown mill, but new treatment facilities were installed during that time. The latest available data indicated that Dicks Creek (RM 47.6), which receives wastewater from the ARMCO-Middletown facility, is still degraded in terms of chemical/physical water quality. Improvements in ammonia-nitrogen levels discharged by the ARMCO-New Miami facility (RM 38.7-39.3) were attributed to both declining production and new treatment facilities. The correlation of these apparent effluent improvements with commensurate improvement in the condition of biological communities was not well demonstrated. However, other factors played an equally important role in the observed results.

Prospects for Recovery

The biological communities of the lower mainstem Great Miami River have demonstrated the capability to recover from past episodes of chemical/physical water quality degradation. However, the rate at which currently degraded segments of the mainstem are likely to recover is dependent on a number of factors. The recovery of degraded aquatic communities is a function of the physical, chemical, and biological characteristics of the receiving waters. The rate of recovery in flowing water systems is dependent upon; 1) the distance an area is located from the source(s) of stress, 2) the existence of undamaged tributaries, and 3) residual toxicity (Cairns et al. 1971). These factors are certainly applicable to the recovery of biological communities in the lower mainstem Great Miami River.

Appendix Table A-1: Raw chemical/physical data for conventional and nutrients parameters for the lower mainstem Great Miami River, June 5 - October 9, 1980.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 92.6 - Taylorsville Dam													
SC 610050													
80/06/05 08 00	7.6	19.2	7.2	368	3.4	43	0.20	8.00	0.24	2.30	0.68	234	3900
80/06/10 07 45	8.6	16.8	7.2	517	2.4	40	0.16	5.04	0.08	1.40	0.32	117	3400
80/06/19 08 30	9.4	18.8	7.8	740	1.8	14	0.09	4.33	0.02	0.80	0.23	31	290
80/06/26 08 15	7.2	21.0	7.7	573	3.1	16	0.12	5.58	0.07	1.10	0.30	60	-
80/07/01 08 15	8.0	20.0	7.3	405	3.5	31	0.09	6.24	0.15	1.90	0.71	212	6600
80/07/08 08 00	6.8	22.0	7.5	606	2.2	12	0.08	4.53	0.04	0.80	0.23	74	660
80/07/17 08 20	7.0	25.0	7.9	612	2.5	21	0.07	3.86	0.04	0.90	0.29	58	730
80/07/22 08 00	5.5	24.5	8.0	573	5.7	18	0.02	2.15	0.04	1.50	0.31	36	-
80/08/04 08 45	-	24.0	8.0	767	4.2	18	0.17	2.20	0.02	1.10	0.50	122	220
80/08/12 08 20	4.9	24.5	8.0	595	2.1	22	0.82	0.04	0.08	1.70	0.45	22	11000
80/08/21 08 20	7.4	23.5	7.8	560	2.9	21	0.07	2.31	0.04	1.30	0.40	100	2400
80/08/28 08 00	7.5	23.0	8.0	675	3.6	17	0.05	2.22	0.02	1.10	0.40	40	390
80/09/25 09 05	7.7	18.2	8.0	700	3.7	13	0.10	2.33	0.03	1.00	0.50	42	680
80/09/30 09 00	-	16.2	8.2	728	-	14	0.18	2.72	-	1.16	0.58	35	170
80/10/01 08 30	8.2	17.0	7.9	710	4.3	21	0.20	2.92	0.02	1.10	0.64	37	-
80/10/09 08 30	8.9	15.0	-	-	-	15	0.25	4.45	0.02	0.80	0.60	85	260

000196

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River RM 83.6 - Keowee Str. (Dayton) SC 600310													
80/06/05 08 45	7.2	19.8	7.2	351	3.8	24	0.26	8.00	0.24	2.10	0.64	227	6000
80/06/10 08 35	8.2	18.0	7.5	520	2.8	19	0.15	4.93	0.09	1.50	0.34	129	3800
80/06/19 09 10	8.8	19.2	7.8	733	2.0	12	0.09	4.32	0.07	0.70	0.25	22	1700
80/06/26 09 00	6.2	22.0	7.8	621	3.1	12	0.16	5.42	0.11	1.10	0.27	36	980
80/07/01 09 00	7.4	20.5	7.5	386	3.8	37	0.09	6.00	0.16	2.00	0.71	296	7400
80/07/17 09 05	6.5	26.0	8.0	690	3.1	21	0.08	4.31	0.07	0.80	0.26	29	17000
80/07/22 08 45	6.7	24.0	7.9	565	7.5	24	0.15	2.05	0.06	1.80	0.31	47	56000
80/08/04 09 30	-	25.0	8.2	748	7.5	23	0.11	1.73	0.06	1.50	0.45	138	970
80/08/12 08 55	6.5	25.0	8.1	625	1.7	12	1.63	0.05	0.05	1.70	0.50	34	3200
80/08/21 09 10	7.3	24.0	7.7	545	2.5	23	0.09	2.29	0.06	1.00	0.40	59	910
80/08/28 08 30	8.1	23.8	8.0	700	4.9	13	0.06	2.42	0.06	1.20	0.48	32	1400
80/09/03 07 00	7.3	24.0	8.2	-	6.1	57	0.14	1.81	-	1.80	0.47	27	-
80/09/04 07 00	6.5	24.3	8.1	-	5.5	36	0.51	1.80	-	5.46	0.50	24	-
80/09/05 07 00	6.6	24.9	8.1	-	3.5	44	0.14	1.91	-	1.75	0.46	22	-
80/09/25 09 40	7.4	19.4	8.0	700	5.5	21	0.31	2.40	0.10	1.50	0.60	32	800
80/10/01 09 10	7.6	18.0	7.9	830	5.7	21	0.45	2.65	0.08	1.40	0.71	29	-

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Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. /100ml
Stillwater River													
RM 82.6, 0.3 - Triangle Park (Dayton)													
SC 600120													
80/06/05 09 10	8.8	20.0	7.4	262	1.3	25	0.29	6.80	0.36	2.6	0.85	360	-
80/06/10 09 10	9.0	17.0	7.7	528	2.0	31	0.10	6.22	0.10	2.1	0.78	371	6000
80/06/19 09 35	9.2	18.5	8.2	653	1.2	14	0.04	4.89	0.04	0.7	0.28	90	660
80/06/26 09 30	7.0	21.8	8.1	625	2.2	14	0.02	4.42	0.03	0.8	0.28	82	1800
80/07/01 09 20	8.4	21.2	7.5	210	2.9	44	0.25	3.75	0.23	3.1	1.14	710	4800
80/07/17 09 30	6.8	24.8	8.2	718	2.8	13	0.00	3.68	0.01	0.7	0.26	89	800
80/07/22 09 30	6.6	24.0	8.0	644	3.3	16	0.02	2.11	0.04	1.1	0.30	59	10000
80/07/24 18 00	-	25.8	-	478	14.0	42	0.05	0.85	0.04	2.1	0.22	91	-
80/08/04 10 00	-	24.0	7.9	640	2.6	12	0.06	2.97	0.04	0.8	0.30	118	230
80/08/12 09 15	6.9	24.1	7.7	490	1.4	64	0.82	0.24	0.05	1.3	0.33	12	3000
80/08/21 09 25	8.0	23.8	7.[illegible]	470	1.8	25	0.03	2.51	0.04	1.2	0.45	131	2900
80/08/28 09 00	8.3	23.0	[illegible]	765	2.7	8	0.00	2.09	0.01	0.9	0.31	56	910
80/09/03 07 00	7.5	23.8	-	-	9.4	33	0.01K	-	-	0.9	0.38	48	-
80/09/04 07 00	6.8	24.2	-	-	3.2	28	0.01K	-	-	1.1	0.24	30	-
80/09/05 07 00	6.6	24.4	-	-	2.1	28	0.03	-	-	1.3	0.30	77	-
80/09/25 10 00	8.3	18.5	8.1	750	5.5	19	0.02	1.14	0.02	1.2	0.32	64	230K
80/10/01 09 30	9.6	17.2	8.1	790	9.0	29	0.05	0.80	0.01	1.5	0.47	61	-

0001198

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. /100ml
Mad River													
RM 81.5, 0.2 - Webster Str. (Dayton)													
SC 610150													
80/06/05 10 15	8.4	17.6	7.8	311	2.4	24	0.28	7.40	0.25	2.30	0.750	308	2800
80/06/10 10 15	8.8	16.2	8.0	690	2.3	12	0.13	3.70	0.06	1.00	0.350	72	-
80/06/19 10 50	11.2	18.0	8.0	682	1.2	4	0.04	3.39	0.08	0.40	0.190	39	-
80/06/26 10 35	8.6	20.5	8.1	668	2.6	17	0.06	3.39	0.08	0.80	0.350	43	1900
80/07/01 10 20	8.8	19.2	7.9	627	3.7	12	0.12	3.26	0.06	0.90	0.270	87	6900
80/07/17 10 40	8.0	23.8	8.1	601	2.6	10	0.02	3.20	0.10	0.60	0.240	98	1200
80/07/22 11 00	7.4	22.0	7.8	480	5.3	36	0.03	2.16	0.08	2.10	0.690	413	75000
80/08/04 12 00	-	22.0	7.4	330	5.2	52	0.11	1.42	0.10	2.10	0.790	518	46000
80/08/12 10 25	7.8	22.0	7.7	360	4.5	75	2.86	0.01	0.06	2.40	0.754	532	56000
80/08/21 10 25	8.5	22.5	7.9	640	1.4	16	0.04	2.67	0.05	0.70	0.180	56	12000
80/08/28 10 15	9.2	21.2	7.6	705	1.6	8	0.03	2.83	0.04	0.50	0.220	28	4800
80/09/03 07 00	8.7	21.7	8.2	-	6.3	33	0.02	2.10	-	0.79	0.200	8	-
80/09/04 07 00	8.9	22.4	8.2	-	2.7	26	0.06	2.49	-	1.08	0.320	9	-
80/09/05 07 00	8.7	22.6	8.1	-	1.4	40	0.01	2.80	-	0.84	0.250	4	-
80/09/25 10 50	9.4	17.8	7.9	720	2.3	8	0.04	2.51	0.04	0.55	0.200	22	1600
80/10/01 10 30	10.0	16.8	7.9	750	3.0	8	0.45	2.60	0.04	0.40	0.260	21	-

000189

6399

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 80.6 - Monument Ave. (Dayton)													
SC 610060													
80/06/05 09 40	7.8	20.0	7.3	612	2.8	6	0.15	4.55	0.07	1.0	0.30	308	2800
80/06/10 09 45	8.8	17.5	7.8	429	2.5	35	0.13	5.44	0.10	1.8	0.55	207	4000
80/06/19 10 10	10.0	19.0	8.1	716	1.6	14	0.07	4.31	0.06	0.8	0.26	53	870
80/06/26 10 00	7.4	21.8	8.1	685	3.0	13	0.12	4.17	0.08	1.1	0.30	54	1300
80/07/01 10 00	8.6	21.5	7.5	228	3.0	48	0.22	4.04	0.19	3.2	1.09	703	3700
80/07/17 10 10	7.5	25.1	8.2	628	2.9	13	0.00	3.57	0.06	0.6	0.28	94	29000
80/07/22 10 15	7.4	23.0	7.9	564	6.0	32	0.02	2.07	0.06	1.5	0.41	154	47000
80/08/04 10 45	-	24.0	7.8	444	3.7	35	0.12	1.64	0.08	2.0	0.65	350	47000
80/08/12 09 45	7.7	23.2	7.8	412	3.8	28	1.22	0.03	0.09	2.5	0.60	60	70000
80/08/21 10 00	8.0	24.0	7.7	540	2.2	25	0.07	2.39	0.04	1.1	0.40	109	4200
80/08/28 09 20	8.7	22.0	7.8	790	1.8	2	0.02	2.65	0.04	0.6	0.29	35	480
80/09/03 07 00	8.1	23.6	8.4	-	3.2	32	0.01K	1.70	-	1.1	0.29	26	-
80/09/04 07 00	8.0	23.7	8.2	-	3.1	30	0.01K	1.80	-	2.0	0.25	37	-
80/09/05 07 00	8.0	24.1	8.1	-	3.0	24	0.03	2.08	-	1.2	0.28	28	-
80/09/25 10 30	8.4	18.2	8.0	730	3.3	15	0.03	2.15	0.05	0.8	0.30	29	1700
80/10/01 10 00	8.7	17.5	7.9	790	4.3	15	0.05	2.40	0.04	0.9	0.40	34	-
80/10/09 09 25	8.6	15.0	-	-	2.1	10	0.12	2.52	0.06	0.6	0.36	-	85

000200

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 73.8 - Sellars Rd. (West Carrollton)													
SC 610130													
80/06/05 10 55	7.8	20.0	7.7	372	3.1	22	0.26	7.10	0.22	2.0	0.68	316	2900
80/06/10 11 00	9.2	18.0	7.8	497	3.8	31	0.24	4.67	0.08	1.9	0.49	152	5200
80/06/19 11 45	9.8	21.2	8.0	770	3.8	16	0.86	3.26	0.09	1.8	0.41	52	1600
80/06/26 11 20	7.8	23.0	8.0	608	5.4	23	0.45	3.73	0.10	1.4	0.48	50	850
80/07/01 11 00	8.4	21.0	7.7	333	3.4	33	0.14	4.41	0.16	2.4	0.80	466	6000
80/07/08 10 05	7.4	22.0	8.0	643	3.3	14	0.32	4.02	0.07	1.1	0.34	99	3400
80/07/17 11 15	7.2	26.9	8.0	760	7.0	17	0.67	3.36	0.12	1.6	0.41	186	4900
80/07/22 12 00	7.6	23.0	7.8	513	8.2	24	0.85	1.80	0.07	2.2	0.50	68	100000L
80/08/04 13 45	-	26.0	7.6	664	10.0	19	1.36	2.29	0.18	2.1	0.60	92	11000
80/08/12 11 00	7.6	24.0	7.8	570	3.0	26	1.22	0.01K	0.10	2.1	0.49	40	8800
80/08/21 11 00	7.9	24.5	7.8	590	3.2	25	0.32	2.44	0.07	1.4	0.45	92	4000
80/08/28 10 50	8.1	24.8	7.9	710	4.6	6	0.51	2.45	0.09	1.2	0.46	50	7000
80/09/03 07 00	6.2	25.5	8.1	-	6.6	49	0.38	1.64	0.09	1.9	0.86	29	-
80/09/04 07 00	7.3	26.5	8.1	-	5.2	38	0.47	1.83	0.07	1.8	0.50	21	-
80/09/05 07 00	7.4	26.6	8.1	-	6.3	38	0.63	1.86	0.15	1.9	0.42	16	-
80/09/25 11 20	7.9	22.2	8.0	700	7.3	19	0.89	2.27	0.18	2.0	0.64	36	5500
80/10/01 11 00	8.0	21.5	7.9	870	9.7	21	1.40	2.30	0.18	2.5	0.75	40	-

000201

6899

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 66.9 - Linden Ave. (Miamisburg)													
SC 600150													
80/06/05 11 45	7.6	20.0	7.6	356	3.6	24	0.30	7.00	0.22	2.4	0.82	233	4700
80/06/10 11 45	9.0	18.5	7.8	572	4.9	33	0.37	4.61	0.10	1.8	0.53	149	33000
80/06/19 12 25	9.2	21.5	8.1	768	2.8	16	0.31	3.93	0.16	1.2	0.36	65	15200
80/06/26 12 00	7.4	23.0	8.1	768	5.7	21	0.20	3.84	0.14	1.2	0.57	51	20000
80/07/01 11 30	8.2	21.2	7.7	340	3.4	39	0.16	4.37	0.18	2.7	0.91	587	11000
80/07/08 12 00	6.0	22.8	8.0	657	4.0	14	0.44	4.07	0.14	1.2	0.52	103	71200
80/07/17 12 00	6.4	28.0	8.0	738	5.9	17	0.43	3.67	0.30	1.3	0.51	50	-
80/07/22 13 00	6.7	23.5	7.7	476	7.4	36	0.29	1.80	0.10	2.3	0.64	254	71200
80/08/04 13 00	-	25.0	7.7	606	5.4	23	0.30	2.25	0.14	1.4	-	-	92000
80/08/12 12 00	6.9	25.0	7.6	550	4.7	47	0.81	0.04	0.14	2.6	0.55	168	6600
80/08/21 11 30	7.1	24.5	7.7	585	3.6	25	0.26	2.51	0.11	1.3	0.44	38	48000
80/08/28 11 30	7.2	26.0	7.7	770	5.5	25	0.47	2.88	0.23	1.4	0.45	107	45000
80/09/03 07 00	7.3	25.4	8.1	-	4.2	51	0.45	1.47	0.22	2.2	0.68	31	72000
80/09/04 07 00	6.5	26.3	8.1	-	6.9	42	0.45	2.05	0.21	1.9	0.90	21	-
80/09/05 07 00	6.2	26.3	7.9	-	7.8	57	0.66	1.39	0.41	2.2	0.70	26	-
80/09/25 12 00	6.1	22.0	7.8	780	10.8	23	1.18	2.87	0.36	2.5	0.64	25	-
80/10/01 11 55	7.1	21.2	7.8	880	12.0	31	2.02	2.70	0.38	3.6	0.89	34	10000
80/10/09 10 10	5.8	17.8	-	-	7.7	27	3.05	5.50	0.46	2.9	-1.00	34	-
											0.95	45	7260

000202

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 60.6 - State Route 123 (Franklin)													
SC 600120													
80/06/05 12 55	8.1	20.0	7.7	356	3.9	28	0.32	7.20	0.22	2.1	0.76	262	6000
80/06/10 12 50	8.6	19.5	-	572	4.2	23	0.32	4.70	0.10	1.7	0.50	196	100000L
80/06/19 12 50	8.2	23.8	8.0	791	4.1	16	0.41	4.20	0.27	1.2	0.38	48	19000
80/06/26 13 05	7.8	25.8	7.9	670	5.6	25	0.15	3.96	0.21	1.3	0.52	49	10000
80/07/01 13 00	8.0	21.4	7.4	350	3.1	44	-	-	0.16	-	-	738	230
80/07/08 09 55	7.4	24.0	7.8	718	3.2	12	0.35	4.12	0.19	1.1	0.45	128	-
80/07/17 12 23	6.3	29.8	8.0	820	6.0	17	0.33	3.79	0.34	1.3	0.45	67	11000
80/07/22 08 00	6.8	26.0	7.4	577	9.4	39	0.20	2.08	0.16	2.4	0.62	211	100000L
80/08/04 08 25	6.9	24.8	7.6	627	5.6	25	0.39	2.24	0.24	1.5	0.50	119	5500
80/08/12 13 25	6.0	27.8	7.6	605	5.5	86	0.82	0.14	0.13	2.6	0.87	86	42000
80/08/21 13 05	6.4	26.8	7.8	520	3.6	43	0.25	2.51	0.13	1.5	0.60	139	-
80/08/28 12 20	6.6	27.5	7.8	785	4.7	30	0.32	3.01	0.21	1.1	0.60	45	25000
80/09/03 07 00	7.2	26.9	7.8	-	3.4	28	0.33	1.80	-	2.0	0.60	27	-
80/09/04 07 00	6.6	28.0	7.8	-	6.2	43	0.14	1.78	-	2.0	0.48	27	-
80/09/05 07 00	7.0	28.8	8.0	-	4.7	31	0.26	2.51	-	1.8	0.60	37	-
80/09/25 12 50	6.9	23.8	8.0	770	6.7	21	0.28	2.79	0.24	1.8	0.82	37	5400
80/10/01 13 35	8.9	22.8	7.9	920	7.8	27	0.45	3.10	0.30	1.8	0.76	35	-

000203

6399

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River RM 52.6 - State Route 122 (Middletown) SC 610110													
80/06/05 12 05	8.4	20.0	7.8	372	3.3	43	0.24	7.30	0.24	2.1	0.77	440	11200
80/06/10 11 55	8.4	19.5	-	580	3.8	21	0.30	5.10	0.12	1.6	0.52	177	100000L
80/06/19 12 15	8.3	22.5	8.1	709	3.5	14	0.34	4.50	0.30	0.8	0.34	43	-
80/06/26 12 15	7.7	25.4	7.8	658	4.6	19	0.10	4.07	0.22	1.0	0.39	55	-
80/07/01 12 15	8.6	21.3	8.2	318	3.5	46	0.09	4.55	0.20	2.8	1.01	600	-
80/07/17 11 40	7.8	29.5	7.3	697	5.2	14	0.01	3.58	0.13	0.9	0.44	127	2700
80/07/22 13 00	6.8	25.2	7.7	547	7.0	51	0.16	2.10	0.16	2.9	0.85	376	53000
80/08/04 13 05	7.7	24.2	7.6	530	4.4	23	0.20	2.15	0.18	1.2	0.49	136	11000
80/08/12 12 40	7.4	27.4	8.0	615	5.4	56	0.82	0.17	0.05	2.2	0.67	172	17000
80/08/21 12 20	7.0	25.5	7.8	505	3.2	35	0.14	2.55	0.12	1.4	0.52	167	7400
80/08/28 11 45	7.8	28.3	7.9	740	3.6	21	0.02	2.98	0.12	0.9	0.59	44	2400
80/09/03 07 00	8.3	26.4	7.6	-	4.0	35	0.01	1.67	-	1.6	0.48	25	-
80/09/04 07 00	8.1	26.6	7.9	-	4.6	35	0.37	1.94	-	1.9	0.46	27	-
80/09/05 07 00	8.8	27.7	7.9	-	4.8	42	1.34	3.02	-	1.8	0.50	29	-
80/09/16 09 00	8.0	22.9	8.2	-	4.9	30	0.23	3.14	-	1.8	0.78	32	-
80/09/17 09 00	6.1	22.3	8.0	-	5.1	28	0.70	3.20	-	1.8	0.78	44	-
80/09/18 09 00	7.6	21.8	8.2	-	5.5	45	0.31	2.95	-	1.4	0.60	35	-
80/09/25 12 00	6.8	23.8	8.0	850	5.5	21	0.24	3.12	0.22	1.6	0.79	43	800
80/10/01 12 30	9.5	22.0	7.9	900	7.3	31	0.10	3.45	0.26	1.6	0.75	37	-

000204

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 49.3 - State Route 73 (Middletown)													
SC 600330													
80/06/05 11 30	8.7	20.0	7.6	365	3.5	43	0.27	7.30	0.23	2.2	0.80	441	100000L
80/06/10 11 25	8.5	19.5	7.7	581	3.8	29	0.26	5.18	0.12	1.7	0.52	187	94000
80/06/19 11 35	8.5	22.3	6.3	784	2.2	16	0.12	4.29	0.20	0.9	0.39	54	4500
80/06/26 11 40	7.4	24.8	7.7	648	4.5	10	0.11	3.99	0.22	1.1	0.35	64	3000
80/07/01 11 40	8.6	21.3	7.4	334	3.6	43	0.21	4.59	0.20	2.6	1.02	615	21000
80/07/17 11 05	8.1	29.5	7.4	720	4.9	17	0.01	3.44	0.08	1.1	0.42	125	2400
80/07/22 12 15	7.0	25.2	7.8	578	10.2	55	0.29	2.40	0.23	2.9	0.81	481	38000
80/08/04 12 30	7.6	24.1	7.5	575	4.5	23	0.19	2.06	0.19	1.5	0.50	158	9900
80/08/12 12 00	7.6	28.2	8.0	635	4.3	29	0.57	0.04	0.07	1.9	0.76	80	10000
80/08/21 11 45	7.0	26.3	7.7	530	3.0	35	0.12	2.55	0.12	1.5	0.47	164	-
80/08/28 11 15	7.8	27.8	8.0	710	3.6	39	0.04	2.95	0.10	0.9	0.58	43	1200
80/09/16 09 00	8.2	22.9	8.1	-	4.5	43	0.19	3.18	-	1.9	0.83	44	-
80/09/17 09 00	7.9	22.1	8.1	-	5.4	25	0.02	2.90	-	1.2	0.70	46	-
80/09/18 09 00	8.8	22.2	8.2	-	6.9	30	0.03	3.09	-	1.3	0.56	61	-
80/09/25 11 35	8.2	23.2	8.2	820	5.5	25	0.05	2.71	0.11	1.6	0.71	51	340
80/10/01 12 00	10.1	21.0	8.0	920	7.3	26	0.02K	3.45	0.22	1.7	0.72	44	-

000205

6399

Appendix Table 1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 43.2 - Liberty-Fairfield Rd.													
SC 610090													
80/06/05 10 55	8.4	20.0	7.7	371	4.2	43	0.31	7.30	0.24	2.3	0.85	472	100000L
80/06/10 11 00	8.3	19.0	7.7	559	3.8	31	0.28	5.22	0.12	1.7	0.50	198	44000
80/06/26 10 50	7.0	24.3	7.8	710	3.7	21	0.05	3.80	0.17	0.9	0.37	63	2600
80/07/01 11 05	8.5	21.2	7.3	311	2.8	47	0.20	4.57	0.14	2.6	1.10	765	25000
80/07/17 10 35	7.3	29.5	8.1	812	6.1	17	0.06	3.50	0.10	1.2	0.44	84	2100
80/07/22 11 45	6.6	26.2	7.9	638	8.1	45	0.05	2.74	0.12	2.4	0.72	348	75000
80/08/04 12 00	7.2	24.2	7.5	550	3.4	25	0.13	2.03	0.10	1.5	0.53	192	8800
80/08/12 11 10	6.8	28.0	8.0	650	4.8	32	0.87	0.03	0.10	1.9	0.71	24	130000
80/08/21 11 00	6.8	26.2	7.8	565	2.9	30	0.13	2.52	0.11	1.5	0.57	168	11000
80/08/28 10 30	7.2	26.5	7.8	765	3.3	11	0.05	3.02	0.09	0.8	0.49	48	18000
80/09/16 09 00	8.4	22.0	-	-	4.6	35	0.16	-	-	1.2	0.79	28	-
80/09/17 09 00	8.4	22.0	-	-	4.6	30	0.17	2.89	-	1.3	0.40	2	-
80/09/18 09 00	8.9	21.3	-	-	5.8	34	0.18	3.04	-	1.6	0.60	44	-
80/09/25 10 50	7.5	23.0	8.3	800	5.8	25	0.04	2.94	0.10	1.8	0.69	55	230K
80/10/01 11 25	9.8	20.8	8.0	900	7.4	23	0.25	3.70	0.24	1.7	0.67	36	-
80/10/09 11 30	8.0	19.0	-	-	3.5	25	0.40	3.82	0.29	1.5	0.74	-	-

002006

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 35.7 - State Route 128 (Hamilton)													
SC 600270													
80/06/05 10 20	9.1	20.0	7.8	358	3.5	47	0.26	7.20	0.24	2.8	0.90	395	100000L
80/06/10 10 00	8.4	19.5	7.7	584	3.8	27	0.25	5.38	0.14	1.8	0.59	206	-
80/06/19 10 30	8.4	22.3	8.1	797	2.5	18	0.01	4.35	0.16	0.9	0.35	59	1400
80/06/26 10 00	7.5	24.3	7.8	697	3.9	10	0.06	3.50	0.15	1.0	0.38	59	-
80/07/01 10 15	9.0	21.3	7.5	315	3.5	48	0.17	4.42	0.16	2.7	1.06	776	28000
80/07/17 09 35	7.3	29.5	7.2	787	5.5	18	0.02	3.42	0.10	1.5	0.41	103	1200
80/07/22 11 00	7.3	24.0	7.8	453	6.8	140	0.08	2.27	0.18	7.4	2.92	3062	84000
80/08/04 11 25	7.3	24.0	7.6	486	3.5	25	0.16	1.95	0.11	1.3	0.51	185	1400
80/08/12 10 30	6.8	26.4	8.0	545	4.5	44	0.41	0.07	0.05	2.4	0.58	120	24000
80/08/21 10 00	7.4	25.4	7.8	515	2.8	35	0.08	2.48	0.09	1.4	0.55	168	5000
80/08/28 09 50	7.6	26.5	7.8	850	2.9	11	0.03	2.85	0.06	0.9	0.50	89	34000
80/09/16 09 00	9.4	22.7	8.3	-	3.7	26	0.13	2.96	-	1.8	0.68	57	-
80/09/17 09 00	8.9	22.2	8.2	-	4.8	30	0.15	2.66	-	2.1	0.45	54	-
80/09/18 09 00	10.2	22.4	8.2	-	7.3	42	0.01	2.15	-	1.2	0.44	38	-
80/09/25 10 10	9.8	22.5	8.5	870	6.4	29	0.03	2.36	0.06	1.9	0.60	60	200
80/10/01 10 30	11.7	21.5	8.2	920	6.5	31	2.02	3.25	0.15	1.9	0.67	70	-
80/10/09 13 00	9.7	20.2	-	-	3.9	15	0.22	4.35	0.12	1.1	0.60	-	-

0002027

6399

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River RM 21.4 - River Rd. (New Baltimore) SC 600030													
80/06/05 09 30	8.7	20.0	7.9	369	4.0	49	0.19	7.40	0.23	2.6	0.90	511	19100
80/06/10 09 10	8.3	19.0	7.7	485	3.1	31	0.16	5.44	0.10	1.5	0.55	236	18000
80/06/19 09 40	8.0	21.5	7.9	697	2.5	16	0.01	4.27	0.09	0.8	0.34	63	1400
80/06/26 09 05	6.9	24.3	7.8	652	4.5	16	0.00	3.55	0.12	0.9	0.36	48	-
80/07/01 09 35	8.4	21.3	7.7	345	4.0	50	0.08	4.25	0.22	2.8	1.20	740	34000
80/07/08 08 15	6.9	24.5	7.9	609	2.2	12	0.07	4.33	0.08	0.9	0.40	141	6400
80/07/17 08 40	6.5	28.8	7.9	745	6.0	14	0.05	3.02	0.02	1.1	0.44	98	1500
80/07/22 10 25	7.2	26.5	8.0	678	7.2	53	0.00	2.13	0.02	2.7	0.85	554	28000
80/08/04 10 30	6.7	23.8	7.4	427	3.3	35	0.15	1.75	0.08	1.6	0.70	309	16000
80/08/12 09 40	6.5	26.8	8.1	590	3.3	51	1.43	2.00	0.04	1.0	0.76	252	16000
80/08/21 09 30	6.9	25.0	7.8	525	2.6	41	0.05	2.44	0.08	1.3	0.51	218	43000
80/08/28 08 55	7.0	25.8	8.1	735	3.0	23	0.02	2.87	0.04	0.9	0.47	56	8600
80/09/16 09 00	10.2	22.2	8.4	-	4.0	36	0.11	2.98	-	2.0	0.50	63	-
80/09/17 09 00	9.2	21.6	8.3	-	4.2	40	0.01K	2.86	-	2.0	0.34	71	-
80/09/18 09 00	11.6	21.8	8.3	-	5.6	53	0.01	2.11	-	1.3	0.46	63	-
80/09/25 09 15	7.7	21.8	8.4	830	6.1	29	0.06	2.51	0.02	2.2	0.69	81	110K
80/10/01 09 40	8.8	20.0	8.2	780	6.2	31	0.02K	2.80	0.04	1.7	0.65	63	-
80/10/09 12 20	10.0	18.2	-	-	3.4	24	0.25	4.25	0.09	1.2	0.66	97	-

000208

Appendix Table A-1 continued.

RM-Location Date (Time)	D.O.[a] mg/l	Temp °C	pH S.U.	Cond. 25°C umhos	BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3-N mg/l	NO_2-N mg/l	TKN mg/l	P-T mg/l	TDS mg/l	Fec. Coli. ct/100ml
Great Miami River													
RM 5.6 - Lost Bridge (Elizabethtown)													
SC 600300													
80/06/05 08 30	8.4	19.5	7.8	374	3.3	43	0.17	7.40	0.22	2.4	0.85	244	7800
80/06/10 08 20	8.2	19.0	7.5	541	2.8	47	0.12	5.12	0.08	1.6	0.52	237	12000
80/06/19 08 50	8.4	21.5	8.1	718	2.2	16	0.01	4.03	0.05	0.8	0.34	82	1000
80/06/26 08 05	8.2	24.0	7.8	645	4.3	16	0.00	3.20	0.04	1.0	0.36	58	440
80/07/01 08 40	8.2	21.3	7.4	343	4.0	56	0.08	4.05	0.14	3.1	1.28	849	26000
80/07/17 07 45	6.8	28.3	6.8	719	4.1	17	0.00	3.08	0.02	1.0	0.36	116	1500
80/07/22 09 30	8.5	26.0	8.5	601	6.7	31	0.02	1.90	0.02	1.9	0.31	184	270
80/08/04 09 45	6.3	23.5	7.4	365	4.7	60	0.08	1.47	0.10	2.7	1.50	988	100000L
80/08/12 08 45	6.9	27.4	7.7	610	4.3	40	1.43	0.02	0.05	2.0	0.94	120	9800
80/08/21 08 30	6.8	25.0	7.7	510	2.0	37	0.04	2.40	0.04	1.3	0.51	193	4700
80/08/28 08 00	7.6	25.2	8.0	685	2.7	18	0.02	2.43	0.04	0.9	0.34	58	540
80/09/25 08 20	9.6	20.8	8.2	750	5.6	25	0.06	2.17	0.03	1.8	0.45	72	110K
80/10/01 08 45	9.5	19.5	8.3	800	6.6	10	0.02K	2.25	0.04	1.7	0.49	70	-

000209

6399

Appendix Table A-2. Raw chemical/physical data for hardness, heavy metals, cyanide, phenolics for the lower mainstem Great Miami River mainstem, June 5 - October 9, 1980.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 92.6 - Taylorsville Dam										
SC 610150										
80/06/05 08 00	227	1K	80	10K	8690	5K	40K	60	0.010K	4
80/06/10 07 45	316	1	120	10K	2830	5K	40K	20	0.010K	3
80/06/19 08 30	381	1K	100	10K	850	5K	40K	10	0.010K	2K
80/06/26 08 15	295	1K	40K	5K	2020	5K	40K	10	-	-
80/07/01 08 15	201	1K	40	15	10040	10	40K	50	0.010K	8
80/07/08 08 00	367	1K	40	5	960	5K	40	15	0.010K	7
80/07/17 08 20	315	1K	40K	5	1480	5K	40	10	0.010K	2K
80/07/22 08 00	327	1K	50	5K	910	5K	40K	10	0.010K	2K
80/08/04 08 45	396	1K	40K	10	1740	9	60	15	0.010K	3
80/08/12 08 20	340	1K	40K	5	2120	8	50	15	0.005K	6
80/08/21 08 20	301	1K	40K	10	2140	5K	40K	25	0.010K	6
80/08/28 08 00	430	1K	40K	5	910	5K	40K	20	0.010K	2K
80/09/25 09 05	408	1K	50	5K	1020	5K	40K	15	0.010K	5
80/09/30 09 00	348	5K	30K	30K	920	5K	100	30K	0.010K	4
80/10/01 08 30	354	1K	40K	5K	720	5K	40K	15	0.010K	3
80/10/09 08 30	392	1K	40K	5K	590	9	40K	10	0.010K	3

000210

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 83.6 - Keowee Str. (Dayton)										
SC 600310										
80/06/05 08 45	232	1	40	15	9000	5K	40K	55	0.010K	4
80/06/10 08 35	327	1	40	10K	2990	5K	40K	20	0.010K	2
80/06/19 09 10	388	1K	160	10K	580	5K	40K	10	0.010K	2K
80/06/26 09 00	277	1K	40K	5K	1280	5K	40K	10	0.010K	2
80/07/01 09 00	195	1K	80	15	10590	7	40K	50	0.010K	5
80/07/17 09 05	321	1K	40K	5	760	5K	40	10	0.010K	3
80/07/22 08 45	333	1K	40	5K	900	5K	40K	15	0.010	3
80/08/04 09 30	345	1K	60	5K	770	5K	70	5K	0.010K	4
80/08/12 08 55	374	1K	40K	10	1060	5K	40K	10	0.005	5K
80/08/21 09 10	282	1K	40K	10	1690	5K	40K	15	0.010K	4
80/08/28 08 30	383	1K	40K	10	930	5K	40K	20	0.010K	2K
80/09/03 07 00	285	1K	40K	5	490	14	40K	5	-	-
80/09/04 07 00	273	1K	40	10	480	5K	40K	20	-	-
80/09/05 07 00	290	1K	40K	5K	490	4	40K	25	-	-
80/09/25 09 40	397	1K	40K	5K	700	5K	40K	10	0.010K	4
80/10/01 09 10	354	1K	40K	5K	580	5K	40K	15	0.010K	6

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Stillwater River										
RM 82.6, 0.3 - Triangle Park (Dayton)										
SC 600120										
80/06/05 09 10	178	1	80	15	14550	8	40K	80	0.010K	5
80/06/10 09 10	313	1K	120	10K	10850	5K	40	55	0.010K	2K
80/06/19 09 35	393	1K	60	10K	2420	5K	40K	10	0.010K	2K
80/06/26 09 30	332	1K	40K	5	2610	5K	40K	15	-	-
80/07/01 09 20	117	1K	40K	20	21720	21	40K	95	0.010K	5
80/07/17 09 30	379	1K	40K	5	2160	5K	40	5K	0.010K	2K
80/07/22 09 30	423	1K	60	5	1680	5K	40K	20	0.010K	2K
80/07/24 18 00	-	5K	30K	30K	740	5K	100K	30K	0.010K	4
80/08/04 10 00	310	1K	40K	5K	1920	5K	100	5	0.010K	2
80/08/12 09 15	310	1K	40K	5	2340	5K	40K	20	0.005K	36
80/08/21 09 25	298	1K	40K	5	3580	5K	60	25	0.010K	7
80/09/03 07 00	365	1K	40K	5K	1210	5K	40K	5	-	-
80/09/04 07 00	371	1K	70	5K	1170	5K	40K	5	-	-
80/09/05 07 00	273	1K	40K	15	1230	10	40K	20	-	-
80/08/28 09 00	403	1K	110	5K	1700	5	40K	10	0.010K	2K
80/09/25 10 00	410	1K	40K	5K	1290	5K	40K	10	0.010K	4
80/10/01 09 30	358	1K	40K	5	1150	5K	40K	15	0.010K	7

000212

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Mad River										
RM 81.5, 0.2 - Webster Str. (Dayton)										
SC 610150										
80/06/05 10 15	204	1	40K	10	11790	8	40K	70	0.010K	2K
80/06/10 10 15	394	1K	80	10K	2488	5K	40K	25	0.010K	2K
80/06/19 10 50	388	1K	100	10K	910	5K	40K	15	0.010K	2K
80/06/26 10 35	358	1K	40K	5K	1360	5K	40K	15	0.010K	2K
80/07/01 10 20	345	1K	40K	5	2300	5K	40K	25	0.010K	2
80/07/17 10 40	413	1K	40K	10	1300	5K	40	15	0.010K	2K
80/07/22 11 00	334	1K	50	15	7830	24	40K	60	0.010K	4
80/08/04 12 00	205	1K	40K	20	9930	32	160	70	0.010K	5
80/08/12 10 25	295	1K	80	20	10870	36	120	80	0.005K	5K
80/08/21 10 25	384	1k	40K	10	1360	5K	50	20	0.010K	2
80/08/28 10 15	425	1K	40K	5	900	5K	40K	20	0.010K	2K
80/09/03 07 00	378	1K	40K	5K	320	5K	40K	5K	-	-
80/09/04 07 00	408	1K	70	5K	250	10	40K	5K	-	-
80/09/05 07.00	412	1K	40	5K	280	11	40K	10	-	-
80/09/25 10 50	386	1K	50	5K	540	5K	40K	20	0.010K	3
80/10/01 10 30	363	1K	40K	5K	430	16	40K	10	0.010K	4

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 80.6 - Monument Ave. (Dayton)										
SC 610060										
80/06/05 09 40	412	1	40K	10K	2880	5K	40K	30	0.010K	4
80/06/10 09 45	321	1	100	10K	6910	5K	40	35	0.010K	4
80/06/19 10 10	380	1K	60	10K	1450	5K	40K	5	0.010K	2K
80/06/26 10 00	345	1K	40K	10	1860	5	40K	90	0.010K	2K
80/07/01 10 00	137	1K	40K	20	20980	22	40K	90	0.010K	7
80/07/17 10 10	388	1K	40K	10	1640	5K	40	5K	0.010K	2K
80/07/22 10 15	307	1K	80	10	3450	8	40K	35	0.010K	5
80/08/04 10 45	243	1K	40K	10	7580	26	40K	45	0.010K	7
80/08/12 09 45	321	1K	40K	15	7630	34	60	60	0.005K	11
80/08/21 10 00	297	1K	40K	10	2850	5K	60	20	0.010K	6
80/08/28 09 20	400	1K	40K	5K	1000	5K	40K	15	0.010K	2K
80/09/03 07 00	345	1K	40K	5	550	5K	40K	5	-	-
80/09/04 07 00	359	1K	50	5	560	7	4K	25	-	-
80/09/05 07 00	367	1K	40K	5	560	14	40K	10	-	-
80/09/25 10 30	409	1K	40K	5	650	5K	40K	10	0.010K	2
80/10/01 10 00	374	1K	40K	5	500	5K	40K	5	0.010K	5
80/10/09 09 25	384	1K	40K	5K	440	5K	40K	10	0.010K	3

000214

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 73.8 - Sellars Rd. (West Carrollton)										
SC 610130										
80/06/05 10 55	259	1	40	10	10050	5K	40K	60	0.010K	4
80/06/10 11 00	309	1	40K	10K	4780	5K	40K	40	0.010K	2
80/06/19 11 45	398	1K	80	20	1120	5K	40K	30	0.010K	2
80/06/26 11 20	359	1K	40K	10	1650	6	40K	55	0.010K	2K
80/07/01 11 00	171	1K	40K	28	15780	16	40	70	0.010K	6
80/07/08 10 05	370	1K	40K	5	1190	5K	40	15	0.010K	2
80/07/17 11 15	387	1K	40K	15	1470	1K	50	10	0.010K	2
80/07/22 12 00	266	1K	50	5	2970	17	40K	40	0.010K	4
80/08/04 13 45	307	1K	40K	15	2030	16	90	35	0.010K	5
80/08/12 11 00	379	1K	40K	10	2790	17	50	35	0.005K	12
80/08/21 11 00	349	1K	40K	20	3070	5	60	35	0.010K	5
80/08/28 10 50	374	1K	40K	10	1050	5K	40K	25	0.010K	2K
80/09/03 07 00	565	1K	50	10	510	5K	40K	20	-	-
80/09/04 07 00	301	1K	40K	10	540	5K	40K	20	-	-
80/09/05 07 00	294	1K	40K	10	390	5K	40K	10	-	-
80/09/25 11 20	376	1K	40K	10	790	9	40K	35	0.010K	5
80/10/01 11 00	382	1K	40K	15	780	5	40K	45	0.010K	5

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 66.9 - Linden Ave. (Miamisburg)										
SC 600150										
80/06/05 11 45	225	1	40	10K	10950	8	40K	85	0.010K	4
80/06/10 11 45	292	1	40	10K	4840	5K	40K	50	0.010K	3
80/06/19 12 25	387	1K	100	10K	1080	5K	40	20	0.010K	2
80/06/26 12 00	333	1K	40K	5	1630	5K	40K	25	-	-
80/07/01 11 30	180	1K	40K	20	17530	17	40	80	0.010K	5
80/07/08 12 00	225	1K	40	10	1160	5K	40K	25	0.010K	2
80/07/17 12 00	384	1K	50	15	1190	5K	40	10	0.010K	2
80/07/22 13 00	276	1K	60	10	5730	26	40K	60	0.010K	4
80/07/23 13 00	-	-	-	-	-	-	-	-	0.010K	4
80/08/04 13 00	336	1K	40K	15	3270	22	50	45	0.010K	6
80/08/12 12 00	275	1K	100	15	3690	28	40K	55	0.005K	5K
80/08/21 11 30	357	1K	40K	10	2700	5K	80	25	0.010K	4
80/08/28 11 30	410	1K	40K	15	970	8	40K	20	0.010K	3
80/09/03 07 00	372	1K	40K	10	520	5K	40K	20	-	-
80/09/04 07 00	330	-	40K	20	500	7	40K	25	-	-
80/09/05 07 00	314	1K	40K	15	270	5K	40K	10	-	-
80/09/25 12 00	362	1K	40K	10	640	5K	40K	35	0.010K	7
80/10/01 11 55	387	1K	40K	15	570	7	40K	40	0.028	8
80/10/09 10 10	384	1K	40K	10	570	6	40K	105	0.010K	9

000216

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 60.6 - State Route 123 (Franklin)										
SC 610120										
80/06/05 12 55	217	1	60	10	11450	5	40K	80	0.010K	3
80/06/10 12 50	348	1	60	10	4890	5K	40	45	0.010K	2
80/06/19 12 50	402	1K	60	10K	1120	5	40K	15	0.010K	2K
80/06/26 13 05	317	1K	40K	10	1500	5K	40K	20	0.010K	2K
80/07/01 13 00	188	1K	40K	20	18220	20	40K	90	0.010K	7
80/07/08 09 55	348	1K	50	10	1360	5K	50	30	0.010K	-
80/07/17 12 23	399	1K	40K	10	1330	5K	60	25	0.010K	2
80/07/22 08 00	320	1K	40K	25	4770	30	40	75	0.010K	4
80/08/04 08 25	305	1K	40K	10	2610	11	40	40	0.010K	3
80/08/12 13 25	302	1K	50	25	3140	26	40K	60	0.005K	10
80/08/21 13 05	327	1K	40K	15	3410	8	60	35	0.010K	6
80/08/28 12 20	408	1K	40K	5	1060	5K	40K	20	0.010K	3
80/09/03 07 00	364	1K	60	10	540	5K	40K	15	-	-
80/09/04 07 00	376	1K	50	5	480	5K	40K	15	-	-
80/09/05 07 00	265	1K	40	5	350	5K	40K	10	-	-
80/09/25 12 50	375	1K	60	10	660	5	40K	15	0.010K	9
80/10/01 13 35	358	1K	40K	10	600	5K	40K	20	0.010K	8

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 52.6 - State Route 122 (Middletown)										
SC 610110										
80/06/05 12 05	252	1	40K	10K	11630	14	40K	75	0.010K	4
80/06/10 11 55	357	1	80	10K	4976	5K	40K	35	0.010K	2K
80/06/19 12 15	386	1K	80	10K	1100	5K	40K	20	0.010K	2
80/06/26 12 15	344	1K	80	5K	1550	5K	40K	80	0.010K	2
80/07/01 12 15	198	1K	60	25	17520	19	40K	85	0.010K	8
80/07/17 11 40	379	1K	40K	15	1550	5K	40	20	0.010K	3
80/07/22 13 00	297	1	60	30	10650	28	40K	85	0.010K	3
80/08/04 13 05	273	1K	40K	10	3280	11	110	20	0.010K	4
80/08/12 12 40	315	1K	40K	10	3170	12	40	30	0.007	5K
80/08/21 12 20	333	1K	40K	15	3660	6	40	60	0.010K	3
80/08/28 11 45	404	1K	40K	10	980	5K	40K	20	0.010K	2K
80/09/03 07 00	282	1K	40K	5K	370	5K	40K	5K	-	-
80/09/04 07 00	355	1K	40K	5K	460	14	40K	15	-	-
80/09/05 07 00	295	1K	40K	5	390	5	40K	10	-	-
80/09/16 09 00	327	1K	70	5	600	5K	40K	15	-	-
80/09/17 09 00	383	1K	50	10	680	5	60	20	-	-
80/09/18 09 00	368	1K	40K	10	650	7	40K	20	-	-
80/09/25 12 00	393	1K	40K	10	820	5K	40K	20	0.010K	6
80/10/01 12 30	366	1K	40K	10	620	5K	40K	15	0.010K	7

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 49.3 - State Route 73 (Middletown)										
SC 600330										
80/06/05 11 30	232	1K	40K	15	12040	12	40K	65	0.010K	6
80/06/10 11 25	318	1K	40K	10	4860	5K	40K	50	0.010K	2K
80/06/19 11 35	396	1K	80	10K	1240	5K	40K	25	0.010K	2K
80/06/26 11 40	322	1K	40K	10	1770	5K	40K	25	0.010K	2K
80/07/01 11 40	190	1K	70	20	17970	18	40K	85	0.010K	6
80/07/17 11 05	369	1K	40K	10	1520	5K	50	25	0.010K	2
80/07/22 12 15	381	1K	60	30	9390	27	50	115	0.010K	2
80/08/04 12 30	276	1K	40K	10	3990	10	90	30	0.010K	6
80/08/12 12 00	322	1K	40K	15	2490	11	40K	25	0.005K	5K
80/08/21 11 45	299	1K	40K	15	4000	-	40K	50	0.010K	4
80/08/28 11 15	406	1K	40K	10	930	5K	40K	20	0.010K	2
80/09/16 09 00	411	1K	40K	10	860	12	40K	35	-	-
80/09/17 09 00	386	1K	40K	10	730	8	40K	30	-	-
80/09/18 09 00	368	1K	40K	10	840	10	40K	35	-	-
80/09/25 11 35	373	1K	50	10	880	5K	40K	20	0.010K	10
80/10/01 12 00	379	1K	40K	10	730	8	40K	20	0.010K	5

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 43.2 - Liberty-Fairfield Rd.										
SC 610090										
80/06/05 10 55	247	1K	40K	10	12280	14	40K	75	0.010K	6
80/06/10 11 00	329	1	120	10K	5280	5K	40K	65	0.010K	2
80/06/26 10 50	306	1K	40K	10	1980	5K	40K	25	0.010K	2
80/07/01 11 05	193	1K	40K	20	18360	22	40K	90	0.010K	5
80/07/17 10 35	380	1K	40K	10	1360	5K	40K	20	0.010K	2
80/07/22 11 45	344	1K	40K	20	5100	26	40K	70	0.010K	2
80/08/04 12 00	261	1K	40K	15	4460	14	90	35	0.010K	4
80/08/12 11 10	323	1K	40K	10	2720	14	40K	40	0.005K	12
80/08/21 11 00	310	1K	40K	10	3850	5K	40K	45	0.010K	4
80/08/28 10 30	379	1K	40K	10	1040	5K	40	35	0.010K	2
80/09/16 09 00	369	1K	40K	10	920	5K	40K	40	-	-
80/09/17 09 00	382	1K	40K	10	920	5K	40K	40	-	-
80/09/18 09 00	370	1K	40K	10	830	5K	40	30	-	-
80/09/25 10 50	408	1K	40K	5K	870	5K	40K	30	0.010K	8
80/10/01 11 25	390	1K	40K	5	630	5K	40K	20	0.010K	6
80/10/09 11 30	388	1K	40K	10	500	5K	40K	20	0.010K	6

000220

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 35.7 - State Route 128 (Hamilton)										
SC 600270										
80/06/05 10 20	243	1	60	15	12600	10	40K	85	0.010K	6
80/06/10 10 00	347	1	40K	10K	5580	5	40K	55	0.010K	2
80/06/19 10 30	379	1K	40K	10K	1380	5K	40K	25	0.010K	2K
80/06/26 10 00	302	1K	40K	5	1840	5K	40K	25	-	-
80/07/01 10 15	-	-	-	-	-	-	-	-	0.010K	6
80/07/17 09 35	359	1K	40K	10	2320	5K	40K	[illegible]	0.010K	3
80/07/22 11 00	456	4	100	55	38150	63	40K	230	0.010K	2K
80/08/04 11 25	249	1K	40	10	4700	11	80	35	0.010K	6
80/08/12 10 30	276	1K	40K	15	7780	23	40K	70	0.005K	15
80/08/21 10 00	310	1K	40K	15	3870	8	100	40	0.010K	5
80/08/28 09 50	392	1K	40K	10	1590	5K	40K	30	0.010K	2K
80/09/16 07 00	389	1K	40K	10	900	12	40K	45	-	-
80/09/17 07 00	391	1K	40K	15	860	9	40K	45	-	-
80/09/18 07 00	391	1K	40K	10	780	10	40K	40	-	-
80/09/25 10 10	371	1K	60	5K	860	5K	40K	25	-	-
80/10/01 10 30	397	1K	40K	10	1240	5K	40K	30	0.010K	7
80/10/09 13 00	382	1K	40K	10	870	5K	40K	20	0.010K	5

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 21.4 - River Rd. (New Baltimore)										
SC 600030										
80/06/05 09 30	261	1K	40K	20	13000	12	40K	85	0.010K	4
80/06/10 09 10	325	1K	60	10	6040	5K	40K	60	0.010K	5
80/06/19 09 40	377	1K	40	10	1240	5K	40K	25	0.010K	2
80/06/26 09 05	348	1K	50	5K	1370	5K	40K	85	0.010K	2
80/07/01 09 35	202	1K	40K	25	20240	24	40K	100	0.010K	16
80/07/08 08 15	346	1K	40K	10	1640	5K	50	30	0.010K	-
80/07/17 08 40	376	1K	40K	10	1750	5K	40K	20	0.010K	2
80/07/22 10 25	367	1	70	15	8970	23	40K	65	0.010K	2K
80/08/04 10 30	255	1K	40K	10	8530	23	70	40	0.010K	5
80/08/12 09 40	297	1K	40K	10	5110	7	40K	40	0.005K	25
80/08/21 09 30	330	1K	40K	15	4020	11	50	45	0.010K	4
80/08/28 08 55	396	1K	40K	10	1170	5K	40K	30	0.010K	2K
80/09/16 09 00	286	1K	40K	10	600	5K	40K	35	-	-
80/09/17 09 00	379	1K	40K	15	870	11	40K	45	-	-
80/09/18 09 00	390	1K	40K	15	910	-	50	60	-	-
80/09/25 09 15	414	1K	50	5K	1070	5K	40K	30	0.010K	10
80/10/01 09 40	377	1K	40K	15	890	5	40K	25	0.010K	5
80/10/09 12 20	394	1K	40	5K	770	5K	40K	20	0.010K	5

000222

Appendix Table A-2 continued.

RM (Location) Date (Time)	Hard-T mg/l	Cd-T ug/l	Cr-T ug/l	Cu-T ug/l	Fe-T ug/l	Pb-T ug/l	Ni-T ug/l	Zn-T ug/l	CN-T mg/l	Phenols ug/l
Great Miami River										
RM 5.6 - Lost Bridge (Elizabethtown)										
SC 600300										
80/06/05 08 30	275	1	40K	30	12600	19	40K	90	0.010K	4
80/06/10 08 20	290	1	100	10K	6240	5K	40K	50	0.010K	2
80/06/19 08 50	373	1K	60	10	1660	5K	40K	30	0.010K	2K
80/06/26 08 05	331	1K	60	10	1660	5K	40K	45	0.010K	2
80/07/01 08 40	204	1K	40K	25	21380	24	40K	110	0.010K	14
80/07/17 07 45	331	1K	40K	10	1810	5K	40	25	0.010K	2
80/07/22 09 30	330	1K	40K	10	1610	5K	40K	25	0.010K	2K
80/08/04 09 45	312	1K	40K	25	18870	34	40K	100	0.010K	8
80/08/12 08 45	304	1K	40K	10	6370	16	40K	40	0.005K	8
80/08/21 08 30	345	1K	40K	5	4060	9	60	35	0.010K	5
80/08/28 08 00	374	1K	40K	10	1250	5K	40K	15	0.010K	2K
80/09/25 08 20	398	1K	40K	5K	960	5K	40K	20	0.010K	8
80/10/01 08 45	365	1K	40K	10	880	11	40K	15	0.010K	7

APPENDIX B
Fish Data

000224

Appendix Table B-1. Mean fish community parameters (±SE) based on boat electrofishing catches in the lower mainstem Great Miami River study area, July 9 - October 7, 1980.

RM	n	Composite Index (±SE)	Cumulative Species	Number of Species per Zone (±SE)	Numbers/KM (±SE)	Kg/Km (±SE)	H̄ by Numbers (±SE)	H̄ by Weight (±SE)
91.0	3	9.19 (0.11)	29	21.0 (1.73)	510.67 (64.84)	99.16 (37.04)	2.30 (0.05)	1.56 (9.35)
88.1	3	9.41 (0.03)	27	19.0 (2.08)	540.00 (55.14)	107.15 (25.27)	2.40 (0.06)	1.57 (0.19)
86.2	3	7.99 (0.29	22	14.0 (1.74)	270.67 (59.64)	49.08 (6.40)	1.98 (0.31)	1.30 (0.12)
83.3	3	8.47 (0.28)	19	13.67 (0.89)	301.33 (17.49)	56.82 (5.64)	2.07 (0.13)	1.42 (0.21)
81.8	3	8.17 (0.43)	24	17.33 (1.20)	376.00 (58.46)	176.59 (20.50)	1.86 (0.23)	0.78 (0.20)
80.7	3	9.26 (0.51)	28	19.67 (2.34)	253.33 (49.88)	53.31 (8.63)	2.53 (0.19)	2.01 (0.28)
78.1	3	8.77 (0.41)	22	15.67 (1.45)	272.00 (62.17)	43.54 (10.71)	2.31 (0.08)	1.85 (0.15)
77.1	3	7.77 (0.18)	22	14.00 (0.00)	165.33 (40.73)	71.21 (11.41)	2.23 (0.07)	2.23 (0.07)
74.9	3	6.90 (0.12)	21	11.00 (1.16)	114.00 (18.17)	41.52 (13.25)	1.81 (0.20)	0.92 (0.15)
73.6	3	7.34 (0.37)	20	13.33 (1.77)	245.83 (51.51)	85.18 (43.68)	1.57 (0.37)	0.96 (0.33)
72.9	3	6.12 (0.37)	12	9.33 (1.86)	106.00 (26.10)	46.44 (10.82)	1.49 (0.09)	0.45 (0.07)
71.8	4	6.95 (0.06)	22	13.25 (0.85)	168.45 (11.01)	68.77 (7.14)	1.87 (0.10)	0.41 (0.06)
70.4	3	6.70 (0.16)	16	10.67 (0.88)	163.33 (18.00)	73.55 (11.70)	1.62 (0.04)	0.40 (0.08)
68.7	3	7.57 (0.54)	24	16.33 (1.33)	252.00 (98.97)	69.09 (22.48)	2.04 (0.13)	0.78 (0.09)
65.9	3	6.78 (0.30)	18	10.67 (1.45)	160.67 (43.65)	100.41 (49.49)	1.60 (0.19)	0.49 (0.19)
63.5	3	6.21 (0.15)	14	9.00 (0.55)	94.00 (11.03)	9.32 (3.19)	1.61 (0.18)	1.18 (0.19)
62.3	3	7.81 (0.15)	23	15.33 (0.12)	387.27 (41.36)	64.56 (15.16)	1.94 (0.10)	0.84 (0.16)
59.5	3	7.01 (0.60)	21	13.33 (2.34)	311.33 (63.03)	39.27 (17.60)	1.71 (0.11)	1.14 (0.38)
58.2	3	7.47 (0.41)	18	12.67 (1.15)	157.33 (25.86)	19.00 (3.29)	2.01 (0.11)	1.50 (0.04)
56.5	3	7.00 (0.60)	20	12.67 (2.03)	210.67 (58.52)	45.96 (13.44)	1.52 (0.13)	0.98 (0.47)
53.9	3	6.56 (0.63)	14	10.00 (1.53)	187.33 (87.94)	39.56 (20.09)	1.68 (0.07)	0.72 (0.06)
51.0	3	7.50 (0.20)	19	14.33 (0.88)	289.33 (86.44)	15.91 (2.08)	1.52 (0.24)	1.81 (0.34)
50.2	3	6.69 (0.57)	13	9.33 (0.67)	175.33 (87.70)	21.28 (10.21)	1.70 (0.00)	1.19 (0.10)
49.3	3	6.15 (1.43)	14	8.33 (2.67)	215.33 (104.03)	53.18 (38.16)	1.43 (0.27)	0.71 (0.39)
47.9	3	5.71 (0.53)	13	7.00 (1.16)	111.33 (45.17)	19.09 (6.00)	1.43 (0.21)	0.62 (0.17)
46.8	3	6.92 (0.17)	17	11.00 (1.00)	194.67 (37.82)	31.38 (13.55)	1.61 (0.09)	1.61 (0.09)
44.9	3	7.27 (0.13)	20	12.00 (1.00)	227.33 (41.20)	21.24 (2.56)	1.66 (0.04)	1.39 (0.13)
42.8	3	6.11 (0.37)	12	6.67 (0.33)	214.22 (73.42)	57.15 (24.06)	1.25 (0.09)	0.40 (0.10)
40.2	2	7.07 (0.21)	15	12.00 (1.00)	130.00 (11.70)	16.11 (4.29)	1.72 (0.13)	1.54 (0.17)
38.2	3	7.19 (0.73)	24	13.67 (2.73)	124.67 (21.51)	22.05 (2.61)	2.02 (0.23)	1.23 (0.35)
35.6	3	8.18 (0.19)	28	18.33 (0.67)	441.48 (40.97)	148.29 (44.27)	1.60 (0.10)	1.01 (0.15)
33.7	3	7.46 (0.35)	23	14.33 (0.67)	196.00 (28.06)	55.70 (23.84)	1.74 (0.15)	1.18 (0.26)
28.9	2	7.35 (0.28)	15	12.00 (0.00)	196.67 (46.39)	57.46 (14.53)	1.51 (0.16)	1.24 (0.10)
26.1	3	7.99 (0.09)	22	14.00 (0.58)	160.00 (68.17)	40.08 (9.05)	2.10 (0.18)	1.62 (0.18)
23.6	3	7.57 (0.18)	20	13.00 (1.73)	159.33 (53.31)	65.00 (27.75)	1.87 (0.06)	3.00 (0.13)
18.2	3	8.42 (0.41)	25	16.00 (1.73)	178.00 (11.73)	40.27 (7.24)	2.16 (0.13)	1.83 (0.31)
17.1	3	8.05 (0.31)	24	15.67 (1.20)	204.00 (70.12)	30.05 (2.51)	2.11 (0.23)	1.63 (0.20)
13.1	2	7.41 (0.42)	15	12.00 (1.00)	178.00 (80.24)	46.36 (23.38)	1.78 (0.24)	1.24 (0.58)
11.6	3	7.89 (0.46)	19	11.33 (2.61)	203.33 (78.55)	60.48 (19.23)	1.85 (0.27)	1.44 (0.17)
7.9	3	7.64 (0.36)	22	14.33 (2.34)	112.67 (1.33)	47.88 (11.22)	2.04 (0.21)	1.37 (0.33)
4.6	2	6.61 (0.61)	12	8.67 (0.88)	108.00 (16.79)	37.81 (11.29)	1.48 (0.23)	1.03 (0.27)
0.9	3	7.24 (0.23)	23	13.67 (1.86)	226.00 (92.98)	41.99 (5.64)	1.62 (0.20)	1.13 (0.23)
MR 81.5, 1.2	3	8.92 (0.04)	33	21.33 (0.33)	283.33 (21.39)	85.46 (15.30)	2.48 (0.05)	1.41 (0.11)
SR 82.6, 0.7	3	8.28 (0.26)	18	12.00 (1.00)	286.67 (59.70)	77.29 (10.22)	1.94 (0.03)	1.37 (0.16)
WWR 6.6, 8.2	3	8.07 (0.15)	19	12.33 (0.67)	122.00 (21.41)	59.11 (16.11)	2.05 (0.09)	1.63 (0.29)
WWR 6.6, 3.6	2	8.33 (0.18)	16	13.00 (1.00)	168.72 (166.35)	110.56 (47.44)	1.81 (0.28)	1.42 (0.10)
WWR 6.6, 0.9	3	7.64 (0.24)	19	13.33 (1.45)	272.00 (121.54)	36.42 (9.88)	1.61 (0.29)	1.55 (0.19)
FC 38.6, 0.3	3	8.00 (0.21)	28	19.00 (1.53)	365.28 (128.48)	55.85 (23.66)	2.38 (0.23)	1.87 (0.23)
TC 56.5, 0.3	3	8.73 (0.30)	22	16.33 (2.03)	286.67 (86.66)	34.97 (12.45)	2.32 (0.04)	1.91 (0.02)

SR - Stillwater R.; MR - Mad R.; TC - Twin Cr.; FC - Four Mile Cr.; WWR - Whitewater R.

