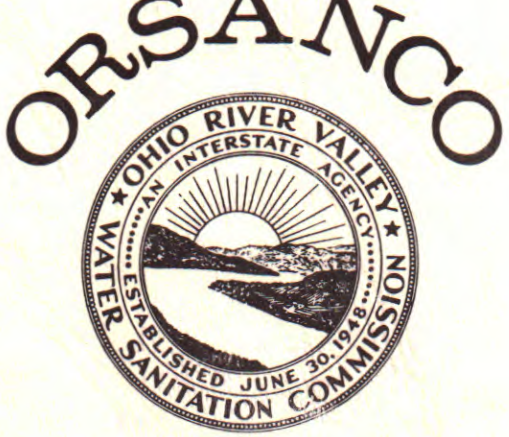
Toxics Substances Control Program

Wheeling to Parkersburg Field Survey



Ohio River Valley Water Sanitation Commission

RESULTS OF OCTOBER 1987 FIELD SURVEY
WHEELING TO PARKERSBURG SEGMENT
OHIO RIVER

Toxic Substances Control Program
Ohio River Valley Water Sanitation Commission
Cincinnati, Ohio

Revised December 1990

TABLE OF CONTENTS

TABLES

FIGURES

I. BACKGROUND

The Ohio River Valley Water Sanitation Commission (ORSANCO) initiated a Toxic Substance Control Program in 1983 to address the growing concern over the detections of low levels of toxic substances in the Ohio River. As part of the Program, ORSANCO is conducting field surveys on segments of the Ohio River. This particular report involves the section from Wheeling to Parkersburg, West Virginia (mile point 85 to 204). A map of the study area with tributaries and mile points can be found in Figure 1. This particular segment survey was the first undertaken by ORSANCO as part of the Toxic Substance Control Program. The segment investigations involve the following:

1. Analyze historic data
2. Recommend field survey
3. Analyze field survey data
4. Recommend follow-up work
5. Analyze follow-up data
6. Determine needs for additional work and/or recommend control program

An analysis of historic data and a report recommending a field survey was completed in 1967. The historic data identified the following parameters of concern; cadmium, cyanide, lead, mercury, nickel, zinc, chloroform, methylene chloride, and tetrachloroethylene. These pollutants are introduced into the river by both point and nonpoint sources, with some pollutants contributed by both. The recommended follow-up work to further define potential point source toxic sources in the study area included the following:

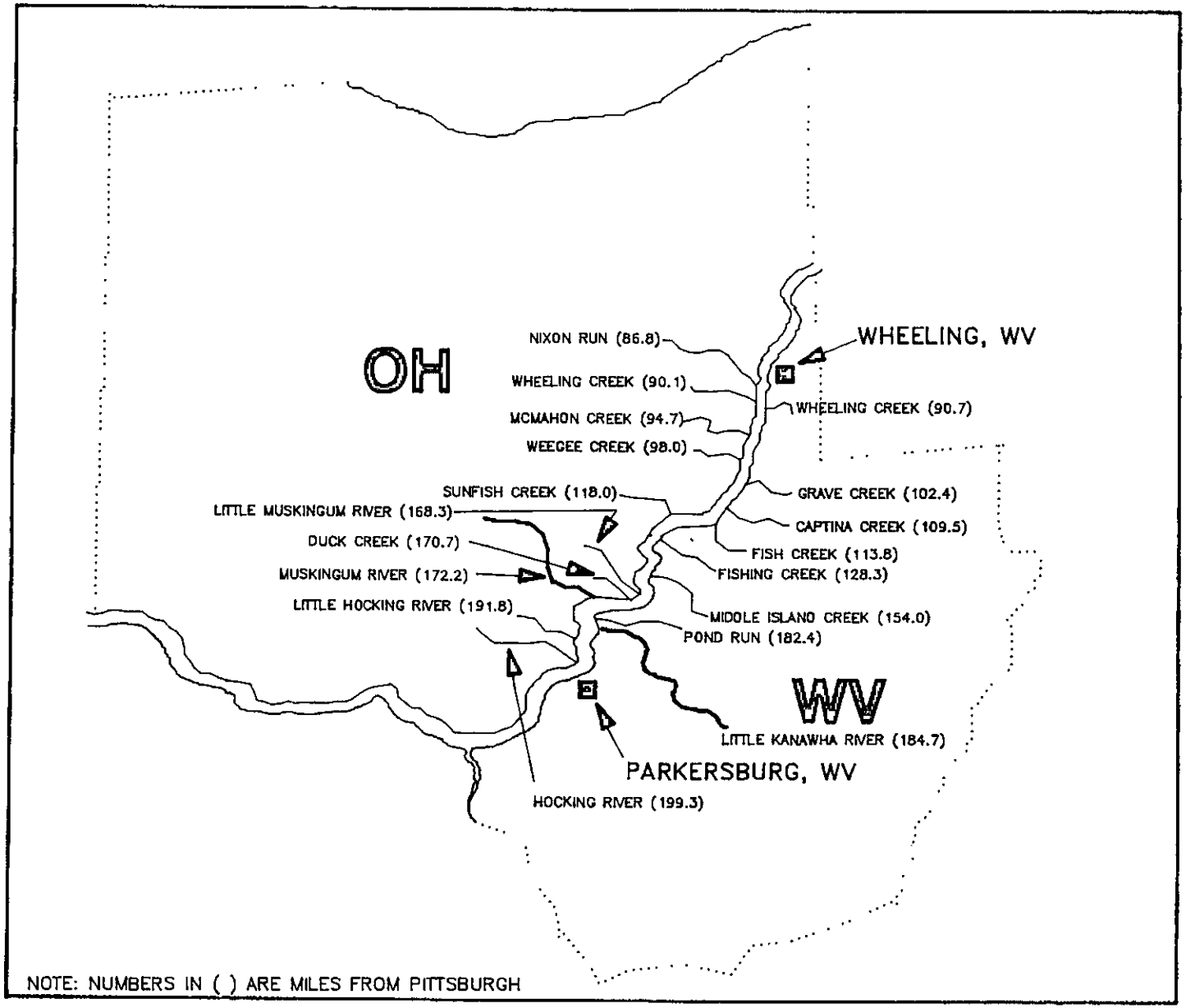
1. End-of-pipe effluent analysis for the parameters of concern at 21 process outfalls

2. Cross-sectional sampling of the Ohio River for the identified parameters of concern at four of ORSANCO's manual monitoring stations (Wheeling, Hannibal, Willow Island, and Belleville) and at four additional sites (Butter Run, Wells Bottom, Marietta, and Vienna).

3. Tributary sediment and instream samples at 18 identified streams.

The recommended river sampling was completed on October 20, 1987. Effluent sampling was conducted separately by the appropriate state agencies in November and December of 1987.

FIGURE 1
MAP - STUDY AREA (WHEELING TO PARKERSBURG)



Parameters of Concern

In the Commission's report The Presence of Toxic Substances in the Ohio River, four categories were applied to identify water quality parameters of concern. These categories were stream criteria exceedances, detection frequency, increase in occurrence from one monitoring location to the next downstream location, and increasing occurrence over the period of record. The stream criteria used were the Commission's Pollution Control Standards, 1985 Revision.

Summarizing by category, the following parameters of concern were identified for the Wheeling to Parkersburg segment:

Criteria Exceedance

Cadmium
Cyanide
Lead
Nickel
Zinc
Chloroform
Chlordane
Methylene Chloride

Frequent Detections

Mercury
Hexachlorobenzene

Increase from Upstream Location

None

Increasing Trend

Tetrachloroethylene

Since the publication of The Presence of Toxic Substances in the Ohio River, the Commission has evaluated the more recent ambient monitoring data with the current standards. The Commission's 305(b) report, Assessment of Water Quality Conditions Ohio River, 1986-1987, evaluates water quality data collected from October 1985 through September 1987.

