INTERSTATE POLLUTION OF OHIO RIVER
PITTSBURGH, PENNSYLVANIA AREA

U.S. ENVIRONMENTAL PROTECTION
AGENCY
REGION III

A REPORT ON POLLUTION
OF THE OHIO RIVER AND ITS TRIBUTARIES
IN THE PITTSBURGH, PENNSYLVANIA AREA

U. S. ENVIRONMENTAL PROTECTION AGENCY

REGION III

1971

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INTRODUCTION

On the basis of reports, surveys or studies, the Administrator of the U. S. Environmental Protection Agency, having reason to believe that pollution from sources in Pennsylvania was endangering the health or welfare of persons in Ohio and West Virginia, called a conference of the Commonwealth of Pennsylvania, the States of Ohio and West Virginia, the Ohio River Valley Water Sanitation Commission (ORSANCO) and the U. S. Environmental Protection Agency (EPA) on the interstate pollution of the Ohio River in the Pittsburgh, Pennsylvania area. The conference was called in accordance with Section 10(d) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1160).

The purpose of this report is to delineate the characteristics of this pollution of the Ohio River, the municipal and industrial sources of this pollution in Pennsylvania, the effects of this pollution upon water quality and water uses; the adequacy of present wastewater treatment facilities; and future abatement requirements.

This report on pollution of the interstate waters of the Ohio River is based upon: previous reports; data and other materials obtained from the Pennsylvania Department of Environmental Resources, ORSANCO, and the U. S. Geological Survey (USGS); information furnished by other Federal, State, and local agencies and individuals; official records of the Department of the Interior; and data obtained by EPA during field studies in May and June 1970, and February and March 1971.

SUMMARY

The Ohio River is formed by the confluence of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania, and flows generally in a northwesterly direction to form the border between West Virginia and Ohio at river mile 40. This report considers the mainstem of the Monongahela River from Allenport, Pennsylvania, at river mile 47, to Pittsburgh, at river mile 0, and the main stem of the Ohio River from Pittsburgh to Chester, West Virginia, at river mile 42. The area is highly industrialized and is noted for its heavy concentration of iron, steel, and metal processing plants.

The Ohio River from Pittsburgh to river mile 42 is used principally for navigation and as an industrial water supply. The Ohio River in Pennsylvania is not used as a major municipal water source because it contains high bacteria densities, high concentrations of phenolic compounds and other materials that cause taste and odor problems. The water is generally unpalatable without extensive water treatment. Fishing and recreational use of the river have been restricted by pollution. The States of Pennsylvania, Ohio and West Virginia have adopted specific criteria for the Ohio River in order to protect legitimate uses as defined in their Water Quality Standards. These criteria were approved by the Administrator of the U. S. Environmental Protection Agency.

Unusually large loads of municipal and industrial wastes are discharged to the Ohio and Monongahela Rivers in Pennsylvania, affecting the area covered by the conference. The largest source of municipal waste is the Allegheny County Sanitation Authority treatment plant at Ohio River mile 3.1. Industrial waste sources vary considerably but the main sources are large iron, steel, and metal processing plants, such as the plants operated by Jones and Laughlin Corporation at Aliquippa, Crucible Steel Corporation at Midland, Shenango, Inc. on Neville Island, several U. S. Steel plants and the Wheeling-Pittsburgh Steel plant at Monesson. These municipal and industrial wastes affect the water quality of the Ohio and Monongahela Rivers by causing excessive bacteria densities; by depleting the dissolved oxygen content of the Ohio River; by forming oily sludges that are toxic to benthic microfauna; and by contributing excessive loads of phenols, iron, oil, heat, settleable solids, and suspended solids.

Aquatic life in these reaches of the Ohio and Monongahela Rivers is largely limited to pollution-tolerant fish and aquatic organisms. The fish population is mainly comprised of those species that are not considered sport fishes, and pollution renders these fish inedible because of fish flavor. Benthic fauna consists of only pollution-tolerant sludgeworms, and these are found in low numbers indicating toxicity.

CONCLUSIONS

1. The Ohio River is polluted by industrial and municipal wastes, originating in Pennsylvania, and endangering the health and welfare of persons in Pennsylvania, West Virginia and Ohio.

2. The Ohio River from Pittsburgh to Chester, West Virginia is polluted by untreated and inadequately treated domestic wastes that create bacterial pollution in the river; the coliform densities exceed the Federal-State Water Quality Standards criteria almost continually. The river can be used for a public water supply only with extensive treatment. Use of the river for recreation is hazardous to human health.

3. The Ohio River from Pittsburgh to Chester, West Virginia is polluted by untreated and inadequately treated organic wastes from municipal and industrial sources that form toxic sludge deposits upon the river bottom and often deplete the dissolved oxygen content of the river below levels necessary to support fish and other aquatic organisms. The dissolved oxygen content of the river is often below the minimum concentration set in Pennsylvania's Water Quality Standards.

4. The Ohio River from Pittsburgh to Chester, West Virginia often contains high concentrations of phenolics, originating from industrial discharges to the Ohio, Monongahela, and Allegheny Rivers in Pennsylvania that cause fish flavor tainting and produce taste and odor problems in municipal water supplies in Pennsylvania, West Virginia and Ohio.

5. The Ohio River from Pittsburgh to Chester, West Virginia is polluted by oil, originating from industrial sources in Pennsylvania, that interferes with uses for recreation, fishing, and municipal water supplies. Oily sludges, toxic to bottom animals, cover much of the river bottom, and oils mark much of the shoreline.

6. The Ohio River from Pittsburgh to Chester, West Virginia is polluted by waste toxic to fish and aquatic organisms. Populations of fish and other aquatic organisms are restricted to pollution tolerant species, and the fish which are present are inedible.

7. The temperature of the Ohio River from Pittsburgh to Chester, West Virginia during critical periods borders upon the maximum temperature permissable to sustain an adequate warm water fish population.

8. Municipal and industrial discharges to tributaries of the Ohio River in Pennsylvania, especially the Monongahela River, contribute substantially to the water quality problems in the Ohio River.

RECOMMENDATIONS

It is recommended that:

1. All boroughs, townships and sanitation authorities in the Commonwealth of Pennsylvania that discharge municipal wastes to the Ohio River and its tributaries, except the Allegheny County Sanitary Authority, provide a minimum of secondary treatment for all their waste waters. Such secondary treatment should provide a minimum of an 85 percent reduction of both suspended solids and oxygen demanding material throughout the year; the oxygen demanding material measured by the 5-day biochemical oxygen demand (BOD_5) test.

2. The Allegheny County Sanitary Authority's treatment plant at Pittsburgh provide, as a minimum, a 90 percent reduction of both suspended solids and oxygen demanding material throughout the year. The rate of discharge by this plant shall not exceed a BOD_5 load of 20,000 pounds per day and a suspended solid load of 40,000 pounds per day.

3. All industrial discharges to the Ohio River and its tributaries in Pennsylvania be treated to reduce the organic waste load by 85 percent as measured by the 5-day biochemical oxygen demand (BOD_5) test.

4. All municipal waste treatment plants in Pennsylvania that discharge to the Ohio River and its tributaries should provide adequate year-round disinfection of their waste water effluents.

Adequate disinfection is that which provides an effluent which will contain a concentration not greater than 200 per 100 ml of fecal coliform organisms as a geometric average value nor greater than 400 per 100 ml of these organisms in more than 10 percent of the samples tested.

5. Waste waters discharged into the Ohio River and its tributaries in Pennsylvania from municipal and industrial sources:

a. Shall not show irridescence nor contain more than 10 mg/l of total oil

b. Shall not contain amounts of the following substances that will cause the concentration in the receiving stream to exceed the acceptable level as specified in the most recent edition of the USPHS Drinking Water Standards:

Arsenic	Lead
Barium	Nickel
Cadmium	Phenols
Chromium, hexavalent	Selenium
Copper	Silver
Cyanide	Zinc

6. Waste waters from industrial and municipal sources that discharge to the Ohio River or its tributaries in Pennsylvania not contain more than 7.0 mg/l of total iron nor 1.0 mg/l of manganese.

7. Waste waters from industrial and municipal sources that discharge to the Ohio River and its tributaries in Pennsylvania shall not contain material toxic or harmful to aquatic life. Waste waters are considered toxic if over half of the test organisms are fatalities in a 96-hour bioassay.

8. Waste waters from industrial sources that discharge to the Ohio River and its tributaries contain no settleable solids nor a concentration of suspended solids in excess of 30 mg/l.

9. All new and proposed expansions of existing thermal electric power plants along the Ohio River and its tributaries in Pennsylvania should include facilities for off-stream cooling throughout the year.

10. All municipal and industrial waste sources in the conference area have the required treatment facilities completed and in operation by December, 1973 except where completion is required earlier by the Federally approved water quality standards. Interim dates for all waste sources in the conference area are to be submitted to the conference chairman within three months.

11. Concentrations of all materials shall be determined according to the procedures outlined in the latest edition of <u>Standard Methods</u>.

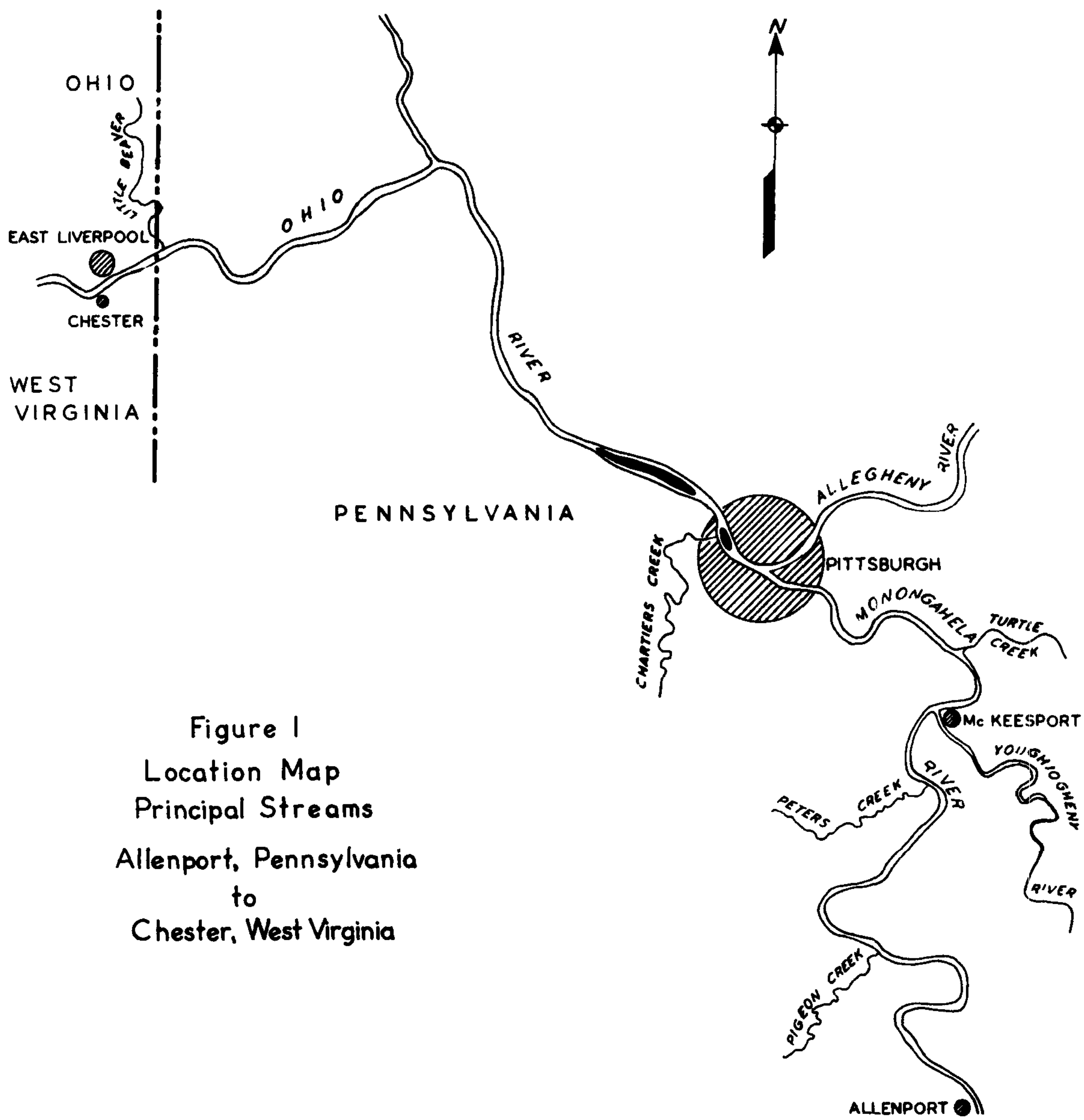


Figure I
Location Map
Principal Streams
Allenport, Pennsylvania
to
Chester, West Virginia

AREA

The Monongahela River flows from northern West Virginia into Pennsylvania near Point Marion, Pennsylvania and continues on a northerly course for 91 miles to Pittsburgh, Pennsylvania (Figure 1). At Pittsburgh, the Monongahela River joins the Allegheny River to form the Ohio River. The Ohio River then flows in a northwesterly direction for 25 miles to its confluence with the Beaver River, south of Beaver Falls, Pennsylvania. From its confluence with the Beaver, the Ohio River flows in a westerly direction for 15 miles to the Pennsylvania-Ohio-West Virginia State boundary approximately three miles east of East Liverpool, Ohio. At this point, the river leaves Pennsylvania and forms the border between the States of Ohio and West Virginia.

The area considered in this report is the main stem of the Monongahela River from Allenport, Pennsylvania, at river mile 47, to its confluence with the Allegheny River at Pittsburgh and the main stem of the Ohio River from Pittsburgh to Chester, West Virginia, at river mile 42. The total population of townships and boroughs adjacent to or near to the Monongahela and Ohio Rivers in this area was approximately 1,100,000 in 1970, including 520,000 in the City of Pittsburgh.[1] A total population of 1,300,000 is served by the Allegheny County Sanitary Authority (ALCOSAN) which discharges to the Ohio River.[2] This disparity between population and population and population served results from the many communities that are served by the ALCOSAN system but are located in neither the Ohio River nor Monongahela River basins.

The Monongahela River at Charleroi, Pennsylvania drains an area of 5,213 square miles, the drainage area increases to 7,381 square miles at Pittsburgh. The largest tributary to the river in this area is the Youghiogheny River that drains an area of 1,768 square miles and flows into the Monongahela River at McKeesport, Pennsylvania. Other major tributaries of the Monongahela River in this area are Turtle, Pigeon and Peters Creeks that drain 147, 59 and 52 square miles, respectively.

The Monongahela River has been canalized in this area with three dams and navigation locks. These structures provide a 9 foot channel for navigation. Locks at Dams 2, 3, and 4 provide vertical lifts of 8.7, 8.2 and 16.6 feet respectively at normal pool for the Monongahela River.

The Ohio River at Pittsburgh drains an area of 19,111 square miles; the drainage area increases to 23,300 square miles at the Pennsylvania State line. In Pennsylvania, the Ohio River has been canalized with three dams and navigation locks -- Emsworth, Dashields and Montgomery. A fourth lock and dam, New Cumberland, is located 14.4 miles downstream from the State line. A 9 foot channel is maintained here also. The vertical lift at the Emsworth, Dashields and Montgomery dams at normal pool are 17.5, 10.0 and 18.0 feet, respectively.

The area is heavily industrialized by basic steel, metal processing and chemical plants that occupy the alluvial plain. The availability of water transportation has made the area an important terminal for barge traffic, especially for coal and petroleum products. The heavy concentration of steel producing facilities in the immediate Pittsburgh area has earned Pittsburgh the title of "Steel Capital of the World."

WATER USES

PRESENT USES

The Monongahela River from Allenport to Pittsburgh is utilized principally for navigation and as an industrial and municipal water supply. The Ohio River in Pennsylvania is also used for navigation and as an industrial water supply, but usage as a municipal water supply is limited. Both rivers are used sparingly for recreation and for fishing, since these uses are severely restricted by pollution. There is presently no use of the Ohio and Monongahela Rivers in this area for hydroelectric power and usage for irrigation has been negligible.

Municipal Water Supply

The Monongahela River is used widely as a source of municipal water. About 623,000 people in this area are served by municipal water systems that use the Monongahela River as a raw water source. The South Pittsburgh Water Company alone serves about 480,000 people. Other major municipal users are the Charleroi, Elizabeth and North Versailles systems that serve 60,000; 37,600; and 16,000 people, respectively.

The Ohio River in Pennsylvania is not used extensively as a raw source for municipal water. In Pennsylvania, only the City of Midland uses the river as a raw water supply for approximately 7,000 people. Midland's raw water intake is located approximately four miles upstream from the Pennsylvania State line.

East Liverpool, Ohio is the only other municipality in this area to use the river as a raw water source; this system serves about 30,000 people.[3] The extensive treatment used by the East Liverpool plant is indicative of the problems encountered when using the Ohio River as a raw water source. Chlorine dioxide is used for disinfection because of its characteristic of effectively destroying phenolic substances that cause taste and odor problems in finished water. The use of chlorine for disinfection of waters containing phenolic substances results in objectionable taste and odor in the finished water. High concentrations of phenols and other taste and odor causing materials necessitate the use of carbon filters to remove the foulness from the water. In the winter months, even this extensive treatment proves ineffective when phenol concentrations are high in the river.[4] All other municipal systems in this area rely upon ground water from infiltration galleries, Ranney wells, or drilled wells for raw water sources.