000226

APPENDIX C
Macroinvertebrate Data

Table C-1. Organisms collected on artificial substrate samplers from the Stillwater River and the Mad River, July-September, 1980[a]

Taxa	Stillwater River Station (RM)[b] 4.7	0.5	Mad River 4.5	0.2
Porifera:				
Meyeninae				+
Coelenterata:				
Hydra sp		6	4	
Turbellaria:				
Unidentified	10+	3		4
Bryozoa:				
Plumatella repens	2			
Annelida:				
Oligochaeta	4	8	152+	42
Helobdella sp		+		
Dina sp	+			+
Isopoda:				
Lirceus sp	2+		+	30+
Amphipoda:				
Gammarus sp		+		
Hyalella azteca		+		+
Decapoda:				
Astacidae				1+
Orconectes sp	+		+	
Hydracarina:				
Unidentified			4	
Ephemeroptera:				
Stenacron sp	+	183+	95+	23+
Stenonema pulchellum group A	266+	782+	867+	170+
Stenonema pulchellum group B		10		6
Stenonema pulchellum group C	+		63	23
Heptagenia sp	+			
Baetis sp	110+	15	216+	54+
Caenis sp		6		
Tricorythodes sp	10	6	40	4
Pseudocloeon sp				+
Odonata:				
Coenagrionidae		1		+
Argia sp	+	+		
Enallagma sp	+	+	+	
Agrion sp			4+	
Hetaerina sp				+
Hemiptera:				
Rheumatobates sp	+	+		
Rhadovelia sp	+			
Mesovelia mulsanti	+	+		

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Table C-1. Continued

Taxa	Stillwater River Station (RM)[b] 4.7	0.5	Mad River 4.5	0.2
Trichoptera:				
Cheumatopsyche sp	1703+	338+	1555+	200+
Symphitopsyche bifida group	2668+	10	736+	218+
Hydropsyche sp			16	
Hydropsyche deprevata group			16	6
Hydropsyche orris				3
Hydropsyche *bidens*-	511			
Hydropsyche *venularis*				3
Neurectipsis sp	2	3		
Hydroptila sp	2			2
Coleoptera:				
Stenelmis sp	+	2+	28+	22+
Dubiraphia sp		1		
Dubiraphia vittata	+			
Ostroservus sp			4	+
Ancyronyx variagata			8	2
Macronychus glabratus		1	12	2+
Psephenus herriki	+	+		
Ectopria sp		+		
Diptera:				
Simuliidae				+
Simulium sp	18+		8+	
Simulium vittatum				10
Pentaneura sp	+	13	77+	64+
Abiabesmyia sp		4		
Nilotanypus sp	10	9	132	17
Polypedilum (*Polypedilum*) trinodense	81+	43	257+	90+
Polypedilum (*Polypedilum*) fallax		11	14	17+
Polypedilum (*Tripodura*) scalaenum	5			4
Tendipes sp		2	7	
Tanytarsus sp		7		4
Cryptochironomus sp				+
Cryptochironomus, sens. lat. sp B		2		
Calopsectra Rheotanytarsus group	167	22	77	
Calopsectra Micropsectra group			14	
Cricotopus sp		+	14	

(Continued on next page)

Table C-1. Continued

Taxa	Stillwater River Station (RM)[b] 4.7	0.5	Mad River 4.5	0.2
Cricotopus bicinctus				4+
Eukiefferiella sp			7	
Trichocladius sp			14	
Corynoneura sp		2		2
Corynoneura (*Thienemanniella*) sp	10			
Empididae	2	1	12+	2+
Anthomyiidae			4	
Gastropoda:				
Ferrissia sp			4	14+
Goniobasis livescens	+	3+		4+
Goniobasis virginica		+		+
Pelecypoda:				
Sphaerium sp	+	+		
Number of organisms/sq.ft.	1117	299	892	209
Number of taxa[c]	19	28	31	31
Diversity index, d[c]	2.04	2.23	3.02	3.57

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile).
(c) Artificial substrate sample only.

Table C-2. Organisms collected on artificial substrate samplers from the Great Miami River, segments 1-2, July - September, 1980 [a]

Taxa	Great Miami River Station (RM) [b]				
	91.1	87.7	87.0	82.0	80.7
Coelenterata:					
Hydra sp 61	6		64+	12	
Turbellaria:					
Unidentified	8	4+	508+	2	
Bryozoa:					
Plumatella repens	1		6		
Urnatella gracilis	1		1		
Annelida:					
Oligochaeta	14	12+	28	133	170
Helobdella lineata		+			
Dina sp		+			
Isopoda:					
Lirceus sp	1		+	2	
Amphipoda:					
Gammarus sp					
Crangonyx sp		2			
Hyalella azteca	+	+			
Decapoda:					
Orconectes sp		1+	+		
Orconectes rusticus	+				
Ephemeroptera:					
Stenacron sp	565+	+	416+	335+	145+
Stenonema pulchellum group A	273	355+	289+	185	411+
Stenonema pulchellum group B	5		12	41	
Stenonema pulchellum group C	88+	77	49	29	93
Stenonema femoratum group A	+	10+			
Heptagenia sp	+		+		
Baetis sp	90+	208+	134+	37+	300+
Caenis sp	5	8+	1	2	
Tricorythodes sp	31+	18	18	38	
Isonychia sp	1	+			
Potamanthus sp		+			
Odonata:					
Boyeria vinosa		+			
Coenagrionidae	2+	+	+		
Argia sp 4	+				
Enallagma sp		+			
Agrion sp	+	+			
Hetaerina sp	1		2		
Hemiptera:					
Corisella sp		+			
Trichocorixa sp		+			

(Continued on next page)

Table C-2. Continued

Taxa	Great Miami River Station (RM)[b] 91.1	87.7	87.0	82.0	80.7
Rheumatobates sp			+		
Rhagovelia sp		+			
Mesovelia mulsanti			+		
Trichoptera:					
Cheumatopsyche sp	387+	1003+	1906+	398	154+
Potamyia sp				35	7+
Symphitopsyche bifida group	25+	1048+	382+	258	356+
Hydropsyche deprevata group					2
Hydropsyche orris				4	7
Hydropsyche bidens		36			
Hydropsyche valanis				4	
Hydropsyche simulans		9			2
Hydropsyche dicantha		224+	31		2
Hydroptila sp	1	9		18	8
Coleoptera:					
Stenelmis sp	3+	+	2+	+	6+
Dubiraphia sp	2				2
Dubiraphia vittata		+	2		
Macronychus glabratus	2		2		6
Psephenus herriki	+				
Diptera:					
Simulium sp					16
Pentaneura sp	101	51	149	88	118
Ablabesmyia sp	23		25		+
Nilotanypus sp	34	51	25	66	21
Polypedilum (Polypedilum) illinoense	79+	613	621+	198+	279+
Polypedilum (Polypedilum) fallax	11	+			11
Polypedilum (Tripodura) scalaenum	11		+		
Tendipes (Limnochironomus) sp			50+		
Tendipes (Limnochironomus) nervosus				22	
Tendipes (Tendipes) sp			+		
Tendipes (Kiefferulus) tendipediformis?			+		
Glyptotendipes sp	23		50		
Glyptotendipes (Phytotendipes) polytomus?		+	+		
Tanytarsus sp	+				
Cryptochironomus sp				22	+
Cyrptochironomus, sens. lat. sp B		2			
Harnischia (Harnischia) abortiva				22	
Calopsectra Rheotanytarsus group	259	2249	1614	1275	97
Calopsectra Calopsectra group	23				

(Continued on next page)

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Table C-2. Continued

Taxa	Great Miami River Station (RM)[b] 91.1	87.7	87.0	82.0	80.7
Cricotopus sp			+	22	21
Psectrocladius sp				22	
Coryneura sp	13			22	
Empididae		12	12+	3	8+
Gastropoda:					
Ferrissia sp				+	4+
Goniobasis livescens	16+	+	+	14+	+
Number of organisms/sq.ft.	433	1190	1165	769	469
Number of taxa [c]	34	18	24	30	32
Diversity index, d [c]	3.44	2.65	2.80	3.40	3.65

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile).
(c) Artificial substrate sample only.

Table C-3. Organisms Collected on Artificial Substrate Samplers from the Great Miami River, Segments 3-4, July - September, 1980 [a]

Taxa	Great Miami River Station (RM) [b]					
	78.0	77.3	76.5	75.2	73.9	71.7
Coelenterata:						
Hydra sp	2			2		
Turbellaria:						
Unidentified	+			2		4
Nematoda:						
Unidentified	1					
Bryozoa:						
Plumatella repens	5		2	+		
Urnatella gracilis					1	
Annelida:						
Oligochaeta	155+	17+	4+	4+	84	382+
Dina sp						1+
Isopoda:						
Lirceus sp	2+	1+	2+			
Amphipoda:						
Crangonyx sp	4					
Hyalella azteca	+			+		
Decapoda:						
Orconectes sp	+	1+	+	+		
Hydracarina:						
Unidentified				10	6	
Ephemeroptera:						
Stenacron sp	90+	127+	40+	25+	133+	185
Stenonema pulchellum group A		328+	394+	390+	80	19
Stenonema pulchellum group B	90	103+	60+	41+	187+	
Stenonema pulchellum group C			+	82	80	
Stenonema femoratum group A						37
Heptagenia sp	20	+	+		+	
Heptagenia flavescens					2	
Baetis sp	191+	349+	272+	44+	530	232+
Caenis sp	4	2	4+	+	4	8
Tricorythodes sp	13	10+	12+	2+	176+	136
Isonychia sp				2		
Odonata:						
Coenagrionidae	+			+		
Argia sp	4		+	+	+	
Hetaerina sp		+				
Trichoptera:						
Cheumatopsyche sp		22+	16+	108+		
Potamyia sp		33	42+		10	
Symphitopsyche bifida group	8+	48+	146+	323+	30	
Hydropsyche orris		61	62	394	375	120
Hydropsyche bidens		17+	16		20	26
Hydropsyche valanis		6	20+	+	30	86+

(Continued on next page)

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Table C-3. Continued

Taxa	Great Miami River Station (RM)[b] 78.0	77.3	76.5	75.2	73.9	71.7
Hydropsyche venularis				11		
Hydropsyche simulans			4	59		
Hydropsyche dicantha					10	
Hydroptila sp	10+		+			4
Chimarra obscura						4
Coleoptera:						
Stenelmis sp		6+	+	6+	+	28+
Dubiraphia sp		1				
Dubiraphia vittata	+					
Optioservus sp		1	2			
Ancyronyx variagata	4				2	
Macronychus glabratus				+	2	
Diptera:						
Simuliidae				6		
Simulium sp		2	6		156	
Simulium vittatum						36+
Pentaneura sp	238+	94+	110+	96+	245	780+
Abiabesmyia sp	60			+		
Nilotanypus sp		12	4			
Polypedilum (Polypedilum) illinoense	389+	59+	118+	70+	1958+	5067+
Polypedilum (Polypedilum) fallax		6				
Tendipes (Limnochironomus) sp					122	
Glyptotendipes sp	30					
Glyptotendipes (Glyptotendipes) senilis					+	
Cryptochironomus sp				+		98+
Cryptochironomus, sens. lat. sp B		12				
Harnischia (Harnischia) abortiva	+					
Caloposectra Rheotanytarus group	537	135	218+	167+	1285+	+
Caloposectra Group A	89+					195
Cricotopus sp	60	+			612+	
Cricotopus bicinctus	179+		4	13	367+	585+
Psectrocladius sp	149				+	
Trichocladius sp		6				
Corynoneura sp					8	8
Empididae	5	1	4	14	22	24
Gastropoda:						
Ferrissia sp	17+		2	+		
Physa sp	+					
Goniobasis livescens	2					
Pelecypoda:						
Sphaerium sp		4+	2+	4+		

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Table C-3. Continued

Taxa	Great Miami River Station (RM)[b]					
	78.0	77.3	76.5	75.2	73.9	71.7
Number of organisms/sq.ft.	472	293	313	375	1307	1613
Number of taxa [c]	28	28	26	24	28	23
Diversity index, d [c]	3.57	3.40	3.34	3.33	3.31	2.18

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile)
(c) Artificial substrate sample only.

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Table C-4. Organisms collected on artificial substrate samplers from the Great Miami River, segment 5, July - September, 1980[a]

Taxa	Great Miami River Station (RM)[b] 67.6	66.2	64.3
Turbellaria:			
Unidentified		4+	
Bryozoa:			
Plumatella sp			+
Annelida:			
Oligochaeta	92+	26	14
Dina sp	+	+	
Amphipoda:			
Hyalella azteca		+	
Decapoda:			
Orconectes sp	+	+	+
Ephemeroptera:			
Stenacron sp	216+	283+	145+
Stenonema pulchellum group A	377+	14+	116+
Stenonema pulchellum group B	81	50	58+
Stenonema pulchellum group C	269	135	492
Stenonema femoratum group A		121+	14
Stenonema femoratum group B			14
Heptagenia sp	27+	8+	87+
Baetis sp	1778+	25+	211+
Caenis sp	4	7	
Tricorythodes sp	282+	33+	145+
Callibaetis sp		+	+
Odonata:			
Coenagrionidae		+	
Argia sp	4+	4	+
Enallagma sp	+		
Ischnura sp	+		
Agrionidae	2		
Hetaerina sp			+
Hemiptera:			
Gerris sp			+
Trichoptera:			
Cheumatopsyche sp	62	3+	29
Hydropsyche orris	934		336
Hydropsyche bidens	62		6
Hydropsyche valanis	21+	7	13
Hydropsyche venularis			16
Hydropsyche simulans	21		
Hydropsyche dicantha	21		
Neureclipsis sp	21		
Chimarra obscura	21		

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Table C-4. Continued

Taxa	Great Miami River Station (RM)[b] 67.6	66.2	64.3
Coleoptera:			
Stenelmis sp	8+	7+	
Dubiraphia sp		3	
Ancyronyx variagata	2	1	4
Hydroporus sp		+	
Diptera:			
Simuliidae sp			2
Simulium sp	28		
Pentaneura sp	690+	298	342+
Abiabesmyia sp	+	18	
Nilotanypus sp	10		
Polypedilum (*Polypedilum*) *illinoense*	86+	126+	183+
Polypedilum (*Polypedilum*) *fallax*	10	18	
Polypedilum (*Tripodura*) *scalaenum*	38+		
Glyptotendipes sp			23
Harnischia (*Harnischia*) *abortiva*		+	
Caloopsectra Rheotanytarsus group	58	36+	103
Cricotopus bicinctus			23
Psectrocladius sp	38	27	+
Empididae	188+		16
Gastropoda:			
Ferrissia sp	+	1+	4+
Physa sp	2		+
Number of organisms/sq.ft.	1091	251	479
Number of taxa[c]	31	24	24
Diversity index, d[c]	3.30	3.33	3.59

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile).
(c) Artificial substrate sample only.

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Table C-5. Organisms collected on artificial substrate samplers from the Great Miami River, segment 6, July - September, 1980[a]

Taxa	Great Miami River Station (RM)[b] 60.2	58.8	55.0
Turbellaria:			
Unidentified		+	+
Bryozoa:			
Plumatella sp			5+
Plumatella repens		38+	
Urnatella gracilis			1
Annelida:			
Oligochaeta	100	13+	24+
Dina sp		+	+
Isopoda:			
Lirceus sp		+	
Amphipoda:			
Unidentified		+	
Decapoda:			
Orconectes sp	+		
Ephemeroptera:			
Stenacron sp	+	110+	97+
Stenonema pulchellum group A	179+	101+	48+
Stenonema pulchellum group B	44	51+	113+
Stenonema pulchellum group C	268+	364+	467+
Heptagenia sp	+	76+	+
Baetis sp	388+	74+	129+
Caenis sp			8
Tricorythodes sp	264+	136+	253+
Odonata:			
Coenagrionidae			+
Argia sp		+	1
Hemiptera:			
Sigara sp			
Trichoptera:			
Cheumatopsyche sp		52+	387+
Potamyia sp	8	52+	290+
Symphitopsyche bifida group		17+	+
Hydropsyche orris	5014+	889+	766+
Hydropsyche bidens	1540	314+	161+
Hydropsyche valanis	243+	17	64+
Hydropsyche venularis	203+	+	
Hydropsyche simulans	324	52+	16+
Hydropsyche dicantha			+
Hydroptila sp	4	2	19
Coleoptera:			
Stenelmis sp	8+		+

(Continued on next page)

Table C-5. Continued

Taxa	Great Miami River Station (RM)[b] 60.2	58.8	55.0
Diptera:			
Pentaneura sp	378+	212+	578+
Polypedilum (*Polypedilum*) *illinoense*	1816+	172+	689+
Tendipes sp			22
Glyptotendipes sp			22+
Tanytarsus (*Stictochironomus*)? sp		+	
Cryptochironomus, sens. lat. sp B		40	22
Harnischia (*Harnischia*) *abortiva*		30	
Caloopsectra Rheotanytarsus group	113	51+	44
Tricotopus bicinctus	+		44
Psectrocladius sp		10	
Corynoneura sp		10	8
Ceratopogonidae			4
Empididae	60	4	4
Gastropoda:			
Ferrissia sp	8	10+	1
Gyraulus sp		2	
Goniobasis livescens		+	
Number of organisms/sq.ft.	2192	580	857
Number of taxa[c]	19	27	29
Diversity index, d[c]	2.65	3.58	3.61

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile).
(c) Artificial substrate sample only.

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Table C-6. Organisms Collected on Artificial Substrate Samplers from the Great Miami River, Segment 7, July-September, 1980 [a]

Taxa	Great Miami River Station (RM)[b]						
	51.5	50.7	49.3	47.7	46.8	44.5	43.2
Porifera:							
Spongilla lacustris				+			
Turbellaria:							
Unidentified		2	2	1		2+	
Nematoda:							
Unidentified						6	
Bryozoa:							
Plumatella repens	10+	3+	1+	+	1	6	1
Urnatella gracilis	1	1	1	1+		1	1
Annelida:							
Oligochaeta	110	350	72	23	232	58	32+
Dina sp	4+			+		+	
Isopoda:							
Lirceus sp						2	
Decapoda:							
Astacidae		+		+			
Hydracarina:							
Unidentified		6					
Ephemeroptera:							
Stenacron sp	340+	15+	315+	294+	110+	128+	+
Stenonema pulchellum group A		369+	136+	516+	77	132+	745+
477+							
Stenonema pulchellum group B		103+	45+	43+	62	88+	256+
95							
Stenonema pulchellum group C		414+	393+	229	448+	417+	1022+
524+							
Stenonema femoratum group A				+	22+	43+	
Stenonema femoratum group B				+			
Heptagenia sp	30	15+	14+	93+	+	106+	16+
Baetis sp	56+	360+	196+	116+	192+	120+	172+
Caenis sp	6	4	8	7	44	30+	8
Tricorythodes sp	172+	232+	186+	23+	280+	102+	44+
Isonychia sp					+		1
Odonata:							
Gomphus sp				+			
Gomphus (Gomphus) descriptus				+			
Argia sp	2+	+		4+	+	4+	1
Enallagma sp			+			+	
Agrionidae			2				
Hemiptera							
Corixidae		2					
Trichoptera:							
Cheumatopsyche sp	160+	8	7+	7+	112	58+	+
Potamyia sp	366+		33+	10+	135	146	515+
Symphitopsyche bifida group		16			22		
Hydropsyche orris	481+	614+	447+	70+	1100+	534	4117

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Table C-6. Continued

Taxa	Great Miami River Station (RM)[b] 51.5	50.7	49.3	47.7	46.8	44.5	43.2
Hydropsyche bidens	114+	202+	40+		67	29	281
Hydropsyche valanis		+			+	19	
Hydropsyche simulans	69	24+	33	2+	112	58	328
Hydropsyche dicantha					22		
Ceraclea sp				+			
Hydroptila sp		+		+	4	4	+
Coleoptera:							
Stenelmis sp	+	4			1	2+	4
Dubiraphia sp	10						
Laccophilus sp			+				
Diptera:							
Simulium vittatum				1			
Pentaneura sp	434+	371+	326	162+	720	410+	149+
Polypedilum (Polypedilum) illinoense	347+	1729+	549+	110+	491+	242+	1594+
Polypedilum (Polypedilum) fallax		25	4	6		19	
Polypedilum (Tripodura) scalaenum	195	25	30		105	19	25+
Tendipes sp		25	15				
Tendipes (Tendipes) sp							+
Glyptotendipes sp	22	+					
Glyptotendipes (Glyptotendipes) senilis						19	
Glyptotendipes (Phytotendipes) lobiferus			+				
Cryptochironomus sp					+		
Cryptochironomus, sens. lat. sp B	22	124	30	17+	18	37	75
Harnischia (Harnischia) abortiva	+		+	+			
Calopsectra Rheotanytarus group	325+	173	119	99+	70	261	125
Calopsectra Calopsectra group				6			
Tricotopus sp	22	+	30		+		+
Tricotopus bicinctus					+		
Psectrocladius sp	22+	+	15		+	19	
Corynoneura sp	4			2			
Corynoneura (Thienemanniella) sp		+			+		
Empididae	6	12	2+	9	88	34	100
Lispe sp							+
Gastropoda:							
Ferrissia sp	10+	20	6+	+	16+	18	4+
Goniobasis livescens				9+			

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Table C-6 continued.

Taxa	Great Miami River Station (RM)[b]						
	51.5	50.7	49.3	47.7	46.8	44.5	43.2
Pelecypoda:							
Sphaerium sp						+	
Number of organisms/sq.ft.	845	987	654	332	920	912	1738
Number of taxa [c]	31	29	29	26	26	34	24
Diversity index, d [c]	3.99	3.27	3.62	3.41	3.68	3.73	2.65

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile).
(c) Artificial substrate sample only.

Table C-7. Organisms Collected on Artificial Substrate Samplers from the Great Miami River, Segments 8-9, July-September, 1980 [a]

Taxa	Great Miami River Station (RM)[b]				
	40.3	37.8	34.1	33.0	30.8
Turbellaria:					
Unidentified		+	+		
Nematoda:					
Unidentified		2			
Bryozoa:					
Plumatella sp	+				
Plumatella repens	3	2	4+	+	
Urnatella gracilis	1	+	1	1	
Annelida:					
Oligochaeta	15	56	246	16+	+
Helobdella lineata		+			
Isopoda:					
Lirceus sp		12+			
Amphipoda:					
Hyalella azteca		2	+		
Decapoda:					
Astacidae			+		
Orconectes sp	1+				
Ephemeroptera:					
Stenacron sp	113+	414+	50+	103	
Stenonema pulchellum group A	30+	120	132+	131+	+
Stenonema pulchellum group B	75	46	33	56	
Stenonema pulchellum group C	301+	248+	99	243+	+
Stenonema femoratum group A	8	9+	19		
Stenonema femoratum group B	8				
Heptagenia sp	53	18+	+	+	
Baetis sp	35+	2	20+	10+	+
Caenis sp	3	7+	14	12	
Tricorythodes sp	40+	14+	10+	27+	+
Isonychia sp	+		2		
Odonata:					
Gomphus sp	+				
Boyeria vinosa		+			
Coenagrionidae	+	2			
Argia sp 1	2+	8+	+	+	
Trichoptera:					
Cheumatopsyche sp	40+	10	54+	+	
Potamyia sp	73+	5	17	247+	+
Symphitopsyche bifida group		13			
Hydropsyche orris	59+	39	142+		
Hydropsyche bidens		7	42+		

(Continued on next page)

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Table C-7. Continued

Taxa	Great Miami River Station (RM)[b] 40.3	37.8	34.1	33.0	30.8
Hydropsyche valanis	5		13	+	
Hydropsyche simulans	5+	33	121+		
Cyrnellus fraternus	2				
Hydroptila sp		4			
Coleoptera:					
Stenelmis sp	1	+		+	
Dubiraphia vittata	3+				
Macronychus glabratus		4			
Diptera:					
Pentaneura sp	221+	63+	329+	379+	
Abiabesmyia sp	3	11			
Polypedilum (*Polypedilum*) *illinoense*	78+	3	164+	117+	+
Polypedilum (*Tripodura*) *scalaenum*	85	66	66	39	
Tendipes (*Limnochironomus*) sp		22			
Glyptotendipes sp			+		
Tanytarsus sp		11			
Cryptochironomus sp	3				
Cryptochironomus, sens. lat. sp B	6	121	65		
Harnischia (*Harnischia*) *abortiva*			+		
Calopsectra Rheotanytarsus group	7	54	66	78+	
Calopsectra Calopsectra group		11			
Psectrocladius sp		13			
Coryneneura sp	3				
Empididae	12+	2	10	22	
Lispe sp +					
Dolichopodidae		4			
Gastropoda:					
Ferrissia sp	2	+	312+	8+	+
Physa sp	22				
Number of organisms/sq.ft.	425	232	375	397	-
Number of taxa[c]	26	25	31	30	
18[d]					
Diversity index, d[c]	3.62	2.99	3.82	3.91	-

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile).
(c) Artificial substrate sample only.
(d) Number of qualitative taxa. Quantitative data not available.

Table C-8. Organisms Collected on Artificial Substrate Samplers from the Great Miami River, Segments 10-11, July - September, 1980 [a]

Taxa	Great Miami River Station (RM)[b] 24.8	22.5	15.1	9.5	8.2
Porifera:					
Spongilla fragilaris		+			
Turbellaria:					
Unidentified				+	
Bryozoa:					
Plumatella repens		+	1+	+	
Urnatella gracilis		+	1+		
Annelida:					
Oligochaeta			15	10	+
Helobdella sp				+	
Dina sp			+		
Isopoda:					
Lirceus sp				+	
Ephemeroptera:					
Stenacron sp	+	+	45+	18+	+
Stenonema pulchellum group A	+	+	90+	24+	+
Stenonema pulchellum group B		+	316+	60+	+
Stenonema pulchellum group C	+	+	541+	42+	+
Stenonema femoratum group A			+		
Heptagenia sp	+	+	+	+	+
Baetis sp	+	+	27+	11+	+
Tricorythodes sp		+	30+	6	
Isonychia sp			12	6+	
Odonata:					
Argia sp	+	+	4	+	
Agrion sp		+			
Trichoptera:					
Cheumatopsyche sp	+	+	32+	5+	
Potamyia sp	+	+	266+	121+	+
Symphitopsyche bifida group	+				
Hydropsyche orris	+	+	1436+	500+	+
Hydropsyche bidens				44	
Hydropsyche valanis	+	+	21+	5+	+
Hydropsyche venuiaris					+
Hydropsyche simulans	+	+	670+	258+	+
Ceraclea sp				+	
Chimarra obscura		+			
Coleoptera:					
Stenelmis sp			4	4+	+
Dubiraphia sp			4	2	
Psephenus herriki	+	+	+	+	
Dytiscus sp		+			

(Continued on next page)

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Table C-8. Continued

Taxa	Great Miami River Station (RM)[b] 24.8	22.5	15.1	9.5	8.2
Diptera:					
Tipula sp					+
Pentaneura sp		+	318	84	+
Tendipedinae					+
Polypedilum (*Polypedilum*) *illinoense*		+	212+	168+	+
Polypedilum (*Polypedilum*) *fallax*			11		
Polypedilum (*Tripodura*) *scalaenum*			11	15	
Glyptotendipes sp			+		
Cryptochironomus sp					+
Cryptochironomus, sens. lat. sp B			42	12	
Xenochironomus sp		+			
Eukiefferiella *Kheotanytarsus* group			106	26	
Corynoneura sp			2	6	+
Ceratopogonidae					+
Empididae			13		
Gastropoda:					
Ferrissia sp		+	4+	+	+
Goniobasis livescens		+	+		
Pelecypoda:					
Sphaerium sp		+	+		+
Number of organisms/sq. ft.	-	-	847	711	-
Number of taxa[c]	13[d]	26[d]	27	22	22[d]
Diversity index, d[c]	-	-	3.10	3.09	-

(a) Qualitative samples were also collected from the natural substrate and their presence is indicated by a +.
(b) RM (river mile).
(c) Artificial substrate sample only.
(d) Number of qualitative taxa. Quantitative data not available.

Appendix C-9. Benthos sampling station characteristics for the Great Miami River Basin

Stillwater River:

River Mile 4.7

General Location:	Stillwater River off Frederick Pike, downstream of Peters Pike bridge, Montgomery County, River Mile 4.7
Substrate:	Primarily bedrock, boulders, and rubble with some silt
Average width:	30 feet
Average depth:	1.5 feet
Canopy:	75% open
Habitat:	Run
Land Use:	Agricultural/rural with some upstream residential
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 0.5

General Location:	Stillwater River at Triangle Park, upstream of Ridge Ave. bridge, Dayton, Montgomery County, River Mile 0.5
Substrate:	Primarily rubble and gravel with some boulders, sand, silt, detritus, and fibrous peat
Average width:	50 feet
Average Depth:	3.5 feet
Canopy:	75% open
Habitat:	Slow run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

Mad River:

River Mile 4.5

General Location:	Mad River off SR 4, upstream of Harshman Road bridge, Montgomery County, River Mile 4.5
Substrate:	Primarily boulders and rubble with some gravel, sand, detritus, fibrous peat, and muck
Average width:	40 feet
Average depth:	2 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 0.2

General Location:	Mad River at Deeds Park, downstream of Webster Street bridge, Dayton, Montgomery County, River Mile 0.2
Substrate:	Primarily gravel and sand with some detritus
Average width:	40 feet
Average depth:	3.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

000249

Great Miami River

River Mile 91.1

General Location:	Great Miami River off Rip Rap Road, downstream of Little York Road bridge, Montgomery County, River Mile 91.1
Substrate:	Primarily rubble, gravel, and sand
Average width:	60 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 87.7

General Location:	Great Miami River off Birch Drive, downstream of Wagoner-Ford Road bridge, Montgomery County, River Mile 87.7
Substrate:	Primarily boulders with some rubble, gravel, silt, and detritus
Average width:	60 feet
Average depth:	1.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural with some upstream residential
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 87.0

General Location:	Great Miami River downstream of Needmore Road bridge, Dayton, Montgomery County, River Mile 87.0
Substrate:	Primarily rubble, gravel, sand, silt, and detritus
Average width:	40 feet
Average depth:	2 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 82.0

General Location:	Great Miami River off North Bend Blvd., downstream of Steele Dam, Dayton, Montgomery County, River Mile 82.0
Substrate:	Primarily gravel, sand, and silt with some boulders and rubble
Average width:	70 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Slow run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 80.7

General Location:	Great Miami River off Monument Ave., downstream of I-75 bridge, Dayton, Montgomery County, River Mile 80.7
Substrate:	Primarily gravel and sand with some boulders, rubble, and silt
Average width:	100 feet
Average depth:	2 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 78.0

General Location:	Great Miami River off Carillon Blvd., upstream of D,P, & L Tait lowhead, Dayton, Montgomery County, River Mile 78.0
Substrate:	Primarily sand with some boulders, rubble, gravel, silt, detritus, fibrous peat, and pulpy peat
Average width:	100 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 77.3

General Location:	Great Miami River off Carillon Blvd., downstream of D,P, & L Tait lowhead, Dayton, Montgomery County, River Mile 77.3
Substrate:	Primarily rubble and gravel with some sand and silt
Average width:	150 feet
Average depth:	1 foot
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 76.5

General Location:	Great Miami River off East River Road, upstream of Dayton WWTP, Moraine, Montgomery County, River Mile 76.5
Substrate:	Primarily gravel and sand with some boulders, rubble, silt, and detritus
Average width:	100 feet
Average depth:	1.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 75.2

General Location:	Great Miami River off East River Road, downstream of Dayton WWTP, Moraine, Montgomery County, River Mile 75.2
Substrate:	Primarily rubble and gravel with some sand and silt
Average width:	100 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 73.9

General Location:	Great Miami River upstream of Sellars Road bridge, Moraine, Montgomery County, River Mile 73.9
Substrate:	Primarily rubble and gravel with some boulders, sand, and silt
Average width:	100 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 71.7

General Location:	Great Miami River off Hydraulic Road, upstream of Montgomery County Western Regional WWTP, West Carrollton, Montgomery County, River Mile 71.1
Substrate:	Primarily gravel with some sand and silt
Average width:	100 feet
Average depth:	1 foot
Canopy:	Open
Habitat:	Run
Land Use	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 67.6

General Location:	Great Miami River off Upper River Road, upstream of Bear Creek, Miamisburg, Montgomery County, River Mile 67.6
Substrate:	Primarily boulders and rubble, with some gravel, sand, silt, and detritus
Average width:	100 feet
Average depth:	2.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 66.2

General Location:	Great Miami River off Riverview Ave., upstream of Miamisburg WWTP, Montgomery County, River Mile 6[illegible]
Substrate:	Primarily rubble and silt with some boulders, gra[illegible], and detritus
Average width:	90 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 64.3

General Location:	Great Miami River off Dayton-Cincinnati Pike, downstream of D,P & L Hutchings lowhead, Montgomery County, River Mile 64.3
Substrate:	Primarily rubble with some sand and silt
Average width:	100 feet
Average depth:	2.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 60.2

General Location:	Great Miami River off Dayton-Oxford Road, downst[illegible] of New York Central RR bridge, Franklin, Warren [illegible] County, River Mile 60.2
Substrate:	Primarily gravel with some rubble, sand, and silt
Average width:	150 feet
Average depth:	1 foot
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 58.8

General Location:	Great Miami River off Hobart Road, downstream of Franklin WWTP, Warren County, River Mile 58.8
Substrate:	Primarily boulders with some rubble and gravel
Average width:	100 feet
Average depth:	3.5 feet
Canopy:	75% open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

000253

River Mile 55.0

General Location:	Great Miami River off Carmody Blvd., downstream of SR 4 bridge, Middletown, Butler County, River Mile 55.0
Substrate:	Primarily gravel and sand with some boulders, rubble, and silt
Average width:	150 feet
Average depth:	2.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 51.5

General Location:	Great Miami River off Main Street, downstream of Middletown lowhead, Middletown, Butler County, River Mile 51.5
Substrate:	Primarily gravel and sand with some boulders rubble, silt, detritus, fibrous peat, and muck
Average width:	100 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 50.7

General Location:	Great Miami River off Main Street at Middletown Sand and Gravel, Middletown, Butler County, River Mile 50.7
Substrate:	Primarily sand and gravel with some boulders, rubble, silt, detritus, and fibrous peat
Average width:	100 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 49.3

General Location:	Great Miami River upstream of SR 73 bridge, Trenton, Butler County, River Mile 49.3
Substrate:	Primarily rubble with some boulders, gravel, sand, silt detritus, and fibrous peat
Average width:	125 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 47.7

General Location:	Great Miami River upstream of Dick's Creek, Butler County, River Mile 47.7
Substrate:	Primarily rubble and gravel with some sand and silt
Average width:	175 feet
Average depth:	3.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 46.8

General Location:	Great Miami River downstream of Dick's Creek, Butler County, River Mile 46.8
Substrate:	Primarily rubble and gravel with some boulders, sand, and detritus
Average width:	175 feet
Average depth:	3.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 44.5

General Location:	Great Miami River at Rockdale Road, Rockdale, Butler County, River Mile 44.5
Substrate:	Primarily rubble and gravel with some bedrock, boulders, sand, and detritus
Average width:	175 feet
Average depth:	3.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 43.2

General Location:	Great Miami River downstream of Liberty-Fairfield Road bridge, Butler County, River Mile 43.2
Substrate:	Primarily gravel and sand with some rubble, silt, and detritus
Average width:	175 feet
Average depth:	3.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 40.3

General Location:	Great Miami River off Augspurger Road, upstream of Armco-Hamilton, Butler County, River Mile 40.3
Substrate:	Primarily rubble and gravel with some boulders, sand, silt, and detritus
Average width:	110 feet
Average depth:	3.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 37.8

General Location:	Great Miami River off Riverside Drive (US 127), downstream of Armco-Hamilton and Fourmile Creek, Hamilton, Butler County, River Mile 37.8
Substrate:	Primarily rubble, gravel, and detritus with some boulders, sand, and silt
Average width:	190 feet
Average depth:	4 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 34.1

General Location:	Great Miami River off Neilan Road, upstream of Hamilton WWTP, Hamilton, Butler County, River Mile 34.1
Substrate:	Primarily rubble and gravel with some boulders, silt, fibrous peat, and muck
Average width:	100 feet
Average depth:	4 feet
Canopy:	Open
Habitat:	Run
Land Use:	Municipal/industrial
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 33.0

General Location:	Great Miami River off Forest Lake Lane, at Joyce Park, Butler County, River Mile 33.0
Substrate:	Primarily boulders and rubble with some gravel, sand, silt, and detritus
Average width:	125 feet
Average depth:	3.5 feet
Canopy:	75% open
Habitat:	Run
Land Use:	Municipal
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 30.8

General Location:	Great Miami River off East River Road, at Fairplay, Butler County, River Mile 30.8
Substrate:	Primarily rubble and gravel with some boulders, sand, silt, and detritus
Average width:	90 feet
Average depth:	5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Dipnet, handpick

River Mile 24.8

General Location:	Great Miami River off East River Road, upstream of DOE-FMPC, Hamilton County, River Mile 24.8
Substrate:	Primarily boulders and rubble with some sand, silt, and detritus
Average width:	100 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Dipnet, handpick

River Mile 22.5

General Location:	Great Miami River off River Road at Fairfield Sportman's Club, New Baltimore, Hamilton County, River Mile 22.5
Substrate:	Primarily boulders and rubble with some sand, silt, and detritus
Average width:	100 feet
Average depth:	4 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Dipnet, handpick

River Mile 15.1

General Location:	Great Miami River off Mill Street, Miamitown, Hamilton County, River Mile 15.1
Substrate:	Primarily boulders and rubble with some sand, silt, detritus, and fibrous peat
Average width:	150 feet
Average depth:	3 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

000257

River Mile 9.5

General Location:	Great Miami River off East Miami River Road, downstream of Jordan Creek, Hooven, Hamilton County, River Mile 9.5
Substrate:	Primarily rubble and gravel with some boulders, sand and silt
Average width:	150 feet
Average depth:	2.5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Artificial substrate, dipnet, handpick

River Mile 8.2

General Location:	Great Miami River downstream of US 50 bridge, Cleves, Hamilton County, River Mile 8.2
Substrate:	Primarily rubble and gravel with some boulders, sand, silt, detritus, and fibrous peat
Average width:	150 feet
Average depth:	5 feet
Canopy:	Open
Habitat:	Run
Land Use:	Agricultural/rural
Sampling Method:	Dipnet, handpick

SECTION II

WATER QUALITY MODELING

- THE LOWER MAINSTEM OF THE GREAT MIAMI RIVER -

Prepared by

State of Ohio Environmental Protection Agency

Division of Wastewater Pollution Control

Section of Water Quality Planning and Assessment

000259

Several issues involving the Great Miami River have been brought forward since the completion of this Comprehensive Water Quality Report. These issues, along with discussion and solutions, are presented individually below.

Reaeration Rates in Segment 2

The reaeration rate analysis for Segment 2 was completed in 1981; since that time, Ohio EPA's analytical capabilities for reducing K_2 data have been considerably expanded. Skalsky and Fischer, 1984, analyzed fifty-four valid determinations of reaeration rate (K_2) and compared them with K_2 values estimated by eighteen different equations found in the literature. The comparisons were divided into four classes, based on stream conditions, and best-fit equations were developed for each class.

To substantiate the Segment 2 reaeration rates, the data has been reanalyzed using these more sophisticated techniques. The sensititivy analysis confirmed that the critical section of Segment 2 for D.O. modeling lies between RM 55 and RM 37.3; a K_2 value of 1.62 day was used there for the WLA. Using the new techniques, a rearation rate of 1.86 day is estimated for the same critical reach. Thus, the original determination of reaeration rates is substantiated by the more detailed study.

Chautauqua Dam

The Chautauqua Dam, upstream of the discharge from the Franklin WWTP, failed in 1982. Since the dam will not be rebuilt, the impact of the failure on water quality was assessed through additional simulations. Velocities and depth through the area were approximated from similar reaches. Results show that while reaeration in the former "pool" area is increased, the loss of reaeration over the dam causes a net decrease in instream D.O. downstream from the Chautauqua Dam. The D.O. decreases to a low of 4.9 mg/l in the Middletown Dam pool at approximately 57.5. Below this dam, the D.O. recovers and is not affected significantly by the absence of the Chautauqua Dam. The failure of this dam adds uncertainty to the condition of water quality in Segment 2, and re-inforces the earlier premise that all entities in Segment 2 remain at their current permit limits until further study. Any future studies of Segment 2 should extend upstream to this area.

LeSourdsville WWTP

In June, 1983, the NH_3-N limit for the LeSourdsville WWTP was increased from 1.0 mg/l to 2.5 mg/l. While the original permit allowed for 1.0 mg/l NH_3-N, the plant was designed to meet 2.5 mg/l effluent NH_3-N. Since the plant was partially funded using federal grants, the NH_3-N limit should not be further relaxed. A revised discharger table is included in this addendum.

Fantasy Farm WWTP

In the time since the field surveys and modeling were completed, the Fantasy Farm WWTP has stopped discharging to the Great Miami River. Effluent from Fantasy Farm is now treated at the LeSourdsville WWTP. All references to Fantasy Farm have been removed from the report.

Dayton Power and Light-Tait Station

Since 1982, the DP&L Tait Station has operated only during peak demand periods. Since this entity does not contribute significantly to the flows or loads in the Great Miami River, no adjustments to the modeling is necessary. Any possible effect on instream temperature was adequately assessed in the original sensitivity analysis.

GMC - Harrison Radiator

GMC - Harrison Radiator, referred to as GMR - Delco #3 throughout the report, has radically changed its operations since the report was written. Effluent flow has decreased from 3.45 MGD to 0.56 MGD. At the same time, concentrations of metals have increased, such that concentrations listed in this report may be violated, while the corresponding loads would be maintained. In light of this, concentrations have been removed from the discharger data table for this entity (as found in Appendix B).

Armco - Middletown and New Miami

The Ohio EPA is in the process of reissuing permits to the Middletown and New Miami facilities of Armco. Due to changes in plant operation and to new technology, the new permits will be substantially different from the old ones. Some outfalls no longer exist, while others have been added or renumbered. Armco had requested that the new permit reflect the findings of this CWQR. Revised discharger tables and conservative substance allocation tables are included in this addendum.

A comparison of values in the new permit with those in this CWQR is included in Addendum Tables 1 and 2 for Armco Middletown and Armco New Miami, respectively. Only limits for the 001 outfall at the Middletown facility are included since outfalls 002-005 discharge to Dicks Creek. It was assumed that WWH WQS would be met at the mouth of Dicks Creek.

Federal law dictates that effluents from dischargers to the state's waterways must meet BAT or BEJ guidelines or maintain WQS, whichever is more stringent. For all Armco outfalls, WQS are more restrictive only in the case of lead; therefore, with the exception of lead, the limits set forth in the new permit (based on BAT/BEJ guidelines) should apply.

A re-evaluation of the loading of total lead has been completed. The assimilative capacity for lead of the Great Miami at the Armco Middletown 001 discharge is 72.39 lbs/day. A total of 66.13 lbs/day lead has been allocated to upstream dischargers. This means that Armco could discharge 6.26 lbs/day without violating WQS at that point. However, the lowest level of lead which Armco can consistently discharge is 10.5 lbs/day. This additional 4.24 lbs/day represents only an insignificant violation of the WQS in the river.

Addendum Table 1. Comparison of CWQR and permit values for Armco Middletown outfall 001.

Parameter	Effluent Load (lbs/day) 8/83 Permit	CWQR
Total Suspended Solids	3000	-
Oil and Grease	300	-
Zinc	18.48*	23.95
Lead	13.30	0.96[a]
(613) NH_3-N	451	528
Phenols	2.0	25.9
Cyanide	15.2	63.0

[a] based on old permit.

* See p 248

000263

Discharger: General Motors Corporation - Addendum
Harrison Radiator Division, Moraine North Plant
(Delco Air #3)

Facility Number: 1IC00008001
Permit Number: C108
Receiving Stream (River Mile): GMR (74.42)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)	0.672	0.081	-	
pH (S.U.)	7.57	7.31	6.5-9.0	
COD (lbs/day) / (mg/l)	444.6 / 79.33	791.2 / 132.92	-	
BOD_5 (lbs/day) / (mg/l)	59.42 / 10.6	-	-	
TSS (lbs/day) / (mg/l)	51.93 / 9.33	38.05 / 6.17	---- / 29.0	
D.O. (mg/l)	9.73	5.92	5.0	
P (lbs/day) / (mg/l)	0.99 / 17.67	0.56 / 0.10	29.0 / -	
O&G (lbs/day) / (mg/l)	-	23.74 / 3.77	---- / 10.0	
Cr (lbs/day) / (mg/l)	0.202 / 0.036	0.10 / 0.016	4.29 / -	1.8 / -
Cr^{+6} (lbs/day) / (mg/l)	-	-	0.46 / -	-
Ni (lbs/day) / (mg/l)	0.112 / 0.020	0.06 / 0.010	17.2 / -	17.20 / -
Zn (lbs/day) / (mg/l)	0.235 / 0.042	0.23 / 0.034	9.7 / -	9.70 / -
Fe (lbs/day) / (mg/l)	0.712 / 0.127	0.88 / 0.163	42.8 / -	28.80 / -

Addendum Table 2. Comparison of CWQR and permit values for Armco New Miami outfall 001.

Outfall	Parameter	effluent loads (lbs/day) 8/83 Permit	CWQR
611 (001)	Total Suspended Solids	185	-
	NH_3-N	239.8	331
	Cyanide	7.5	40.0
	Phenols	10.6	10.7
	Zinc	1.1	10.1
	Lead	0.75	-[a]

[a] based on old permit

As with Armco Middletown, lead is the only parameter which presents a discrepancy between the 8/83 permit and the CWQR. Lead for the New Miami facility was not included in the CWQR since it had not previously appeared in an Armco New Miami permit. However, the discharge of 0.75 lbs/day lead from the New Miami 001 outfall will not cause a violation of the WQS and should be allowed.

Discharger: LeSourdsville Regional WWTP Addendum

Facility Number: 1PK00011001
Permit Number: K611
Receiving Stream (River Mile): GMR (45.65)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)	1.59	1.774	4.0	
T (^{o}C)	20.56	20.81	-	
pH (S.U.)	-	7.09	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				671.0 / 20.1
BOD_5 (lbs/day) / (mg/l)	60.56 / 4.57	73.84 / 4.70	334.0 / 10.0	
TSS (lbs/day) / (mg/l)	61.93 / 4.67	80.30 / 4.90	400.0 / 12.0	
D.O. (mg/l)	8.55	8.02	6.0 min.	83.5 / 2.5
NH_3-N (lbs/day) / (mg/l)	5.44 / 0.41	10.27 / 0.71	S. 33.0 / 1.0	83.5 / 2.5
NO_2-N (lbs/day) / (mg/l)	-	3.51 / 0.22	-	
NO_3-N (lbs/day) / (mg/l)	(NO_2&NO_3) 123.2 / 9.29	84.58 / 5.56	-	
Cl_2-R (mg/l)	-	0.365	daily max. 0.50	
P (lbs/day) / (mg/l)	119.6 / 9.02	51.57 / 3.87	33.0 / 1.0	
F-C (#/100 ml)	-	206.	1000	

Zn Allocation-Addendum

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0	74.11		3.504 / 0.013			3.504
Ohio Suburban WWTP	87.45	6.19	56.19	83.29	7.064 / 0.273	9.108 / 0.273			12.612
Mad River	81.48	160.85	232.04	343.94		168.70 / 0.195			182.282
Dayton WWTP	76.11	111.38	358.26	531.03	255.72 / 0.545	327.18 / 0.545	- / 0.60	339.73 / 0.566 [2]	522.678
GM Delco - Air #3	74.42	5.34	363.60	538.95	12.72 / 0.482	13.873 / 0.482	18.61 / 0.6	9.70 / - [4]	532.378
Montgomery Co. W. Regional WWTP	71.48	30.94	417.84	619.34	17.749 / 0.204 [1]	34.02 / 0.204			568.959
Armco (Middletown) 001	51.45	28.2	447.69	663.59		25.384 / 0.167	370.0 / -	18.48 / - [5]	593.694
(613)		(1.56)			7.004 / 1.857 [1]	15.614 / 1.857			
Middletown WWTP	48.29	40.22	488.21	723.65	17.85 / 0.142	30.784 / 0.142			624.478
Dicks Creek	47.61	3.0	495.23	734.06	9.265 / 0.573	WQS 4.45 / 0.275			630.228
Armco 001 (New Miami)	38.74	11.02	168.26	249.40	13.17 / 0.251	14.909 / 0.251			
(611)		(4.96)			1.635 / 0.377 [1]	10.079 / 0.377	79.0 / -	1.1 / - [5]	202.434

1 Annual average discharge data (1980)
2 Adjusted to meet WQS
3 EEQ is recommended
4 Existing permit limitation retained
5 BEJ limit set forth in present permit

000267

Pb Allocation-Addendum

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0	8.09		1.348 / 0.005			1.348
Mad River	81.48	160.85	232.04	37.52		18.0 / 0.021			21.079
Dayton WWTP	76.11	111.38	358.26	57.93	39.69 / 0.085	51.03 / 0.085	- / 0.08	33.0 / 0.055 [2]	54.079
Montgomery Co. W. Regional WWTP	71.48	30.94	417.84	67.57	3.33 / 0.036 [1]	6.004 / 0.036	- / 0.16 at any time	9.2 / 0.055 [2]	63.591
Armco Middletown 001 (611[4])	51.45	28.2 (2.79)	447.69	72.39	0.56 / 0.144	2.165 / 0.144	0.96 / -	6.26[5] / -	72.390
Middletown WWTP	48.29	40.22	488.21	78.94	4.96 / 0.037	8.021 / 0.037			80.411
Armco 001 (New Miami) (611)	38.74	11.02	168.26	27.21				0.75 / -	
Hamilton WWTP	34.0	38.21	568.30	91.89	3.32 / 0.036	7.414 / 0.036			89.398
Fairfield WWTP	32.0	9.28	577.58	93.40	0.95 / 0.040	2.0 / 0.04			91.398

1 Annual average discharge data (1980)
2 Adjusted to meet WQS
3 Existing permit limitations retained
4 New permit in terms of 001 outfall only
5 The lowest level of lead which Armco can consistently discharge is 10.5 lbs/day. An insignificant violation results from this greater load.

000268

6399

Discharger: Armco Steel (Middletown) Addendum

Facility Number: 1ID00001001
Permit Number: D101
Receiving Stream (River Mile): GMR (51.45)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present[a] Permit	Allocated based on new permit
001 - Combined outfalls 611[b], 612[b], 613 and 614[c]				
Flow (MGD)	18.0			d
T (°C)	23.75			-
BOD_5 (lbs/day) / (mg/l)	1436.0 / 9.57		1516.0 / -	
TSS (lbs/day) / (mg/l)	4253.0 / 28.33		-	3000 / -
O&G (lbs/day) / (mg/l)				300 / -
Pb (lbs/day) / (mg/l)	0.60 / 0.004		-	10.50 / -
Zn (lbs/day) / (mg/l)	25.07 / 0.167		370.0 / -	18.48 / -
611[b]				
pH (S.U.)			6.0-9.0	
TSS (lbs/day) / (mg/l)))			416.0 / -	

000269

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
O&G (lbs/day) / (mg/l)			147.0 / -	
Pb (lbs/day) / (mg/l)			0.96 / -	
Fe (lbs/day) / (mg/l)			121.0 / -	
612[b]				
Flow (MGD)		0.620	-	
pH (S.U.)		7.67	6.0-9.0	
BOD_5 (lbs/day) / (mg/l)		59.38 / 11.33	-	
TSS (lbs/day) / (mg/l)		61.80 / 10.50	--- / 30.0	
O&G (lbs/day) / (mg/l)		25.17 / 4.60	-	
Pb (lbs/day) / (mg/l)		0.27 / 0.056	-	
Fe (lbs/day) / (mg/l)		3.10 / 0.484	-	
613				
Flow (MGD)		0.383	-	-
pH (S.U.)		6.07	6.0-9.0	-
BOD_5 (lbs/day) / (mg/l)		39.77 / 3.11	-	
TSS (lbs/day) / (mg/l)		210.3 / 53.10	414.0 / -	-
NH_3-N (lbs/day) / (mg/l)		43.06 / 15.54	528.0 / -	451.0 / -
O&G (lbs/day) / (mg/l)		16.72 / 5.10	138.0 / -	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Zn (lbs/day) / (mg/l)		13.98 / 3.725	-	-
Phenol (lbs/day) / (mg/l)		-	25.9 / -	1.98 / -
CN (lbs/day) / (mg/l)		2.10 / 0.847	63.0 / -	15.18 / -
614[c]				
Flow (MGD)				-
pH (S.U.)				-
TSS (lbs/day) / (mg/l)				-
O&G (lbs/day) / (mg/l)				-
Zn (lbs/day) / (mg/l)				-
Pb (lbs/day) / (mg/l)				-

[a] Permit loading limitations were established using a design flow (18.2 MGD).
[b] outfall not included in new permit.
[c] replaces 611 and 612 in new permit.
[d] average flow in new permit for outfall 001 is 11.1 MGD.

000271

Discharger: Armco Steel (New Miami) Addendum

Facility Number: 1ID00002001 & 004
Permit Number: D102
Receiving Stream (River Mile): 001 - GMR (38.74)
002 - GMR (39.0)
003 - GMR (39.30)
004 - GMR (39.38)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present[a] Permit	Allocated based on new permit
001 (611 & 621)[b]				
T (°C)	23.67	26.96	-	
611				
Flow (MGD)	-	-	-	-
T (°C)	-	-	-	
pH (S.U.)	-	-	-	6.5 - 9.0
$CBOD_{20}$ (lbs/day) / (mg/l)				606.0[c] / 10.2
BOD_5 (lbs/day) / (mg/l)	290.5 / 5.10	-	525.0 / -	
TSS (lbs/day) / (mg/l)	1139.0 / 20.0	-	132.0 / -	185.02 / -
NH_3-N (lbs/day) / (mg/l)	57.14 / 1.0	-	331.0 / -	239.8 / -
O&G (lbs/day) / (mg/l)	-	-	263.0 / -	
Zn (lbs/day) / (mg/l)	2.85 / 0.05	-	79.0 / -	1.1 / -
Pb (lbs/day) / (mg/l)	-	-	-	0.75 / -
Fe-diss. (lbs/day) / (mg/l)	(Fe-total) 34.92 / 0.613	-	120.0 / -	
Phenol (lbs/day) / (mg/l)	2.11 / 0.037	-	10.7 / -	10.6 / -

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
CN (lbs/day) / (mg/l)	2.05 / 0.036	-	40.0 / -	7.5 / -
621[b]				
T (°C)		-	-*	
pH (S.U.)		-	-	
O&G (lbs/day) / (mg/l)		-	240.0 / -	
002				
Flow (MGD)		0.062	-	-
T (°C)		-	-	
pH (S.U.)		7.43	6.0-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				18.1 / 42.0
BOD_5 (lbs/day) / (mg/l)		0.0 / 0.0	---- / 30.0	---- / 30.0
TSS (lbs/day) / (mg/l)		10.74 / 22.0	---- / 30.0	---- / 30.0
NH_3-N (lbs/day) / (mg/l)		3.26 / 7.23	---- / 5.0	
F-C (#/100 ml)		4.8	200	1000
003[b]				
Flow (MGD)		0.30		
T (°C)		24.87		
pH (S.U.)		7.17		
004[b]				
Flow (MGD)	10.767	7.799	-	
T (°C)	23.42	26.08	-	
pH (S.U.)	-	7.58	6.0-9.0	

000273

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
TSS (lbs/day) / (mg/l)	2245.0 / 25.0	5784.0 / 96.25	127.0 / -	
NH_3-N (lbs/day) / (mg/l)	131.4 / 1.46	52.01 / 1.05	317.5 / -	
O&G (lbs/day) / (mg/l)	-	173.5 / 2.75	37.93 / -	
Phenol (lbs/day) / (mg/l)	1.796 / 0.02	13.6 / 0.022	5.29	
CN (lbs/day) / (mg/l)	10.87 / 0.121	-	-	

* The effluent temperature cannot exceed upstream temperature by more than 8.3°C in May thru September or by 12.8°C in October thru April.

a Permit loading limitation was established using design flows.

b outfall not included in new permit.

c parameter not listed in new permit.

pp Present permit limitation.

ACKNOWLEDGEMENTS

The field data collection for this project was planned and implemented by Colleen Crook. Numerous staff members from Ohio EPA participated in the field data collection.

The modeling was done by Lester Fischer, Mark Garner, Daniel Lindsay, and Tong Kim. The conservative parameter allocation was done by Tong Kim. The manuscript was prepared by Daniel Lindsay, Lester Fischer, Colleen Crook, Tong Kim, and Mark Stedfeld. The graphics were prepared by Trinka Mount. The manuscript was typed by Lisa Palsgrove-Smith and reviewed by Seif Amragy, Lester Fischer, Mark Garner, and Tong Kim, who acted as editor of the report.

We would like to thank the USEPA, the Miami Conservancy District (MCD), and all of the area industries and municipalities for their cooperation and participation with this project. We would especially like to thank Graham Mitchell from the Southwest District Office of the Ohio EPA, Don Schregardus of the USEPA, and Jon Phillippi and David Tucker of GKY and Associates for their invaluable assistance in all phases of the project.

INTRODUCTION

This section of the report explains the water quality simulation of approximately 76 miles of the Great Miami River (GMR) mainstem between Dayton and Miamitown, Ohio (see Figures 32 and 33), performed in order to allocate wasteloads to dischargers along the watercourse. Section I has dealt with the biological assessment of existing and past conditions within the aquatic community. Water quality simulation differs from biological assessment in that its goal is to create a mathematical representation of the river's physical and biochemical activity. Using a series of equations which are solved with a computer, the relationship between pollutant discharges and resulting water quality can be predicted. Such a series of equations is called a "water quality model," and is a valuable planning tool, particularly in the wasteload allocation (WLA) process which provides a technical basis for discharger permit limitations.

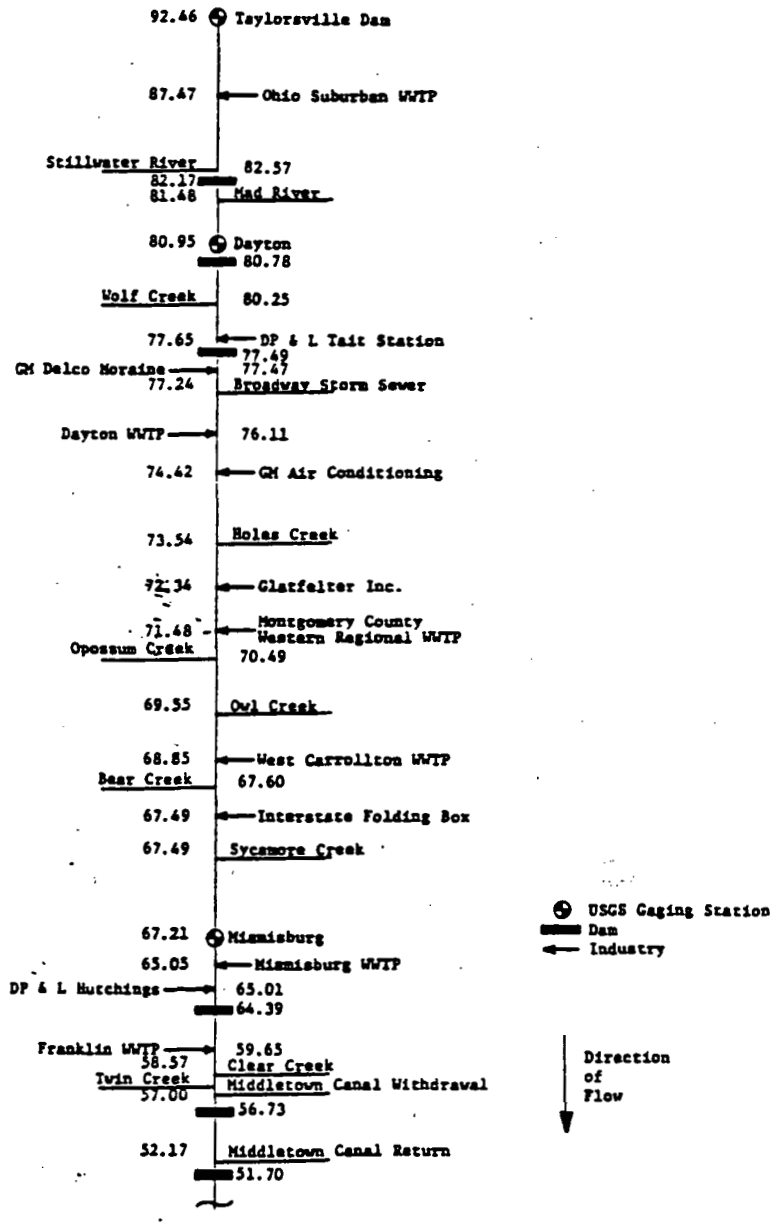
Ohio EPA uses QUAL-II (SEMCOG version), a comprehensive and versatile stream water quality model which can simulate up to 13 water quality constituents in various combinations. The model assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (the longitudinal axis of the stream or canal). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow. It also has the capability to compute instream dissolved oxygen (D.O.) and ammonia (NH_3-N) levels, and thus to indicate if a prespecified treatment level will meet Water Quality Standards (WQS).

