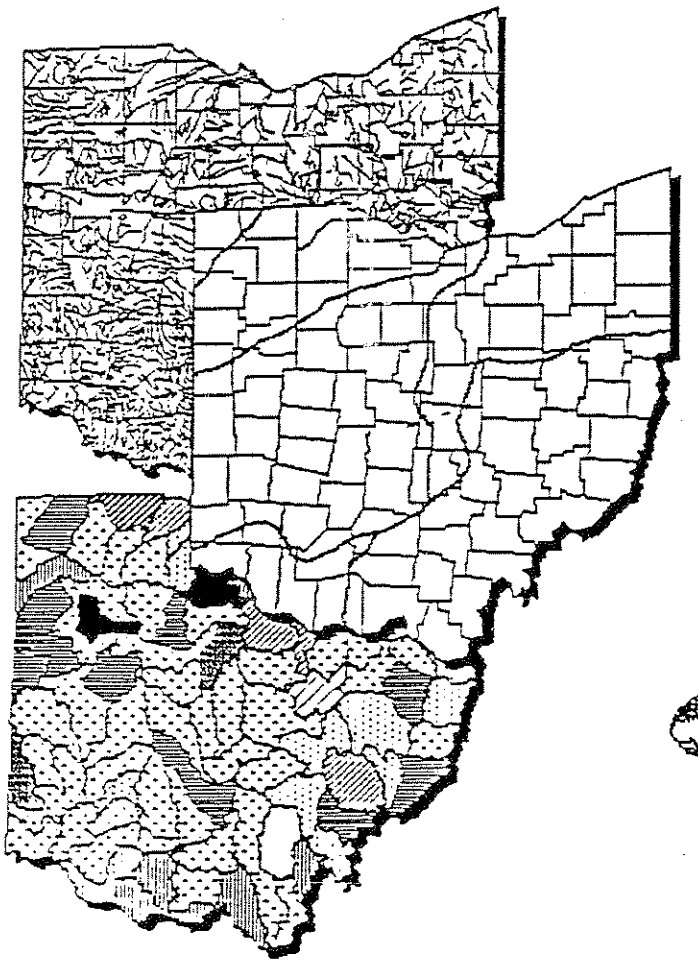
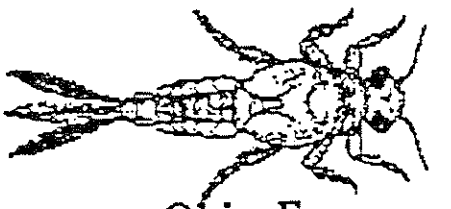
State of Ohio
Environmental Protection Agency

Ecological Assessment Section
Division of Water Quality
Planning & Assessment

Biological and Water Quality Study of the Chagrin River Basin

Cuyahoga, Lake, Geauga, and Portage Counties (Ohio)





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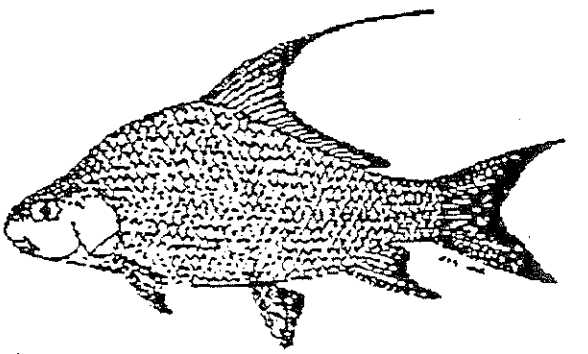

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Biological and Water Quality Study of the Chagrin River Basin

Cuyahoga, Lake, Geauga, and Portage Counties (Ohio)

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December 31, 1991

prepared by

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Biological and Water Quality Survey of the Chagrin River Basin (Cuyahoga, Lake, Geauga, and Portage Counties)

Ohio EPA Division of Water Quality Planning and Assessment

Ecological Assessment Section
Nonpoint Source Program Management Section
Surface Water Section, Northeast District Office

INTRODUCTION

Sampling in the Chagrin River basin was restricted to sites on the East Branch from near Kirtland Hills (RM 10.0) to the Chagrin River, the Aurora Branch from near Aurora (RM 11.5) to the Chagrin River, and the mainstem in the vicinity of Chagrin Falls between Silver Creek (RM 34.2) and the Aurora Branch (RM 27.1). Sampling was conducted during the summer of 1990 with the exception of the four upstream sites on the Aurora Branch which were sampled during the summer of 1991.

Specific objectives of this evaluation were:

1) to re-evaluate the Chagrin River in the vicinity of IVEX of Ohio (formerly Chase Bag), first surveyed in 1986 (Ohio EPA 1987b), to document current biological and chemical/physical condition, status of the assigned beneficial uses including the Warmwater Habitat (WWH) aquatic life use and State Resource Water (SRW) designation, and potential influence of upstream nonpoint sources (*i.e.*, suburban development),

2) to evaluate the Aurora Branch in the vicinity of the McFarland Creek Wastewater Treatment Plant (WWTP) and the Aurora Central WWTP to assess current biological and chemical/physical condition, status of the assigned beneficial uses including the WWH aquatic life use and SRW designation, and potential influence of upstream point and nonpoint sources, and

3) to evaluate the E. Br. Chagrin River in the vicinity of Kirtland to assess the water quality effects of the unsewered community of Kirtland and to verify the appropriateness of the assigned beneficial uses including the current Coldwater Habitat (CWH) aquatic life use and SRW designation in the segment from near Kirtland Hills to the mouth.

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (*e.g.* NPDES permits) and eventually be incorporated into the State water quality management plans and the biennial 305(b) report (Ohio Water Resource Inventory).

SUMMARY OF RESULTS

Conclusions

Attainment status of the designated aquatic life uses for the stream segments surveyed in the Chagrin River study area are tabulated in Table 1. As indicated, WWH attainment was full in the Chagrin River upstream from the IVEX of Ohio facility and partial, but near non-attainment, at the site immediately downstream. A narrative based assessment of the status of the CWH designation of the East Branch indicated that the 10+ miles surveyed were fully attaining the CWH aquatic life use. However, continued attainment of the CWH use is threatened by increasing suburban development in the watershed. As for the Aurora Branch, WWH attainment was full for over 5.5 miles between the two evaluated WWTPs and for a 2.0 mile reach near the mouth. Areas of partial attainment included the 0.5 miles evaluated upstream from the Aurora Central WWTP, a nearly 2.0 mile reach downstream from that facility, and a 1.5 mile zone immediately downstream from the McFarland Creek WWTP. Non-attainment was restricted to a 0.4 mile reach immediately downstream from the Aurora Central plant. A comparison of biological index scores for the Invertebrate Community Index (ICI), Index of Biotic Integrity (IBI), and Modified Index of Well-Being (MIwb) at 3 to 4 common sites sampled in the basin in 1986 (Ohio EPA 1987b) shows no significant differences between the 1990 and 1986 results. Differences in biological index scores were within the range of insignificant departure established for each index. Specific conclusions regarding each stream surveyed in 1990 and 1991, including comparisons with 1986 data where applicable, are presented below.

Chagrin River

◊ Results of macroinvertebrate and fish community sampling in the Chagrin River indicated that IVEX of Ohio discharges continue to adversely affect resident warmwater biotas. Biological index scores for each organism group were essentially the same as in 1986 when the segment was previously sampled (Ohio EPA 1987b).

◊ The impacts seemed most attributable to the effect of heavy deposition of solids blanketing nearly all available instream habitat downstream from the facility. Associated structural and functional alterations of the communities resulted in moderate declines in fish community performance from upstream background conditions and much more substantial declines in macroinvertebrate community performance. Ambient water quality sampling revealed a doubling of suspended solids (TSS) concentrations and 5-day biochemical oxygen demand (BOD_5) downstream from the IVEX facility, but these values were not at levels expected to cause the observed degree of deposition and biological degradation. As such, the possibility of intermittent slug or batch discharges of solids from the main IVEX discharge and/or runoff from an outside pulp storage area must be strongly considered as the cause of the observed fish and macroinvertebrate community depression.

Table 1. Summary of aquatic life use attainment status for stations in the Chagrin River basin sampled during the summers of 1990 and 1991. Attainment status of the Chagrin River and the Aurora Branch is based on Warmwater Habitat (WWH) biocriteria for the Erie/Ontario Lake Plain (EOLP) ecoregion of Ohio (OAC 3745-1-07, Table 7-17). Status of the Coldwater Habitat (CWH) use assigned to the East Branch Chagrin River is based on the Ohio WQS narrative definition (OAC 3745-1-07 Part B).

River Mile Fish/Invert.	IBI	MIwb	ICI	QHEI	Attainment Status	Comment
Chagrin River (WWH) - 1990						
33.4/33.4	45	8.3	46	82	FULL	Upst. IVEX of Ohio (RM 30.1)
29.9/30.0	35^{ns}	7.4^{ns}	26*	70	PARTIAL	Dst. IVEX of Ohio
E.Br. Chagrin River (CWH) - 1990						
10.4/10.3	43	8.6	54	73	FULL	Background quality
6.6/ 6.6	40	7.8	50	75.5	FULL	Upst. Kirtland Tributaries
3.7/ 3.5	38	8.3	48	59.5	FULL	Kirtland Tributaries area
2.4/ 2.4	45	8.5	42	76.5	FULL	Dst. Kirtland Tributaries
Aurora Branch (WWH) - 1991						
11.3/11.3	32*	N/A[1]	40	78	PARTIAL	Upst. Aurora Central WWTP (RM 11.2)
11.2/11.2	25*	N/A	20*	63.5	N/A[2]	Aurora Central WWTP mixing zone
11.1/11.1	27*	N/A	40	80	NON	Near-field WWTP effect
9.0/ 9.1	36^{ns}	N/A	48	78	FULL	Dst. Aurora Central WWTP (SR 306)
Aurora Branch (WWH) - 1990						
9.0/8.9	31*	N/A	50	79.5	PARTIAL	Dst. Aurora Central WWTP (SR 306)
3.9/3.5	38	7.9	46	82	FULL	Upst. McFarland Creek WWTP (RM 3.4)
3.4/3.4	37^{ns}	8.0	46	-	N/A	McFarland Creek WWTP mixing zone
3.3/3.3	36^{ns}	6.6*	50	70.5	PARTIAL	Near-field WWTP effect
- /2.0	-	-	54	-	(FULL)	Dst. McFarland Creek WWTP
0.3/0.3	41	8.3	48	76	FULL	Near mouth

Ecoregion : Biocriteria :	Erie/Ontario Lake Plain (EOLP) WWH	EWH	CWH
ICI	34	46	
IBI (headwater)	40	50	NO
IBI (wading)	38	50	NUMERIC
MIwb (wading)	7.9	9.4	CRITERIA

ns Nonsignificant departure from the ecoregional biocriteria (≤ 4 IBI and ICI units; ≤ 0.5 MIwb units).

* Significant departure from the ecoregional biocriteria (> 4 IBI and ICI units; > 0.5 MIwb units); poor and very poor index values are underlined.

( ) One or more of the three required indices not available for the determination of attainment status.

N/A[1] Modified Iwb not applicable at headwater sites.

N/A[2] Biocriteria not applicable in mixing zones.