Fishing

In the eighteenth and nineteenth centuries, explorers, frontiersmen, settlers, and naturalists were impressed with the abundance and size of the fishes that they took from the Ohio River as they descended the river from Pittsburgh. Today, the river is used for fishing although the use is limited by the type of fish population (predominantly rough species such as carp, bullheads and gizzard shad) and the edibility of the fish (caused by fish tainting). Fishermen are also reluctant to fish in the river because of the oil, scum, and debris that persists near major municipalities and industries. The Pennsylvania Fish Commission does not stock either the Ohio or Monongahela Rivers, although many tributary streams in the area are stocked.

Recreation

Boating is the main recreational use of the Ohio and Monongahela Rivers in Pennsylvania, although the use falls short of what would be expected if the rivers were clean. The Corps of Engineers reports that the nine marinas, ramps, and/or docks along the 40 miles of Ohio River in Pennsylvania have a mooring capacity of 185 berths. Similar figures for the 47 miles of the Monongahela River reveal that 14 marinas, ramps and/or docks have a mooring capacity of 226 berths. For comparison, the Allegheny River from Pittsburgh upstream to mile point 40 have a mooring capacity of 1657 berths at 33 facilities.[5]

The oil, scum, and floating debris that persists in most sections of the Ohio and Monongahela Rivers limit their use for contact recreation. More important, although not visible, are the dangerously high bacterial counts, indicative of the presence of pathogenic organisms. Bacteria densities often exceed the level which is considered hazardous for secondary, non-contact recreation such as boating and fishing.

Industrial Water Supply

The Ohio and Monongahela Rivers are used extensively by industries in this area as a source of process and cooling water. Total water use exceeds 6.2 billion gallons per day, of which approximately three-fourths is used as once-through cooling water for thermal electric power generation. Major iron and steel producers account for approximately 20 percent of the industrial water use, the bulk of which is also used for cooling purposes. It has been estimated that cooling water comprises approximately 80 percent of the total water use in basic steel production, but reuse may alter the percentage considerably.[6] The balance of the industrial water (approximately 5 percent) is used by metal processing plants, chemical plants, petroleum processing plants, and various other operations.

Navigation

Navigation is one of the most important uses of the Ohio and Monongahela Rivers in Pennsylvania. Along with the accompanying industrial uses, navigation is an integral part of the economic development along these two rivers. The Corps of Engineers has issued permits for a total of 171 river terminals from Allenport to Pittsburgh on the Monongahela River and from Pittsburgh to mile point 42 on the Ohio River.

The following table lists the number of terminals capable of handling specific materials:

Material	Number of Terminals
Oil and gasoline	29
Stone, sand and gravel	35
Coal and coke	29
Iron and steel	23
Industrial chemicals	15

The above listing is not additive in that many facilities have the capability of handling two or more materials. Terminals for mooring services and miscellaneous materials complete the list.[7]

Total tonnage by material type that passed through Lock No. 2 on the Monongahela River during 1970 was as follows:[8]

Material	Tonnage-1970	Percent
Coal and coke	16,029,420	74.1
Iron and steel	1,167,000	5.4
Oil and gasoline	1,708,290	7.9
All other	2,722,380	12.6
Total	21,627,090	100.0

Similar data for the Emsworth Lock on the Ohio River is:[8]

Material	Tonnage-1970	Percent
Coal and coke	13,904,350	57.7
Iron and steel	2,933,199	12.2
Oil and gasoline	3,217,200	13.4
All other	4,021.100	16.7
Total	24,075,843	100.0

The preceding table is indicative of the predominance of the coal and steel industries in this area.

Irrigation

Use of the Ohio and Monongahela Rivers in Pennsylvania for irrigation is negligible. In 1966, the Corps of Engineers reported that the Pittsburgh standard metropolitan statistical area, which included the upper Ohio River basin plus the lower Monongahela, Allegheny, and Beaver River basins, used only 100 acre-feet per year for irrigation. For comparison, this volume of water would be equivalent to an average annual flow of less than 0.2 cfs.[9]

WATER USES AS DEFINED BY WATER QUALITY STANDARDS

In the submission of Water Quality Standards to the Administrator of the U. S. Environmental Protection Agency, the States listed the uses for each interstate stream in order to determine the applicable water quality criteria. The following delineates the uses of the Ohio and Monongahela Rivers as given by each State's Water Quality Standards.

Pennsylvania

1. Aquatic Life- Warm Water Fish
2. Water Supply - Domestic, Industrial, Livestock, Wildlife and Irrigation
3. Recreation - Boating, Fishing, Water Contact Sports and Natural Area
4. Other - Power, Navigation and Treated Waste Assimilation

West Virginia

1. Water Contact Recreation
2. Water Supply, Public
3. Water Supply, Industrial
4. Water Supply, Agricultural
5. Propagation of Fish and Other Aquatic Life
6. Water Transport, Cooling and Power
7. Treated Wastes Transport and Assimilation

Ohio

1. Public Water Supply
2. Industrial Water Supply
3. Aquatic Life - Warm Water Fish
4. Recreation

GENERAL WATER QUALITY CRITERIA

Each State's Water Quality Standards include general criteria designed to protect the water uses of streams. The following are the general criteria adopted by the respective States and the U. S. Environmental Protection Agency:

Pennsylvania

The water shall not contain substances attributable to municipal, industrial or other waste discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life. Specific substances to be controlled include, but are not limited to, floating debris, oil, scum, and other floating materials; toxic substances; substances that produce color, tastes, odors or settle to form sludge deposits.

West Virginia

Certain characteristics of sewage, industrial wastes or other wastes or factors which render waters directly or indirectly detrimental to the public health or unreasonably and adversely affect such waters for present or future reasonable uses, are objectionable in all the waters of the State. Therefore, the State Water Resources Board does hereby proclaim that the following general conditions are not to be allowed in any of the waters of the State.

No sewage, industrial wastes or other wastes entering any of the waters of the State shall cause therein or materially contribute to any of the following conditions thereof, which shall be the minimum conditions allowable:

1. Distinctly visible floating or settleable solids, suspended solids, scum, foam or oily sleeks of unreasonable kind or quality;
2. Objectionable bottom deposits or sludge banks;
3. Objectionable odors in the vicinity of the waters;
4. Objectionable taste and/or odor in municipal water supplies;
5. Concentrations of materials poisonous to man, animal or fish life;

6. Dissolved oxygen concentration to be less than 3.0 parts per million at the point of maximum oxygen depletion;
7. Objectionable color;
8. Objectionable bacterial concentrations;
9. Requiring an unreasonable degree of treatment for the production of potable water by modern water treatment processes as commonly employed.

Ohio

Minimum conditions applicable to all waters at all places at all times:

1. Free from substances attributable to municipal, industrial or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits;
2. Free from floating debris, oil, scum and other floating material attributable to municipal, industrial or other discharges in amounts sufficient to be unsightly or deleterious;
3. Free from materials attributable to municipal, industrial or other discharges producing color, odor or other conditions in such degree as to create a nuisance;
4. Free from substances attributable to municipal, industrial or other discharges in concentrations or combinations which are toxic or harmful to human, animal or aquatic life.

SPECIFIC WATER QUALITY CRITERIA

In addition to the general criteria, each State adopted specific criteria to protect the water uses of streams. Specific approved criteria adopted by the respective States and the U. S. Environmental Protection Agency for the Ohio River are listed in Table 1. The specific criteria for the Monongahela River in Pennsylvania are identical to the specific criteria of the Ohio River except that there is not a fluoride criterion for the Monongahela River. Table 2 enumerates Ohio's proposed temperature criteria for the Ohio River.

TABLE 1

Current Approved Specific Criteria - Ohio River

	Pennsylvania 1/	West Virginia Present	West Virginia Changes Effective 10/72	Ohio Present	Ohio Proposed
Ranges					
pH (Standard Units)	6.0 - 8.5	5.0-9.0	6 - 8.5	5.5-9.0 6.5-8.5*	6.0-8.5
Maximums					
Temperature (°F)	87°				
(May - November)	-	93° 2/	87°	-	3/
(December - April)	-	73° 2/	73°	-	3/
Temperature Change (over natural)	5°				
Threshold Odor No. at 60° C	24	24*	8*	24*	
Total Coliforms/100 ml		1000**		1000**	
For 5/15 - 9/15	1000**				
For 9/16 - 5/14	5000**				
Radioactivity (p Ci/1)					
Gross Beta	-	1000		1000	
Dissolved Strontium - 90	-	10			
Dissolved Alpha	-	3			

NOTES: * - Denotes daily average

** - Denotes monthly average

1/ Specific criteria for the Monongahela River in Pennsylvania is identical to those for the Ohio River.

2/ Approved by the Administrator of the U. S. Environmental Protection Agency as interim criteria only.

3/ See Table 2

Table 1 (cont.)

	Pennsylvania	West Virginia		Ohio	
		Present	Changes Effective 10/72	Present	Proposed
Maximum Concentrations (mg/1)					
Toxic Substances	-	1/10 TLm_{48}	1/10 TLm_{96}	1/10 TLm_{48}	
Arsenic	-	0.01		0.05	
Barium	-	0.5		1.0	
Cadmium	-	0.01		0.01	
Chromium (hexavalent	-	0.05		0.05	
Lead	-	0.05		0.05	
Silver	-	0.05		0.05	
Nitrates	-	45.0		-	
Phenol	0.005	0.001		-	
Cyanide	-	0.025		0.20	
Fluoride	1.0 4/	1.0		2.0	
Selenium	-	0.01		0.01	
Iron (Total)	1.5	-		-	
Manganese (Total)	1.0	-		-	
Dissolved Solids	750.0	-		750.0	
Dissolved Solids	500.0**	-		500.0**	
Minimum Concentrations (mg/1)					
Dissolved Oxygen	4.0	3.0	5.0		4.0
For 16 of any 24 hours		5.0	-		-
Daily average	5.0	-	-		5.0

4/ Not applicable to Monongahela River

Table 2

Ohio's Proposed Temperature Criteria for the Ohio River

Maximum Temperature (^oF) During Month

January	50	July	89
February	50	August	89
March	60	September	87
April	70	October	78
May	80	November	70
June	87	December	57

SOURCES OF WASTES

GENERAL

Waste discharges from municipal and industrial sources have deleterious effects upon receiving waters in the conference area. Municipal wastes contain oxygen demanding materials that can reduce dissolved oxygen in a stream; severe reduction of dissolved oxygen can limit or destroy fish, fish food organisms and other aquatic life. Municipal wastes also contain high numbers of intestinal bacteria from man's excretions, including pathogenic organisms. Objectionable surface scums, sludge deposits and turbidity in a stream may result from municipal waste discharges that contain greasy substances, settleable solids and suspended solids.

Industrial wastes may also contain oxygen demanding materials, settleable and suspended solids, and greasy substances and oils. In addition, some industrial wastes contain objectionable chemicals and toxic substances that can taint fish flesh, kill aquatic life and damage a water source for use as a municipal supply. Industries use water extensively for cooling purposes. Heated waters reduce the dissolved oxygen saturation concentration of a water body and increase the biochemical oxidation of organic wastes, further reducing the dissolved oxygen content.

Limited data are available on industrial and municipal discharges to the Ohio and Monongahela Rivers in Pennsylvania, although some sources have been documented quite thoroughly. Personnel of the U. S. Environmental Protection Agency obtained available data (1965 to present) on these discharges from the files of the Pennsylvania Department of Environmental Resources.[10] Tables 3 and 4 list municipal wastes sources discharging to the Ohio and Monongahela Rivers in the area. Tables 5 and 6 are similar listings for major industrial discharges to the Ohio and Monongahela Rivers. Other industrial dischargers to these Rivers are listed in Tables 7 and 8.

TABLE 3

SOURCES OF MUNICIPAL WASTES

OHIO RIVER-PITTSBURGH TO EAST LIVERPOOL, OHIO (River Mile 42)

			Bacterial Loads*				Oxygen Demand Loads **			
River Mile	Name	Type of Treatment	Sewered Population	% Bacteria Removed by Treatment	Discharged to Watercourse BPE	% of Tot.	P. E. Before Treatment	% Removed by Treatment	Discharged to Watercourse P. E.	% of Tot.
3.1R	Allegheny County Sanitary Authority	Primary $+Cl_2$	1,300,000+	97.9	52,000	84.1	1,300,000	31.0	897,000	91 6
7.6R	Dixmont State Hospital (Killbuck Twp.)	Secondary $+Cl_2$	2,200	98.5	55	0.1	2,200	90.0	220	0.0
8.6R	Glenfield Borough	None	740	0	740	1.2	740	0.0	740	0.1
10.2L	Coraopolis Borough	Intermediate $+Cl_2$	19,000	95.0	950	1.5	19,000	48.2	9,900	1.0
11.3R	Osborne-Sewickley Boroughs	Intermediate $+Cl_2$	8,000	95.0	400	0.6	8,000	50.0	4,000	0.4
13.9R	Edgeworth-Leetsdale Borough	Intermediate $+Cl_2$	2,200	95.0	33	0.1	2,200	47.0	1,170	0.1
14.5L	Crescent Twp.-Heights Municipal Authority	Secondary $+Cl_2$	2,500	98.5	37	0.1	2,500	95.0	130	0.0
15.9R	Ambridge Borough	Primary $+Cl_2$	17,000	92.5	1,275	2.1	17,000	35.0	11,000	1.1
20.0L	Aliquippa Borough	Primary $+Cl_2$	30,000	92.5	2,250	3.6	30,000	35.0	19,500	2.0
20.3R	Baden Borough	Primary $+Cl_2$	12,000	92.5	900	1.4	12,000	35.0	7,800	0.8
21.6R	Conway Borough	Primary $+Cl_2$	2,500	92.5	187	0.3	2,500	35.0	1,620	0.2
24.4L	Monaca Borough	Primary $+Cl_2$	8,500	92.5	638	1.0	8,500	35.0	5,520	0.6
25.0R	Rochester-Rochester Twp. (Rochester Municipal Auth.)	Primary $+Cl_2$	13,000	92.5	975	1.6	13,000	35.0	8,450	0.9
26.2R	Beaver Borough									
	Plant #1	Primary $+Cl_2$	7,500	92.5	562	0.9	7,500	35.0	4,880	0.5
	Plant #2	Secondary $+Cl_2$	2,500	98.5	37	0.1	2,500	90.0	250	0.0
28.0R	Borough Twp. MSA (Inc. Vanport)	Primary $+Cl_2$	2,900	92.5	218	0.3	2,900	35.0	1,880	0.2
36.3R	Midland Borough	Primary $+Cl_2$	8,000	92.5	600	1.0	8,000	35.0	5,200	0.5
		TOTALS	1,438,540		61,857	100.0	1,438,540		979,260	100.0

*All bacterial loads except that of the ALCOSAN plant were estimated.

**All oxygen demand loads were estimated except the following plants - ALCOSAN, Dixmont State Hospital, Coraopolis, Osborne-Sewickley, Edgeworth-Leetsdale, Crescent and Beaver Plant #2.

Table 4

SOURCES OF MUNICIPAL WASTES

MONONGAHELA RIVER-ALLENPORT TO PITTSBURGH

River Mile	Name	Population Served	Type of Treatment
12	Duquesne	15,000	Secondary + chlorination
14	McKeesport	75,000	Intermediate + chlorination
16	Dravosburg	3,000	Secondary + chlorination
18	Glassport	6,500	Secondary + chlorination
20	Clairton	16,000	Primary + chlorination
25	Elizabeth Borough	3,200	Intermediate + chlorination
29	New Eagle	2,620	Secondary + chlorination
32	Monongahela	8,390	Primary + chlorination
34	Donora	31,500	Secondary + chlorination
39	Monesson	18,425	None
41	Charleroi	8,150	Secondary + chlorination
43	Belle Vernon	5,000	Secondary + chlorination
44	Fayette City	1,160	Primary + chlorination
46	Allenport	7,000	None

TABLE 5

MAJOR INDUSTRIAL DISCHARGERS

OHIO RIVER - PENNSYLVANIA

River Mile	Industry	Discharge MGD	Critical Constituents* (pounds/day)	Remarks
2.3L	Duquesne Light Co. Reed Power Station	406.0	Heat	Coal Spillage
5.1L	Marquette Cement Co.	0.6	SS-2,100	
5.2L	Shenango, Inc.	28.0	ALK-88,000; BOD_{20}-14,800; CN-480; Oil-X; Phenols-280; SS-9,380	
5.2L	USS Chemicals	2.0	ALK-1,000; COD-1,000; BOD-320; V.S.-3,700; SS-1,100	
6.4L	NOPCO Chemical Co.	0.17	BOD-2,000; D.S.-11,600; Oil-X	
6.9L	Neville Chemical Co.	0.15	Phenols-X	
7.2L	Shenango, Inc.	4.0	Fe-200: Heat	
10.8L	Pittsburgh Forging Co.	1.4	Heat	Cooling Water
11.3L	Blaw-Knox Co.	1.0	Heat	Cooling Water
11.5L	Russel Birdsale & Ward	0.3	CN-X	
15.2L	Duquesne Light Co. Phillips Power Station	480.0	Heat	Cooling Water
15.9R	H. K. Porter Co.	0.23	CN-X;Fe-X; Zn-X	

TABLE 5 (cont.)