In the 305(b) report the Ohio River is divided into waterbodies. Four waterbodies make up the Wheeling to Parkersburg segment: Pike Island to Hannibal (M.P. 84.2 to 126.4), Hannibal to Willow Island (M.P. 126.4 to 161.7), Willow Island to Muskingum (M.P. 161.7 to 172.2), and Muskingum to Belleville (M.P. 172.2 to 203.9). In each waterbody use attainment is assessed by comparison of monitoring data with stream criteria established in ORSANCO's Pollution Control Standards, 1987 Revision and/or U.S. EPA Ambient Water Quality Cancer Risk Levels.

Use attainment was further defined as fully supporting, partially supporting and non-supporting use, depending on the percentage of time criteria was exceeded. For this report those parameters where a waterbody is rated as partially supporting or non-supporting are defined as parameters of concern. Summarized by category, the parameters of concern for this study segment are listed in Table 1.

TABLE 1

PARAMETERS OF CONCERN

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

PARTIALLY SUPPORTED	NON-SUPPORTED	
Chloroform	Nickel	Lead*
	Arsenic	Copper*
	Mercury	Phenol

*These parameters have a significant decreasing trend from 1977 to 1987, based on seasonal Kendall Test.

Inventory of Potential Sources

The study area contains 91 National Pollutant Discharge Elimination System (NPDES) permitted facilities. A summary of the dischargers is included in Table 2. Appendix A lists the permitted discharges in the study area.

TABLE 2

SUMMARY OF DISCHARGES TO THE OHIO RIVER

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

TYPE OF FACILITY	NUMBER
Municipal Wastewater Treatment Plants	30
Coal Handling Facilities	13
Chemical Plants	11
Manufacturing Plants	13
Power Plants	5
Water Treatment Plants	4
Bulk Terminals	6
Railroad Yards	2
Sand and Gravel Operations	2
Cooling Water Discharges	5
	Total 91

Twenty-six Resource Conservation and Recovery Act (RCRA) Treatment, Storage or Disposal Facilities (TSDF) are located near the Ohio River within the study area. Appendix A lists all of the RCRA facilities near the Ohio River. Fifteen of the facilities are in Ohio, while 11 are located in West Virginia. Approximately 6,138 tons of hazardous waste were generated in 1984 at Ohio facilities and 12,140 tons at West Virginia facilities. Each of these facilities could be a potential source of toxics in the study area.

Seven of the communities in the study area have combined sewer systems (see Table 3). These systems overflow during period of heavy rainfall resulting in the release of untreated sewage. The release of untreated sewage is another potential source of toxic substances to the Ohio River.

TABLE 3

COMMUNITIES WITH COMBINED SEWERS

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

MUNICIPALITY	MILE POINT
Wheeling, WV	90.8
Benwood, WV	93.0
Belmont County, OH	94.0
McMechen, WV	96.2
Moundsville, WV	102.4
New Martinsville, WV	128.7
Parkersburg, WV	184.0

Another possible source of contamination is the transport of toxics from ground water to the Ohio River. Preliminary investigations have identified 55 potential sites for ground water contamination in the segment. Twenty-two sites have been associated with severe contamination of ground water in the segment. Appendix B lists the sites with the potential for ground water contamination. Contaminants identified include mercury and other metals, organics, and inorganics.

Two municipalities draw water directly from the segment as do 28 industries. Also, 27 municipalities draw their water supply from the aquifer which lies below the river in the segment. Total municipal supply to the direct intakes is 8.2 million gallons per day (MGD), and 23.2 MGD from the aquifer supply, totaling 31.4 MGD. Appendix D lists all of the water intakes in the study segment.

Appendix E lists the public water supplies along the main stem using ground water.

II. SURVEY DESIGN

Objectives

The objective of the study was to investigate the presence of chloroform and heavy metals under low flow conditions to emphasize point source effects. In addition to testing for the above compounds, conventional water quality parameters were also measured. These included temperature, pH, conductivity, dissolved oxygen. hardness, alkalinity, and total suspended solids. Measuring values for these parameters display the vertical or lateral stratification in the stream.