◊ Analysis of annual loadings based on IVEX monthly operating report data revealed a steady decline in median daily discharge flow from 1985-1990, but loadings of BOD_5 and TSS have either remained the same or fluctuated erractically. These numbers suggest that plant treatment performance in removing oxygen demanding material and solids has declined over the last five years.

◊ Analysis of bottom sediment from Chagrin River sites upstream and downstream from IVEX indicate that elevated and highly elevated levels of chromium, copper, and lead are accumulating downstream from the facility. If present at biologically available concentrations, these metals have the potential to be toxic to aquatic life and thus could be an additional influence on instream communities. It is not known whether accumulation of these metals is associated with the IVEX process discharge, runoff from the pulp storage area, or an entirely different source. Compared with sediment data collected in 1986 (Ohio EPA 1987b), the 1990 results indicated that sediment quality has remained relatively unchanged although some metals, cadmium and zinc in particular, were at much lower concentrations than in 1986.

E. Br. Chagrin River

◊ No impacts to East Branch faunas could be attributed to the unsewered areas of Kirtland. Biological index scores for fish and macroinvertebrates differed little between sites immediately upstream from tributaries draining areas with on-site systems and those sites immediately downstream. Chemical water quality results indicated no problems other than several fecal coliform exceedences downstream from the affected tributaries. Although not directly detrimental to indigenous faunas, these exceedences do indicate the presence of sewage which, if left untreated, can ultimately be a concern with regards to aquatic life. However, these exceedences do jeopardize attainment of the Primary Contact Recreation use and indicate that inputs of improperly treated domestic sewage from unsewered Kirtland sources are a potential threat to the East Branch resource. It was not possible to isolate discrete sources or the affected tributaries given the limited scope of the sampling.

◊ Observed faunal depressions at some East Branch locations appeared linked to localized bank stabilization and channel modification activities. The resulting increased amounts of instream sand and silt had a minor influence on the biological communities, particularly the fish, and did not cause a substantial degradation of the aquatic resource. All four sampling sites supported diverse, balanced communities of both fish and macroinvertebrates.

◊ Both the macroinvertebrate community and, to a lesser extent, the fish community were composed of a number of organisms considered to be cool/coldwater species. In addition, two species of crayfish listed as "Special Interest" by the Ohio Department of Natural

Resources were collected from the stream. Generally, however, the density and diversity of the cool/coldwater community component declined progressively in a downstream direction and, at the most downstream sites, overall community structures were more warmwater oriented than cool/coldwater. The declining cool/coldwater populations seemed to correlate best with increasing predominance of suburban land uses. As such, continued full attainment of the CWH aquatic life use in the East Branch, particularly in its lower reaches, has to be considered seriously threatened given the continuing developmental pressures in the watershed.

Aurora Branch

◊ Biological survey results from 1990 and 1991 indicated that the Aurora Branch fish community was slightly impacted downstream from the McFarland Creek WWTP and more severely impacted downstream from the Aurora Central WWTP. The zones of depression in the fish community were a maximum of 1.5 miles in length below the McFarland Creek plant and a little more than 2.0 miles in length below the Aurora Central facility. Additionally, the fish community at the background site upstream from the Aurora Central WWTP was depressed which, along with elevated levels of fecal coliform bacteria, suggested the existence of other point and nonpoint sources of sewage and nutrient enrichment in the upper watershed. Conversely, macroinvertebrate communities outside the mixing zones were unaffected by the discharges and reflected good to exceptional water quality conditions at all sampling locations. Fish and macroinvertebrate communities collected in 1990 compared favorably with those collected at a limited number of similar locations in 1986 (Ohio EPA 1987b) and suggested little or no change in biological condition at these sites over the last five-years.

◊ Neither organism group responded in a manner that suggested acute effluent toxicity in either the mixing zone of the McFarland Creek WWTP or the Aurora Central WWTP. At most, structural and functional changes in the fish community and, to a lesser extent, the macroinvertebrate community suggested mild (McFarland Creek) and moderate to severe (Aurora Central) organic enrichment.

◊ Routine chemical water column grab sampling during 1991 in the vicinity of the Aurora Central WWTP indicated that discharges from the 001 outfall were not having an impact on Aurora Branch chemical water quality. No exceedences of Ohio WQS, other than iron, were detected with three grab samples taken at the downstream sites. However, during a late June 1991, modeling survey, Ohio EPA staff observed what appeared to be poor quality effluent being discharged from the 001 outfall for an extensive period of time. These mixed results and observations suggested that the 001 effluent is of questionable quality at times and could be negatively influencing downstream biological and water quality conditions.

◊ An additional source of water quality degradation to the Aurora Branch was an unauthorized discharge pipe located about 30 feet downstream from the Aurora Central 001 outfall. Though discharges appeared to be relatively infrequent, field observations of an erosion pocket at the pipe mouth and substantial solids deposition in the surrounding pool confirmed their occurrence. Sampling of one such event by Ohio EPA staff in July 1991, detected the release of solids and nutrients at levels sufficient to cause downstream enrichment and biological degradation.

◊ Chemical water column sampling results from the lower Aurora Branch during 1990 indicated that the McFarland Creek WWTP was not having a discernible impact on chemical water quality. TSS concentrations and chemical oxygen demand (COD) values were sporadically elevated downstream from the McFarland plant, but were not at levels sufficient to cause significant chemical water quality impacts. However, at some ambient water quality sites in Ohio, elevated COD values in conjunction with low BOD values have been found to be associated with an inhibition of WWTP biological treatment processes and a decline in effluent quality. Because similar effluent conditions seem to be sporadically occurring at the McFarland Creek facility, the possibility exists that influences of this nature could be a cause of the slight degradation observed in the downstream fish community. As a follow-up, Ohio EPA staff collected two sets of grab samples during 1991 in the vicinity of the McFarland Creek WWTP at a number of Aurora Branch and adjacent tributary sites. The results of the analyses were inconclusive with regards to source and magnitude of COD.

◊ Fish community depression, as reflected by IBI and MIwb values at or below ecoregional biocriteria downstream from both the Aurora Central WWTP and the McFarland Creek WWTP, is good evidence that the Aurora Branch, at these locations, is at or has exceeded its capacity to assimilate loadings from the WWTPs *as they are currently being operated*. Additionally, it is very likely that effects on the fish community by these two plants are being exacerbated by other point and nonpoint sources in the upstream watershed. The slightly depressed fish community and elevated fecal coliform counts at the most upstream site are strong evidence of such inputs. Instream and riparian habitat in the Aurora Branch is of very good quality at all of the surveyed sites and should be supporting more diverse and functionally sound fish populations. Thus, the current cumulative loadings of pollutants from within the entire watershed are seemingly the most limiting factor in the ability of the stream to achieve a high quality fish community in its lower 11+ miles.

Recommendations

◊ All currently designated beneficial uses for the surveyed streams should be retained based on chemical/physical and biological sampling conducted in 1990 and 1991. For the Chagrin River in the vicinity of Chagrin Falls and the Aurora Branch, beneficial uses include the Warmwater Habitat aquatic life use, Primary Contact Recreation use, Agricultural and Industrial Water Supply uses, and State Resource Water designation. For the E. Br. Chagrin River, all the above uses apply with the exception that Coldwater Habitat is the assigned aquatic life use.

◊ The IVEX of Ohio treatment plant operations should be thoroughly reviewed to ensure efficient, consistent, and effective pollutant treatment. The possibility of batch loadings or slugs of suspended solids needs to be investigated and, if found, the permit limits and/or monitoring requirements need modification to eliminate such events. If such discharges are occurring and are in violation of the existing permit limitations, an enforcement action should be initiated given the documented biological impairment downstream from the facility.

◊ The source or sources of high sediment chromium, copper, and lead accumulating downstream from the IVEX facility needs to be identified and an appropriate mitigative action taken. This may include monitoring requirements or permit limitations for these metals if the contaminant origin is the main process discharge or collection and treatment of runoff if the metals originate from the outside pulp storage area.

◊ Because of the threatened status of the CWH aquatic life use of the East Branch, serious efforts should be made to preserve the uniqueness of this aquatic resource. All applicable state and local statutes and best management practices regulating construction activity runoff and post-construction stormwater retention and handling should be strictly enforced. Additionally, attempts to ensure protection of the river's riparian corridor should be initiated and encouraged given its importance in the regulation of ambient water temperature, control of overland runoff, and stability of the stream channel and banks. It may be necessary for local authorities to enact a more stringent management approach to upland development in order to preserve the uniqueness and coolwater flavor of this resource.

◊ Follow-up chemical and bacterial sampling of East Branch tributaries in the Kirtland area needs to be conducted to isolate sources of bacterial contamination. Results should be used to target areas for upgrading of on-site systems and/or to prioritize areas for future sewer projects.

◊ The observation of a sporadic, low quality 001 effluent and the occurrence of unauthorized discharges to the Aurora Branch from the unpermitted pipe at the Aurora Central WWTP need further investigation to determine the exact nature of the situation. Both suggest the presence of problems associated with basic plant treatment processes, a situation that needs to be thoroughly evaluated and mitigated. 1991 survey results indicate that instream fish and macroinvertebrate community depression downstream from the WWTP seems best linked to these poor quality discharges and that proper plant operation may result in significant improvement to the Aurora Branch resource.

◊ For the Aurora Branch in the vicinity of the McFarland Creek WWTP, the potential ramifications of high COD values as they pertain to plant operations and effluent quality need to be a consideration in permit renewal and may necessitate more intensive monitoring of effluent COD over the short-term.

◊ Given the State Resource Water designation of all the surveyed streams, the siting of new wastewater sources or the expansion of existing facilities within the Chagrin River watershed should be strongly discouraged unless such new or expanded facilities are constructed to eliminate other existing or imminent sources within the watersheds and result in overall reductions in loadings and improved wastewater treatment in the basin. This is especially critical in the Aurora Branch watershed as indicated by the 1990 and 1991 biosurvey results.

Future Monitoring Needs

◊ All surveyed stream segments should be monitored on a routine basis (*i.e.*, within the 5-year basin approach) to track the status of the State Resource Water designations and to check on efforts to improve biological and chemical quality in currently impaired areas.

◊ Sampling in the uppermost reaches of the Aurora Branch seems warranted given the evidence of elevated bacterial levels and biological degradation detected in 1991 sampling at the site located upstream from the Aurora Central WWTP.

STUDY AREA DESCRIPTION

The Chagrin River basin is located in Cuyahoga, Lake, Geauga, and Portage Counties in northeast Ohio. The relatively small basin drains an area of 267 square miles (Ohio Dept. of Natural Resources, 1960; 1985). Table 2 presents the general characteristics of the three streams investigated in the study area.

The study area is situated within the Erie/Ontario Lake Plain ecoregion. The nearly level to rolling terrain exhibits a mosaic of cropland, pasture, livestock and poultry production, woodland, and forest. Dairy cattle are raised throughout the ecoregion with approximately one-tenth of the region providing pasture for cattle. Cropland covers about one-third of the area and is interspersed with pasture, woodland, and forest. Approximately 20% of the ecoregion is urbanized with some oil and gas drilling and strip mining for coal also occurring (Omernik and Gallant, 1988).

A significant concern in the Chagrin River basin is with the increase in population growth and residential development particularly in the middle portion of the basin. It is strongly suspected that growth in residential areas over the last decade has led to increased water resource impacts through conversion of undeveloped lands and increased wastewater flows. A more thorough description of the Chagrin River basin is available in NOACA (1984).