River Mile	Industry	Discharge MGD	Critical Constituents* (pounds/day)	Remarks
16.8L	Jones and Laughlin Steel Co. Aliquippa Works	227.0	BOD-12,000; BOD_{20}-26,700; CN-207 to 445; T.Fe-9,800 to 19,000; Oil-X; Phenols-151 to 281; SS-28,000 to 29,000; SO_4-44,000 to 150,000; TS-250,000	pH 1.2 to 12.0
17.0R	Wykoff Steel Co.	0.2	T.Fe-633; D.Fe-592	
18.0R	Armco Steel Corp Armco Division	8.0	BOD_{20}-3,340; T. Fe-530	
23.0R	Pennsylvania-Central RR	0.14	ABS-X; BOD-X; D.S.-X; Oil-X	
23.9L	Pittsburgh Screw & Bolt Co.	0.06	BOD_{20}-240; SO_4-287	
23.9L	VASCO (Vanadium Alloy Steel Company)	1.1	ALK-9,200; T.Fe-133; SS-1,670	pH-12.2
24.0R	Valvoline Oil Company		Oil-230	
24.2L	Pittsburgh Tube Company	0.27	ACD-X; Fe-X	pH-3.0
24.3L	Pittsburgh Tool Steel Wire Co.	0.02	D.Fe-60; T.Fe-67; SO_4-390; SS-154	pH-3.0
26.5R	Superior Drawn Wire	0.01	T.Fe-168; SO_4-250; SS-80	pH-3.1

TABLE 5 (cont.)

River Mile	Industry	Discharge MGD	Critical Constituents* (pounds/day)	Remarks
28.1L	Westinghouse Electric Co.	0.45	SO_4-1,400	
28.5L	St. Joseph Lead Company	109.7	Heat-X; SS-4,100	
29.7L	Sinclair-Koppers Company	70.0	BOD-11,900	pH-2.7 to 11.4
34.5L	Duquesne Light Co. Shippingport Atomic Power Station	150.0	Heat	Cooling
36.5R	Crucible Steel Company	66	Fe-22,800; Oil-10,000; Phenol-433; SS-118,000	

*KEY TO TABLE

WASTE CONSTITUENTS

ABS - Alkylbenzene Sulfonate

ACD - Acid, equivalents of $CaCO_3$

ALK - Alkalinity, equivalents of $CaCO_3$

BOD - Biochemical Oxygen Demand, 5-day

BOD_{20} - Biochemical Oxygen Demand, 20-day

CN - Cyanide

COD - Chemical Oxygen Demand

Cr - Chrome

D - Dissolved

Fe - Iron

pH - Hydrogen Ion Concentration

S - Solids

SS - Suspended Solids

SO_4 - Sulfate

T - Total

V - Volatile

X - Insufficient data

Zn - Zinc

River Mile - Miles from Pittsburgh, R and L denote right or left bank looking downstream.

TABLE 6

MAJOR INDUSTRIAL DISCHARGERS

MONONGAHELA RIVER-ALLENPORT TO PITTSBURGH

River Mile	Industry	Critical Constituents* (pounds/day)	Remarks
7-9	U. S. Steel - Homestead Works	Phenol-127 Cyanide-178 Suspended Solids- 920,000 Oil-X*	Granulated Slug
10.9-11.3	U. S. Steel-Braddock Edgar Thompson Works	Phenol-81 Cyanide-320	
13.2	U. S. Steel-Duquesne Works	Phenol-160 Cyanide-62	
14.7-15.5	U. S. Steel-McKeesport National Tube Works	Phenol-25 Cyanide-90 Oil-X	
17.4-17.8	U. S. Steel-Irvin Works	Oil-3500 Fe-3200	pH-2.7
18.4-21.8	U. S. Steel-Clairton Works	Phenol-210 Oil-X Tar-X	
23.7	Pennsylvania Industrial Chemical Company	Phenol-47	
39.3-40.4	Wheeling-Pittsburgh Steel Corp.-Monesson Plant	Phenol-2000 Cyanides-180 Suspended Solids-20,000 Oil-X	

*X-Insufficient Data

TABLE 7

OTHER INDUSTRIAL DISCHARGERS

OHIO RIVER - PENNSYLVANIA

River Mile	Name	Remarks
0.0R	Tri-Point Ice Cream Company	All wastes to ALCOSAN 1/
1.2R	General Dynamics Corporation Liquid Carbonics Division	Cooling Water only
1.3R	Cowan Manufacturing Company	All wastes to ALCOSAN
3.0L	Gordon Terminal Service Co.	
3.5L	Federal Enamel and Stamp Co. (FESCO)	
4.0R	Suburban Laundry	Will connect to Bellevue System
4.1L	National Cylinder Gas Co. Davis Island Yards	All wastes trucked away
5.1L	Matlack Inc.	All wastes to ALCOSAN
5.8L	Gulf Oil Co.	All wastes trucked away
7.7L	Vulcan Materials Co.	
8.8L	Blaw-Knox Company Lewis Works	
10.3L	Sterling Varnish Co.	Cooling water only
14.5R	Elwin G. Smith & Co., Inc.	
14.6R	Bethlehem Steel Company	
14.8	Copper Range Company C. G. Hussey & Company	

1/ Allegheny County Sanitary Authority

TABLE 7 (cont.)

River Mile	Name	Remarks
14.8R	J & J Rocket Carwash, Inc.	
15.9L	Gavlick Construction Company	
16.0R	American Bridge Company	
16.9L	H. K. Porter Company	
16.9R	H. H. Robertson Company	
28.5R	Petroleum Solvents, Inc.	
33.8L	Shippingport Sand and Gravel Co.	

TABLE 8

OTHER INDUSTRIAL DISCHARGERS

MONONGAHELA RIVER-ALLENPORT TO PITTSBURGH

River Mile	Industry
3.4	Jones & Laughlin Steel Corporation
5.7	American Oil
7.0	Mesta Machine
9.2	Ashland Oil Company
9.4	Bethlehem Steel
13.8	Firth Sterling Steel Company
16.1	Boswell Oil Company
16.2	Gateway Asphalt Company
18.4	Copperweld Steel Company
21.8	Jones & Laughlin Steel Corporation
24.5	Jones & Laughlin Steel Corporation
24.7	Ashland Oil & Refining Company
30.3	U. S. Steel Corporation
30.7	Monongahela Iron and Metal Company
32.7	Monongahela Iron and Metal Company
38.9	Page Steel & Wire Company
40.8	American Oil
43.3	Guttman Oil Company
46.8	Wheeling-Pittsburgh Steel Company

BACTERIAL LOADS (MUNICIPAL)

Coliform bacteria in raw and treated sewage are used to indicate the density of sewage associated bacteria, including disease-producing pathogens. Though generally harmless in themselves, coliform bacteria have been considered indicators of the presence of these pathogenic bacteria. Bacteria loads are often expressed in terms of a bacterial population equivalent (BPE), which is the average amount of coliform bacteria normally contained in sewage contributed by one person in one day. One BPE is equal to 400 billion coliform bacteria per day.

Sewage treatment plants can drastically reduce the amount of bacteria in sewage depending upon capacity, type of disinfection practiced and the skill of the plant operators. Table 3 is a list of the major sewage treatment plants that discharge to the Ohio River in Pennsylvania. From the table, it can be seen that the ALCOSAN system contributes 84.1 percent of the bacterial load to the Ohio River in Pennsylvania. This load is equivalent to a raw sewage discharge from 52,000 people. Table 4 shows that Monesson and Allenport discharge untreated sewage from a total of 25,400 people into the Monongahela River.

OXYGEN DEMANDING LOADS (MUNICIPAL AND INDUSTRIAL)

The oxygen demand of municipal and industrial wastes, as measured by the biochemical oxygen demand (BOD) test, indicates their potential for reducing the dissolved oxygen of a stream.

BOD usually refers to a 5-day test (BOD_5), but in some cases wastes are tested for 20 days (BOD_{20}). For sewage, the 5-day test usually suffices. The BOD loadings are often expressed in population equivalents (PE), one population equivalent being equal to 0.17 pounds per day of BOD_5. Occasionally, industrial waste loads are also expressed in population equivalents.

Table 3 contains a tabulation of estimated population equivalents of municipal discharges to the Ohio River in Pennsylvania. The ALCOSAN plant at river mile 3.1 discharged the equivalent of untreated wastes from approximately 900,000 people; this load represented 94 percent of the total oxygen demand from all municipalities that discharged to the Ohio River in Pennsylvania. ALCOSAN's discharge contained the equivalent of 121,000 pounds per day of BOD_5.

In 1967 and 1968, the ALCOSAN plant discharged approximately 128,000 pounds per day of BOD_5 from an influent load of less than 200,000 pounds per day. For the future, the Commonwealth of Pennsylvania has restricted the total loadings from the ALCOSAN plant to 60,000 pounds per day of BOD_5. This restriction, at present, would call for a 70 percent reduction of the total load of 200,000 pounds per day (BOD_5). The Commonwealth of Pennsylvania is presently requiring all other municipal plants to install facilities to removal 85 percent of the BOD_5. ORSANCO's proposed effluent standards call for a 90 percent removal of BOD_5 at the ALCOSAN plant.

Information was not available on the oxygen demand loads from municipal wastes along the Monongahela River in this area. Using standard sanitary engineering figures, however, it could be estimated that the municipal systems in Table 4 discharge about 16,000 pounds per day of BOD_5, including 4300 pounds per day in untreated sewage.

The limited data available on industrial wastes indicate that the total industrial oxygen demand may be greater than the municipal oxygen demand after municipal secondary treatment facilities become a reality. Oxygen demand data from the Commonwealth showed that only seven industrial plants accounted for an oxygen demand of approximately 60,000 pounds per day of BOD_5; the information was not complete for these seven. The Jones and Laughlin plant at Aliquippa alone discharged about 27,000 pounds per day of BOD_{20} from the eight of 34 outfalls for which data were available. Shenango, Inc. on Neville Island accounted for a daily load of 14,800 pounds of BOD_{20}. BOD loading data were not available from other major industries such as the Crucible Steel Company plant at Midland. These figures are presented only to show the relative minimum loadings since complete data were not available. There was no information available on BOD loadings from industries along the Monongahela River.

PHENOL SOURCES

Coke, a major raw material in iron and steel production, is made by heating coal in the absence of air. Process water used to quench the hot coke oven gas becomes burdened with many organic and inorganic materials, notably phenolic compounds. These phenolic compounds contaminate receiving waters if not removed from the waste water.

Some coke plant operations now use water containing phenols as quench water for the hot coke. Although this may reduce the load of phenols discharged by the coke plant, it increases the loadings from the blast furnaces that subsequently receive the coke. A major problem is that the great volumes of flue gas wash water containing phenols from blast furnaces limit effective means of treatment as compared to smaller flows in the coke plant.

Data concerning discharges of phenols in this reach of the Ohio and Monongahela Rivers are scarce. Nevertheless, information in the Commonwealth files indicates that approximately 1,000 pounds of phenol per day enter the Ohio River. The Crucible Steel plant at Midland discharged 433 pounds per day, while Jones and Laughlin, Aliquippa and Shenango, Inc. Neville Island, both accounted for 280 pounds per day. Phenolic materials have been detected at other discharges but data were incomplete. EPA conducted an effluent sampling program of major industries along the lower Monongahela River in early 1971. Table 6 shows that approximately 2500 pounds per day of phenol was discharged to the Monongahela River during this period.

OIL SOURCES

Cold rolling mills in the steel industry use large volumes of oil that often contaminate wastewaters. Oils can also derive from machining operations, lubricating oils and various other metal processing operations. In addition, large volumes of gasoline, oil and oil derivatives are shipped, loaded and unloaded, on these navigable streams.

The Commonwealth's files contained information of oil loads from only the Crucible Steel Company at Midland, which discharged about 10,000 pounds per day of oil in a water-oil emulsion. EPA biologists, during the study in May-June, 1970, reported that "masses of dense globs of oils were observed floating downstream from a series of wastewater outfalls belonging to the Jones and Laughlin Steel Company at river mile 16.9. Severe oil pollution was apparent downstream from the Crucible Steel Company's wastewater outfalls at river mile 36.3".[11]

EPA's industrial effluent sampling program in early 1971 revealed that oil was evident in several industrial discharges to the Monongahela River. U. S. Steel's Irvin Works had a discharge that contained about 3500 pounds per day of oil.

HEAT SOURCES

The largest unnatural sources of heat to these two rivers in this area were six thermal electric power plants. The following list shows the plants, their capacities and an estimated rate at which heat is added to the rivers:

Name	Capacity (megawatts)	Estimated Heat Load Rate (billion BTU's/hr)
Duquesne Light Co., Elrama Plant	425	2.29
West Penn Power Co., Mitchell Plant	449	2.42
Duquesne Light Co., Reed Plant	180	0.97
Duquesne Light Co., Phillips Plant	315	1.70
Duquesne Light Co., Shippingport	90	0.76
St. Joseph Lead Company	100	0.54
Total	1,559	8.68

The two plants along the Monongahela River, the Elrama and Mitchell Plants, would theoretically raise the temperature of the river 41.9° F during a low flow of 500 cfs. The remaining plants in the above table would theoretically raise the Ohio River 5.4° F during a low flow of 3300 cfs. Other heat sources were major iron and steel plants which use about 80 percent of their total water usage for cooling.

SUSPENDED SOLIDS (MUNICIPAL AND INDUSTRIAL)

Steel mills discharge large loads of suspended solids. Flue gas wash waters from blast furnaces and basic oxygen furnaces contain high concentrations of suspended solids in their high flow discharges. Process waters from rolling mills also contain considerable amounts of suspended solids. Municipal treatment plants, depending on their removal efficiencies, are another source of suspended solids.

The largest municipal source of suspended solids in this area was the ALCOSAN plant which discharged approximately 54 tons per day. Data were insufficient to obtain the total amount of suspended solids from the other municipal treatment plants.

From data available, industrial plants in this area discharged about 83 tons per day of suspended solids into the Ohio River. Crucible Steel at Midland accounted for 59 tons per day of suspended solids, Jones and Laughlin at Aliquippa was responsible for 14 tons per day. The U. S. Steel Plant at Homestead discharged about 450 tons per day of granulated slag into the Monongahela River.

IRON

Acid wastewaters from pickling operations in metal processing plants contain considerable amounts of dissolved iron, both from the pickling solution and the acid rinse waters. Rolling mills can discharge large quantities of suspended and settleable iron oxides (mill scale). In addition, flue gas wash waters from blast furnaces and basic oxygen furnaces contain significant quantities of suspended iron.

From the limited data available, the amount of iron discharged to the Ohio River in this area was approximately 22 tons per day. The Crucible Steel Company plant at Midland discharged about 11 tons per day; the Jones and Laughlin plant at Aliquippa accounted for another 9 tons per day. Data on the discharge of iron were not available for most industries in this area.

CYANIDES

The discharge of cyanide to water bodies is critical to the aquatic environment because of the toxic nature of the material. Cyanides are present in wastewaters from coke plants, by-product plants and blast furnace flue gas wash water. Cyanides are also used extensively in metal plating processes, thus becoming another source of cyanides.

The limited data available indicate that the Ohio River receives about 925 pounds per day of cyanides. Information on cyanide discharges were available for only Shenango, Inc., on Neville Island and Jones and Laughlin at Aliquippa; these loadings were 480 and 445 pounds per day, respectively. The effluent sampling program performed by EPA in early 1971 showed that about 1,000 pounds per day of cyanide were being discharged by industries into the Monongahela River.