In employing any computer model to simulate instream reactions, the user must be certain that the model accurately depicts the stream system's behavior. This can be assured by fulfilling two requirements: (1) the model must be mathematically sound, and (2) the model must be properly adjusted to represent the particular stream section in question.

USEPA and others such as the National Council of the Paper Industry for Air and Stream Improvement (NCASI) have extensively documented QUAL-II's mathematical formulations. Adapting QUAL-II's coefficients and equations to the GMR, a process referred to as model calibration, is described at length later in this section. Verification is the process of testing and reinforcing the model calibration. Ohio EPA performed two intensive field surveys (discussed below) during September 1980, to provide data for the QUAL-II calibration. Data for the QUAL-II verification was obtained from 1970 field work by the Miami Conservancy District (MCD) and from 1980 Ohio EPA weekly monitoring data.

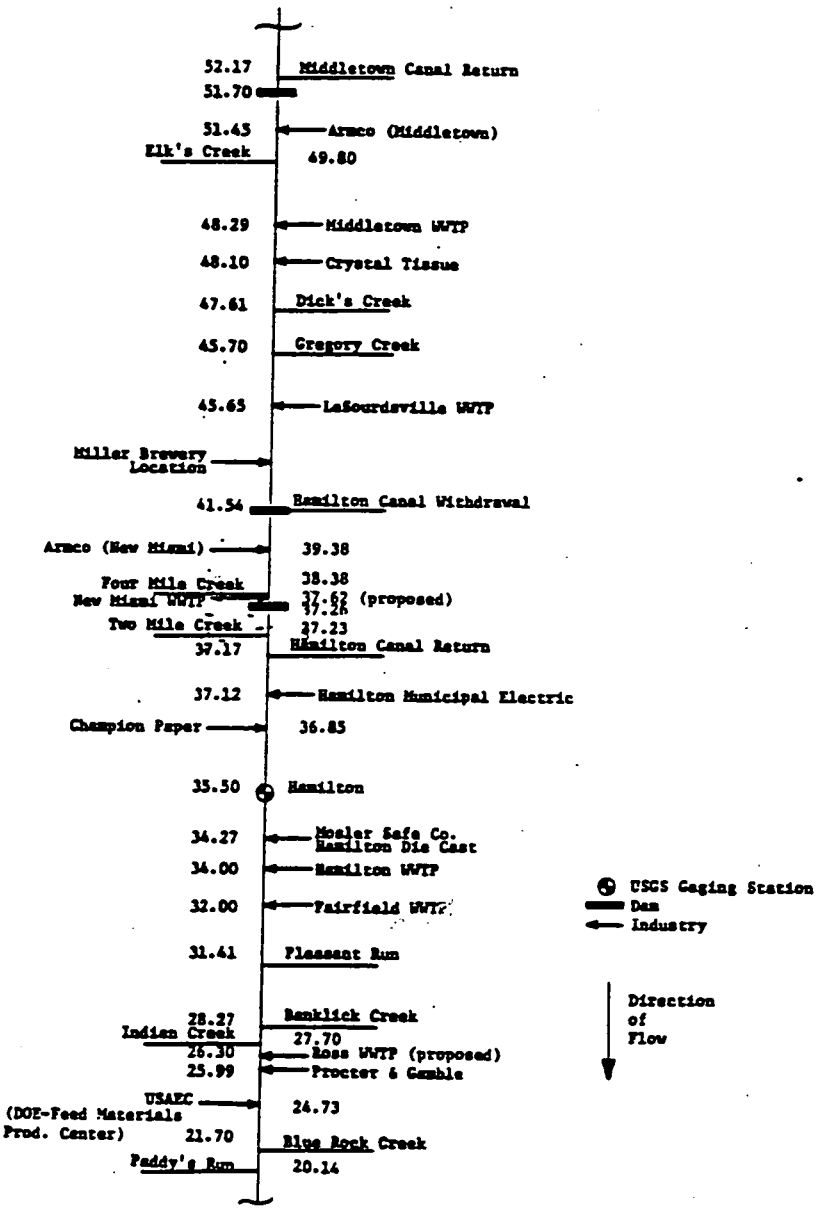
Once the model has been calibrated and verified on the basis of field data, it can be used to analyze the varied conditions resulting from changes in topography, climate, multiple discharges, and stream flows. The model is designed to indicate whether simulated treatment levels achieve Water Quality Standards (WQS); if not, reductions (allocations) of wasteloads are simulated, until WQS are met.

Figure 32. Great Miami River Schematic - Segment 1.



000277

Figure 33. Great Miami River Schematic - Segment 2.



Ohio EPA thus analyzed discharger impacts on GMR water quality and derived wasteload allocations. The sensitivity of the results to input conditions was also examined. These analyses are discussed after the calibration and verification. All of these analyses are used to make the recommendations for permit limitations found in the summary protion of this report. In addition, Appendix A contains the details of the WLA for conservative parameters and Appendix B summarizes the WLA for all parameters and all dischargers, showing present permitted levels, existing effluent quality, and allocated values. Appendix C shows the effluent quality needed to meet WQS in winter.

The purpose of this study is to determine the impact of wasteloads on the mainstem of the Great Miami River in terms of dissolved oxygen, nitrogen series levels, and conservative parameters (specifically heavy metals) indicated in NPDES permits. Minor tributaries and dischargers outside the study area were considered to have no significant impact on the modeled area. Toxicants, thermal loading, and tributary impact may be the subject of future studies at the discretion of the interested agencies, but are beyond the scope of this study. This is reflected in the field surveys discussed on the following pages, as well as in the modeling based on these surveys.

FIELD STUDIES

From June through October, 1980, Ohio EPA conducted studies of the Great Miami River from river mile (RM) 91.14 (above Dayton) to RM 14.93 (Miamitown). The purpose of the surveys was to collect the data needed to calibrate the QUAL-II water quality simulation model and develop wasteload allocations for discharges to the Great Miami River, as well as to justify the expenditure of federal construction grant monies throughout the basin. Several types of studies were required to collect sufficient data.

Intensive chemical/physical sampling of industrial and municipal waste discharges, major tributaries, and the Great Miami River was conducted for three consecutive days to provide the data base needed for model calibration. Additional studies conducted on the Great Miami River mainstem included: (1) Chlorophyll-a analysis on grab samples, (2) sediment oxygen demand studies, and (3) weekly water quality monitoring based on grab samples collected at 12 mainstem and 2 tributary sites from June 6 through October 9.

In conjunction with the intensive surveys, the U.S. Geological Survey (USGS) conducted instream reaeration studies for Ohio EPA on 7 reaches of the Great Miami River using the hydrocarbon tracer technique (Rathbun, Schultz, and Stephens, 1975). Stream reaeration coefficients were developed from this data and were used as input to the model. Nitrogen decay rate studies were conducted simultaneously with the USGS reaeration studies.

The 76 miles of the Great Miami River included in the study area were divided into 2 segments in order to simplify field work and modeling. Segment 1 extended from just below the USGS gaging station at the Taylorsville dam (RM 92.51) to the confluence of the Middletown Hydraulic Canal and the Great Miami (RM 51.70). Segment 2 extended from RM 52.63 to RM 14.92 (formerly U.S. Route 52 in Miamitown). Intensive surveys were conducted on the two segments separately (See Tables 46 and 47).

TABLE 46
GMR Study Plan - Segment 1

G	Grab Sample	CSt	Chemical Composite Stream Sample
PP	Pool Profile	Q	Flow
DR	Decay Rate Sampling Site	DH	Dam Height
XS	Cross Section	DW	Dam Width
CI	Effluent Composite Sample		

RM	Site Description	Parameters
92.46	USGS Gaging Station (Taylorsville 03263000)	Q
91.14	Little York Rd. Bridge	CSt
87.47	MCD North Regional WWTP-Ohio Suburban	Q, CI
83.57	North Dixie Drive Bridge	CSt
82.57	On Stillwater River at Ridge Ave. Bridge	CSt, Q @ gage @ Englewood
82.17	Dam (Island Park)	DH, DW, PP, DO above/below
81.48	On Mad River at Webster Street Bridge	CSt, Q @ gage @ 5.9
80.95	USGS Gaging Station (Dayton 03270500)	Q, CSt
80.78	Dam (below Mad River)	DH, DW, DO above/below, PP
80.65	Monument Street Bridge	CSt
80.25	On Wolf Creek at Sunrise Ave. Bridge	Q, G
78.95	USGS Four Parameter Gaging Station (Near Stewart Street 03271075)	pH, Temp, Cond, D.O.
78.80	Stewart Street Bridge	D.O., Temp once daily
77.65	Dayton Power & Light-Tait (auto sampler)	CSt, continuous DO & Temp of influent
77.49	DP&L Tait 001 outfall	continuous DO & Temp
77.49	Dam (DP&L, above Moraine)	DH, DW, DO above/below, PP
77.48	DP&L Tait 003 outfall	CSt, Q
77.48	GM Delco Moraine 002	G, Q
77.47	GM Delco Moraine 003	G, Q
77.24	Broadway storm sewer (Dayton Walther)	CI, Q
77.24	Broadway Bridge	Temp & D.O. profile once daily
76.11	Dayton WWTP	CI, Q
74.42	GM Air Conditioning Plant #3	CI, Q
74.15	GM Air Conditioning Plant #2	CI, Q
73.78	Sellars Rd. Bridge	CSt, XS
73.54	On Holes Creek*	Q, G
72.34	Glatfelter Paper	CI, Q
71.48	Montgomery Co. Western Regional WWTP	CI, Q
70.49	On Opossum Creek*	Q, G
69.88	Carrollton Rd. Bridge	CSt, XS

(continued)

TABLE 46 (continued)

69.55	On Owl Creek (auto sampler)	Q, CSt
68.85	West Carrollton WWTP	CI, Q
67.60	On Bear Creek*	G, Q
67.49	Interstate Folding Box Co.	CI, Q
67.49	On Sycamore Creek*	G, Q
67.21	USGS Gaging Station (Miamisburg 03271510)	Q
66.90	Linden Avenue Bridge	CSt, XS
66.75	USGS Four Parameter Gaging Station (near Linden Avenue 03271510)	pH, Temp, Cond, D.O.
65.05	Miamisburg WWTP	CI, Q
65.01	DP&L Hutchings 002	CI, Q
64.62	Dayton Power & Light - Hutchings influent (auto samplers)	Q, CSt of influent
64.39	Dam (above Chautauqua)	DH, DW, DO above/below, PP
64.37	Dayton Power & Light - Hutchings 001	Q, Temp, D.O.
62.37	Floodgate (at Chautauqua)	DH, DW, DO above/below, PP
61.00	River Arms Apts. & Laundry	Q, 1 grab during survey
60.58	SR 123 Bridge (River St in Franklin)	CSt, XS
59.65	Franklin WWTP	CI
58.57	On Clear Creek*	Q, G
57.42	On Twin Creek*	Q, G
57.00	Middletown Hydraulic Canal Withdrawal at Carmody Ave. Bridge	Q, XS, CSt
56.73	Dam (above Middletown Canal)	DH, DW, DO above/below, PP
55.14	State Route 4 Bridge	CSt, XS
52.63	Central Sutphin Bridge	CSt, XS
52.17	Middletown Hydraulic Canal Return at SR 122 Bridge	Q, CSt
51.70	Dam (below Middletown Canal Return)	DH, DW, DO above/below, PP

*Frequency of sampling of these tributaries will be determined at the time of the survey based on tributary flow.

TABLE 47
GMR Study Plan - Segment 2

G	Grab Sample	CSt	Chemical Composite Stream Sample
PP	Pool Profile	Q	Flow
DR	Decay Rate Sampling Site	DH	Dam Height
XS	Cross Section	DW	Dam Width
CI	Effluent Composite Sample		

RM	Site Description	Parameters
52.63	Central Sutphin Bridge	CSt, XS
52.17	Middletown Hydraulic Canal Return	Q, CSt
51.70	Dam (below Middletown Canal Return)	DH, DW, DO above/below, PP
51.45	Armco 001	Q, CI
51.45	Armco Storm Sewer (auto sampler during nite)	CI
49.80	On Elk Creek	G, Q
49.27	State Route 73 Bridge	CSt,XS
48.29	Middletown WWTP	CI, Q
48.10	Crystal Tissue	CI, Q
47.61	On Dicks Creek	CSt, Q
45.70	On Gregory Creek*	G, Q
45.65	LeSourdsville Regional WWTP	G, Q
44.35	USGS Four Parameter Gaging Station (Rockdale 03272410)	pH, Temp, Cond, D.O.
43.80	Future location of Miller Brewery	
43.23	Wayne Madison Road Bridge	CSt, XS
41.55	Hamilton Hydraulic Canal Withdrawal*	Q, XS, CSt
41.54	Dam (above Hamilton Canal)	DH, DW, DO above/below, PP
39.38	Armco Steel 004	CI, Q
38.74	Armco Steel 001	CI, Q
38.38	On Four Mile Creek	CSt, Q
37.26	Dam (above Hamilton Canal Return)	DH, DW, DO, PP
37.23	On Twomile Creek*	G, Q
37.17	Hamilton Hydraulic Canal Confluence at footbridge	CSt, Q
37.12	Hamilton Municipal Electric	CI, Q
36.96	Hamilton Bridge	CSt, Q, XS
36.85	Champion Papers 003	CI, Q
35.69	Pershing Rd. Bridge	CSt
35.50	USGS Gaging Station (Hamilton 03274000)	Q, XS, CSt
34.27	Mosler Safe, Hamilton Dye Cast, Chessie System via storm sewer	CI, Q
34.00	Hamilton WWTP	CI, Q

(continued)

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TABLE 47 (Continued)

32.00	Fairfield WWTP	CI, Q
31.41	On Pleasant Run*	G, Q
29.97	RR Bridge (auto sampler)	CSt, XS
28.27	On Banklick Creek*	Q, G
27.70	On Indian Creek*	Q, G
26.21	SR 126 Bridge	CSt, XS
25.99	Procter & Gamble	CI, Q
24.73	U.S. A.E.C.	CI, Q
21.70	On Blue Rock Creek*	Q, G
21.45	USGS Four Parameter Gaging Station (New Baltimore 03274600)	pH, Temp, D.O., Cond.
21.45	New Baltimore Bridge	CSt
20.14	On Paddy's Run*	Q, G
14.93	US 52 Bridge	CSt, XS

*Frequency of sampling of these tributaries will be determined at the time of the survey based on tributary flow.

INTENSIVE SURVEYS

Composite samples were collected at locations where pollutant loadings were expected to vary significantly in a 24-hour period. Daily average parameter concentrations were determined from these samples. Composite samples were collected at Great Miami mainstem stations, major dischargers, and major tributaries (areas where outfalls were expected to have a major impact on the mainstem water quality). Daily grab samples were collected at stations where the pollutant loadings were not expected to vary over a 24-hour period. Grab samples were collected of the minor industries and tributaries without dischargers. Wherever possible, the effluent samples were collected immediately prior to chlorination.

Mainstem sampling locations were chosen so they would bracket the major dischargers, locating one station immediately upstream and one downstream. Sampling stations on tributaries were selected as close to the mouths as possible. Accessibility was also a factor in sampling station selection. Bridge sites were chosen as sampling stations if possible. Automatic samplers were placed at the sites where access was difficult.

The automatic samplers collected equal hourly sample portions, which were later combined into a daily composite. Individual portions for the manual composite samples were collected every four hours, at approximately 7:00 AM, 11:00 AM, 3:00 PM, 7:00 PM, 11:00 PM, and 3:00 AM. No time schedule was established for the grab samples. All samples were submitted to the lab for analysis at the end of each 24-hour sampling period.

Dissolved oxygen (D.O.), pH and temperature measurements were collected simultaneously with the individual portions of the composite samples. D.O. and temperature measurements were collected from at least 3 points at all mainstem sampling sites: one at the water quality sampling location, and one at each side of the river. Measurements for pH were collected at the water quality sample collection location only. Temperature, D.O. and pH were collected simultaneously with the grab samples. Personnel from the industrial and municipal dischargers collected the effluent samples from their plants during the survey, as well as performing D.O., pH, and temperature measurements.

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The samples were analyzed for the following parameters:

BOD_{20}	Phenol
$CBOD_{20}$	Cyanide
NH_3-N	Residue, Total
NO_3-N + NO_2-N	Residue, Total Filterable
TKN	Residue, Total Non-Filterable
Total Phosphorus	Cadmium
Ortho Phosphorus	Chromium
Total Organic Carbon	Copper
COD	Iron
Hardness	Lead
Chloride	Nickel
	Zinc

Segment 1

Intensive water quality monitoring in Segment 1 occurred September 3, 4, and 5, 1980. Water quality was monitored at 11 Great Miami River mainstem locations and 10 tributary stations. Effluent quality samples were collected from 6 municipal wastewater treatment plants (WWTP) and 8 industrial discharges.

Chemical/physical water quality of the Great Miami River was monitored at 9 bridge sites and 2 power plant cooling water influent channels. Composite water quality samples were collected manually at the following bridges:

Little York Rd. (RM 91.14)
Keowee St. (RM 83.57)
Monument Ave. (RM 80.65)
Sellars Rd. (RM 73.78)
Carrollton Rd. (RM 69.88)
Linden Ave. (RM 66.90)
State Route 123 (RM 60.58)
State Route 4 (RM 55.14)
Central Sutphin Rd. (RM 52.63)

Automatic samplers and continuous dissolved oxygen/temperature monitors were set at the cooling water influent channels (withdrawals from the GMR) of the following stations:

Dayton Power and Light (DP&L) Tait (RM 77.65)
Dayton Power and Light (DP&L) Hutchings (RM 64.62)

In order to define D.O. concentrations and temperature values upstream of the Dayton WWTP, D.O. and temperature measurements were collected at the Broadway St. bridge (RM 77.25). Measurements were collected at frequent intervals across the river, since the river is not well mixed at this site due to the DP&L Tait and GM Delco Moraine outfalls located immediately upstream of the site.

Wastewater treatment plant personnel at the six major municipal facilities located in Segment 1 collected composite effluent samples during the three-day survey. The WWTPs located in Segment 1 are:

Ohio Suburban WWTP (RM 87.47)
Dayton WWTP (RM 76.11)
Montgomery County Western Regional WWTP (RM 71.48)
West Carrollton WWTP (RM 68.85)
Miamisburg WWTP (RM 65.05)
Franklin WWTP (RM 59.65)

Personnel from industrial entities collected daily grab samples from the following:

GM Delco Moraine 002 (RM 77.48)
GM Delco Moraine 003 (RM 77.47)
Dayton Walther Corporation outfall (discharge into the Broadway storm sewer at RM 77.24).

Personnel from the industrial entities collected composite effluent samples from the following:

DP&L Tait 002 (RM 77.48)
DP&L Hutchings 002 (RM 65.01)
GM Delco Air, Plant #2 (RM 74.72)
GM Delco Air, Plant #3 (RM 74.15)
Glatfelter Paper (RM 72.34)
Interstate Folding Box (RM 67.49)

Grab water quality samples, pH, temperature, D.O. and discharge measurements were collected near the mouths of the following tributaries:

Wolf Creek (RM 80.25)
Holes Creek (RM 73.54)
Opossum Creek (RM 70.49)
Bear Creek (RM 67.60)
Sycamore Creek (RM 67.49)
Clear Creek (RM 58.57)
Twin Creek (RM 57.42).

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Composite water quality samples, pH, temperature, and D.O. measurements were collected at the following tributary sites:

Stillwater River at Ridge Ave. (RM 0.3, GMR RM 82.57)
Mad River at Webster St. (RM 0.21, GMR RM 81.48)
Storm Sewer at Broadway St. bridge (RM 77.24)
Owl Creek at mouth (automatic sampler; GMR RM 69.55).

USGS gaging stations located on the Stillwater and Mad Rivers were monitored for discharge values while manual discharge measurements were conducted daily on the storm sewer and Owl Creek. During the intensive surveys on both Segments 1 and 2, the Great Miami River discharge was monitored at the USGS gaging stations at Miamisburg and Hamilton (this information is included in the calibration flow description).

Segment 2

Intensive sampling of Segment 2 (RM 52.63 to RM 14.93) occurred on September 16, 17, and 18, 1980. This survey was conducted in the same manner as the intensive survey on Segment 1. Composite samples were collected at 8 Great Miami mainstem sites. Loadings of 12 tributaries in the reach were monitored. Personnel from the 4 major WWTPs in the segment collected composite samples of their outfalls. Industrial discharges expected to have an impact on the mainstem water quality were also monitored.

Chemical/physical water quality of the Great Miami River was monitored at 8 bridges during the three-day survey. Composite samples were collected manually at the following Great Miami mainstem sites:

Central Sutphin Ave. (RM 52.63)
State Route 73 (RM 49.27)
Pershing Ave. (RM 35.69)
State Route 126 (RM 26.21)
New Baltimore bridge (RM 21.45)
Miamitown bridge (RM 14.93).

Automatic samplers and continuous D.O./temperature monitors were placed at

Wayne Madison Rd. (RM 43.23)
Railroad bridge (RM 29.97).

Grab samples and discharge measurements were taken daily near the mouths of the following tributaries:

Elk Creek (RM 49.80)
Gregory Creek (RM 45.70)
Four Mile Creek (RM 38.38)
Indian Creek (RM 27.70)

The following tributaries were samples at least once during the three-day survey:

Pleasant Run (RM 31.41)
Banklick Creek (RM 28.27)
Blue Rock Creek (RM 21.70)
Paddy's Run (RM 20.14)

Composite samples were collected at

Middletown Hydraulic Canal at SR 122 (RM 52.17)
Dick's Creek at the mouth (RM 47.61)
Hamilton Hydraulic Canal (RM 37.71)

Composite water quality samples, pH, D.O., and temperature measurements were collected of the storm sewer discharging to the Great Miami at RM 51.00. The Armco Steel (Middletown) outfall 001 discharges directly into this storm sewer. Hamilton Die Cast, Mosler Safe and Chessie Systems Railroad yard all discharge into another storm sewer discharging to the Great Miami River at RM 34.27. This storm sewer was sampled twice daily for water quality, pH, D.O., and temperature.

Hamilton Municipal Electric ash water, outfalls 608 and 609 (RM 37.17), were sampled once daily. Ohio EPA personnel measured the D.O., pH, and temperature from these outfalls twice daily.

Twenty-four hour composite samples were collected by plant personnel at

Armco Steel (Middletown) 001 outfall (RM 51.45)
Crystal Tissue Corporation (RM 48.10)
Armco Steel (New Miami) 004 and 001 outfalls
(RM 39.38 and RM 38.74 respectively)
Champion Paper 003 outfall (RM 36.85)
Procter & Gamble Miami Valley Laboratories (RM 25.99)
U.S. A.E.C. (RM 24.73)

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SAMPLING TECHNIQUES

All water quality samples from bridge sites were collected in stainless steel buckets. The exact sampling location was marked on each bridge to ensure continuity in the sample collection. Prior to the survey, conductivity was measured at each sampling location to ensure uniform stream mixing across the river. All sampling techniques used during the survey conformed to the standards set forth in the Ohio EPA Quality Assurance Manual (Ohio EPA, 1980).

Each portion added to the composite samples was of the same volume. A glass container was used to transfer the sample portion from the stainless steel bucket to the sample container.

All samples were cooled after being collected. The industries and municipalities collecting effluent samples were instructed to store the samples at 4°C or less until the samples were retrieved by the Ohio EPA. Those industries and municipalities without refrigeration facilities were supplied with coolers and ice for sample storage. The water quality samples collected by Ohio EPA personnel were stored in ice-filled coolers. The temperature of the ice bath was checked several times daily to ensure it did not rise above 4°C.

Portable ISCO and Manning automatic samplers were used to collect hourly samples at several stations as previously discussed. The base of each sampler was packed with ice to maintain a sample temperature of 4°C. The containers were collected at the end of each 24-hour sampling period, mixed, and transported to the laboratory.

QUALITY ASSURANCE PROCEDURES

Sample Preservation

The appropriate sample preservative (see Ohio EPA Quality Assurance Manual, 1980) was added to all sampling containers one week prior to the intensive sampling portion of the survey. After the preservatives were added to the empty containers, the lids were tightly secured to prevent any atmospheric loss of the preservatives.

Possible contamination of the water samples by the containers or preservatives was carefully monitored. Pre-preserved containers were distributed to the three sampling crews and to 25% of the entities collecting effluent samples for the survey. The containers remained in the sampling vehicles and at the industry or WWTP for the duration of the survey. After the completion of the survey, sample containers were filled with distilled water and analyzed with the remainder of the water quality samples.

Duplicate and Split Samples

Duplicate and split samples were collected as a quality assurance measure. Five quality assurance samples were collected during each survey; one duplicate for each type of sample collected. Duplicate samples were collected of one composite mainstem sample, one industrial effluent sample, one WWTP effluent sample and one tributary grab sample. One sample collected by an automatic sampler was split for quality assurance.

Meter Calibration

Calibration procedures used by the Ohio EPA sampling crews met or exceeded all requirements set forth in the Quality Assurance Manual. The D.O. meters used in the river and tributary sampling portion of the three-day sampling program were calibrated at least twice daily using the Winkler titration method on water taken from the GMR. The accuracy of the D.O. meters used by the industries was checked by comparison with an Ohio EPA calibrated D.O. meter. Temperatures measured by the dissolved oxygen meters were compared with thermometer readings at least twice daily, and field-measured temperatures were adjusted based on discrepancies between the two measurements. The pH meters used during the survey were calibrated every 4 hours, using pH 7 and pH 10 buffer solutions. Malfunctioning meters were replaced. All calibration data for the meters was recorded in log books.

Three USGS four-parameter monitors (temperature, D.O., pH, and conductivity) were located in the intensive survey study area. To monitor the accuracy of the monitors during the intensive survey, grab samples were collected at the bridges nearest the monitors. Winkler titrations were run on these samples and the results were compared to the D.O. values noted by the monitors.

The flow-measuring devices used by individual entities were examined prior to the intensive survey by a representative of the Ohio EPA. All flow monitoring devices were deemed accurate at the time of the survey.

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DISCUSSION

Difficulties were encountered with the automatic samplers during the Segment 1 intensive sampling. The samplers were set to collect 300 ml each hour; the volume actually collected, however, varied from zero to 300 ml. All the water samples that had been collected over each 24-hour period, despite their volume, were mixed thoroughly and submitted to the laboratory. This problem with the automatic samplers was corrected for the sampling in Segment 2.

Analysis of the phenol data showed major inconsistencies. Data from the first day of the survey showed phenol levels much higher than those determined for the two other days, with data the third day reflecting the lowest levels. Investigation revealed that chemicals in the laboratory interfered with the analysis of the first day's data. Only the third day's results, after the problem was corrected, are reliable. Cyanide data also showed inconsistencies.

Eighty-one percent of the quality assurance samples analyzed were within the Ohio EPA quality assurance limits of replicability (This percentage does not include all cyanide and phenolics samples). The maximum allowable difference between the duplicate samples was $\pm$ 15%. The nutrient samples (NH_3-N, NO_3-N + NO_2-N, TKN, and Phosphorus) were held to with $\pm$ 10%.

Upon examination of the quality assurance samples for ammonia, 50% of the samples were within Ohio EPA limits. Fifteen out of 30 pairs of samples were found to exceed the $\pm$ 10% limitations. Seventy-three percent of the TKN samples were within acceptable limits, while 80% of the NO_3-N + NO_2-N samples were acceptable.

Ohio EPA Quality Assurance Guidelines for BOD_{20} are the following:

BOD Value	Variation Allowed
7 mg/l	0.5 mg/l
15 mg/l	0.6 mg/l
>15 mg/l	20%

Ninety percent of the carbonaceous BOD samples and 78% of the total BOD_{20} samples were within these limits. Seventy percent of the total BOD_5 and carbonaceous BOD_5 samples were within the Ohio EPA Quality Assurance guidelines.

RELATED STUDIES

Chlorophyll-a Analysis

To gain information on the location and concentration of algal communities in the Great Miami River, grab samples were collected daily during the three-day intensive surveys and analyzed for chlorophyll-a. Samples were collected at 6 bridge sites in each study segment. The samples were collected between 9:00 AM and 11:00 AM and filtered within 2 hours. The filtrate was then placed in a sealed glass container and stored in a cooler filled with dry ice. The samples were stored at minimum temperature until the analyses were conducted in the Ohio EPA laboratory, using the fluorometric procedure outlined in Standard Methods (1978).

Sediment Oxygen Demand Studies

Sediment oxygen demand (SOD) studies were conducted on the Great Miami River mainstem in an attempt to quantify the rate of oxygen consumption by sediments both upstream of dams and downstream of WWTPs. It was hypothesized that sediment at these sites would create a significant oxygen demand, possibly causing instream D.O. concentrations to decrease.

SOD measurements were attempted upstream of the major dams in the study area and downstream from the major WWTP's using a benthic respirometer at the following locations:

1. GMR @ RM 82.0
2. GMR @ RM 65.9
3. GMR @ RM 57.4
4. GMR @ RM 42.0

The SOD present during the time the calibration surveys were conducted was found to be minimal, in terms of model calibration attempts. Also, as noted in Section I, sediment deposits were difficult to find, even in the dam pools. Possibly, the large sediment deposits expected to be found were flushed out of the system due to the record high stream flows recorded during the summer.

Weekly Monitoring

Ohio EPA Southwest District Office Surveillance staff collected weekly water quality grab samples at 12 Great Miami River mainstem sites and 2 tributary sites from June to October, 1980. The purpose of the sampling was two-fold:

1) to monitor water quality trends in the GMR from upstream of Dayton to Miamitown;
2) to collect data to be used during verification of the QUAL-II model. Verification, however, was primarily based on the MCD data mentioned earlier.

Greater detail of these studies is found in Section I of this report.

Reaeration

The U.S. Geological Survey conducted hydrocarbon tracer studies to determine reaeration coefficients for 7 reaches of the Great Miami River. The studies were conducted during September and October, 1980. The reaches were chosen based on representative hydraulic and physical characteristics. Reaeration coefficients determined for these reaches were to be used for other sections of the GMR having similar hydraulic and physical characteristics as described with the calibration. Hydrocarbon tracer studies were conducted on the following reaches of Great Miami River:

Reach 1:	Ohio Suburban WWTP, RM 87.05 to RM 83.57
Reach 2:	Stewart St. to Broadway St., RM 78.80 to RM 77.24
Reach 3:	Dayton WWTP, RM 75.84 to RM 72.48
Reach 4:	LeSourdsville WWTP, RM 44.55 to RM 42.52
Reach 5:	Hamilton WWTP, RM 35.69 to RM 32.00
Reach 6:	Fairfield WWTP, RM 30.76 to RM 26.21
Reach 7:	Ross to New Baltimore, RM 26.21 to 21.45

The analysis and use of the data is discussed with the model calibration.

MODEL CALIBRATION AND VERIFICATION

As stated earlier, constants in the formulation of the QUAL-II model equations must be adjusted to reflect instream conditions. Each constant describes a physical or chemical characteristic of the stream being simulated. While these constants usually fall within certain accepted ranges, it is important to analytically determine their values for specific streams. This is the basic aim of the calibration process.

Dividing calibration into two categories, geometric and biochemical, can help the modeler understand the process. Geometric calibration defines the relationships between width, depth, slope, roughness, and flow, making use of time-of-travel, cross-section and reaeration data. Biochemical calibration defines the dynamics of biological and/or chemical reactions such as biochemical deoxygenation, ammonia decay, and algae growth. The result is an adaptation of QUAL-II to the natural processes of a particular stream.

It is particularly important to understand, however, that calibration is not a curve-fitting process, but a data definition process. The model must behave (mathematically) like the actual stream in every case, not only in the calibration. Therefore, each item considered in the calibration, whether geometric or biochemical, must be quantified from data and not just manipulated to produce a good simulation. Geometric constants must be defined by geometric data and biochemical rate constants must be developed from appropriate biochemical data. Additionally, care should be exercised to ensure that the mass of each reacting species is conserved in all biochemical reactions.

Ohio EPA, in cooperation with USEPA, USGS, and MCD, conducted intensive surveys on two adjacent segments of the Great Miami River during 1980, as described above. The data collected was used extensively during the model calibration.

GEOMETRIC CALIBRATION

Geometric model calibration defines the relationships between a stream's geometric characteristics, including width, depth, slope, flow obstructions, and channel features. The two most important items to quantify are depth and velocity. Depth affects the prediction of reaeration and velocity. Velocity affects the computed time-of-travel. These two parameters will strongly influence the water quality simulation; therefore, a comprehensive set of stream data must be assembled. Data collected by the Miami Conservancy District (MCD) is the most intensive data set available, and was used by Ohio EPA. For a more detailed presentation of the data, see Land Characteristics, Stream and Basin Parameters (MVRPC T7 report, June 1976). The data set includes reach delineation along with measured flow and velocity under two or three flow conditions. In addition, MCD has derived an equation for average depth as a power function of stream flow. A similar function for velocity was developed by Ohio EPA using reported velocity values.

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Additional velocity data is available from the USGS report, Time of Travel of Water in the Great Miami River, Dayton to Cleves, Ohio (Daniel P. Bauer, 1966). Time-of-travel measurements, made by USGS as part of Ohio EPA's 1980 reaeration studies, were also considered. A more complete data set was available for Segment 1 than for Segment 2. For this reason, it was desirable to use a depth/velocity formulation for Segment 2 that would require less data but would still give accurate results. The following procedure was used to justify an alternative formulation for Segment 2. First, the MCD forulations (described below) were selected for use in Segment 1. The informaton will be referred to as the "base" for comparison purposes. Depths and velocities for Segment 1 under calibration conditions were calculated using this base. Next, an alternative formulation (volume displacement - also described below) that requires less data was also used to calculate depths and velocities for Segment 1. If the two methods produced similar results, the alternative formulation could be considered adequate for use in Segment 2.

Base Formulation:

Velocity - Ohio EPA fit the MCD velocity data to a power curve relationship:

$$V = aQ^b$$

where
a = coefficient
b = exponent
Q = flow
V = velocity

The data was analyzed by a power curve least-squares regression and the coefficient "a" and exponent "b" derived.

Depth - Determined from the MCD data set presented in Table 6 of the MVRPC T7 report. MCD fit depth variations with flow to a power function of the form:

$$D = cQ^f$$

where
D = depth
Q = flow
c = coefficient
f = exponent

MCD derived the coefficient and exponent in this formulation by performing a least-squares regression of flow and depth data.

Width - Determined from the MCD data presented in Table 6 on page 80 of the MVRPC T7 report (1976). These widths are assumed to remain relatively constant with minor variations in discharge.

Alternative Formulation:

Depth - Determined by the MCD coefficient and exponent values as described in the base formulation.

Width - Determined from the MCD data as described in the base formulation.

Velocity - Determined by a volume-displacement computation. Dividing the computed stream reach volume by the flow rate under consideration yielded the reach time-of-travel. The average reach velocity was then computed by dividing the reach length by the time-of-travel.

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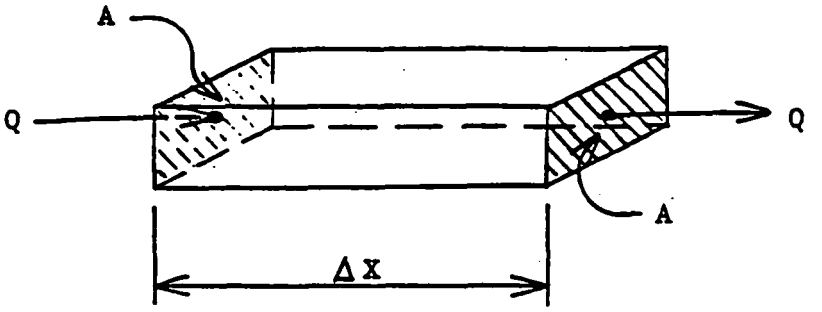
The following equations were developed for use in volume-displacement computations of average reach velocity:



using Q = flow in the reach volume
A = representative cross-sectional area
ΔX = reach length,

$VOL = A * \Delta X$
$TOT = VOL / Q$
$V = \Delta X / TOT$,

where VOL = reach volume
TOT = time of travel through the reach
V = average reach velocity,

with any set of consistent units for the above variables.

Comparison:

Table 48 summarizes the computed total times-of-travel under flow conditions during the 1980 intensive survey (described in the calibration flows description). The results show that the alternative formulation accurately reproduces the base velocity distribution for Segment 1; it was therefore used for geometric calibration for Segment 2.

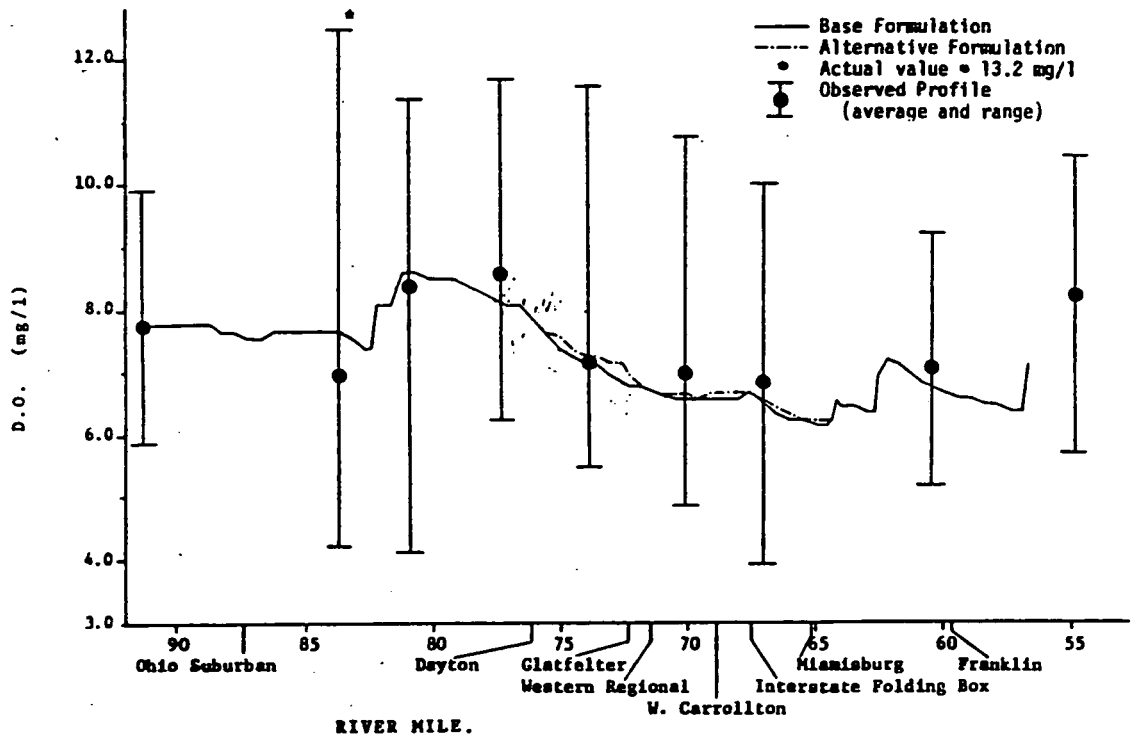
Another way to review and compare the velocity formulations is by analysis of the calibration D.O. curve (see Figure 34). The modeler must be very cautious at this point not to confuse a valid justification of geometric formulation with D.O. curve-fitting; but it is interesting to compare D.O. variations resulting from differing velocity formulations to gauge simulation sensitivity to velocity. Though this was not part of Ohio EPA's velocity calibration, the fact that the selected velocity formulation also produced good D.O. simulation results (when combined with the remainder of the calibration) is a confirmation of the calibration's success.

In summary, the GMR geometric calibration has been based only on geometric data. Considerable care has been exercised to ensure its independence from data used for biochemical calibration. The excellent data collected by MCD made the process reliable and accurate. The comparisons described above were developed on Segment 1 to justify the choice of the alternative formulation as a velocity computation that could be applied to both Segment 1 and Segment 2 in the geometric calibration. The match is so close, in fact, that it was possible to use the base formulation itself for Segment 1, without producing any inconsistency with the use of the alternative formulation for Segment 2.

TABLE 48
Comparison of Alternate Velocity Formulations

	Time-of-Travel (days)	
	Segment 1	Segment 2
Base:		
D. by MCD Coefficients V. by Ohio EPA Coefficients	3.16	--
Alternative Formulation		
D. by MCD coefficients V. by volume - displacement	2.95	2.37

Figure 34. Comparison of the velocity formulations.



000301

REAERATION

Dissolved oxygen (D.O.) balance in a river is dependent upon two primary factors: natural reaeration of the river and removal of D.O. through the oxidation of organic material. Reaeration calibration is similiar to geometric calibration in that it defines physical stream characteristics. It could even be discussed under that heading, except for its unique nature. Reaeration deals with a single issue, that of oxygen transport across the air-water interface and through the water column.

In reaeration, oxygen is entrained by physical processes in the stream, offsetting oxygen depletion by other processes. It is often expressed as an exponential relationship between D.O. deficit (the difference between saturation and instream D.O. levels) and time:

$$D = D_0 \, e^{-K_2 t}$$

where
- D = D.O. deficit (mg/l) at time t
- D_0 = initial D.O. deficit (mg/l) at time zero
- K_2 = reaeration rate (day^{-1})
- t = elapsed time (days).

Other factors affecting D.O. levels are discussed with the biochemical calibration. Modeling accuracy can hinge, however, on properly deriving or predicting the reaeration rate (K_2). Reaeration determination is not a D.O. curve-fitting process; like the geometric characteristics, reaeration rates must be based on appropriate observations of the specific stream being modeled.

During 1980, Ohio EPA contracted USGS to measure reaeration in the Great Miami River. As discussed earlier with the field surveys, these studies were conducted using a modified tracer technique with ethylene gas. The reaeration studies covered only 21.87 miles out of a total of 76.21 miles of the Great Miami River considered in this report. For that reason, universal application of the resulting reaeration rates or an average of them seemed inappropriate. Therefore, Ohio EPA analyzed the reaeration information and evaluated several predictive equations, seeking one that would produce consistent prediction of the measured reaeration in the GMR.

The five predictive equations that were evaluated appear below.

O'Connor: $K_2 = 1.29\ V^{.5}/D^{1.5}$

Churchill: $K_2 = 11.5\ V^{.97}/D^{1.67}$

Dobbins: $K_2 = 23.3\ V^{.73}/D^{1.75}$

Owens: $K_2 = 21.7\ V^{.67}/D^{1.85}$

where K_2 = reaeration rate (day^{-1})
V = representative reach velocity (fps)
D = representative reach depth (ft)

Tsivoglou: $K_2 = \frac{C\Delta H}{TOT}$

where K_2 = reaeration rate (day^{-1})
C = escape coefficient
ΔH = headloss in reach (ft)
TOT = time-of-travel through reach (days)

Depth and velocity appear in the predictive equations. Thus, the development of the geometric calibration will affect the choice of reaeration predictive equations, and an adequate geometric formulation must be found before analyzing them.

In selecting a predictive equation for K_2, Ohio EPA analyzed the reaeration data using the velocity formulation discussed as part of the Geometric Calibration. Reaches where reaeration was measured as part of OEPA's studies are listed in the Field Studies section. Two additional reaches were measured but are not present in the table and were not analyzed because each included a dam. Table 29 presents the comparison of the predictive equations with field-measured reaeration rates. The O'Connor formulation most consistently predicts the field measured K_2's for Segment 1. Therefore Ohio EPA used the O'Connor formulation for Segment 1.

The measured reaeration rates in Segment 2, however, were not effectively predicted by any of the reaeration formulations, as Table II-4 indicates. Since the flows under which the reaeration rates were measured were close to the flows during collection of the model calibration data, a single reaeration rate, representing the measured values, was chosen for use in all of Segment 2. Reach 4 was the only reaeration measurement between RM 55 and RM 37, the critical portion of Segment 2 for D.O modeling; therefore, the reaeration rate applied to Segment 2 was based on this measurement. The adjustment of the rate to low-flow conditions is described under Wasteload Allocation, Low-Flow Conditions Segment 2.

TABLE 49
Calculated K_2 and Field K_2 (day $^{-1}$ @ 20°C)

Reach	Site River Mile	Field-Measured K_2	Calculated K_2 O'Connor	Churchill	Dobbins	Owens	Tsivoglou
Segment #1							
1	87.05 - 85.20	4.06	2.958	1.796	3.853	3.431	0.565
	85.20 - 83.57	2.20	3.642	2.263	4.911	4.435	0.565
3	75.84 - 73.83	3.59	2.958	2.644	4.421	3.608	3.404
	73.83 - 72.48	1.39	1.601	0.694	1.713	1.555	0.701
Segment #2							
4	44.55 - 42.52	5.25	0.560	0.309	0.573	0.445	1.364
5	35.69 33.97	13.90	2.84	2.47	4.27	3.54	2.28
	33.97 32.00	9.02	2.87	2.52	4.33	3.58	2.16
6	30.76 28.45	1.05	2.11	1.82	2.96	2.35	4.80
	28.45 26.21	4.59	2.16	2.79	4.11	3.18	7.60
7	26.21 23.55	3.95	2.03	1.58	2.74	2.22	4.53
	23.55 21.45	2.82	2.54	2.41	3.78	2.98	5.14

Analysis of the data of Table 49 shows that reaeration rates measured in Segment 2 were not effectively predicted by the O'Connor reaeration formulation. Generally, the measured reaeration is higher than the predictive equations yield. Since the flow under which the reaeration was measured was close to the flow during collection of the model calibration data, the measured rate of 5.3 day^{-1} (4.8 day^{-day} at 20°C) was used as a basis for reaeration rate determination for Segment 2. When modeling under low-flow conditions, additional analysis of the data was used to project the field data to a low-flow condition. This is described under Wasteload Allocation, Low-Flow Conditions Segment 2.

Several dams located on the Great Miami river also contribute significantly to the stream's dissolved oxygen levels. The version of QUAL-II used by Ohio EPA is not designed to account for these point sources of reaeration, so K_2 input to the model had to be externally manipulated to produce the necessary reaeration. This was accomplished by setting up 0.1 mile reaches in the model at the dam locations and using a high reaeration rate through each short reach to produce the desired reaeration.

The reaeration potential of each dam was determined by analyzing field data collected during the 1980 intensive surveys. The data includes D.O., temperature, and time of measurement, above and below each dam. The data was compared with the results of two predictive equations. Neither of the equations consistently followed the data, so they were not used.

Instead, the final dam reaeration predictions were based on the actual data values, and were calculated by solving the D.O. deficit expression for K_2:

$$K_2 = \frac{-1}{t} \ln(D/Do)$$

In the above equation, the D.O. deficits above and below each dam (D_o and D respectively) were computed as the difference between saturation D.O. at the measured temperature and measured D.O., at each point. The length of each reach which represented a dam (0.1 mile) was divided by the average velocity through the reach to obtain the time-of-travel. The above equation was then used to calculate the reaeration rate (K_2) for the dam.

In cases where the data was suspect, the rate for a dam of similar characteristics was substituted. The reaeration rates used for the calibration are shown in Table 50. Each was assumed as the K_2 through the entire short reach, thus simulating the reaeration across each dam.

FLOWS

Proper definition of the flow regime is another very important aspect of the modeling process. However, it is not usually considered part of the model calibration, because it does not involve the formulation of a predictive equation or of reaction constants. Definition of the flow regime involves accounting for the source, quantity, and quality of all flows entering or leaving the river system. This takes the form of a flow balance of known sources to and withdrawals from the system. A mass balance of conservative parameters may then be used to verify the flow balance.

000305

TABLE 50
Reaeration Over Dam

Segment	Dam	RM	H(ft)	K_2 (day^{-1})	K_2 at 20°C
1	Island Park Dam	82.17	7.2	217.10 at 10°C	254.20
	Dayton Low Dam	80.78	5.0	172.2 at 10°C	201.59
	Tait Station Dam	77.49	8.5	176.58 at 13°C	197.50
	Hutchings Station Dam	64.39	3.0[a]	20.24 at 14.9°C	21.94
	Chautauqua[c]	62.58	8.5[b]	71.35 at 14.9°C	77.33
	Middletown Dam	56.73	8.5	93.77 at 14.9°C	101.63
2	Dam below Middletown-Canal Return	51.10	1.5	25.95 at 14.9°C	30.48
	Dam above Hamilton Canal	41.54	3.3	25.95 at 14.9°C	30.48
	Dam above Hamilton Canal Return	37.26	9.5	63.6 at 14.9°C	68.93

a The dam is 10 ft. high. At the time of the intensive survey, however, the Chautauqua Dam flooded 7 ft. of the dam's height, leaving only a 3 ft. fall.

b Assumed similar to the Middletown Dam.

c Refer to Addendum.

In addition, the modeler must determine the relationship between the flow regime that existed while the calibration data set was collected and the flow regime expected under critical flow conditions. Location and definition of all sources of stream flow (i.e., reservoirs, groundwater) is critical to this task, which will be discussed in more detail.

For each survey period, the average flow in the GMR was calculated by combining upstream flow, tributary flows, and discharger flows. Flows measured by USGS gages at Miamisburg and Hamilton were then compared with these calculations. The calculated flow during the Segment 1 survey period was 1140 cfs and average gage flow at Miamisburg was 1170 cfs (see Figure 35). Corresponding values for the Segment 2 survey period were 1232 cfs and 1255 cfs at the Hamilton gage (see Figure 36). For each case, the small difference (2.5% for Segment 1 and 1.8% for Segment 2) was linearly distributed in the model over the length of the segment studied.

Hydrographs from the Taylorsville, Mad River, and Stillwater River gages are shown in Figure II-6. Note that the shape of the Mad River hydrograph reflects the daily flooding of the Dayton well field. Other flows necessary for the flow balance were the effluent flow of the dischargers and tributaries along the water course. The significant flow contributors in Segment 1 and Segment 2, along with their water quality, are summarized in Tables 51 through 54.

The final check on the flow balance is to compare conservative water quality parameter (Cl^- and TDS) concentrations measured during the field survey with those computed considering the previously defined flow balance and each of the point source inputs. Figures 38 through 41 show that in both segments the formulated flow regime adequately recreates the mass balance that occurred instream during the calibration survey.

BIOCHEMICAL CALIBRATION

This phase of calibration defines the way QUAL-II will simulate instream biochemical reactions. Specifically, the rates of carbonaceous biochemical deoxygenation (K_1) and ammonia-nitrogen decay (K_3) are determined. As stated earlier, this must be done independently of the geometric calibration and is not a D.O. curve-fitting exercise, but a CBOD and NH_3-N data definition process. The end result will be accurate simulations, not only of D.O. profiles, but also of CBOD and NH_3-N levels in the Great Miami River.

Deoxygenation Rate:

The deoxygenation rate (K_1) was developed from the 1980 Ohio EPA intensive survey data. Low instream $CBOD_{20}$ concentrations, however, made the development of an instream deoxygenation rate difficult; therefore, bottle rates were determined by a daily difference method (Tsivoglou, 1958). The results are outlined in Table 55. A deoxygenation rate of 0.18 day^{-1} (at 20^oC) was used in the water quality modeling, and compares well with the rate in MCD's data base (1974).

Figure 35. River flows during the Segment 1 Intensive Survey

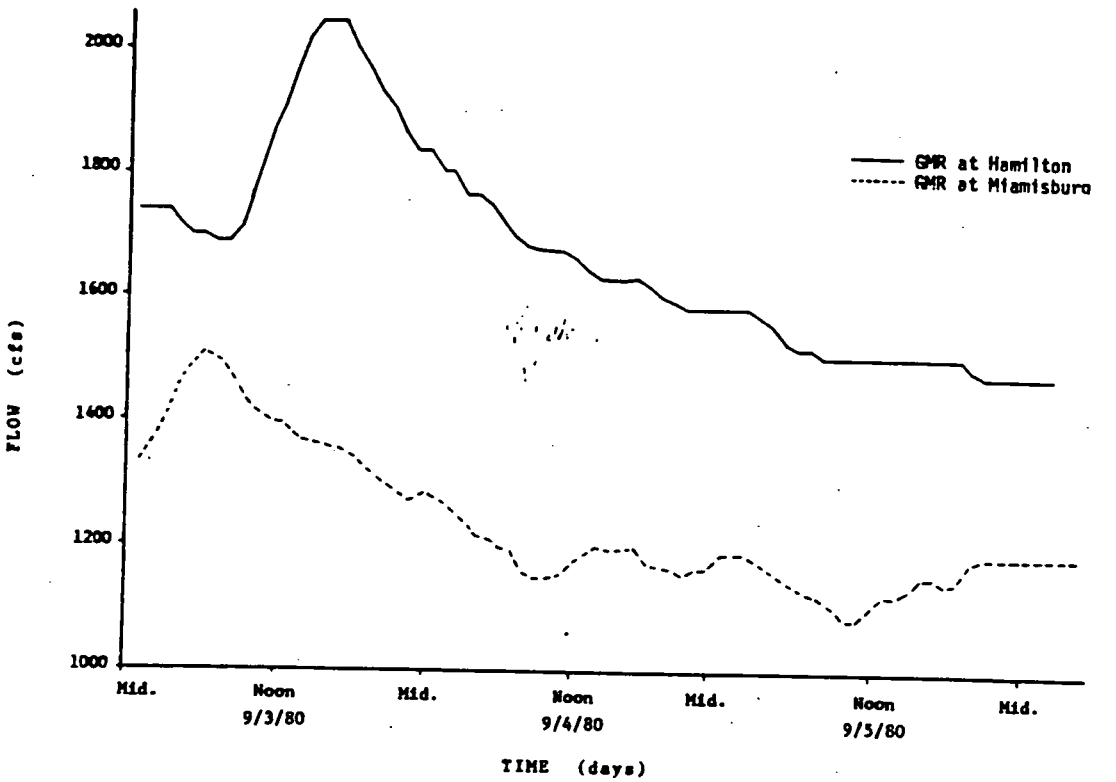


Figure 36. River flow during the Segment 2 Intensive Survey.

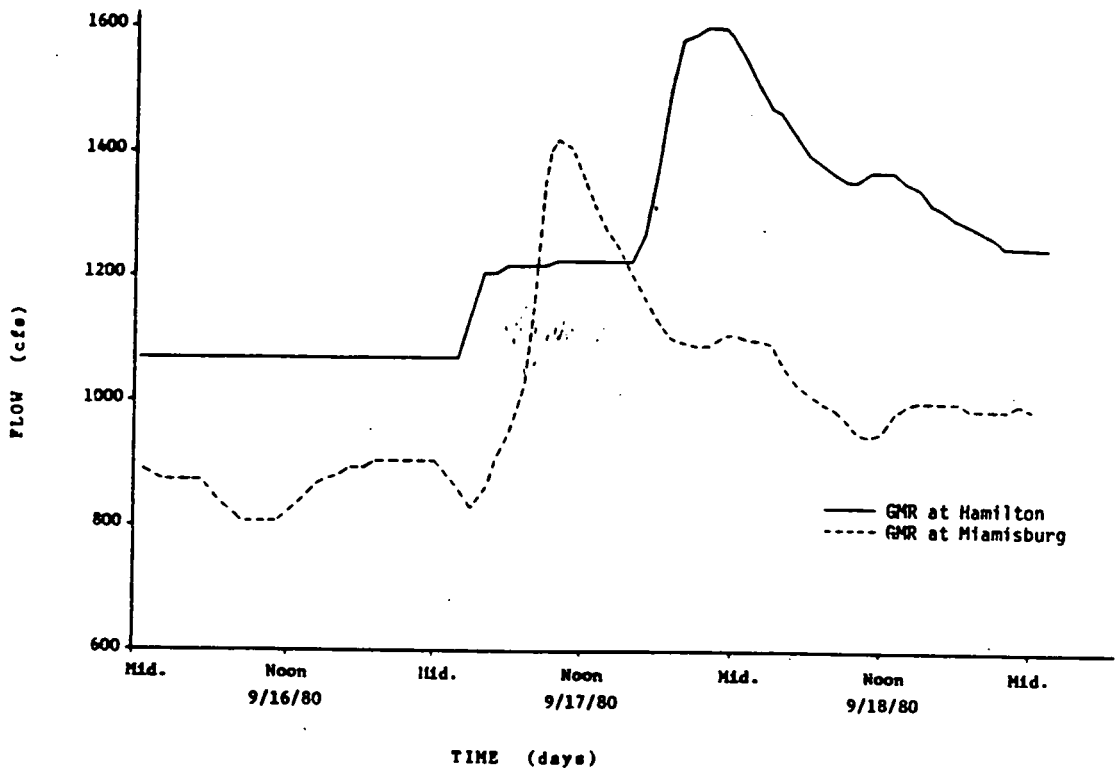


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Figure 37. Major input flows during the Segment 1 Intensive Survey.

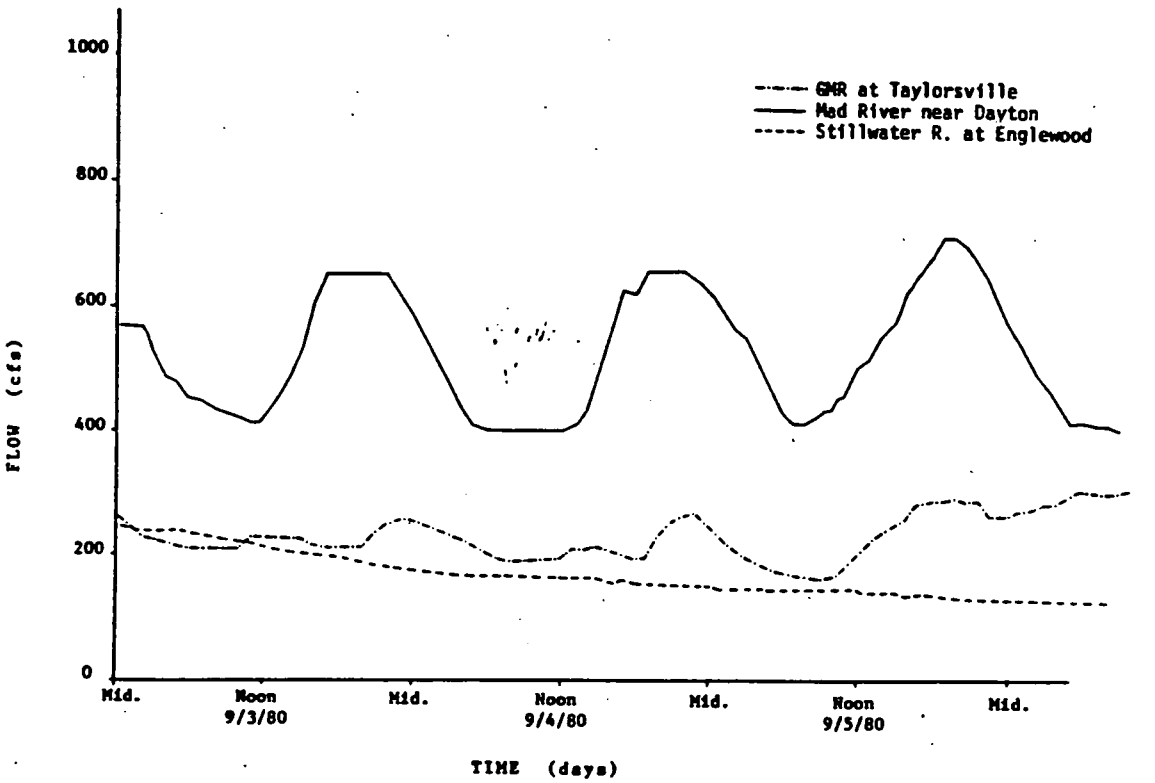

Table 51. Segment 1: Tributary flows and background water quality.

River Mile	Trib. Name	Flow (cfs) Intensive Survey	Flow (cfs) Critical Low Flow	W.Q. parameter Conc. (mg/l)* BOD_5	$CBOD_{20}$	NH_3-N	NO_2-N + NO_3-N	D.O.
91.14	Headwaters (Little York Rd)	225.33	50.0	3.83	7.17	0.09	1.65	7.52
82.57	Stillwater River	181.66	15.00	4.90	8.47	0.02	1.60	6.96
81.48	Mad River	547.44	160.85	3.47	7.53	0.03	2.55	8.75
80.25	Wolf Creek	23.77	1.30	2.20	4.30	0.01	0.61	7.10
73.54	Holes Creek	2.44	0.70	2.50	5.0	0.01	1.30	7.70
70.49	Opossum Creek	1.14	-	2.90	4.80	0.04	1.47	9.40
69.55	Owl Creek	6.21	5.77	31.77	53.13	0.05	0.48	6.40
67.60	Bear Creek	11.47	1.10	1.47	4.07	0.01	0.18	8.40
58.56	Clear Creek	6.23	0.30	2.77	4.87	0.01	0.88	7.17
57.42	Twin Creek	100.50	4.50	2.47	3.87	0.013	1.47	7.97
57.00	Middletown Hydr. Canal Withdrawal	151.67	180.00	5.33	9.20	0.13	2.10	7.3[illegible]
52.17	Middletown Hydr. Canal Return	151.67	180.00	4.20	7.63	0.10	1.70	7.45

* Measured during intensive survey and assumed for critical low flow.