METHODS

All chemical, physical, and biological field, laboratory, data processing, and data analysis methods and procedures adhere to those specified in the *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices* (Ohio Environmental Protection Agency 1989a), *Biological Criteria for the Protection of Aquatic Life,* Volumes II & III and the Volume II Addendum (Ohio Environmental Protection Agency 1987a, 1989b, 1989c), and *The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application* (Rankin 1989).

Attainment/non-attainment of aquatic life uses is determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. The biological community performance measures that are used include the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb), both of which are based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. IBI and ICI are multi-metric indices patterned after an original IBI described by Karr (1981) and Fausch et al. (1984). The MIwb is a measure of fish community abundance and diversity using numbers and weight information: it is a modification of the original Index of Well-Being applied to fish community information from the Wabash River (Gammon 1976, Gammon et al. 1981).

Performance expectations for the basic aquatic life uses (Warmwater Habitat-WWH, Exceptional Warmwater Habitat-EWH, and Modified Warmwater Habitat-MWH) were developed using the regional reference site approach (Hughes et al. 1986; Omernik and Gallant 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of an aquatic life use is FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if one or more attains and at least one does not attain, and NON if all three (or those available) fail to meet the applicable criteria or when one or two organism groups indicate poor or very poor performance, even if the other group is attaining the applicable criteria.

Physical habitat is evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to determine the QHEI score which generally ranges from 20 to 100. The QHEI is used to evaluate the characteristics of a stream segment, not just the characteristics of a single sampling site. As such, individual sites may have much poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values higher than 60 are generally conducive to the establishment of warmwater faunas while those scores in excess of 75-80 typify habitat conditions which may have the ability to support exceptional faunas.

During this survey, macroinvertebrates were sampled using modified Hester/Dendy multiple-plate artificial substrate samplers supplemented with a qualitative assessment of the available natural substrates at each of twelve sampling locations within the watershed. Fish were sampled two times during the summer at eleven locations using pulsed DC electrofishing gear. Sampling sites consisted of 150 meter reaches electrofished using standard Ohio EPA wading procedures. Habitat was evaluated at each fish sampling zone using QHEI methodologies. Chemical sampling in the study area consisted of three to five water column grab samples collected through the summer at each of twelve sampling locations in addition to two sediment samples collected at Chagrin River locations. Descriptive information for each sampling location is presented in Table 3.

RESULTS AND DISCUSSION

Chemical Water Quality

Chagrin River

◊ The chemical results indicated that, with the exception of suspended solids (TSS) and biochemical oxygen demand (BOD_5), discharges emanating from the IVEX of Ohio facility (either via the main process or runoff from an outside pulp storage area) were not having a discernible impact on the water quality of the Chagrin River when compared to upstream background conditions. TSS concentrations in two of three sets of samples were double the upstream values at RM 33.4 (Table 4) but were at concentrations that should not affect downstream habitat and water quality. Similarly, BOD_5 values generally doubled from upstream to downstream but appeared to have little effect on instream dissolved oxygen concentrations which were maintained at acceptable levels at both sites (Table 4). No criteria for TSS or BOD_5 are currently codified in the Ohio Water Quality Standards (WQS).

◊ The only exceedences of Ohio WQS involved iron concentrations which occurred at both Chagrin River sites (Table 5); as such, these exceedences could not be directly attributed to IVEX discharges, though concentrations increased by about 50% at RM 30.0 compared to RM 33.4. In any event, iron concentrations above Ohio WQS are a common occurrence throughout Ohio because of natural background soil concentrations and, at the detected levels, should have had no deleterious effect on the WWH biotas of the Chagrin River.

◊ All other monitored parameters were well below Ohio WQS and were within acceptable ranges or below analytical detection limits. Toxics monitoring for priority pollutants, conducted at RM 30.0, detected no metals or organic chemicals above analytical detection limits.

◊ 1985-1990 annual loadings data compiled from entity monthly operating reports revealed lower, stable median daily BOD_5 loadings after a high in 1985; however, a steady decline in median daily discharge flow over the same period suggests that plant treatment performance in removing oxygen demanding material has declined (Figure 1).

◊ Based on the loadings data for suspended solids, a somewhat similar pattern is revealed (Figure 1). However, in this case, median daily loadings have been quite erractic with peaks in some years (1987, 1988) and lower loadings in others (1986, 1989). This may be an indication of a monitoring problem, but if not, it is apparent that solids removal at the IVEX facility is also a process subject to instability with regards to treatment performance.

Even considering the volatility in the numbers, median daily discharge rates were more than halved between 1985 and 1990, yet median daily TSS loadings remained essentially unchanged.

E. Br. Chagrin River

◊ Exceedences of the fecal coliform criterion for protection of the Primary Contact Recreation use occurred on 2 of 3 sampling runs at RM 2.3 downstream from the Kirtland area (Table 5). The only other exceedences were for iron which occurred at all East Branch sites at least one time. The fecal coliform exceedences indicated that inputs of improperly treated domestic sewage from unsewered areas of Kirtland is reaching the East Branch and has the potential to affect the water quality of the East Branch; it could ultimately degrade the aquatic biotas if the situation is left unresolved. Due to the limited scope of the sampling, it was not possible to isolate sources or tributaries responsible for the observed bacterial contamination.

◊ No other water quality problems were detected in the East Branch. All other analyzed parameters were within acceptable ranges or below analytical detection limits and at levels protective of the CWH aquatic life use.

Aurora Branch

◊ Although most water quality parameters at the sampling site upstream from the Aurora Central WWTP were generally at background levels, elevated fecal coliform counts strongly suggested the existence of sewage inputs from sources farther upstream. Three summer samples ranged from 270 to 2100 colonies per 100 ml, the latter being an exceedance of the Ohio WQS outside the mixing zone 30-day average criterion of 1000 per 100ml for the designated Primary Contact Recreation (PCR) use.

◊ Routine chemical water column grab sampling results from the vicinity of the Aurora Central WWTP indicated that discharges from the 001 outfall were not having an impact on Aurora Branch chemical water quality (Table 4). No exceedences of Ohio WQS, other than iron, were detected with three grab samples taken at the downstream sites (Table 5). However, Ohio EPA staff, during a late June modeling survey, observed what appeared to be poor quality effluent being discharged from the 001 pipe for an extensive period of time. These mixed results and observations suggested that the 001 effluent is of questionable quality at times and could be negatively influencing downstream biological and water quality conditions.

◊ Sampling of the 001 effluent before chlorination revealed dissolved oxygen concentrations in violation of the NPDES permit effluent limits; however, there was no

indication of a negative effect on instream oxygen levels at downstream sites, including within the mixing zone.

◊ An additional source of water quality degradation to the Aurora Branch was an unknown and unauthorized discharge pipe located about 30 feet downstream from the Aurora Central 001 outfall. Though discharges appeared to be relatively infrequent, field observations of an erosion pocket at the pipe mouth and substantial solids deposition in the surrounding pool confirmed their occurrence. One such event occurred on July 31, 1991, and was observed by Ohio EPA field personnel. The discharge was about the same volume as the 001 discharge and lasted at least 15 minutes. An ambient sample, collected at a mid-pool location about 30 feet downstream from the discharge, revealed very high levels of suspended solids (246 mg/l), phosphorus (7.15 mg/l), and nitrate-nitrite (9.58 mg/l). BOD_5, ammonia, and Kehldahl nitrogen were also elevated but not to the same degree. Periodic discharges of such poor quality effluent would be sufficient to impact the biological communities of the Aurora Branch.

◊ Results of water column chemical sampling at downstream sites in the Aurora Branch indicated that the McFarland Creek WWTP was not having a major impact on chemical water quality. With the exception of iron concentrations, there were no chemical exceedences of Ohio WQS at the sites downstream from the WWTP (Table 5). TSS concentrations and chemical oxygen demand (COD) values, parameters not codified in the Ohio WQS, were sporadically elevated downstream from the McFarland plant, but were not at levels sufficient to cause significant chemical water quality impacts. However, at some ambient water quality sites in Ohio, elevated COD values in conjunction with low BOD values have been found to be associated with an inhibition of WWTP biological treatment processes and a decline in effluent quality. Because similar effluent conditions seem to be sporadically occurring at the McFarland Creek facility, the possibility exists that influences of this nature could be a cause of the slight degradation observed in the downstream fish community. As a follow-up, Ohio EPA staff collected two sets of grab samples during 1991 in the vicinity of the McFarland Creek WWTP at a number of Aurora Branch and adjacent tributary sites; samples were analyzed for COD by two different analytical laboratories. The results of the analyses were inconclusive with regards to source and magnitude of COD.

◊ 1985-1990 annual loadings data for key McFarland Creek WWTP parameters, compiled from monthly operating reports, are depicted in Figure 2. For the time period, median daily flows have been increasing steadily along with median daily loadings of oxygen demanding substances (as reflected by BOD_5). Conversely, median daily TSS loadings have declined by more than 50% over the same time frame. This somewhat contradictory situation (higher BOD_5 yet lower TSS) is unexplainable although it could be attributed to dissolved substances exerting a BOD or a reflection of the higher COD values. In any event, loadings and associated mean discharge concentrations of these two parameters are relatively low and reflect good effluent quality. Most importantly, trends in the flow data reflect the increasing demands on the WWTP to provide considerably more wastewater treatment.

Sediment Quality

Chagrin River

◊ Two sediment samples were collected from the Chagrin River upstream (RM 33.4) and downstream (RM 29.9) from the IVEX of Ohio facility (Table 6). All metals analyzed at the upstream site were at levels considered non-elevated (*i.e.*, comparable to background) by the Illinois stream sediment classification system developed by Kelly and Hite (1984). Downstream from IVEX, five of eight metals were found in concentrations substantially higher than Illinois background conditions. Most noteworthy were the sediment concentrations of lead, chromium, and copper which were ranked as highly elevated, elevated, and elevated, respectively. All three have the potential to be toxic to aquatic life at biologically available sediment concentrations, but, at the present time, no criteria are available for sediment parameters. The data clearly indicates that accumulations of these metals in the sediments are occurring to a greater degree downstream than upstream from the IVEX facility.

◊ A comparison of the 1990 sediment data with data collected at RM 29.8 as part of a 1986 survey (Ohio EPA 1987b) indicates that sediment quality, with two exceptions, has remained relatively unchanged. In 1986, sediment concentrations of lead, copper, and chromium were extremely elevated, elevated, and slightly elevated, respectively, not much different than in 1990. Additionally, however, 1986 levels of cadmium and zinc were highly elevated and extremely elevated, respectively. Conversely, concentrations of both metals in 1990 were at or only slightly elevated from background.

Physical Habitat Assessment

Chagrin River

◊ Suspended solids were noticeably present in the Chagrin River water column downstream from the IVEX facility. These solids appeared to be adversely impacting habitat quality with excessive accumulations on the natural substrates in virtually all areas of the river including riffles. Conversely, little or no solids were observed to be in the water column or covering substrates at the upstream station (RM 33.4). Otherwise, habitat quality at both sites was optimal with good riffle/pool development and stream beds composed of a wide variety of substrate types.

◊ Overall, QHEI scores at the two Chagrin River sites averaged 76 which suggested that existing habitat conditions, less the downstream negative influence of settled solids, were capable of supporting WWH fish and macroinvertebrate communities (Table 7, Figure 3). The average of 76 agreed well with the average QHEI of 78 scored in 1986 which was based on 10 mainstem sites covering 30+ stream miles.