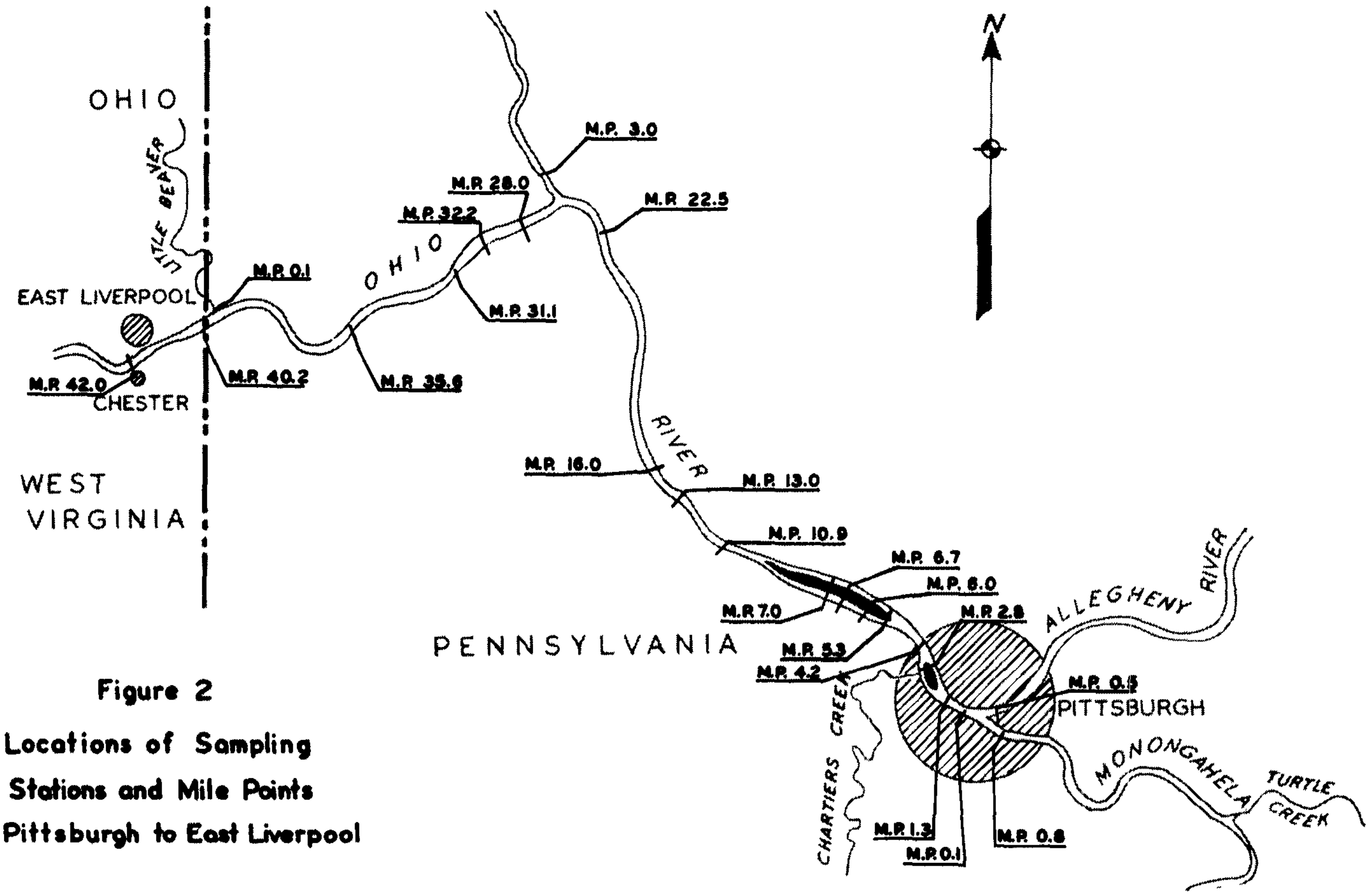


Figure 2

Locations of Sampling Stations and Mile Points Pittsburgh to East Liverpool

EFFECT OF POLLUTION ON WATER QUALITY AND USES

Various studies and surveys have been made to define the effects of pollution on water quality and water uses in the Ohio and Monongahela Rivers in this area. In addition, the U. S. Environmental Protection Agency maintains several sampling stations in the area as part of its Pollution Surveillance Program.[12]

Figure 2 and Table 9 describe 22 stations that were sampled for physical, chemical and bacteriological analysis by EPA in a special study of the Ohio River in May and June, 1970. Five of these stations coincide with Pollution Surveillance stations that EPA has maintained since 1968:

River Mile	Description
0.5	Allegheny River at Sixth Street Bridge
0.8	Monongahela River at Smithfield Street Bridge
16.0	Ohio River at South Heights, Pennsylvania
3.0	Beaver River near mouth at Route 18 Bridge
40.2	Ohio River at Pennsylvania-West Virginia-Ohio State Line

Concurrent with the special study in May and June, 1970, the National Field Investigations Center, made a study on the biological effects of pollution in this section of the Ohio River.[11]

The Ohio River Valley Water Sanitation Commission maintains an electronic monitor at South Heights, Pennsylvania, that provided additional data.[13] The ORSANCO station is near the EPA surveillance station at South Heights. Another source of data was an intensive study done by the University of Pittsburgh in 1964 and 1965 on water quality in the

TABLE 9
SAMPLING STATIONS
SPECIAL STUDY-EPA-OHIO RIVER
May-June, 1970

Description	M. P.
Allegheny River at Sixth Street Bridge	0.5
Monongahela River at Smithfield Bridge	0.8
Ohio River near Seaplane Dock	1.3
Chartiers Creek at Bridge near mouth	0.1
Ohio River-Back Channel of Brunot Island @ Power Line	2.8
Ohio River opposite M & O Dredging Company Dock	4.2
Ohio River, Back Channel at Neville Island @ P & LE RR Bridge	5.3
Ohio River, Back Channel at Neville Island opposite Pittsburgh-DesMoines Dock	7.0
Ohio River, opposite Upstream Lock Wall Emsworth Dam	6.0
Ohio River, opposite Downstream Arrival Point for Emsworth Dam	6.7
Ohio River, opposite Sewickley Coast Guard Depot Light	10.9
Ohio River, Upstream of Warning Light for Dashields Dam	13.0
Ohio River opposite American Bridge Dock	16.0
Ohio River opposite C C. Bunton Navigation Light	22.5
Beaver River at Rt. 18 Bridge	3.0
Ohio River, Upstream of Vanport Highway Bridge	28.0
Ohio River opposite Montgomery Dam Upper Light	31.1
Ohio River opposite Downstream Arrival Point for Montgomery Dam	32.2
Ohio River, Navigation Channel, opposite Phillis Island Light	35.6
Little Beaver River at Highway Bridge near mouth	0.1
Ohio River opposite East Liverpool Water Intake	40.2
Ohio River opposite Chester, West Virginia Water Intake	42.0

Allegheny, Monongahela, and Ohio Rivers.[14] This study provided data at the Pollution Surveillance stations plus an additional station on the Ohio River at Rochester, Pennsylvania, river mile 25.2.

BACTERIAL POLLUTION

Municipal sewage contains enormous numbers of bacteria, among which there are frequently pathogenic bacteria, derived from human excreta. These pathogenic bacteria can cause gastro-intestinal diseases such as typhoid fever, dysentery and diarrhea. Infectious hepatitis, a virus disease, can also be caused by ingesting sewage-polluted water. Eye, ear, nose, throat or skin infections may result from bodily contact with such water. As the densities of pathogenic bacteria are reduced by sewage treatment or forces of natural purification, the hazards of contacting disease are proportionately reduced.

Sewage also contains readily detectable coliform bacteria, which typically occur in excreta or feces and are always present in sewage-polluted water. Though generally harmless in themselves, coliform bacteria have been considered indicators of the presence of pathogenic bacteria. The coliform group includes several types of bacteria which may come from sources other than excreta.

Testing for fecal coliform bacteria is becoming more popular as an indicator of bacterial pollution because fecal coliform bacteria specifically inhabit the intestinal tract of man and warm-blooded animals. The presence of these organisms in water is positive proof of fecal contamination which may contain associated, disease producing organisms.

Coliform Bacteria

Presently, the States of Pennsylvania, West Virginia and Ohio use the total coliform group as an indicator of bacterial pollution. The State of Ohio is in the process of changing its recreational criterion for bacteria to the fecal coliform group. Specific bacterial criteria by State are listed in Table 1, on page 24.

The survey by the University of Pittsburgh in 1964-65 included analyses for bacterial indicators. Table 10 lists the monthly average of the total coliform densities found in the Ohio, Allegheny, and Monongahela Rivers. Both the Ohio River at Rochester and the Monongahela River at Pittsburgh exceeded Pennsylvania's present recreational criterion of 1,000 total coliforms per 100 ml in all five months that were designated as recreational. In addition, both rivers exceeded the municipal water supply criterion of 5,000 total coliforms per 100 ml in seven of 12 months.

Pollution Surveillance of the U. S. Environmental Protection Agency has taken monthly samples at five stations in this area since June, 1968. Table 11 is a tabulation of the total coliform densities found in the monthly samples at these stations. To date, the Monongahela River at Pittsburgh has exceeded the bacterial criterion for recreation in 10 of 13 recreational months; the water supply criterion was exceeded in 10 of 23 months. Data were similar at the Ohio River

TABLE 10

UNIVERSITY OF PITTSBURGH STUDY
MONTHLY AVERAGE TOTAL COLIFORM DENSITY
(Number per 100 ml)

River River Mile	Ohio 25.2	Monongahela 0.8	Allegheny 0.5
October, 1964	15,600	8,700	2,900
November	9,900	77,800	56,000
December	3,300	16,500	1,500
January, 1965	4,800	2,300	2,100
February	3,900	320	570
March	2,400	1,300	818
April	2,000	1,300	419
May	25,300	3,100	5,300
June	15,100	15,700	8,500
July	13,800	26,600	7,600
August	15,200	17,100	4,800
September	7,400	14,000	33,400
Total Number of Samples	77	76	76

TABLE 11
U. S. ENVIRONMENTAL PROTECTION AGENCY POLLUTION SURVEILLANCE

Total Coliform Density - Monthly Sample
(Number per 100 ml)

	Allegheny River	Monongahela River	Ohio River	Beaver River	Ohio River
River Mile	0.5	0.8	16.0	3.0	40.2
Date					
June, 1968	610	520	33,000		2,200
July	15,000	2,800	7,800		2,200
August	7,400	50	320		6,000
September	40,000	26,000	33,000	26,000	3,300
October	42,000	270,000	37,000	48,000	18,000
November	20,000	100	40,000	-	85,000
December	3,200	50	3,500	23,000	15,000
January 1969	1,800	4,300	4,400	62,000	40,000
February	2,300	3,100	3,000	18,000	5,400
March	790	160	40,000	1,500	4,700
April	1,800	24,000	53,000	8,000	6,300
May	6,400	6,000	28,000	47,000	11,750
June	42,000	31,000	34,000	2,900	1,500
July	13,000	400	17,000	8,000	18,000
August	500	7,600	63,000	1,500	39,000
September	23,000	28,000	11,000	1,800	2,200
October	21,000	23,000	34,000	4,100	3,200
November	22,000	390	53,000	26,000	4,100
December	22,000	41,000	63,000	44,000	10,800
January 1970	7,300	2,700	3,700	6,100	3,600
February	1,300	760	3,200	19,000	4,100
March	690	780	790	11,000	3,500
April	-	-	-	7,800	1,900
May	30,000	47,000	96,000	7,800	120,000
June	25,000	2,900	25,000	22,000	4,100
July	2,400	25,000	5,200	9,500	7,800
October	5,500	16,000	77,000	22,000	34,000
November	5,200	13,000	68,000	160,000	100,000
December	4,100	12,000	13,000	64,000	31,000
January 1971	370	1,500	2,600	18,100	2,700
March	4,600	1,300	1,200	26,000	4,900
April	5,600	100	5,700	2,900	3,400
May	4,400	6,200	69,000	16,000	7,700
June	33,000	13,000	31,000	80,000	55,000
July	7,200	71,000	-	-	450,000

station at river mile 16. The Ohio River at this point exceeded Pennsylvania's bacterial criterion for recreation in 11 of 12 months; the water supply criterion was exceeded in 13 of 21 months The bacterial pollution of the Ohio River persists to the Pennsylvania-Ohio-West Virginia State boundary. The Ohio River at the State line exceeded West Virginia's bacterial criterion in all samples; Ohio's recreational criterion in all recreational months; and Ohio's bacterial criterion for water supply in more than 50 percent of the samples.

In the study of the Ohio River in May and June, 1970, total coliform densities of the Ohio River in Pennsylvania exceeded the 5,000 per 100 ml bacterial criterion for water supply in 43 of 44 samples (97.7 percent). In the recreational period, the river's total coliform density exceeded 1,000 per 100 ml in 179 of 180 samples (99.4 percent). Figure 3 shows the average total coliform densities as plotted against river mile of the Ohio River. The bar graph shows that every sampling station downstream from the Allegheny County Sanitation Authority treatment plant to river mile 16 had average coliform densities in excess of 100,000 per ml. These densities exceed Pennsylvania's water supply criterion by twenty-fold and the recreational criterion by a hundredfold. The river at one station (river mile 6.7), had an average total coliform density of over 600,000 per 100 ml or 600 times the approved bacterial criterion for recreation in Pennsylvania.

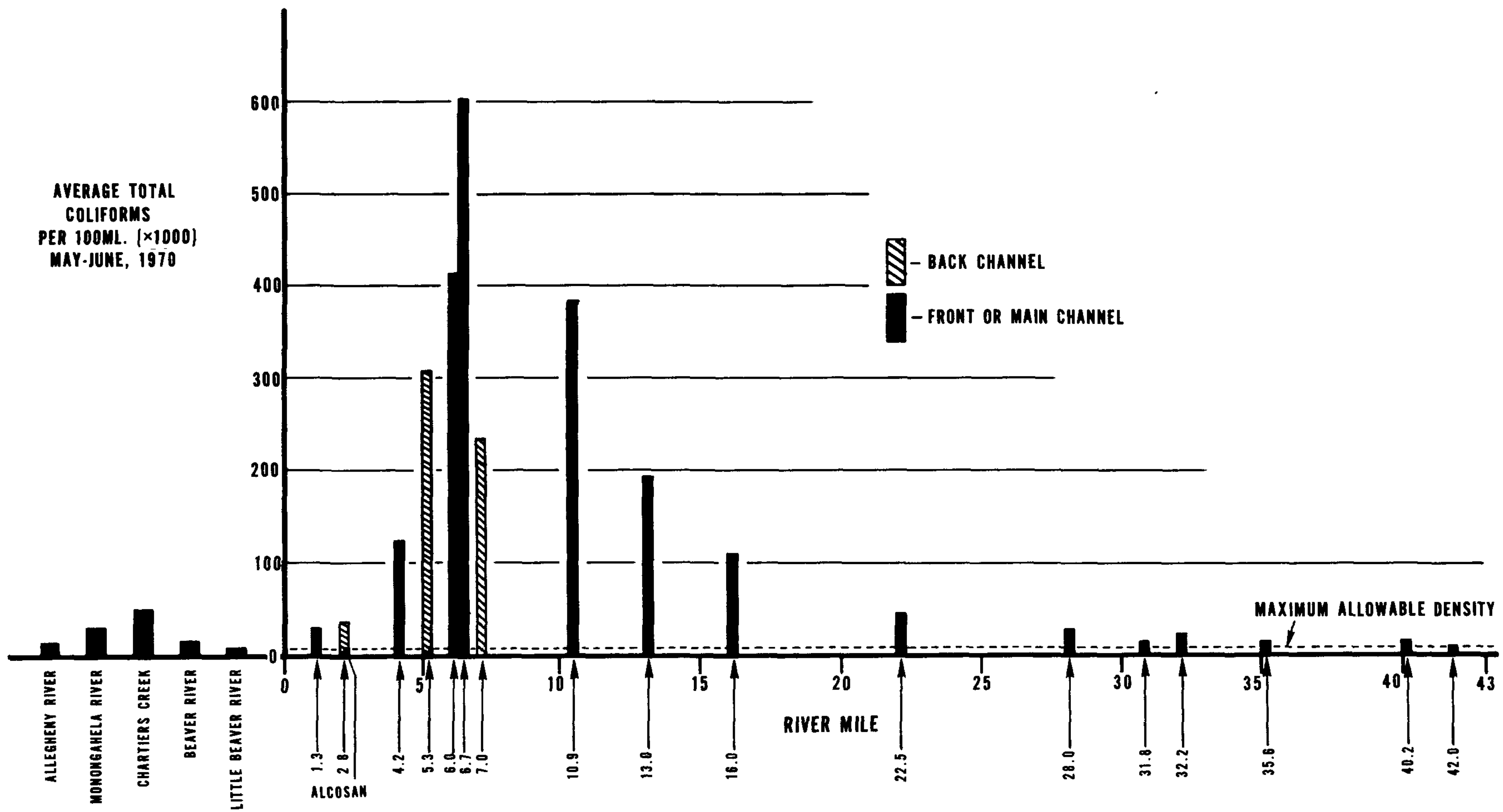


FIGURE 3 SPECIAL STUDY-FWQA-OHIO RIVER/MAY-JUNE, 1970

The bacterial pollution of the Ohio River in Pennsylvania persisted to the State line. The river at this point had total coliform densities that exceeded West Virginia's bacterial criterion in all samples, Ohio's bacterial criterion for water supply in 11 of 15 samples, and Ohio's bacterial criterion for recreation in all samples.

Salmonella Bacteria

To emphasize the sanitary significance of the indicator bacteria, a pathogen study was made at selected sampling points during the 1970 survey. While coliform densities indicate the magnitude of fecal pollution which may contain disease-producing organisms, detection of pathogenic *Salmonella* bacteria in water is positive proof that these disease-producing bacteria are actually present.

Modified Moore swab samples were studied for *Salmonella* at the following stations:

River Mile	Description
0.5	Allegheny River at Sixth Street Bridge
0.8	Monongahela River at Smithfield Street Bridge
3.0	Beaver River at Route 18 Bridge
4.2	Ohio River at Bellevue, Pennsylvania
16.0	Ohio River at South Heights, Pennsylvania
40.2	Ohio River at Pennsylvania State Line

Salmonella, an enteric pathogen, was isolated from all these sampling stations, proving the existence of a health hazard.

OXYGEN DEMAND AND DISSOLVED OXYGEN

Domestic sewage and industrial wastes contain organic matter that decomposes and exerts an oxygen demand on receiving waters; this demand subsequently reduces the dissolved oxygen content of receiving streams unless replenished by the atmosphere or photosynthesis. When the oxygen demand exceeds the natural re-oxygenation rate of a stream, the dissolved oxygen content of the stream can be depleted below the level necessary to support fish and other aquatic organisms.

