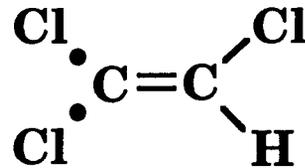
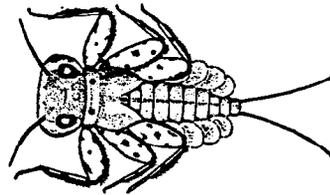




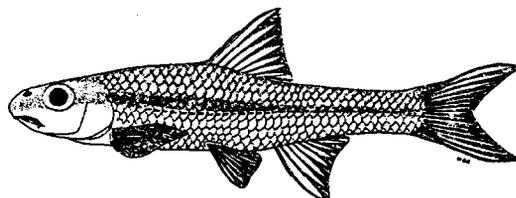
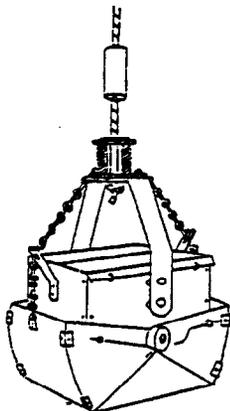
Investigations of Biological Communities and Toxic Impacts in Sugar Creek and Selected Tributaries

Dover Chemical Co.

Dover, Ohio



Trichloroethylene (TCE)



July 14, 1992

**Investigation of Biological Communities and Toxic Impacts
in Sugar Creek and Selected Tributaries**

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OEPA Technical Report EAS/1992-7-3

prepared for

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prepared by

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Introduction

The Dover Chemical study area included the lower four miles of Sugar Creek and two small tributaries, Goettge Run and Brandywine Creek. Goettge Run is located along the south side of the Dover Chemical property. Dover Chemical is a Superfund site located in Dover, Ohio. Dover Chemical has operated at its present location since World War II and currently produces chlorinated paraffins and other chlorinated organic compounds. The surface soils, sediments and groundwater are contaminated with dioxins and chlorinated dibenzofurans, as well as chlorinated organic compounds including monochlorobenzene, dichlorobenzenes, and carbon tetrachloride. This contamination resulted from past disposal practices during the 1950s through the 1970s. The Dover Chemical Company discharges process wastewater and treated groundwater into Sugar Creek at river mile (RM) 2.10.

Specific objectives of this evaluation were to:

- 1) monitor and assess fish and macroinvertebrate communities to determine possible impacts on the biota in streams in the vicinity of Dover Chemical;
- 2) assess physical habitat conditions in Sugar Creek, Goettge Run, and Brandywine Creek
- 3) assess dissolved oxygen and pH levels in Goettge Run, Brandywine Creek and Sugar Creek; and
- 4) establish background biological conditions for use in an assessment of potential risks from bioconcentration and biomagnification of chemicals of concern.

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (e.g. NPDES permits, Director's Orders), the Ohio Water Quality Standards (OAC 3745-1), and eventually be incorporated into the State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Water Inventory (305[b] report).

Conclusions

In September and October 1991 Ohio EPA's DWQPA staff, at the request of DERR, conducted biological community sampling on Sugar Creek, Goettge Run and Brandywine Creek in the vicinity of Dover Chemical. The results of these sampling events are summarized below.

- o Dissolved oxygen and pH levels in Sugar Creek were well within the Warmwater Habitat (WWH) D.O. and pH criterion. Numerous violations of the WWH D.O. criterion were recorded in Brandywine Creek and Goettge Run, where minimum D.O. values recorded were 1.6 and 2.1 mg/l, respectively. Results from Goettge Run revealed slightly acidic pH conditions, with values ranging between 5.9 and 6.2 S.U.

- o Polychlorinated dibenzodioxins (PCDD), polychlorinated dibenzofurans (PCDF) and hexachlorobenzene were measured in surface water, sediment and fish tissue samples from Sugar Creek during 1991 by Weston Consultants. PCDD/PCDF contamination of all three sampling media was noted in Sugar Creek, with the highest concentrations observed adjacent to and downstream from the Dover Chemical discharge. Maximum PCDD/PCDF TEQ equivalent concentrations for water, sediment and whole body fish tissue were 0.1714 ppt (parts per trillion), 0.2280 ppt and 32.3531 ppt, respectively. Hexachlorobenzene measurements in whole body fish tissue reported the highest concentration (730 ppb) in Sugar Creek 0.3 miles downstream from Dover Chemical.
- o Sugar Creek physical habitat was generally good to excellent and adequate for supporting a warmwater biological community. Of significant note was a thick layer (up to 2 feet in depth) of fine grained material (silt/clay/organic consistency) covering the stream bottom in Sugar Creek for at least 1.5 miles downstream from the Dover Chemical effluent discharge. This material was not evident in Sugar Creek upstream from the Dover Chemical discharge (see Plate 1).
- o Physical habitat in Goettge Run, a small headwater stream, was severely impacted by extensively embedded bottom conditions. Coal fines, small chunks of coal and sediment were readily observed in the stream bottom downstream from a coal processing facility, and shallow non-functioning riffles, runs and pools were predominant. Goettge Run should be able to support a warmwater biological community with a reduction in the discharge of coal fines and suspended solids.
- o Bottom substrates in Brandywine Creek were predominated by cobble which was extensively embedded and covered by silt/ clay material. Overall physical habitat was fair, although conditions appeared adequate to support a headwater, warmwater habitat biological community.
- o Fish and macroinvertebrate community sampling was conducted in Sugar Creek, Goettge Run and Brandywine Creek during September and October, 1991. In Sugar Creek upstream from Dover Chemical, biological communities were reflective of good water quality conditions. Both fish and macroinvertebrate communities were attaining the Ohio Water Quality Standards Warmwater Habitat biocriteria. Significant populations of pollution sensitive organisms were observed.
- o For at least 0.5 miles downstream from the Dover Chemical discharge, Sugar Creek biological communities during 1991 exhibited fair to poor results . Sugar Creek bottom sediments in all pooled areas immediately downstream from the Dover Chemical discharge (RM 2.10) to at least RM 0.6 were severely embedded with a fine grained silt/ clay/ organic material. This material appeared to have a significant deleterious affect on bottom dwelling fish and macroinvertebrates.
- o Fish communities in the lower 0.6 miles of Sugar Creek exhibited marginally good conditions. However, a substantial number of fish collected were from the riffle/run