E. Br. Chagrin River

◊ The average QHEI for the sampled segment of the E. Br. Chagrin River was 71 (Figure 3). Although QHEI thresholds have not been established for CWH streams, the presence of quality habitat capable of supporting WWH communities should also be conducive to cool/coldwater faunas since both community assemblages will typically have many species in common.

◊ QHEI scores in the East Branch would have been higher except for the increased bedload of finer sediments (i.e., sand and silt) at 3 of 4 sampling sites which negatively influenced scoring (Table 7). The presence of this sediment was probably temporary in nature since much of it originated from bank and channel modifications actively underway in the watershed around Kirtland. However, increased basin development will probably result in permanent changes in the hydrology of the East Branch which could result in higher instream erosive forces and exacerbated siltation and sedimentation problems.

Aurora Branch

◊ The average QHEI for the sampled 11+ mile segment of the Aurora Branch was 77 (Figure 3). Although some siltation and substrate embeddedness was noted downstream from the McFarland Creek WWTP and heavy solids deposition was present downstream from the Aurora Central facility, habitat conditions, as reflected by QHEI values in this range, were easily conducive to supporting WWH biotas and potentially could support exceptional communities (Table 7). The existing WWH aquatic life use should have been easily achievable given the near exceptional physical habitat conditions at all the sites sampled in both 1990 and 1991.

Macroinvertebrate Community Assessment

Chagrin River

◊ A significant impact to the macroinvertebrate community occurred at RM 30.0 downstream from the IVEX of Ohio facility. The 20 point decrease in the ICI from the upstream site at RM 33.4 (46 to 26) reflected a decline from a near exceptional assemblage of macroinvertebrates to a fair assemblage not achieving the WWH ecoregional biocriterion (Table 8, Figure 4).

◊ Six out of ten ICI metrics were adversely affected at the downstream site. Major scoring changes included marked decreases in mayfly diversity (Metric 2), tanytarsini midge abundance (Metric 7), and EPT (mayfly/stonefly/caddisfly) taxa diversity (Metric 10) coupled with marked increases in abundances of dipterans/non-insects (Metric 8) and pollution tolerant organisms (Metric 9).

◊ Downstream community impacts seemed most attributable to the effect of heavy deposition of solids blanketing nearly all available instream habitat. The resultant modification of habitat led to structural and compositional changes in the macroinvertebrate fauna. Most revealing was the decline in EPT taxa collected from the natural substrates. The 22 taxa collected upstream included 3 species of stoneflies along with 11 mayfly and 8 caddisfly taxa. The decline to 8 EPT taxa downstream included just 4 taxa each of mayflies and caddisflies. The exceptionally diverse, balanced community present upstream was replaced downstream by a much more species poor fauna predominated by a few organism groups.

◊ Essentially no change has occurred in the Chagrin River benthos since collections were made in 1986 (Ohio EPA 1987b). ICI scores from the same sites in 1986 were identical with those collected in 1990. As in 1990, the 1986 collection at RM 33.4 revealed an incredible diversity of aquatic life. The 81 different kinds of macroinvertebrates qualitatively collected from natural substrates at this site in 1986 totaled the highest number recorded by the Ohio EPA which has made collections at over 2000 locations across Ohio.

E. Br. Chagrin River

◊ Macroinvertebrate communities in the East Branch reflected very good to exceptional conditions with ICI scores ranging from 54 at the most upstream site (RM 10.3) to 42 at RM 2.4, the most downstream site (Table 8, Figure 4).

◊ The steady decline in ICI from upstream to downstream could not be attributed to any one obvious factor, although stream and bank modifications had taken place or were actively taking place in the vicinity of all but the upstream site. The decline may have been a reflection of cumulative influences from these activities or a reflection of habitat and water quality stresses associated with changing land use patterns upstream (rural) to downstream (suburban). There were no indications of major effects directly attributable to tributaries draining unsewered areas of Kirtland.

◊ A number of populations of macroinvertebrates were present in the East Branch that are generally associated with coolwater streams in Ohio. Included were four species of caddisflies (Trichoptera), one fishfly species (Megaloptera), and five midge taxa (Diptera-Chironomidae). Most were present at 2 or more of the four sampling sites; however, diversity and abundance tended to decline in a downstream direction. The number of different coolwater taxa present and their widespread distribution thoughout the East Branch reaffirmed the appropriateness of the CWH aquatic life use designation for the entire stream.

◊ Two species of rare crayfish, the Northern crayfish (Orconectes virilis) and the Great Lakes crayfish (O. propinquus) were collected from the East Branch with one or both being present at three of the four sampling sites. These crayfish (Decapoda-Cambaridae) have

been listed by the Ohio Department of Natural Resources (DNR) as Special Interest Animals. This classification is used for a species or subspecies which may become threatened in Ohio under continued or increased environmental stress.

Aurora Branch

◊ ICI scores from all stations in the Aurora Branch outside of mixing zones not only easily achieved the WWH biocriterion (34) but, in the lower 10 miles, equalled or exceeded the EWH criterion of 46 (Table 8, Figure 4). Pollution sensitive stoneflies, mayflies, and caddisflies were well represented and numbered between 19 and 25 taxa in the vicinity of the McFarland Creek WWTP (evaluated in 1990) and between 10 and 15 taxa farther upstream near the Aurora Central plant (evaluated in 1991).

◊ Macrinvertebrate community degradation in the vicinity of the Aurora Central WWTP was very localized and restricted to the general mixing zone area which included the 001 effluent and the unpermitted discharge pipes. Outside of this area, macroinvertebrate communities were of good quality as reflected by ICI scores of 40 both upstream (RM 11.3) and downstream (RM 11.1) from the plant. Degradation in the mixing zone was moderately severe and resulted in an ICI score of 20. Compared to the upstream site, the mixing zone community was predominated by pollution tolerant organisms, particularly aquatic worms, and was poorly represented by pollution sensitive mayflies and caddisflies. The response of the macroinvertebrate community reflected an organic enrichment rather than toxic influence and was best attributed to the large volume of settled solids in the general area.

◊ Sampling of the macroinvertebrates at RM 9.1 in 1991 revealed exceptional community conditions and indicated that effects from the Aurora Central discharges were limited in extent. The ICI score of 48 at this site was nearly identical to the score of 50 that was achieved just downstream at RM 8.9 in 1990.

◊ There was no obvious detrimental effect on the macroinvertebrate community attributable to discharges from the McFarland Creek WWTP (RM 3.4). ICI values downstream from the plant at RMs 3.3 and 2.0 were the highest scored from the Aurora Branch. However, there were some indications of minor structural changes in the communities in the vicinity of the WWTP (most noteworthy of which was an increase in pollution tolerant organisms), but these were not significant enough to affect overall ICI scoring.

◊ The higher ICI scores downstream from the WWTP may have been a reflection of an enhancing effect stimulated by slight organic enrichment, an occurrence commonly observed in smaller Ohio streams with a large but good quality, nonindustrial point source. Such streams are often near their capacity to naturally assimilate organic wastes and are, in effect, being fertilized by the discharge.

◊ There were no indications of toxicity associated with the WWTP effluent as evidenced by the high quality macroinvertebrate community sampled within the mixing zone (RM 3.4).

◊ Communities collected near the McFarland Creek facility in 1990 compared favorably with those collected at similar locations in 1986 (Ohio EPA 1987b). ICI scores at three locations ranged from 48 to 50 in 1986 and 46 to 54 in 1990. As in 1990, there was no discernible negative impact associated with the McFarland Creek WWTP discharge.

Fish Community Assessment

Chagrin River

◊ A measurable impact to the Chagrin River fish community was detected downstream (RM 29.9) from the IVEX of Ohio facility. Both IBI and MIwb scores declined considerably from those at the upstream site (RM 33.4) where the WWH biocriteria were fully achieved (Table 9, Figures 5 and 6). Scores at the downstream site, only just nonsignificant departures from the biocriteria, reflected a substantial change in the fish community attributable to discharges from the IVEX facility.

◊ The decline in the IBI at RM 29.4 when compared to RM 33.4 was due to structural and functional changes within the fish community. Number of simple lithophils (those fish needing clean substrates for reproduction), number of insectivores (those feeding on benthic larval insects), and total relative number of fish all declined at the site resulting in IBI metrics 8, 10, and 11 scoring lower than at RM 33.4. Conversely, number of pollution tolerant fish and omnivorous fish (those capable of utilizing multiple food sources as needed) increased at RM 29.4 which resulted in lower scores for metrics 6 and 7. Such structural and functional changes reflected an imbalanced fish community and indicated a moderate level of community stress downstream from the IVEX facility.

◊ Comparison with sampling conducted in 1986 at the same locations reflected essentially no change in the fish community since that survey (Ohio EPA 1987). IBI and MIwb scores at RMs 33.4 and 29.9 (46/8.3 and 36/7.8, respectively) were nearly identical with the 1990 values (45/8.3 and 35/7.4, respectively).

E. Br. Chagrin River

◊ No impact to the East Branch fish community could be attributed to unsewered areas of Kirtland. Values of both the IBI and MIwb were actually higher downstream from Kirtland (RM 2.4) than upstream at RMs 6.6 and 3.7 (Table 9, Figures 5 and 6). Observed differences at the immediate upstream sites appeared most related to localized bank stabilization and channel modification activities that resulted in increased amounts of instream sand and silt in the vicinity of these sites. These differences may have also been a reflection of the gradual change from cool/coldwater to more warmwater conditions. The

differences were minor, however, and did not reflect a substantial impact on the fish community.

◊ Although only a few of the 27 fish species captured in the East Branch are classified as cool/coldwater species by Ohio EPA (1988) or Trautman (1981), the presence of good populations of longnose dace along with one individual brook trout and redside dace collected at the most upstream site supported the appropriateness of the designated CWH aquatic life use for this stream. Trautman (1981) reports that many trout species have historically been stocked in the watershed; Ohio DNR reports that some stocking, including brook trout, continues at the present time (Division of Wildlife Staff, Pers. Comm.).

Aurora Branch

◊ Impairment of the fish community was detected both upstream and downstream from the Aurora Central WWTP (Table 9, Figures 5 and 6). However, the most severe degradation was detected in the mixing zone and at the near-field site downstream from the plant and seemed best linked to the poor quality discharges from the unpermitted pipe. Declines in IBI scores at these sites were due to increases in tolerant, omnivorous, and pioneering fishes when compared to the upstream site. The observed fish community degradation was not reflective of a toxic condition but rather reflected moderate to severe organic enrichment and habitat degradation attributed to heavy solids depostion. Influences from this WWTP were likely localized in nature and probably did not extend for more than a few miles downstream.

◊ Sampling at RM 9.0 in both 1990 and 1991 resulted in somewhat mixed results with an IBI score of 31 in 1990 and a higher score of 36 in 1991; the latter score was a non-significant departure from the WWH biocriterion while the former was clearly a significant departure. These results suggested the possibility of a lingering effect from upstream sources, but it was doubtful if such conditions extended much farther downstream. Results from the 1990 sampling indicated marginal but full achievement of fish community biocriteria by RM 3.9, upstream from McFarland Creek.