ORSANCO's continuous monitoring of the Ohio River water at South Heights, Pennsylvania, provides an hourly analysis of the dissolved oxygen content in the river for 1966, 1967, 1968 and 1969. ORSANCO reported for these years the percent of days when the daily minimum dissolved oxygen (i. e., hourly value) did not go below 4.0 mg/l as 83.5 percent, 91.0 percent, 92.0 percent and 95 percent, respectively. In essence, this means that for 60 days in 1966, 33 days in 1967, 29 days in 1968 and 18 days in 1969, the minimum hourly dissolved oxygen content of the Ohio River was below 4.0 mg/l, Pennsylvania's dissolved oxygen criterion. The data for 1966 are not complete in that the monitor was inoperative for most of the time during the critical months of July, September and October. ORSANCO's October report for 1969 indicates that the dissolved oxygen content of the river at South Heights had a minimum of 2.2 mg/l and a minimum daily average of 2.6 mg/l. The ORSANCO report also states that the criterion was met only 68 percent of the month.

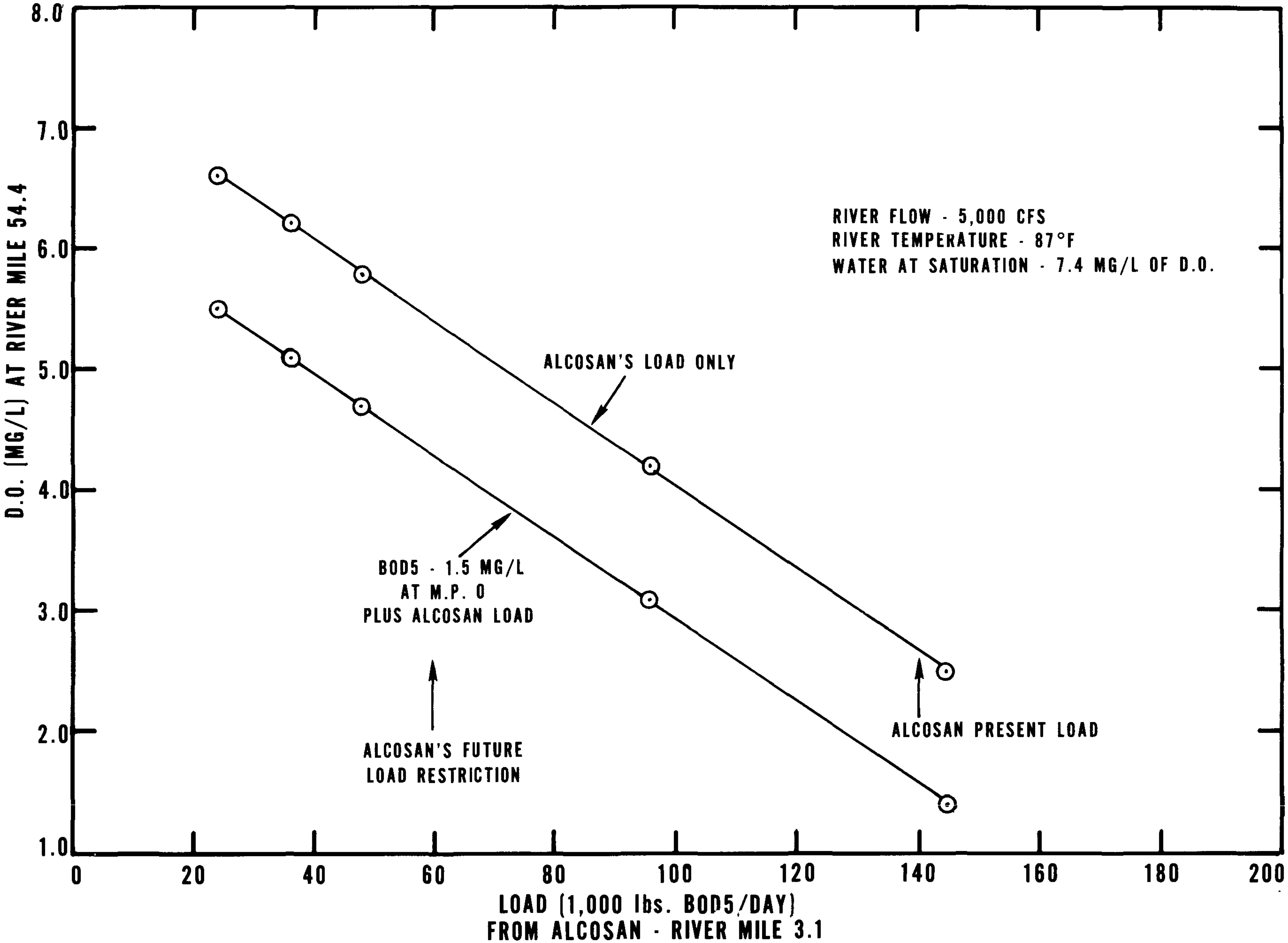
ORSANCO has developed a D.O.-BOD mathematical model for the Ohio River in the Pittsburgh area.[15] The model projects a dissolved oxygen content of 2.7 mg/l at river mile 54.4, based upon ALCOSAN's present loading of 140,000 lb/day of BOD_5, a river temperature of 87° F., and a critical flow of 5,000 cfs.(Figure 4). If it were assumed that the BOD_5 at river mile 0 were 1.5 mg/l, a figure that approximates the average BOD in the Monongahela and Allegheny Rivers, then the dissolved oxygen content at river mile 54.4 would drop to 1.6 mg/l. These projections neglect all other municipal and industrial organic loads to the Ohio River in Pennsylvania.

The State of Pennsylvania has restricted ALCOSAN's total load to the Ohio River at 60,000 lb/day of BOD_5 (i.e., 70 percent reduction of present raw waste load) upon completion of secondary treatment. According to the D.O.-BOD model, this load would reduce the dissolved oxygen of the river at river mile 54.4 to 4.3 mg/l, when the loads of the Monongahela and Allegheny Rivers are included, but other sources are neglected. It may be deduced from the ORSANCO model that the loadings from municipal and industrial sources will reduce the dissolved oxygen content of the river at river mile 54.4 below acceptable criteria with ALCOSAN discharging 60,000 lb/day of BOD_5.

PHENOLS

Phenolic materials have plagued municipal water users of the Ohio River for years. Chlorination of finished water containing excessive phenols imparts a medicinal taste and odor to the water. Experience has shown that phenolic concentrations in the Ohio and Monongahela Rivers are at a maximum in the winter months when the biological

FIGURE 4
ORSANCO'S DO-BOD MODEL



degradation is retarded by cold water temperatures. The following data, from the University of Pittsburgh study in 1964-1965, illustrates the phenolic problem in this area, especially during the winter months:

River	River Mile	Phenolic Concentration (parts per billion)			
		Minimum	Maximum	Average	Average (Dec-Apr)
Monongahela	43.3	0	10	2	1
Youghiogheny	35.5	0	9	2	2
Monongahela	0.8	0	127	23	45
Allegheny	0.6	0	16	2	3
Ohio	25.2	0	46	10	21

The data shows that phenolic concentrations were minimal at river mile 43.3 on the Monongahela River and river mile 35.5 on the Youghiogheny River but greatly increased as the Monongahela River approached the Point in Pittsburgh. The data also showed that the average phenolic concentrations during the winter months were about double the yearly average for the Monongahela River station at river mile 0.8 and the Ohio River at river mile 25.2. Although the University of Pittsburgh study was carried out several years ago, the data serves to show the changes of phenolic concentrations in the river systems in the Pittsburgh area.

More recent data gathered by the U. S. Environmental Protection Agency's Pollution Surveillance, as shown in Table 12, illustrates the violations of Pennsylvania's phenolic criterion of 0.005 mg/l for the Ohio and Monongahela Rivers. The Monongahela River at river

TABLE 12

U. S. ENVIRONMENTAL PROTECTION AGENCY
Phenol Concentration - Monthly Sample
(mg/l)

	Allegheny River	Monongahela River	Ohio River	Beaver River	Ohio River
River Mile	0.5	0.8	16.0	3.0	40.2
Date					
June, 1968	.002	.002	.001	-	.003
July	.000	.000	.000	-	.000
August	.000	.003	.001	-	.004
September	.004	.001	.003	.001	.004
October	.003	.004	.000	.005	.001
November	.003	.046	.006	-	.006
December	.000	.045	.009	.007	.006
January, 1969	.056	.056	.009	.009	.010
February	.027	.027	.026	.026	.021
March	.063	.063	.024	.024	.007
April	.013	.013	.010	.010	-
May	.010	.010	.000	.000	.010
June	.001	.001	.002	.002	.004
July	.000	.000	.003	.003	.004
August	.003	.003	.004	.004	.009
September	.000	.000	.000	.000	.003
October	.003	.003	.003	.003	.003
November	.016	.016	.003	.003	.003
December	.030	.030	0.13	0.13	.005
January, 1970	.004	.049	.026	.026	.060
February	.010	.056	.026	.026	.013
March	.005	.004	.000	.000	.009
April	.003	.014	.004	.004	.006
May	.001	.000	.001	.001	.000
June	.010	.009	.001	.001	.000
July	.000	.000	.000	.000	.000
October	.001	.004	.000	.000	.005
November	.004	.007	.005	.009	.009
December	.005	.013	.003	.014	.011
January, 1971	.005	.020	.022	.008	.017
March	.005	.009	.003	.029	.016
April	.002	.022	.009	.004	.007
May	.005	.006	.005	.006	.007
June	.000	-	.003	.003	-
July	-	-			-
Average	.009	.016	.007	.008	.008
Average (Dec.-April)	.021	.034	.013	.014	.016

mile 0.8 had a maximum phenolic concentration of 0.063 mg/l and an average winter concentration of phenols of 0.034 mg/l for the period of record. The Ohio River at the State line had a maximum concentration of 0.060 mg/l of phenols and an average winter concentration of 0.016 mg/l of phenols. The Ohio River at this point consistently exceeded the phenolic criteria of the States of West Virginia and Ohio (i.e., 0.001 and 0.005 mg/l respectively), especially in the winter months. The special study in the warm months of May and June, 1970 showed low phenolic concentrations at most sampling stations.

OIL POLLUTION

Oil pollution is the most visible form of pollution in the Ohio and Monongahela Rivers in this area. Surface oil destroys the aesthetic value of the river and restricts its use for recreation. Most of the complaints lodged by citizens to the U. S. Environmental Protection Agency about this area are in reference to floating surface oils. Oils also coalesce with natural sediment and other suspended material to form bottom deposits that are toxic to bottom animals, thus restricting the use of the river for aquatic life.

During the special study in May and June, 1970, biologists reported that masses of oil were being discharged from the Jones and Laughlin Steel Corporation plant at Aliquippa (river mile 16.9) and from the Crucible Steel Corporation plant at Midland (river mile 36.3).[11] These oils were traced to the State line and were still evident three miles downstream from the State line. Comparison of surface oils, at the State line to the oil below the Jones and Laughlin plant by infra-red spectroscopy showed the oils to be almost identical. Oil from the Crucible Steel plant, which discharges a water-oil emulsion, was not detected below the State line on the surface.

The biologists also collected sediment samples which were analyzed for oil. Sediment oil concentrations (Table 13) ranged from 1 to 12 times greater than concentrations reported in the literature to be toxic to bottom animals.[16] Only pollution-tolerant sludgeworms were found living in the sediments, and their low number indicated toxic conditions. Oil concentrations in the sediment were as high as 21,200 parts per million. Comparison of sediment oils near the Crucible Steel plant (river mile 36.5) and at the State line (river mile 40.2) to the water-oil emulsions present at the surface near the Crucible plant's outfall by infra-red spectroscopy showed that "all three samples may have originated from the same source."[17]

HEAT POLLUTION AND TEMPERATURE

Heated discharges to a river are a form of pollution when increased river temperatures adversely affect aquatic life and the ability of a stream to assimilate treated organic wastes. High water temperatures reduce the oxygen content of a stream by reducing the dissolved oxygen saturation concentration and by increasing the rate of biochemical oxidation of organic waste.

Chemical Analyses of Bottom Sediments
of Ohio River, May 1970

River Mile	Left Shore Samples Carbon mg/gm Sediment*	Left Shore Samples Nitrogen mg/gm Sediment*	Left Shore Samples Oil mg/gm Sediment*	Right Shore Samples Carbon mg/gm Sediment*	Right Shore Samples Nitrogen mg/gm Sediment *	Right Shore Samples Oil mg/gm Sediment
4.0	59.0	1.6	6.3	-	-	-
7.0	12.0	0.6	0.8	-	-	-
9.0**	80.0	2.5	3.1	-	-	-
10.8	90.0	2.5	7.7	89.0	2.5	6.2
13.0	-	-	-	76.0	3.6	12.5
18.9	69.0	3.1	10.1	-	-	-
22.5	80.0	2.7	10.3	-	-	-
28.0	96.0	2.9	6.6	17.0	0.6	1.4
31.0	82.0	2.8	20.4	-	-	-
33.0	-	-	-	10.0	0.5	0.8
36.5	51.0	1.2	1.9	99.0	3.8	21.2
37.5	-	-	-	94.0	2.8	10.3
40.2	123.0	1.9	4.2	59.0	2.5	8.1
43.3	51.0	1.6	5.1	71.0	1.8	4.7
Tributaries						
Monongahela R. (M-0.9)	74.0	2.1	10.0	66.0	2.5	10.5
Chartiers Creek (2.4-0.3)	44.0	3.1	7.7			
Beaver R. (25.5-0.5)	69.0	2.3	13.5			
Little Beaver R. (39.5-0.2)	45.0	3.1	1.9			

* Dry Weight
** Back channel of Neville Island
\- No Sample, Bottom Scoured of Sediments

Total industrial water use of the Ohio and Monongahela Rivers in this area exceeds 6.3 billion gallons per day, of which approximately three-fourths is used for once-through cooling water for thermal electric power generation. Cooling water for three major iron and steel producers could account for an additional 15 percent of the total water use. Present projections show that thermal electric power capacity will double every 10 years on the national average. In this reach of the Ohio River in Pennsylvania, this duplication of capacity is expected to occur in the next five years.[18] This alarming increase of thermal power capacity poses a threat to water quality in the Ohio River. These waters cannot accept heated waste waters without quality degradation and sacrifices of beneficial uses.

Although current detailed temperature data for these reaches of the Ohio and Monongahela Rivers are limited to a few sources, they indicate that a problem exists now. The University of Pittsburgh study reported a 5.4° F rise in the annual mean temperature of the Ohio River at Ambridge in water year 1965 as compared to U. S. Geological Survey records for 1944-1951. The study also revealed that the Monongahela River at Belle Vernon had an average temperature of 78.0° F during August, 1965, and a maximum temperature of 82.4° F. During this same month, the Monongahela River station at Pittsburgh had an average temperature of 87.8° F and a maximum temperature of 91.4° F. EPA's Pollution Surveillance data also shows the Monongahela River at Pittsburgh reached a temperature of 91.4° F during the same month.

ORSANCO's continuous monitor at South Heights has detected a maximum temperature of 85.8° F in August, 1968; EPA's data shows a maximum of 86.0° F at this station during the same month. Another monitor at Stratton, Ohio showed the highest temperature recorded (87.9° F) in the entire Ohio River in 1968. The monitor is located 14 miles downstream from the Pennsylvania State line, and there are no major heat sources in this reach.

IRON

Iron is relatively insoluble in the presence of oxygen at the pH ranges common to these sections of the Ohio and Monongahela Rivers. Dissolved iron discharged into the river would tend to flocculate as ferric hydroxide. Eventually, the ferric hydroxide will settle to coat exposed surfaces and to form sludge deposits that destroy aquatic life. During high flows, scouring action will re-suspend much of the iron from the bottom.

In addition to ferric hydroxide, many steel plants and metal processing plants discharge insoluble iron oxides in their wastewaters. These oxides usually settle to form sludge deposits near the discharge point. Iron oxides, however, are also re-suspended by high river velocities and are subsequently deposited far from the original point of discharge.

For many years, it was thought that high iron concentrations in the upper Ohio River were the result of acid mine drainage in the Allegheny and Monongahela River basins. A study sponsored by ORSANCO on the upper Ohio River during and immediately after the extended steel shut-down in 1959 showed that "dissolved iron concentrations at most stations during the shut-down averaged 0.1 ppm (parts per million); after start-up of the mills, concentrations were two to seven times that value."[19] Therefore, iron in the upper Ohio River Basin is not solely due to acid mine drainage.

The Commonwealth of Pennsylvania has set a total iron criterion for the Ohio and Monongahela Rivers of 1.5 mg/l. Figure 5 is a plot of the average monthly total iron concentrations and river flows for the Ohio River at Rochester in the 1964-65 period. Pennsylvania's criterion was violated on the average for all months from December through April. The correlation between iron concentration and river flows is probably due to the re-suspension of deposited iron from the river bed.