Sampling Locations

The sampling locations for this study were chosen to isolate the effects of "clusters" of discharges to the Ohio River. The sampling occurred at the effluent of 21 process outfalls and in the main stream above and below each cluster. Eighteen tributaries were chosen for sediment and water column sampling to characterize inputs of toxic substances. A total of seven discharge clusters were selected to perform a mass balance on the river. The clusters are identified in Table 4.

TABLE 4

DESCRIPTION OF SAMPLING CLUSTERS AND NUMBER OF DISCHARGES SAMPLED

WHEELING TO PARKERSBURG SEGMENT TOXIC SUBSTANCES CONTROL PROGRAM

CLUSTER (MILE POINT)	INDUSTRIAL DISCHARGES	MUNICIPAL DISCHARGES
86.8 TO 107.0	4	1
107.0 TO 117.4	6	0
117.4 TO 126.4	4	1
126.4 TO 161.7	3	0
161.7 TO 171.9	1	1
171.9 TO 183.1	2	1
183.1 TO 203.9	3	0
TOTAL	23	4

Participants

Individuals from the following agencies participated in the field survey: Ohio EPA, West Virginia DNR and U.S. EPA Region III. These agencies provided equipment and personnel to complete the survey and ORSANCO's appreciation is extended to them. Table 5 lists where each agency sampled and provided laboratory services.

TABLE 5

AGENCY PARTICIPANTS

AGENCY	INDUSTRIAL DISCHARGES MUNICIPAL DISCHARGES
West Virginia DNR	Wheeling Waterworks to Hannibal (M.P. 86.8 to 126.4)
Ohio EPA	Willow Island to Belleville (M.P. 161.7 to 203.9)
U.S. EPA	Provided transportation

**Howard Laboratories provided VOC analysis.*

Quality Assurance/Quality Control Plan

A Quality Assurance/Quality Control (QA/QC) Plan was developed for the survey and was approved by all agencies participating. Ohio EPA and West Virginia DNR performed analyses of samples for metals and conventional parameters. Howard Laboratories performed analyses for volatile organic compounds. A copy of the QA/QC Plan is included as Appendix F.

III. SURVEY RESULTS

Overall

Ohio River flow conditions at mile point 102.4 during the survey (16,900 cubic feet per second (cfs)) were between the average monthly flow (27,200 cfs) and minimum average monthly flow (9,470 cfs).

Main stem conditions (Maximum, Minimum, Average) for temperature, pH, conductivity, dissolved oxygen, hardness, and alkalinity are listed in Table 6. Water quality criteria were not exceeded for these parameters during the survey period.

TABLE 6

OHIO RIVER CONDITIONS

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

PARAMETER	MAX	MIN	AVG
Temperature, °C	15.5	11	14.4
pH, s.u.	8.8	6.5	7.6
Conductivity, umhos/cm	431	250	316.5
Dissolved Oxygen, mg/L	12.8	9.5	11.3
Hardness, mg/L as CaCO3	144	104	118.8
Alkalinity, mg/L as CaCO3	89	40	45.6

Parameters not detected in the stream included most volatile organic compounds (VOCs). Of the VOCs analyzed for, five were detected and one, chloroform, exceeded the instream criterion for human health exposure (0.19 μg/L). Chloroform exceeded the criterion at Wheeling (M.P. 86.8), Wells Bottom (M.P. 117.3), Hannibal (M.P. 126.4), Duck Creek (M.P. 170.7, tributary), and Belleville (M.P. 203.9). A listing of the VOCs analyzed for is shown in Table 7.