segment of the sampling site (an area of low silt/ clay/ organic deposition). Fish kills in the lower Sugar Creek have been reported by ODNR during 1988, 1989 and 1990. Macroinvertebrate sampling at RM 0.6 indicated poor water quality, with low taxa richness and a predominance of pollution tolerant organisms.

- o Qualitative benthic sampling was conducted immediately upstream and downstream of the Dover Chemical discharge location on Sugar Creek, bracketing the discharge. At the upstream location, RM 2.11, the total taxa was 33 and EPT (Ephemeroptera, Plecoptera, and Tricoptera - indicators of good water quality) taxa richness was 9, indicating good water quality conditions. At the downstream location, RM 2.09, the total taxa was 10 and EPT taxa richness was 0, indicating poor water quality conditions. The downstream site was located upstream from the Goettge Run confluence.
- o Sugar Creek biological communities downstream from Dover Chemical were **not attaining** the ecoregion biocriteria for a WWH stream. The cause of the non-attainment appears attributable to the Dover Chemical effluent discharge.
- o No fish were collected or observed in Goettge Run during 1991. Sampling of the macroinvertebrate community indicated poor water quality, with an EPT taxa richness of one. Low pH and dissolved oxygen levels and severe bottom embeddedness (coal fines and small chunks of coal along with silt/clay) appear to contribute to the degraded macroinvertebrate community and to conditions unsuitable for the support of a fish community. Biological conditions were **not attaining** either WWH use criteria or Limited Resource Water (LRW) guidelines.
- o Biological communities in Brandywine Creek were reflective of fair (fish) to poor (macroinvertebrates) water resource conditions. The fish and macroinvertebrate communities were predominated by pollution tolerant species. Extensive silt embeddedness was noted in Brandywine Creek at RM 0.2. Brandywine Creek was **not attaining** the WWH criteria.