000311

Table 52. Segment 1: Measured discharge flow and effluent quality.

River Mile	Entity Name	Flow (cfs)	W.Q. parameter Conc. (mg/l)				
			BOD_5	$CBOD_{20}$	NH_3-N	NO_2-N + NO_3-N	D.O.
87.48	Ohio Suburban WWTP	4.821	28.60	37.20	16.37	0.16	4.39
77.49	DP&L 002 Tait	7.596	1.87	2.27	0.01	1.44	6.54
77.48	GM - Delco Moraine 002	4.369	3.0	4.87	0.16	0.02	6.00
77.47	GM - Delco Moraine 003	4.41 (Estimate)	2.37	3.70	0.26	0.01	6.00
77.24	Broadway Storm Sewer	1.432	2.15	3.20	0.06	0.65	8.23
76.11	Dayton WWTP	90.633	31.03	45.60	14.67	0.79	6.22
74.42	GM - Air Plant - #3	1.04	10.60	19.20	0.53	0.91	9.73
74.15	GM - Air Plant - #2	1.902	5.87	10.23	0.14	0.77	9.97
72.34	Glatfelter	5.734	15.87	37.53	3.82	0.24	6.87
71.48	Montgomery Co. - Western Regional WWTP	16.141	1.40	3.90	0.40	7.34	7.75
68.85	West Carrollton WWTP	1.604	49.47	91.00	19.37	0.29	1.58
67.49	Interstate Folding Box	1.202	76.0	109.0	0.03	0.06	6.40
65.05	Miamisburg WWTP	2.563	8.87	12.77	21.87	0.23	5.40
65.01	DP & L (Hutchings) 002	4.378	1.50	3.10	0.14	1.04	6.27
59.65	Franklin WWTP	5.353	10.10	17.47	2.46	2.69	2.33

Table 53. Segment 2: Tributary flows and background water quality.

River Mile	Trib. Name	Flow (cfs) Intensive Survey	Flow (cfs) Critical Low Flow	W.Q. parameter Conc. (mg/l)* BOD_5	$CBOD_{20}$	NH_3-N	NO_2-N + NO_3-N	D.O.
52.63	Headwaters (Central Sutphin Rd)	954.83	267.69	5.17	8.37	0.41	3.10	8.05
52.17	Middletown Hydr. Canal Return	123.67	180.00	5.00	8.87	0.41	2.93	8.03
49.80	Elk Creek	1.04	0.30	0.17	0.57	0.21	6.56	9.20
47.61	Dicks Creek	15.40	3.00	5.67	7.23	0.74	2.27	5.82
45.70	Gregory Creek	2.11	0.65	1.37	2.17	0.07	0.33	8.90
38.38	Four Mile Creek	55.80	7.64	1.97	4.60	0.17	2.47	9.10
37.13	Hamilton Hydr. Canal Return	465.60	200.00	4.17	7.53	0.09	2.96	8.80
31.41	Pleasant Run	3.10	0.60	2.60	4.30	0.18	0.69	8.00
28.27	Banklick Creek	0.67	0.13	1.50	2.30	0.13	1.46	[illegible]
27.70	Indian Creek	11.27	2.33	0.93	1.73	0.15	1.46	9[illegible]
21.70	Blue Rock Creek	2.32	0.45	2.50	3.10	0.20	3.95	8.10

* Measured during intensive survey and assumed for critical low flow.

000313

Table 54. Segment 2: Measured discharge flows and effluent quality.

River Mile	Entity Name	Flow (cfs)	W.Q. parameter Conc. (mg/l)				
			BOD_5	$CBOD_{20}$	NH_3-N	NO_2-N + NO_3-N	D.O.
51.45	Armco (Middletown) 001	27.85	9.57	14.77	0.72	2.92	8.15
48.29	Middletown WWTP	28.33	6.37	8.67	1.10	3.54	3.33
48.10	Crystal Tissue	3.68	35.20	50.80	0.05	0.02	5.27
45.65	LeSourdsville Regional WWTP	2.46	4.57	9.17	0.41	9.29	8.55
43.80	(Future Miller Brewery)						
39.38	Armco (New Miami) 004	16.66	5.67	9.03	1.46	4.45	8.23
38.74	Armco (New Miami) 001	10.57	5.10	5.87	1.00	2.73	8.20
37.12	Hamilton Municipal Elec.	155.80	4.70	7.30	0.09	2.55	7.50
36.85	Champion Papers 003	0.42	4.20	7.87	0.05	2.31	6.70
34.27	Storm Sewer	1.62	17.63	31.80	0.08	0.15	2.90
34.00	Hamilton WWTP	25.04	4.87	6.73	0.05	5.42	6.70
32.00	Fairfield WWTP	6.36	4.87	7.07	0.90	12.63	7.40
25.99	Procter & Gamble	0.33	1.57	2.43	0.10	6.08	3.60
24.73	U.S. A.E.C.	0.64	1.37	1.67	0.06	7.20	6.69

Figure 38. Calibration flow check - Segment 1 chloride levels.

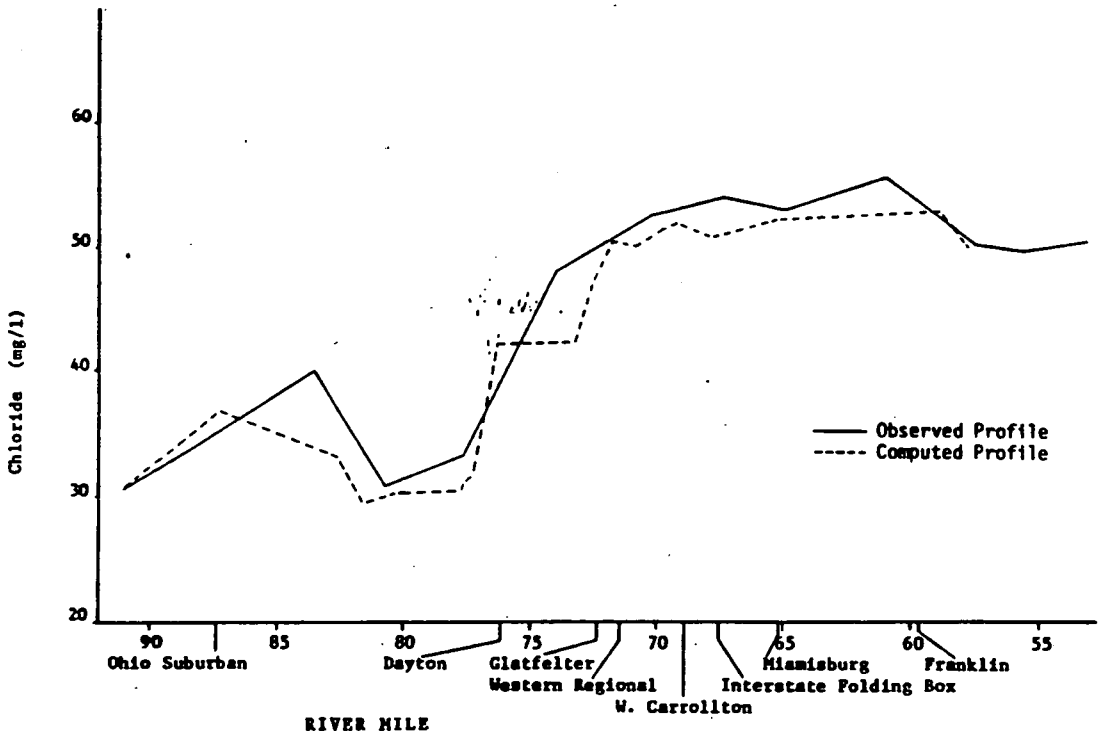

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Figure 39. Calibration flow check - Segment 2 chloride levels.

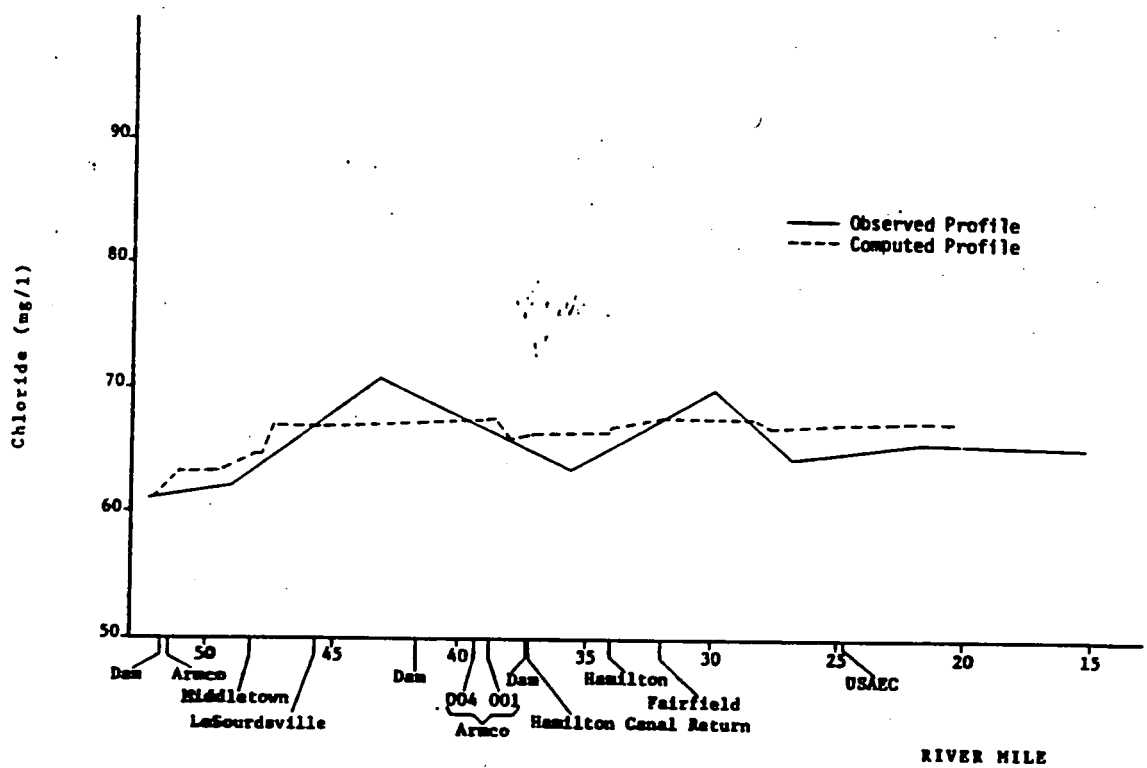

Figure 40. Calibration flow check - Segment 1 TDS levels.

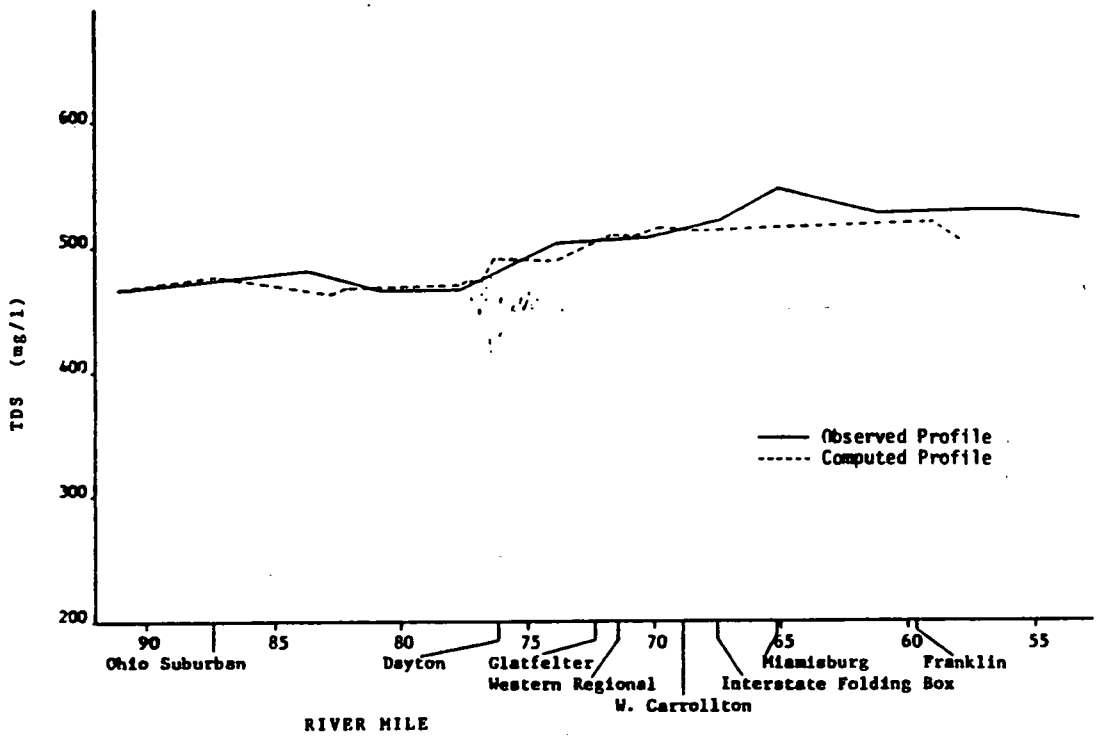

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Figure 41. Calibration flow check - Segment 2 TDS levels.

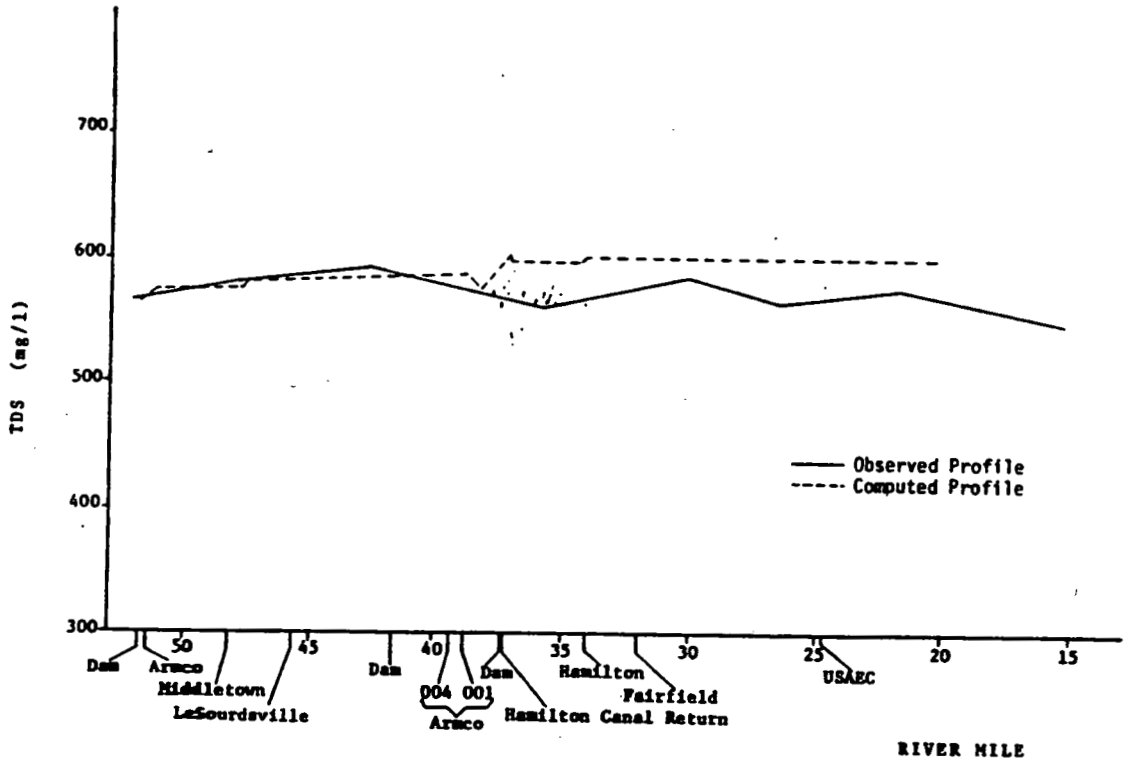


TABLE 55
Bottle Decay Rates

Sampling Station	CBOD Decay Rate (K_1) Day 1	Day 2	Day 3	Correlation Coef (r^2) Day 1	Day 2	Day 3
Little York Rd.	0.13	0.16	0.17	0.98	0.98	0.96
North Dixie Rd.	0.20	0.22	0.16	0.93	0.95	0.98
Monument St.	0.10	0.19	0.16	0.92	0.95	0.95
Sellers Rd.	0.21	0.18	0.15	0.95	0.98	0.98
Carrollton Rd.	0.16	0.16	0.17	0.93	0.98	0.97
Linden Ave.	0.12	0.21	0.18	0.87	0.93	0.97
State Route 123	0.17	0.15	0.13	0.98	0.98	0.93
Middletown Hydraulic Canal	0.14	0.18	0.17	0.94	0.98	0.98
State Route 4	0.14	0.17	0.13	0.99	0.96	0.93
Central Sutphin Rd.	0.15	0.14	0.15	0.92	0.94	0.95

The deoxygenation rate was adjusted to instream temperature (T) by the following relationship:

$$K_1(\text{at } T) = K_1(\text{at } 20^oC) \times (1.047)^{T-20}$$

The computed $CBOD_{20}$ profile coincided well with the observed profile in Segment 1 (Figure 42) until approximately RM 74. The increase in CBOD at this point could not be quantified from the known discharger loadings. At this point, it was theorized that an unknown source of CBOD was responsible for the observed increase. A $CBOD_{20}$ input of sufficient quantity to produce this instream CBOD increase was therefore included as a term in the segment loading. Figure 42 represents the final deoxygenation rate calibration for Segment 1, which includes this CBOD source at RM 72.3.

At points in Segment 2, however, calibration was not possible because of inconsistencies between data and the modeled reaction kinetics. As a result, the $CBOD_{20}$ simulation curves did not compare well with intensive survey data (Figure 43). Discrepancies between observed and predicted $CBOD_{20}$ profiles may have been caused by algal presence in the unfiltered samples, or by additional BOD sources between RM 55-50 and RM 35-30.

Further investigation would be needed to verify that these sources exist and to quantify them. Instead, the possible effects of long-term CBOD exertion by dying algae or other organisms were examined. BOD_5 values were multiplied by 1.5 to obtain equivalent $CBOD_{20}$ levels which "filtered out" the algal CBOD effects. Resulting $CBOD_{20}$ values closely approximated the computed values instream (Figure 44), so these "calibrations" were considered adequate simulations of Segment 2.

Nitrification Rate:

The nitrification rate (K_3) was also developed from the 1980 Ohio EPA intensive survey data. Unlike K_1, however, K_3 was determined from instream concentration and time-of-travel data. Using a method which plots the natural logarithm of the ammonia-nitrogen concentration against time-of-travel (as shown in Figure 45), Ohio EPA derived the decay rate of the system.

This ammonia-nitrogen decay rate of 1.5 day^{-1} is very high compared to commonly accepted literature values which range from 0.003 to 0.5. An important difference however, is that the derived K_3 rate is a total river value which reflects the influences of biochemical action both within the water column and on the bottom (attached growth), while the literature values pertain only to water column activity. Thus, the computed K_3 represents the total water system and would be an accurate overall measure. QUAL-II considers only water column activity (nitrifying bacteria and algae) however, so the nitrification rate should be chosen to match the model's formulations, as well as to properly depict instream conditions.

Figure 42. Calibration - Segment 1 CBOD levels.

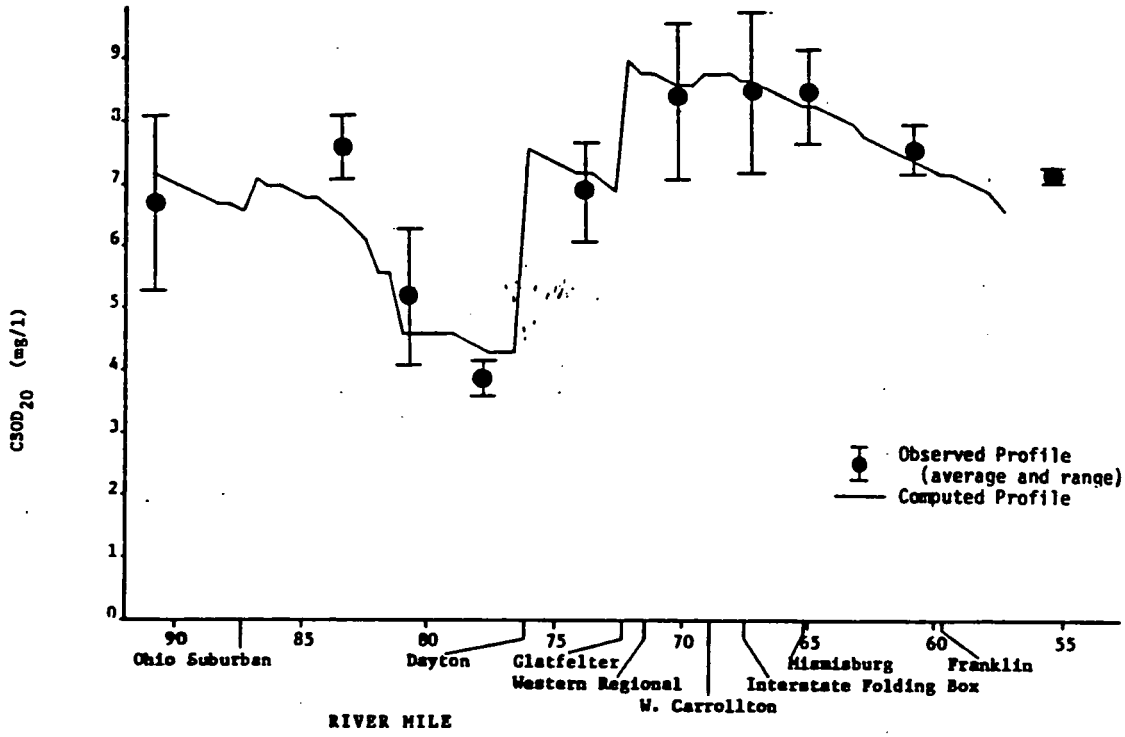


Figure 43. Calibration - Segment 2 CBOD levels (using measured $CBOD_{20}$ values).

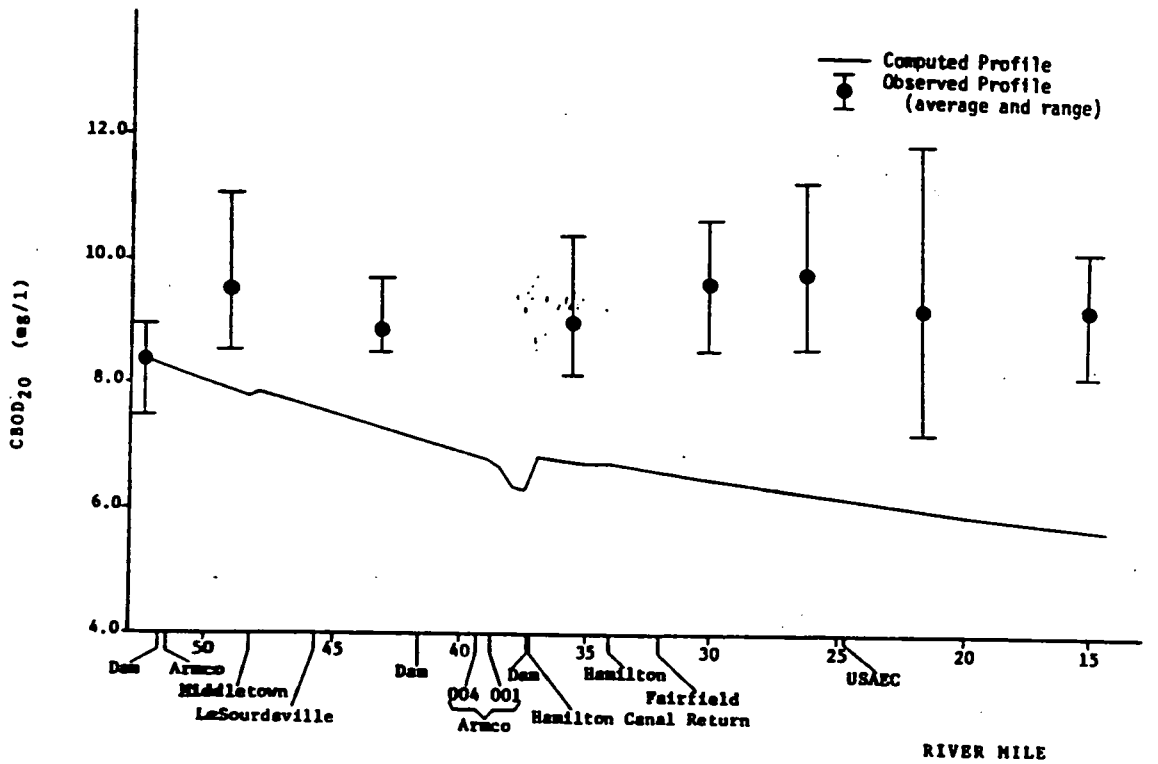
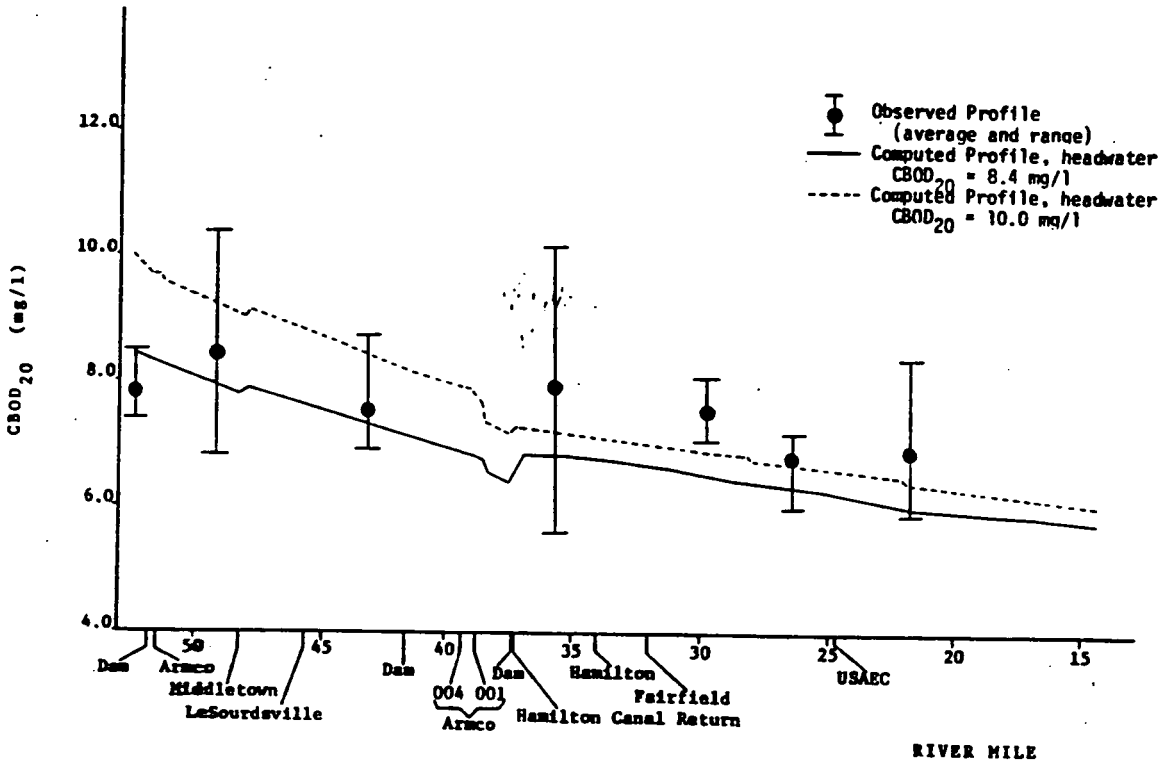
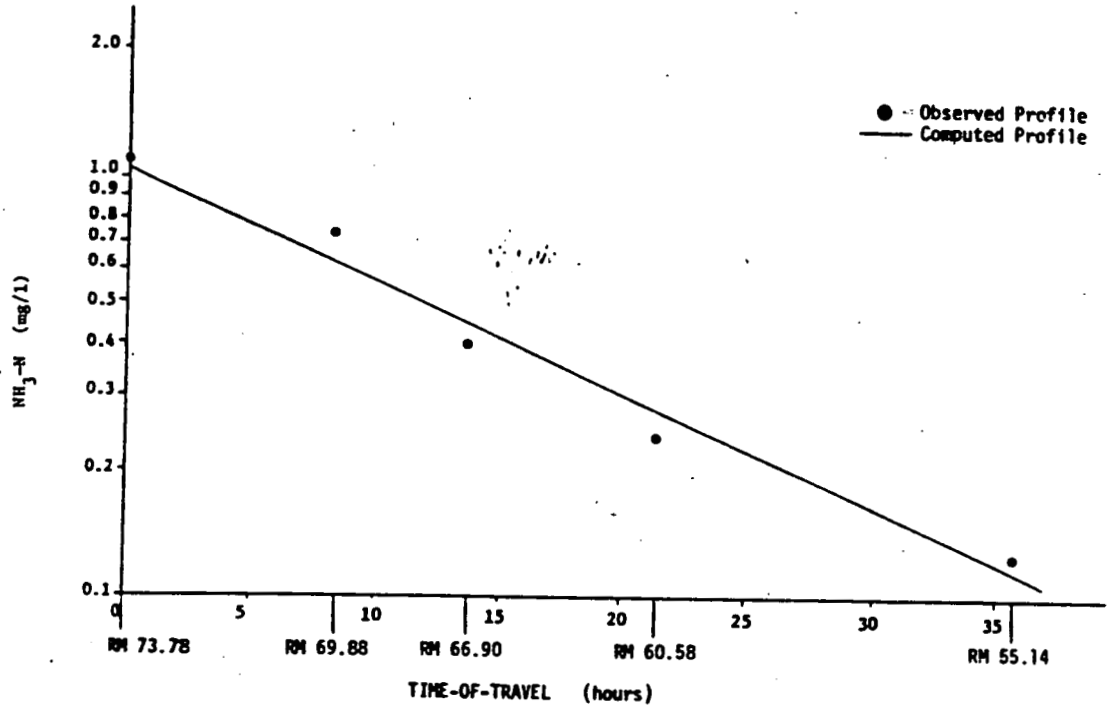


Figure 44. Calibration - Segment 2 CBOD levels (using measured $CBOD_{20}$ values).



000323

Figure 45. Ammonia decay rate determination.



The nitrate levels shown in Figures 46 and 47 must also be considered. If the nitrification rate was actually in the range of 1.5 as the data predicts, then these profiles would show much more nitrate being produced by the oxidation of the ammonia. However, the nitrate profiles do not exhibit this, hence the derived rate indicates ammonia uptake other than direct biochemical nitrification. This apparent ammonia removal was attributed to areas of locally intense ammonia uptake.

Analysis of the stream bed geometry indicates that several shallow riffles exist in the Great Miami River, and this was confirmed by Ohio EPA's Section of Surveillance and Water Quality Standards. They had done extensive biological sampling along the river and observed that these areas were characterized by rocky bottoms with extensive attached growth. Areas similar to these are common in Ohio streams and exhibit high ammonia removal rates.

Thus proper modeling requires representation of ammonia removal both in the water column and on the bottom. This was accomplished by assuming a water column ammonia nitrification rate of 0.4 day^{-1} which is consistent with literature values and maintains the ammonia mass balance. Ammonia sink terms were then created to simulate localized ammonia uptake in shallow, rock-bottomed areas interspersed along the river, where attached biological growth would remove ammonia. Two such sinks were located at RM 72.2 and RM 61.1 in Segment 1 and a similar sink was located in Segment 2, extending from RM 51.6 to RM 48.3. These sinks were formulated to match observed NH_3-N concentreations by externally removing an incremental amount of ammonia-nitrogen from each of the 0.1 mile computational elements involved. With the lower K_3 rate, nitrate levels were also reproduced more accurately (Figures 46 and 47). The resulting ammonia levels for calibration are shown in Figures 48 and 49; the impact of the observed sinks was evaluated by a sensitivity analysis.

CALIBRATION RESULTS

The process of calibration as outlined has independently derived geometric and biochemical parameters. The final step of the calibration is to incorporate the parameters in the water quality simulation model. The end product is a model of the Great Miami River that accurately predicts instream water quality. Table 56 presents the final values for the model coefficients developed from the biochemical calibration process.

Results of the deoxygenation and nitrification rate determination are shown in graphs of simulated CBOD (Figures 42 through 44), NH_3-N (Figures 48 and 49), and NO_3-N (Figures 46 and 47). Figure 50 completes the description of model calibration for Segment 1; this D.O. simulation graph illustrates the success of the calibration process for this segment. However, difficulties were encountered in calibrating the model for Segment 2.

One complicating factor in the Segment 2 calibration was algae. The effects of algal photosynthetic/respiratory activity on stream D.O. is well documented (O'Connor and Di Toro, 1970). During the intensive survey on Segment 2, major algal populations were evident (Tables 57 and 58) and made large contributions to the oxygen budget, so that super-saturated conditions existed instream at several points.

Figure 46. Calibration - Segment 1 nitrate levels.

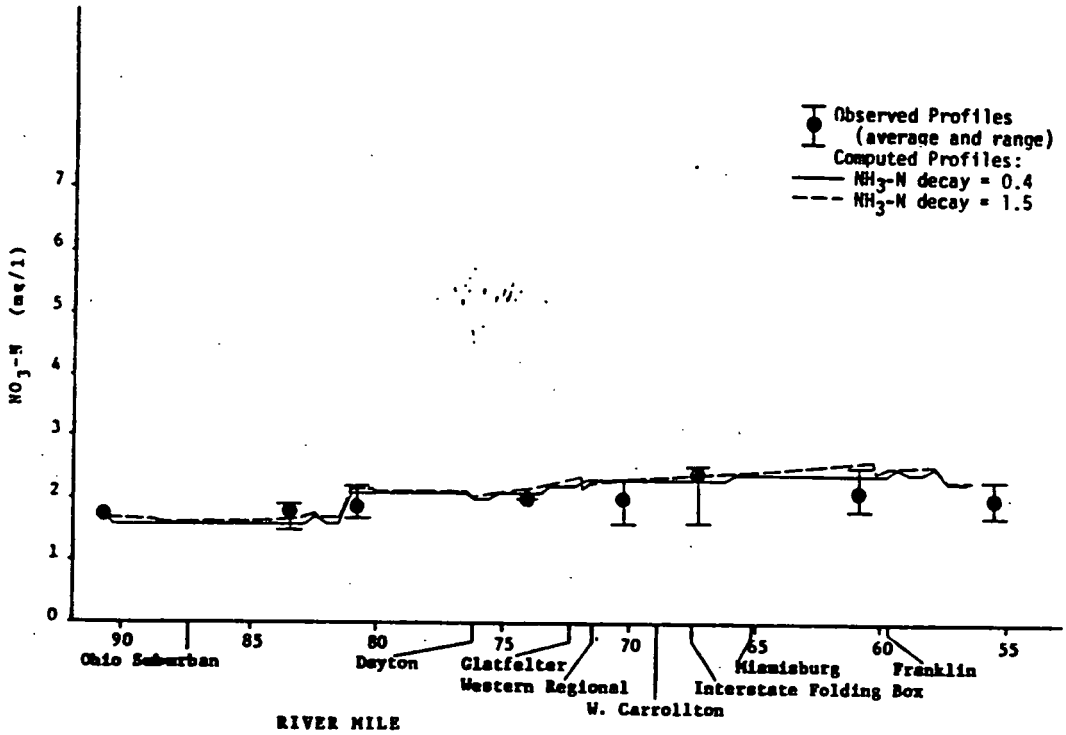


Figure 47. Calibration - Segment 2 Nitrate levels (with and without algae).

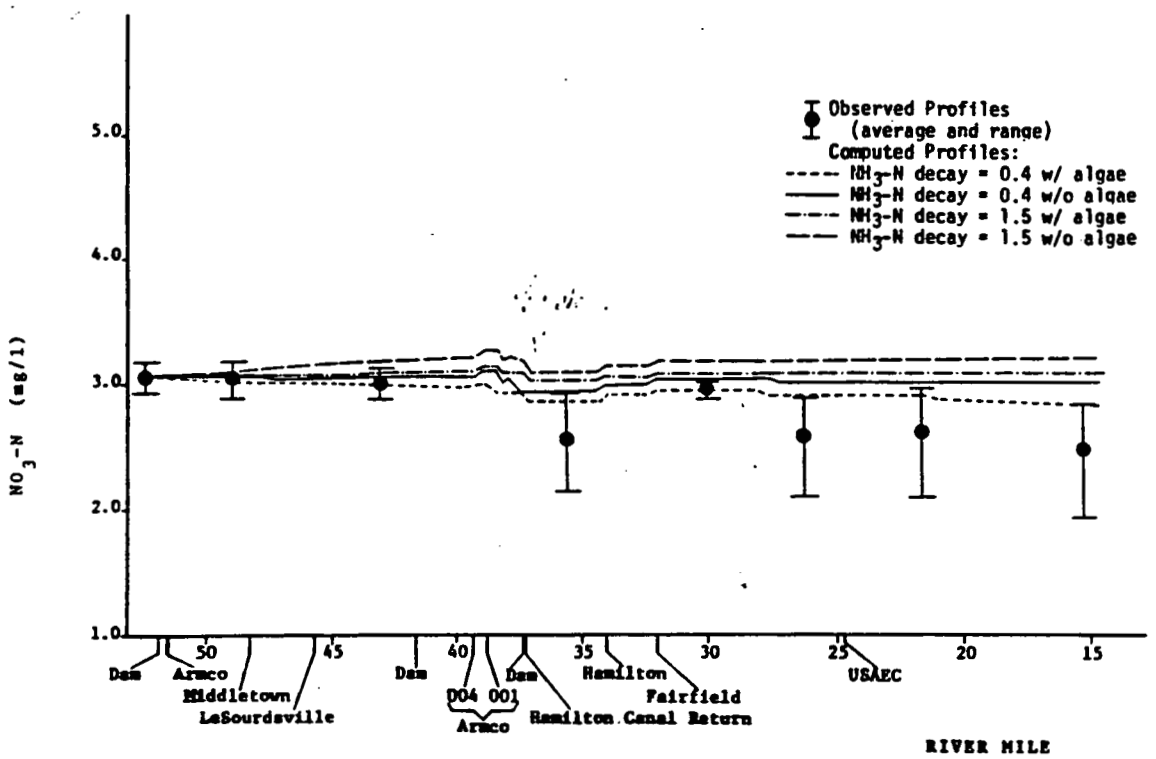


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Figure 48. Calibration - Segment 1 ammonia levels (with ammonia sink).

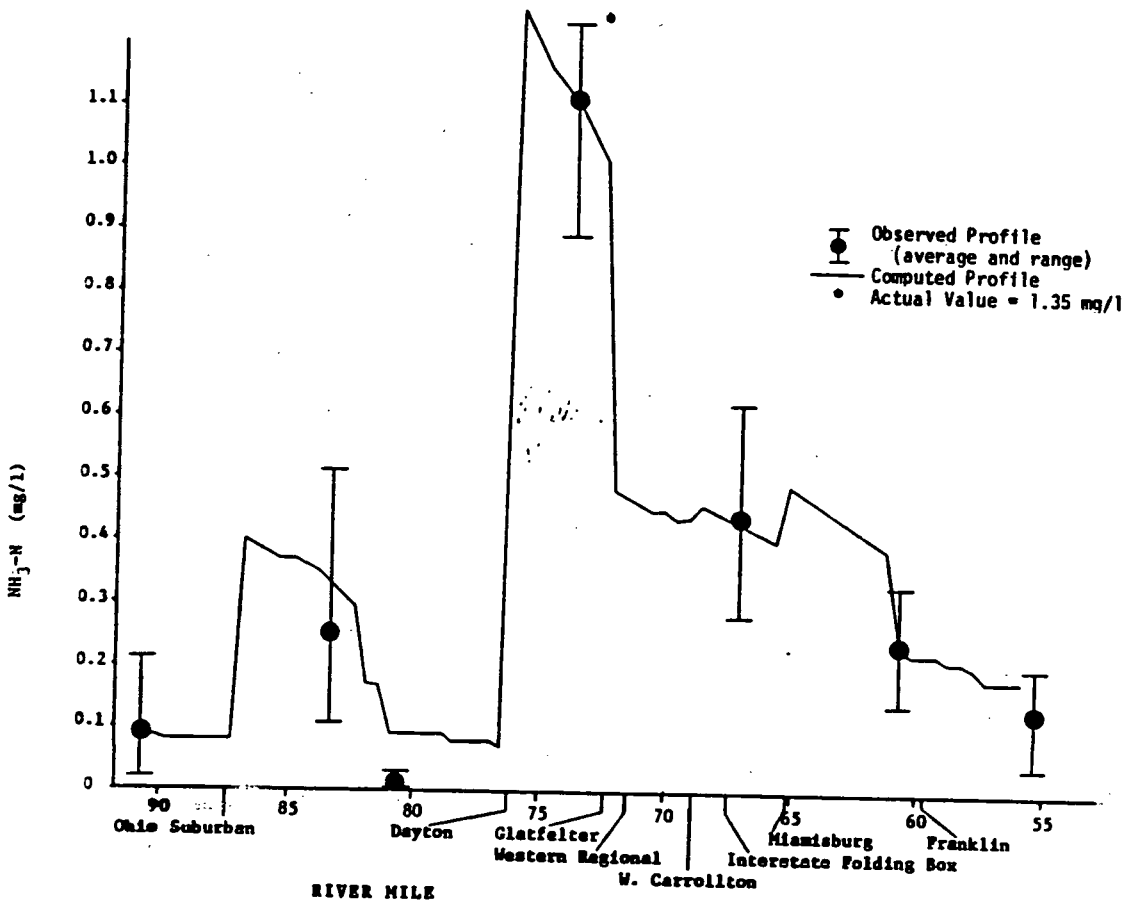

Figure 49. Calibration - Segment 2 ammonia levels (with and without ammonia sink).

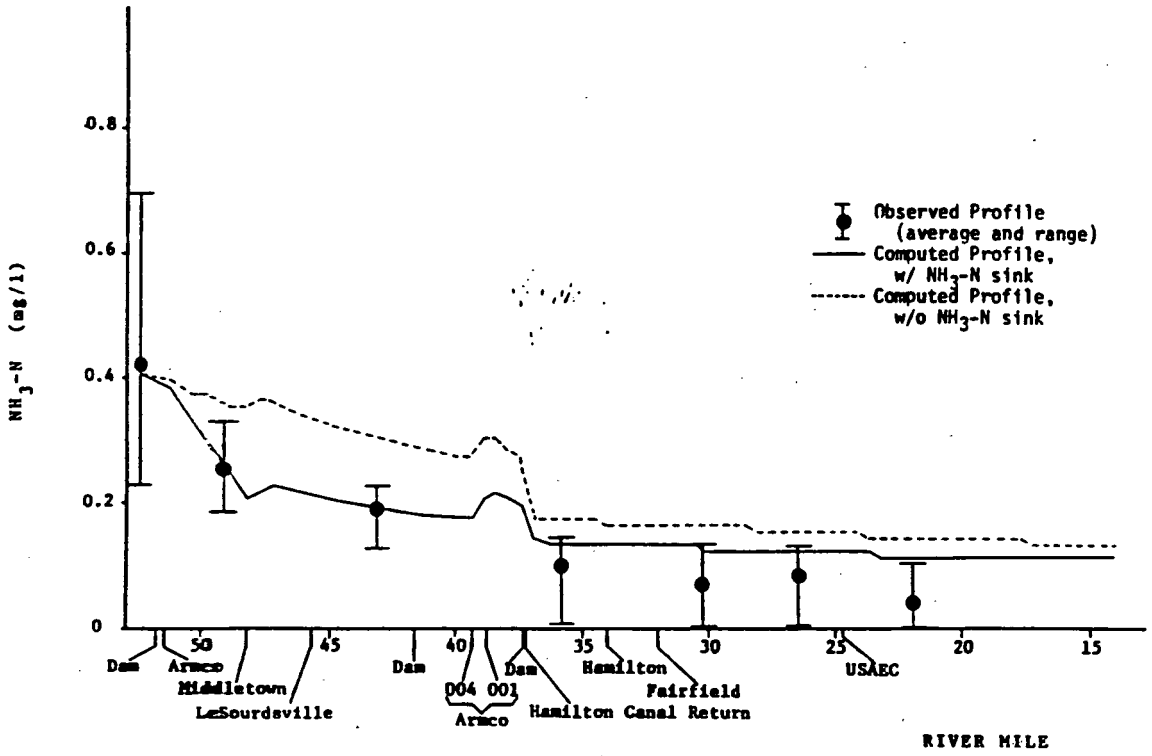

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Figure 50. Calibration - Segment 1 D.O. levels.

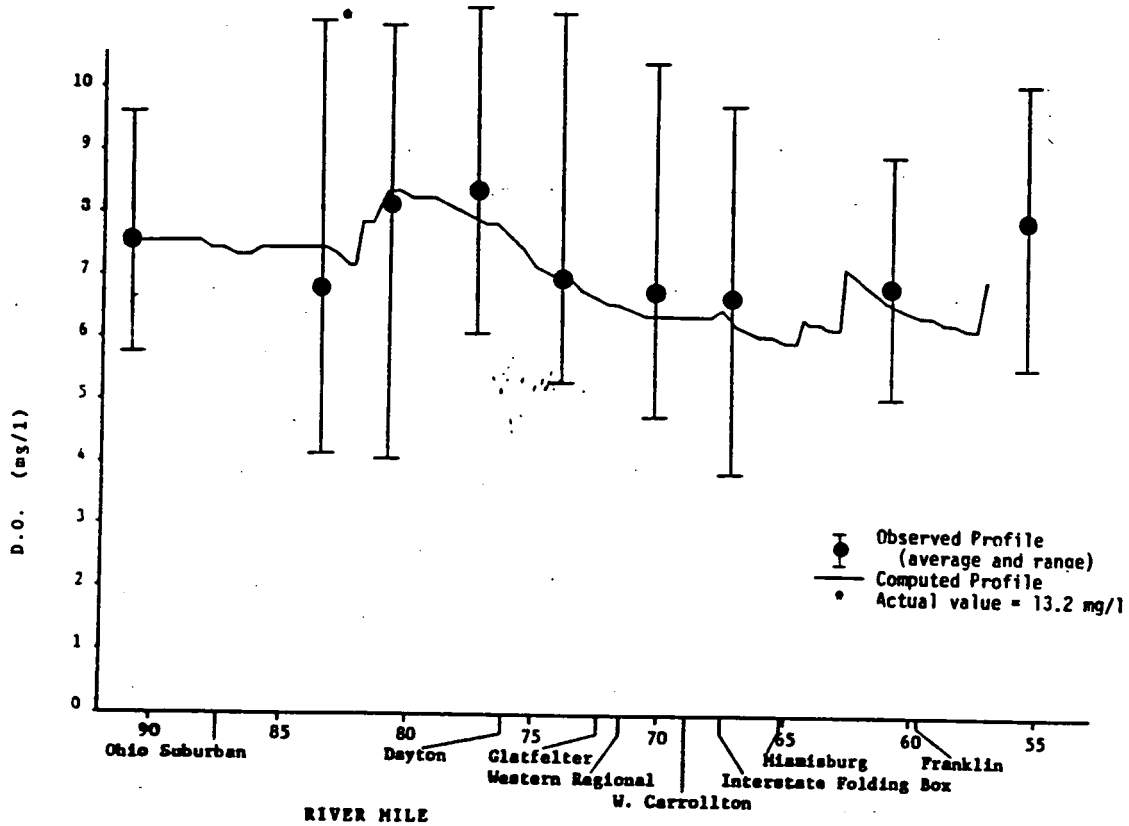


TABLE 56
Decay Rate Constants Determination

Decay Process	Rate Constants (day^{-1} at $20^{o}C$)
CBOD deoxygenation	0.18
NH_3-N nitrification to NO_2-N	0.4
NO_2-N nitrification to NO_3-N	0.6

TABLE 57
Chlorophyll-a (ug/l) during Survey (Segment 1)

Site Description	RM	Date (1980) Sep. 3	Sep. 4	Sep. 5	Average
Dixie-Keowee St.	83.57	12.58	-	34.73	23.66
Stewart St.	78.80	14.71	33.01	21.45	23.06
Sellars Rd.	73.78	16.67	39.04	22.64	26.12
Linden Ave.	66.90	21.50	41.82	32.79	32.04
Chautauqua Rd.	64.72	19.03	40.21	38.82	32.69
State Route 122	52.17	20.43	54.09	52.34	42.29

TABLE 58
Chlorophyll-a (ug/l) during Survey (Segment 2)

Site Description	RM	Date (1980) Sep. 16	Sep. 17	Sep. 18	Average
Central Sutphin Rd.	52.63	34.73	43.78	34.22	37.58
State Route 73	49.27	84.56	79.45	39.33	67.78
Wayne Madison Rd.	43.23	61.75	62.93	86.85	70.51
State Route 127	35.69	93.81	86.73	47.20	75.91
State Route 126	26.21	140.15	114.46	133.73	129.45
New Baltimore Bridge	21.45	106.97	134.36	101.30	114.21

To help account for these effects, QUAL-II was calibrated in its "dynamic" mode for Segment 2 of the GMR. Since sample data were reported as daily composites, the best resolution that could be obtained from the model's output were also 24-hour averages. Integration times were specified as one hour so that results were not significantly affected by numerical dispersion and storage and run times did not become excessive. Output was listed for every three hours of simulated time and averaged over 24-hour blocks, so that it would be comparable with the observations. The total time of simulation was set at 60 hours to best approximate the observed time-of-travel (thus allowing headwater conditions to fully propagate through the system).

During model calibration for Segment 2, the simulation proved highly sensitive to headwater conditions, which (for calibration) were set at measured three-day average values. "Headwaters" for this segment (conditions above Middletown) represent the effects of upstream dischargers (in Segment 1) on the water quality afforded to downstream dischargers. This point is discussed in detail later. Initial conditions at downstream points also affect the simulation, but only so far as they determine the time necessary for the simulated river system to reach equilibrium.

Ammonia-nitrogen concentrations were somewhat higher when algal effects were simulated. At first glance, this appears erroneous, because the model is set up to uptake ammonia-nitrogen preferentially over nitrate-nitrogen. Due to the high relative concentration of NO_3-N to NH_3-N, however, algae use significantly more nitrate than ammonia, even if the algae strongly prefer ammonia-nitrogen. Nitrate conversion to ammonia-nitrogen through decomposition of dying algae constitutes an additional ammonia source in these simulations, so the results are not at all unreasonable.

Though it was suggested that algae would account for the high field measurements of D.O., QUAL-II runs based on observed algae populations did not simulate D.O. values that high. The most plansible explanation for this is QUAL-II's simple algae growth repesentations. The growth and diurnal D.O. variations depicted by the field data represent conditions which QUAL-II is not designed to simulate. The model can be forced to reproduce the observed diurnal D.O. variations, but only with unrealistically high chlorophyll-a levels.

Another possible explanation for this discrepancy is the D.O. measurements themselves, which were point readings taken near the surface. These may have been unrepresentative of the water column and cross-section. The D.O. meter measures an activity difference across the probe membrane, so microscopic bubbles instream (which algal activity can produce) also may have affected D.O. readings.

Thus, during calibration of Segment 2 excessive algal D.O. contributions made it impossible to reproduce the point values of the D.O. observations, because of QUAL-II model mechanisms and possibly because of the data collection method. As calibration was attempted, model output was accepted when it closely resembled the form of the data collected. Figures 51 and 52 show the accepted calibrations, indicating algal and non-algal runs.

Figure 51. Calibration - Segment 2 ammonia levels (with and without algae).

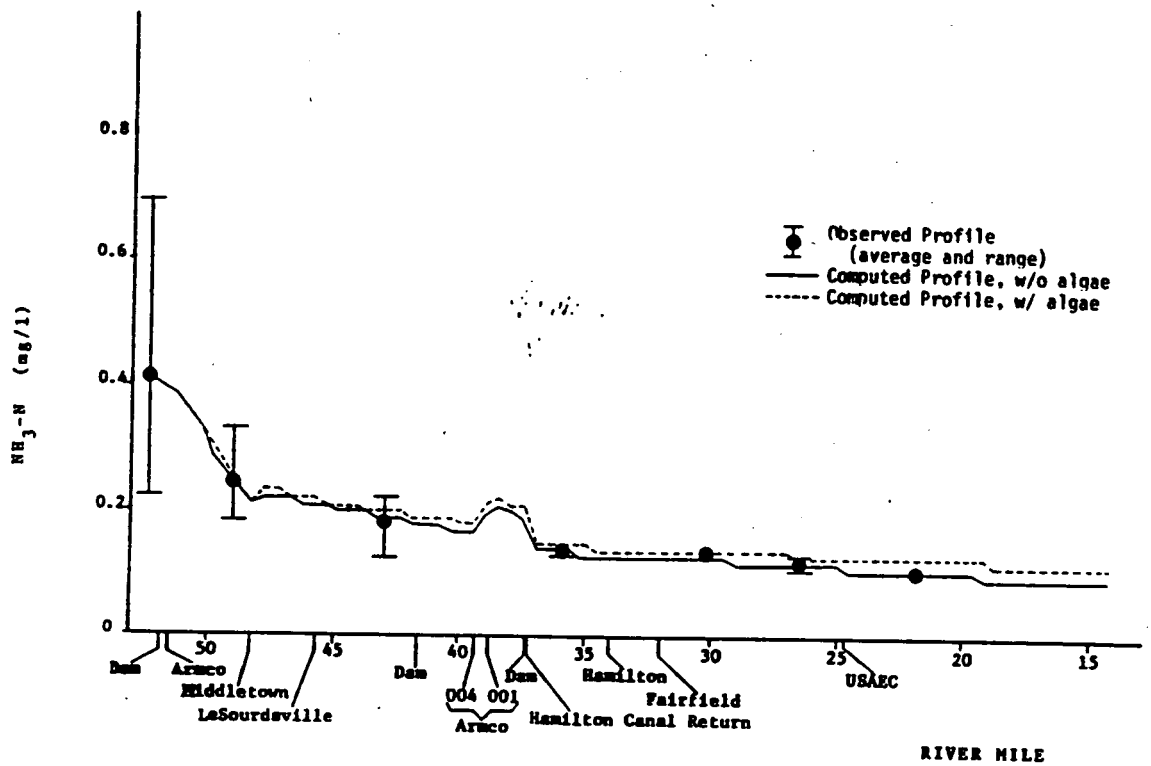
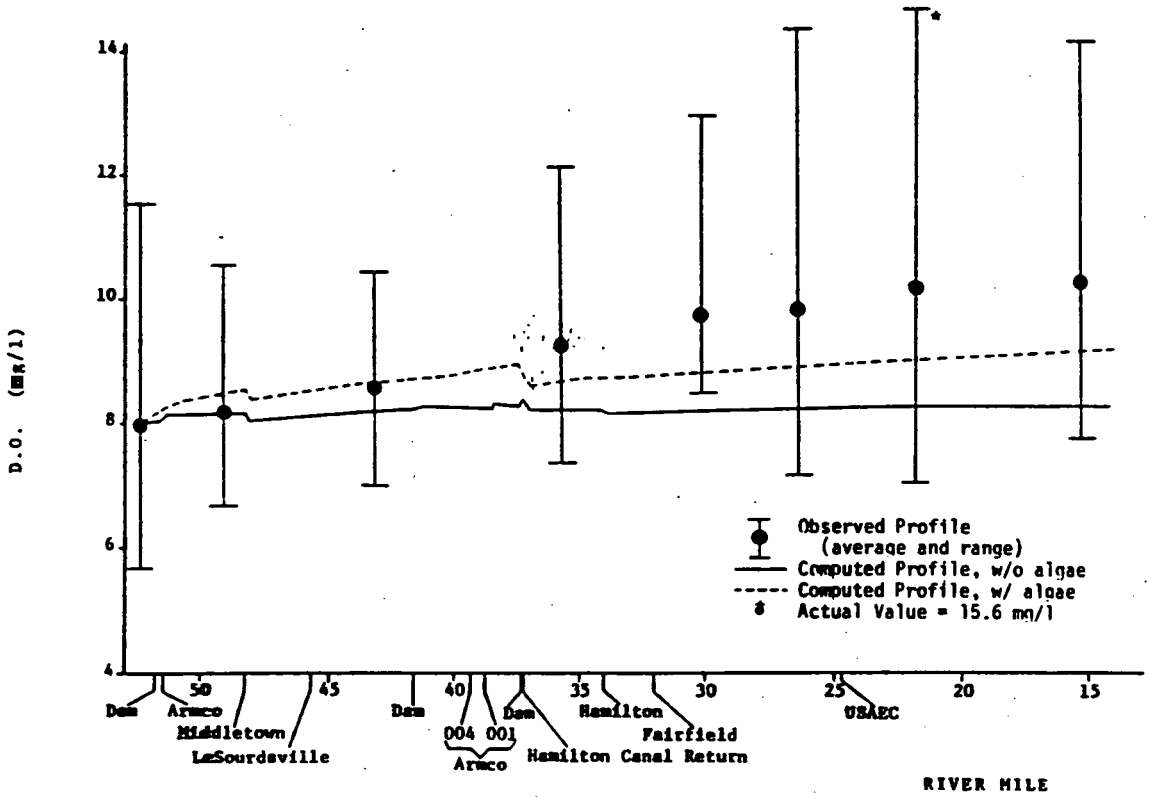


Figure 52. Calibration - Segment 2 D.O. levels (with and without algae).



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VERIFICATION

Once model calibration is complete, the next step is model verification. This process establishes the validity of the calibrated parameters. To ensure the reliability of the verification, calibration and verification data must be independently gathered under different flow regimes.

Ohio EPA took two directions in verifying the calibrated Great Miami River QUAL-II model. The primary verification data was obtained from studies that MCD (Miami Conservancy District) performed in 1970 for MVRPC (Miami Valley Regional Planning Commission). Secondly, Ohio EPA gathered weekly data from June 5, 1980, to October 9, 1980, at 14 sites along the river, 13 of which coincided with intensive survey sites. The latter data does not form a strict verification data set since it was not collected intensively, but it does support the MCD data. Proper treatment of this data will be discussed below.

Segment 1

During 1969 and 1970, MCD studied areas along the Great Miami River that include both Segments 1 and 2. Instream data was collected while following a dye slug down the river by sampling before, during, and after the passage of the dye peak. This method of data collection yields valuable insights into stream dynamics. The data set obtained during 1970 was the most complete, and therefore was chosen for use in Ohio EPA's model verification.

This data was gathered under quite different instream physical and chemical conditions than existed during the 1980 Ohio EPA intensive surveys. Since 1970, the basin's hydrology has been changed physically by the construction of the C. J. Brown Reservoir. Low-flow criteria established prior to the operation of the reservoir are no longer valid and new criteria must be considered. Additionally, a step dam crossing the river near West Carrollton (RM 72.38), present in 1970, had been washed away prior to 1980. Biochemically, instream BOD concentrations were higher and D.O. lower during 1970.

These differences in conditions between the 1970 and 1980 surveys make this an excellent calibration-verification exercise since the data sets are clearly independent. Therefore, several runs of Ohio EPA's calibrated model were used for verification by adding a dam to the river configuration and adjusting the velocities to represent the 1970 flow regime. Figures 53 and 54 summarize the results of the Segment 1 verification simulations, and comparison of the D.O. simulation curve with measured instream values shows a very good correlation.

In addition, 1980 weekly monitoring data collected during stable flow regimes compares favorably with simulated D.O. (Figures 55 and 56), though it is not temporally and spatially consistent with calibration and verification assumptions. Finally, note that the range of flows represented by the calibration and verification data sets encompasses the flow at which the wasteload allocations will be derived (as discussed later). This, along with consistency of the calibration-verification results, illustrates the stability of the Great Miami River system.

Figure 53. Verification - Segment 1 CBOD (1970 MCD data).

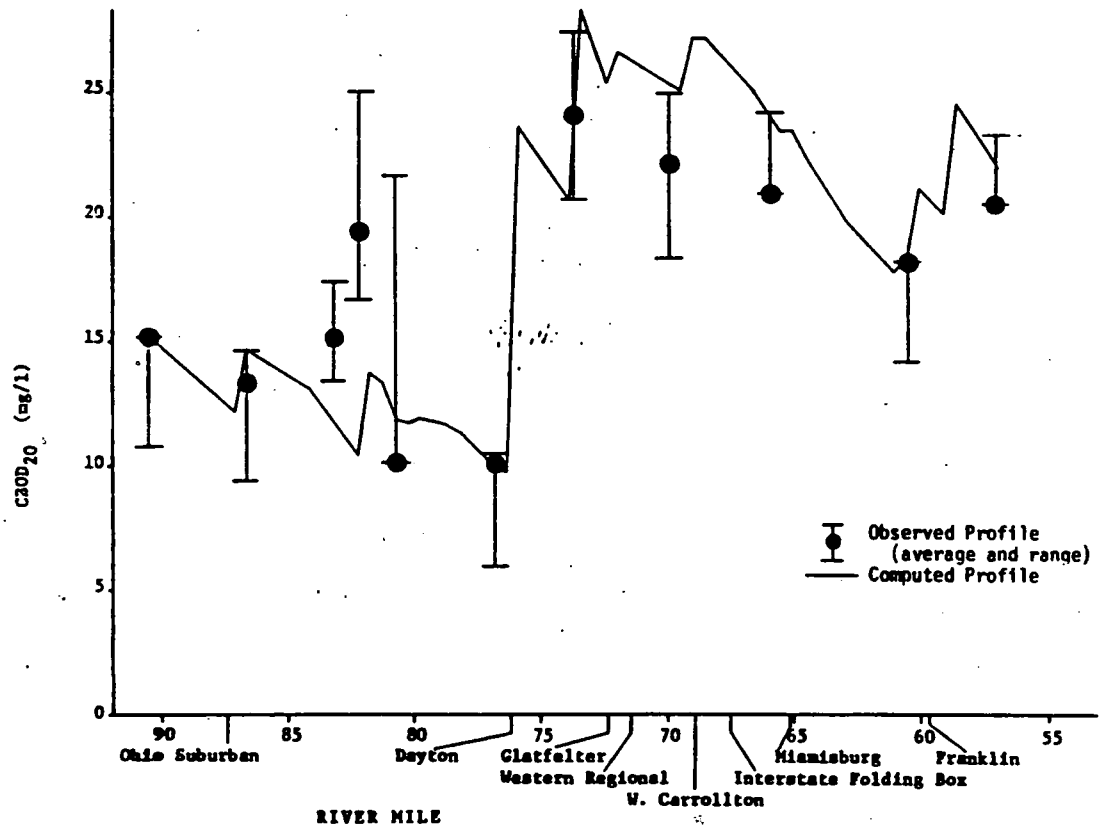

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Figure 54. Verification - Segment 1 D.O. levels (1970 MCD data).