TABLE 7

VOLATILE ORGANIC COMPOUNDS ANALYZED

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

COMPOUND	COMPOUND
Benzene	p-Xylene
Vinyl Chloride	o-Xylene
Carbon Tetrachloride	m-Xylene
1,2-Dichloroethylene	1,1-Dichloroethane
Trichloroethylene	1,2-Dichloropropane
1,1-Dichloroethylene	1,1,2,2-Tetrachloroethane
1,1,1-Trichloroethane	Ethylbenzene
*p-Dichlorobenzene	1,3-Dichloropropane
*m-Dichlorobenzene	Styrene
*o-Dichlorobenzene	Chloromethane
#Chloroform	Bromomethane
Bromodichloromethane	1,2,3-Trichloropropane
Chlorodibromomethane	1,1,2,2-Tetrachloroethane
Bromoform	Chloroethane
trans-1,2-Dichloroethylene	1,1,2-Trichloroethane
cis-1,2-Dichloroethylene	2,2-Dichloropropane
*Chlorobenzene	o-Chlorotoluene
Dichloromethane	p-Chlorotoluene
1,1-Dichloropropane	Bromobenzene
Tetrachloroethylene	1,3-Dichloropropene
Toluene	Ethylene dibromide
1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane
1,2,4-Trichlorobenzene	1,3,5-Trimethylbenzene
1,2,3-Trichlorobenzene	p-Isopropyltoluene
n-Propylbenzene	Isopropylbenzene
n-Butylbenzene	Tert-butylbenzene
Naphthalene	Sec-butylbenzene
Hexachlorobutadiene	Fluorotrichloromethane
	Dichlorodifluoromethane
	Bromochloromethane

* = Detected Instream
# = Exceeded Instream Criteria

All inorganics analyzed for were detected instream, however they did not exceed the instream criterion (criteria are listed in Table 8). All constituents analyzed were for total recoverable concentration.

TABLE 8

INSTREAM CRITERIA

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

CHEMICAL CONSTITUENTS
NOT TO EXCEED THE FOLLOWING CONCENTRATIONS

CONSTITUENT	CONCENTRATION, UNITS PER LITER
Arsenic	50.0 μg
Barium	1000.0
Phenolics	5.0
Selenium	10.0
Silver	50.0
Dichlorobenzenes	400.0
Chloroform	0.19
Nickel	13.4

CONSTITUENT	CHRONIC CRITERIA CONCENTRATION (μg/L)	ACUTE CRITERIA CONCENTRATION (μg/L)
Cadmium	$e^{(.7852[\ln \text{Hard}.-3.490)}$	$e^{(1.128[\ln \text{Hard}.-3.828)}$
Copper	$e^{(.8545[\ln \text{Hard}.-1.465)}$	$e^{(.9422[\ln \text{Hard}.-1.464)}$
Lead	$e^{(1.273[\ln \text{Hard}.-4.705)}$	$e^{(1.273[\ln \text{Hard}.-1.460)}$
Zinc	$e^{(.8473[\ln \text{Hard}.+.7614)}$	$e^{(.8473[\ln \text{Hard}.+.8604)}$
Chromium (hexavalent)	11	16
Cyanide (free)	5	22
Mercury	.012	2.4

Appendix G lists the field sampling results from the segment survey.

Assessment by Objective

The objectives of the study were to characterize the presence of chloroform and heavy metals under low flow conditions in the Ohio River, and to identify sources of these chemicals. Table 9 lists each of the discharge clusters and the key parameters associated with them. Key parameters include mercury, lead, chloroform, and dichlorobenzenes. These substances are characterized in the sections to follow:

Mercury

Mercury concentrations exceeded the instream chronic criterion above and below each discharge cluster from M.P. 86.8 to 126.4 (Ohio EPA did not analyze for mercury). Table 10 lists the concentration, and agency sampling and analyzing for each location where mercury was detected.

Figure 2 presents the instream concentration for mercury from M.P. 86.8 to 126.4. All instream values in Figure 2 are in exceedance of the chronic criterion (.012 μg/L) for mercury. The detection limit for mercury is high (0.1) compared to the criterion (0.012) thus, all values below detection may or may not exceed the criterion. Instream concentrations increase from mile point (M.P.) 86.8 to 107.0 on the left and right descending bank, suggesting a significant input of mercury to the river. However, the instream concentration at mid-channel falls below the detection level. A possible explanation for this is the mixing effect Willow Island has on the river. Fifty-five industrial facilities have been identified as a potential source of ground water contamination in the segment. Twenty-two of the 55 are known to have contaminated ground water in this segment, one being LCP Chemicals (M.P. 102.1) contributing mercury.