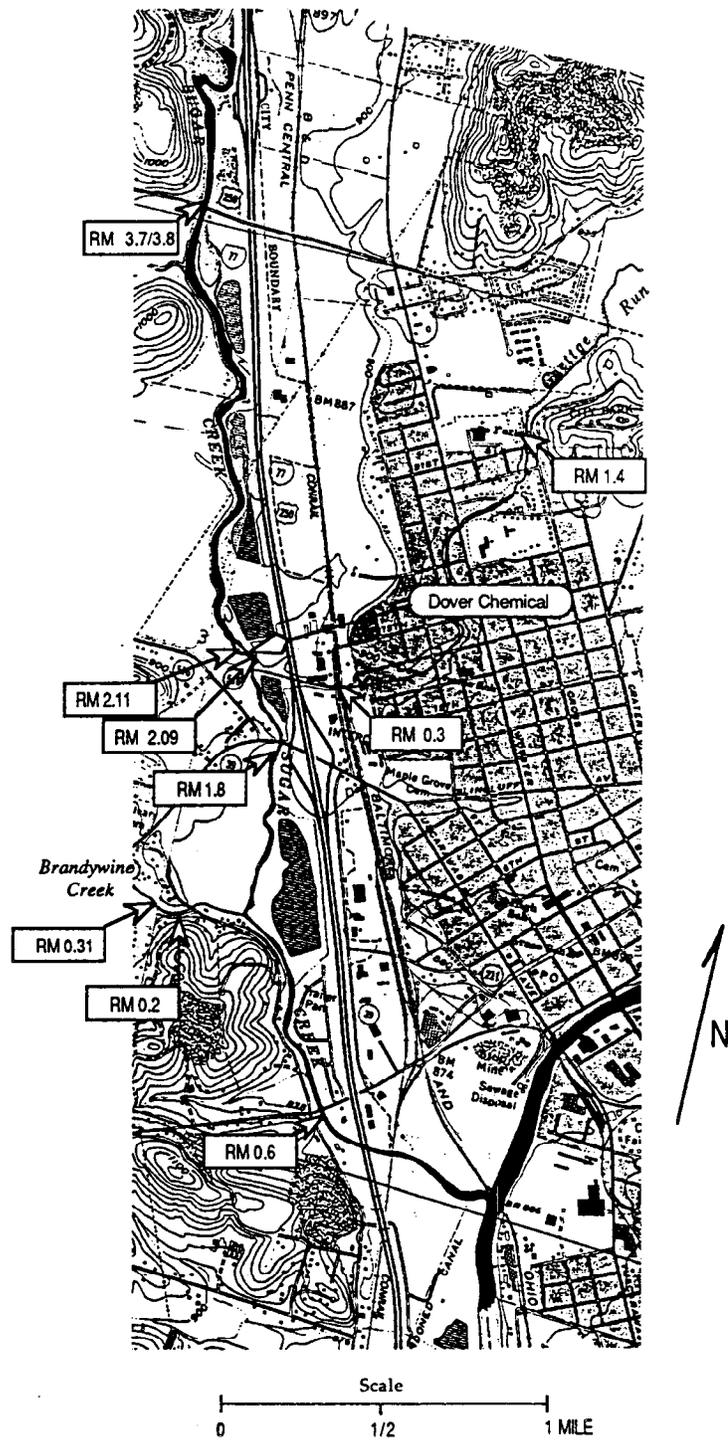


Figure 1. Map of the Sugar Creek, Goettge Run and Brandywine Creek biological and dissolved oxygen/ pH sampling sites indicated by river mile. Specific sampling location information is listed in Table 2.

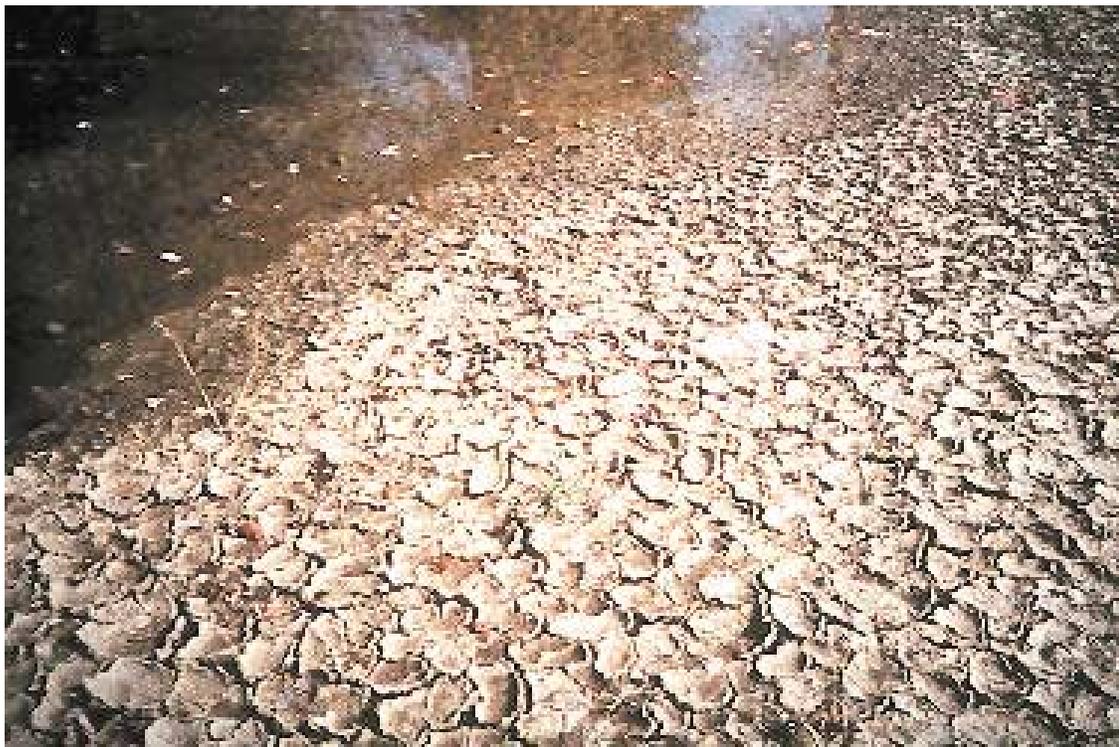


Plate 1. View of the bottom sediments in Sugar Creek. Top photo shows the relatively clean gravel and cobble substrate of Sugar Creek upstream from the Dover Chemical effluent discharge. Bottom photo, taken 0.2 miles downstream from Dover Chemical, reveals severe deposition of fine grained solids.

Recommendations

Use Designation Status

The current Warmwater Habitat aquatic life use should be maintained for Sugar Creek and Brandywine Creek. Goettge Run is not currently listed in the Ohio Water Quality Standards and based on existing information, Warmwater Habitat is the recommended use. Goettge Run has the potential physical habitat to maintain a warmwater biological community with a reduction in the discharge of coal fines and chunks and suspended solids from a coal processing facility.

Future Monitoring/Investigation Needs

Sediment and Dover Chemical effluent sampling needs to be conducted to permit a more thorough assessment of conditions in Sugar Creek. This is particularly important in light of the substantial deposition of suspended solids in Sugar Creek downstream from the Dover Chemical NPDES effluent discharge. Suspected chemicals to be analyzed for include chlorinated paraffins and production chemicals currently manufactured at Dover Chemical.

The Eberhart Coal Co. coal processing facility on County Road 80, which discharges to Goettge Run, should be investigated. A retention pond on the down slope side of the facility for holding surface runoff is almost completely filled-in with coal fines and soils. Overflow from the holding pond enters Goettge Run via a small drainage ditch. A notable increase in sediment bed load and the presence of coal chunks and coal fines was observed in Goettge Run downstream from the coal processing facility.

Study Area

The study area encompassed the lower four miles of Sugar Creek, the lower 1.5 miles of Goettge Run and one sampling location on Brandywine Creek near the mouth (Figure 1).

Methods

All 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 (Ohio Environmental Protection Agency 1987, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI); Rationale, Methods, and Application (Rankin 1989) for habitat assessment.