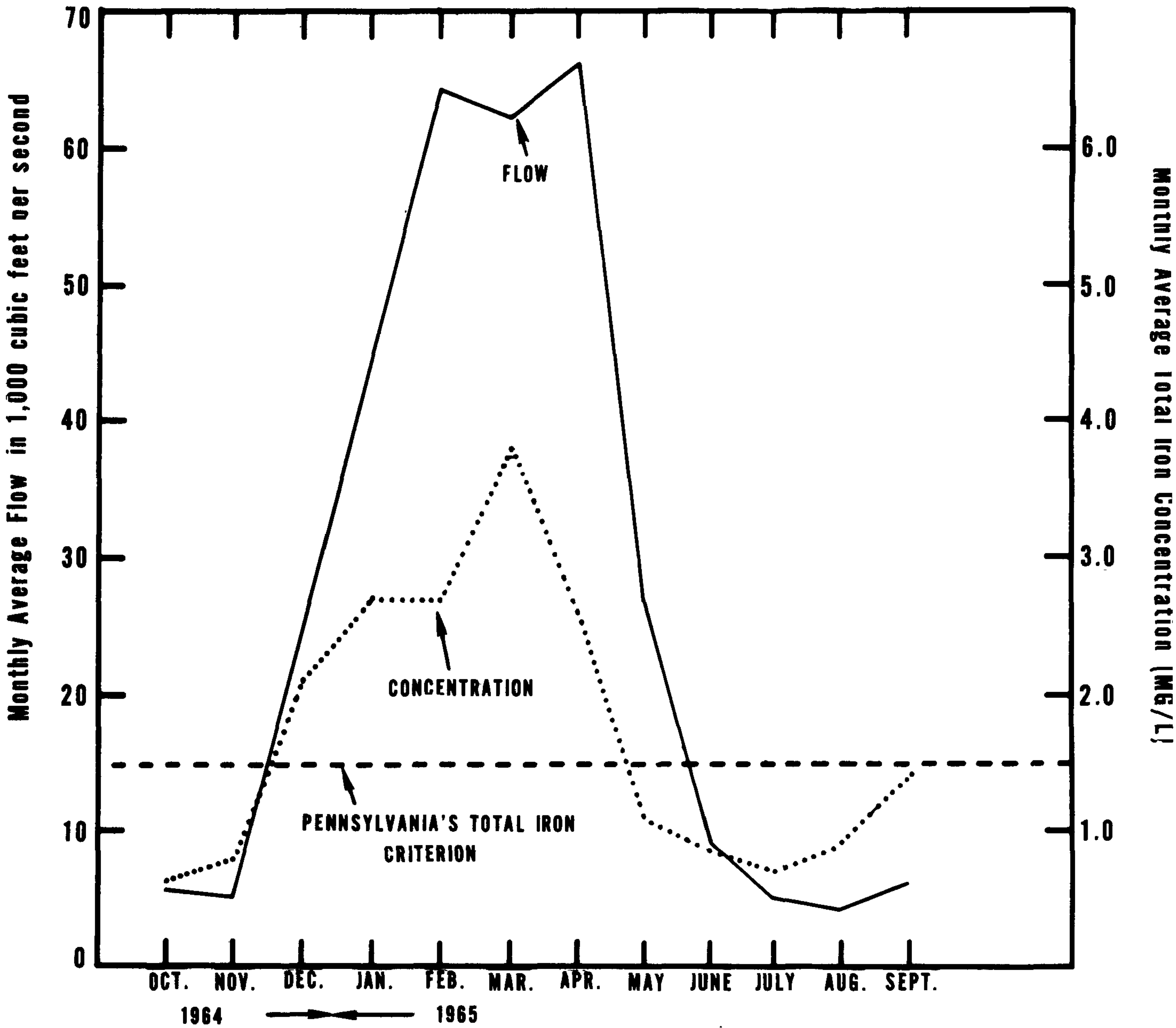
EPA's Pollution Surveillance data on iron concentration showed the following since June, 1968:

		Total Iron Concentration (mg/l)		
River	River Mile	Minimum	Maximum	Average
Monongahela	0.8	0.1	2.6	1.1
Allegheny	0.5	0.1	2.7	1.0
Ohio	16.0	0.1	3.7	0.9
Ohio	40.0	0.2	5.8	1.3

Of particular importance is the fact that the maximum and average total iron concentrations actually increase rather than decrease as the river approaches the State line. This increase results from the addition of large amounts of iron to the Ohio River in this area.

FIGURE 5

OHIO RIVER AT ROCHESTER, PENNSYLVANIA



SLUDGE DEPOSITS

Sludge deposits on a stream bottom are indicative of either inadequately treated municipal or industrial wastes or a combination of both. Sludge deposits, apart from aesthetic considerations, restrict the development of a desirable fauna in a stream.

The biological study of the Ohio River in May and June, 1970 showed that bottom sediments in this area contained toxic concentrations of oil and concentrations of organic carbon and nitrogen typical of organic sludge originating from inadequately treated sewage waste water (Figure 6). The reported concentrations of organic carbon and nitrogen in the sediments and the absence of strong odors of decomposition indicated that these sludges were not undergoing active decomposition. Toxic concentrations of oil in the sediment inhibited the development of a benthic fauna conducive to the biological decomposition of nitrogenous wastes. Specific effects of sludge deposits are included in the discussion of BOTTOM SEDIMENTS AND ORGANISMS section of this report titled EFFECTS OF POLLUTION ON AQUATIC LIFE.

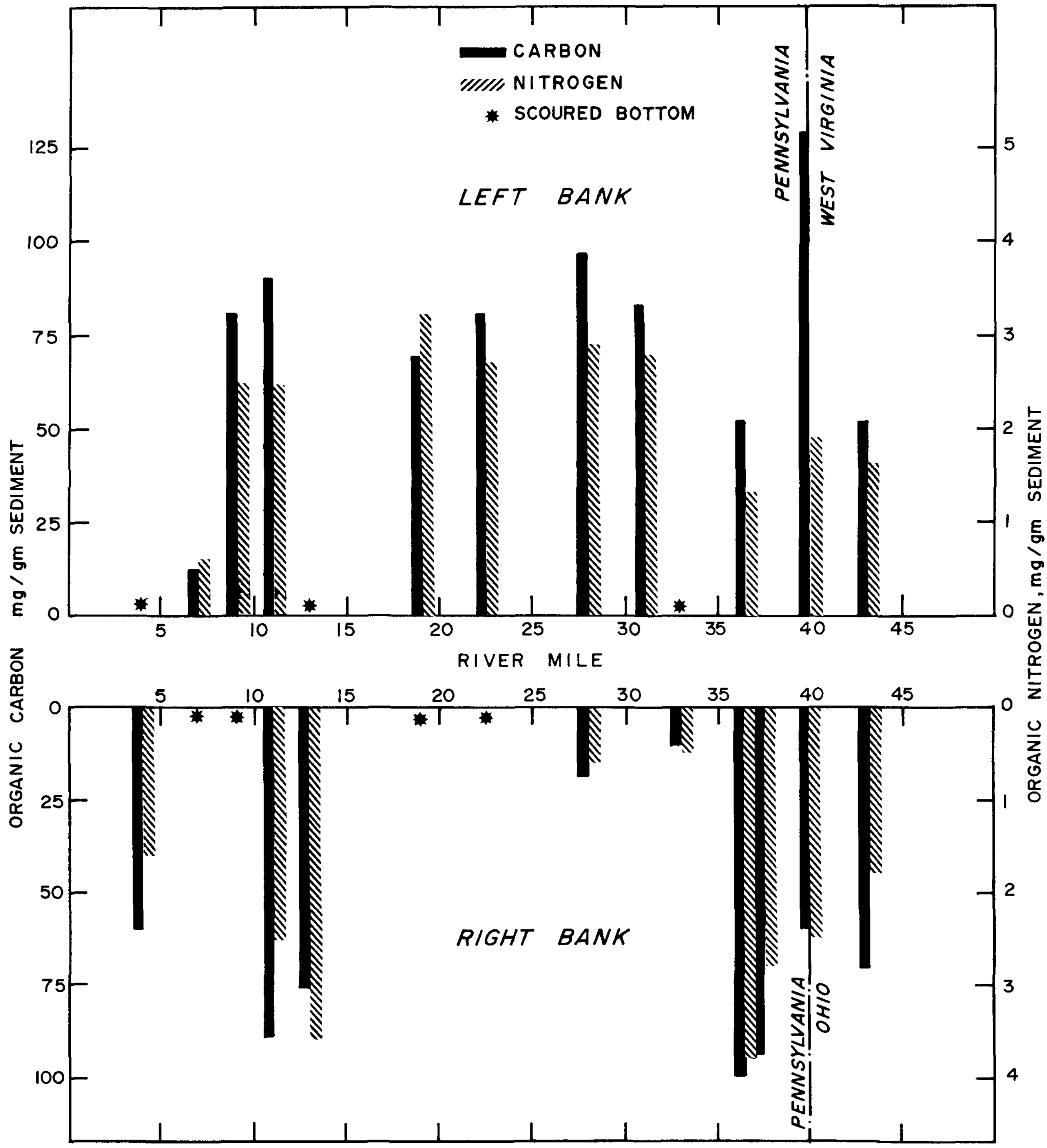


FIGURE 6 - ORGANIC CARBON AND NITROGEN CONTENT OF SEDIMENT SAMPLES FROM OHIO RIVER, PITTSBURGH, PA. DOWNSTREAM TO E. LIVERPOOL OHIO, MAY 1970.

EFFECTS OF POLLUTION ON AQUATIC LIFE

EPA conducted a biological survey of the Ohio River in Pennsylvania in May and June 1970 to identify the effects of pollutants on aquatic life. Six major areas of concern were investigated: algae, attached growths, nutrients, bottom organisms and substrate, fish life and fish flesh tainting. Analysis of each of these areas can reflect the impact of pollution on the aquatic environment. The suspended algae, or phytoplankton, are important because they are part of the basis of the food-chain that ends with fish; they add oxygen to the water through the process of photosynthesis; they remove oxygen from the water through the process of respiration; and if super-abundant, they may create nuisances and impart objectionable taste and odors to water supplies. The attached growths of microorganisms perform the same environmental roles as the suspended algae, but they "monitor" the continuing changes in quality of the overpassing water. Nutrients in water are important when they support super-abundant plant life, so it is necessary to study the availability of nutrients. The community of bottom organisms is part of the vital link between algae and fish in the food chain. The composition of these communities is an excellent indicator of water quality conditions. The composition of the substrate strongly affects these communities. The substrate is also the place where fishes deposit their delicate eggs to incubate. Fish are the top of the food pyramid in the aquatic ecosystem. The species, number and quality of fishes that inhabit a stream reflect the water quality of that body of water. Waste water effluents have been known to taint flavors of fish flesh. To identify such waste sources, fish with acceptable flavor were exposed upstream and downstream from suspected sources. Such a test procedure shows the direct influence of pollution.

SUSPENDED ALGAE

According to historical data, the upper Ohio River does not support algae populations typical of rivers with similar characteristics. Pollution sensitive algae occurred rarely; the populations were predominantly pollution-tolerant. Occasionally samples had no algae, indicating toxic conditions.

Samples collected in May 1970 contained very low numbers of algae, ranging from 162 to 643 cells per milliliter. The number of algal cells and the quantity of chlorophyll both increased downstream, indicating an increase in the viability and photosynthesis potential of the algae.

Water samples collected in May 1970 were bio-assayed to determine their potential for algal growth. Only five of 22 samples sustained algal growth for the duration of the 17-day test.[20] Eleven samples supported short term growth, but growth was stimulated and sustained by addition (at seventh day) of nitrogen and phosphorus. Six of the samples were toxic to the inoculated algae. Results of the assays are summarized in Figure 7. Waters from the Allegheny and Monongahela Rivers were toxic to the test algae. Toxicity to

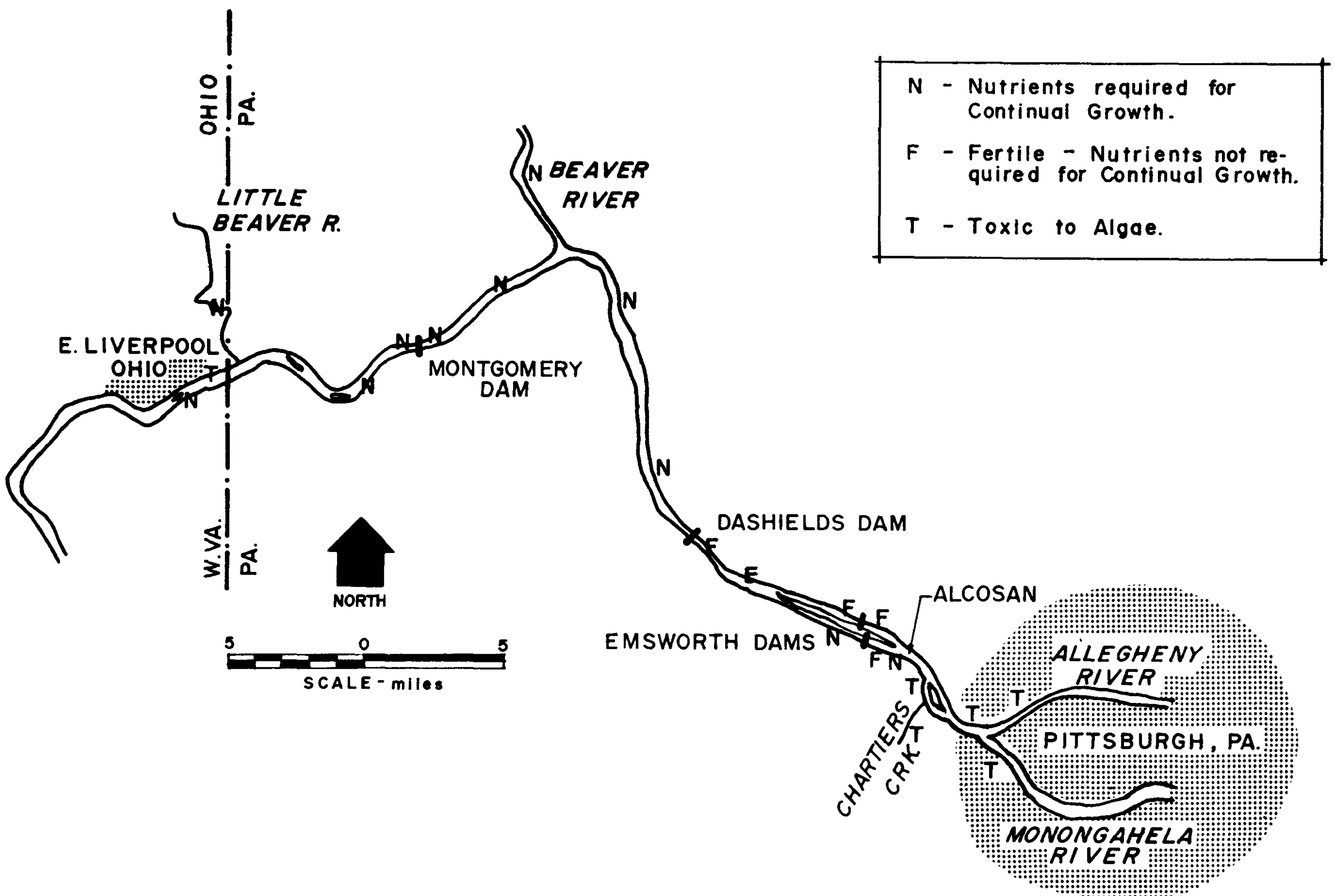


FIGURE 7 - SUMMARY OF ALGAL RESPONSES IN BIO-ASSAYS, OHIO RIVER, JUNE, 1970

algae persisted in the Ohio River downstream of the confluence. Downstream from the Allegheny Sanitary Authority discharge, the waters were not toxic to the the test algae, and contained sufficient nutrients to stimulate the growth of algae for the 17-day test period. Downstream from Dashields Dam, the river waters were short of nutrients for algal growth with the exception of the water sample from the West Virginia-Pennsylvania State line which was toxic to the test algae. This sample contained large quantities of oil and emulsifiers which can be toxic to aquatic life.

ATTACHED GROWTHS

Attached growths collected during this study reflected conditions from mid-May to mid-June. These growths were predominantly the more pollution-tolerant blue-green algae at most of the sampling stations (Figure 8).

Downstream of the ALCOSAN waste effluent, there was a reduction in both the number of cells and number of kinds of attached growths. Protozoa, which thrive where there is an abundance of bacteria and microscopic sewage particles, made up a significant part of the population.