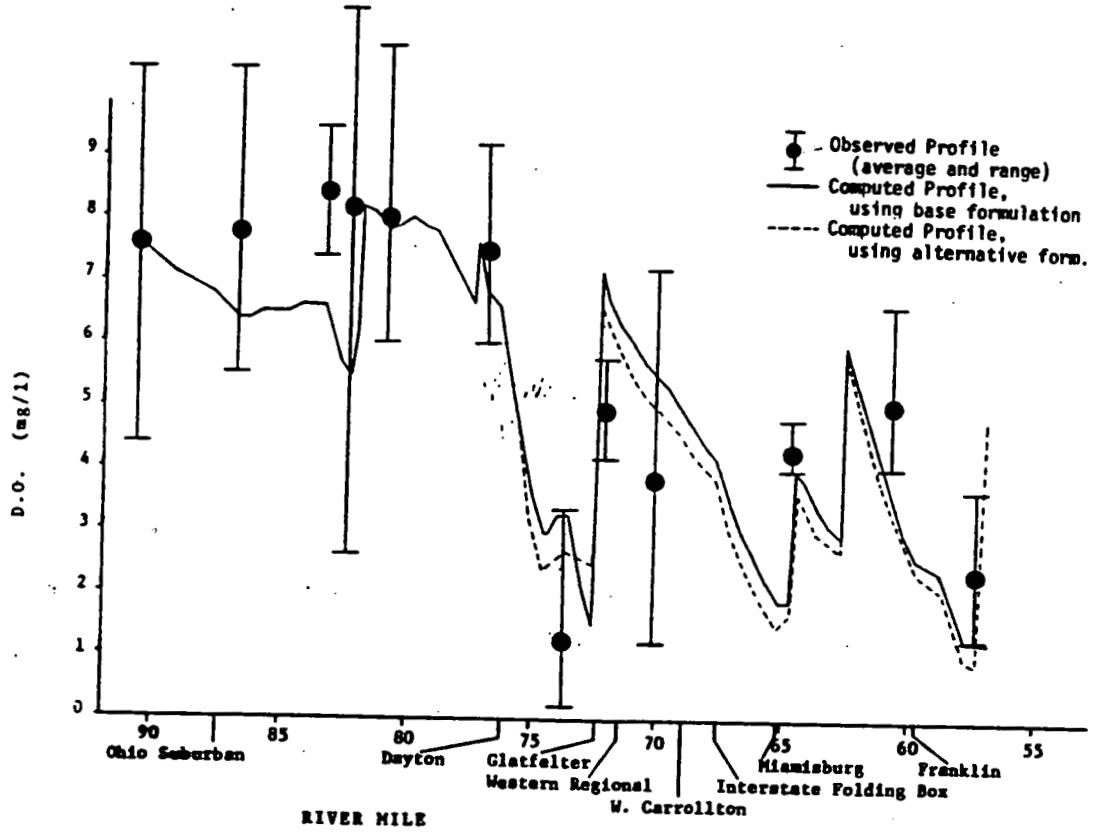


Figure 55. Verification - Segment 1 D.O. levels (Ohio EPA monitoring data, July 17, 1980).

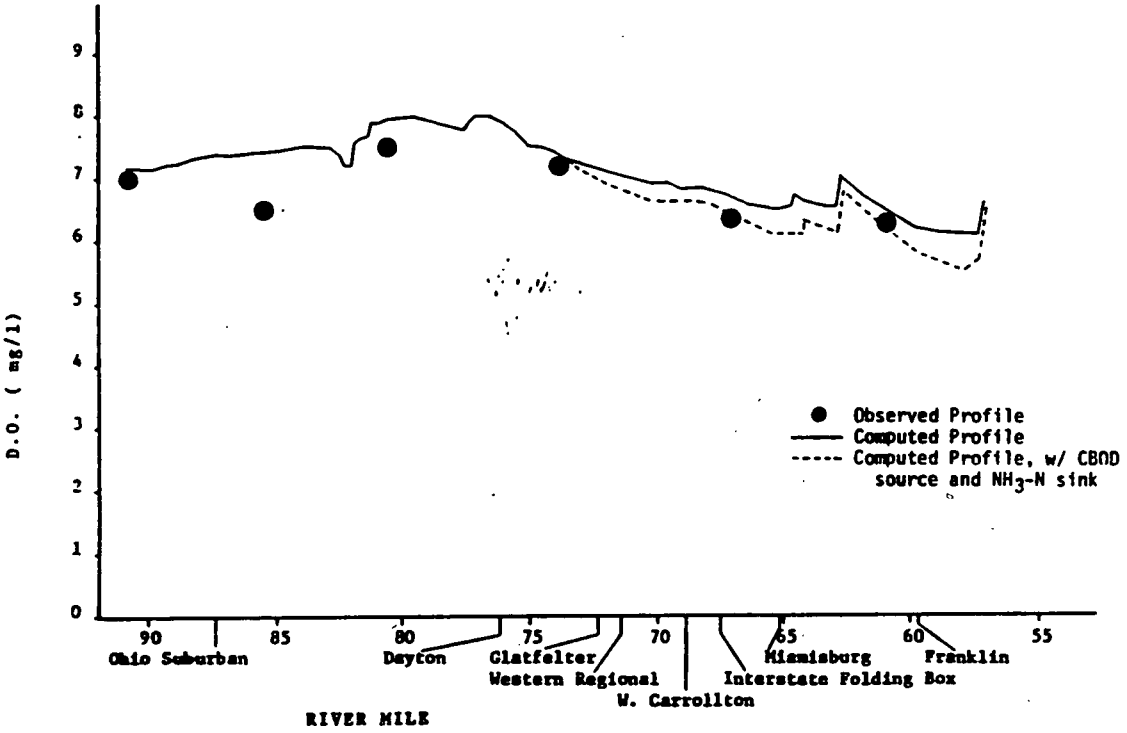
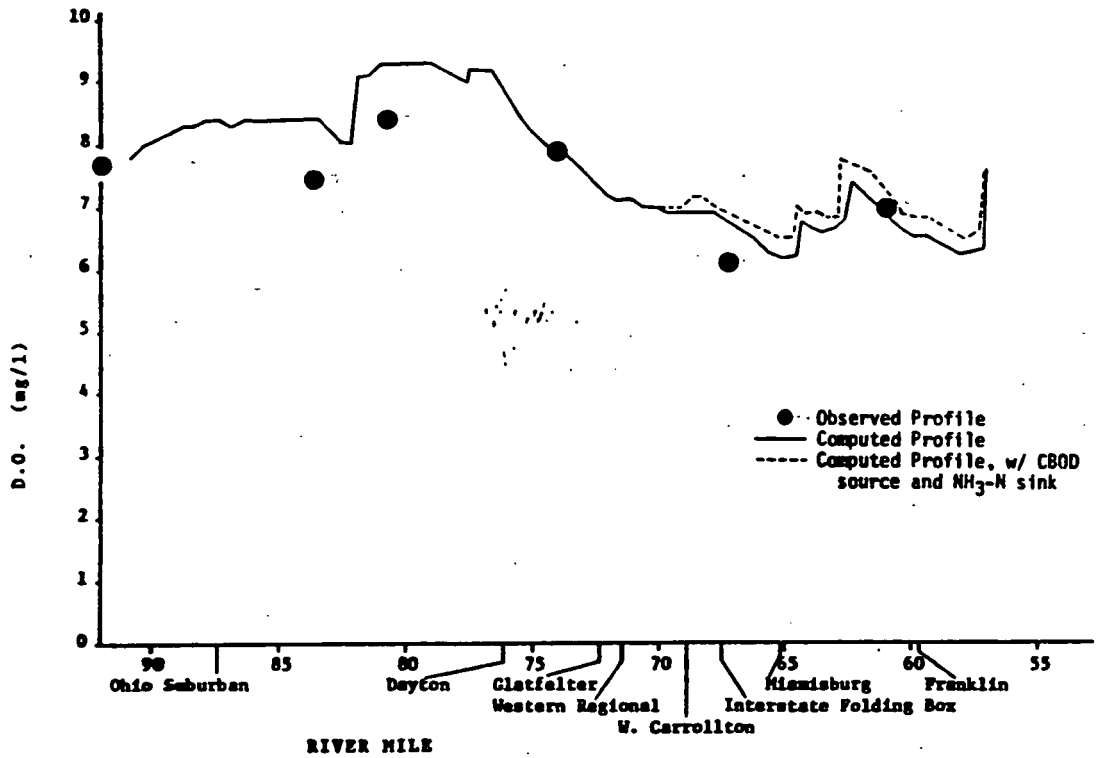


Figure 56. Verification - Segment 1 D.O. levels (Ohio EPA monitoring data, September 25, 1980).



Segment 2

Verification proved to be much more difficult for Segment 2 than for Segment 1. First of all, the instream reactions are more complex than in Segment 1, requiring consideration of algae and other factors. Secondly, there is not as much suitable data available for Segment 2.

Several data sets exist from previous studies, such as Velz (1954), ODNR (1974), and USGS gage continuous monitoring data. These data may be used to study long-term water quality changes, but are not of sufficient resolution to serve as model verification data. Other characteristics of the data sets also influence their applicability to model verification.

Data from Velz (1954) was gathered before secondary treatment was commonly practiced. As such, it reflects the presence of higher BOD and more settleable organic influences. Also, industrial discharges were a greater detriment to stream water quality at that time.

The 1974 Ohio Department of Natural Resources study addressed planning issues, but was not directed toward defining stream water quality. USGS continuous monitoring data is not of sufficient spatial resolution for use as a verification data set, but could be used to support an appropriate data set.

One available data set is usable for model verification, the 1970 MCD data. As described above, this data set is clearly independent of the 1980 Ohio EPA calibration data. Like the calibration data, however, the MCD data set does not provide a full definition of the more complex reaction kinetics found in Segment 2. Therefore, the verification of Segment 2 is less exact than that for Segment 1. The final product of this calibration and verification process is a model capable of predicting water quality; however, the wasteload allocation studies based on it should not exceed the limitations of the model's calibration and verification.

The Segment 2 model was set up for the verification simulations by inputting the appropriate hydraulic and background water quality information. The MCD verification data was converted to $CBOD_{20}$ for comparison to the calibrated model's output. To do this, ammonia oxidation influences were estimated from reported NH_3-N data, and subtracted from BOD_{20} values to yield an approximate $CBOD_{20}$. These $CBOD_{20}$ "data", along with the calibrated model's simulated $CBOD_{20}$ values, are shown in Figure 57.

Comparison of the slope of the simulated CBOD curve with the MCD data indicates that the calibrated decay rate is very close to the actual rate. The values in the vicinity of RM 42 to RM 37 demonstrate the inadequacy of information at the Hamilton Hydraulic Canal; the graph reflects the large impact of Armco's discharge to the GMR when 470 cfs are diverted to the canal. Similarly, the absolute value discrepancy near RM 48.5 results from an uncertain definition of the load from the Middletown WWTP. Neither of these problems should detract from the verification.

As stated previously, D.O. curves are not part of the calibration/verification process, but the end product. Interpreting the D.O. curve (Figure 58) for the verification data does present problems, however. Like the Ohio EPA 1980 data used in the calibration, the MCD 1970 data exhibit more instream D.O. than the modeling kinetics produce.

Figure 57. Verification - Segment 2 CBOD levels (1970 MCD data).

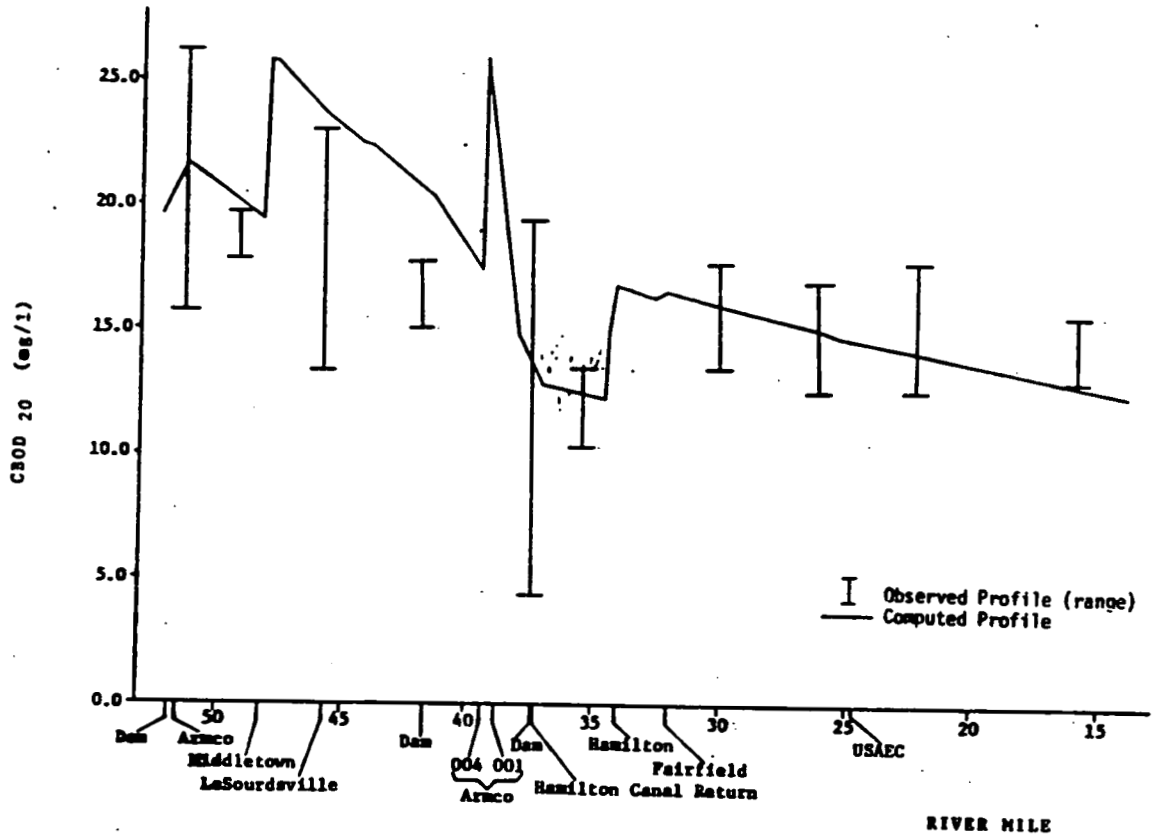
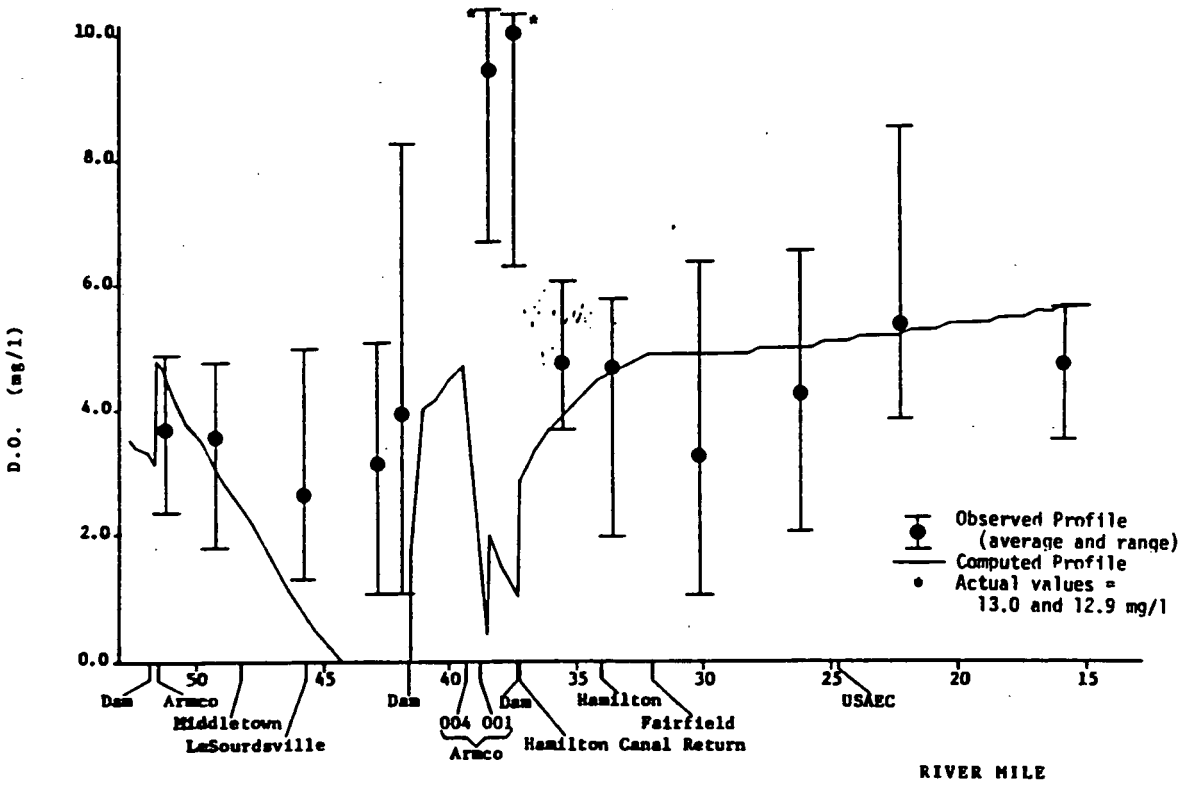


Figure 58. Verification - Segment 2 D.O. levels (1970 MCD data).



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Diurnal D.O. variations emphasize algal effects in the MCD data, occurring in the vicinities of RM 43 and RM 38, both of which are pool areas. Since the verification simulation does not involve algal D.O. production, it is not surprising that the simulated D.O. profile does not completely follow the data.

The main emphasis of the model verification for Segment 2, however, is the deoxygenation rate; the CBOD curves clearly support the rate developed during model calibration. Better simulation of the D.O. data is prohibited by the lack of information describing complex reactions in the GMR below Middletown (see Section I). As a result, the verification for Segment 2 is not as analytically rigid as that for Segment 1. The application of the model to Segment 2 for wasteload allocation must also be less rigid, properly considering the range of flows encompassed by the calibration and verification study and the assumptions made.

Biological Interpretation

A final cross-validation of the modeling results was made by comparing simulated instream D.O. and ammonia-nitrogen concentrations with the results of the biological sampling (fish and macroinvertebrates) described in Section I. Although the relationship between the biological results and modeling results is not strictly analytical, it is interpretative.

Modeling data is generally collected over a short period of time (i.e., 3-5 days) maintaining specific mathematical and statistical relationships necessary to guarantee the linkage between momentum, transport, and reaction mechanisms. These characteristics limit the relevance of the data interpretation to the specific time period during which the data was collected. In contrast, biological data reflects the long-term characteristics of the water body in question. Aquatic organisms, particularly fish and macroinvertebrates, are generally present over a much longer time period and are therefore subjected to the prevailing environmental conditions. Thus, good agreement between the modeling predictions and the trends in the fish and macroinvertebrate communities would be an added indication of the credibility and applicability of the modeling results.

The interpretive analysis compared model projections at low flow with the biological indices described in Section I. Modeled low-flow conditions are described in the next subsection of the report, and were used for this analysis because they represent the critical conditions which determine aquatic life diversity. The results of the analysis can provide greater confidence in using QUAL-II to simulate low flow and develop wasteload allocations.

Good agreement between the modeling and biological results was found for two sections of the study area: 1) downstream from the Ohio Suburban WWTP and 2) downstream from the Dayton WWTP to the Miami-Erie canal. A less well-defined area of agreement occurred downstream from the Middletown metropolitan area. The discussion of these areas below refers to figures found later in this section, as well as to information found in Section I of this report.

Although the low-flow simulation of D.O. (Figure 60 and 61) did not reveal any water quality standards (WQS) violations downstream from Ohio Suburban WWTP, the longitudinal trend agreed well with patterns in fish and macroinvertebrate community abundance and diversity (Section I: Figure 16, Table 44). Although the biological condition of this reach was better than the mainstem downstream from Dayton, it was worse than adjacent sections within and upstream from Dayton. High ammonia-nitrogen concentrations (Figure 62) were predicted for this section of the mainstem as well.

Good agreement extended downstream from Dayton for both simulated D.O. (Figures 60 and 61) and ammonia-nitrogen (Figure 62). Water quality standard violations for D.O. were predicted in the vicinity of RM 65-68 which overlaps a biologically degraded section of the mainstem (Section I: Figure 17, Table 44).

Another area of biological degradation in the vicinity of RM 71-74 coincided with high ammonia-nitrogen predictions (Figure 62), and also agreed with the D.O. simulation that included the old West Carrollton dam (Figure 67). A possible explanation for the two distinct areas of biological degradation between RM 65 and RM 74 was the position of a key tributary (Bear Creek at RM 67.6) and the higher-than-normal flow. Both factors probably contributed to the recovery observed near RM 68. In 1976, during a much lower flow but similar point-source loading conditions, the fish community was depressed for the entire section of the mainstem between RM 63 and RM 74. This situation corresponds very closely to the low flow D.O. simulation at secondary treatment levels.

The area adjacent to and downstream from the Middletown metropolitan area showed a less well defined agreement between the biological and modeling results. The D.O. sag predicted for the reach at RM 38-40 was downstream from an area of biological degradation near RM 42-44 (Figure 70). A better correlation was observed with high predicted ammonia-nitrogen values between RM 45-48 (Figure 71). A complicating factor in the biological results was the possible interaction of substances in the effluents of ARMCO - Middletown 001 and the Middletown WWTP (see Section I).

Overall, the degree of agreement between the modeling and biological results in the area downstream from Dayton was quite good. However, the situation in and downstream from Middletown was compounded by multiple discharges and substances (as discussed in Section I) that may have contributed to the less well-defined agreement with the biological results. This illustrates the complex nature of this section of the mainstem.

WASTELOAD ALLOCATION

To maintain water quality standards (WQS) in Ohio rivers and streams, discharges into these watercourses must be regulated, because each discharger's effluent flow and quality will impact instream water quality. Every stream segment has a natural capacity to assimilate a limited amount of wastewater. Wasteload allocation (WLA) is the process of distributing the available assimilative capacity among the dischargers to a given stream segment.

For the Great Miami this is a complex process. To determine the ability of the river to receive and assimilate different wastes requires an understanding of the river's physical characteristics, chemical interactions, and existing water quality. The modeler must be able to quantify the stream flow, velocity, depth, quality and location of each discharge, and the instream reaction kinetics.

Non-conservative water quality parameters change in concentration due to chemical reactions (such as oxidation of ammonia to nitrate), biological action (such as uptake of oxygen by bacteria) or physical action (such as entrainment of oxygen through turbulence). Since these reactions take place over time, the downstream velocity of a given mass of water determines the location of a pollutant's maximum impact on instream water quality. Multiple entities discharging non-conservative pollutants at various locations along the watercourse require combination of their impacts, which further complicates the modeling.

The process for non-conservative parameters allocation is heavily dependent on the use of a computerized stream model; for this reason, much of the QUAL-II calibration in the previous section focused on these critical instream reactions. The model makes it possible to study the impact of individual wasteloads on instream water quality, and predict what improvements in water quality will be attained through construction of specific levels of effluent treatment.

Concentrations of conservative water quality parameters are mostly unaffected by chemical reactions. For modeling purposes, their concentrations are assumed to be affected only by dilution. Their greatest potential for toxicity (defined by the WQS) is usually found immediately after the pollutant is discharged and mixes with the water instream. Potential for toxicity decreases as other flows enter the stream providing dilution. Modeling the impacts of conservative pollutants on instream water quality involves a simple mass balance for each parameter each time a flow enters the modeled stream.

The discussions in this portion of the report focus on QUAL-II modeling of non-conservative parameters. The wasteload allocation of conservative parameters in the GMR is described at the end of this section and detailed in Appendix A. The discussion will proceed as follows: development of low-flow conditions for Segment 1, Segment 1 non-conservative parameter wasteload allocation, additional low-flow developments for Segment 2, Segment 2 non-conservative parameter wasteload allocation, and finally the conservative parameter wasteload allocation for both segments.

Discharger effluent compositions will follow the following nomenclature: Á-B-C where A represents the discharge $CBOD_{20}$, B represents the NH_3-N concentration, and C represents the D.O., all in mg/l. Also, figures and tables have been grouped and are located following this major portion of tex

LOW-FLOW CONDITIONS, SEGMENT 1

The Great Miami River mainstem was simulated using the calibrated and verified QUAL-II model under conditions of critical low flow. Since the calibration and verification were developed from field data at much higher flows, portions of the flow regime had to be redefined to describe the river under low-flow conditions. In addition, some of the kinetic rate constants had to be adjusted to the low-flow conditions. This portion of the report describes the determination of low-flow conditions.

Background Water Quality

In both segments, the water quality of the headwaters and tributaries was assumed to be the same during low-flow conditions as during the intensive surveys (see Tables 51 and 53). Inflows from small tributaries were determined to have negligible impact on water quality in the mainstem. Average values for each parameter were used as the background water quality for headwaters and tributaries. Each of these averages was based on three daily composite samples obtained during 1980 intensive surveys. Temperature and pH values for the critical low-flow period were developed from USGS gaging station records and were those values exceeded 25 percent of the time during low-flow seasons.

Background Flows

Background stream flows were developed from USGS low-flow gaging records and the US Corps of Engineers reservoir release schedule for the C. J. Brown reservoir. The seven-day, ten-year low flow ($Q_{7,10}$) at the Taylorsville USGS gaging station (50 cfs) was used for headwater conditions at RM 92.46. USGS low-flow yield information was used to develop background tributary flows. Under low-flow conditions, surface runoff and groundwater inflows along the modeled segments of the stream were considered minimal, as were inflows from small tributaries.

The critical low flow for the Mad River (160.85 cfs) includes flow augmentation from C. J. Brown Reservoir, located on Buck Creek which is tributary to the Mad River. The reservoir is designed to provide a minimum release of 5.0 cfs and a maximum of 120.0 cfs, ensuring a minimum flow of 420.0 cfs at Miamisburg during the low-flow season for water quality purposes (Army Corps of Engineers, 1981). Since the WLA is based on design flows of dischargers rather than current discharge rates, C.J. Brown's assumed release for modeling purposes needed only to be set at approximately 20 cfs, well within the reservoir's capacity to discharge under low-flow conditions.

In both segments, design levels were assumed for wastewater flows from municipal and industrial dischargers, as shown in Tables 59 and 60. To compute low-flow in the GMR mainstem, the discharges were added to the

upstream flow and tributary flows, then withdrawals were subtracted. Simulated hydraulic canal diversions of 180 cfs for Middletown and 350 cfs for Hamilton were based on historical records provided by MCD.

Projected low-flow conditions are shown in Figure II-28. These conditions represent approximately one-half to two-thirds less flow than observed during the intensive survey, so adjustments to the QUAL-II model calibration were anticipated.

Channel Geometry

Of primary importance in simulation of low-flow conditions is the determination of depth and velocity relationships. As described for the calibration, coefficient-exponent values were developed from data gathered by the MCD. These are applicable to Segment 1 at low flow as well as at the intensive survey flow.

Instream Reaction Rates

Since most calibrated coefficients are temperature-dependent and not flow-dependent, they need only be adjusted to the instream temperature. These adjustments are made automatically by QUAL-II. An exception is the reaeration rate, K_2, which depends on both flow and temperature. Fixed values of K_2 are valid only for the particular flow for which they were determined. Temperature adjustments are made by the following equation.

$$K\,(T^{o}C) = K\,(20^{o}C)\,A^{(T-20)}$$

where K = decay rate, base e
T = stream temperature, ^{o}C
A = 1.0159 for reaeration
= 1.047 for all others

During calibration, O'Connor's formula best predicted instream reaeration rates in Segment 1, and was used to determine rates during low-flow simulations (see model calibration).

Except for any temperature adjustments performed by QUAL-II, the stream CBOD and NBOD (or NH_3-N) decay rates also were assumed to be the same under low flow as those determined for the calibration. These rates were verified under low-flow conditions during the model verification.

IMPACT ANALYSIS, SEGMENT 1

The wasteload impact analysis formed the basis for the Segment 1 wasteload allocation. The primary goal of the impact analysis is to quantify the impact of each parameter an entity discharges on the water quality in the reach. Since there are several dischargers on Segment 1 of the Great Miami River, the analysis focuses on impacts in the critical reach. In Segment 1, impact analyses were computed for the impacts of both CBOD and NH_3-N concentrations on instream D.O. levels.

As a preliminary step in developing the impact analyses for non-conservative parameters, Ohio EPA simulated low-flow water quality based on two different discharge scenarios. In the first, all municipal discharge levels were set to represent AST levels (10 mg/l $CBOD_5$, 2 mg/l NH_3-N, 5 mg/l D.O.) and industrial dischargers were set to current permit levels (see Appendix II-B). The resulting D.O. profile, shown in Figure 60, has a minimum D.O. of 4.7 mg/l. This simulation became the basis for the wasteload impact analysis.

In the second simulation, all discharge levels were set at their respective permit limits. This simulation produced a minimum D.O. of 4.4 mg/l near Miamisburg (see Figure 61) and NH_3-N levels that exceeded the water quality standard downstream of the Dayton WWTP (see Figure 62).

To determine the needed reductions in wasteloads from dischargers to the GMR, their individual impacts on instream water quality must be assessed. This depends on their locations as well as effluent flows and quality. The greater a discharger's impact on instream water quality, the greater the required reduction in its wasteload.

The base level conditions used for impact analysis were described above. One by one, each discharger's wasteload for each non-conservative parameter (i.e. CBOD and NH_3-N) was changed to zero and water quality simulated to determine the difference in instream D.O. concentrations. By comparing these differences with the increase in D.O. needed to meet WQS, wasteload reductions proportional to the impacts were calculated which would bring about the needed improvement in stream water quality.

Many of the smaller dischargers in Segment 1 were found to have negligible impact on instream water quality, and were left at present permit limitations or secondary treatment levels, as applicable. These include West Carrollton WWTP, Interstate Folding Box, Miamisburg WWTP, River Arms Apt./Laundry, River Arms Apartments and Franklin WWTP. At the AST equivalency, Ohio Suburban WWTP had virtually no impact on simulated instream D.O. or NH_3-N levels downstream of Dayton WWTP. Therefore, only Dayton WWTP, Glatfelter Paper Company, and Western Regional WWTP were included in the impact analysis and the resulting allocation process. Figure 63 summarizes the impacts of these three dischargers.

WASTELOAD ALLOCATION, SEGMENT 1

The wasteload impact analysis indicated that West Carrollton WWTP, Interstate Folding Box, Miamisburg WWTP, River Arms Apt./Laundry, River Arms Apartments, and Franklin WWTP do not significantly affect low-flow simulated water quality. These dischargers are allocated secondary treatment equivalency for municipal dischargers or their current permit limits for industrial dischargers. Secondary treatment equivalency refers to an effluent of 30 mg/l $CBOD_5$, 15 mg/l NH_3-N, and 2.0 mg/l D.O. for regular municipal wastes or an adjustment of these levels to account for municipal dischargers with significant industrial contributions. Table 61 summarizes the allocated wasteloads for dischargers in Segment 1.

000349

Ammonia-nitrogen was allocated based on both ammonia toxicity criteria and D.O. criteria. Allocation based on ammonia toxicity quantified the discharges at the point of mix by using a mass balance equation and then simulating the instream ammonia decay. As the simulation progresses downstream inflows are added to the system. The mass balance equation used is as follows.

$$C = \frac{C_m Q_m + C_b Q_b}{Q_m + Q_b}$$

where
- C = concentration
- Q = flow
- m = discharger m
- b = background conditions

The ammonia decay equation used is as follows:

$$C = CIe^{-K_3 t}$$

where
- C_I = initial concentration, mg/l
- C = concentration after time t
- K3 = ammonia-nitrogen decay rate, day^{-1}
- t = time of passage, days

NH_3-N was also allocated as part of the D.O. impact analysis. The final ammonia-nitrogen allocations are a product of the most critical condition imposed by the two criteria. The results of this allocation appear in Table 61.

The proposed MCD North Regional WWTP will include the Ohio Suburban WWTP flows; therefore, Ohio Suburban will not appear in the wasteload allocation. The allocation for MCD North Regional WWTP is a function of both D.O. and ammonia toxicity problems in the area of RM 82.5. In order to maintain both dissolved oxygen and ammonia-nitrogen water quality standards in this reach, the MCD North Regional effluent must meet limits of 54-3.2-5.

The wasteload impact analysis demonstrated that Dayton WWTP, Glatfelter Paper, and Western Regional WWTP all contributed significantly to water quality problems in the vicinity of RM 66. It was also used to determine needed reductions in CBOD and NH_3-N for each of the entities. The resulting wasteload allocations are 14.0-1.1-5.0 for Dayton WWTP, 81.5-0.9-5.0 for Glatfelter Paper, and 25.8-.5-5.0 for Western Regional WWTP. These effluent levels maintain both D.O. and NH_3-N instream water quality limits. Figures 64 and 65 summarize the respective water quality simulations.

Since the Dayton WWTP provides the major contribution to water quality problem in the reach (see Figure 63), an alternative reduction scheme was evaluated with Dayton WWTP's effluent at 15-1-6 and both Glatfelter Paper and Western Regional WWTP at their current permit limitations, 88.9-2.6-5.0 and 28.0-2.5-6.0, respectively. In this simulation, an increase of effluent D.O. from 5.0 mg/l to 6.0 mg/l for the Dayton WWTP and the Western Regional WWTP

helped to offset the higher CBOD and NH_3-N levels. The results of the simulation are shown in Figures 64 and 65; a minimum D.O. of 4.7 mg/l was predicted and the standard for NH_3-N was maintained. Table 61 summarizes the results of the Segment 1 wasteload allocation.

SENSITIVITY ANALYSIS, SEGMENT 1

As part of the wasteload allocation process it is important to be able to quantify the sensitivity of the system to various input parameters which define the water quality simulation. Any parameter to which the simulations are sensitive should be carefully and accurately determined. By the same reasoning, parameters to which the system is not sensitive need not be extensively researched, thus resulting in the most efficient and economical allocation of the analyst's resources.

The Segment 1 sensitivity analysis involved assessing sensitivity to the following input parameters: deoxygenation rate, nitrification rate, Owl Creek CBOD, temperature, pH, upstream water quality and Mad River water quality. In addition to these parameters, the sensitivity of the system to the NH_3-N sink introduced during the model calibration and to the proposed dam at West Carrollton was assessed.

The sensitivity analysis (see Table 62) indicates that the instream D.O. is most sensitive to the deoxygenation rate and the temperature. In both of these cases the choice of the parameter value is based on extensive data. Instream NH_3-N concentrations are most sensitive to instream pH values. Again, these were developed from large data sets and are representative numbers.

The results of the NH_3-N sink sensitivity analyses are presented in Figure 66. The minimum D.O. in one water quality simulation which includes the sink term is 5.0 mg/l, while the minimum of one without the sink term is 4.7 mg/l. The difference is within the computational accuracy of the system. Another consideration concerning the NH_3-N sink is that it most probably originated from algal activity affecting the calibration data. Large populations of algae are not usually desirable, and cannot be depended upon to improve water quality in the stream at low flow. Due to the undesirability of instream algae and the sink's minimal impact on instream water quality, the NH_3-N sink was not included in the wasteload allocation simulation runs.

The model calibration also discussed a CBOD source term, which was included since the instream CBOD indicated a rise at approximately RM 72 (previously explained). The CBOD source was not included in the wasteload allocation for two reasons. First, the source would cause an insignificant impact on wasteload allocation. Secondly, the Ohio EPA staff believes that it represented only a short term occurrence present during the intensive survey.

Finally, the impact of a proposed dam at West Carrollton was analyzed. As shown in Figure 67, simulated D.O. levels upstream of the dam decrease significantly, but remain above WQS. Downstream, however, D.O. levels are increased as a result of reaeration from the dam. The effect on the D.O. profile, particularly at the sag point, depends on the amount of reaeration the dam provides.

A particularly interesting result of the imposition of this proposed dam is the longitudinal shift in the critical D.O. area upstream. It also leaves the critical reach in the RM 66 vicinity. This illustrates that the channel geometry is the governing phenomenon controlling the Great Miami River assimilation capacity and the stream water quality. The aquatic life diversity indices discussed in Section I indicate stress in this zone. Although the proposed dam would not alter the wasteload allocation for Segment 1, it would cause more of the river to have degraded water quality and thus degraded aquatic habitat. Therefore, for the purpose of wasteload allocation, it does not exhibit a significant impact, but for river use planning, where stream water quality carries an aesthetic value, this may evoke a re-evaluation of the proposed dam's benefits.

RESULTS, SEGMENT 1

The final product of water quality modeling is a wasteload allocation based technically on water quality standards and modeling. Allocations developed from purely technical considerations, however, may not always reflect attainable treatment trains. In these cases it is necessary to propose and evaluate treatment levels practically attainable, yet representative of the wasteloads developed on the basis of the impact analysis. Segment 1 wasteload allocations have been based on a fairly rigid application of the impact analysis, thus not all allocations reflect reasonable design criteria. These problems were considered as part of the final recommendations for permit limitations found in the summary portion of this report. Evaluation of alternatives and final recommendations appear there. Appendix B includes the result of the wasteload allocation studies for all parameters.

Data collection needed to enhance the accuracy of the wasteload allocation is also described below. In several areas, the density of the field information becomes critical, and further field data collection should include additional study in these areas.

Segment 1 includes two areas where water quality impacts are critical. The first is the reach above the confluence of the Mad River and the Great Miami River, extending from RM 91.14 to RM 81.48. The only discharger contributing to this reach is Ohio Suburban WWTP which will be replaced by MCD North Regional WWTP. Mathematically, an effluent quality of 54.0-3.2-5.0 from MCD North Regional WWTP (18.56 cfs) will prevent violation of stream water quality standards (WQS) in this reach.

The second critical reach extends from approximately RM 81.48 to RM 52.6. Dayton WWTP, Glatfelter, Inc., and Western Regional WWTP significantly contribute to water quality violations found here under simulated low-flow conditions. Several simulations were conducted to quantify each discharger's individual impact on water quality, and then to set each discharger's effluent characteristics. Since Dayton WWTP exerted the major influence on water quality downstream of Dayton (Segment 1), it is recommended that effluent limitations for Glatfelter Inc. and Western Regional WWTP remain at current permitted levels, while the Dayton WWTP should treat its effluent to the level of 15.0-1.0-6.0 to maintain WQS.

Table 61 summarizes the wasteload allocation for dischargers in Segment 1 and also indicates the resultant instream water quality at critical points. Recommendations for permit limitations reflect not only the technically derived wasteloads, but also economic considerations, alternative treatment evaluations, and public input. These recommendations for permit limitations are presented in the summary portion of this report (opening pages, Tables 1 and 3).

LOW-FLOW CONDITIONS, SEGMENT 2

Background Water Quality

The development of background water quality for Segment 2 parallels that described for Segment 1. Here the water quality is greatly influenced by the quality of water entering the system from Segment 1. As a result, several model simulations were made to assess its impact on Segment 2 water quality simulations and on the wasteload allocations. These two topics are discussed in the Impact Analysis and Sensitivity Analysis portions of this report, respectively.

Background Flows

The development of background flows for Segment 2 follows from the development for Segment 1. Additional discharge and tributary inflows were added while the methodology used to develop them was unchanged from Segment 1.

One notable difference for Segment 2 flow concerns the Hamilton Hydraulic Canal. Research into allowable canal diversions did not reveal an agreement describing the canal diversion procedure. This presents a problem because as the percentage of flow diverted into the canal increases, less flow is left in the river to assimilate the pollutant load. Additionally, the dam at RM 37.3 creates a pool which magnifies the affects of the decreased river flow. This affects all of the wasteload allocations.

The Hamilton Canal diversion flow of 350 cfs for the wasteload allocation was based on historical records provided by MCD. This flow is fairly high and results in a conservative wasteload allocation. The canal flow is included in the sensitivity analysis to illustrate the impact of the diversion on the wasteload allocation.

Figure 59 (previously cited for Segment 1), illustrates the modeled low-flow conditions for Segment 2.

Channel Geometry

Segment 2 velocities were determined by a volume-displacement analysis (alternative formulation described for Segment 1).

Instream Reaction Rates

Reaction rates for the Segment 2 wasteload allocation were adjusted to low-flow conditions as previously described for Segment 1.

000353

As discussed under Calibration and Verification, Reaeration, no reaeration equation was found to effectively predict field-measured rates in Segment 2, so a single representative reaeration rate was chosen for use throughout the segment, except where dams were located. The rate was adjusted for WLA by applying the ratio of low-flow and calibration velocities in each reach, following the form of the Tsivoglou formulation, in which reaeration is proportional to velocity. The resulting rates, though reflecting the difference in flow, still were not typical of literature values for a river like the Great Miami, so they were reduced by 50%. In the sensitivity analysis (described later) the effects of no reduction to 90% reduction were examined. Refer to the Addendum for further discussion of the reaeration rates used.

Algae

Large algal populations can radically alter the balance of D.O. and BOD in the river system. Though dissolved oxygen is added by algae during one phase of the photosynthetic/respiratory cycle, it is depleted during the other phase. In addition, dead and decomposing algae can exert a high BOD load. For these reasons, algae is generally regarded as an undesirable, rather than beneficial, constituent of stream water quality (Beck, 1978).

During the intensive survey, significantly higher populations of algae were observed in Segment 2 as compared to Segment 1. To calibrate the QUAL-II model, the algal influence on water quality in Segment 2 was considered, using both "dynamic" and steady-state modes of the QUAL-II model, and non-algal simulations were also run and compared. However, algal communities are extremely volatile, and their growth/death processes are poorly understood and quantified, so they are difficult to accurately simulate.

The effects of algae on water quality at low flow were also examined, using the QUAL-II model. For the reasons above, however, the recommendations made in this report consider only the simulations without algal influence.

IMPACT ANALYSIS, SEGMENT 2

The wasteload impact analysis for Segment 2 was similar to that for Segment 1. This yielded information regarding the relative impact of dischargers, but did not form the fundamental basis for the wasteload allocation as in Segment 1. Additional complexities, described in the biological interpretation section, caused the wasteload allocation to be approached from a less rigid technical direction.

For wasteload impact analysis, the impacts of Middletown WWTP and Armco (see Addendum) are summarized in Figures 68 and 69. The impacts of other dischargers were considered, including the proposed discharge of the Miller Brewery (under construction). These other dischargers did not significantly contribute to water quality problems in critical reaches and therefore were not included in the figure.

The analysis was performed using a base level of treatment of all entities discharging at current (1981) permit limitations. Additional simulations were made with discharge levels set at AST and secondary for municipal WWTP dischargers and industrial dischargers at their current permit levels in both cases. Figures II-39 and II-40 summarize the results of these water quality simulations.

Another consideration in this segment is the quality of water entering the system. Since water entering Segment 2 has the residual pollutant loading from Segment 1, it becomes important to assess the effect of upstream loading on the Segment 2 wasteload allocation. Therefore, the quality of water entering Segment 2 is included as part of the impact analysis.

In summary, Figures 68 and 69 indicate that Middletown WWTP and the water quality upstream of RM 52.6 exert the greatest influence on water quality in Segment 2. Thus, the wasteload allocation for Segment 2, described in the following pages, will focus on quantifying the allocation to Middletown WWTP since it is the most critical to the system.

Crystal Tissue, LeSourdsville Regional WWTP, Miller Brewery, Brentwood Estates WWTP, Hamilton WWTP, Fairfield WWTP, Ross WWTP, Procter and Gamble, and DOE-Feed Materials Production Center, which are not included in the figures, do not significantly contribute to water quality problems in the critical reach.

Figure 69 also shows the impact of the proposed New Miami WWTP (RM 37.62) on NH_3-N levels just upstream of the dam at the Hamilton Canal Return. Though the discharge flow will be small (3.3 cfs), the reduced flow in the GMR due to the canal diversion magnifies the impact of the NH3-N load. The corresponding impact on D.O. is small, however, especially since high reaeration is provided only 0.3 miles downstream at the dam (see Figures 68 and 70).

WASTELOAD ALLOCATION, SEGMENT 2

As described in the Impact Analysis, several of the dischargers' effluents do not significantly contribute to the non-conservative parameter water quality problems within the segment. Therefore, loads have been allocated to the minimum degree of treatment allowable under Ohio law. These entities include the municipal dischargers listed above, which have been allocated secondary treatment, and the industrial discharges listed above which have been allocated their current permit limitations.

000355

The wasteload impact analysis revealed that Middletown WWTP exerts the greatest single influence on stream water quality in Segment 2 (Refer to Figures 68 and 69). Reducing the CBOD effluent concentration of Middletown from 40.8 $CBOD_{20}$ to 27.2 mg/l $CBOD_{20}$ causes the minimum D.O. to increase from 4.6 to 4.7 mg/l (see Figure 72). In these simulations, NH3-N and D.O. effluent concentrations remained at their current permit limitations, 8.0 and 5.0 mg/l, respectively.

Instream ammonia-nitrogen concentrations in Segment 2 are primarily impacted by effluents from Middletown WWTP and two Armco industrial discharges (Figure 69). At present permitted levels, however, no violations of the WQS for NH_3-N are apparent (see Figure 71). Alternative effluent levels of both CBOD and NH_3-N are examined in the summary portion of this report (see Table 1).

A wasteload allocation was determined for the proposed New Miami WWTP discharge to the GMR. Water quality simulations indicated that the proposed plant would have a significant impact on the Great Miami River water quality, particularly NH_3-N levels, in the critical reach below the Middletown WWTP. If the plant were located as proposed, it would be required to have treatment beyond secondary.

SENSITIVITY ANALYSIS, SEGMENT 2

In Segment 2, the sensitivity analysis encompasses the effects of the water quality of water entering Segment 2 from Segment 1, the Hamilton Hydraulic Canal flow diversion, the ammonia sink term, and the reaeration rates on the simulated water quality.

The quality of water entering Segment 2 from Segment 1 proved to be particularly important to the water quality in Segment 2. Consequently, Ohio EPA's final recommendation for permit limitations for Segment 2 will reflect the recommended permit limitations for Segment 1 and their rate of implementation. Figure 68 and 69 illustrated the effect of the upstream water quality on Segment 2 water quality simulations.

The influence of the Hamilton Hydraulic Canal withdrawal on the Great Miami River mainstem, summarized by Figures 73 and 74, is also important to Segment 2 water quality under low-flow conditions. The withdrawal primarily affects the allocation of ammonia and conservative pollutants. If the local interested parties agree to a maximum canal flow less than the 350 cfs modeled (providing more than 170 cfs in the GMR mainstem under low-flow conditions), the figures show that water quality improvements will result. If, on the other hand, higher canal flows (lower GMR mainstem flows) are allowed, violations of the WQS will result unless wasteloads are decreased beyond current permit limitations. The determination of the canal diversion flow rate used for the low-flow modeling has been previously described and is based on documentation and historical records available to Ohio EPA.

During model calibration an ammonia sink term was included as part of the Segment 2 ammonia simulations. The effect of the ammonia sink term on low-flow water quality simulation was adjusted, as described in the Segment 1 discussion, to represent the decreased background flows. Results indicate that under low-flow conditions the sink has minimal impact on simulated water quality and consequently was not included in the wasteload allocation runs.

The calibration and verification section of the report described the problems surrounding quantifying a predictive reaeration equation applicable to Segment 2. As discussed above, measured reaeration rates were adjusted for instream flow differences to low-flow conditions. It is important at this point to evaluate the sensitivity of Segment 2 water quality simulations under low-flow conditions to this rate. In the sensitivity analysis, the simulations were run with reaeration rates as measured and reduced 50% (used for the WLA) and 90% from the measured values.

The 90% reaeration rate reduction depletes D.O. an additional 2.5 mg/l. This condition is not supported by available information, and so it is viewed as an extreme case. Within the bounds of low-flow simulations and the bounds of reasonable reaeration rates, the Segment 2 wasteload allocation is not strongly influenced by the reaeration rate.

RESULTS, SEGMENT 2

The culmination of the calibration, verification, and wasteload allocation modeling process is a technically defensible wasteload allocation. Allocations developed from the technical standpoint of modeling may not always reflect reasonably attainable treatment trains. In these cases, it is necessary to propose and evaluate treatment levels practically attainable, yet representative of wasteloads developed on the basis of impact analysis. In Segment 2 of the Great Miami River this was not necessary, since the impact analysis was less rigorously developed, as described previously, and the low-flow water quality analysis was fairly simple.

Under current discharge limitations for non-conservative substances, it appears that water quality standards within Segment 2 of the GMR can be maintained at nearly all points. Possible exceptions to this are in the reach directly below Middletown WWTP (NH_3-N), in the dam pool above the Hamilton Hydraulic Canal withdrawal (D.O.), and in the section of the mainstem deprived of flow by this withdrawal. Unfortunately, no data is available to confirm whether these violations actually occur during summer low flows. Therefore, it is difficult to technically justify stringent effluent limits for the dischargers to this segment of the river.

The proposed site for the New Miami WWTP, however, is in a very stressed area with limited dilution flow during critical low-flow seasons. Therefore, unless the plant is located elsewhere, its effluent must be treated to 37.5-5-5. For this and the Armco (New Miami) discharges, further reductions in wasteloads will be required in order to meet WQS, if Hamilton Hydraulic canal flow exceeds 350 cfs during critical flow, reducing GMR flow to less than 170 cfs. In such a case, effluent limits for Middletown WWTP might also need to be reduced.

000357

In addition to the above, the following observations are made and actions proposed:

1. Some improvements for the Dayton WWTP are currently under construction. Others will require several years to install. The Dayton WWTP is the major discharger in the basin, and it has already been shown that this facility significantly affects background water quality coming into Segment 2 at Middletown, and that the WLA for the segment is sensitive to this background water quality. Therefore, more stringent limits for entities in Segment 2 will not be recommended at this time. Based on this study, permits for entities in Segment 2 should be re-issued with existing limitations, except were BAT or other legal constraints require more restrictive limitations.

2. Ohio EPA's Section of Water Quality Surveillance and Standards has located stress zones at Middletown and within the dam pool above Hamilton. Unfortunately, the causes of these apparent degradations are uncharacterized. However, these zones do correspond to points where modeling efforts indicate either unknown influences (ammonia sink term) or D.O. sags (above Hamilton dam and canal return). Further study will be required to fully understand the cause and effect relationships in this area before additional limitations or controls can be established.

3. Observations of stream water quality can be affected dramatically by the presence of significant algal populations during the summer months. These communities can affect both D.O. and the nitrogen-series. Hence, it seems reasonable to conclude that these contributions need to be realistically accounted for in model calibration and verification. Additional data is required in this particular segment to adequately and completely describe the instream process.

4. Reliable information (sufficient for use in calibration and verification) delineating stream water quality under low-flow conditions and current discharge loadings does not exist for Segment 2 of the GMR. Therefore, additional data should continue to be collected to meet this need.

Table 63 summarizes the wasteload allocation for discharges in Segment 2 and also indicates the resulting instream water quality at critical points. Final recommendations for permit limitations reflect not only the technically derived wasteloads but also economic considerations, alternative treatment evaluations, and public input. Final recommendations for permit limitations are presented in the summary portion of this report (opening pages, Tables 1 and 3). Revisions to this information are included in the Addendum.

Figure 59. Great Miami River flows used in modeling.

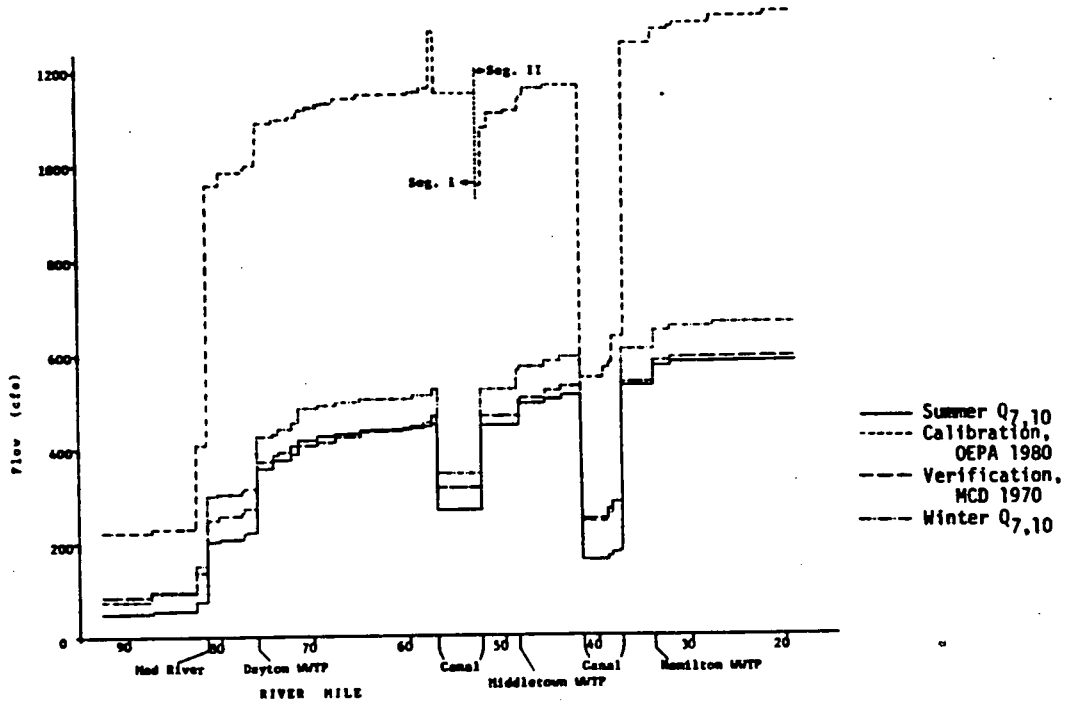

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Figure 60. Low flow simulation of Segment 1 D.O. levels (all industries at permit limitations).

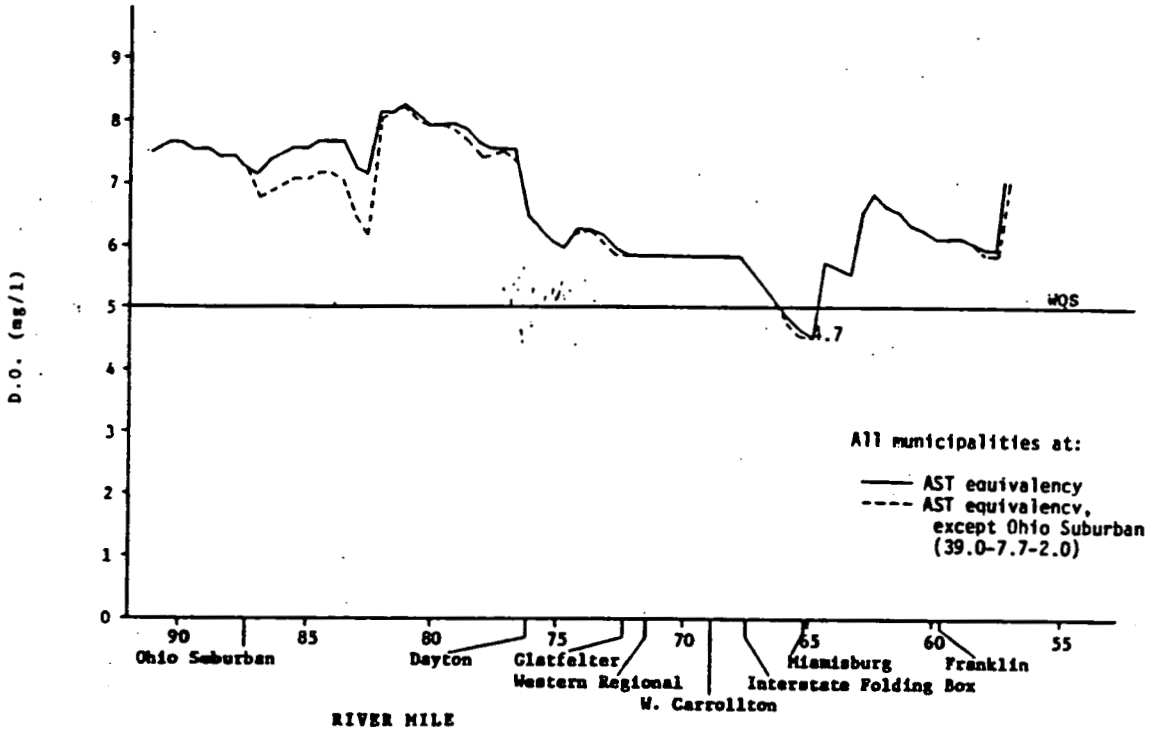
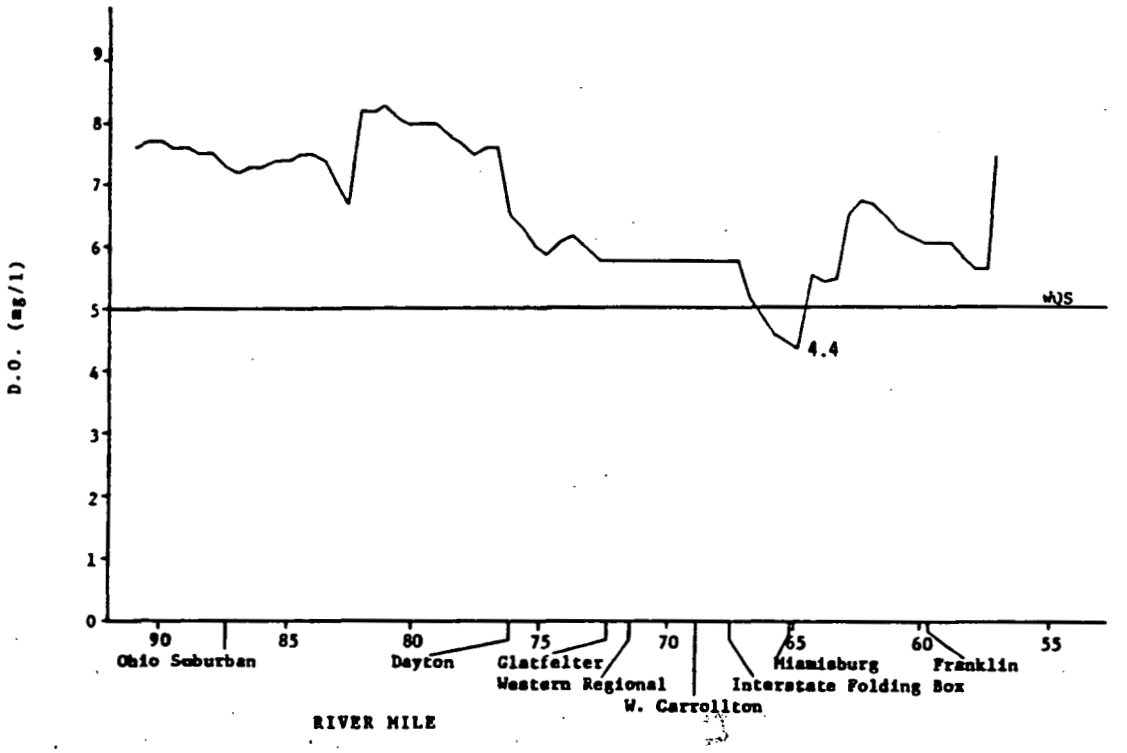


Figure 61. Low flow simualtion of Segment 1 D.O. levels (all entities at permit limitations).



000361

Figure 62. Low flow simulation of Segment 1 ammonia levels (all entities at permit limitations).