Attainment/non-attainment of aquatic life uses was determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. The biological community performance measures that were used included 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. The 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 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 was FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if at least one of the indexes did not attain and performance did not fall below the fair category, and NON if all indices either failed to attain or any index indicated poor or very poor performance.

Physical habitat was 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 were 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 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 were generally conducive to the establishment of warmwater faunas while those which scored in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

During this survey, macroinvertebrates were sampled at most stations using modified Hester/Dendy multiple-plate artificial substrate samplers supplemented with a qualitative assessment of the available natural substrates. Exceptions included the two Sugar Creek sites immediately upstream and downstream from the Dover Chemical discharge (RM 2.09 and RM 2.11) where the macroinvertebrate community was evaluated based on qualitative sampling of all available aquatic habitat types. Qualitative macroinvertebrate sampling consists of an inventory of species with no attempt to quantify the populations and a measure of EPT (Ephemeroptera - mayfly, Plecoptera - stonefly, and Trichoptera - caddisfly) taxa richness - an indication of the prevalence of pollution sensitive organisms.

Fish were sampled 2 times using pulsed DC electrofishing gear using the wading method (130 - 250 meter zones). All dissolved oxygen/ pH and biological sampling locations are listed in Table 2.

Table 1. Summary of the biological use attainment status for Sugar Creek, Goettge Run and Brandywine Creek, based on 1983, 1988 and 1991 sampling.

Attainment status follows guidance provided in Ohio EPA (1989).

River Mile	Modified	Attainment			Comments	
Fish/Invert. IBI	Iwb	ICI	QHEI ^a	Status ^b		
Western Allegheny Plateau - WWH use Designation						
1991						
Sugar Creek						
3.7/ 3.7	46	8.7	36	79	FULL	Ust. Dover Chemical, SRP Site
-/ 2.11	-	-	G ^d	-	(FULL)	Riffle Ust. Dover Chemical
-/ 2.09	-	-	P ^d	-	(NON)	Riffle Dst. Dover Chemical, Ust. Goettge Run
1.8/ 1.8	32*	<u>5.8*</u>	<u>8*</u>	74	NON	Dst. Dover Chemical
0.6/ 0.6	47	7.9 ^{ns}	<u>4*</u>	71	NON	Dst. Dover Chem, Brandywine Cr./ Kimble Landfill
Goettge Run						
1.4/ 1.4	<u>12*</u>	c	<u>12*</u>	38	NON	Dst. Coal Processing Plant, no fish
0.3/ -	<u>12*</u>	c	-	51	(NON)	Near Dover Chemical, no fish
Brandywine Creek						
0.2/ 0.2	34*	c	<u>12*</u>	47	NON	Dst. Kimble Landfill
1988						
Sugar Creek						
3.8/ 3.7	46	8.8	40	75	FULL	Ust. Dover Chemical, SRP Site
0.6/ 0.1	30*	6.2*	18*	NA	NON	Dst. Dover Chem, Brandywine Cr./ Kimble Landfill; Fish Kill
1983						
Sugar Creek						
3.8/ 3.7	52	9.3	42	73	FULL	Ust. Dover Chemical, SRP Site.
-/ 1.8	-	-	48	-	(FULL)	Dst. Dover Chemical
0.1/ 0.6	29*	7.5*	38	66	PARTIAL	Dst. Brandywine Cr./ Kimble Landfill
				(Old QHEI)		

* - Significant departure from ecoregion biocriteria; poor and very poor results are underlined.

^{ns} - Nonsignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).

a - All Qualitative Habitat Evaluation Index (QHEI) values are based on the most recent version (Rankin 1989).

b - Use attainment status based on one organism group is parenthetically expressed.

c - Headwater sites - Modified Iwb criteria do not apply.

d - Narrative evaluation used in lieu of ICI (E = Exceptional; G = Good; F = Fair; P = Poor).

Use Designation	Ecoregion Biocriteria: Western Allegheny Plateau (WAP)						ICI
	IBI			MIwb			
	Boat	Wading	Headwaters	Boat	Wading	Headwaters	
EWH	48	50	50	9.6	9.4	NA	46
WWH	40	44	44	8.6	8.4	NA	36

Results and Discussions

Chemical/ Physical Water Quality (Table 4, Figure 2)

- o Dissolved oxygen levels in Sugar Creek (Table 4, Figure 2) were well above the 4.0 mg/l WWH minimum criterion for the three locations measured with Datasonde monitors. At all locations, mean values ranged from 7.9 to 9.1 mg/l, with minimum values of 5.2 to 5.9 mg/l. Numerous violations of the WWH D.O. criterion were recorded in Brandywine Creek and Goettge Run, where minimum D.O. values recorded were 1.6 and 2.1 mg/l, respectively. At least 25 percent of the Goettge Run D.O. values were below the WWH minimum criterion.
- o Measurements of pH in Sugar Creek and Brandywine Creek (Table 4, Figure 2) during October, 1991 ranged between 7.0 and 8.1 S.U., well within acceptable levels. Results from Goettge Run revealed slightly acidic conditions, with values ranging between 5.9 and 6.2 S.U. These pH values were measured using a Datasonde continuous monitor.
- o Polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were measured in surface water, sediment and fish tissue samples from Sugar Creek during 1991 by Weston Consultants (Sampling Report 1992). Contamination of all three sampling media was noted in Sugar Creek, with the highest concentrations observed adjacent to and downstream from the Dover Chemical discharge. Maximum PCDD/PCDF TEQ equivalent concentrations for water, sediment and whole body fish tissue were 0.1714 ppt, 0.2280 ppt and 32.3531 ppt, respectively. Maximum PCDD/PCDF values reported from Sugar Creek were recorded at State Route 39, approximately 0.3 miles downstream from the Dover Chemical discharge. Hexachlorobenzene was also tested for in surface water, sediment and fish tissue from Sugar Creek. Surface water and sediment results were reported as 'not detected' at all three Sugar Creek locations. Whole body fish tissue findings noted the highest hexachlorobenzene concentration (730 ppb) in Sugar Creek occurred at State Route 39, 0.3 miles downstream from Dover Chemical. Hexachlorobenzene bioconcentrates extensively in a number of fish and invertebrates (Howard 1989).