◊ The mixing zone of the McFarland Creek WWTP (RM 3.4) was not acutely toxic to fish. No significant avoidance of this area could be detected and both the IBI and MIwb scores were essentially unchanged from the upstream site. Conversely, the fish collection at RM 3.3, immediately outside the mixing zone, resulted in lower index values, most significantly for the MIwb (Table 9, Figures 5 and 6). This pattern of no mixing zone toxicity, but downstream depression suggested an organic enrichment rather than toxicity problem.

◊ The high gradient of the stream coupled with its natural assimilitive capacity and no additional sources of stress resulted in a recovered fish community at RM 0.3 where IBI and MIwb WWH biocriteria were achieved. The zone of slight depression in the fish

community downstream from the McFarland Creek facility was probably no more than 1.5 miles in length.

◊ Comparison with sampling conducted in 1986 at RM 0.3 suggested little difference in fish community condition either sampling year (Ohio EPA 1987b). 1986 IBI and MIwb scores of 37 and 8.0, respectively, were slightly lower than those collected in 1990 (41 and 8.3, respectively), but these still achieved the WWH biocriteria.

Status of Aquatic Life Use Designations

Attainment status of the WWH aquatic life use was full in the Chagrin River upstream from the IVEX of Ohio facility and partial, but near non-attainment, at the site immediately downstream. A narrative based assessment of the status of the CWH designation of the East Branch indicated that the 10+ miles surveyed were fully attaining the CWH aquatic life use. However, continued attainment of the CWH use is threatened by increasing suburban development in the watershed. As for the Aurora Branch, WWH attainment was full for over 5.5 miles between the two evaluated WWTPs and for a 2 mile reach near the mouth. Areas of partial attainment included the 0.5 miles evaluated upstream from the Aurora Central WWTP, a nearly two mile reach downstream from that facility, and a 1.5 mile zone immediately downstream from the McFarland Creek WWTP. Non-attainment was restricted to a 0.4 mile reach immediately downstream from the Aurora Central plant. A comparison of biological index scores for the Invertebrate Community Index (ICI), Index of Biotic Integrity (IBI), and Modified Index of Well-Being (MIwb) at 3 to 4 common sites sampled in the basin in 1986 (Ohio EPA 1987b) shows no significant differences between the 1990 and 1986 results. Differences in biological index scores were within the range of insignificant departure established for each index.

Table 2. Stream characteristics and identified pollution sources in the Chagrin River basin study area, 1990 and 1991.

Stream Name	Length (Miles)	Gradient (Ft/Mile)	Drainage ($Miles^2$)	Identified NPS Pollution Categories	Point Sources Evaluated
Chagrin River	47.9	15.9	267.0	Agriculture Urban Resource Extraction	IVEX of Ohio (RM 30.1)
E. Br. Chagrin River	19.4	34.8	50.8	Agriculture Urban On-site Waste Treatment Hydromodification	
Aurora Branch	16.1	20.0	57.6	Agriculture Urban	McFarland Creek WWTP (RM 3.4) Aurora Central WWTP (RM 11.2)

Table 3. Sampling locations (water chemistry - C, sediment chemistry - S, benthos - B, fish - F) in the Chagrin River basin study area, 1990 and 1991.

Stream River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Chagrin River - 1990				
33.4	B,F,C,S	41°27'41"/81°21'10"	Upst. SR 87	South Russell
30.0	B	41°26'03"/81°23'15"	Dst. Cleveland St.	Chagrin Falls
29.9	F,C,S	41°26'03"/81°23'16"	Dst. Cleveland St.	Chagrin Falls
E. Br. Chagrin River - 1990				
10.4	F,C	41°36'55"/81°17'01"	Upst. Mitchells Mill Rd.	Chesterland
10.3	B	41°37'02"/81°16'54"	Dst. Mitchells Mill Rd.	Chesterland
6.6	B,F,C	41°37'45"/81°19'00"	Dst. Booth Rd.	Mentor
3.7	F	41°37'50"/81°21'28"	Upst. SR 615	Mentor
3.5	B,C	41°37'47"/81°21'36"	Upst. SR 615	Mentor
2.4	B,F,C	41°37'46"/81°22'16"	Upst. Markell Rd.	Mentor
Aurora Branch - 1991				
11.3	B,F,C	41°19'28"/81°20'17"	Upst. Aurora Central WWTP	Aurora
11.2	B,F,C	41°19'31"/81°20'13"	Aurora Central WWTP mixing zone	Aurora
11.1	B,F,C	41°19'33"/81°20'09"	Dst. Aurora Central WWTP	Aurora
9.1	B	41°20'34"/81°20'34"	Upst. SR 306 and Smith Creek	Aurora
9.0	F,C	41°20'37"/81°20'32"	Upst. SR 306 and Smith Creek	Aurora
Aurora Branch - 1990				
9.0	F,C	41°20'37"/81°20'32"	Upst. SR 306 and Smith Creek	Aurora
8.9	B	41°20'40"/81°20'36"	Dst. SR 306	Aurora
3.9	F,C	41°23'05"/81°23'23"	Upst. Bainbridge Rd.	Chagrin Falls
3.5	B	41°23'23"/81°23'22"	Upst. McFarland Creek WWTP	Chagrin Falls
3.4	B,F	41°23'25"/81°23'22"	McFarland Creek WWTP mixing zone	Chagrin Falls
3.3	B,F,C	41°23'28"/81°23'25"	Dst. McFarland Creek WWTP	Chagrin Falls
2.0	B,C	41°24'16"/81°24'15"	Adj. Chagrin River Rd.	Chagrin Falls
0.3	B,F,C	41°25'06"/81°24'47"	Upst. Chagrin River Rd.	Chagrin Falls

Table 4. Selected results, mean(minimum-maximum)[a], of chemical/physical sampling in the Chagrin River basin study area, 1990 and 1991.

River Mile	DO (mg/l)	TSS (mg/l)	BOD_5 (mg/l)	COD (mg/l)
Chagrin River - 1990				
33.4	7.8(7.7-7.9)	16(8-27)	1.5(1.2-2.0)	22(20-26)
29.9	8.2(7.8-8.4)	23(20-30)	3.3(2.1-4.8)	21(20-23)
E.Br. Chagrin River - 1990				
10.4	9.5(9.0-10.2)	10(5-19)	1.0(1.0-1.0)	20(20-20)
6.6	9.1(9.0-9.3)	9(5-17)	1.0(1.0-1.1)	20(20-20)
3.5	9.1(8.8-9.8)	24(5-43)	1.0(1.0-1.0)	20(20-20)
2.4	8.7(8.2-9.0)	24(5-43)	1.0(1.0-1.0)	20(20-20)
Aurora Branch - 1991				
11.3	6.9(6.7-7.1)	17(8-33)	1.4	12(10-22)
11.2	6.9(6.7-7.0)	19(5-32)	1.6	11(10-18)
11.1	7.1(6.7-7.5)	27(17-42)	1.3(1.0-2.3)	17(10-36)
9.0	7.5(7.1-7.8)	23(8-48)	1.6	13(10-24)
E[b]	2.4(1.6-3.0)	10(8-12)	2.8(1.7-4.8)	16(14-22)
Aurora Branch - 1990				
9.0	8.5(8.2-9.2)	8(5-13)	1.1(1.0-1.3)	20(20-20)
3.9	8.5(8.1-9.0)	12(5-27)	1.2(1.0-1.5)	20(20-20)
3.3	8.9(8.4-9.7)	21(5-64)	1.2(1.0-1.7)	34(20-56)
2.0	8.4(8.3-8.6)	22(8-48)	1.3(1.0-1.6)	20(20-20)
0.3	8.8(7.8-9.4)	24(5-64)	1.2(1.0-1.7)	20(20-20)

a Means calculated using detection limits as the minimum value where reported minimum was less than instrument detection limit.

b Aurora Central WWTP 001 effluent (before chlorination); discharge to Aurora Branch at RM 11.2.

Table 5. Exceedences of Ohio EPA water quality criteria (OAC 3745-1-07) for chemical/physical parameters measured in the Chagrin River basin study area, 1990 and 1991.

Stream Name (Aquatic Life Use)	River Mile	Parameter Exceeded (Value)
Chagrin River (WWH) - 1990		
	33.4	Iron (1630, 1030 ug/l)[a]
	30.0	Iron (1800, 2230, 1510 ug/l)
E. Br. Chagrin River (CWH) - 1990		
	10.3	Iron (1390 ug/l)
	6.7	Iron (1630 ug/l)
	3.5	Iron (2200, 3300 ug/l)
	2.3	Iron (1800, 2210 ug/l
		Fecal Coliform (2600, 3300 /100ml)[b]
Aurora Branch (WWH) - 1991		
	11.3	Iron (1930 ug/l)
		Fecal Coliform (2100 /100ml)
	11.2	Iron (1860 ug/l)
	11.1	Iron (1350, 2300 ug/l)
	9.0	Iron (2310 ug/l)
	E[c]	Dissolved Oxygen (1.6, 2.6, 3.0 mg/l)[d]
Aurora Branch (WWH) - 1990		
	9.0	Iron (1260 ug/l)
	3.5	Iron (1410, 1020 ug/l)
	3.3	Iron (1580, 1030, 1320 ug/l)
	2.0	Iron (2590, 1810, 1460 ug/l)
	0.3	Iron (3660, 1720, 2040 ug/l)

a Listed iron values exceed the outside the mixing zone 30-day average criterion of 1000 ug/l for the WWH (Chagrin River and Aurora Branch) and CWH (E.Br. Chagrin River) aquatic life uses.

b Listed fecal coliform values exceed the outside the mixing zone 30-day average criterion of 1000 /100ml for the designated Primary Contact Recreation (PCR) use of the E. Br. Chagrin River.

c Aurora Central WWTP 001 effluent (before chlorination); discharge to Aurora Branch at RM 11.2.

d Listed dissolved oxygen values violate the NPDES permit effluent limits.

Table 6. Concentrations of heavy metals in sediments collected at stations in the Chagrin River basin study area, 1990.[1]

Stream name / River Mile	Sediment Concentration (mg/kg. dry weight) Ar	Cd	Cr	Cu	Fe	Pb	Ni	Zn
Chagrin River								
33.4	6.23[a]	0.483[a]	9.6[a]	8.67[a]	10400[a]	8.02[a]	8.6	41.6[a]
29.9	7.83[a]	0.393[a]	25.1[c]	61.30[c]	21000[b]	98.30[d]	20.0	96.9[b]

1 All parameter concentrations, excluding nickel, are ranked based on a stream sediment classification system described by Kelly and Hite (1984).

a Non-elevated
b Slightly elevated
c Elevated
d Highly elevated
e Extremely elevated

Table 7. Matrix of QHEI scores and corresponding Warmwater Habitat and Modified Warmwater Habitat attributes from the Chagrin River basin study area, 1990 and 1991.