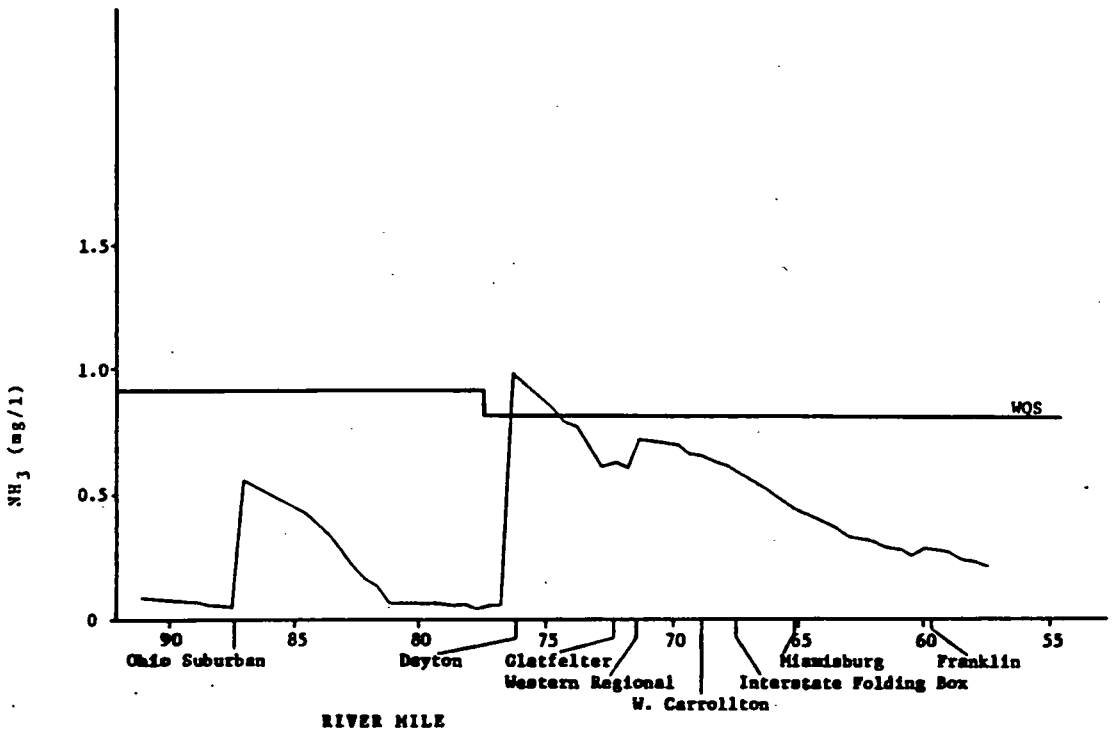
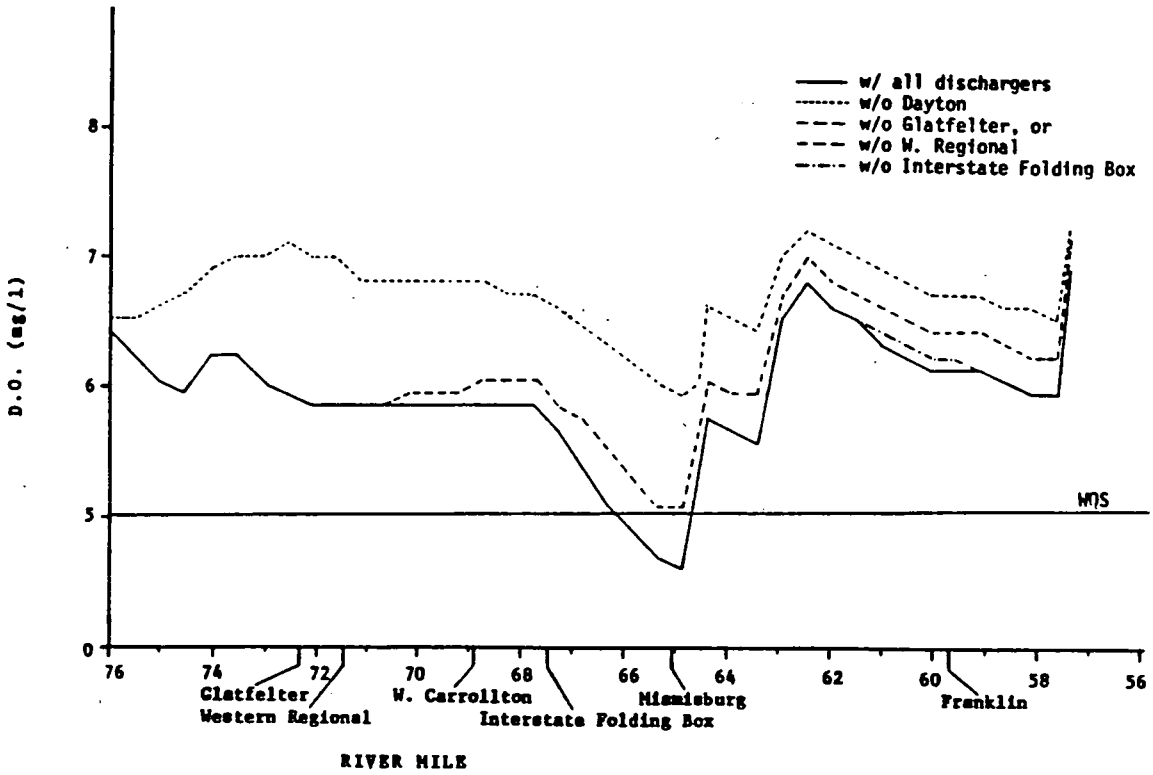


Figure 63. Impact analysis - Segment 1 D.O. levels (all industries at permit limitations and all municipals at AST equivalency).



000363

Figure 64. Low flow simulation of Segment 1 D.O. levels (WLA from impact analysis).

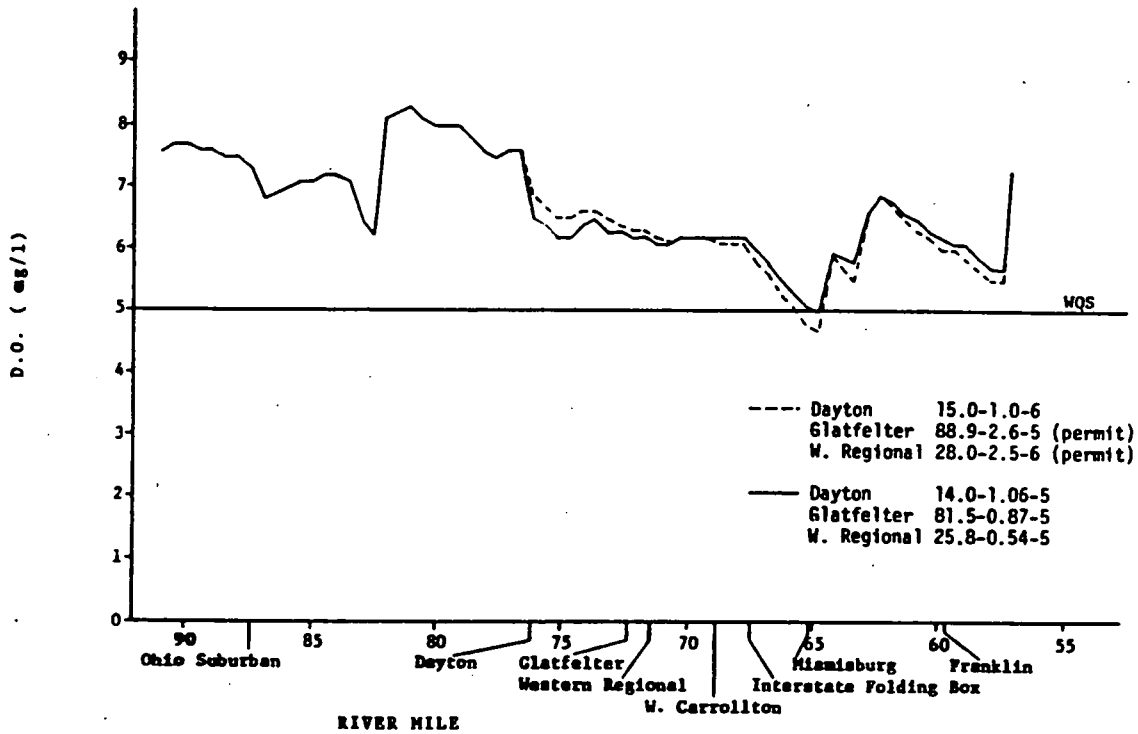
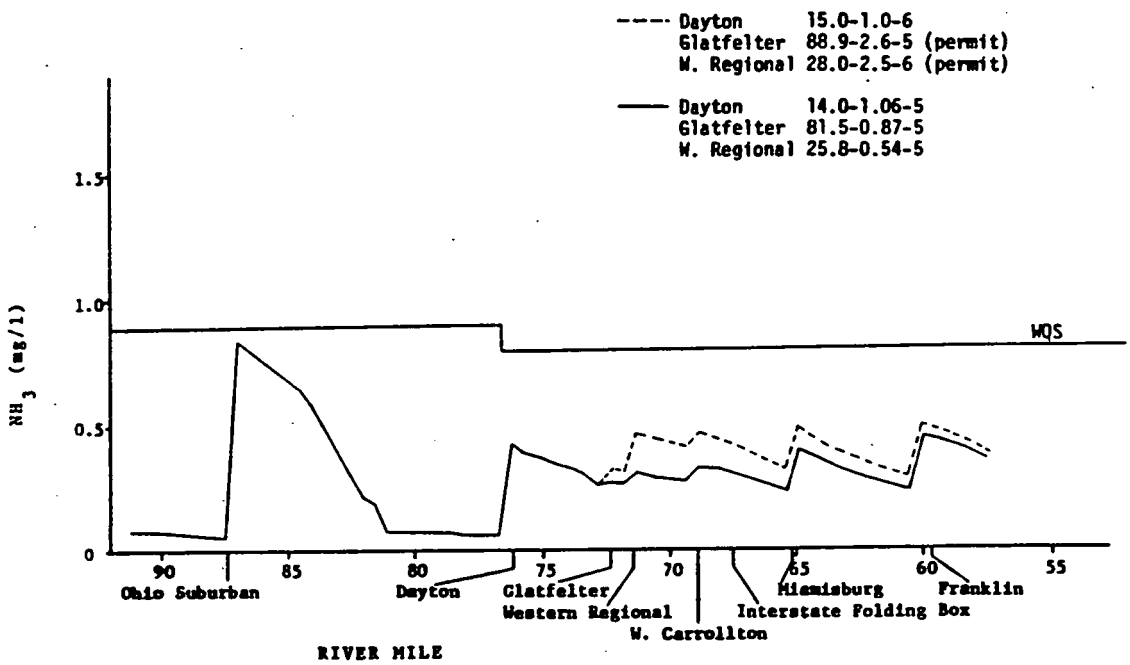


Figure 65. Low flow simulation of Segment 1 ammonia levels (WLA from impact analysis).



000365

Figure 66. Effect of ammonia sinks on Segment 1 D.O. levels.

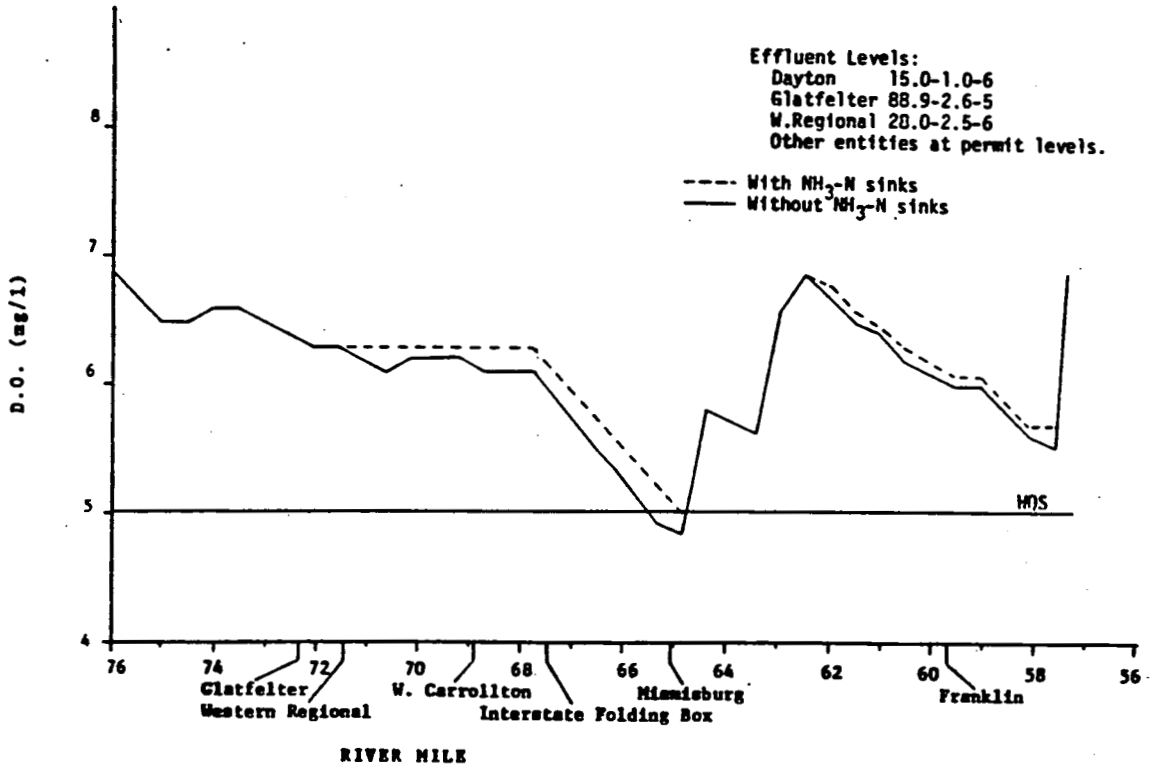


Figure 67. Effect of W. Carrollton dam on Segment 1 D.O. levels.

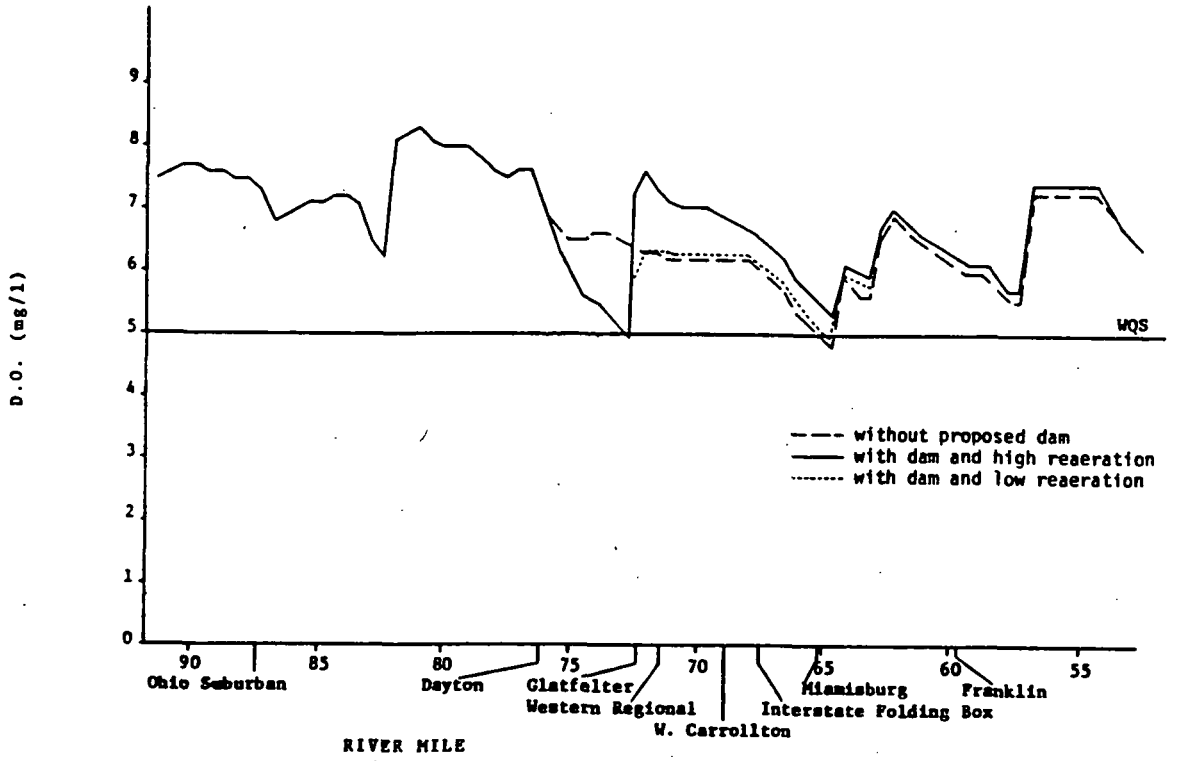


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Figure 68. Impact analysis - Segment 2 D.O. levels (all entities at permit limitations).

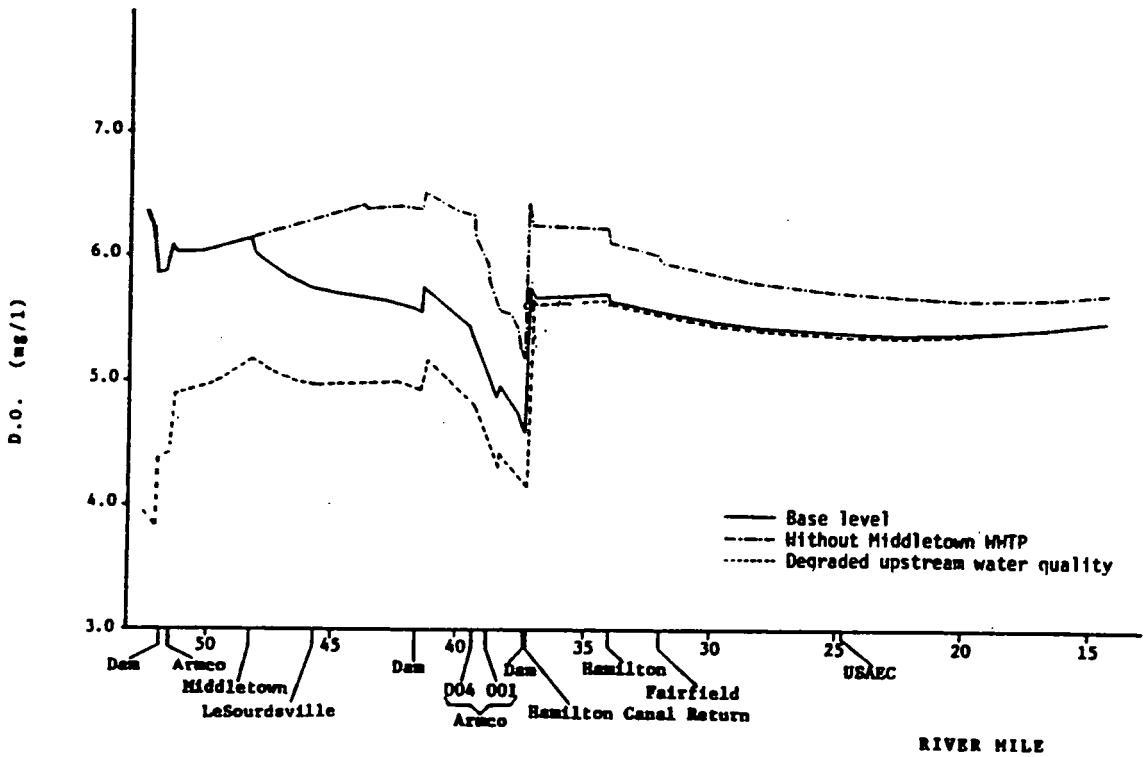
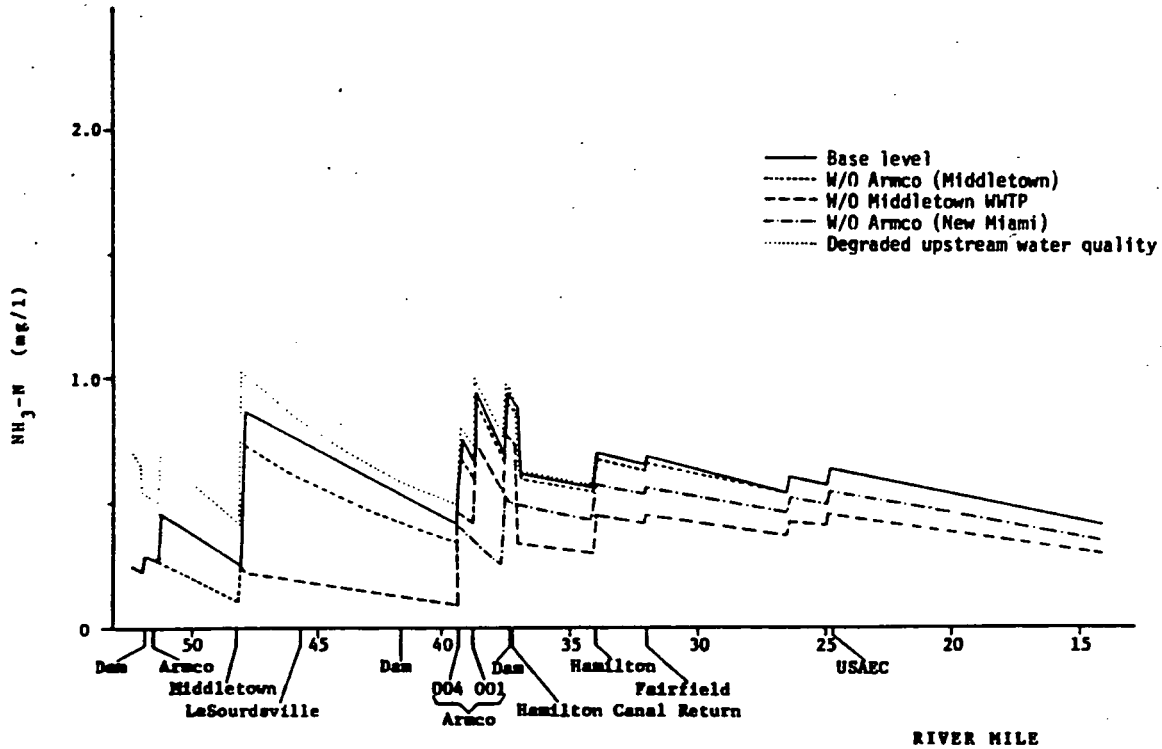


Figure 69. Impact analysis - Segment 2 ammonia levels (all entities at permit limitations.



000369

Figure 70. Low flow simulation of Segment 2 D.O. levels (all industries at permit limitations).

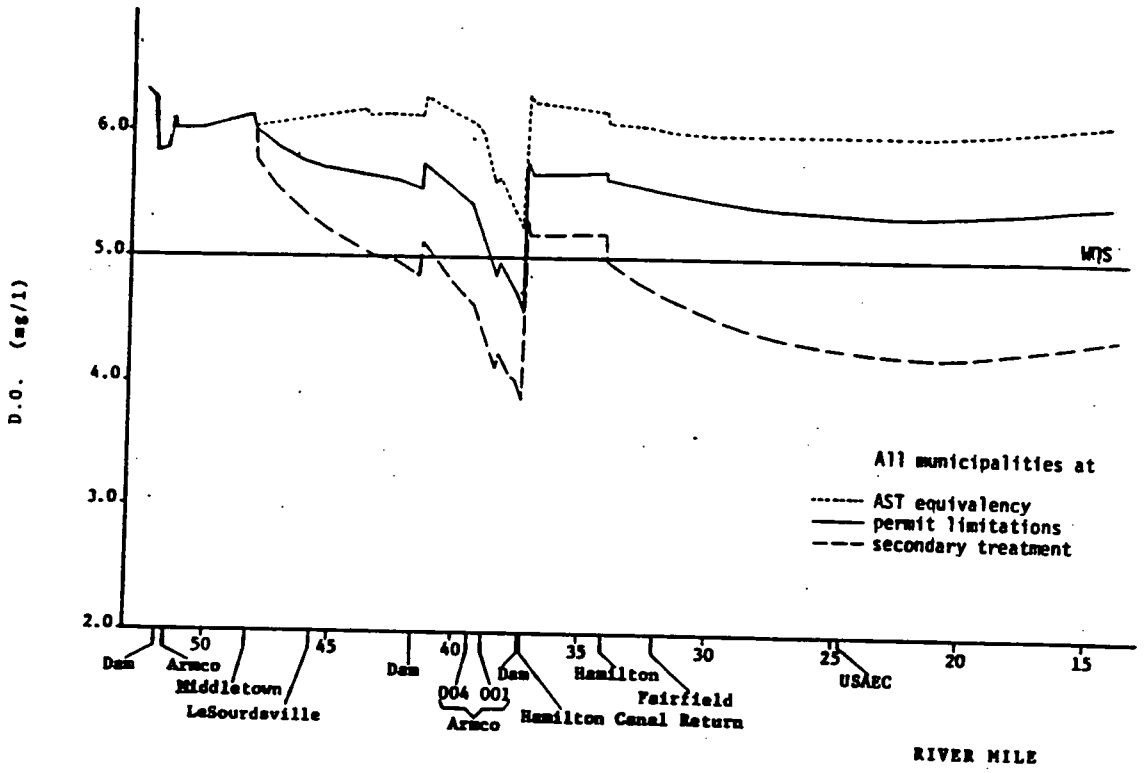
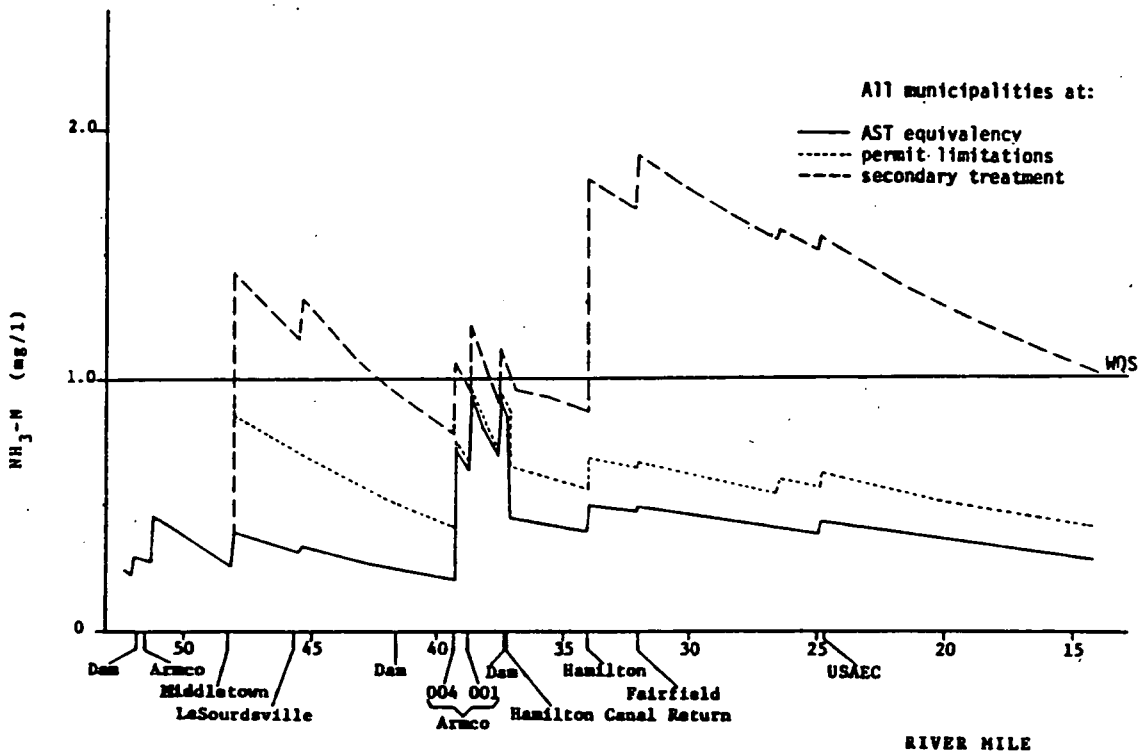


Figure 71. Low flow simulation of Segment 2 ammonia levels (all industries at permit limitations).



000371

Figure 72. Low flow simulation of Segment 2 D.O. levels (Middletown WLA from impact analysis).

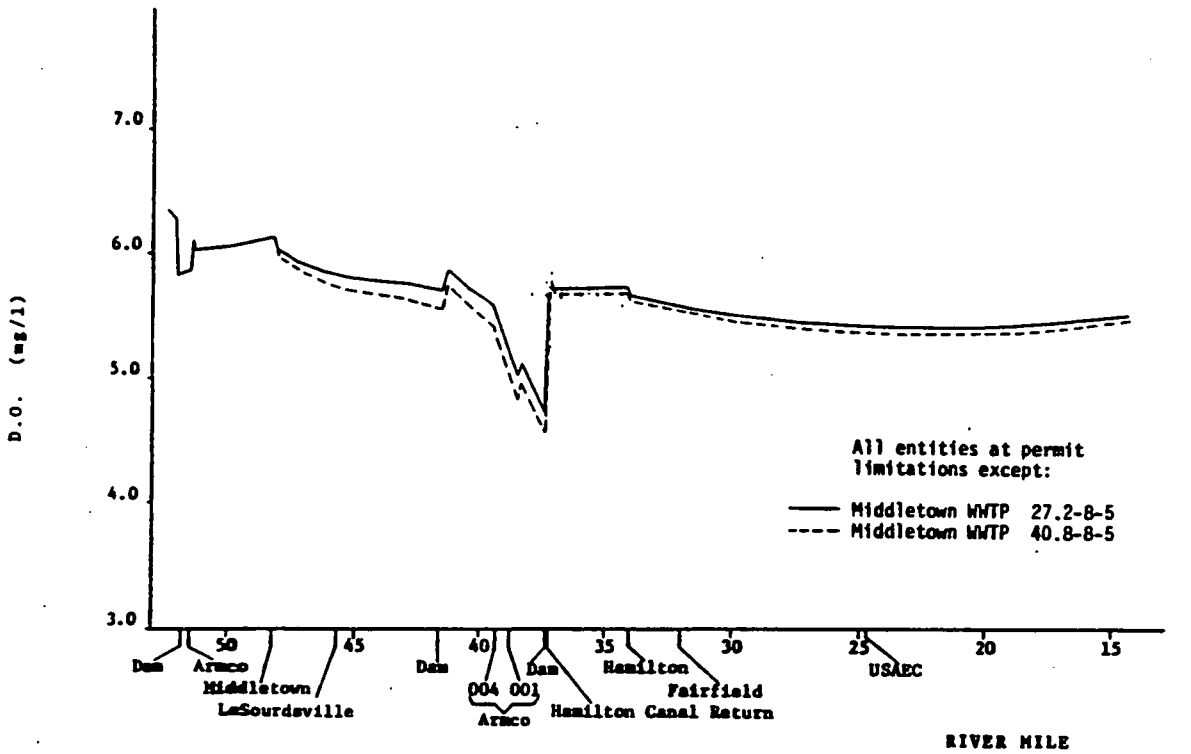


Figure 73. Effect of Hamilton Hydraulic Canal on Segment 2 D.O. levels (all entities at permit limitations).

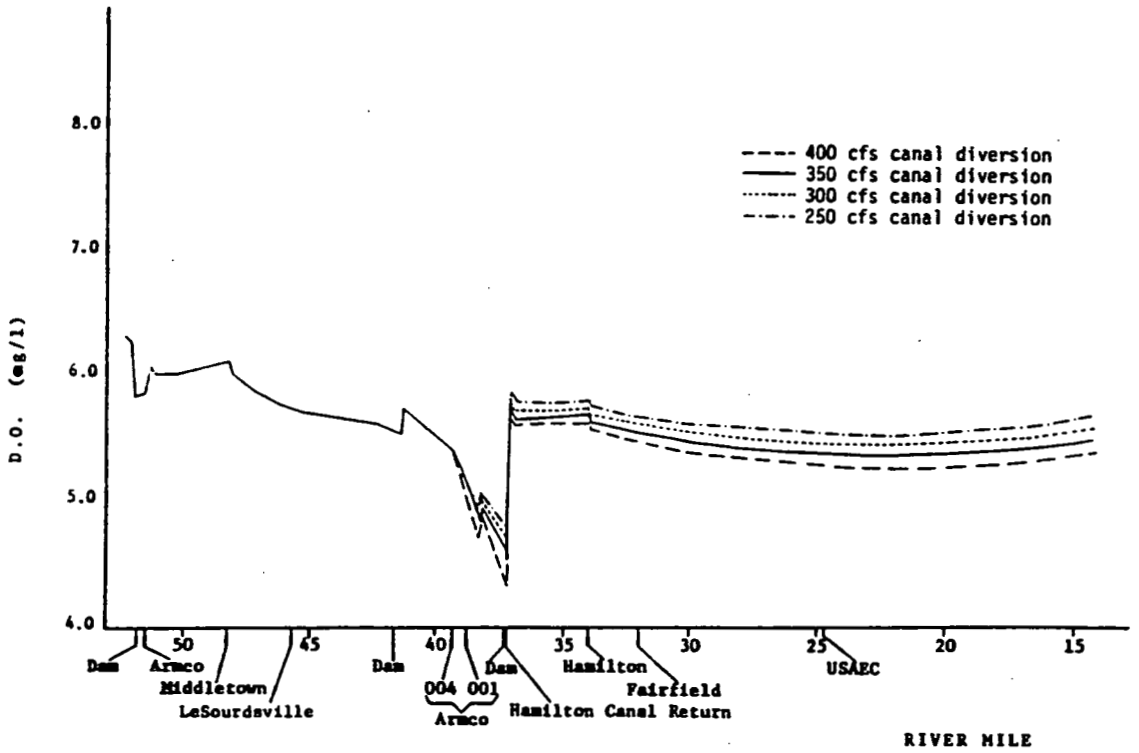


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Figure 74. Effect of Hamilton Hydraulic Canal on Segment 2 ammonia levels (all entities at permit limitations).

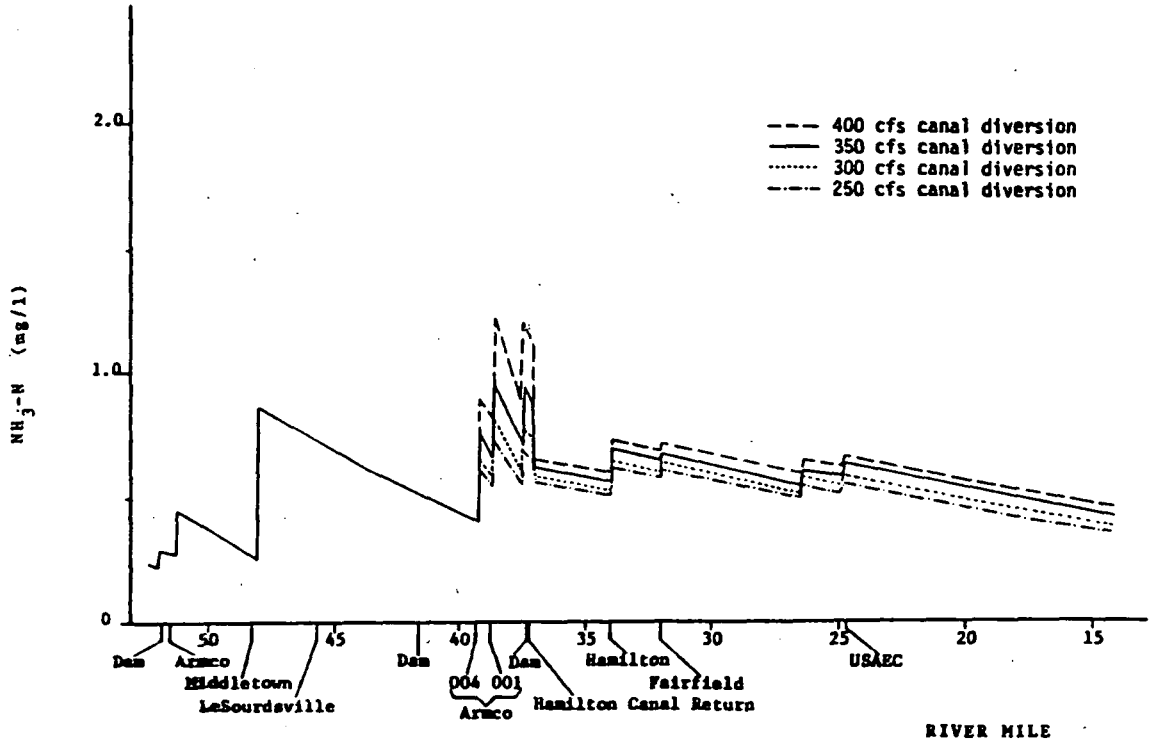

TABLE 59

Design Flow of Segment 1 Dischargers for WLA

Entity Name	Permit Number	OEPA RM	MCD RM	Design Flow MGD	Design Flow cfs
Ohio Suburban WWTP	S 600	87.45	86.55	4.00	6.19
MCD N. Regional WWTP	D 620	87.47	86.55	12.00	18.56
DP & L (Tait) 002	B 103	77.49	76.65	1.90	2.94
GM-Delco Moraine 002	N 130	77.48	76.60	4.48	6.93
GM-Delco Moraine 003	N 130	77.47	76.55	1.38	2.13
Dayton Walther	N 137	77.24	76.35	0.996	1.54
Monsanto Research	N 108	77.03	-	0.504	0.78
Dayton WWTP	F 600	76.11	75.25	72.00	111.38
GM-Delco Air Plant #3	C 108	74.42	73.50	3.45	5.34
GM-Delco Air Plant #2	C 107	74.15	73.20	7.11	11.0
Glatfelter Inc.	A 104	72.34	71.55	7.50	11.60
Montgomery County - W. Regional WWTP	L 602	71.48	71.45	20.00	30.94
West Carrollton WWTP	D 614	68.85	67.97	1.20	1.86
Interstate Folding Box	A 105	67.49	66.75	0.35	0.54
Miamisburg WWTP	D 617	65.05	64.25	4.00	6.19
DP & L (Hutchings) 002	B 104	64.62	63.75	1.70	2.63
Franklin WWTP	D 604	59.95	58.80	4.50	6.96

TABLE 60

Design Flow of Segment 2 Dischargers for WLA

Entity Name	Permit Number	OEPA RM	MCD RM	Design Flow MGD	Design Flow cfs
Armco (Middletown) 001[a]	D 101	51.45	50.60	18.20	28.16
Middletown WWTP	E 603	48.29	47.45	26.0	40.22
Crystal Tissue	A 100	48.10	47.15	2.60	4.02
LeSourdsville WWTP	K 611	45.65	44.70	4.0	6.19
Nicolet Industry	A 106	44.28	43.40	0.129	0.20
Miller Brewery (proposed)	-	43.80	42.80	6.10	9.44
Butler County - Brentwood Estates WWTP	G 649	42.25	41.37	0.045	0.07
Armco (New Miami) 004[a]	D 102	39.38	38.57	7.0	10.83
Armco (New Miami) 002[a]	D 102	39.00	38.15	0.047	0.07
Armco (New Miami) 001[a]	D 102	38.74	37.88	7.12	11.02
New Miami WWTP (proposed)	-	37.62	-	2.12	3.28
Hamilton Municipal Electric	B 108	37.12	36.32	102.70	155.88
Champion Paper 003	A 109	36.85	36.08	0.50	0.77
Hamilton WWTP	E 602	34.00	33.28	24.70	38.21
Fairfield WWTP	D 603	32.00	31.26	6.00	9.28
Ross WWTP (proposed)	-	26.30	-	1.60	2.48
Proctor and Gamble	N 110	25.99	25.35	0.30	0.46
USAEC - Feed Material Prod. Center (001)	OH0009580	24.73	24.15	0.493	0.76

[a] Also refer to Addendum

TABLE 62
SEGMENT 1
SENSITIVITY ANALYSIS

PARAMETER	Instream Concentration (mg/l) $CBOD_{20}$ (max.)	D.O. (min.)	NH_3-N (max.)
Base Level[b]	10.3	4.7	0.8
K_1 = 0.32	8.8	3.8	0.8
K1 = 0.08	11.9	5.6	0.8
K_3 = 0.6	10.3	4.5	0.8
K3 = 0.08	10.3	5.2	0.9
Upstream D.O. (5.8)	10.3	4.7	0.8
Upstream D.O. (9.7)	10.3	4.7	0.8
Upstream CBOD (8.1)	10.3	4.6	0.8
Upstream CBOD (5.3)	10.2	4.7	0.8
No CBOD from Owl Creek	10.1	4.8	0.8
T (22-24-26)[a]	10.5	5.0	0.8
T (26-28-30)[a]	10.1	4.3	0.8
pH (7.8)	10.3	4.6	1.4
pH (8.2)	10.3	4.7	0.5
Upstream NH_3-N (0.21)	10.3	4.7	0.8
Upstream NH_3-N (0.02)	10.3	4.7	0.8
Low D.O. (6.5) from Mad River	10.3	4.7	0.8
High D.O. (9.9) from Mad River	10.3	4.7	0.8
Low NH_3-N (0.01) from Mad River	10.3	4.7	0.8
High NH3-N (0.06) from Mad River	10.3	4.6	0.8
Low CBOD (2.8) from Mad River	10.1	4.7	0.8
High CBOD (5.0) from Mad River	10.5	4.6	0.8
Base Level[b] With NH_3-N Sink	9.9	5.0	0.8

(Continued)

TABLE 62
SEGMENT 1
SENSITIVITY ANALYSIS (CONTINUED)

PARAMETER	Instream Concentration (mg/l)		
	$CBOD_{20}$ (max.)	D.O. (min.)	NH_3-N (max.)
With Proposed Dam @ RM 72.6	-	5.3	0.8
Without Proposed Dam	-	4.7	0.8
Base Level[c] With BOD Source and NH_3-N Sink	14.3	4.7	0.8
Base Level[c] Without BOD Source and NH_3-N Sink	14.3	4.8	0.8
Base Level[c] With NH_3-N Sink only	14.3	5.0	0.8

[a] Temperature increases due to thermal discharges from DP&L (Tait) and DP&L (Hutchings).

[b] Ohio Suburban (6.19 cfs, 7.7 mg/l NH_3-N) used for a base level.

[c] MCD N. Regional (18.56 cfs, 3.19 mg/l NH_3-N) used for a base level.

TABLE 63
SEGMENT 2
NON-CONSERVATIVE PARAMETER
WASTELOAD ALLOCATION RESULTS

Entity Name[a]	Allocated Effluent Levels CBOD20	NH3-N	D.O.
ARMCO-Middletown 001[b]	-	3.5	5.0
Middletown WWTP	27.2	8.0	5.0
Crystal Tissue	36.0	-	5.0
LeSourdsville Reg. WWTP	25.0	2.5	6.0
Miller Brewery (proposed)	90.0	-	5.0
Butler Co.- Brentwood Estates	25.0	1.5	3.0
ARMCO - New Miami 004[b]	-	5.4	5.0
ARMCO - New Miami 002[b]	42.0	5.0	5.0
ARMCO - New Miami 001[b]	10.2	5.6	5.0
New Miami WWTP (proposed)	37.5	5.0	5.0
Hamilton WWTP	75.0	2.5	5.0
Fairfield WWTP	75.0	2.5	5.0
Ross WWTP (proposed)	75.0	15.0	2.0
Procter and Gamble	60.0	-	5.0
DOE-Feed Materials Production Center (US AEC)	27.0	20.0	5.0

[a] Other entities were left at present permit limitations.
b Also refer to Addendum.

000379

CONSERVATIVE PARAMETER WASTELOAD ALLOCATION

The method applied to the Great Miami River to determine wasteload allocations of conservative parameters, particularly heavy metals, is described below, followed by a discussion of the results. Low-flow conditions assumed for the simulation of non-conservative parameters were also used in this allocation process. The total existing load (background load) is the sum of upstream load, tributary input load, and discharger load. Available assimilative capacity is distributed among allocating dischargers proportional to the base load ratio as described below.

At any point in the stream, the concentration of any conservative pollutant can be computed by mass balance analysis as

$$C = \frac{C_n Q_n + C_b Q_b}{Q_n + Q_b}$$

where "b" represents background, "n" represents the nth discharger, "C" is concentration and "Q" is flow. For water quality standards to be met, "C" must be equal to or less than the WQS at every point.

As applied to the GMR, the allocation was performed as follows:

1. The existing effluent quality (EEQ) load for each point source was determined using the third quarter averages over the last 5 years. In a few cases, this historical data was not available, so data over a shorter period of time or in a different form was used.

2. The background loads (upstream and tributary) were determined from Ohio EPA weekly monitoring and intensive survey data. The effects of dischargers on Mad River were then added. In one case, the background load exceeded WQS, and therefore was reduced to WQS for the allocation.

3. Critical low flow defined for the non-conservative parameter wasteload allocation was used for upstream and tributary flow conditions, and design flows were used for dischargers.

4. Assimilative capacity of the GMR at any point was obtained by multiplying the total flow by instream WQS and a conversion factor.

5. A discharger was included in the allocation if the final table of its present permit contains a limit for the particular parameter. In addition, the effluent levels of chromium (Cr) from Dayton WWTP (EEQ) exceeded the GMR's available assimilative capacity at this point, so it was also allocated.

6. Available stream assimilative capacity was determined by deducting the existing background load (the sum of upstream load, tributary input loads, and non-allocated discharger loads) at any point in the GMR.

7. The base load in most cases was the discharger's final permit limitation for a given parameter. If BAT or BPT guidelines were available, however, they were used.

8. Available assimilative capacity was distributed among dischargers proportionally to the base load ratio (base load of a discharger divided by the sum of base loads).

9. The allocated load was computed as available assimilation capacity multiplied by the base load ratio.

10. The allocated load was not allowed to exceed the base load.

Using the above method, heavy metals (cadmium, chromium, copper, iron, lead, nickel, zinc) were allocated to dischargers in both segments of the GMR. Except for nickel, for which the water quality standard (WQS) is taken from Quality Criteria for Water (the "Red Book", USEPA, 1976), allocations were based on the Ohio EPA Water Quality Standards (Chapter 3745-1 of the Ohio Administrative Code). WQS are not specified for other heavy metals such as Al, As, Mn, Cr^{+6}, and dissolved Fe; therefore, these parameters did not receive wasteload allocations. Instead, they were allowed to remain at the present final table permit limitations.

Appendix A presents the results of wasteload allocations for conservative parameters as applicable. Each parameter table contains the critical low flow (cfs) and assimiliative capacity (lbs/day) of the GMR at that point, the load at existing effluent quality and that projected for low flow, the current permit limitation, the allocated load (lbs/day) vs. the concentration (mg/l), and the cumulative allocated load (lbs/day) at the reach of each major point source (including that source). Accompanying figures show the assimilative capacity versus the allocated load for the particular conservative parameters.

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APPENDIX A

Conservative Parameters Allocation

Fe Allocation -

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0			181.37 / 0.673			181.37
Stillwater River	82.57	15.0	71.19	383.71	WQS	80.85 / 1.0			262.22
Mad River	81.48	160.85	232.04	1250.70		606.02 / 0.699			868.24
DP&L (TAIT) 002	77.48	2.94	236.28	1273.55	11.01 / 0.910	14.42 / 0.910			882.66
(601)					0.008 / 0.759 [5]		- / 1.0	- / 1.0 [2]	
(604)					1828.3 / 873.51 [5]		- / 1.0	- / 1.0 [2]	
GM Delco Moraine 002	77.48	6.93	24.32	1310.90		53.68 / 1.437			936.34
GM Delco Moraine 003	77.47	2.13	245.34	1322.38		13.09 / 1.14			949.43
Dayton WWTP	76.11	111.38	358.26	1931.02		288.16 / 0.48			1244.31
GM Delco Air. #3	74.42	5.34	363.60	1959.80	23.79 / 0.977	28.121 / 0.977	42.8 / -	28.80 / 1.0 [3]	1273.11
Armco[6] (Middletown) 001	51.45	28.20	447.69	2413.05					
(611)		2.79			4.208 / 1.104 [1]	16.60 / 1.104	121.0 / -	16.60 / 1.10 [3]	1354.30

000384

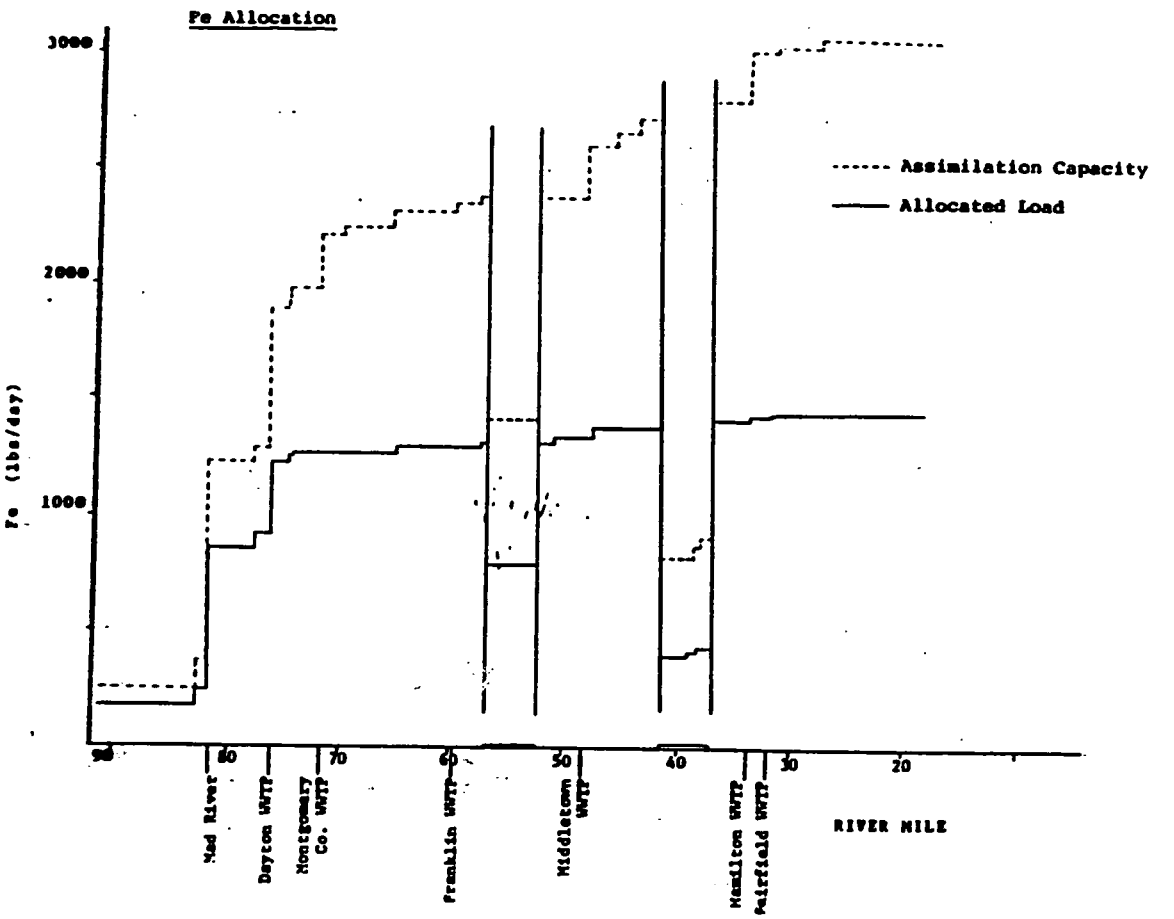
6399

Fe Allocation - 2

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Armco[6] (New Miami) 001	38.74	11.02	168.26	906.92					
(611)		4.96			0.806 / 0.209 [1]	12.41 / 0.209			469.823
Hamilton Municipal Electric 002	37.12	150.0	529.18	2852.28					1433.70
(612)		(0.016)			0.018 / 3.48	0.30 / 3.48	- / 1.0	- / 1.0 [2]	
(613)		(0.031)			0.007 / 0.274	0.046 / 0.274	- / 1.0	- / 1.0 [2]	
(611)		(unknown)			-	-	- / 1.0	- / 1.0 [2]	
USAEC 001	24.73	0.76	584.34	3149.59		0.299 / 0.073			1451.03
(001B & 001C)							0.904 / -	0.904 / - [4]	

1 Annual average discharge data (1980).
2 BPT and proposed BAT.
3 EEQ recommended.
4 Present permit limitation retained (BEJ).
5 Two year average (1977, 1978).
6 Also refer to Addendum.

000385


Fe Allocation
3000
2000
1000
Fe (lbs/day)
Assimilation Capacity
Allocated Load
90
80
70
60
50
40
30
20
RIVER MILE
Mad River
Dayton WWTP
Montgomery Co. WWTP
Franklin WWTP
Middletown WWTP
Hamilton WWTP
Fairfield WWTP

Cu Allocation

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0	22.9		1.348 / 0.005			1.348
Mad River	81.48	160.85	232.04	106.31		21.70 / 0.025			25.116
DP&L Tait 002	77.48	2.94	236.28	108.25	1.64 / 0.119	1.886 / 0.119			27.002
(601)					0.005 / 0.298 [4]		- / 1.0	- / 1.0 [2]	
(604)					64.103 / 30.33 [4]		- / 1.0	- / 1.0 [2]	
GM Delco Moraine 002	77.48	6.93	243.21	111.43		2.166 / 0.058			29.168
Dayton WWTP	76.11	111.38	358.26	164.14	114.18 / 0.231	138.68 / 0.231	- / 0.10	60.03 / 0.10 [3]	89.680
GM Delco Air #2	74.15	11.0	374.60	171.63		3.439 / 0.058			93.12
Montgomery Co. W. Regional WWTP	71.48	30.94	417.84	191.43	5.598 / 0.064 [1]	10.673 / 0.064	- / 0.2 at any time	33.4 / 0.2 [3]	127.3
Mound Lab 001	65.9	0.0074	427.11	195.68	- / 0.19	0.0076 / 0.19	- / 0.5 max	- / 0.5 max [3]	138.8
Middletown WWTP	48.29	40.22	488.21	223.67	2.47 / 0.017	3.685 / 0.017			136.6

000382

Cu Allocation - 2

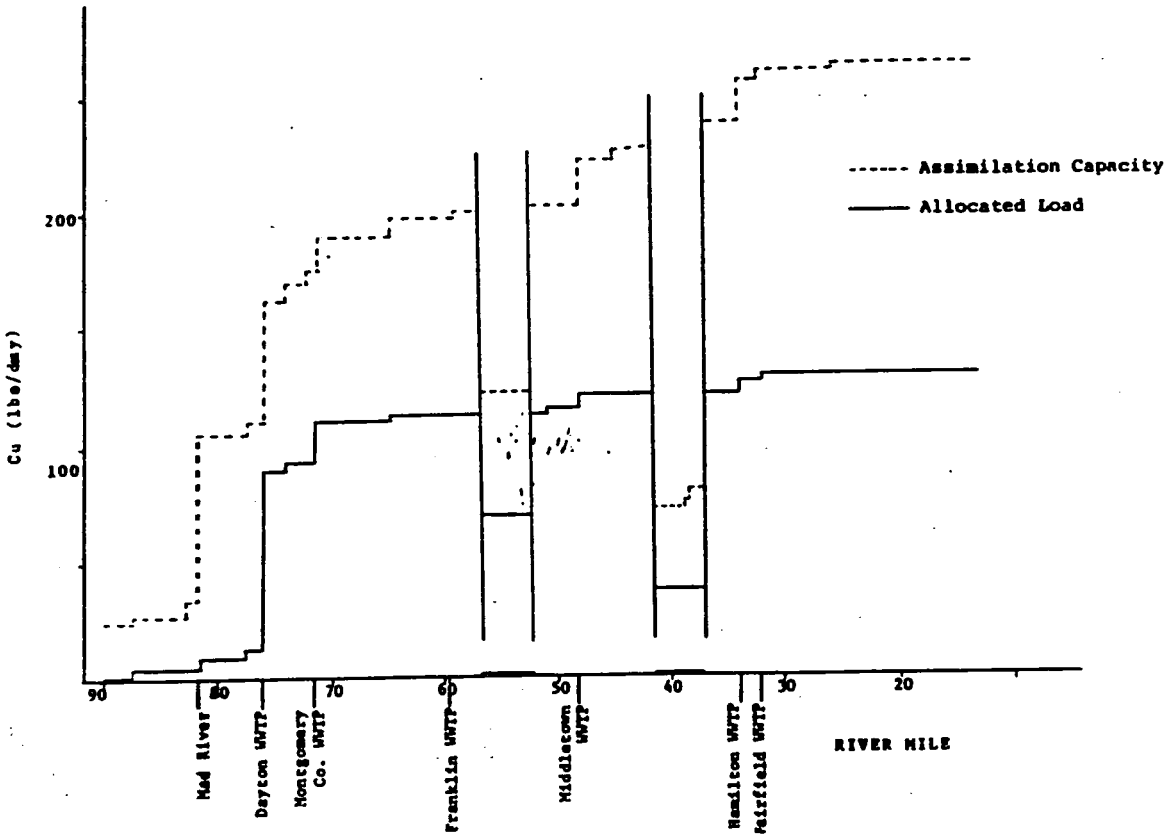
Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Hamilton Municipal Electric 002	37.12	150.0	529.18	242.44					122.38
(612)		(0.016)			0.002 / 0.645	0.056 / 0.645	- / 1.0	- / 1.0 [2]	
(613)		(0.031)			0.001 / 0.036	0.006 / 0.036	- / 1.0	- / 1.0 [2]	
(611)		(unknown)						- / 1.0 [2]	
Hamilton WWTP	34.0	38.21	568.30	260.37	1.43 / 0.02	4.119 / 0.02			126.50
Fairfield WWTP	32.0	9.28	577.58	264.62	1.790 / 0.042	2.101 / 0.042			128.60
USAEC 001	24.73	0.76	584.34	267.72	0.082 / 0.02	0.082 / 0.02			
(001B & 001C)							0.055 / -	0.055 / - [3]	128.9

1 Annual average discharge data (1980).
2 BPT and proposed BAT.
3 Existing permit limitations retained (BPJ).
4 Average of two years data (1977, 1978).

000388

6399

Cu Allocation



000389

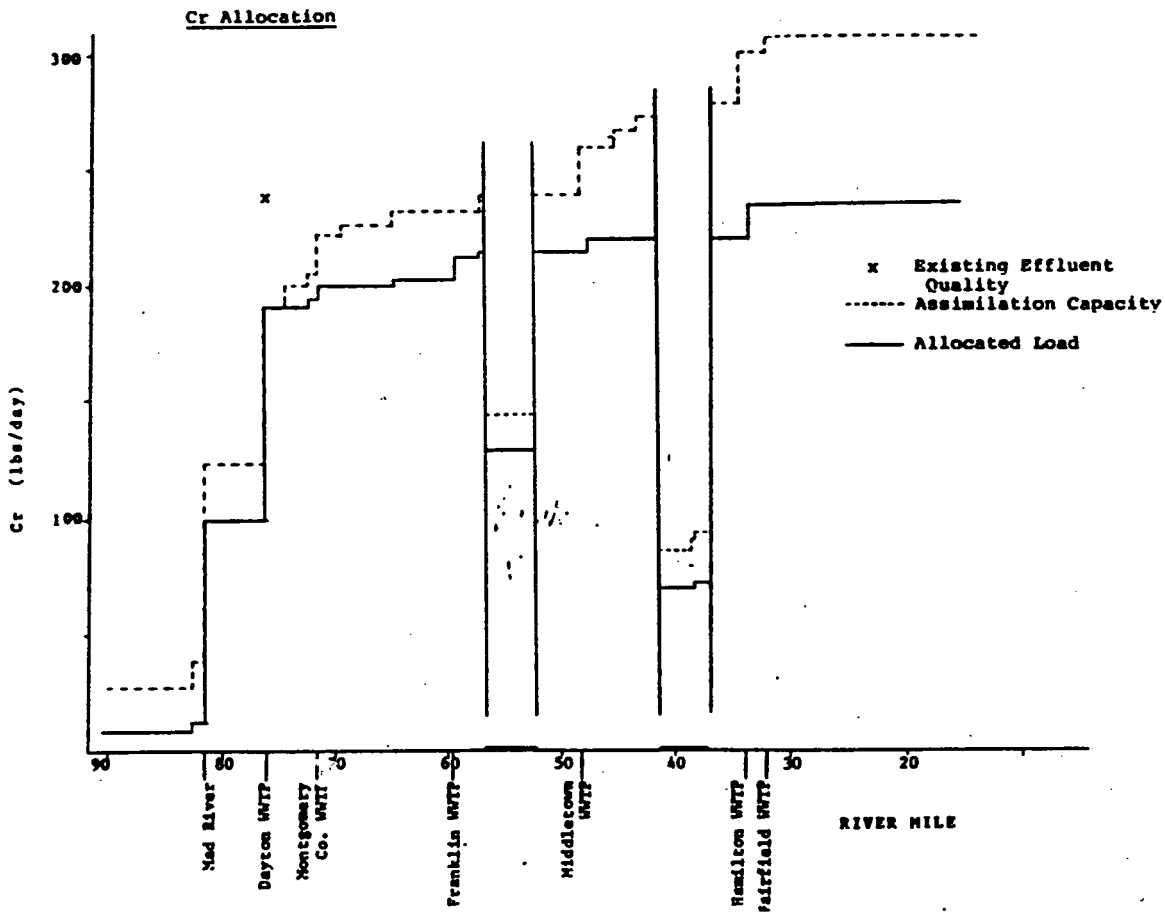
Cr Allocation

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0	26.95		9.43 / 0.035			9.43
Stillwater River	82.57	15.0	71.19	38.37		2.991 / 0.037			13.188
Mad River	81.48	160.85	232.04	125.07	WQS	86.70 / 0.10			99.888
Dayton WWTP	76.11	111.38	358.26	193.10	111.56 / 0.231	138.678 / 0.231		92.62 / 0.154 [1]	193.097
GM, Delco Air Plant #3	74.42	5.34	363.60	195.98	1.54 / 0.059	1.698 / 0.059	4.29 / -	1.80 / 0.06 [3]	194.897
GM, Delco Air Plant #2	74.15	11.0	374.60	201.91	1.565 / 0.027	1.60 / 0.027	5.50 / -	2.40 / 0.04 [3]	197.297
Montgomery Co. W. Regional WWTP	71.48	30.94	417.84	225.22	2.035 / 0.019	3.168 / 0.019			202.775
Mound Lab 001-C	65.90	0.0074	427.12	230.22		0.0032 / 0.08	- / 0.5 max	- / 0.5 max [2]	205.614
Middletown WWTP	48.29	40.22	488.21	263.15	3.48 / 0.028	6.07 / 0.028			214.875
Hamilton WWTP	34.0	38.21	568.30	306.31	3.52 / 0.054	11.12 / 0.054			228.212
USAEC 001 (001B & 001C)	24.73	0.76	584.34	314.96		0.082 / 0.02	0.11 / -	0.11 / - [2]	229.322

1 Adjusted to meet WQS.
2 Existing permit limitations retained (BPJ).
3 EEQ is recommended.

000390

6399


Cr Allocation
300
200
100
Cr (lbs/day)
x
x Existing Effluent Quality
Assimilation Capacity
Allocated Load
90
80
70
60
50
40
30
20
RIVER MILE
Mad River
Dayton WWTP
Montgomery Co. WWTP
Franklin WWTP
Middletown WWTP
Hamilton WWTP
Fairfield WWTP

000391

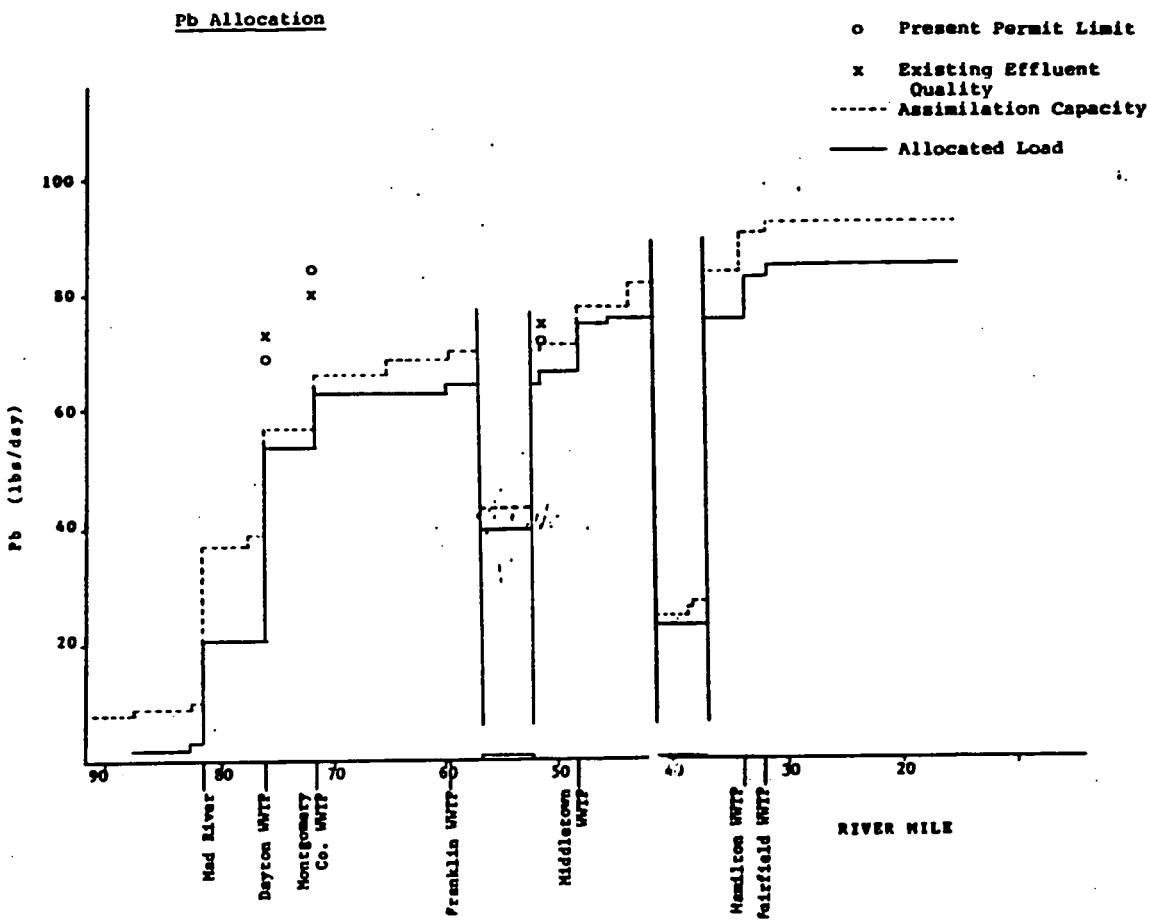
Pb Allocation[4]

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0	8.09		1.348 / 0.005			1.348
Mad River	81.48	160.85	232.04	37.52		18.0 / 0.021			21.079
Dayton WWTP	76.11	111.38	358.26	57.93	39.69 / 0.085	51.03 / 0.085	- / 0.08	33.0 / 0.055 [2]	54.079
Montgomery Co. W. Regional WWTP	71.48	30.94	417.84	67.57	3.33 / 0.036 [1]	6.004 / 0.036	- / 0.16 at any time	9.2 / 0.055 [2]	63.591
Armco Middletown[4] 001 (611)	51.45	28.2 (2.79)	447.69	72.39	0.56 / 0.144	2.165 / 0.144	0.96 / -	0.96 / - [3]	67.085
Middletown WWTP	48.29	40.22	488.21	78.94	4.96 / 0.037	8.021 / 0.037			75.912
Armco 001[4] (New Miami)	38.74	11.02	168.26	27.21					
Hamilton WWTP	34.0	38.21	568.30	91.89	3.32 / 0.036	7.414 / 0.036			84.093
Fairfield WWTP	32.0	9.28	577.58	93.40	0.95 / 0.040	2.0 / 0.04			86.093

1 Annual average discharge data (1980).
2 Adjusted to meet WQS.
3 Existing permit limitations retained.
4 Also refer to Addendum.