Physical Habitat for Aquatic Life (Table 3)

- o Sugar Creek within the study area (lower four miles) was predominated by bottom substrates of gravel and cobble. At RM 0.6, limestone bedrock was also prevalent downstream from the State Route 39 bridge. Qualitative Habitat Evaluation Index (QHEI) scores for Sugar Creek (60 - 79) were reflective of good stream habitat. Of significant note was a thick layer (up to 2 feet in depth) of fined grained material (silt/clay consistency) covering the stream bottom in Sugar Creek for at least 1.5 miles downstream from the Dover Chemical effluent discharge. This material was not evident in Sugar Creek upstream from the Dover Chemical discharge.
- o Goettge Run physical habitat was evaluated in the lower 1.5 miles. The substrates were predominated by gravel and sand which were moderately to extensively embedded and covered by silt type material. Goettge Run is a small stream (less than three meters wide) with shallow pool (maximum depth less than 30 cm) and riffle areas (maximum depth less than 5 cm). Coal fines and small chunks of coal were readily observed in the sediment of Goettge Run. QHEI scores for Goettge Run ranged between 38 and 50.

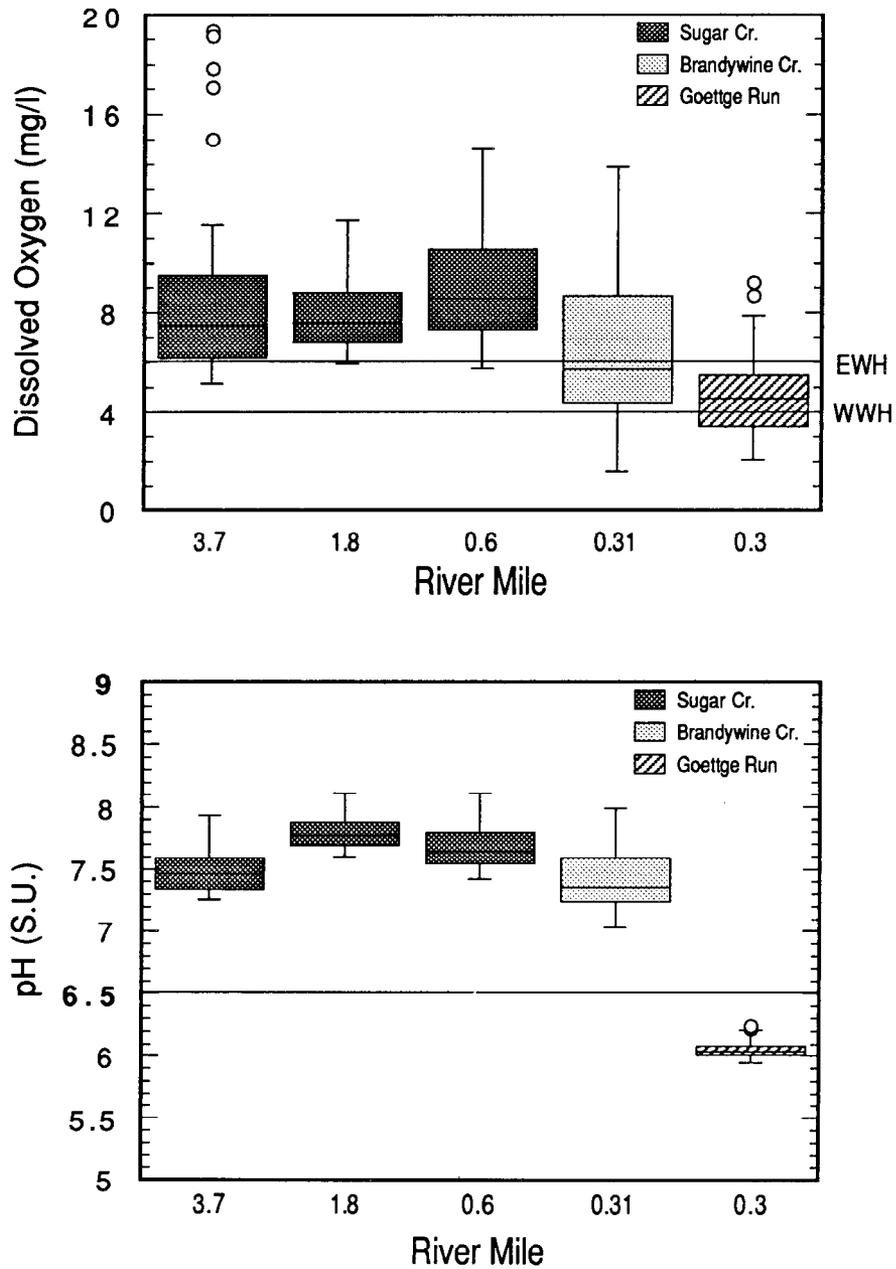


Figure 2. Boxplots of dissolved oxygen data (mg/l) and pH (SU) recorded with Datasonde continuous monitors at various locations in Sugar Creek, Goettge Run and Brandywine Creek during October 23-30, 1991. The pH criteria (6.5-9.0) and minimum D.O. criteria for the WWH (4 mg/l) and EWH (6 mg/l) use designations are indicated.