Key QHEI Components

WWH Attributes — MWH Attributes: *High Influence* / *Moderate Influence*

ver ile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 4 0 cm (WD,HW)	Total (High Influence) MWH Attributes	Recovering Channel	Heavy/Mod. Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Embeddedness	Ext./Mod. Riffle Embeddedness	No Riffle	Total (Moderate Influence) MWH Attributes	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
001) – CHAGRIN RIVER																																		
ear: 90																																		
3.4	82.0	16.39	■	■		■	■	■	■	■	■	■	9						0													0	.10	.10
9.4	70.0	20.00	■	■		■	■	■	■		■		7				●		1		▲			▲					▲	▲		4	.25	.75
002) – E. BR. CHAGRIN RIVER																																		
ear: 90																																		
0.4	73.0	18.18	■			■	■	■	■		■		6						0		▲								▲	▲		3	.14	.57
6.6	75.5	33.30		■		■	■	■	■	■	■		7						0	▲	▲									▲		3	.13	.50
3.9	79.0	16.70	■	■		■	■	■	■		■		7						0										▲	▲		2	.13	.38
3.7	59.5	12.50				■	■		■		■		4				●		1	▲	▲			▲						▲		4	.40	1.20
2.4	76.5	10.87	■	■		■	■	■	■	■	■		8						0											▲		1	.11	.22
005) – AURORA BRANCH																																		
ear: 91																																		
1.3	78.0	24.39	■	■		■	■	■		■	■	■	8						0									▲				1	.11	.22
1.2	63.5	24.39	■	■				■		■	■		5			●			1					▲	▲			▲			▲	4	.33	1.00
1.1	80.0	24.39	■	■		■	■	■	■	■	■	■	9						0													0	.10	.10
9.0	78.0	17.54	■	■		■	■	■	■	■	■	■	9						0													0	.10	.10
ear: 90																																		
9.0	79.5	17.54	■	■		■	■	■	■	■	■	■	9						0													0	.10	.10
3.9	79.0	16.70	■	■		■	■	■	■		■		7						0										▲	▲		2	.13	.38
3.3	70.5	4.76	■	■		■	■	■	■		■		7						0					▲					▲	▲		3	.13	.50
0.3	76.0	17.24	■			■	■	■	■	■	■	■	8						0													0	.11	.11

Table 8. Summary of macroinvertebrate data collected from artificial substrates at sampling sites in the Chagrin River basin study area, July - August, 1990 and 1991.

Stream River Mile	Narrative Evaluation	ICI	No. Quant. Taxa	Relative Density (ft^2)	No. Qual. Taxa	Qual. EPT[a]
Chagrin River (WWH) - 1990						
33.4	Exceptional	46	43	598	67	22
30.0	Fair	26*	38	1966	43	8
E. Br. Chagrin River (CWH) - 1990						
10.3	Exceptional[b]	54	43	1181	42	14
6.6	Exceptional[b]	50	39	533	43	17
3.5	Exceptional[b]	48	43	401	31	9
2.4	Very Good[b]	42	36	297	35	12
Aurora Branch (WWH) - 1991						
11.3	Good	40	34	232	47	11
11.2	Fair	20	32	464	13	0
11.1	Good	40	28	231	35	7
9.1	Exceptional	48	40	365	42	12
Aurora Branch (WWH) - 1990						
8.9	Exceptional	50	37	871	56	21
3.5	Exceptional	46	48	281	51	15
3.4	Exceptional	46	51	531	48	16
3.3	Exceptional	50	49	460	45	12
2.0	Exceptional	54	39	651	51	13
0.3	Exceptional	48	33	862	45	18

Erie/Ontario Lake Plain (EOLP) Ecoregion:	WWH	EWH	CWH
ICI Biocriteria[c]:	34	46	No Criterion

* Significant departure from the ecoregional biocriterion (>4 ICI units).

a EPT: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxa richness.

b Narrative evaluation based on the Ohio WQS definition of the CWH aquatic life use.

c OAC 3745-1-07, Table 7-17.

Table 9. Fish community indices based on electrofishing data collected at sampling sites in the Chagrin River basin study area, July - September, 1990 and 1991.

Stream River Mile	Cum. Species	Mean Rel. Number	Mean Rel. Weight	Modified Index of Well. Being (MIwb)	Index of Biotic Integrity (IBI)	QHEI[a]	Narrative Evaluation[b]
Chagrin River (WWH) - 1990							
33.4	15	954	22.6	8.3	45	82	Good
29.9	20	363	23.8	7.4[ns]	35[ns]	70	Marginally Good
E. Br. Chagrin River (CWH) - 1990							
10.4	19	1499	10.0	8.6	43	73	Good[c]
6.6	21	932	5.3	7.8	40	75.5	Marg. Good -Good[c]
3.7	21	1067	6.4	8.3	38	59.5	Good[c]
2.4	19	1248	11.0	8.5	45	76.5	Good[c]
Aurora Branch (WWH) - 1991							
11.3	11	2007	7.7	N/A	32*	78	Fair
11.2	10	1191	32.0	N/A	25*	63.5	Poor
11.1	13	1142	16.3	N/A	27*	80	Poor
9.0	12	1995	9.2	N/A	36[ns]	78	Marg. Good
Aurora Branch (WWH) - 1990							
9.0	12	1218	9.9	N/A	31*	79.5	Fair
3.9	15	1329	12.7	7.9	38	82	Good
3.4	12	2004	24.2	8.0	37[ns]	-	Good-Marg. Good
3.3	17	872	8.5	6.6*	36[ns]	70.5	Fair-Marg. Good
0.3	20	1359	29.0	8.3	41	76	Good

Erie/Ontario Lake Plain (EOLP) Ecoregion:	WWH	EWH	CWH
IBI Biocriteria (headwater)[d]:	40	50	
IBI Biocriteria (wading)[d]:	38	50	No
MIwb Biocriteria (wading)[d]:	7.9	9.4	Criteria

ns Nonsignificant departure from the ecoregional biocriteria (≤ 4 IBI units; ≤ 0.5 MIwb units).

* Significant departure from the ecoregional biocriteria (> 4 IBI units; > 0.5 MIwb units); poor and very poor index values are underlined.

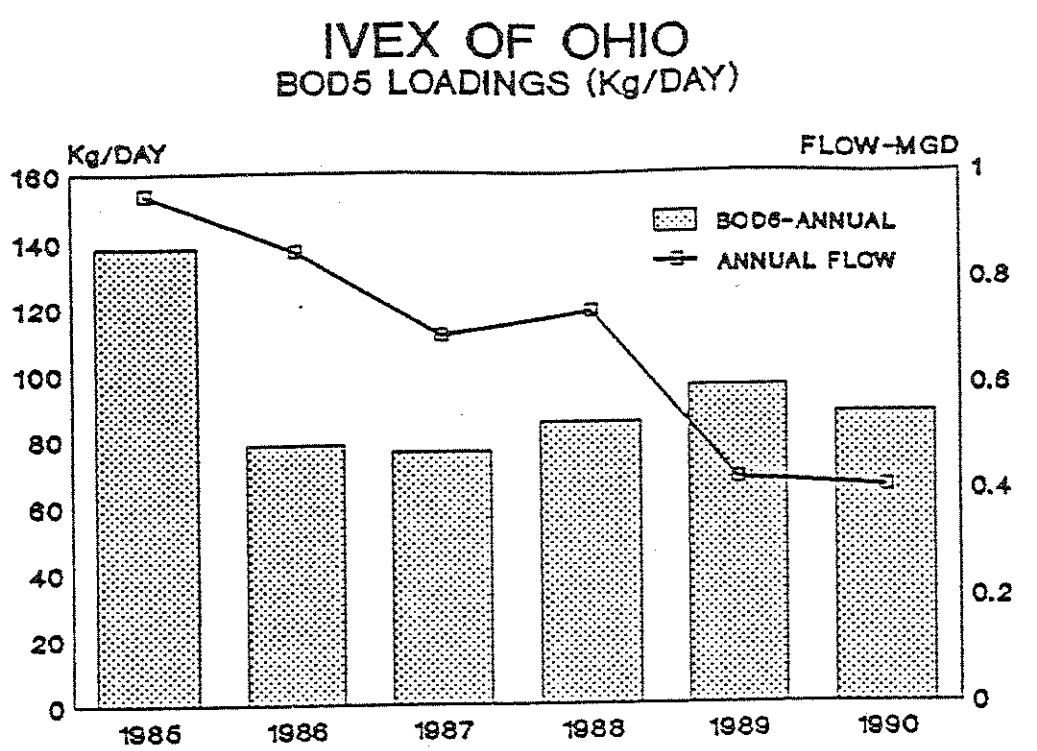
N/A Modified Iwb not applicable at headwater sites.

a QHEI - Qualitative Habitat Evaluation Index.

b Based on MIwb and IBI scores.

c Narrative evaluation based on the Ohio WQS definition of the CWH aquatic life use.

d OAC 3745-1-07, Table 7-17.



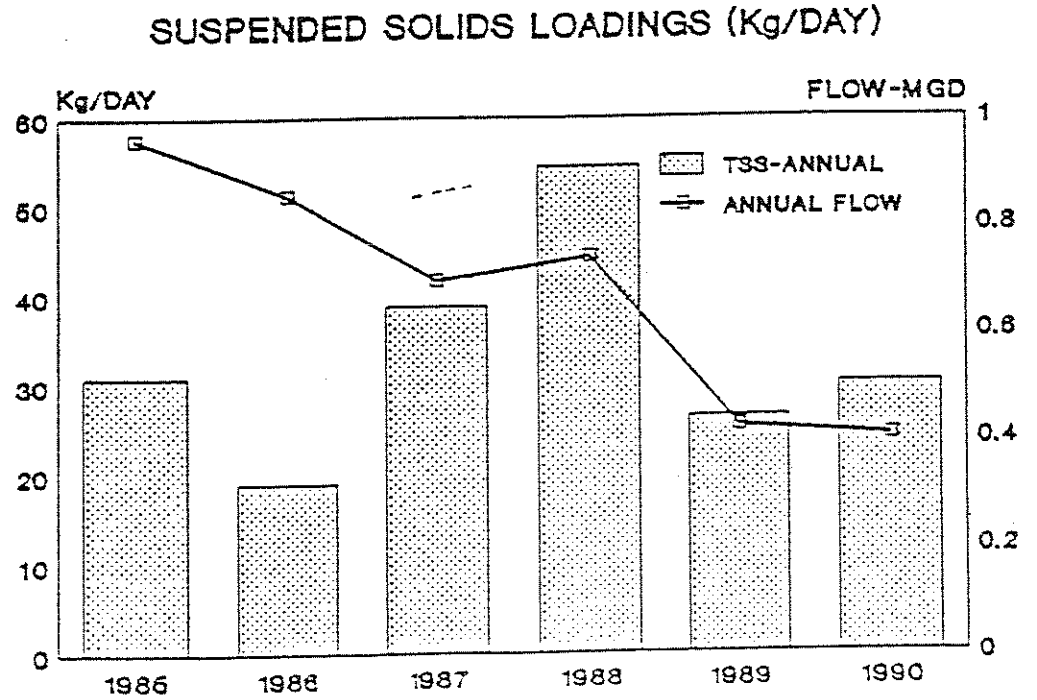


Figure 1. Trend of 50th percentile daily loadings of biochemical oxygen demand (BOD_5) and total suspended solids (TSS) plotted versus median daily discharge flow for the IVEX of Ohio discharge to the Chagrin River, 1985-90.