As the decomposing organic material released nutrients, the attached forms responded with an increase in numbers and chlorophyll content (Figures 9 and 10). Further downstream, the data are similar to those observed upstream of the organic source. This indicated that the effects of the organic discharge were no longer manifested

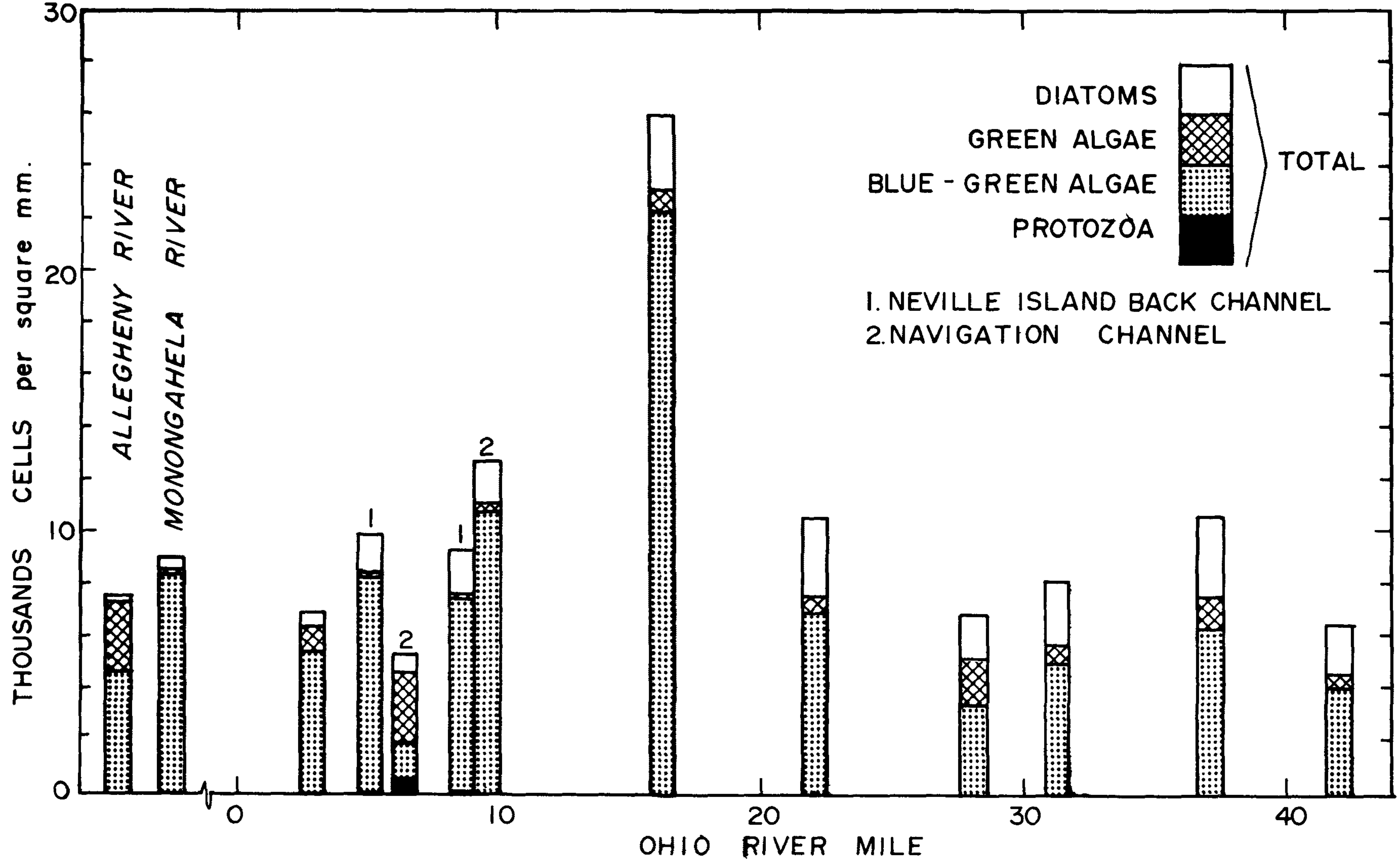


FIGURE 8 - NUMBERS AND COMPOSITION OF ATTACHED GROWTHS, OHIO RIVER. MAY-JUNE, 1970

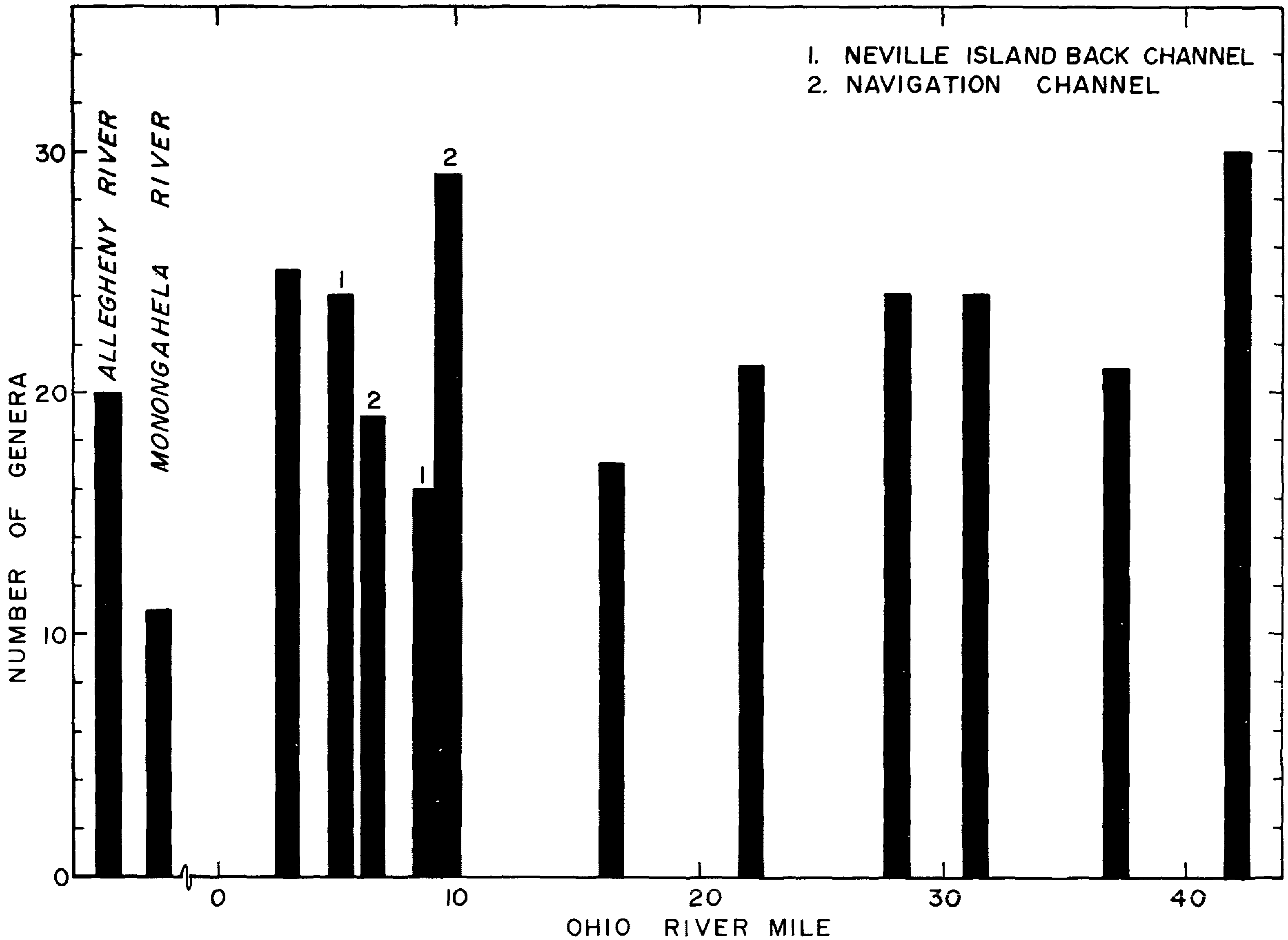


FIGURE 9 - NUMBER OF KINDS OF ORGANISMS IN ATTACHED GROWTH COMMUNITIES, OHIO RIVER, MAY-JUNE, 1970

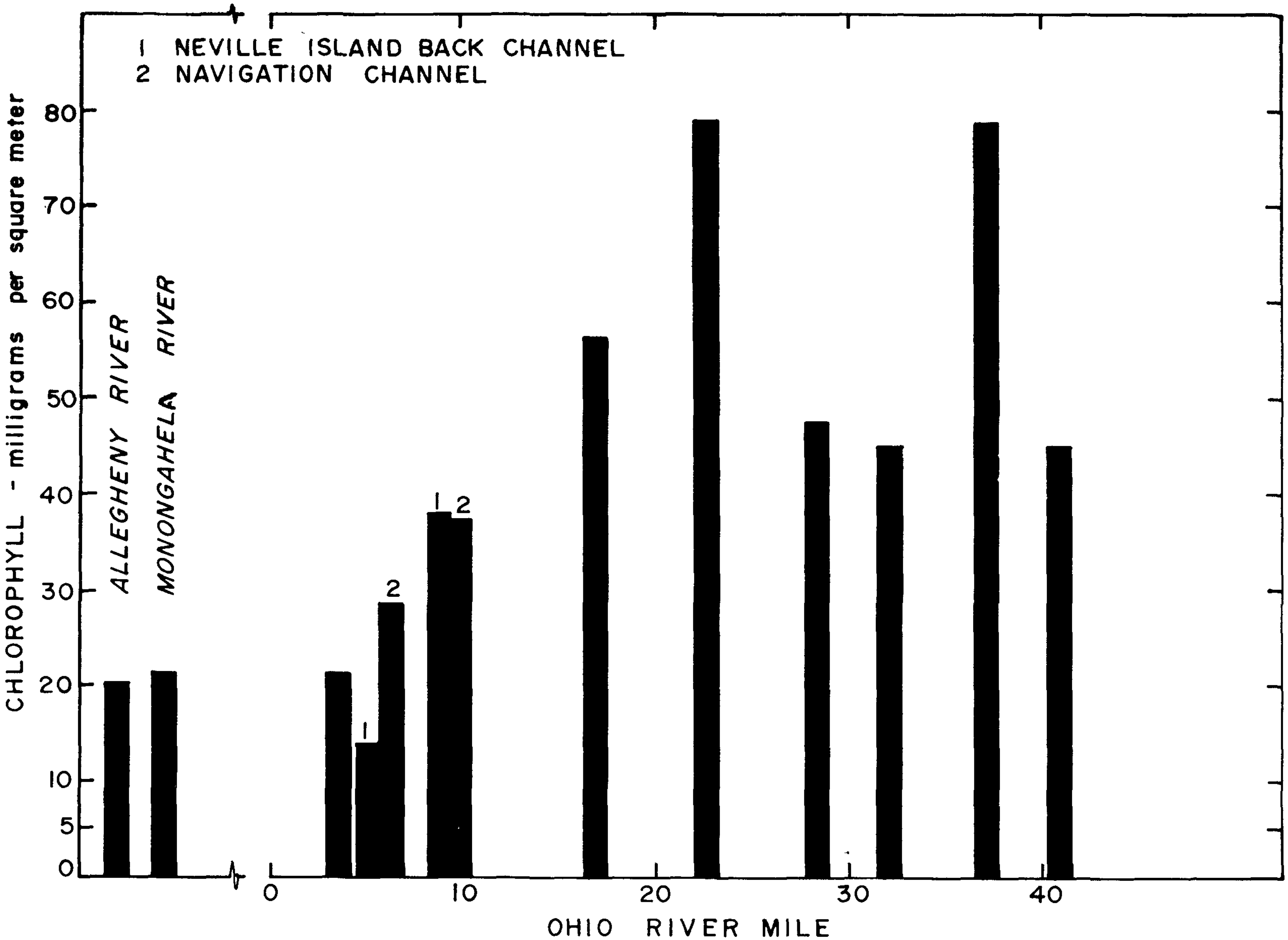


FIGURE 10 - QUANTITY OF CHLOROPHYLL IN ATTACHED GROWTH COMMUNITIES, OHIO RIVER, MAY-JUNE, 1970

or were masked by other discharges.

NUTRIENTS

According to historical data, excessive quantities of iron in and added to the upper Ohio River may be reducing the availability of phosphorus for algal growths. Iron tends to precipitate at the confluence of the Monongahela and Allegheny Rivers. The precipitating iron can either react with or absorb phosphate ions or phosphorus. The reactions are the cause for the shortage of nutrients observed in the algal bio-assays. Nitrogen would not be a limiting nutrient since there is usually an abundance of inorganic nitrogenous compounds.

BOTTOM SEDIMENTS AND ORGANISMS

Bottom sediments in the study area contained toxic concentrations of oil. Concentrations of organic carbon and nitrogen in the sludge were typical of organic sludge originating from inadequately treated sewage wastewater. Concentrations of organic carbon and nitrogen in bottom sediments increased from river mile 3.1 downstream to at least river mile 43.0 (Figure 6 on page 71).

The reported concentrations of organic carbon and nitrogen in the sediments and the absence of strong odors of decomposition indicate that these sludges were not undergoing active decomposition. Toxic concentrations of oil in the sediment inhibited the development of a benthic fauna conducive to the biological decomposition of nitrogenous wastes. Only pollution-tolerant sludgeworms were found living in the sediments, and their low numbers indicated conditions of toxicity. Figure 11 illustrates the locations of the benthic sampling points, and Table 14 lists the bottom fauna composition.

In addition to the direct quantitative bottom sampling, artificial rock substrates[21] were installed for a four-week period in May and June. These artificial substrates were suspended off the bottom and provided a habitat for colonization by bottom animals that was not affected by variations in sediment or bottom materials. Figure 12 and Table 15 summarize the populations of animals found inhabiting these baskets. With the exception of sludgworms, the samples generally contained few organisms. Pollution-sensitive animals were only rarely found. The low number of kinds and the low populations at most sampling points suggest the presence of toxic materials. Though ALCOSAN discharges organic materials at mile point 3.2, animals that would increase their population because of the increased food supply were found in low numbers indicating the presence of toxic materials. At three points, the baskets contained large numbers of organisms (Figure 12); these were primarily worms. Each of these areas are below significant sources of iron-bearing waste waters. Precipitation of iron on the rocks or the growth of filamentous iron bacteria would provide soft materials on the rocks and in the crevices. These soft materials provided a more suitable substrate than rocks for the burrowing pollution-tolerant worms.

FISH POPULATIONS

The number of kinds of fish inhabiting waters are an indication

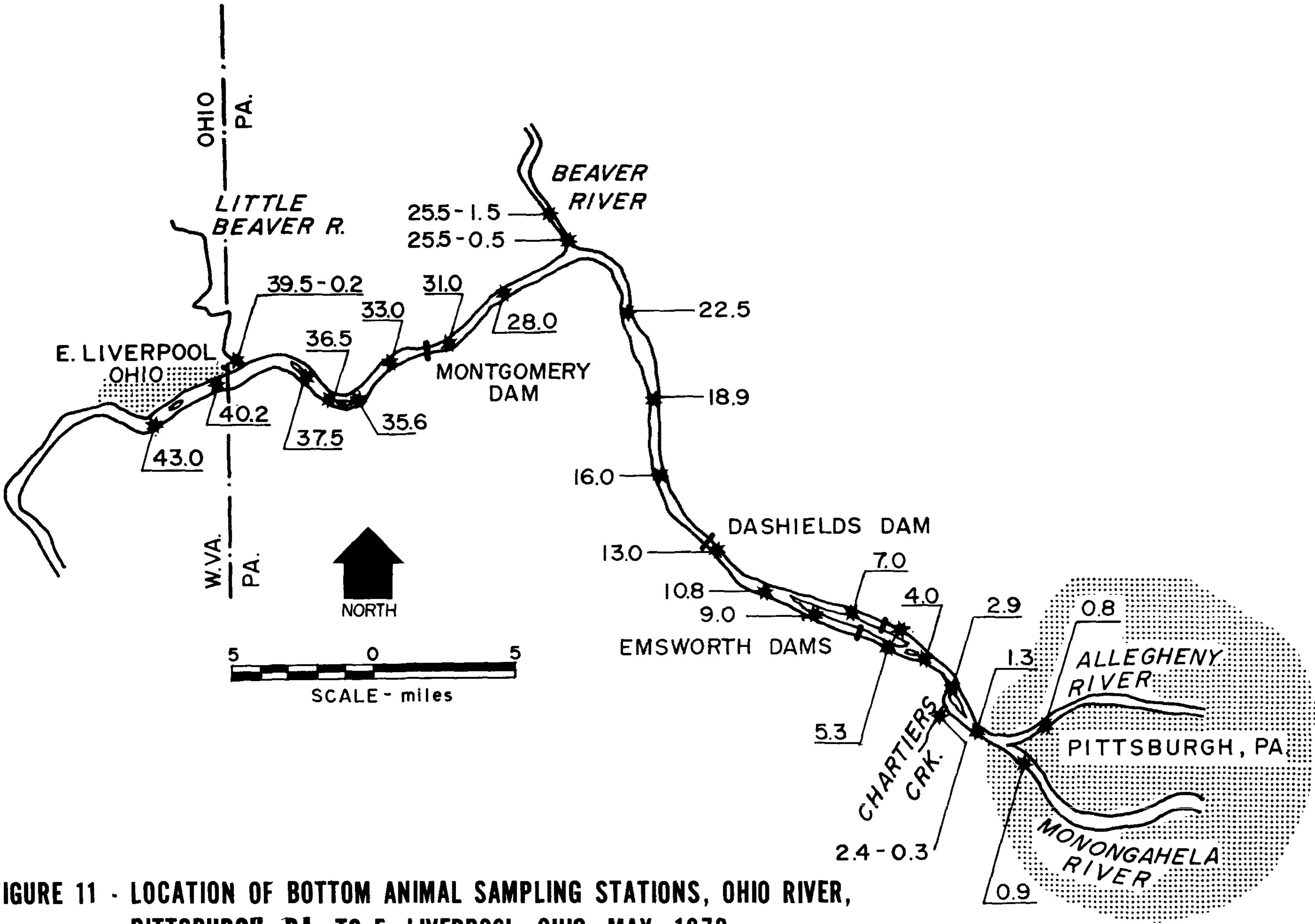


FIGURE 11 - LOCATION OF BOTTOM ANIMAL SAMPLING STATIONS, OHIO RIVER, PITTSBURGH, PA. TO E. LIVERPOOL, OHIO, MAY, 1970

TABLE 14

Bottom organisms collected from Ohio River

from Pittsburgh, Pennsylvania, downstream to

East Liverpool, Ohio, May 1970

Stations (River Miles)

Kinds of Organisms	1.3		2.9		4.0		5.3**		5.3		7.0		9.0**	10.8		13.0	16.0		18.9	22.5		28.0		31.0	
	L	R	L*	R*	L	R*	L	R	R	L	R	L	R	L	R	R	L*	R*	L	L	R*	L	R	L	R
Midges Spaniotoma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scuds Gammarus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crane Flies Tipulidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phantom Midges Chaoborus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leeches Hirunidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludgeworms Tubificidae	2	14	-	-	5	-	-	10	-	-	18	-	18	-	-	5	-	-	-	-	-	48	5	2	-
Subtotal/ oz. ft.	2	14	0	0	5	0	0	10	0	0	18	0	18	0	0	5	0	0	0	0	0	48	5	2	0
Subtotal/ Kinds	1	1	0	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	1	0

* River bottom scoured.