- o Physical habitat in Brandywine Creek was evaluated in the lower 0.2 miles. Substrates were predominated by cobble which was extensively embedded and covered by silt/ clay sediment. Pool areas were generally shallow, with a maximum depth of 35 cm. Brandywine Creek at RM 0.2 scored a QHEI of 47.

Macroinvertebrate Community (Table 1, Figure 3)

Macroinvertebrate sampling was conducted in September and October, 1991. These sampling dates exceeded the usual September 30 cutoff for summer macroinvertebrate sampling.

- o Sugar Creek RM 3.7 was upstream from Dover Chemical, Goettge Run, and Brandywine Creek. This site was one of Ohio EPA's reference sites which were used to establish ambient biological conditions in the Western Allegheny Plateau ecoregion. The ICI value for 1991 was 36, indicating the benthic community attained the ecoregion biocriteria for WWH streams. The ICI values were 40 in 1988 and 42 in 1983. EPT taxa richness was 14 in 1991, 9 in 1988, and 8 in 1983. The 1991 ICI value may have been slightly depressed due to the late time frame in which sampling took place.
- o Qualitative benthic sampling was conducted immediately upstream and downstream of the Dover Chemical discharge location on Sugar Creek, bracketing the discharge. At the upstream location, RM 2.11, the total taxa was 33 and EPT taxa richness was 9, indicating good water quality conditions. At the downstream location, RM 2.09, the total taxa was 10 and EPT taxa richness was 0, indicating poor water quality conditions.
- o Sugar Creek RM 1.8 was downstream from the Dover Chemical discharge and Goettge Run. The ICI value for 1991 was 8, indicative of poor water quality. This was a considerable drop from the 1983 value of 48 and indicates non-attainment of the ecoregion biocriteria for WWH streams. EPT taxa richness was 2 in 1991, compared to 10 in 1983, indicating a severe decline in water quality.
- o Sugar Creek RM 0.6 was downstream from the Dover Chemical discharge, Goettge Run, and Brandywine Creek. The ICI value for 1991 was 4, reflecting poor water quality conditions. This was a considerable drop from the 1983 value of 38 and indicates non-attainment of the ecoregion biocriteria for WWH streams. EPT taxa richness was 1 in 1991, compared to 5 in 1983, indicating a decline in water quality.
- o Goette Run was sampled at RM 1.4. The ICI was 12 indicating poor water quality and non-attainment of the ecoregion biocriteria for WWH streams. EPT taxa richness (1) was poor.
- o Brandywine Creek was sampled at RM 0.2. The ICI was 12 indicating poor water quality and non-attainment of the ecoregion biocriteria for WWH streams. EPT taxa richness (3) was marginal.

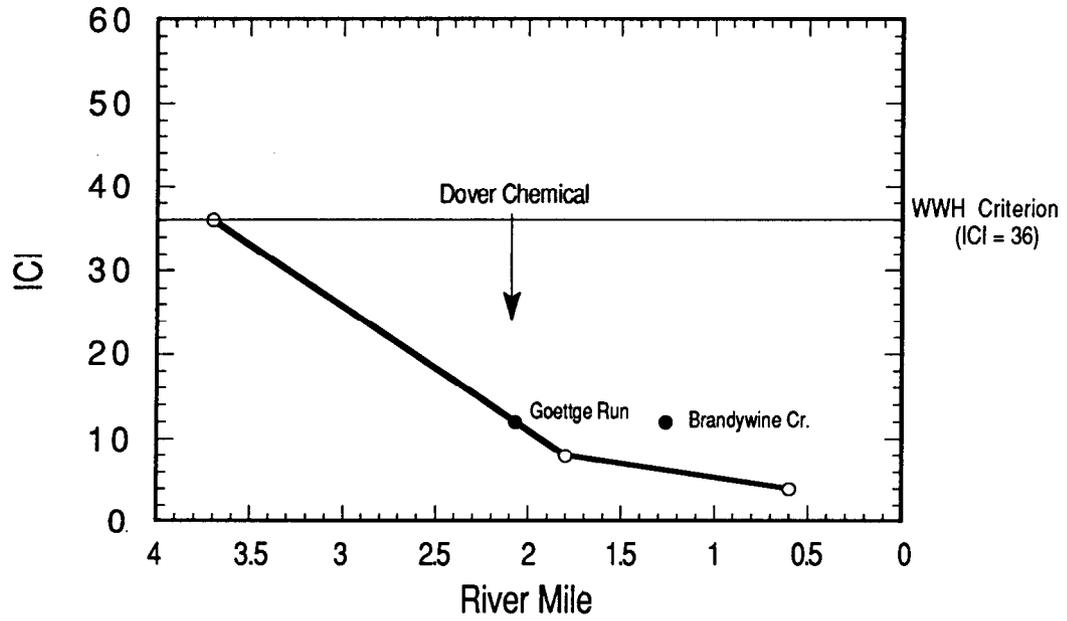


Figure 3. Longitudinal trend of the Invertebrate Community Index (ICI) in the Sugar Creek study area, 1991.