There is a drop in the instream concentration on the right descending bank from M.P. 107.0 to 117.3, however the left and mid-stream samples show a significant increase. From M.P. 117.3 to 126.4 the instream concentrations decrease to approximately the same level. Unfortunately discharger sampling did not occur on the same day, therefore no accurate quantifications of mercury influences can be concluded.

Although mercury water column samples frequently exceeded criterion, mercury levels in fish tissue do not exceed the FDA action level of 1.0 mg/kg. These findings are presented

TABLE 9

INSTREAM SAMPLING LOCATIONS AND KEY PARAMETERS

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

CLUSTER	LOCATION	OHIO RIVER MILE POINT	KEY PARAMETERS	INDUSTRIAL DISCHARGES	MUNICIPAL DISCHARGES
86.8 TO 107.0	Wheeling Wheeling Creek Grave Creek Butter Run	86.8 91.0 102.4 107.0	Lead, Dichlorobenzenes, Mercury, Chloroform Lead, Mercury Lead, Mercury Dichlorobenzenes, Mercury	7	4
107.0 TO 117.4	Wells Bottom	117.3	Lead, Dichlorobenzenes, Mercury	4	0
117.4 TO 126.4	Hannibal	126.4	Lead, Dichlorobenzenes, Mercury	4	0
126.4 TO 161.7	Fishing Creek Middle Island Creek Willow Island	128.3 154.0 161.7	Mercury Mercury Lead, Mercury	2	0
161.7 TO 171.9	Duck Creek Buckley Island	170.7 171.9	Dichlorobenzenes, Chloroform Mercury	1	1
171.9 TO 183.1	Muskingum River	172.2	Lead, Mercury	2	1
183.1 TO 203.9	Parkersburg Pond Run Little Kanawha River Belleville	183.1 184.1 184.7 203.9	Dichlorobenzenes, Mercury Mercury Dichlorobenzenes, Mercury Mercury, Chloroform	3	1

TABLE 10

CONCENTRATIONS FOR EXCEEDANCES

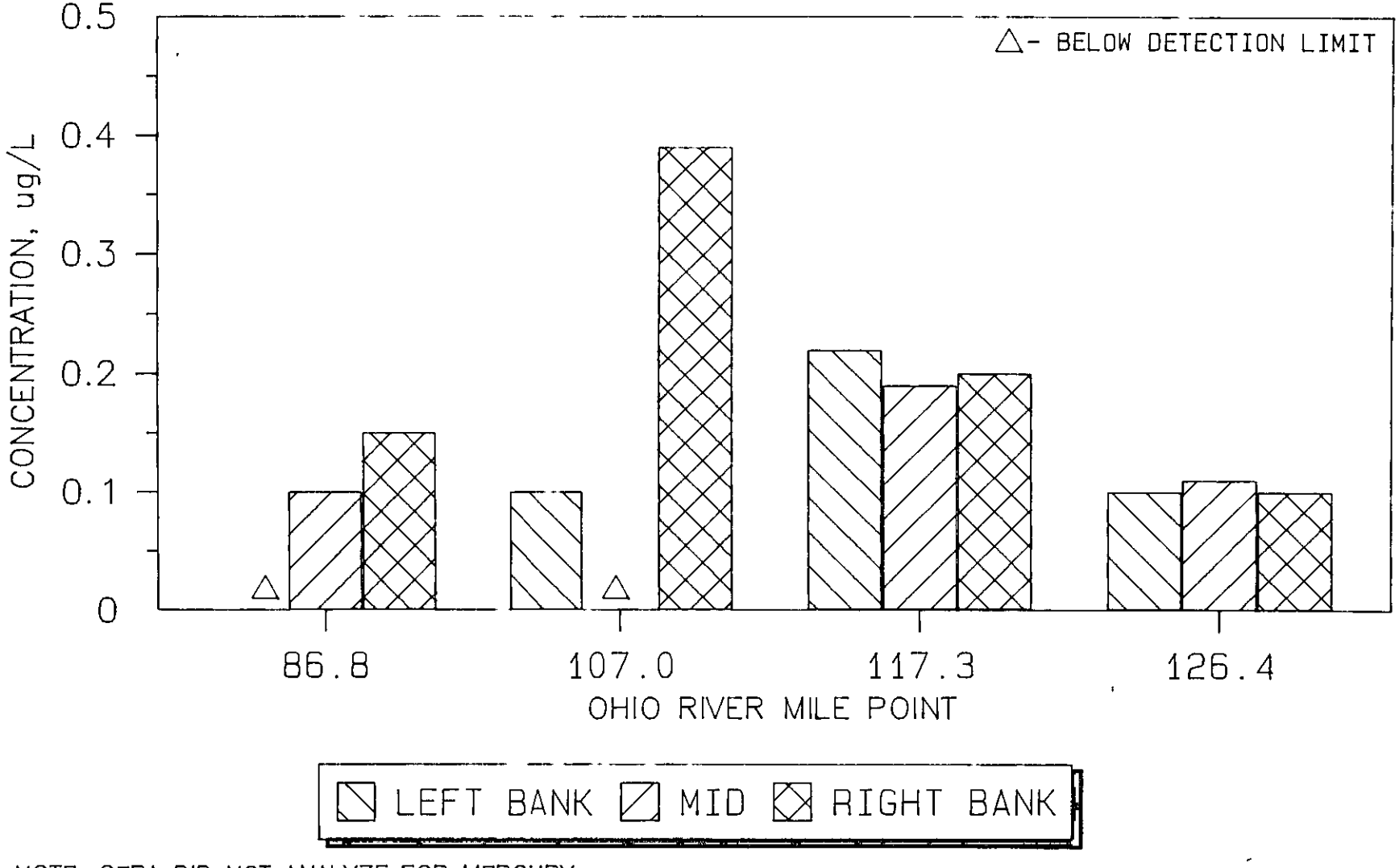
WHEELING TO PARKERSBURG SEGMENT
Toxic Substances Control Program