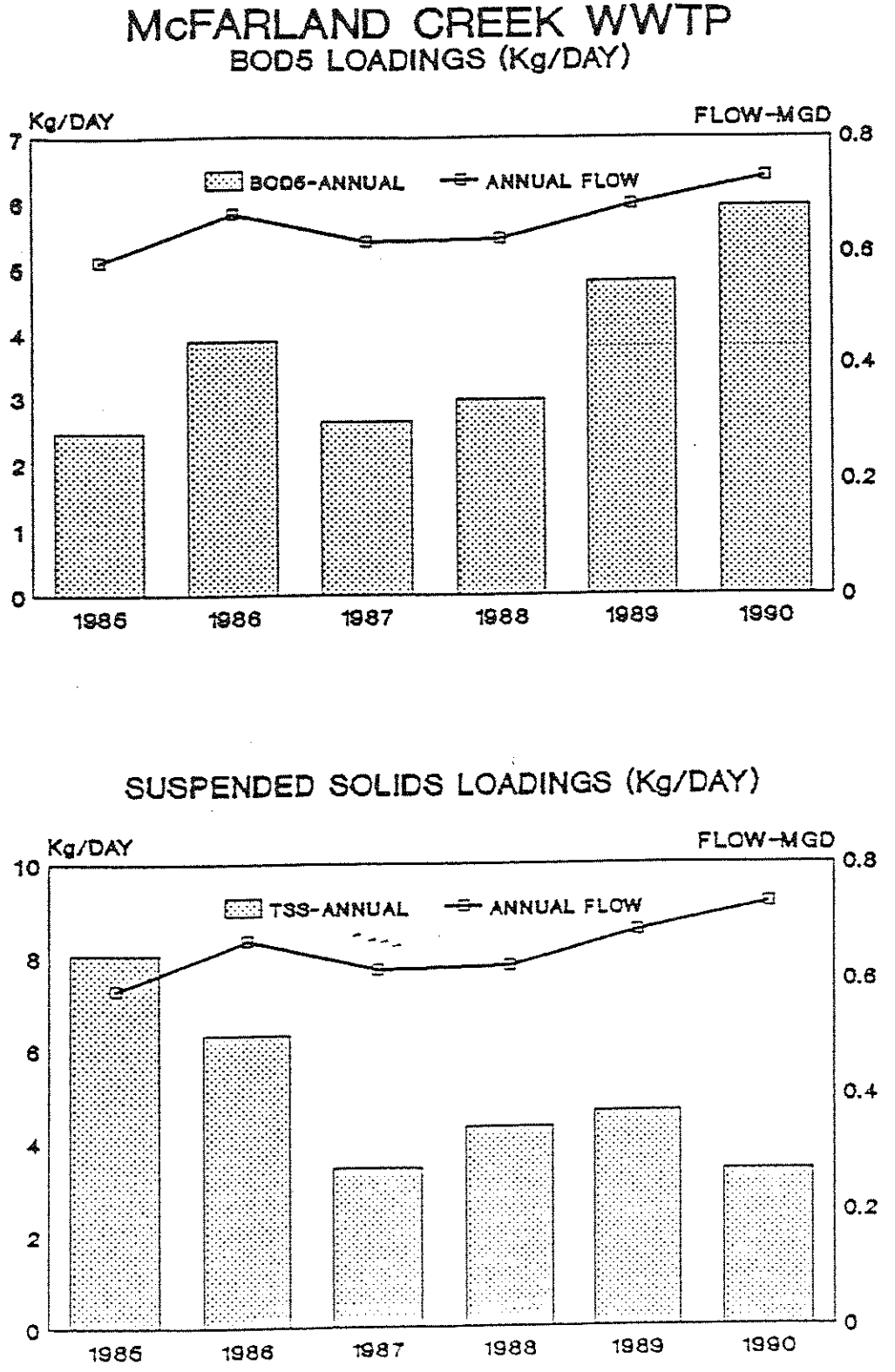


Figure 2. Trend of 50th percentile daily loadings of biochemical oxygen demand (BOD_5) and total suspended solids (TSS) plotted versus median daily discharge flow for the McFarland Creek WWTP discharge to the Aurora Branch, 1985-90.

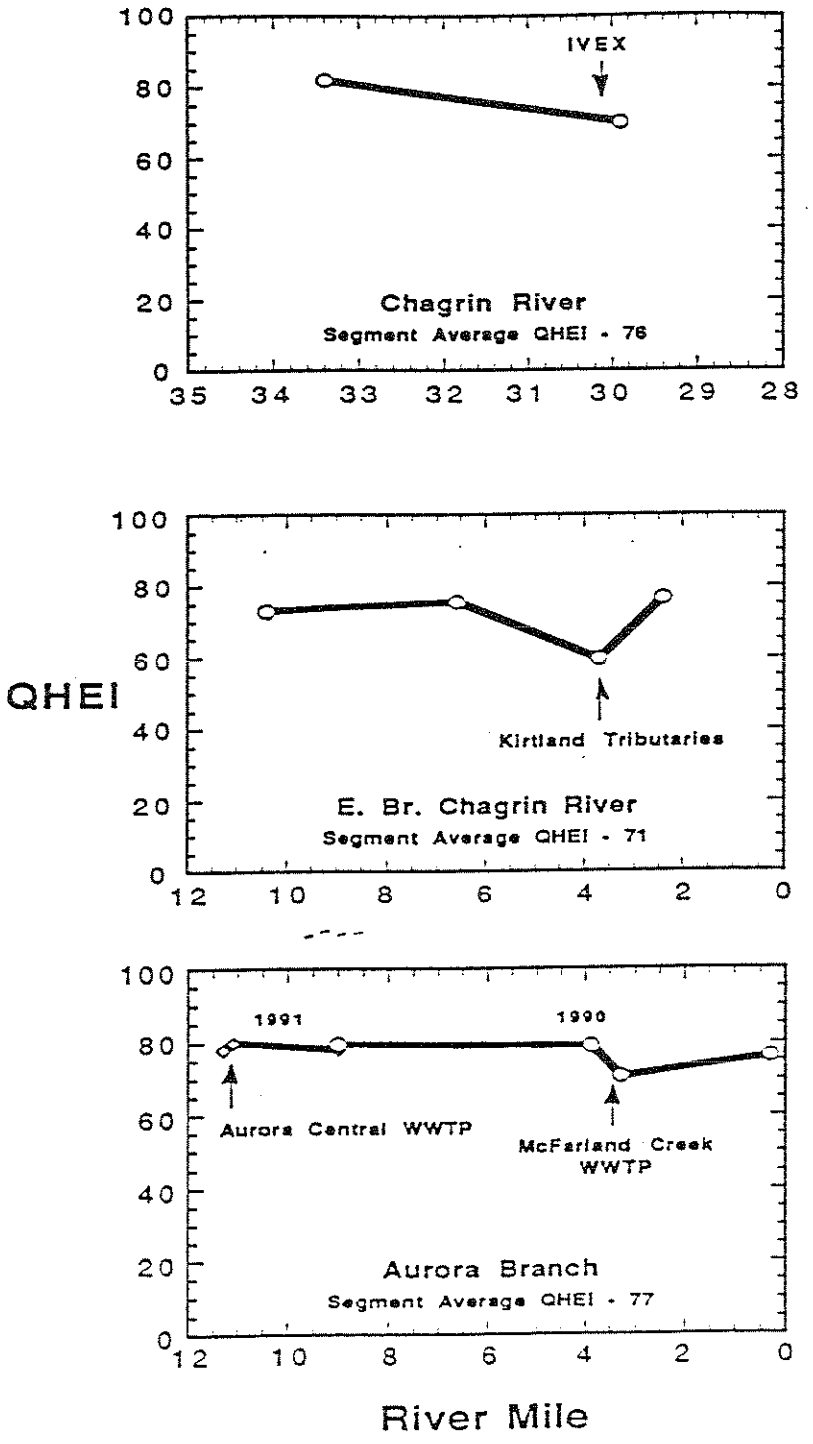


Figure 3. Longitudinal trends of the Qualitative Habitat Evaluation Index (QHEI) in the Chagrin River basin study area, 1990 and 1991. Average reach scores greater than 60 are generally conducive to the establishment of warmwater aquatic communities, while average reach scores greater than 75 are generally conducive to the establishment of exceptional aquatic communities.

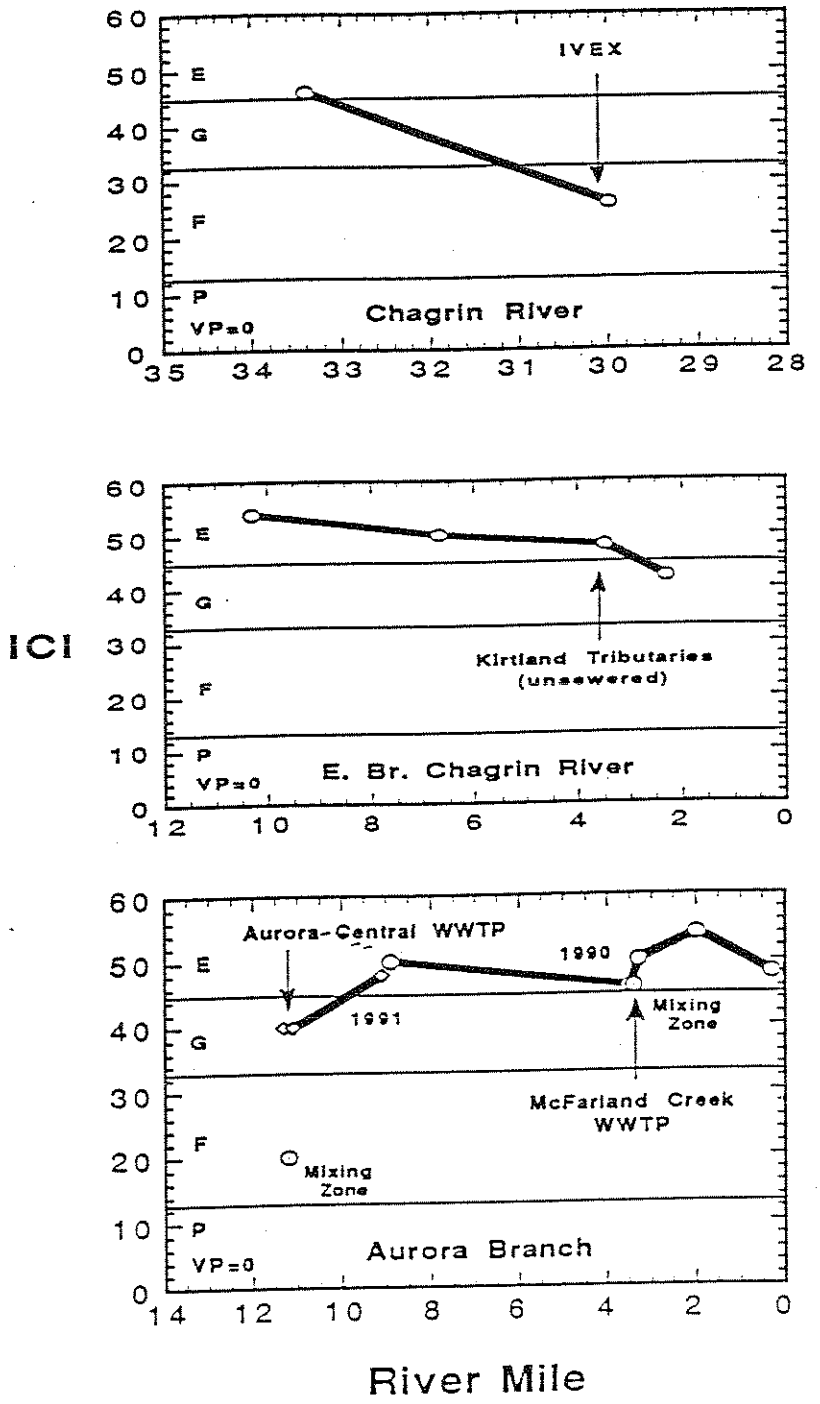


Figure 4. Longitudinal trends of the Invertebrate Community Index (ICI) in the Chagrin River basin study area, 1990 and 1991. E denotes exceptional invertebrate communities (meets EWH criteria), G denotes good invertebrate communities (meets WWH criteria), and F, P, and VP denote fair, poor, and very poor invertebrate communities (non-attainment of aquatic life use). Evaluation categories for the E. Br. Chagrin River figure are for comparative purposes only and are not applicable to the designated CWH aquatic life use.