Fish Community (Table 1, Figure 4)

- o Upstream from the Dover Chemical discharge to Sugar Creek, the 1983, 1988 and 1991 fish communities were reflective of good water quality conditions (RM 3.7/ 3.8 achieved ecoregion biocriteria) with an IBI range of 46 - 52 and a MIwb range of 8.7 - 9.3. Significant populations of northern hog sucker, golden redbreast, smallmouth and rock basses, several darter species and mottled sculpin were observed. Impairment was not documented in the fish communities of Sugar Creek upstream from the Dover Chemical discharge.
- o For at least 0.5 miles downstream from the Dover Chemical discharge, Sugar Creek fish communities during 1991 exhibited fair to poor results (IBI = 32, MIwb = 5.8). Sugar Creek bottom sediments in all pooled areas immediately downstream from the Dover Chemical discharge (RM 2.10) to at least RM 0.6 were severely embedded with a fine grained silt/ clay/organic material. This material appeared to have a significant deleterious affect on bottom dwelling fish sensitive to stream siltation. Pollution sensitive to moderately pollution sensitive sucker and darter species were drastically reduced in numbers compared to the sampling location upstream from Dover Chemical.
- o Fish communities in the lower 0.6 miles of Sugar Creek (1983, 1988 and 1991) revealed fair to good conditions. Sampling results from 1991 at RM 0.6, revealed IBI and MIwb values (47 and 7.9, respectively) in the good to marginally good range; however, a substantial number of fish collected were from the riffle/run segment of the sampling site (an area of low silt/ clay deposition). As was observed further upstream at RM 1.8, the large pool in the sampling zone was severely embedded with a fine grained silt/ clay material. Fish sampling results from 1988 at RM 0.6 were in the fair range; a fish kill was reported in the lower Sugar Creek during the 1988 study period. Fish kills in the lower Sugar Creek have also been reported by ODNR during 1989 and 1990. Sampling fish during 1983 at RM 0.1 indicated fair water quality conditions, with both the IBI (29) and the MIwb (7.5) below warmwater habitat use attainment levels..
- o No fish were collected or observed in Goettge Run at RM 0.3 or RM 1.4. Low pH and dissolved oxygen levels and severe bottom embeddedness (coal fines and small chunks of coal along with silt/clay) appear to contribute to conditions unsuitable for the support of a fish community. Water quality was considered very poor.
- o The fish community in Brandywine Creek at RM 0.2 was indicative of fair water quality. The IBI score of 34 was below ecoregional expectations for the WWH biocriteria. The fish community was predominated by pollution tolerant creek chub, white sucker and bluntnose minnow (all three together comprised 75 percent of the total number of fish collected). Extensive silt embeddedness was noted in Brandywine Creek at RM 0.2.