000392

6399


Pb Allocation
o Present Permit Limit
x Existing Effluent Quality
Assimilation Capacity
Allocated Load
Pb (lbs/day)
100
80
60
40
20
90
80
70
60
50
40
30
20
RIVER MILE
Mad River
Dayton WWTP
Montgomery Co. WWTP
Franklin WWTP
Middletown WWTP
Hamilton WWTP
Fairfield WWTP

000393

Zn Allocation[5]

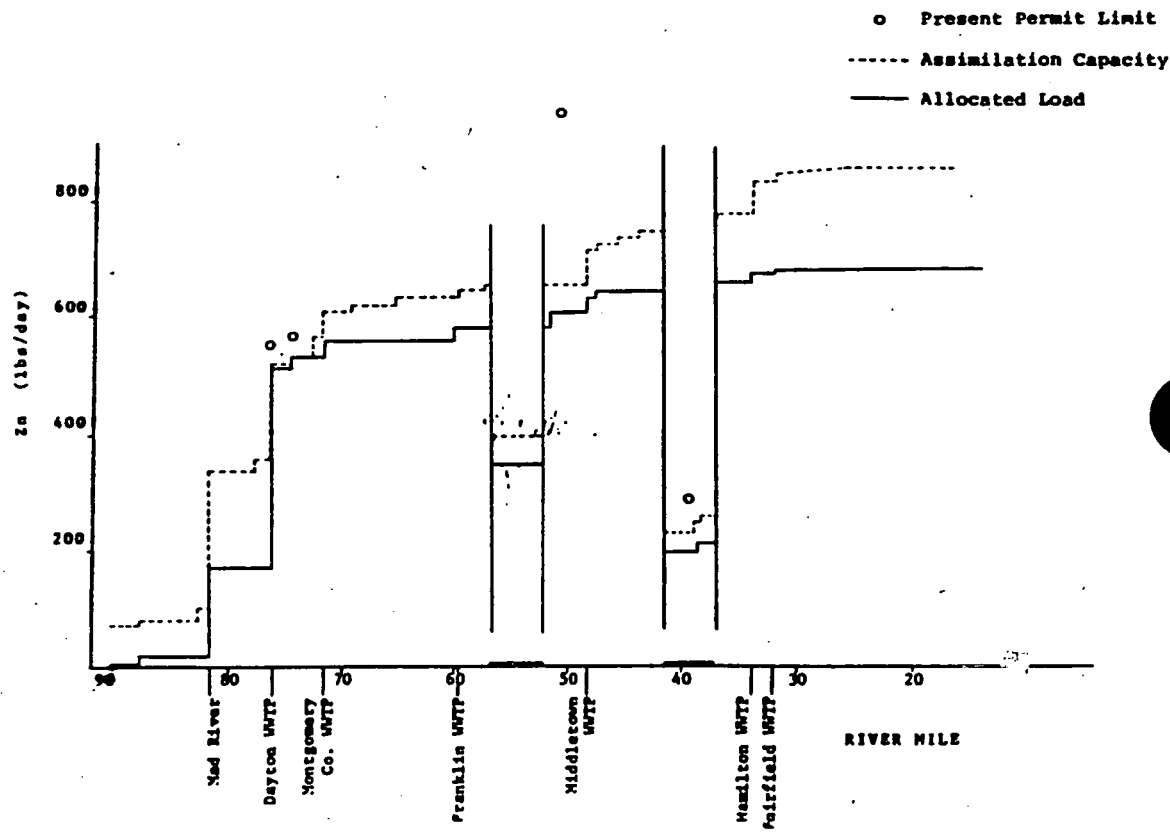
Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day) / (mg/l) EEQ	Load (lbs/day) / (mg/l) Critical Flow	Permit (lbs/day) / (mg/l)	Allocated (lbs/day) / (mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0	74.11		3.504 / 0.013			3.504
Ohio Suburban WWTP	87.45	6.19	56.19	83.29	7.064 / 0.273	9.108 / 0.273			12.612
Mad River	81.48	160.85	232.04	343.94		168.70 / 0.195			182.282
Dayton WWTP	76.11	111.38	358.26	531.03	255.72 / 0.545	327.18 / 0.545	- / 0.60	339.73 / 0.566 [2]	522.678
GM Delco - Air #3	74.42	5.34	363.60	538.95	12.72 / 0.482	13.873 / 0.482	18.61 / 0.6	9.70 / - [4]	532.378
Montgomery Co. W. Regional WWTP	71.48	30.94	417.84	619.34	17.749 / 0.204 [1]	34.02 / 0.204			568.959
Armco (Middletown)[5] 001	51.45	28.2	447.69	663.59		25.384 / 0.167	370.0 / -	23.95 / - [3]	599.164
(613)		(1.56)			7.004 / 1.857 [1]	15.614 / 1.857			
Middletown WWTP	48.29	40.22	488.21	723.65	17.85 / 0.142	30.784 / 0.142			629.948
Dicks Creek	47.61	3.0	495.23	734.06	9.265 / 0.573	WQS 4.45 / 0.275			635.698
Armco 001[5] (New Miami)	38.74	11.02	168.26	249.40	13.17 / 0.251	14.909 / 0.251			
(611)		(4.96)			1.635 / 0.377 [1]	10.079 / 0.377	79.0 / -	10.08 / - [3]	211.414

1 Annual average discharge data (1980).
2 Adjusted to meet WQS.
3 EEQ is recommended.
4 Existing permit limitation retained.
5 Also refer to Addendum.

000394

6399

Zn Allocation



000395

Cd Allocation

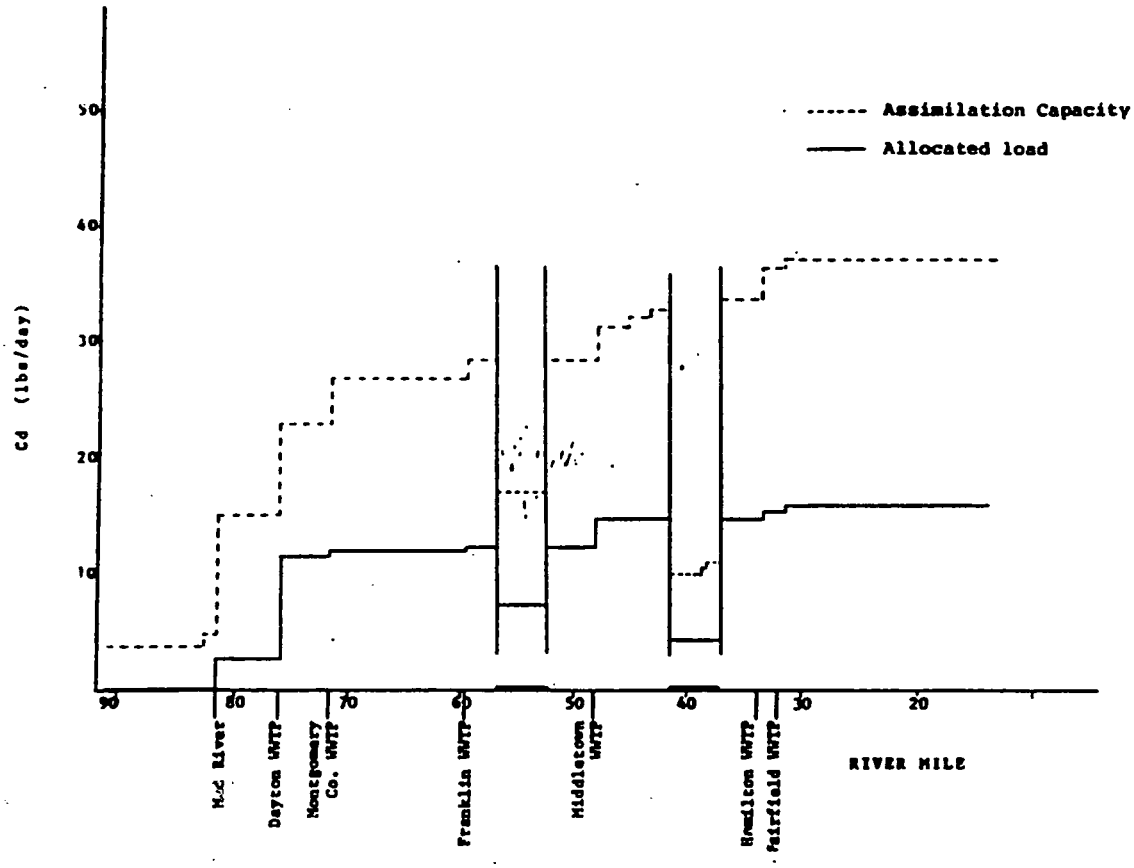
Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0			0.0			0.0
Mad River	81.48	160.85	232.04	15.01		2.40 / 0.003			2.764
Dayton WWTP	76.11	111.38	358.26	23.17	5.35 / 0.012	7.20 / 0.012	- / 0.015	9.0 / 0.015 [1]	11.764
Montgomery Co. W. Regional WWTP	71.48	30.94	417.84	27.03	0.26 / 0.003	0.50 / 0.003			12.098
Mound Lab 001-C	65.90	0.0074	427.12	27.63		0.0032 / 0.08	- / 0.1 max	- / 0.1 max [1]	12.172
Middletown WWTP	48.29	40.22	488.21	31.58	1.76 / 0.011	2.385 / 0.011			14.815
Hamilton WWTP	34.0	38.21	568.30	36.76	0.196 / 0.003	0.618 / 0.003			15.60
Fairfield WWTP	32.0	9.28	577.58	37.36	0.275 / 0.009	0.45 / 0.009			16.05

[1] Existing permit limitation retained (BPJ).

000396

6399

Cd Allocation



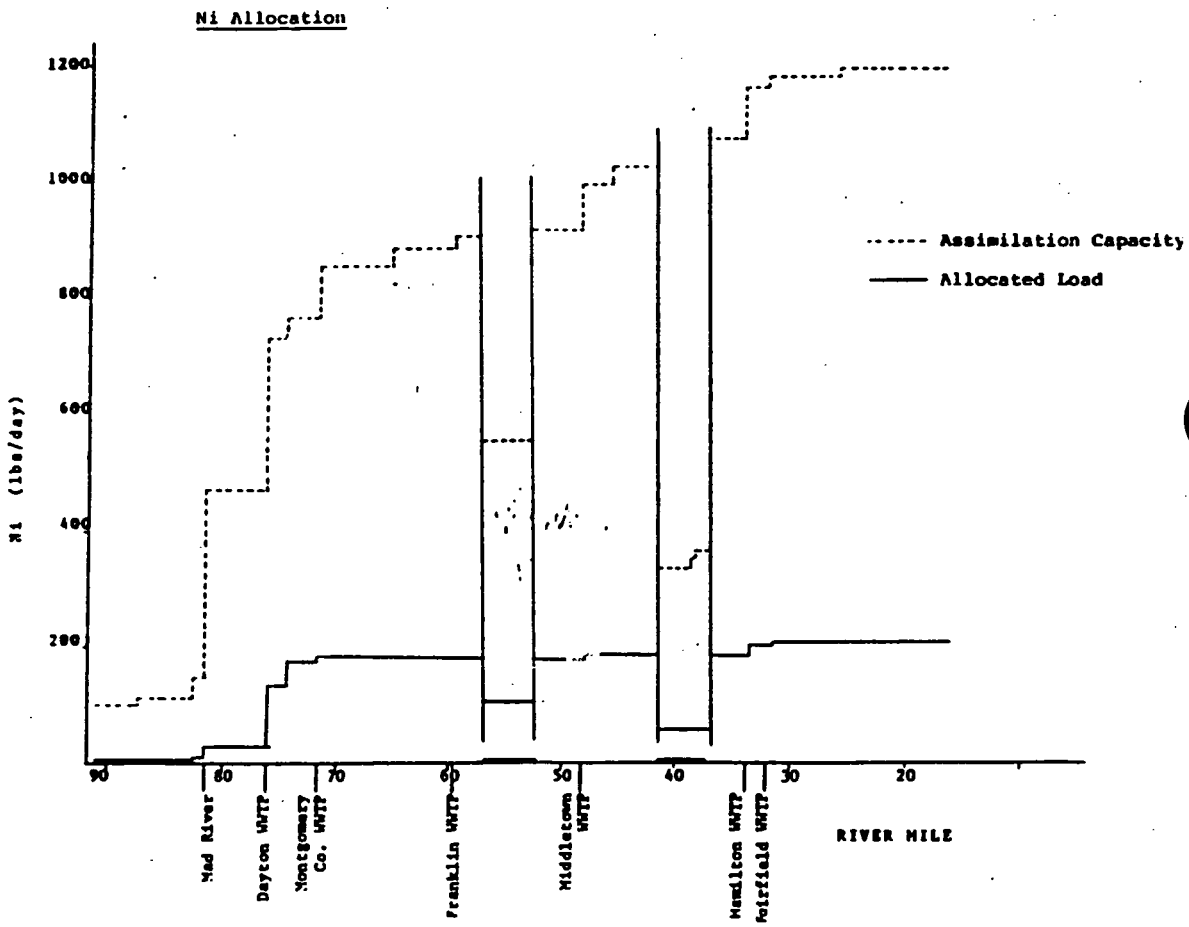
Ni Allocation

Major Contributor	RM	Critical Low Flow (cfs) Source	Critical Low Flow (cfs) Cumul.	Assimil. Capacity (lbs/day)	Load (lbs/day / mg/l) EEQ	Load (lbs/day / mg/l) Critical Flow	Permit (lbs/day / mg/l)	Allocated (lbs/day / mg/l)	Total Allocated (lbs/day)
Upstream (Little York Rd)	91.14		50.0	103.76		7.277 / 0.027			7.277
GM Delco Air #3	74.42	5.34	363.60	754.52	17.54 / 0.664	19.112 / 0.664	17.2 / 0.6	17.2 / 0.6 [1]	169.0
GM Delco Air #2	74.15	11.0	374.60	777.35 / 0.037	2.208 / 0.037	2.194 / -	6.98 / -	6.98 [1]	176.0
Mound Lab 001-C	65.90	0.0074	427.12	886.34		0.008 / 0.195	- / 0.5 max	- / 0.5 max [1]	179.8
USAEC 001 (001B & 001C)	24.73	0.76	584.34	1212.59		0.164 / 0.040	0.273 / -	0.273 / - [1]	212.5

[1] Existing permit limitations retained, even if less than WLA (BPJ).

000398

6399


Ni Allocation
1200
1000
800
600
400
200
Ni (lbs/day)
Assimilation Capacity
Allocated Load
90
80
70
60
50
40
30
20
RIVER MILE
Mad River
Dayton WWTP
Montgomery Co. WWTP
Franklin WWTP
Middletown WWTP
Hamilton WWTP
Fairfield WWTP

000399

APPENDIX B

Municipal/Industrial Discharger Data

Discharger: MCD North Regional WWTP*

Facility Number: 1PD00020001
Permit Number: D620
Receiving Stream (River Mile): GMR (87.47)

Effluent Information:

Parameter (Unit)	1980* Survey	1980 3rd Q* Mean Daily Effluent	Present Permit[1]	Allocated[2]
Flow (MGD)			-	
pH (S.U.)			6.5 - 9.0	
BOD_5 (lbs/day) / (mg/l)			1411.0 / 15.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				3902.0 / 39.0
TSS (lbs/day) / (mg/l)			1690.0 / 18.0	
D.O. (mg/l)			5.0	5.0
NH_3-N (lbs/day) / (mg/l)			S. 141.8 / 1.5 W. 234.8 / 2.5	S. 319.0 / 3.19
Cl_2 (mg/l)			0.5 max.	
F-C (#/100 ml)			S. 1000	
O&G (lbs/day) / (mg/l)			939.2 / 10.0	

*Proposed plant (No existing data).
1. Permit loading limitation was established using a flow of 11.2 MGD
2. Allocated loading limitation was established using a flow of 12.0 MGD

000401

Discharger: Ohio Suburban Water Co. WWTP

Facility Number: 1PS00000001
Permit Number: S600
Receiving Stream (River Mile): GMR (87.45)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present* Permit	Allocated*
Flow (MGD)	4.821	3.3		
T (C)	22.72	20.9	-	
pH (S.U.)	7.0-7.2	7.0	6.5-9.0	
BOD_5 (lbs/day) / (mg/l)	743.2 / 28.60	783.7 / 28.2	534.2 / 16.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				1301.0 / 39.0
TSS (lbs/day) / (mg/l)	424.4 / 16.33	732.5 / 25.9	671.0 / 20.0	
D.O. (mg/l)	4.39	4.0	5.0 min.	5.0
NH_3-N (lbs/day) / (mg/l)	425.3 / 16.37	528.9 / 19.4	S.166.92 / 5.0	257.0 / 7.7
NO_2&NO_3 (lbs/day) / (mg/l)	4.07 / 0.16	21.7 / 0.8		
Cl_2-R (mg/l)	-	0.30	0.5 max.	
P (lbs/day) / (mg/l)	245.5 / 9.48	189.51 / 6.92	33.30 / 1.0	
F-C (#/100 ml)	-	28.3	1000 (summer only)	
O&G (lbs/day) / (mg/l)	-	0.0 / 0.0	-	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Cd (mg/l)	0.001	0.026 / 0.001	-	
Cr (mg/l)	0.040	0.102 / 0.004		
Cu (lbs/day) / (mg/l)	1.809 / 0.045	2.163 / 0.077		
Pb (lbs/day) / (mg/l)	0.121 / 0.003	0.051 / 0.020		
Ni (lbs/day) / (mg/l)	0.804 / 0.020	0.538 / 0.021		
Zn (lbs/day) / (mg/l)	3.22 / 0.080	17.662 / 0.690		

*Permit and allocated loading limitations were established using a design flow (4.0 MGD).

Discharger: Sunny Acres MHP WWTP

Facility Number: 1PV00005001
Permit Number: V605
Receiving Stream (River Mile): GMR (87.31)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present* Permit	Allocated
Flow (MGD)		0.035	0.04	
T (^{o}C)		21.4		
pH (S.U.)		7.25	6.0-9.0	
BOD_5 (lbs/day) / (mg/l)		2.96 / 10.13	10.14 / 30.0	
TSS (lbs/day) / (mg/l)		7.52 / 25.75	10.14 / 30.0	
D.O. (mg/l)		5.53	5.0 min.	
Cl_2-R (mg/l)		0.5	daily max. 0.5	
F-C (#/100 ml)		6278.6	200	

*Permit expired 6-30-1977. Present permit is initial limitations.

Discharger: General Motors Corporation
Delco Moraine Division

Facility Number: 1IN0009600 1
Permit Number: N196
Receiving Stream (River Mile): GMR (84.50)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		1.577	(3.0)	
T (^{o}C)		20.0	-	
pH (S.U.)		7.15	6.5-9.0	
O&G (lbs/day) / (mg/l)		469.5 / 37.50	-	

000405

Discharger: TRW Inc.
Globe Inc. Division

Facility Number: 1IN0003800 1
Permit Number: N138
Receiving Stream (River Mile): GMR (84.50)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.05	-	
T (^{o}C)		31.08	-	
pH (S.U.)		7.50	6.5-9.0	

Discharger: Price Brothers Co.

Facility Number: 1IN00062002
Permit Number: N162
Receiving Stream (River Mile): GMR (84.08)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		24.58	-	
T (^{o}C)		7.57	-	
pH		-	6.5-9.0	
O&G (lbs/day)		0.0	----	
(mg/l)		0.0	20.0	

Discharger: Chrysler Corporation
General Manufacturing Division

6399

Facility Number: 1IN00089002-003
Permit Number: N189
Receiving Stream (River Mile): GMR (81.78)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
002				
Flow (MGD)		1.121	(0.314)	
T (^{o}C)		26.03	daily max. 32.2	
pH (S.U.)		7.88	6.5-9.0	
003				
Flow (MGD)		1.127	(0.472)	
T (^{o}C)		26.03	daily max. 32.2	
pH (S.U.)		8.0	6.5-9.0	

Discharger: General Motors Corporation
Inland Division

Facility Number: 1IN0004000 1
Permit Number: N140
Receiving Stream (River Mile): GMR (79.95)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
001				
Flow (MGD)		0.160	(0.188)	
T (^{o}C)		24.77	-	
pH (S.U.)		8.0	6.0-9.0	
003				
Flow (MGD)		0.010	(0.045)	
T (^{o}C)		25.33	-	
pH (S.U.)		8.33	6.0-9.0	
004				
Flow (MGD)		0.103	(0.036)	
T (^{o}C)		27.0	-	
pH (S.U.)		7.83	6.0-9.0	
005				
Flow (MGD)		0.020	(0.034)	
T (^{o}C)		25.33	-	
pH (S.U.)		8.17	6.0-9.0	

000409

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
006				
Flow (MGD)		0.010	(0.134)	
T (^{o}C)		28.33	-	
pH (S.U.)		8.33	6.0-9.0	
007				
Flow (MGD)		0.010	(0.04)	
T (^{o}C)		27.0	-	
pH (S.U.)		7.83	6.0-9.0	
008				
Flow (MGD)		0.098	(0.14)	
T (^{o}C)		25.85	-	
pH (S.U.)		8.33	6.0-9.0	
010				
Flow (MGD)		0.010	(0.12)	
T (^{o}C)		24.33	-	
pH (S.U.)		8.33	6.0-9.0	

Discharger: Howard Paper Mills Inc.

Facility Number: 1IN0006000 1
Permit Number: N160
Receiving Stream (River Mile): GMR (79.75)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.240	(0.350)	
T (^{o}C)		19.61	23.0	
pH (S.U.)		7.12	6.5-9.0	

Discharger: Standard Register Co.

Facility Number: 1IN0003500l
Permit Number: N135
Receiving Stream (River Mile): GMR (79.24)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		5.028	(0.226)	
T (^{o}C)		19.65	25.0	
pH (S.U.)		2.49	6.5-9.0	

Discharger: General Motors Corporation
Delco Moraine Division

Facility Number: 1IN00030001-003
Permit Number: N130
Receiving Stream (River Mile): 001 - GMR (77.45)
002 - GMR (77.48)
003 - GMR (77.47)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
001				
Flow (MGD)			(0.109)	
T (^{o}C)			-	
pH (S.U.)			6.5-9.0	
002				
Flow (MGD)	2.824	2.689	(1.38)	
T (^{o}C)	20.45	21.33	-	
pH (S.U.)	7.48	7.21	6.5-9.0	
003				
Flow (MGD)	2.85	-	(4.48)	
T (^{o}C)	21.8	18.97	-	
pH (S.U.)	7.96	7.02	6.5-9.0	

000413

Discharger: Dayton Power & Light
(Tait Station)

Facility Number: 1IB00003001-004
Permit Number: B103
Receiving Stream (River Mile): 001 - GMR (77.49)
002 - GMR (77.33)
003 - GMR (77.43)
004 - GMR (77.57)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
001				
Flow (MGD)		196.139	(205.90)	
T (°C)		30.85	-	
Cl_2-R (mg/l)		0.228	0.2	
002				
Flow (MGD)	4.91	3.372	(1.90)	
pH (S.U.)	7.68	7.57	6.0 - 9.0	
TSS (lbs/day) / (mg/l)	54.45 / 1.33	185.7 / 6.52	---- / 30.0	
O&G (lbs/day) / (mg/l)	-	2.49.1 / 5.51	---- / 15.0	
Fe (lbs/day) / (mg/l)	4.10 / 0.1	19.40 / 0.644	-	
Cu (lbs/day) / (mg/l)	0.61 / 0.015	3.14 / 0.104	-	
As (lbs/day) / (mg/l)	-	0.727	-	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
601				
TSS (lbs/day) / (mg/l)			---- / 30.0	-
Fe (lbs/day) / (mg/l)			---- / 1.0 max.	---- / 1.0
Cu (lbs/day) / (mg/l)			---- / 1.0 max.	---- / 1.0
602				
TSS (lbs/day) / (mg/l)			---- / 30.0	
603				
TSS (lbs/day) / (mg/l)			---- / 30.0	
O&G (lbs/day) / (mg/l)			---- / 15.0	
604				
TSS (lbs/day) / (mg/l			---- / 30.0	
O&G (lbs/day) / (mg/l)			---- / 15.0	
Fe (lbs/day) / (mg/l)			---- / 1.0 max.	---- / 1.0
Cu (lbs/day) / (mg/l)			---- / 1.0 max.	---- / 1.0
003				
Flow (MGD)		0.039	(0.005)	
pH (S.U.)		8.40	6.0-9.0	
TSS (lbs/day) / (mg/l)		22.92 / 245.0	---- / 50.0 max.	
004				
Flow (MGD)		0.005	-	

Discharger: Dayton Walther Corporation

Facility Number: 1IN00037001-003
Permit Number: N137
Receiving Stream (River Mile): GMR (77.24)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
001				
Flow (MGD)	-	0.232	0.996	
T (°C)	23.52	20.27	32.2	
pH (S.U.)	7.0	6.70	6.5-9.0	
TSS (lbs/day)	----	4.65	156.1	
(mg/l)	11.5	37.00	-	
002				
Flow (MGD)		0.157	-	
T (°C)		18.21	32.2	
pH (S.U.)		7.46	6.5-9.0	
003				
Flow (MGD)		0.014	-	
T (°C)		23.27	32.2	
pH (S.U.)		7.05	6.5-9.0	

Discharger: Monsanto Research Corporation

Facility Number: 1IN00008001
Permit Number: N108
Receiving Stream (River Mile): GMR (77.03)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.450	(0.504)	
T (^{o}C)		69.51	32.2	
pH (S.U.)		7.39	6.0-9.0	

Discharger: Dayton WWTP

Facility Number: 1PF00000001
Permit Number: F600
Receiving Stream (River Mile): GMR (76.11)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit 1	Allocated 2
Flow (MGD)	58.587	60.751		
T (°C)	26.56	26.13		
pH (S.U.)	7.2	7.13	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				9007.0 / 15.0
BOD_5 (lbs/day) / (mg/l)	15159.0 / 31.03	18003.0 / 35.21	7136.7 / 10.0	
TSS (lbs/day) / (mg/l)	8873.9 / 18.0	23418.0 / 45.79	8563.0 / 12.0	
D.O. (mg/l)	6.22	7.36	5.0	6.0
NH_3-N (lbs/day) / (mg/l)	7167.0 / 14.67	6228.0 / 11.44	S. 713.2 / 1.0 W. 1427.0 / 2.0	600.5 / 1.0
NO_2-N (lbs/day) / (mg/l)		303.0 / 0.62	-	
NO_3-N (lbs/day) / (mg/l)	(NO_2&NO_3) 385.9 / 0.79	573.8 / 1.14	-	
Cl_2-R (mg/l)		0.28	0.5 (Summer only)	
P (lbs/day) / (mg/l)	2255.0 / 4.61	2435.0 / 4.81	--- / 1.0	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
F-C (#/100 ml)	-	31.0	1000 (Summer only)	
O&G (lbs/day) / (mg/l)	-	3955.4 / 7.58	---- / 10.0	
Cd (lbs/day) / (mg/l)	1.47 / 0.003	3.07 / 0.059	---- / 0.015	9.0 / 0.015
Cr (lbs/day) / (mg/l)	87.95 / 0.180	160.64 / 0.303	-	92.62 / 0.154
Cu (lbs/day) / (mg/l)	59.61 / 0.122	99.91 / 0.186	---- / 0.100	60.03 / 0.10
Pb (lbs/day) / (mg/l)	10.26 / 0.021	34.36 / 0.643	---- / 0.080	33.0 / 0.055
Ni (lbs/day) / (mg/l)	40.56 / 0.083	56.02 / 0.105	-	-
Zn (lbs/day) / (mg/l)	133.39 / 0.273	152.79 / 0.285	---- / 0.600	339.73 / 0.566

1. Permit loading limitations was established using a flow of 85.0 MGD.
2. Allocated loading limitation was established using a flow of 72.0 MGD. (Permit renewed 10/28/81. WLA analysis for Dayton was based on the previous permit limitations.)

000419

Discharger: General Motors Corporation[a]
Harrison Radiator Division, Moraine North Plant
(Delco Air #3)

Facility Number: 1IC00008001
Permit Number: C108
Receiving Stream (River Mile): GMR (74.42)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated[a]
Flow (MGD)	0.672	0.081	-	
pH (S.U.)	7.57	7.31	6.5-9.0	
COD (lbs/day) / (mg/l)	444.6 / 79.33	791.2 / 132.92	-	
BOD_5 (lbs/day) / (mg/l)	59.42 / 10.6	-	-	
TSS (lbs/day) / (mg/l)	51.93 / 9.33	38.05 / 6.17	---- / 29.0	
D.O. (mg/l)	9.73	5.92	5.0	
P (lbs/day) / (mg/l)	0.99 / 17.67	0.56 / 0.10	29.0 / -	
O&G (lbs/day) / (mg/l)	-	23.74 / 3.77	---- / 10.0	
Cr (lbs/day) / (mg/l)	0.202 / 0.036	0.10 / 0.016	4.29 / -	1.8 / 0.062
Cr^{+6} (lbs/day) / (mg/l)	-	-	0.46 / -	-
Ni (lbs/day) / (mg/l)	0.112 / 0.020	0.06 / 0.010	17.2 / -	17.20 / 0.60
Zn (lbs/day) / (mg/l)	0.235 / 0.042	0.23 / 0.034	9.7 / -	9.70 / -
Fe (lbs/day) / (mg/l)	0.712 / 0.127	0.88 / 0.163	42.8 / -	28.80 / 1.0

[a] Also refer to Addendum.
[b] Allocated loading limitation was established using a flow of (3.45 MGD).

Discharger: General Motors Corporation
Harrison Radiator Division, Moraine South Plant
(Delco Air #2)

Facility Number: 1IC00007001
Permit Number: C107
Receiving Stream (River Mile): GMR (74.15)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit *	Allocated Allocated *
Flow (MGD)	1.229	1.530	(7.11)	
T (°C)	25.83	-	-	
pH (S.U.)	7.67	7.52	6.0-9.0	
TSS (lbs/day) / (mg/l)	78.90 / 7.67	86.16 / 7.92	---- / 17.6	
P (lbs/day) / (mg/l)	4.63 / 0.45	2.13 / 0.20	84.0 / -	
O&G (lbs/day) / (mg/l)	-	40.12 / 3.69	---- / 10.0 daily max.	
Cr (lbs/day) / (mg/l)	0.205 / 0.020	0.17 / 0.016	5.5 / -	2.40 / 0.04
Cr^{+6} (lbs/day) / (mg/l)	-	-	0.59 / -	
Ni (lbs/day) / (mg/l)	0.205 / 0.020	0.27- / 0.025	6.98 / -	6.98 / -
Fe (lbs/day) / (mg/l)	1.66- / 0.162	1.96- / 0.182	-	
Al (lbs/day) / (mg/l)	-	2.19- / 0.200	5.9 / -	

* Permit and allocated loading limitations were established using a design flow (7.11 MGD).

000421

Discharger: Glatfelter Company - Ohio Mill

Facility Number: 1IA00004001
Permit Number: A104
Receiving Stream (River Mile): GMR (72.34)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present* Permit	Allocated*
Flow (MGD)	3.707	3.656	(7.5)	
pH (S.U.)	8.27	8.10	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				5561.0 / 88.9
BOD_5 (lbs/day) / (mg/l)	490.4 / 15.87	658.5 / 21.64	2350.5 / 37.5	
TSS (lbs/day) / (mg/l)	299.2 / 10.0	1054.8 / 31.59	5894.0 / 94.0	
D.O. (mg/l)	6.87	6.71	5.0	5.0
NH_3-N (lbs/day) / (mg/l)	118.12 / 3.82	129.12 / 4.22	163.2 / 2.6	162.6 / 2.6
P (lbs/day) / (mg/l)	20.31 / 0.657	25.94 / 0.84	-	

*Permit and allocated loading limitations were established using a design flow (7.5 MGD).

Discharger: Montgomery County Western Regional WWTP

Facility Number: 1PL00002001
Permit Number: L602
Receiving Stream (River Mile): GMR (71.48)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present* Permit	Allocated*
Flow (MGD)	10.434	10.989	20.0	
T (^{o}C)	24.35	22.77	-	
pH (S.U.)	7.84	-	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				4670.0 / 28.0
BOD_5 (lbs/day) / (mg/l)	121.8 / 1.40	234.4 / 2.49	1668.0 / 10.0	
TSS (lbs/day) / (mg/l)	289.6 / 3.0	284.4 / 3.00	2002.0 / 12.0	
D.O. (mg/l)	7.75	7.74	6.0	6.0
NH_3-N (lbs/day) / mg/l	35.09 / 0.40	25.53 / 0.270	417.0 / 2.5 (Summer only)	417.0 / 2.5
NO_2-N (lbs/day) / (mg/l)	-	6.14 / 0.075	-	
NO_3-N (lbs/day) / (mg/l)	-	772.0 / 8.29	-	
Cl_2-R (mg/l)	-	0.24	0.5 (Summer only)	
P (lbs/day) / (mg/l)	485.5 / 5.40	325.4 / 3.584	167.0 / 1.0	
F-C (#/100 ml)	-	95.4	1000	

000423

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
O&G (lbs/day) / (mg/l)	-	612.4 / 6.92	--- / 20.0 at any time	
Cd (lbs/day) / (mg/l)	0.087 / 0.001	0.26 / 0.003		
Cr (lbs/day) / (mg/l)	3.48 / 0.040	2.04 / 0.019		
Cu (lbs/day) / (mg/l)	1.48 / 0.017	4.38 / 0.044	--- / 0.2 at any time	16.70 / 0.10
Pb (lbs/day) / (mg/l)	0.26 / 0.003	3.53 / 0.037	--- / 0.16 at any time	9.20 / 0.055
Ni (lbs/day) / (mg/l)	1.74 / 0.020	1.21 / 0.027		
Zn (lbs/day) / (mg/l)	1.57 / 0.018	14.98 / 0.138		

*Permit and allocated loading limitations were established using a design flow (20.0 MGD)

Discharger: West Carrollton WWTP

Facility Number: 1PD00014001
Permit Number: D614
Receiving Stream (River Mile): GMR (68.85)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated*
Flow (MGD)	1.037	0.962	-	
T (^{o}C)	21.75	26.19	-	
pH (S.U.)	7.39	7.69	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				1251.0 / 75.0
BOD_5 (lbs/day) / (mg/l)	427.7 / 49.47	431.5 / 53.27	--- / 10.0	
TSS (lbs/day) / (mg/l)	1002.0 / 117.67	502.0 / 57.97	--- / 12.0	
D.O. (mg/l)	1.58	5.85	5.0	2.0
NH_3-N (lbs/day) / mg/l	167.4 / 19.37	77.2 / 9.55	S. --- / 2.5 W. --- / 5.0	S. 150.0 / 15.0
NO_2-N (lbs/day) / (mg/l)	-	102.1 / 12.85	-	
Cl_2-R (mg/l)	-	0.019	0.5 (Summer only)	
P (lbs/day) / (mg/l)	71.18 / 8.23	57.83 / 7.24	-	
F-C (#/100 ml)	-	772.0	1000 (Summer only)	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
O&G (lbs/day) / (mg/l)	-	0.00 / 0.00	-	
Cd (lbs/day) / (mg/l)	0.009 / 0.001	0.042 / 0.005	-	
Cr (lbs/day) / (mg/l)	0.75 / 0.087	0.23 / 0026		
Cu (lbs/day) / (mg/l)	2.006 / 0.232	0.63 / 0.072		
Pb (lbs/day) / (mg/l)	0.095 / 0.011	0.30 / 0.033		
Ni (lbs/day) / (mg/l)	0.17 / 0.020	0.18 / 0.020		
Phenol (lbs/day) / (mg/l)	397.37 / 0.046	-		

*Allocated loading limitation was established using a design flow (1.2 MGD)

Discharger: Interstate Folding Box Co.
Miamisburg Box Board Div.

Facility Number: 1IA00005001
Permit Number: A105
Receiving Stream (River Mile): GMR (67.49)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated*
Flow (MGD)	0.777	-		
pH (S.U.)	7.7	7.84	6.0-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				496.8 / 170.0
BOD_5 (lbs/day) / (mg/l)	492.39 / 76.0	146.31 / 187.2	301.0 / -	
TSS (lbs/day) / (mg/l)	93.94 / 14.5	70.14 / 89.6	700.0 / -	
D.O. (mg/l)	6.4	6.7	5.0 min.	5.0
NH_3-N (lbs/day) / (mg/l)	0.19 / 0.03	-	--- / 2.5	7.31 / 2.5
NO_2&NO_3 (lbs/day) / (mg/l)	0.39	-	-	
P (lbs/day) / (mg/l)	0.68 / 0.10			

*Allocated loading limitation was established using a design flow (0.35 MGD).

000427

Discharger: USAEC Mound Laboratory (DOE)

Facility Number: OH0009857 (001)
Permit Number:
Receiving Stream (River Mile): GMR (65.90)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
001-A				
Flow (MGD)		0.130	(0.13)	
T (^{o}C)		17.1	-	
pH (S.U.)		5.3 min.	6.5-9.0	
BOD (lbs/day) / (mg/l)		---- / 2.6	---- / 10.00	pp
TSS (lbs/day) / (mg/l)		---- / 10.7	---- / 15.00	
Cl_2-R (mg/l)		0.15	-	
F-C (#/100 ml)		-	1000	
001-B				
Flow (MGD)			(0.10)	
pH (S.U.)			6.5-9.0	
COD (lbs/day) / (mg/l)			-	
TSS (lbs/day) / (mg/l)			7.5	
Cl_2-R (mg/l)			0.02	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
O&G (lbs/day) (mg/l)			10.0	
001-C				
Cd (lbs/day) (mg/l)			daily max. (0.1)	pp
Cr (lbs/day) (mg/l)			daily max. (0.5)	pp
Cu (lbs/day) (mg/l)			daily max. (0.5)	pp
Ni (lbs/day) (mg/l)			daily max. (0.5)	pp
CN (lbs/day) (mg/l)			daily max. (1.0)	pp
002				
Flow (MGD)			(0.6)	
pH (S.U.)			6.5-9.0	
TSS (lbs/day) (mg/l)			15	
Cl_2-R (mg/l)			(0.02)	
O&G (lbs/day) (mg/l)			(10.0)	

pp Present permit limitation.

Discharger: Miamisburg WWTP

Facility Number: 1PD00017001
Permit Number: D617
Receiving Stream (River Mile): GMR (65.05)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated*
Flow (MGD)	1.657	1.829	-	
T (°C)	24.25	23.40	-	
pH (S.U.)	7.63	7.59	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				2502.0 / 75.0
BOD_5 (lbs/day) / (mg/l)	122.5 / 8.87	128.6 / 8.30	---- / 20.0	
TSS (lbs/day) / (mg/l)	96.74 / 7.0	134.3 / 8.75	---- / 20.0	
D.O. (mg/l)	5.40	5.85	5.0	2.0
NH_3-N (lbs/day) / (mg/l)	302.1 / 21.87	296.5 / 19.26	S. ---- / 2.5 W. ---- / 5.0	S. 500.0 / 15.0
NO_2-N (lbs/day) / (mg/l)	-	1.44 / 0.08	-	
NO_3-N (lbs/day) / (mg/l)	3.13 / 0.23	13.30 / 0.84	-	
Cl_2-R (mg/l)	-	0.495	0.5 (Summer only)	
P (lbs/day) / (mg/l)	82.87 / 5.99	78.47 / 5.060	-	
F-C (#/100 ml)	-	403.0	-	
O&G (lbs/day) / (mg/l)	-	225.3 / 14.00	1000 (Summer only)	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Cu (lbs/day)	0.595	0.40	-	
(mg/l)	0.018	0.021		
Ni (lbs/day)	1.323	0.27	-	
(mg/l)	0.040	0.014		
Zn (lbs/day)	0.89	0.40	-	
(mg/l)	0.027	0.021		

*Allocated loading limitation was established using a design flow (4.0 MGD)

000431

Discharger: Dayton Power and Light Company
Hutchings Station

Facility Number: 1PB00004001
Permit Number: B104
Receiving Stream (River Mile): 001 - GMR (64.37)
002 - GMR (65.01)
004 - GMR (64.69)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
001				
Flow (MGD)		213.969	(235.0)	
T (^{o}C)		32.84	-	
Cl_2-R (mg/l)		0.10	0.2	
002				
Flow (MGD)	2.83	1.826	(1.7)	
pH (S.U.)	7.77	8.0	6.0-9.0	
TSS (lbs/day) / mg/l	78.34 / 3.70	153.7 / 9.93	- / 30.0	
O&G (lbs/day) / mg/l	-	33.50 / 3.0	- / 15.0	
Cu (lbs/day) / mg/l	0.779 / 0.033	1.00 / 0.079	-	
Fe (lbs/day) / mg/l	2.29 / 0.097	4.49 / 0.343	-	
As (lbs/day) / mg/l	-	0.35 / 0.032	-	
004				
Flow (MGD)	-	0.003	(0.005)	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
pH (S.U.)		7.53	6.0-9.0	
BOD_5 (lbs/day) / (mg/l)		0.24 / 6.83	- / 30.0	
TSS (lbs/day) / (mg/l)		0.31 / 9.92	- / 30.0	
Cl_2-R (mg/l)		1.76	-	
F-C (#/100 ml)		48.43	200	

000433

Discharger: Springboro - Chautauqua WTP

Facility Number:
Permit Number: Y1200
Receiving Stream (River Mile): GMR (62.29)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.470		
Fe, (lbs/day)		40.93		
susp. (mg/l)		10.40		
Mn, (lbs/day)		2.38		
susp. (mg/l)		0.55		

Discharger: River Arms Apartment and Laundromat WWTP

Facility Number: 1PW00002001
Permit Number: W602
Receiving Stream (River Mile): GMR (61.13)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.003	-	
pH (S.U.)		6.5	6.0-9.0	
BOD_5 (mg/l)		0.09 / 5.50	5.07 / 30.0	
TSS (lbs/day) / (mg/l)		0.30 / 11.50	5.07 / 30.0	
D.O. (mg/l)		-	6.0	
F-C (#/100 ml)		-	200.0	

000435

Discharger: River Arms Apartments WWTP

Facility Number: 1PW00000001
Permit Number: W600
Receiving Stream (River Mile): GMR (61.00)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		-	0.015	
pH (S.U.)		7.00	6.0-9.0	
BOD_5 (lbs/day)		0.39	3.75	
(mg/l)		10.00	30.0	
TSS (lbs/day)		1.56	3.75	
(mg/l)		28.00	30.0	
D.O. (mg/l)		7.53	6.0	
F-C (#/100 ml)		-	200	

Discharger: Phillips Petroleum Company

Facility Number: 1IG00007001
Permit Number: G107
Receiving Stream (River Mile): GMR (60.32)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		-	(0.02)	
pH (S.U.)		7.13	6.0-9.0	
O&G (lbs/day) / (mg/l)		- / 9.67	- / 10.0	

Discharger: Franklin Regional WWTP

Facility Number: 1PD00004001
Permit Number: D604
Receiving Stream (River Mile): GMR (59.65)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)	3.460	3.938	(4.5)	
T (^{o}C)	24.73	25.63		
pH (S.U.)	7.55	7.66	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				3246.0 / 86.5
BOD_5 (lbs/day) / (mg/l)	291.4 / 10.10	591.3 / 17.41	1877.0 / 50.0	
TSS (lbs/day) / (mg/l)	259.7 / 9.0	1334.0 / 38.44	1877.0 / 50.0	
D.O. (mg/l)	2.33	6.66	5.0	pp
NH_3-N (lbs/day) / (mg/l)	70.98 / 2.46	302.20 / 9.06	94.0 / 2.5	pp
NO_2&NO_3 (lbs/day) / (mg/l)	56.84 / 1.97	63.41 / 2.06	-	
Cl_2-R (mg/l)	-	0.25	0.5 max. (Summer only)	
P (lbs/day) / (mg/l)	12.5 / 0.42	40.55 / 1.19	38.0 / 7.0	
F-C (#/100 ml)	-	276.0	1000.0 (Summer only)	
O&G (lbs/day) / (mg/l)	-	0.00 / 0.00	-	
Cd (lbs/day) / (mg/l)	0.045 / 0.001	0.13 / 0.004	-	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Cr (lbs/day)	1.79	0.45	-	
(mg/l)	0.040	0.014		
Cu (lbs/day)	0.89	0.81	-	
(mg/l)	0.020	0.025		
Pb (lbs/day)	0.134	1.03	-	
(mg/l)	0.003	0.032		
Ni (lbs/day)	0.089	0.89	-	
(mg/l)	0.020	0.027		
Zn (lbs/day)	2.59	2.68	-	
(mg/l)	0.058	0.078		

pp Present permit limitation.

000439

Discharger: Armco Steel (Middletown)[a]

Facility Number: 1ID00001001
Permit Number: D101
Receiving Stream (River Mile): GMR (51.45)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present* Permit	Allocated*
001 - Combined outfalls 611, 612, 613				
Flow (MGD)	18.0		(18.2)	-
T (^{o}C)	23.75			-
BOD_5 (lbs/day)	1436.0		1516.0	-
(mg/l)	9.57		-	
TSS (lbs/day)	4253.0		-	-
(mg/l)	28.33			
Pb (lbs/day)	0.60		-	-
(mg/l)	0.004			
Zn (lbs/day)	25.07		370.0	23.95
(mg/l)	0.167		-	-
611				
pH (S.U.)			6.0-9.0	-
TSS (lbs/day)			416.0	-
(mg/l)))			-	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
O&G (lbs/day) / (mg/l)			147.0 / -	-
Pb (lbs/day) / (mg/l)			0.96 / -	0.96 / -
Fe (lbs/day) / (mg/l)			121.0 / -	16.60 / 1.10
612				
Flow (MGD)		0.620	-	
pH (S.U.)		7.67	6.0-9.0	
BOD_5 (lbs/day) / (mg/l)		59.38 / 11.33	-	
TSS (lbs/day) / (mg/l)		61.80 / 10.50	- / 30.0	
O&G (lbs/day) / (mg/l)		25.17 / 4.60	-	
Pb (lbs/day) / (mg/l)		0.27 / 0.056	-	
Fe (lbs/day) / (mg/l)		3.10 / 0.484	-	
613				
Flow (MGD)		0.383	-	
pH (S.U.)		6.07	6.0-9.0	
BOD_5 (lbs/day) / (mg/l)		39.77 / 3.11	-	
TSS (lbs/day) / (mg/l)		210.3 / 53.10	414.0 / -	
NH_3-N (lbs/day) / (mg/l)		43.06 / 15.54	528.0 / -	pp
O&G (lbs/day) / (mg/l)		16.72 / 5.10	138.0 / -	

000441

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Zn (lbs/day) / (mg/l)		13.98 / 3.725	-	
Phenol (lbs/day) / (mg/l)		-	25.9 / -	
CN (lbs/day) / (mg/l)		2.10 / 0.847	63.0 / -	

a Also refer to Addendum.
* Permit and allocated loading limitations were established using a design flow (18.2 MGD).
pp Present permit limitation.

Discharger: Middletown WWTP

Facility Number: 1PE00003001
Permit Number: E603
Receiving Stream (River Mile): GMR (48.29)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit[1]	Allocated[2]
Flow (MGD)	18.31	21.786	(48.0)	
T (°C)	21.22	21.11	-	
pH (S.U.)	-	7.09	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				5898.4 / 27.2
BOD_5 (lbs/day) / (mg/l)	972.2 / 6.37	2799.0 / 15.19	12128.0 / 30.0	
TSS (lbs/day) / (mg/l)	560.4 / 3.67	1013.0 / 5.67	12128.0 / 30.0	
D.O. (mg/l)	3.33	-	-	5.0
NH_3-N (lbs/day) / (mg/l)	168.0 / 1.10	227.5 / 1.23	3308.0 / 8.0 (Summer only)	1735.0 / 8.0
NO_2-N (lbs/day) / (mg/l)	-	228.4 / 1.27	-	
NO_3-N (lbs/day) / (mg/l)	(NO_2&NO_3) 540.0 / 3.54	338.5 / 1.82	-	
Cl_2-R (mg/l)	-	0.103	0.5 D. max. S. only	
P (lbs/day) / (mg/l)	27.95 / 0.183	-	-	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
PO_4 (lbs/day) / (mg/l)	-	30.56 / 0.163	-	
F-C (#/100 ml)	-	280.6	1000	
O&G (lbs/day) / (mg/l)	-	508.2 / 2.67	-	
Cd (lbs/day) / (mg/l)	0.153 / 0.001	2.55 / 0.0133	-	
Cr (lbs/day) / (mg/l)	3.054 / 0.020	1.75 / 0.010	-	
Cu (lbs/day) / (mg/l)	0.458 / 0.003	1.48 / 0.008	-	
Pb (lbs/day) / (mg/l)	0.458 / 0.003	3.31 / 0.018	-	
Ni (lbs/day) / (mg/l)	3.054 / 0.020	2.89 / 0.016	-	
Zn (lbs/day) / (mg/l)	12.98 / 0.085	15.80 / 0.091	-	
CN (lbs/day) / (mg/l)	7.50 / 0.076	13.04 / 0.081	- / 0.650	
Phenol (lbs/day) / (mg/l)	0.916 / 0.006	-	- / 0.10	

1. Permit loading limitation was established using a flow of 48.0 MGD (old design flow).

2. Allocated loading limitation was established using a flow of 26.0 MGD (new design flow).

Discharger: Crystal Tissue

Facility Number: 1IA00000001
Permit Number: A100
Receiving Stream (River Mile): GMR (48.10)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)	2.376	2.342	-	
T (°C)	30.73	32.15	-	
pH (S.U.)	7.77	7.51	6.5-9.0	
$CBOD_{20}$ (lbs/day)				780.0
(mg/l)				36.0
BOD_5 (lbs/day)	697.4	465.2	557.9	
(mg/l)	35.20	22.64	-	
TSS (lbs/day)	1196.0	386.4	696.9	
(mg/l)	60.33	18.75	-	
D.O. (mg/l)	5.27	5.54	-	
NH_3-N (lbs/day)	1.06	2.87	-	
mg/l	0.05	0.15		
NO_2&NO_3 (lbs/day)	0.46	-	-	
(mg/l)	0.02			
P (lbs/day)	5.55	-	-	
(mg/l)	0.28			

000445

Discharger: LeSourdsville Regional WWTP

Facility Number: 1PK00011001
Permit Number: K611
Receiving Stream (River Mile): GMR (45.65)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)	1.59	1.774	4.0	
T (°C)	20.56	20.81	-	
pH (S.U.)	-	7.09	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				671.0 / 20.1
BOD_5 (lbs/day) / (mg/l)	60.56 / 4.57	73.84 / 4.70	334.0 / 10.0	
TSS (lbs/day) / (mg/l)	61.93 / 4.67	80.30 / 4.90	400.0 / 12.0	
D.O. (mg/l)	8.55	8.02	6.0 min.	83.5 / 2.5
NH_3-N (lbs/day) / (mg/l)	5.44 / 0.41	10.27 / 0.71	S. 33.0 / 2.5	2.5
NO_2-N (lbs/day) / (mg/l)	-	3.51 / 0.22	-	
NO_3-N (lbs/day) / (mg/l)	(NO_2&NO_3) 123.2 / 9.29	84.58 / 5.56	-	
Cl_2-R (mg/l)	-	0.365	daily max. 0.50	
P (lbs/day) / (mg/l)	119.6 / 9.02	51.57 / 3.87	33.0 / 1.0	
F-C (#/100 ml)	-	206.	1000	

pp Present permit limitation.

Discharger: Miller Brewery*

Facility Number:
Permit Number:
Receiving Stream (River Mile): GMR (43.80)

Effluent Information:

Parameter (Unit)	1980* Survey	1980 3rd Q* Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)			(6.1)	
$CBOD_{20}$ (lbs/day)				4579.0
(mg/l)				-
BOD_5 (lbs/day)			-	
(mg/l)			45.0	

*Proposed plant (no existing data).

000447

6399

Discharger: Butler County - Brentwood Estates

Facility Number: 1PG00049001
Permit Number: G649
Receiving Stream (River Mile): GMR (42.25)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present* Permit	Allocated
Flow (MGD)		-	(0.045)	
T (^{o}C)		24.92	-	
pH (S.U.)		7.41	6.5 - 9.0	
$CBOD_{20}$ (lbs/day) / mg/l				9.4 / 25.0
BOD_5 (lbs/day) / (mg/l)		- / 10.2	3.75 / 12.0	
TSS (lbs/day) / (mg/l)		- / 35.6	3.75 / 12.0	
D.O. (mg/l)		5.80	3.0 min.	pp
NH_3-N (lbs/day) / (mg/l)		- / 10.7	S. 0.66 / 1.5	pp

* Permit loading limitation was established using a design flow (0.045 MGD).
pp Present permit limitation.

000448

Discharger: Armco Steel (New Miami)[a]

Facility Number: 1ID00002001 & 004
Permit Number: D102
Receiving Stream (River Mile): 001 - GMR (38.74)
002 - GMR (39.0)
003 - GMR (39.30)
004 - GMR (39.38)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present** Permit	Allocated**
001 (611 & 621)				
T (°C)	23.67	26.96	-	
611				
T (°C)	-	-	-	
pH (S.U.)	-	-	-	
$CBOD_{20}$ (lbs/day) / (mg/l)				606.0 / 10.2
BOD_5 (lbs/day) / (mg/l)	290.5 / 5.10	-	525.0 / -	
TSS (lbs/day) / (mg/l)	1139.0 / 20.0	-	132.0 / -	
NH_3-N (lbs/day) / (mg/l)	57.14 / 1.0	-	331.0 / -	pp
O&G (lbs/day) / (mg/l)	-	-	263.0 / -	
Zn (lbs/day) / (mg/l)	2.85 / 0.05	-	79.0 / -	10.08 / -
Fe-diss. (lbs/day) / (mg/l)	(Fe-total) 34.92 / 0.613	-	120.0 / -	
Phenol (lbs/day) / (mg/l)	2.11 / 0.037	-	10.7 / -	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
CN (lbs/day) / mg/l	2.05 / 0.036	-	40.0 / -	
621				
T (^{o}C)		-	-*	
pH (S.U.)		-	-	
O&G (lbs/day) / mg/l		-	240.0 / -	
002				
Flow (MGD)		0.062	-	
T (^{o}C)		-	-	
pH (S.U.)		7.43	6.0-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				18.1 / 42.0
BOD_5 (lbs/day) / (mg/l)		0.0 / 0.0	- / 30.0	
TSS (lbs/day) / (mg/l)		10.74 / 22.0	- / 30.0	
NH_3-N (lbs/day) / (mg/l)		3.26 / 7.23	- / 5.0	pp
F-C (#/100 ml)		4.8	200	
003				
Flow (MGD)		0.30		
T (^{o}C)		24.87		
pH (S.U.)		7.17		
004				
Flow (MGD)	10.767	7.799	-	
T (^{o}C)	23.42	26.08	-	
pH (S.U.)	-	7.58	6.0-9.0	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
TSS (lbs/day)	2245.0	5784.0	127.0	
(mg/l)	25.0	96.25	-	
NH_3-N (lbs/day)	131.4	52.01	317.5	pp
(mg/l)	1.46	1.05	-	
O&G (lbs/day)	-	173.5	37.93	
(mg/l)		2.75	-	
Phenol (lbs/day)	1.796	13.6	5.29	
(mg/l)	0.02	0.022		
CN (lbs/day)	10.87	-	-	
(mg/l)	0.121			

[a] Also refer to Addendum.

* The effluent temperature cannot exceed upstream temperature by more than 8.3°C in May thru September or by 12.8°C in October thru April.

** Permit and allocated loading limitation were established using design flo

pp Present permit limitation.

000451

Discharger: Hamilton North WTP

Facility Number: 1PW00061001
Permit Number: W1061
Receiving Stream (River Mile): GMR (38.61)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.045	-	
pH (S.U.)		10.42		
TSS (lbs/day)		12645.0		
(mg/l)		37429.0		

Discharger: New Miami WWTP*

Facility Number:
Permit Number:
Receiving Stream (River Mile): GMR (37.62)

Effluent Information:

Parameter (Unit)	1980* Survey	1980 3rd Q* Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)			(2.12)	
$CBOD_{20}$ (lbs/day) / (mg/l)				663.0 / 37.5
NH_3-N (lbs/day) / (mg/l)				88.4 / 5.0
D.O. mg/l				5.0

*Proposed plant (no existing data).

000453

Discharger: Hamilton Municipal Electric Co.

Facility Number: 1IB00008001
Permit Number: B108
Receiving Stream (River Mile): 002 - GMR (37.12)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
002				
Flow (MGD)		0.050		
pH (S.U.)		6.69	6.0 - 9.0	
TSS (lbs/day) / (mg/l)		0.0 / 0.0	- / 30.0	
O&G (lbs/day) / (mg/l)		1.42 / 3.50	- / 15.0	
607, 608, 609*				
Cu (lbs/day) / (mg/l)			- / 1.0	
Fe (lbs/day) / (mg/l)			- / 1.0	

* 607, 608 and 609 are just condenser cooling water. Therefore, they should be replaced by 611, 612 and 613 (boiler blowndown) for Cu and Fe limitation.