** Back channel

TABLE 14 (cont.)

Kinds of Organisms	33.0		35.6	36.5	37.5	40.2		43.3		Chartiers Creek	Beaver River		Little Beaver River	Allegheny River 0.8		Monongahela River 0.9	
	L*	R	L	R	R	L	R	L	R	2.4-0.3	25.5-0.5	25.5-1.5	39.5-0.2	L*	R	L	R
Midges Spaniotoma	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Scuds Gammarus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
Crane Flies Tipulidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phantom Midges Chaoborus	-	-	-	-	-	-	-	-	-	4	-	2	-	-	-	-	-
Leeches Hirunidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Sludgeworms Tubificidae	-	73	27	9	-	-	15	20	7	8	-	12	3	-	165	2	26
Subtotal/ oz. ft.	0	73	27	9	0	0	15	20	7	16	0	14	3	-	177	2	26
Subtotal/ Kinds	0	1	1	1	0	0	1	1	1	3	0	2	1	0	3	1	1

* River bottom scoured.

** Back channel

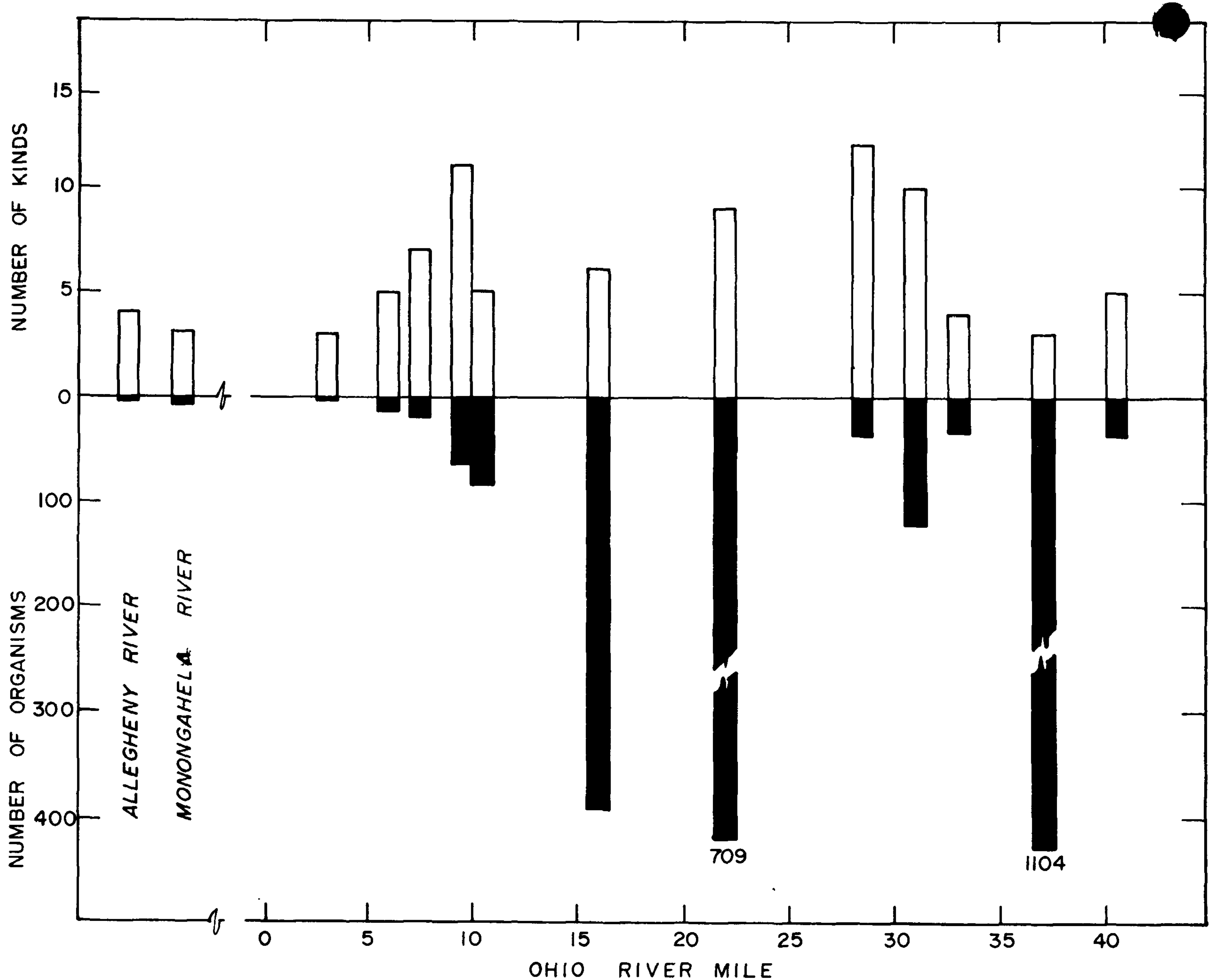


FIGURE 12 - BOTTOM ANIMALS COLLECTED IN ROCK BASKET SAMPLERS, UPPER OHIO RIVER, MAY-JUNE, 1970.

Table 15. Summary of Bottom Animals Collected from

Basket Samplers--Upper Ohio River

May-June, 1970

No./Basket

River Mile -	A*-6.7	M*-11.2	O 3.1	5.3	6.2	9.1	9.1	16.7	22.3	28.0	31.7	34.7	37.0	40.2
ORGANISM:														
Diptera (True Flies)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomidae (Midges) pupae	-	-	-	-	-	5	-	2	6	1	6	1	16	-
Chironomidae larvae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ablabesmyia mallochi	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Conchapelopia	-	-	-	1	-	-	-	-	2	-	1	-	-	-
Psectrocladius sp. 3 Rob.	-	-	-	1	-	1	1	4	6	5	-	7	-	8
P. sp. 4 Rob.	-	-	-	-	-	-	-	-	-	-	5	-	-	-
P. flavus gr.	-	-	-	-	-	-	-	-	2	-	1	-	-	-
Cricotopus bicinctus gr.	1	-	-	-	-	-	-	26	8	2	23	7	88	8
C. junus	-	1	-	-	-	3	-	6	-	2	-	-	-	-
C. trifasciatus gr.	1	-	-	-	1	12	3	-	12	6	2	-	-	-
Diplocladius sp. ?	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Polypedilum sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-
P. scalaenum	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Parachironomus abortivus ?	-	-	-	-	-	2	-	-	-	-	-	-	-	-
P. pectinatellae	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Dicrotendipes nervosus	-	-	-	-	-	1	-	-	-	-	-	-	-	-
D. neomodestus	-	-	-	-	-	-	-	1	-	-	-	-	-	-
D. incurvus gr.	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Ephemeroptera (Mayflies)														
Stenonema integrum	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Plecoptera (Stoneflies)														
Perlesta placida	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Odonata														
Zygoptera (Damselflies)														
Enallagma exsulans	-	2	1	1	3	1	2		1	6	-	-	-	-
Crustacea														
Isopoda (Sowbugs)														
Asellus sp.	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Amphipoda (Scuds)														
Crangonyx sp.	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Decapoda (Crayfish)														
Orconectes sanborni	2	-	1	-	1	-	-	-	-	2	-	1	-	-
Oligochaeta (Segmented Worms)														
Naididae	-	5	1	10	11	35	75	354	670	10	81	16	1000	21
Nematoda (Roundworms)	-	-	-	3	-	1	-	-	-	-	2	-	-	-
Mollusca														
Gastropoda (Snails)														
Physa sp.	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Bryozoa (Moss Animals)														
Fredericella sp.	-	-	-	-	X	-	-	-	-	X	X	-	-	X
Plumatella sp.	-	-	-	-	-	-	-	-	-	X	X	-	-	X
Coelenterata (Hydras)														
Hydra sp.	-	-	-	-	-	-	-	-	X	-	-	-	X	-
Hydracarina (Water Mites)	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Individuals	5	8	3	16	20	64	82	394	709	37	122	32	1104	37
Total Taxa	4	3	3	5	7	11	5	6	9	12	10	4	3	5

*A - Allegheny River; M = Monongahela River.

X = present

of the water quality. Since 1957, a number of fish studies have been conducted in this reach of the Ohio River.[12,22,23] These have involved sampling the populations in the lock chambers at the Emsworth, Dashield, and Montgomery Dams.

A July 1959 study at Montgomery Locks and Dam produced 21 fish species, which is the greatest number collected in the lock chamber samples in this section of the river. This study was conducted following closure of the steel industries by strike. Krumholz and Minckley[23] compared the 1959 studies (before and after the strike) and concluded that after the industry shutdown, there was an improvement in water quality accompanied by an increase in the variety and abundance of fishes. Further, they showed the principal difference in species composition was the occurrence of pollution sensitive fishes that invaded the previously polluted area, presumably from nearby unpolluted waters. Six of these species, collected in the study after the industry closure, were not collected previously in the lock chambers, nor have they been collected since.

There was a marked increase in the total weights and total number of individuals in the sample results during the 1967-69 study over the 1957-59 study. Fish production was greater in this section of the Ohio River in the late sixties than in the late fifties.

The species composition of the 1967-69 studies is dominated by carp and bullheads. This condition indicates that the water quality favors the more pollution-tolerant fish. A few pollution-sensitive fishes, notably the longperch darter and the walleye, were collected in the 1967-69 study. The important sport and commercial fishes such as channel catfish, the sunfishes and walleyes have never comprised over 10 percent of the fish population.

FISH TAINTING

Channel catfish of acceptable flavor were placed in the Allegheny, Monongahela and Ohio Rivers at various points. After three days exposure, the fish were retrieved and subjected to a panel taste test. The panel scored the flavor of each sample on a 7-point scale ranging from 7, no unnatural flavor, to 1, very extreme, unacceptable flavor. Fish flesh having scores of 5 to 7 were considered to have acceptable flavors.

The flavors of catfish exposed one mile upstream from the Ohio River confluence in the Allegheny and Monongahela Rivers were unacceptable. Excepting at two exposure points (river mile 4.9 and 14.5), all catfish exposed along the left bank of the Ohio River in the study reach acquired unacceptable flavors. Along the left bank of the Ohio River, particularly bad unacceptable flavors were acquired by exposed catfish at the following points: (1) downstream from the waste outfall of Shenango, Inc., at river mile 5.8 (score 3.8); (2) dowstream from waste outfalls of the Jones and Laughlin Steel Company at river miles 17.9 (score 3.2), 19.3 (toxic), and 22.2 to 24.2 (scores 3.8 to 3.9); (3) downstream from waste outfalls of the Pittsburgh Tube Company and Monaca sewage treatment plant at mile 28.4 (score 3.2); and (4) downstream from waste outfalls of the Sinclair-Koppers Company at river miles 29.8 (score 3.6) and 30.0 (score 3.0).

All test fish exposed along the right bank of the Ohio River in the study reach acquired flavors that were not acceptable. Along the right bank of the Ohio River, particularly bad unacceptable flavors were acquired by exposed catfish at the following points: (1) downstream from the point of discharge from the Allegheny County Sanitary Authority sewage treatment plant at river mile 3.2 (score 3.6); (2) downstream from the mouth of tributary Legionville Run at river mile 18.8 (score 3.9); (3) downstream from waste outfalls of the Penn-Central Railroad Company at river mile 21.4 (score 3.8); (4) downstream from the waste discharge of the Borough sewage treatment plant at river mile 28.2 (score 3.7); (5) downstream from waste discharges from the Midland sewage treatment plant and Crucible Steel Company at river miles 36.6 (score 2.8) and 39.3 (score 3.8). Ohio River waters at the State boundary lines (river mile 40.0) imparted unacceptable flavors to exposed catfish.

BIBLIOGRAPHY

1. U. S. Bureau of the Census, "U. S. Census of Population, 1970. Number of Inhabitants, Pennsylvania." Final Report PC(1)-40A. U. S. Government Printing Office, Washington, D. C. 1971.

2. Shroyer, Edward. Personal interview with George Brinsko, Plant Superintendent, Allegheny County Sanitary Authority of inventory municipal wastes. Federal Water Quality Administration, Wheeling, West Virginia. May 2, 1970.

3. U. S. Department of Health, Education, and Welfare. "Municipal Water Facilities, 1963 Inventory." Public Health Service Publication No. 775 (revised), Vols. 2, 3, and 5. U. S. Government Printing Office, Washington, D. C. 1964.

4. U. S. Government memorandum from G. V. Bryant to J. W. Ferguson. Federal Water Quality Administration, Wheeling, West Virginia. August 4, 1970.

5. U. S. Army Engineer Division, Ohio River. "Ohio River and Tributaries - Small Boat Harbors, Ramps, Landings, etc." Corps of Engineers, Cincinnati, Ohio. April 1970.

6. U. S. Department of the Interior, Federal Water Pollution Control Administration. The Cost of Clean Water. Vol. III, FWPCA Publication No. I.W.P.-1. U. S. Government Printing Office, Washington, D. C. September 1967.

7. U. S. Army Engineer Division, Ohio River. "River Terminals, Ohio River and Tributaries." Corps of Engineers, Cincinnati, Ohio. April 1970.

8. U. S. Army Engineer Division, Ohio River. Unpublished data. Corps of Engineers, Cincinnati, Ohio.

9. U. S. Army Engineer Division, Ohio River. "Ohio River Basin Comprehensive Survey." Appendix F, Agriculture. Corps of Engineers, Cincinnati, Ohio. 1966.

10. Official file of the Pennsylvania Department of Health, Region V, Pittsburgh, Pennsylvania.

11. U. S. Department of the Interior, Federal Water Quality Administration. "Effects of Waste Water Discharges on Aquatic Life of the Ohio River (Pittsburgh, Pennsylvania to Pennsylvania State boundary). FWQA, Cincinnati, Ohio. 1970.

12. U. S. Environmental Protection Agency, Unpublished data.

13. Ohio River Valley Water Sanitation Commission. Yearbooks. ORSANCO, Cincinnati, Ohio. 1965-1969.

14. Shapiro, M. A., Audelman, J. B., and Morgan, P. V. "Intensive Study of the Water at Critical Points on the Monongahela, Allegheny, and Ohio Rivers in the Pittsburgh, Pennsylvania Area." Report to the Federal Water Pollution Control Administration, Project No. PH-86-64-124. University of Pittsburgh, Pittsburgh, Pennsylvania. 1966.

15. Ohio River Valley Water Sanitation Commission. "DO-BOD Model Study for the Pittsburgh Area." ORSANCO, Cincinnati, Ohio. 1970

16. McCauley, R. N. "The Biological Effects of Oil Pollution in a River." Limnology and Oceanography, Vol. 11, p. 475-486. Amer. Soc. of Lim. & Ocean., Inc., Lawrence, Kansas. 1966.

17. U. S. Government memorandum from F. K. Kawahara to I. L. Dickstein. Federal Water Quality Administration, Cincinnati, Ohio. June 15, 1970.

18. National Coal Association. "Steam Electric Plant Factors." National Coal Association, Washington, D. C. 1969.

19. Anonymous. "River-quality Conditions During a 16-week Shutdown of Upper Ohio Valley Steel Mills." ORSANCO, Cincinnati, Ohio. 1961.

20. Anonymous. "Provisional Algal Assay Procedure." Joint Industry/Government Task Force on Eutrophication. 1969.

21. Anderson, J. B. and Mason, W. T., Jr. "A Comparison of Benthic Macroinvertebrates Collected by Dredge and Basket Sampler." Journal Water Pollution Control Federation, Vol. 4, p. 252-259. JWPCF, Washington, D. C. 1969.

22. Krumholz, L. A., Charles, J. R., and Minckley, W. L. "The Fish Populations of the Ohio River. In: Aquatic Life Resources of the Ohio River." ORSANCO, Cincinnati, Ohio. 1962.

23. Krumholz, L. A. and Minckley, W. L. "Changes in Fish Population in the Ohio River Following Temporary Pollution Abatement." Transaction American Fisheries Society, Vol 93, p. 1-5. Amer. Fish. Soc., Lawrence, Kansas. 1964.