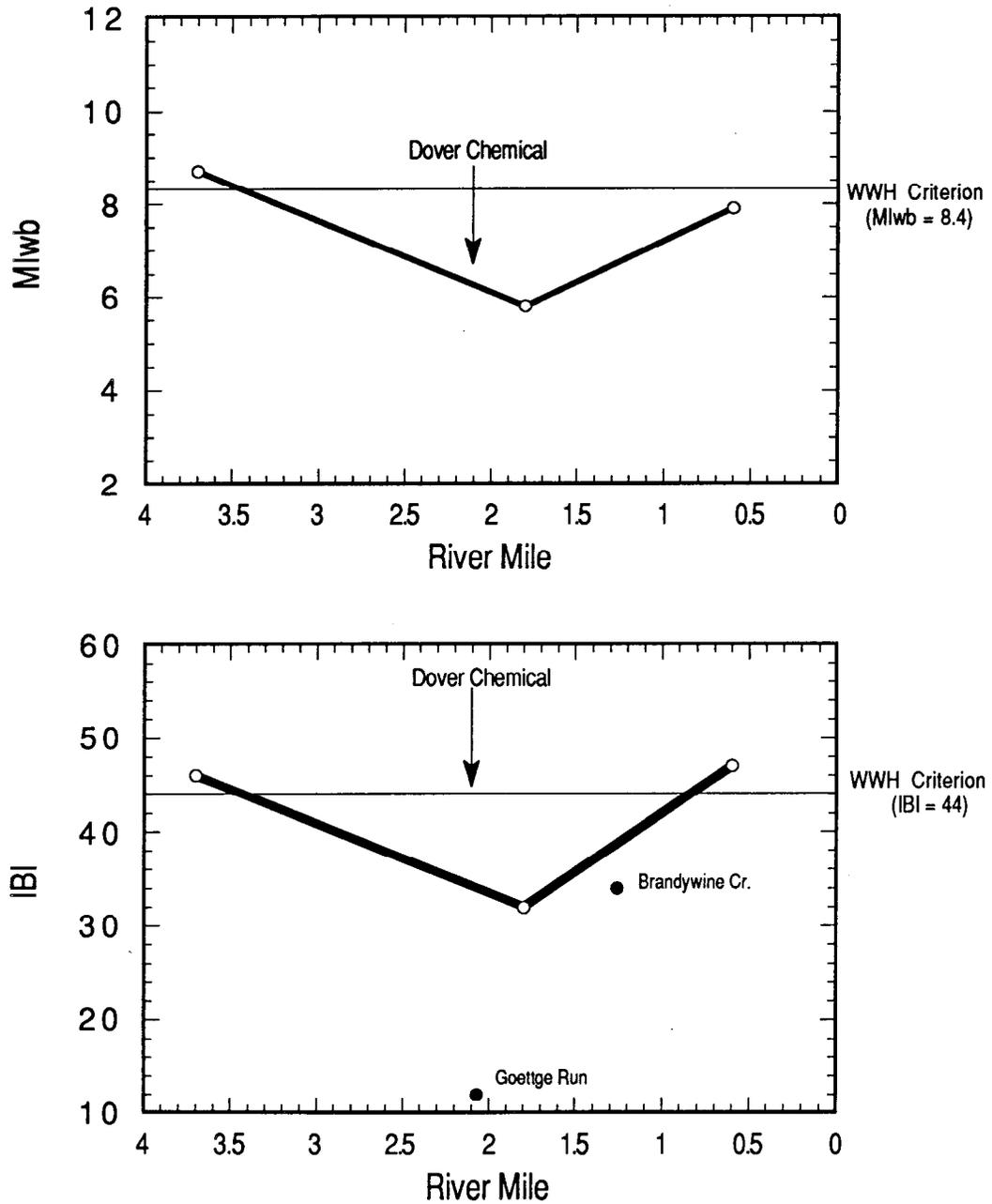


Figure 4. Longitudinal trend of the Index of Biotic Integrity (IBI; lower) and the Modified Index of Well-being (MIwb; upper) in the Sugar Creek study area, 1991.

1991 Use Attainment Summary (Table 1)

- o Sugar Creek upstream from the Dover Chemical discharge (RM 3.8 - 2.11) is fully attaining the WWH aquatic life use designation. Fish and macroinvertebrate communities were well within the biocriteria for WWH streams. Downstream from the Dover Chemical discharge (RM 2.10 - 0.0), Sugar Creek was **not attaining** the WWH aquatic life use designation, with the biological communities in the marginally good to poor range.
- o Brandywine Creek was sampled in the lower 0.2 miles during 1991. Based on one sampling location, Brandywine Creek was **not attaining** the WWH aquatic life use designation.
- o Goettge Run, an unlisted stream in the Ohio Water Quality Standards, was severely degraded during the 1991 study period. No fish were collected or observed at two sampling locations and the macroinvertebrate community was in the poor range (ICI = 12). Fish and macroinvertebrate sampling results from Goettge Run were **not attaining** either WWH use criteria or Limited Resource Water guidelines.

Table 2. Sampling locations (benthos - B, fish - F, dissolved oxygen - D, pH - P) in the Sugar Creek study area, 1992.

Stream/ River Mile	Type of Sampling	Latitude/ Longitude	Landmark	USGS 7.5 min. Quad. Map
<i>Sugar Creek</i>				
3.7	B, F, D, P	40°33'03"/ 81°30'23"	Crossing Rd.	Strasburg, Ohio 1978
2.11	B	40°31'53"/ 81°29'54"	Ust. Dover Chemical	Dover, Ohio 1984
2.09	B	40°31'51"/ 81°29'52"	Dst. Dover Chemical	Dover, Ohio 1984
1.8	B, F, D, P	40°31'39"/ 81°29'43"	S.R. 39 (North)	Dover, Ohio 1984
0.6	B, F, D, P	40°30'45"/ 81°29'19"	S.R. 39 (South)	Dover, Ohio 1984
<i>Goettge Run</i>				
1.4	B, F	40°32'39"/ 81°29'07"	Dover City Park	Dover, Ohio 1984
0.3	F, D, P	40°31'51"/ 81°29'33"	Davis St.	Dover, Ohio 1984
<i>Brandywine Creek</i>				
0.31	D, P	40°31'10"/ 81°29'58"	Adj. Renner Rd.	Dover, Ohio 1984
0.2	B, F	40°31'11"/ 81°29'53"	Ust. Rt. 211	Dover, Ohio 1984

Table 4. Summary of diurnal dissolved oxygen (mg/l) and pH (S.U.) data recorded with Datasonde continuous monitors at three locations in Sugar Creek, and one location each in Brandywine Creek and Goettge Run. Data was collected from October 23 - 30, 1991.

River Mile	Total Hours	Mean (mg/l)	Median (mg/l)	Minimum (mg/l)	Maximum (mg/l)	25th %ile (mg/l)	75th %ile (mg/l)
Dissolved Oxygen							
<i>Sugar Creek</i>							
3.7	95	8.20	7.49	5.16	19.34	6.16	9.48
1.8	166	7.89	7.59	5.94	11.71	6.79	8.78
0.6	166	9.06	8.58	5.73	14.61	7.32	10.57
<i>Goettge Run</i>							
0.3	167	4.56*	4.58	2.09**	9.19	3.42**	5.51
<i>Brandywine Creek</i>							
0.31	168	6.61	5.71	1.59***	13.90	4.38	8.66
pH							
<i>Sugar Creek</i>							
3.7	165	7.48	7.46	7.26	7.94	7.34	7.59
1.8	166	7.79	7.77	7.60	8.11	7.69	7.88
0.6	166	7.68	7.64	7.42	8.11	7.54	7.79
<i>Goettge Run</i>							
0.3	167	6.05+	6.04+	5.95+	6.24+	6.01+	6.09+
<i>Brandywine Creek</i>							
0.31	168	7.42	7.35	7.03	7.99	7.24	7.58

* violation of the average WWH dissolved oxygen criterion (5.0 mg/l).

** violation of the minimum WWH dissolved oxygen criterion (4.0 mg/l).

*** violation of the Limited Resource Water minimum dissolved oxygen criterion (2.0 mg/l).

+ violation of the pH criterion (6.5-9.0 SU).

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