611, 612, 613				
Cu (lbs/day) / (mg/l)			- / 1.0	- / 1.0
Fe (lbs/day) / (mg/l)			- / 1.0	- / 1.0

Discharger: Champion Papers

Facility Number: 1IA00009002 & 003
Permit Number: A109
Receiving Stream (River Mile): 002 - GMR (36.75)
003 - GMR (38.85)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
002 (cooling water)				
Flow (MGD)		7.464	-	
T (^{o}C)		28.30	-	
pH (S.U.)		7.17	6.5-9.0	
003 (cooling water)				
Flow (MGD)	0.273	0.333	-	
T (^{o}C)	25.3	24.12	-	
pH (S.U.)	8.35	7.0	6.5-9.0	

Discharger: Hamilton Die Casting Co.

Facility Number: 1IN0007600l
Permit Number: N176
Receiving Stream (River Mile): GMR (34.27)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.058	(0.055)	
			daily max.	
T (^{o}C)		23.98	32.2	
pH (S.U.)		7.57	6.0-9.0	
TSS (lbs/day)		1.69	-	
(mg/l)		3.33	30.0	
O&G (lbs/day)		3.18	-	
(mg/l)		6.33	10.0	

Discharger: Mosler Safe Co.
Hamilton Plant No. 2

Facility Number: 1IN00087001
Permit Number: N187
Receiving Stream (River Mile): GMR (34.06)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.003	(0.025)	
			daily max.	
T (^{o}C)		13.35	32.2	
pH (S.U.)		7.0	6.0-9.0	
Ni-diss. (lbs/day)		0.0	0.21	
(mg/l)		0.005	-	

Discharger: Hamilton WWTP

6399.

Facility Number: 1PE00002001
Permit Number: E602
Receiving Stream (River Mile): GMR (34.0)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present* Permit	Allocated
Flow (MGD)	16.18	17.877	(24.7)	
T (°C)	-	27.34	-	
pH (S.U.)	-	7.22	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				15450.0 / 75.0
BOD_5 (lbs/day) / (mg/l)	656.7 / 4.87	808.1 / 5.50	6180.0 / 30.0	
TSS (lbs/day) / (mg/l)	1394.0 / 10.33	1307.0 / 8.89	6180.0 / 30.0	
D.O. (mg/l)	-	6.37	5.0	pp
NH_3-N (lbs/day) / (mg/l)	6.75 / 0.05	9.65 / 0.06	S. 515.0 / 2.5 W. 1030.0 / 5.0	pp
NO_2-N (lbs/day) / (mg/l)	-	4.06 / 0.03	-	
NO_3-N (lbs/day) / (mg/l)	(NO_2&NO_3) 730.9 / 5.42	851.7 / 5.72	-	
Cl_2-R (mg/l)	-	0.0	daily max. 0.5	
P (lbs/day) / (mg/l)	101.2 / 0.75	274.0 / 1.84	-	
F-C (#/100 ml)	-	2592.0	1000	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
O&G (lbs/day) / (mg/l)	-	770.4 / 5.0	-	
Cd (lbs/day) / (mg/l)	0.135 / 0.001	0.13 / 0.001	-	
Cr (lbs/day) / (mg/l)	13.49 / 0.10	1.809 / 0.014	-	
Cu (lbs/day) / (mg/l)	0.405 / 0.003	0.0 / 0.0	-	
Pb (lbs/day) / (mg/l)	0.675 / 0.005	1.16 / 0.009	-	
Ni (lbs/day) / (mg/l)	7.152 / 0.053	0.0 / 0.0	-	
Zn (lbs/day) / (mg/l)	6.48 / 0.048	1.16 / 0.009	-	

* Permit loading limitation was established using a design flow (24.7 MGD).

pp Present permit limitations.

Discharger: Hamilton S. WTP

Facility Number: 1PW00060001
Permit Number: W1060
Receiving Stream (River Mile): (33.94)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)		0.0		
TSS (mg/l)	-	-	- 15.0	
pH (S.U.)	-	-	6.0 - 11.5	

Discharger: Fairfield WWTP

Facility Number: 1PD00003001
Permit Number: D603
Receiving Stream (River Mile): GMR (32.0)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)	4.11	3.431	(6.0)	
T (°C)	-	22.27	-	
pH (S.U.)	-	7.42	6.5-9.0	
$CBOD_{20}$ (lbs/day) / (mg/l)				3753.0 / 75.0
BOD_5 (lbs/day) / (mg/l)	166.8 / 4.87	169.3 / 5.66	1501. / 30.0	
TSS (lbs/day) / (mg/l)	79.87 / 2.33	226.6 / 8.69	1501.0 / 30.0	
D.O. (mg/l)	-	6.48	5.0 min.	pp
NH_3-N (lbs/day) / (mg/l)	30.85 / 0.90	45.62 / 1.58	125.1 / 2.5 (S. only)	pp
NO_2-N (lbs/day) / (mg/l)	-	4.24 / 0.15	-	
NO3-N (lbs/day) / (mg/l)	(NO_2&NO_3) 432.9 / 12.63	157.3 / 6.06	-	
Cl_2-R (mg/l)	-	0.23	daily max. S. 0.5	
P (lbs/day) / (mg/l)	126.5 / 3.69	103.0 / 4.08	-	
F-C (#/100 ml)	-	30.0	1000	
Cd (lbs/day) / (mg/l)	0.034 / 0.001	0.29 / 0.014	-	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Cr (lbs/day)	0.686	0.719	-	
(mg/l)	0.02	0.034		
Cu (lbs/day)	0.171	3.32	-	
(mg/l)	0.005	0.118		
Pb (lbs/day)	0.103	1.184	-	
(mg/l)	0.003	0.053		
Ni (lbs/day)	0.686	2.06	-	
(mg/l)	0.020	0.103		
Zn (lbs/day)	0.686	2.58	-	
(mg/l)	0.020	0.096		

pp Present permit limitation.

Discharger: Ross WWTP*

Facility Number:
Permit Number:
Receiving Stream (River Mile): GMR (26.30)

Effluent Information:

Parameter (Unit)	1980* Survey	1980 3rd Q* Mean Daily Effluent	Present* Permit	Allocated
Flow (MGD)			(1.60)	
$CBOD_{20}$ (lbs/day)				1000.0
(mg/l)				75.0
NH_3-N (lbs/day)				200
(mg/l)				15.0
D.O. (mg/l)				2.0

*Proposed plant (no existing data).

000463

Discharger: Procter & Gamble Co.
(Miami Valley Lab.)

Facility Number: 1IN0001001
Permit Number: N110
Receiving Stream (River Mile): GMR (25.99)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
Flow (MGD)	0.214	0.217	-	
T (°C)	21.83	-	-	
pH (S.U.)	7.07	7.28	6.9-9.0	
BOD_5 (lbs/day)	2.80	13.66	46.31	pp
(mg/l)	1.57	6.46	30.0	
TSS (lbs/day)	76.75	13.12	46.31	
(mg/l)	40.3	5.92	30.0	
D.O. (mg/l)	3.6	4.56	1.0 min.	pp
Cl_2-R (mg/l)	-	0.20	daily max. 0.5	
F-C (#/100 ml)	-	60.0	1000	

pp Present permit limitation.

Discharger: US Atomic Energy Commission (DOE)
Feed Material Production Center

Facility Number: OH0009580
Permit Number: -
Receiving Stream (River Mile): GMR (24.73)

Effluent Information:

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
001 (Total Discharge)				
Flow (MGD)	0.412	0.493	-	
T (^{o}C)	20.03	22.0	-	
pH (S.U.)	7.63	6.5 (min.)	6.5-10.0	
BOD_5 (lbs/day)	4.70	-	-	
(mg/l)	1.37	19.0		
TSS (lbs/day)	3.44	-	-	
(mg/l)	1.0	24.0	20.0	
D.O. (mg/l)	6.69	-	-	
NH_3-N (lbs/day)	0.22	-	61.74	pp
(mg/l)	0.06	42.0	-	
	(NO_2&NO_3)			
NO_3-N (lbs/day)	24.77	-	3506.0	
(mg/l)	7.20	83.0	-	
Cl_2-R (mg/l)	-	0.27	0.1 (max.)	
Cr (lbs/day)	-	-	-	
(mg/l)	0.04	0.02		
Cu (lbs/day)	-	-	-	
(mg/l)	0.005	0.02		
001A (Sanitary Treatment Plant)				
Flow (MGD)			-	

Parameter (Unit)	1980 Survey	1980 3rd Q Mean Daily Effluent	Present Permit	Allocated
BOD_5 (lbs/day) / (mg/l)			11.03 / 20.0	pp
TSS (lbs/day) / (mg/l)			11.03 / 20.0	
F-C (#/100 ml)			1000	
001B & 001C (General Sump and Clearwell, resp.)				
Flow (MGD)			-	-
TSS (lbs/day) / (mg/l)			-	-
Cr (lbs/day) / (mg/l)			0.11 / -	0.11 / -
Cr^{+6} (lbs/day) / (mg/l)			0.0088 / -	-
Cu (lbs/day) / (mg/l)			0.055 / -	0.055 / -
Ni (lbs/day) / (mg/l)			0.273 / -	0.273 / -
Fe (lbs/day) / (mg/l)			0.904 / -	0.904 / -
001D (Storm sewer lift station)				
Flow (MGD)			-	
TSS (lbs/day) / (mg/l)			- / 30.0	
O&G (lbs/day) / (mg/l)			-	
001E (Bioreactor)				
Flow (MGD)			-	
NH_3-N (lbs/day) / (mg/l)			26.46 / -	pp
NO_3-N (lbs/day) / (mg/l)			136.71 / -	

pp Present permit limitation.

APPENDIX C

Winter Wasteload Allocation

000487

Appendix C - Winter Wasteload Allocation

In addition to the modeling under summer low flow conditions, wasteloads were allocated to the municipal entities for winter $Q_{7,10}$ conditions. All industrial dischargers were left at their summer limitations.

In order to calculate the winter WLA, all stream flows (upstream and tributaries) had to be revised to reflect winter $Q_{7,10}$ conditions. Refer to Figure II-28 for a flow profile for Segments 1 and 2 under winter conditions. In winter, the instream temperature decreases, affecting reaction rates and the WQS for NH_3-N. Based on the winter pH and temperature, the winter NH_3-N standards are as follows:

RM 92.46 to RM 81.6	4.1
RM 81.5 to RM 77.6	3.5
RM 77.5 to RM 14.0	2.6

As with the summer WLA, the first step was to calculate effluent NH_3-N levels that would maintain the WQS for NH_3-N for toxicity. The results indicated that all of the municipal WWTPs except Dayton and Montogmery County Western Regional could discharge a secondary level of NH_3-N (assumed to be 15.0 mg/l). Dayton would need to discharge 8.2 mg/l, while Montogmery County could discharge 10.7 mg/l and maintain the WQS for NH_3-N toxicity.

All of the municipals were then input with a $CBOD_{20}$ equivalent to secondary treatment. The modeling results indicated that there would be no violation of the WQS for D.O. Winter modeling described are summarized in Tables C-1 and C-2.

TABLE C-1
SEGMENT 1
NON-CONSERVATIVE PARAMETER
WASTELOAD ALLOCATION RESULTS

Entity Name	Recommended $CBOD_{20}$	Permit NH_3-N	Limitations (mg/l) D.O.
Ohio Suburban WWTP	75.0	15.0	2.0
MCD N. Regional WWTP (8.5 MGD)	75.0	15.0	2.0
MCD N. Regional WWTP (12.0 MGD)	75.0	15.0	2.0
Dayton WWTP	75.0	8.24	5.0
P. H. Glatfelter Inc.	88.9	2.6	5.0
Montgomery Co. W. Regional WWTP	75.0	10.70	5.0
West Carrollton WWTP	75.0	15.0	2.0
Interstate Folding Box	170.0	2.5	5.0
Miamisburg WWTP	75.0	15.0	2.0
River Arms Apt./Laundry	75.0	15.0	2.0
River Arms Apartments	75.0	15.0	2.0
Franklin WWTP	125.0*	15.0	2.0

*Increased $CBOD_{20}$ due to significant industrial input.

000469

TABLE C-2
SEGMENT 2
NON-CONSERVATIVE PARAMETER
WINTER WASTELOAD ALLOCATION RESULTS

6399

Entity Name	$CBOD_{20}$	NH_3-N	D.O.
ARMCO - Middletown 001	-	3.5	5.0
Middletown WWTP	75.0	15.0	2.0
Crystal Tissue	36.0	-	5.0
Fantasy Farm	75.0	15.0	2.0
LeSourdsville Reg. WWTP	75.0	15.0	2.0
Miller Brewery (proposed)	90.0	15.0	5.0
Butler Co. - Brentwood Estates	75.0	15.0	2.0
ARMCO - New Miami 004	-	5.4	5.0
ARMCO - New Miami 002	42.0	5.0	5.0
ARMCO - New Miami 001	10.2	5.6	5.0
New Miami WWTP (proposed)	75.0	15.0	2.0
Hamilton WWTP	75.0	15.0	2.0
Fairfield WWTP	75.0	15.0	2.0
Ross WWTP (proposed)	75.0	15.0	2.0
Proctor and Gamble	60.0	-	5.0
DOE - Feed Materials Production Center	27.0	20.0	5.0

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APPENDIX D

Cyanide and Phenol Allocation

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Appendix D - Cyanide and Phenol Allocation

Wasteload allocations for cyanide and phenols have been completed using the conservative parameter method. Since the Water Quality Standard (WQS) for cyanide is based on total cyanide, and because there is an absence of both criteria in the WQS for free cyanide and an accepted analytical method to determine free cyanide, the WLA will be based on total cyanide until the WQS is revised. The present WQS for total cyanide is 0.025 mg/l; the WQS for phenolic compounds is 0.010 mg/l.

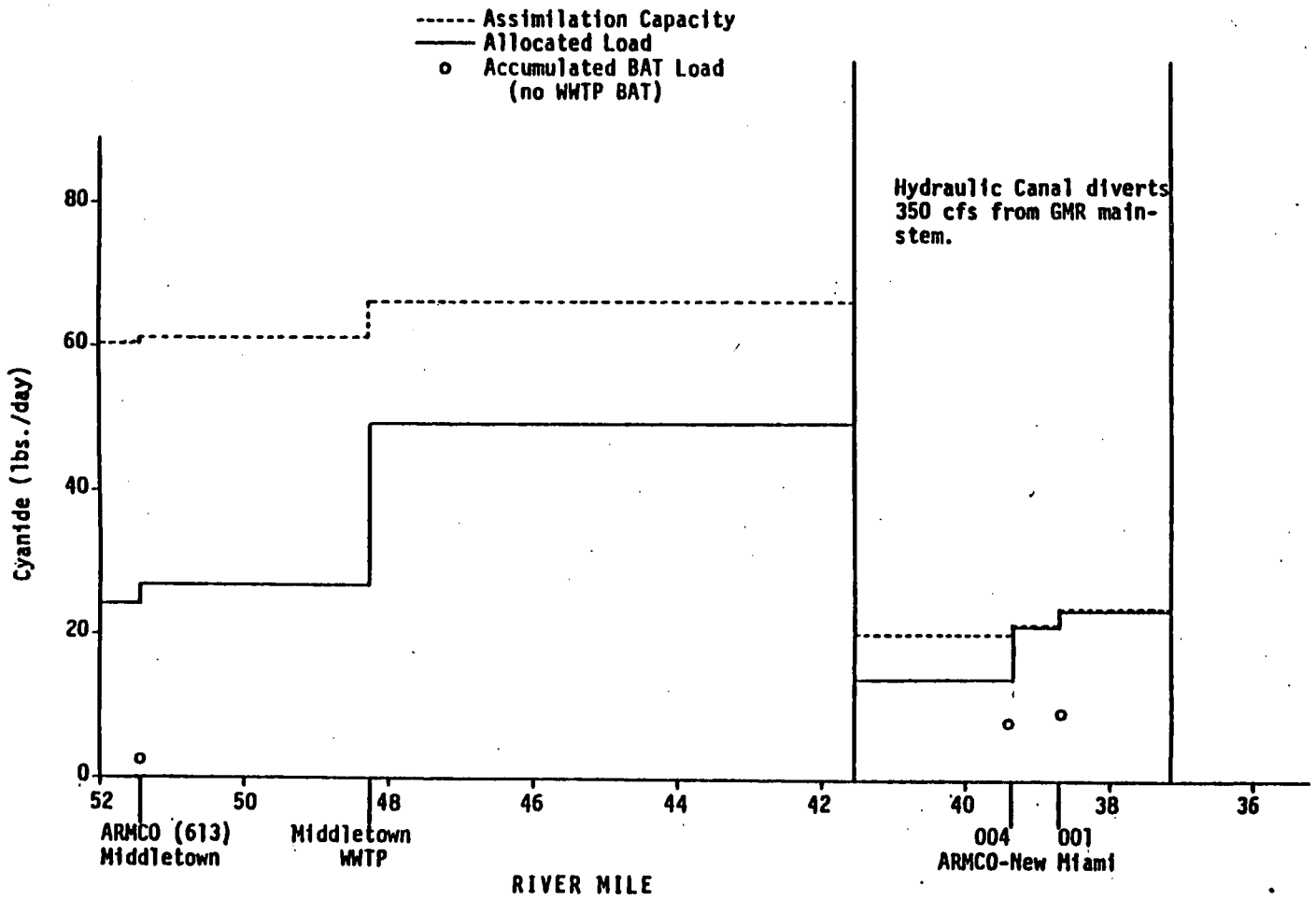
Only those entities which have phenol and/or cyanide limits in their permits were included in the allocations. These discharges, all in Segment II, are the ARMCO Middletown Plant outfall (613), the Middletown WWTP, and the ARMCO New Miami Plant (outfalls 001 and 004). Upstream quality was determined by averaging the weekly monitoring data collected by OEPA during the summer of 1980 at RM 52.17. The allocations were conducted according to the method outlined in the text of the attached report (pages 111-112).

For both cyanide and phenol loadings, the ARMCO New Miami discharges are greatly affected by the diversion of dilution water to the hydraulic canal at RM 41.54. For phenols, at existing flow and load conditions, the GMR from 51.45 to RM 38.74 can be classified as an Effluent Limited Segment. Therefore, no allocation is being made. The WQS for cyanide requires all entities to discharge at or below BAT levels in order to avoid a WQS violation in this segment. Since no BAT level is available for the Middletown WWTP, a load of 22.0 lbs/day has been allocated to that entity. Industrial BAT levels are as follows:

ARMCO - Middletown (613)	2.8 lbs/day
ARMCO - New Miami (004)	7.2 lbs/day
ARMCO - New Miami (001)	1.5 lbs/day

Figure D-1 shows the cyanide load situation in the GMR.

Figure D-1. Cyanide Allocation.



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APPENDIX E

Addendum to the Simplified Method

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

ADDENDUM
TO
"Simplified Analytical Method for Determining NPDES Effluent Limitations for POTW's Discharging into Low-Flow Streams: National Guidance"

I. INTRODUCTION

This addendum provides several technical revisions to the "Simplified Analytical Method" that clarify, correct, or modify (based on additional information and analyses which have become available) certain sections of the original national guidance document dated September 26, 1980. The guidance provided herein supercedes that in the respective sections of the original document.

Users of this method (as well as others) are strongly encouraged to develop additional data and other information on reaction rates and other factors applicable to this method, and to submit this additional data and other information, along with suggested improvements for the method, to:

Chief, Wasteload Allocations Section
Monitoring Branch
MDSD/OWRS (WH-553)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

(Telephone: (202)-426-7778)

This additional data and other information is needed so that appropriate additional improvements to the method can be made periodically. Users may also, when appropriate, make any modifications to this method that will allow the method to more accurately represent regional or local conditions. Any changes should be supported with an adequate technical justification, including sufficient applicable data.

Where the results of the water quality analysis indicates the need for treatment beyond secondary, State users of this method are encouraged to coordinate the modeling analysis with a review of the environmental benefits and costs of the receiving water's applicable water quality standards. Such assessments should be conducted in accordance with the revised water quality standards regulations and EPA guidance, when published.

II. TECHNICAL REVISIONS

A. Applications and Constraints (page 3).

As stated in the original guidance document, the analytical techniques which are used in water quality modeling should be the simplest possible that will still allow the water quality manager to make confident and defensible water pollution control decisions. In many cases, where relatively simple conditions exist, simplified modeling efforts that have minimal manpower and data requirements are often adequate to make such decisions. Use of simplified efforts, when appropriate, can result in both substantial savings in State and EPA resources and cost-effective and technically sound effluent limitations to be achieved.

Recent experience and analyses indicate that this simplified method, when followed properly and with little or no site-specific data being employed, should normally result in both technically sound water quality justifications being developed for nitrification levels of treatment and substantial savings in State and EPA resources. However, it has also been noted that this simplified analysis alone (i.e., without any site-specific data) usually cannot provide the confidence needed to adequately justify permit limits more stringent than about 10 mg/l $CBOD_5$ and 1.5 mg/l NH_3-N, including relatively costly filtration treatment after nitrification. Therefore, this simplified method cannot be used by itself to justify permit limits more stringent than 10 mg/l $CBOD_5$ and 1.5 mg/l NH_3-N (including filtration after nitrification).

Where treatment more stringent than 10 mg/l $CBOD_5$ and 1.5 mg/l NH_3-N (including filtration after nitrification) appears to be needed, appropriate supporting site-specific data should be collected and used in the analysis in order to increase confidence in the variables used in this model, in the the modeling results that are obtained, and, most importantly, in the treatment decision itself. This additional level of analysis should also be accompanied by a rigorous sensitivity analysis (see page 20 of the method). Based on past analyses and construction grant project reviews, it appears that this situation (e.g., the need for treatment beyond nitrification) will seldom be required except in certain cases where small streams with very low assimilative capacities are encountered.

B. Ammonia Toxicity Analysis (page 5).

The original guidance document recommends that, if no un-ionized or total ammonia-N standards are available for use, a criterion of 0.02 mg/l un-ionized ammonia be used for freshwater cold water habitats, or 0.05 mg/l un-ionized ammonia be used for freshwater warm water habitats. Additional research, however, indicates that these criteria may in many cases be more stringent than necessary to protect water quality. It is now recommended that the latest EPA ammonia toxicity criteria, when promulgated, be used in conjunction with the supporting ammonia criteria implementation guidance document. Until the new EPA ammonia toxicity criteria are promulgated, AT facilities proposed solely to prevent ammonia toxicity may be approved only with supporting justifications based on either: (1) site-specific biological data showing that the designated uses cannot be restored without reducing ammonia toxicity, or (2) bioassay data (either from a laboratory or similar site) for indigenous species showing that existing or future ammonia toxicity levels will impair designated use attainment (exposure levels and durations for these tests should be similar to those occurring or articipated to occur in the receiving water). (Note: After publication of new ammonia toxicity criteria by EPA, Advanced Treatment processes proposed solely to prevent ammonia toxicity may be approved consistent with these criteria and this simplified method.)

C. Dissolved Oxygen Analysis (page 9).

Equation 5 on page 9 of the method is presently written incorrectly. The correct form, which should be used, is:

$$t_c = [1/(K_2-K_{BOD})] \ \ln [(K_2/K_{BOD}) (1- [D_o(K_2-K_{BOD})/(K_{BOD}UBOD_o)])] \qquad \text{(Eq. 5)}$$

D. Temperature Corrections of Reaction Rates (pages 17-18).

The method presently states that the temperature correction coefficient (θ) for K_3 to be used in Equation 10 is 1.10. A more reasonable correction coefficient for K_3, which should be used, is 1.08. This latter value represents an average of the range of correction factors found by different researchers ("Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling", EPA-600/3-78-105).

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E. Initial Deficit Determination (page 18 and Exhibit 3).

The dissolved oxygen (DO) saturation concentrations table presently included as Exhibit 3 in the method is based on Streeter. Additional evidence which has been accumulated indicates that these saturation DO values are not entirely accurate. The new 15th edition of "Standard Methods" contains an updated table of saturation DO concentrations which represents the most up-to-date and accurate saturation DO concentration data currently available. This table is reproduced in Attachment A of this addendum. It should be noted that the tabulated values for DO saturation are for distilled water at standard pressure (sea level). These values should be corrected for altitude and dissolved solids levels using the formula at the bottom of the table.

It is important for all wasteload allocation and other water quality modeling efforts to be consistent in the use of saturation DO values. Use of the attached table is recommended for this method (and other modeling efforts) because it represents the best information currently available.

F. Conversion from $CBOD_u$ to BOD_5 (page 18).

(a) The method presently discusses conversion ratios of $CBOD_u$ to BOD_5 for various levels of treatment; however, it is unclear whether the method is referencing carbonaceous (based on a nitrification-inhibited test) or total (based on an uninhibited test) BOD_5. Therefore, it should be clarified that the ratios being discussed in the guidance are for $CBOD_u$ to $CBOD_5$ (based on a nitrification-inhibited test). (It is recommended that the permit BOD effluent limits which are finally selected after the water quality analysis be written as a carbonaceous and not a total BOD_5; the use of $CBOD_5$ effluent limits and, correspondingly, a carbonaceous (inhibited) BOD test when monitoring the effluent can help avoid potential data inaccuracies that can result from nitrification occuring in the bottle during an uninhibited BOD test due to the presence of sufficient nitrifiers in the test bottle.)

(b) The $CBOD_u$ to $CBOD_5$ ratio is a function of the level of treatment and the associated degradability of the waste. Thus higher ratios are expected and have been observed for higher levels of treatment since the CBOD remaining in more highly treated effluents degrades more slowly than that in less treated wastewaters.

The method presently suggests that, for plants with treatment levels greater than secondary, a ratio of 2.5 to 3.0 should be used for determining permit limitations. The guidance implied, though did not specifically state, that 2.5 should be used for nitrification levels of treatment and a ratio of approximately 3.0 should be used for treatment levels greater than nitrification.

Additional analyses of very limited sewage treatment plant effluent BOD (total and carbonaceous) 5-day, long-term (ultimate), and time series data indicated that a $CBOD_u$ to $CBOD_5$ conversion ratio of about 2.3 should be used for nitrification facilities. Until additional treatment plant effluent data can be collected and analyzed to further refine this ratio, a factor of 2.3 should be used for nitrification and higher-level treatment facilities. It must be emphasized that this value is presently based on a very limited set of data, and that additional treatment plant effluent data is needed to gain greater confidence in the suggested value. All EPA Regions, the States, and others are again strongly urged to voluntarily participate in a nationwide data gathering effort so that more accurate ratios can be developed.

It is recommended that, whenever possible, existing plant effluent data and/or pilot plant data should be collected to assist in the selection of an appropriate conversion ratio. Caution should be exercised, however, when using data from an existing plant that has a level of treatment that is significantly lower than that which is proposed. Such data should not be blindly applied when selecting the appropriate conversion ratio; it should merely be used as a guide. A sensitivity analysis of the conversion ratio and its implications on the final treatment decision to be made can help the water quality analyst determine the relative importance of gathering such additional data.

It is also recommended that the BOD_5 effluent limits in the treatment plant's permit be reviewed after the new facility is on-line to help ensure that the correct $CBOD_u$ to $CBOD_5$ ratio was applied to the model output. This can be accomplished by collecting and analyzing appropriate plant effluent CBOD data after the new treatment facility is on-line.

G. Permit Conditions (page 22).

The guidance presently requires that, for streams with zero flow at the critical conditions, the results of the modeling analysis should be used as 7-day average effluent limits, and, for streams with nonzero flow at the critical conditions, the currently adopted and applicable State or EPA Regional procedures for applying modeling results should be used. The original guidance also indicates that this issue of applying modeling results to effluent limitations is being analyzed in support of the development of forthcoming policy guidance on wasteload allocations/total maximum daily loads (WLA's/TMDL's).

Technical analyses are being conducted which study the effects of effluent concentration and streamflow variability, different dilution ratios, and the use of alternative averaging period schemes on receiving water quality. Preliminary results indicate that effluent and streamflow variability and, to a lesser extent, differing dilutions are critical factors which often greatly affect the frequency of severe water quality violations.

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A site-specific analysis that considers the effects of the individual stream's flow variability, available dilution, and the selected treatment process' effluent concentration variability on the stream's water quality (including the frequency and severity of water quality violations) should be performed in each case to determine the appropriate averaging period. Technical guidance on performing such analyses is being developed and will soon be released (anticipated date is about July 1982) by the EPA Office of Water Regulations and Standards to aid in the selection of appropriate averaging periods.

Based on currently available data for treatment plant performance, full nitrification treatment is a relatively stable process during the summer months. When considered together with streamflow variability and dilution, this treatment process should normally preclude frequent high levels of water quality violations when the stream flow is at low flow conditions and the stream's flow characteristics are not highly variable. It appears that in most cases, especially where the stream's flow variability is not extremely high, fluctuations in the effluent quality of full nitrification facilities designed to achieve 30-day average permit limitations are not likely to have a significant impact on the aquatic habitat due to increased loadings or decreased dilution. Actual impacts on the aquatic habitat or designated uses will be determined when site-specific analyses are conducted.

APPENDIX F

WLA for Conservative Parameters (Methodology)

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A stream is capable of assimilating pollutant discharges without violating stream water quality standards (WQS). This assimilation capacity is a function of stream water quality standards and critical stream conditions. Conservative pollutants are assumed to have zero rate of biochemical reactions and their concentrations are assumed to undergo changes due only to dilution. Therefore, the capacity of accomodating conservative pollutants of a given stream depends on WQS and critical stream flow.

Total maximum daily load (TMDL) is defined in Federal Register as "Pollutant loading for a segment of water that results in ambient concentration equal to the numerical concentration limit required for the pollutant by the numerical or narrative criteria in the water quality standards." Therefore, TMDL would be equivalent to the assimilation capacity of a stream (segment) for the particular pollutant under critical stream flow.

The total existing load (background load) is the sum of upstream load, tributary input load and discharger load. Available assimilation capacity, computed by subtracting total background load from TMDL for a stream, is distributed among allocating dischargers proportional to the base load ratio (the ratio of base load of a single discharger divided by the sum of base loads).

At any point in the stream, the concentration of any conservative pollutant can be stated by mass balance analysis as,

$$C = \frac{C_n Q_n + C_b Q_b}{Q_n + Q_b}$$

where "b" represents background and "n" represents the nth discharger, "C" is concentration and "Q" is flow. For water quality to be met,

$$WQS = \frac{C_n Q_n + C_b Q_b}{Q_n + Q_b} \quad \text{at evey point.}$$

WLA will be determined by the following method.

1. The existing effluent quality (EEQ) loads for point source dischargers shall be determined by one of the following (in order of preference):

   *(a) Average loads of last 5 years (third quarter average discharge loads).

   (b) The annual average discharge load of most recent year or years in the absence of 5 years historical data.

   (c) Survey data.

2. The background loads (upstream and tributary) shall be determined and adjusted as follow:

Determination of the background load (in order of preference):

(a) If sufficient historical data is collected and shows a trend, this trend should be extrapolated to the critical low flow. If there is no trend or not enough data, the average value should be used.

(b) A set of at least three composite samples collected at a flow approximating the critical low flow can be used to estimate the load at the low flow.

(c) Existing low flow stream data, where available, should be used.

(d) Where adequate data is not available for a specific stream, data on streams which are close in proximity and/or character should be evaluated to estimate background water quality.

(e) If there is no data available, set the background load equal to water quality standard (WQS) or the best estimation.

Adjustment of the background load:

(a) The determined background load shall be compared to the sum of dischargers' permit loads or EEQ loads in the absence of permit loads. The more stringent level of the two shall be used for the background load.

(b) If the determined background load exceeds WQS due to point sources, the background shall be established by reducing the source to a level equivalent to the WQS. If the background load exceeds WQS due to natural or irretrievable man-induced conditions, the WQS or stream use designation should be re-evaluated.

3. While it is difficult to make assumptions of conservative pollutants at various flow conditions, critical low flow for upstream and tributaries and design flow for dischargers should be used as the critical condition for a TMDL.

4. TMDL for a stream or segment shall be obtained from total stream (segment) flow times instream WQS times a conversion factor.

5. Assimilation capacity (TMDL) at a point = stream flow at that point x water quality criteria as listed in the WQS x conversion factor.

6. Dischargers shall be allocated: (1) If the final table of the present NPDES permit contains the limit for the particular parameter, or (2) if EEQ causes violation of instream water quality standards.

7. Available stream assimilation capacity shall be determined by subtracting existing background load (the sum of upstream load, tributary input load, and non-allocating discharger load) from TMDL for a stream (segment).

8. Available assimilation capacity shall be distributed among allocating dischargers (see 6) proportionally to the base load ratio (base load of a discharger divided by the sum of base loads).

9. The base load is defined as:

   (a) for municipal dischargers (in order of preference)
   - Final permit limitation
   - EEQ

   (b) for industrial dischargers (in order of preference)
   - BAT
   - BPT
   - Final table limitation
   - EEQ

10. The allocated load = available assimilation capacity multiplied by the base load ratio.

11. The allocated load shouldn't be greater than the base load. Most industries do not have BAT guidelines. Once BAT guidelines are available, industries must treat to either BAT or to meet WQS, whichever is more stringent.

SECTION III

Economic Review of the Great Miami River

Montgomery and Butler Counties, Ohio

April, 1984

State of Ohio Environmental Protection Agency

Division of Wastewater Pollution Control

361 E. Broad Street, P.O. Box 1049

Columbus, Ohio

Affordability

Municipal Analysis

A municipal affordability analysis relates the costs of a wastewater treatment project to the financial well-being of the community. A simple analysis addresses this relationship at a household level. A comparison is made between the annual cost per household and the Ohio EPA Table B. Table B is a sliding scale of annual payments based on consumer expenditures at various income levels. The annual payment represents the maximum sewer fee which a household can reasonably be expected to pay without adversely affecting the financial health of the household. Costs of the project are generally developed by a consulting engineer as part of the Construction Grants facilities planning process.

Cost/Benefit

Cost/Benefit analysis is used by the Ohio EPA to determine the relationship between the costs of a water pollution control project, and the benefits which are expected as a result of improved water quality. This analysis is directed at the incremental costs and benefits which are related to advanced treatment. The analysis has three major components: identification of incremental costs and benefits, measurement of costs and benefits, and comparison of costs and benefits.

Identification of Incremental Costs and Benefits

Costs

Effluent limits proposed by modeling to meet water quality standards and the biological survey are the major tools used in identifying costs and benefits. In the case of costs, effluent limits indicate the level of technology necessary to meet the water quality standard in the receiving water. Any technology identified as advanced treatment (treatment beyond secondary) is considered in the analysis.

Benefits

Benefits are identified through the comparison of water quality modeling results for secondary treatment and the proposed effluent limits. The length and type of violation of water quality standards under secondary level treatment is compared to the water quality expected with the proposed effluent limits. The difference between the two is identified as the incremental improvement to water quality as a result of advanced treatment. The improvement in the water quality will be translated into a change in uses. Various uses are examined to determine if the use is physically possible, and if so if it exists currently, and/or has the potential to exist.

Uses which are examined include (but are not limited to):

Recreational Activities

Boating	Camping
Canoeing	Fishing
Hiking	Hunting
Picnicing	Sailing
Swimming	Waterskiing

Commercial Activities
- Fishing
- Boat Rentals

Water Supply
- Public
- Industrial
- Agricultural

Aesthetics
- Sight
- Smell

Health Related Conditions

Inherent Ecological Value

Identified potential uses are compared to the modeling results to determine which are attributable to advanced treatment. Potential uses will be divided into two categories: quantifiable and non-quantifiable. Those which are non-quantifiable will be described narratively. Those which are quantifiable will be measured and assigned a value.

Measurement of Costs and Benefits

Costs

The cost of an abatement project will be developed as stated in the affordability procedure. The costs associated with advanced treatment will be used in the cost benefit analysis.

Benefits

Measurement of quantifiable potential stream uses can be accomplished through the use of surveys or through the use of standardized estimating techniques. The use of a survey is the most accurate method; however, it is very resource intensive and is not possible or appropriate in all cases. As an alternative, average participation rates will be developed using the Ohio Statewide Comprehensive Outdoor Recreation Plan (SCORP; Ohio Department of Natural Resources) figures. These rates will then be adjusted to accurately reflect the potential of the stream (based on size, type of recreation, availability of substitutes, etc.).

If a category shows significant incremental use and participation can be developed, a surrogate market value is assigned to estimate the dollar amount which captures the value of that incremental use. Opportunity cost is used to develop a surrogate market value. This concept involves valuing what is foregone, in terms of alternate activities, in order to participate in recreational activities. One-half of the prevailing wage rate is used to proxy the value of time.

Once a value has been assigned to the uses which were identified, it must be discounted to present value. A range of rates is used from 2% (representing a social discount rate) to 10% (more reflective of actual market conditions). This range of discount rates introduces a large amount of variation in the analysis and should be interpreted with a great deal of care.

Non-quantifiable benefits will be described narratively, and will not be assigned a market surrogate. The lack at a market surrogate does not mean that a non-quantified use is less important than one that is quantified. The inherent ecological value of a stream is a nonquantified aspect of the stream that is included in the evaluation. Six criteria have been used to measure this value. They are:

1. The impact of the stream on the downstream receiving waters, and on the biological resources of the watershed as a whole.

2. The availability of high ecological value streams in the watershed.

3. The unique quality (or diversity) of the species in the stream.

4. The projected incremental improvement in water quality from the project.

5. The relative sensitivity of the aquatic community.

6. The degree of irreversable effects preventing recovery of the aquatic community.

Comparison of Costs and Benefits

The market value of the quantifiable benefits are totalled and, together with the non-quantifiable benefits, are compared to the costs associated with the advanced treatment portion of the project. Because it is not possible to represent all uses by a common denominator, it is not necessary to show a one-to-one relationship between costs and benefits. As a result, the final decision is based on the best available information and the goals of the Clean Water Act.

AFFORDABILITY

There are six pollution abatement projects scheduled in the study area: City of Dayton, Miami Conservency District North, Miami Conservency District Franklin, City of Middletown, City of West Carrollton, Butler County Hamilton Suburban and Butler County LeSourdesville. Each of these will be considered

separately. Income and Table B information are found in Table 64; affordability calculations are given in Table 65. The following methods were used to determine the impact on the individual user in each project area:

1. Median household income was taken from the 1980 Census. Dayton income was developed by the Miami Valley Regional Planning Commission from 1980 Census data.

2. The capital cost was amortized at 9.98% over 20 years. 9.98% reflects the first quarter 1983 Ohio Water Development Authority interest rate.

3. Population data was obtained from the 1980 Census. Dayton population was developed by the Miami Valley Regional Planning Commission from 1980 Census data.

4. Middletown cost estimates are current to August 1982. Costs for the MCD North are preliminary and reflect current costs.

Dayton

Currently, The City of Dayton owns and operates a 55.6 MGD (81 cfs) treatment plant. In addition to the residents and industry of Dayton, the plant also services parts of Oakwood, Kettering, Morain, Trotwood, and Englewood as well as unincorporated portions of Montgomery and Greene Counties. Approximately 22% of the flow to the treatment facility is commercial, 20% is industrial and 58% is residential. Three industries, Cargill, Howard Paper and Miles Labs are significant contributors of BOD_5 and NH_3-N. It is estimated by OEPA that pretreatment could result in a 50% reduction of NH_3-N and a 40% reduction in BOD_5. Median houehold income service area is estimated as $14,725 from Miami Valley Regional Planning commission. Based on the urban index, the Table B figure is $67.00. The total number of residential users is estimated at 124,000.

The City of Dayton has recommended upgrading their sewage treatment facilities in three stages.

Stage I: Expansion of capacity and major improvements
- grit removal facilities
- additional primary settling basins
- trickling filter modification
- chlorination facilities
- additional sludge digesters
- secondary settling basins
- chlorine contact basins

Stage II: Interim sludge disposal facilities
- pump stations
- parallel force mains to disposal site
- three fifty-acre lagoons
- decantale pump station

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Table 64. Median Household Income and Table B

MCD North Area		
Tipp City	$17,606	$ 219
Vandalia	$20,502	$ 383
Huber Heights	$18,090	$ 245
Montgomery County	$18,113	$ 247
Miami County	$16,831	$ 177
MCD Franklin Area		
Franklin	$14,864	$ 74
Germantown	$17,492	$ 212
Springboro	$19,439	$ 320
Carlisle	$15,464	$ 105
Warren County	$16,966	$ 184
New Miami Area		
Butler	$17,405	$ 208
West Carrollton Area		
West Carrollton	$19,348	$ 317
Middletown Area		
Middletown	$17,637	$ 220

Table 65: Affordability

	MCD NORTH	MIDDLETOWN	NEW MIAMI	LESOURD[illegible]
TOTAL PROJECT COST	$34,626,000	$12,500,000	$4,842,800	$ 500,000
LOCAL CAPITAL SHARE	$ 8,656,500	$ 3,800,000	$2,179,200	$ 500,000
ANNUAL DEBT SERVICE	$ 1,015,401	$ 445,737	$ 255,600	$ 58,649
ANNUAL O & M	$ 766,500*	$ 1,900,000	$ 133,100	**
ANNUAL REPLACEMENT		$ 222,657	$ 86,200	$ 8,906
TOTAL ANNUAL PAYMENT	$ 1,781,901	$ 2,568,394	$ 474,900	$ 67,555
INDUSTRIAL AND COMMERCIAL SHARE	$ 498,932	$ 1,849,244	n/a	n/a
RESIDENTIAL SHARE	$ 1,282,969	$ 719,150	$ 474,900	n/a
ESTIMATED NUMBER OF RESIDENTIAL USERS	24,200	18,000	3,300	$ 7,700
ANNUAL COST PER RESIDENTIAL USER	$ 53	$ 39	$ 143	$ 9
EXISTING AVERAGE ANNUAL RESIDENTIAL RATE	$ 124	$ 85	0	$ [illegible]
TOTAL AVERAGE ANNUAL RESIDENTIAL RATE	$ 177	$ 124	$ 143	$ 193

* includes replacement cost
** included in existing average annual residential rale

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Stage III: Advanced treatment and phosphorus removal
- AT pump station
- biofilter towers
- aeration basins
- final settling basins
- sludge pump station
- effluent pumping and filtering facilities
- chemical feed systems

Stage I received Step III Construction Grants funding in September, 1982. The total grant award (Steps I, II, and III) was $27,665,950. Stages II and III were scheduled for completion by the City of Dayon as follows:

Stage II:

start design	10/84
complete design	10/85
start construction	12/85
complete construction	12/86

Stage III:

start design	10/85
complete design	10/86
start construction	12/86
complete construction	12/88

Facilities planning has not been completed on stages II and III, and the likelyhood of maintaining the above schedule is questionable. Grant funding for Stages II and III is also questionable, and funding in a manner to meet the above schedule is highly unlikely.

The 1978 Facilities Plan estimated at the costs of the selected plan as follows:

	Capital Cost	O & M Cost
Collection System	$3,939,000	$7,800
Pump Stations & Force Mains	$7,633,000	$217,300
Treatment Improvements		
Primary	$4,202,000	$215,100
Secondary	$7,920,000	$129,500
Advanced Treatment	$44,300,000	$2,687,300
Sludge Processing & Disposal		
Processing	$7,554,000	$283,000
Disposal	$18,021,000	$43,900
TOTAL	$93,569,00	$3,583,900

Determining an impact on the individual household user from meeting the proposed effluent limits is very difficult due to the many variables involved. The three most important are the time frame of construction, the level of federal funding and the industrial share of the costs of treatment. Since the Stage I improvements were funded in 1982, it is assumed that these

costs have been incorporated into the existing rate structure. The existing annual charge per residential user (3 persons per household using 85 gallons of water per capita daily) is estimated at $59.00. The funding of Stage I improvements reflected a project cost of $36 million dollars, which reduced the remaining cost (1978 estimates) of improvements to $57,569,000. The impact of the implementation of these improvements will be reviewed in several ways in order to picture the reasonable possibilities for the project. due to the inability to accurately predict construction costs for future dates, and to the grant condition schedule submitted by Dayton, it will be assumed that Dayton will completed the facilities per the above quoted schedule. Costs will be updated to reflect 1983 levels. Further grant funding will be explored as two options: 1) Stage II receiving 55% funding and no funding for Stage III and 2) No further funding for the project. Industrial and commercial shares of the project cost will also be explored as two options: 1) Major industrial users pretreat wastes and are charged on a flow basis only (42% of costs) and 2) No pretreatment occurs and major users are charged on a strength bases (70% of costs). These options are defined as 1-4 below.

	USEPA Funding	Industrial and Commercial Share
1.	State II 55%; Stage III zero	42%
2.	Zero	42%
3.	Stage II 55%; Stage III zero	70%
4.	Zero	70%

Calculations to determine the annual cost per residential user are contained in Table 66. As can be seen from Table 66, the capital cost of Stages II and II will raise the cost per residential user anywhere from $17 to $42 depending on the assumptions made. It is difficult to predict the corresponding increase in annual operation and maintenace due to the inability to accurately separate Stage I, II and III costs, however it is likely that the increase in O&M costs will vary from $9 to $17 annually. This will result in a total increase in annual cost from $26 to $59. A sensitivity to interest rates is provided in Figure 75. While slight changes in the interest rate will not provide significant relief for individual users under the "best case", in the "worst case" where local capital shares and residential shares are higher, a significant change in the annual cost per user will occur with varing interst rates.

Calculating a total annual cost per user including existing rates results in an estimate from $85 to $118. Both of these figures are above the Table B figure of $67 indciating a potenital adverse impact on the residential user. This analysis is not capable, however, of making a definative statement of affordability on the City of Dayton due to many factors of uncertainty which surround the project. This includes the factors of funding, industrial loading and scheduling as well as actual income levels (this analysis is confined to the use of 1980 data due to uncertainties involved in updating). It is worthy of note, however, that many areas in Ohio of similar 1980 income are currently paying sewer fees simlar to those predicted for Dayton (Table 67). Based on these sewer fees it is reasonable to expect that the proposed project will not create a widespread economic impact.

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Table 66. Dayton cost per residential user calculations

	Option 1	Option 2	Option 3	Option 4
Total Project Cost	$77,900,000	$77,900,000	$77,900,000	$77,900,000
Local Capital Share	$62,500,000	$77,900,000	$62,500,000	$77,000,000
Annual Debt Service	$7,331,206	$9,137,615	$7,331,000	$9,137,615
Industrial & Commercial Share	$3,079,106	$3,837,798	$5,131,700	$6,396,330
Residential Share	$4,252,099	$5,299,816	$2,199,300	$2,741,284
Annual Cost per Residential User	$34	$42	$17	$22

Table 67. Annual Sewer Fee Comparison

Community	Income	1983 Sewer Fee
Mt Sterling	$14,087	$116
S. Charleston	$14,094	$111
Kenton	$14,198	$165
New Richmond	$14,324	$174
Fredricktown	$14,337	$140
Dresden	$14,359	$104
Somerset	$14,375	$108
Greenville	$14,393	$128
Newton Falls	$14,602	$112
Newark	$14,651	$105
Hebron	$14,665	$163
Akron	$14,703	$104
Crestline	$14,767	$145
W. Alexandria	$14,773	$116
Danville	$14,792	$110
Centerburg	$14,840	$117
Vanlue	$14,844	$144
Eaton	$14,868	$168
Ashtabula	$14,881	$118
Marion	$14,944	$152
Montpelier	$14,974	$176

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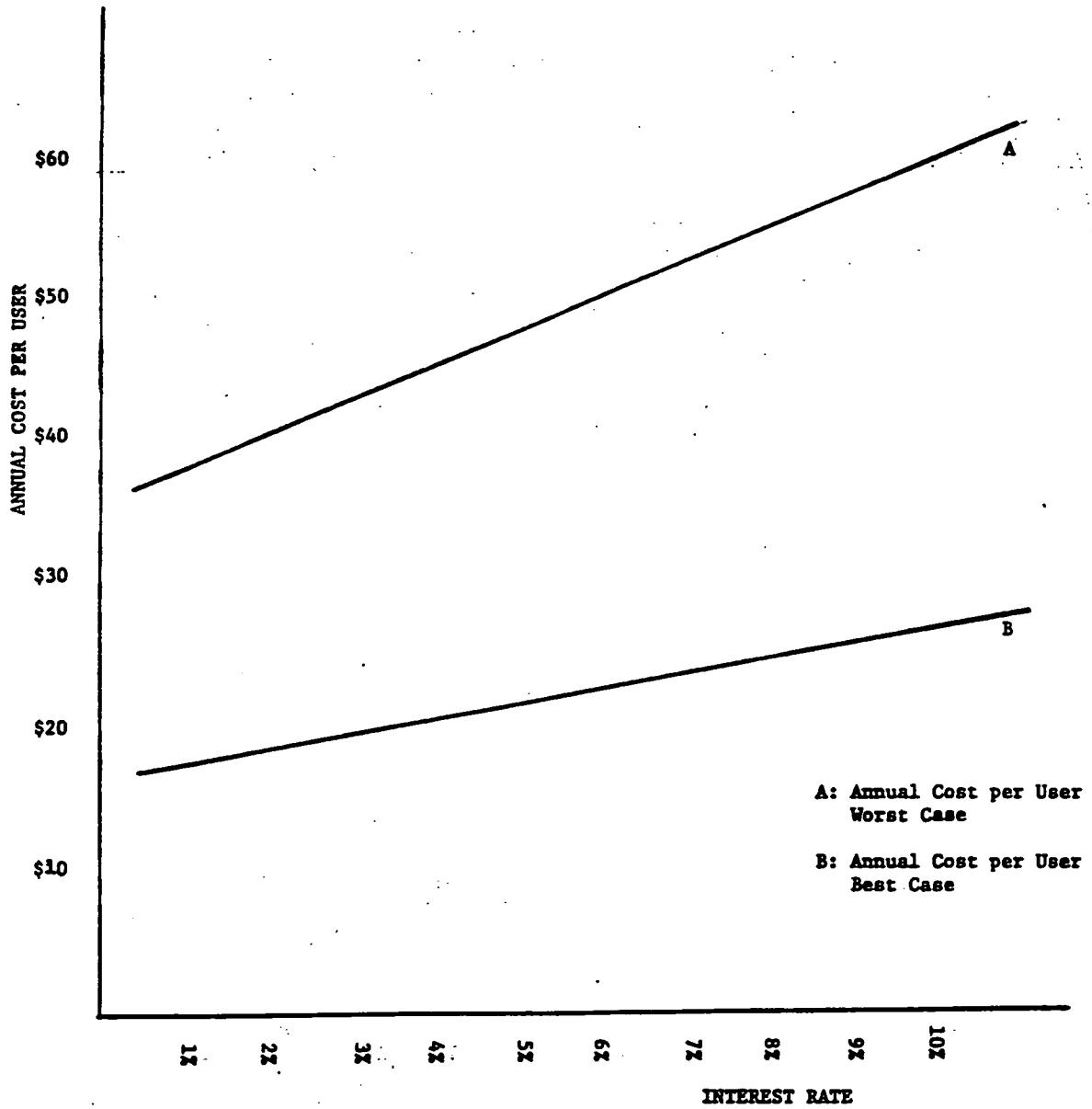

Figure 75. Sensitivity Analysis

MCD North Regional

The MCD North Regional WWTP will replace the Ohio Suburban WWTP at its' existing site and will serve the communities of Tipp City, Vandalia, and Huber Heights, as well as parts of northern Montgomery County and southern Miami County. The estimated population served at start-up is 57,400 people (24,200 households). Commercial, industrial, institutional and governmental flow is approximately 2.02 MGD; residential flow is 4.97 MGD. The total project cost is estimated at $34,626,000; annual operation, maintenance, and replacement is estimated at $766,500. This project is expected to received 75% U.S. EPA funding. Median household income and Table B figures are listed in Table 64. The average annual cost per household is $177; this is not expected to pose a significant financial impact on the individual user.

MCD Franklin

The MCD Franklin WWTP serves the communities of Franklin, Germantown, Carlisle and parts of Warren County. Facilities planning is in process, and recommendations have not be finalized. It is unclear at this time whether the wastes from the Village of Springboro will be transported to the MCD Franklin WWTP. With Springboro, the treatment facility will serve approximately 26,550 people (11,200 households); without Springboro, the treatment facility will serve approximately 21,850 people (9200 households). Income and Table B information are included in Table 64. The actual impact on the individual user will be analyzed when cost data for the recommended facility is available. In addition, the impact of the proposed facility on Stone Container Corporation will also be analyzed as a result of requests made at the public hearing on this report.

Middletown

The City of Middletown is currently involved in facilities planning. Preliminary plans call for upgrading the existing plant to meet the proposed effluent limits. This would include the addition of an influent pump, a primary settling tank, a secondary settling tank and coagulant addition system at the treatment plant; continued use of on-lot systems in outlying portions of Butler and Warren Counties; and the construction of an interceptor and local sewers in the Hunter portion of Warren County with sewage conveyed to the Middletown treatment plant. The draft costs include $12,500,000 capital costs and $1,000,000 annual operation and maintenance. The project is expected to receive 75% U.S. EPA funding for eligible costs. The total new charge, which is estimated for the average household, is $124 annually. The treatment plant serves approximately 18,000 households; the median household income for Middletown is $17,637. Based on a Table B figure of $220, this project is not expected to pose a significant financial impact on the individual user.

West Carrollton

The City of West Carrollton is currently exploring alternatives to constructing their own wastewater treatment facility. Active negotiations are taking place with Montgomery County to transport the waste to the Western Regional WWTP. No cost information is currently available for this or any other option which is being considered.

The City of West Carrollton has a population of 13,148 and a median household income of approximately $19,348. The Table B figure at this level of income is $317, indicating that the total annual payment that the Village commits should not exceed approximately $1,615,000.

Hamilton Suburban

Butler County submitted a Facilities Plan for the Hamilton Suburban facilities planning area in November 1977. Subsequent changes both in regulations and the situation of the area required an ammended facilities plan which is currently in progress. The original Facilities Plan proposed new treatment facilities at Ross and New Miami to serve the area. Since that time it has become clear that the proposed Ross facility is not an implementable option due to public resistance. The current planning is to construct a new facility at New Miami and at the existing Queen Acres site. The Queen Acres site will discharge to Indian Creek and the New Miami site will dischare to the Great Miami River. Neither detailed planning information nor cost information are available on the Queens Acres facility.

The estimated cost of the New Miami facility is $4,842,800 of which $1,497,400 is for sewers and $3,345,400 is for the treatment facility. The median household income for Butler County is $17,405, and the Table B figure is $208 annually. Population figures were taken from the 1977 Facilities Plan for the Hamilton Suburban; 7,800 and 3,300 are estimates for population and number of users respectively. The estimated total annual sewer fee is $143; based on a Table B figure of $208 this project is not expected to pose a significant impact on the individual user.

LeSourdesville

Butler County estimates the capital cost of meeting effluent limitations of 2.5 mg/l NH_3-N at $500,000. This facility serves a population equivalent of 7,700 customers. This figure includes industrial and commercial users and separate figures are not available. No federal funding is anticipated, and this analysis assumes that the entire cost will be borne by Butler County. The existing average annual sewer fee is $184. This project is expected to raise the annual fee by $9 to $193. The median household income for Butler County is $19,584. Based on the urban index, the Table B figure is $351. This project is not expected to pose a signifiant impact on the individual residential user.

COST/BENEFIT

Identification of Costs and Benefits

Costs

The advanced treatment costs are those costs for the City of Dayton associated with meeting an effluent quality of 8 mg/l $CBOD_5$ and 1 mg/l NH_3-N.

Benefits

The benefit assessment measures the difference between secondary discharge and advanced treatment. The existing situation of the Great Miami River does not represent the low end of the measurement of incremental improvements for the benefits assessment. The current discharge by the City of Dayton represents a significantly smaller load to the river than the projected 72 MGD (111.38 cfs) facility would if it discharged secondary quality effluent. This loading would severely impact the aquatic life of the Great Miami River. Table 68 shows the expected use of the river under both the degraded condition and the condition with advanced treatment at the 72 MGD (111.38 cfs) plant.

In March of 1983, the Ohio EPA conducted a household survey of people who live in the area of the Great Miami River. 43 people from the City of Dayton, and 13 and 12 people from the Villages of West Carrollton and Trenton, respectively, participated in the survey. Significant results are included in Table 69.

Measurement of Incremental Costs and Benefits

Costs

The incremental costs of advanced treatment at the Dayton WWTP were developed as part of the Dayton Facilities Plan in 1978. Costs were updated to reflect changes in price levels from 1978 to the fourth quarter of 1981, and are estimated at $44.3 million dollars.

Benefits

Quantitative measurement of all the benefits associated with advanced treatment at the Dayton WWTP is difficult due to uncertainties about particiations rates for recreational activities. Sufficient information does exist to quantify the fishing benefits, all others will be described narratively.

Fishing

The 1980-85 State Comprehensive Outdoor Recreation Plan (ODNR) developed average annual household participation rates for fishing within the State of Ohio. These figures were used to develop total fishing participation for the population within ten miles of the Great Miami River. Unpublished Ohio EPA data shows that approximately 65% of fishing activity takes place within ten miles of the fisher's residence. The prevailing wage rate for Montgomery County was used to measure the monetary value of each fishing occasion. The total fishing value within ten miles of the Great Miami is estimated as $509,828 annually. Table 70 contains the data for this calculation.

This figure may tend to overstate the actual fishing activity on the Great Miami River because it does not take into account alternate fishing sites within the area. Possible alternative sites include: the Little Miami River, Seven Mile and Twin Creeks, and Ceasar Creek Lake. Adequate information does not exist to measure the fishing pressure on those alternative sites. The population measurements ignored the population of the Dayton area because most of those were expected to fish upstream of the Dayton POTW. Some, however, would fish the impacted area. Thus the two effects would have a tendancy to cancel each other.

Table 68. Incremental Uses

USE CATEGORY	SITUATION UNDER SECONDARY	SITUATION UNDER ADVANCED TREATMENT	INCREMENTAL USE
Recreational			
Boating			
Motor			
Canoe			
Sail	The degraded condition		
Hiking	of the river would	significant improvement	
Picnicking	prohibit use for any	in aesthetics and	significant
Swimming	recreational purpose	aquatic community	
Camping	to any significant		
Fishing	degree		
Hunting			
Skiing			
Other	none known	no change	none
Commercial			
Fishing			
Boat Rental	none known	potential	significant
Other	none known	no change	none
Water Supply			
Public	none known	no change	none
Industrial	none known	no change	none
Agricultural	none known	no change	none
Other	none known	no change	none
Intangible Aesthetics			
Sight	unsightly	elimination	significant
Smell	odor	elimination	significant
Other	none known	no change	none

Table 69. Household Survey Results

"Are you familiar with the Great Miami River?"

Yes	53
No	14
Undecided	1
No Response to the Question	0

"How would you describe the water quality of the Great Miami River?"

Good	5
Bad	24
Average	4
Improved-but still has problems	9
Unsure	12
No Response to the Question	14

"Does anyone in your family currently use the Great Miami River for any purpose?"

No	45
Fishing	12
Biking	1
Boating	1
No Response to the Question	9

"Does anyone in your family have problems due to the Great Miami River?"

Litter	1
Dirt and Pollution	1
Odor	1
No	51
No Response to the Question	14

"Would anyone in your family use the Great Miami River if water quality were improved?"*

Yes - unspecified	11
Fishing	15
Would eat the fish which are currently caught	2
Boating	8
Swimming	2
Skiing	1
Not Sure	3
No	24
No response to the Question	9

Table 69. Household Survey Results
(Continued)

"Would you be willing to pay for improvement in the water quality of the Great Miami River through an increase in sewer fees?"

Yes	18
Maybe	3
No	28
Unknown	4
No Response to the Question	15

"Is it important to you that the Great Miami River be improved and protected even though your family may not use it directly?"

Yes	49
No	5
Maybe	1
No Response to the Question	13

* Total more than the number of survey responses due to multiple uses cited.

Table 70. Fishing Benefit

Estimated population within 10 miles of the Great Miami River	220,696 persons; 78,057 households
SCORP participation rate	2.31 annual fishing day per household
Annual fishing participation by area population	180,311 fishing days
Fishing participation within 10 mile radius (65%)	117,202 fishing days
Prevailing Montgomery County Wage Rate	$ 8.70 per hour
Market Value of Area fishing	$509,828
Present Value of Market Value	2% - $8,336,432 5% - $6,353,583 10% - $4,340,451

Other Recreational Uses

Boating, Hiking, picnicking, swimming, camping, hunting, and skiing were all projected to be undiserable under the conditions expected at secondary discharge. The incremental improvement associated with advanced treatment is expected to result in a significant improvement in all of these recreational uses. The measurement of participation rates is not possible, as in the case of fishing, due to insufficient data on consumer behavior for these types of activities. Due to the large population in the area, it is possible to say that each of these activities represent a significant benefit, similar to fishing, which can be associated with advanced treatment at the Dayton WWTP.

Inherent Ecological Value

The Great Miami River is the mainstem river in the basin. The natural habitat has been altered by the construction of dams and by channelization. The biota which exist in the Great Miami River currently are tolerant of polluted conditions. There are no rare or unique species of note established in the Great Miami River. The location of dams may retard the recovery of the aquatic community after the decrease in pollutant loading, however the entire degraded section can be expected to recover after a period of time. The inherent ecological value of the Great Miami River is medium to high.

Comparison of Costs and Benefits

The cost of advanced treatment is estimated at $44.3 million dollars. As a result of this expenditure, significant improvement will occur in the water quality of the Great Miami River which will cause an increase in recreational activities in and along the river including: fishing, boating, hiking, picnicking, camping, hunting, and skiing. Data exists to quantify the fishing value of the river; that value is estimated at $4.3 - 8.3 million dollars over the 20 year life of the project. The other uses identified have similar values but lack sufficient data to assign a market value. The inability does not make the uses less significant in this analysis. The expenditure of funds on advanced treatment will also significantly improve the aesthetics of the area by eliminating odor and other problems associated with insufficient treatment of waste. The inherent ecological value of the Great Miami is medium to high mainly because it is a mainstem river. The expenditure of funds for advanced treatment is seen as a cost beneficial allocation of resources.

Conclusion

The projects proposed for Dayton, Middletown, LeSourdesville and the Miami Conservancy District North project are not expected to pose significant impact on the individual users within the service area. Planning is not far enough along to make any statements concerning the affordability of the projects for the Village of West Carrollton, or the Miami Conservancy District Franklin. The expenditure of funds for advanced treatment at the Dayton facility is a cost-beneficial allocation of resources.