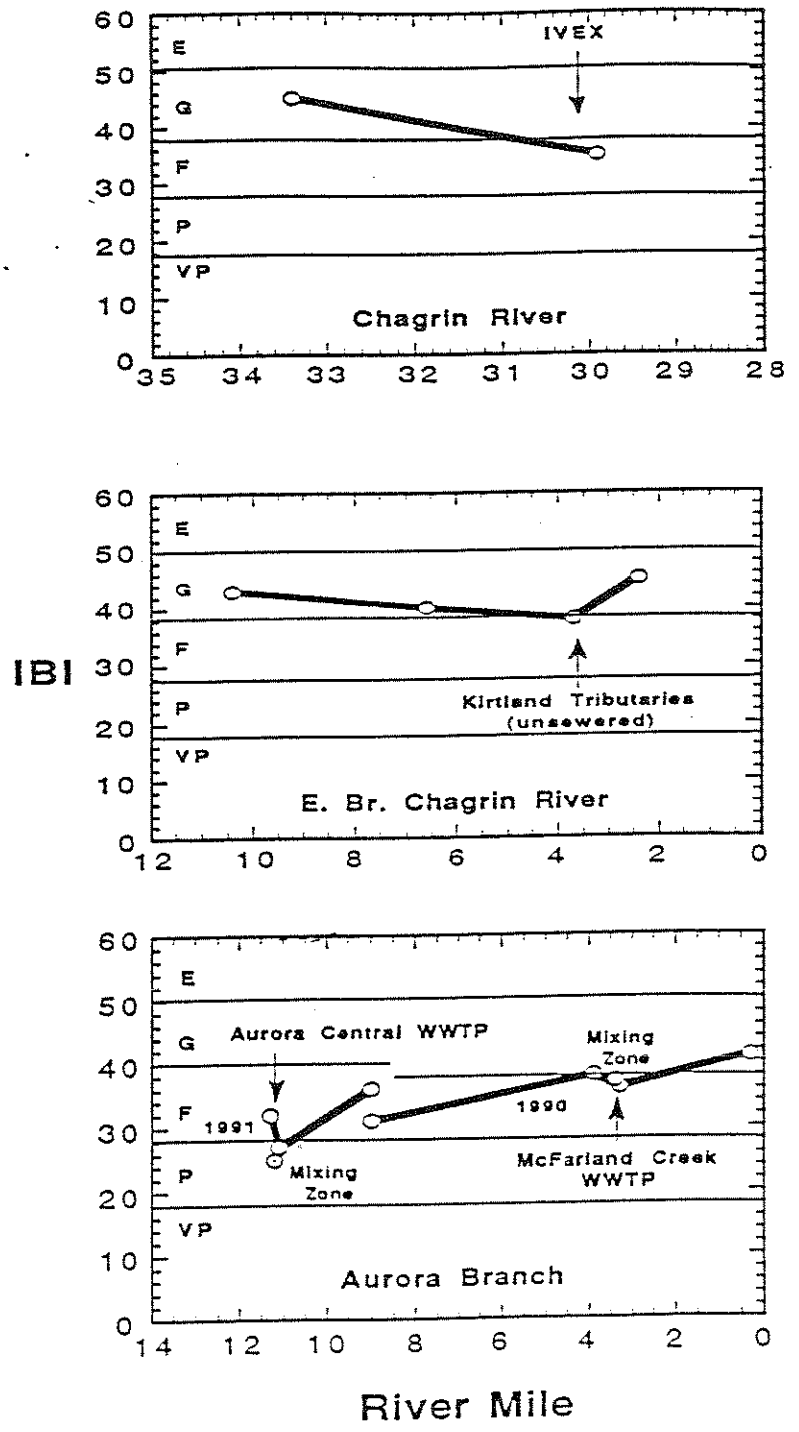


Figure 5. Longitudinal trends of the Index of Biotic Integrity (IBI) in the Chagrin River basin study area, 1990 and 1991. E denotes exceptional fish communities (meets EWH criteria), G denotes good fish communities (meets WWH criteria), and F, P, and VP denote fair, poor, and very poor fish communities (non-attainment of aquatic life use). Evaluation categories for the E. Br. Chagrin River figure are for comparative purposes only and are not applicable to the designated CWH aquatic life use.

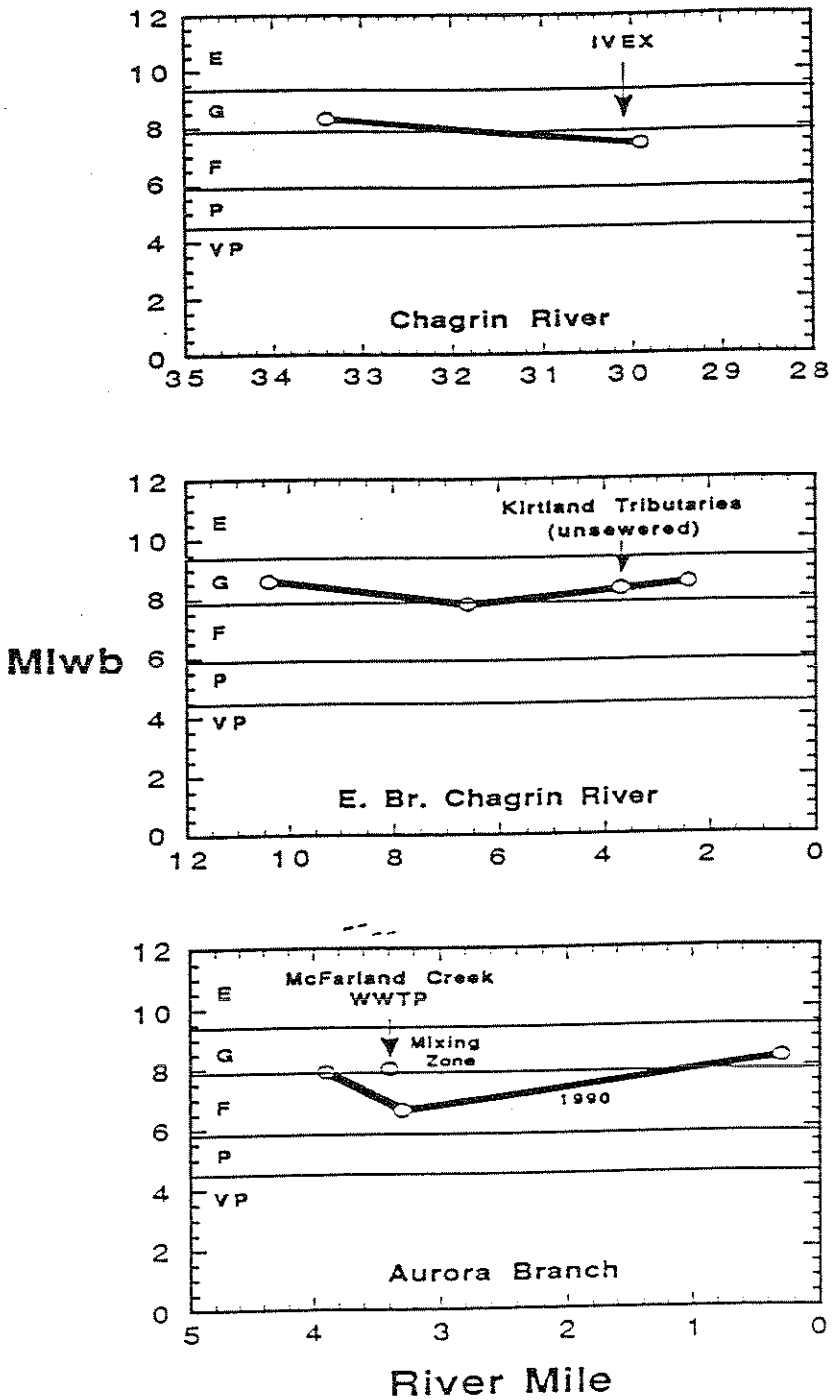


Figure 6. Longitudinal trends of the modified Index of Well-Being (MIwb) in the Chagrin River basin study area, 1990. E denotes exceptional fish communities (meets EWH criteria), G denotes good fish communities (meets WWH criteria), and F, P, and VP denote fair, poor, and very poor fish communities (non-attainment of aquatic life use). Evaluation categories for the E. Br. Chagrin River figure are for comparative purposes only and are not applicable to the designated CWH aquatic life use.

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LIST OF AVAILABLE APPENDIX TABLES

APPENDIX B - MACROINVERTEBRATE DATA

Table B-1. Organisms collected from artificial substrate samplers and from natural substrates in the Chagrin River basin study area, 1990 and 1991.

Table B-2. Evaluation of the macroinvertebrate community by river mile (RM) for the Chagrin River basin study area, 1990 and 1991, using the Invertebrate Community Index (ICI) developed for application to Ohio surface waters. Scores of 6, 4, 2, and 0 are assigned to each metric according to whether it: exceeds (6), approximates (4), slightly deviates from (2), or strongly deviates from (0) an ecological grouping expected in a relatively undisturbed stream or river.

Table B-3. Ohio EPA Macroinvertebrate Evaluations Group Site Description Sheets, Chagrin River basin, 1990 and 1991.

APPENDIX C - CHEMICAL DATA

Table C-1. STORET retrieval of chemical data collected in the Chagrin River basin study area, 1990 and 1991.

APPENDIX F - FISH DATA

Table F-1. Characteristics of electrofishing sampling methods most frequently used by the Ohio EPA to sample fish communities.

Table F-2. Species, relative numbers (#/0.3 km), and relative weights (kg/0.3 km) of fish collected at sampling sites in the Chagrin River basin study area, July - September, 1990 and 1991.

Table F-3. Evaluation of the fish community by river mile (RM) in the Chagrin River basin study area during July- September, 1990 and 1991, using the Index of Biotic Integrity (IBI) modified for application to Ohio waters. Scores of 5, 3, or 1 are assigned to each metric according to whether it: approximates (5), slightly deviates from (3), or strongly deviates from (1) an ecological grouping expected in a relatively undisturbed stream. Numbers in parentheses are numbers of species, individuals, or proportion of individuals, as indicated.

Table F-4. The presence of external anomalies observed on fish from sampling locations in the Chagrin River basin study area, July-September, 1990 and 1991.

Table F-5. Fish species documented in the Chagrin River basin study area as reported in Trautman (1981) and collected by the Ohio EPA during 1990 and 1991.

Table F-6. Ohio EPA Fish Evaluation Group Site Description Sheets, Chagrin River basin, 1990 and 1991.

Appendix Tables available upon written request by contacting:

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Division of Water Quality Planning and Assessment
Ecological Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228