OHIO RIVER MILE POINT	FLOW (CFS)	MERCURY CONC. (ug/L) LEFT	MID	RIGHT	AGENCY SAMPLING AND PROVIDING ANALYSIS
86.8	16,500	<0 1	0.10	0.15	WEST VIRGINIA DNR
107.0	16,940	0.10	<0 1	0.39	WEST VIRGINIA DNR
117.3	17,050	0.22	0.19	0.20	WEST VIRGINIA DNR
126.4	17,060	0.10	0.11	0.10	WEST VIRGINIA DNR

OHIO RIVER MILE POINT	FLOW (CFS)	LEAD CONC. (ug/L) LEFT	MID	RIGHT	AGENCY SAMPLING AND PROVIDING ANALYSIS
86.8	16,500	10	10	10	WEST VIRGINIA DNR
107.0	16,940	<10	<10	<10	WEST VIRGINIA DNR
117.3	17,050	10	10	10	WEST VIRGINIA DNR
126.4	17,060	10	<10	<10	WEST VIRGINIA DNR
161.7	16,840	<2	<2	<2	OHIO EPA
171.9	18,150	<2	<2	<2	OHIO EPA
183.1	19,315	<2	<2	<2	OHIO EPA
203.9	19,600	<2	<2	3	OHIO EPA

NOTE: OEPA DID NOT ANALYZE FOR MERCURY

FIGURE 2
IN-STREAM MERCURY CONCENTRATION
Ohio River MP 86.8-126.4, 10/20/87



NOTE: OEPA DID NOT ANALYZE FOR MERCURY

in ORSANCO's Assessment of Water Quality Conditions for the Ohio River for water years 1988-1989.

Lead

Table 10 lists the lead concentrations detected in the water column of the main stem stations. There are two different detection limits between the laboratories that provided analyses (West Virginia DNR - 10 μg/L, Ohio EPA - 2 μg/L). The concentrations from M.P. 86.8 to 126.4 (West Virginia DNR), a detection is reported as exactly 10 μg/L and a non-detection as <10 μg/L. All values for lead from M.P. 161.7 to 203.9 (Ohio EPA) are <2 μg/L except the right bank at M.P. 203.9 (3 μg/L). From this data, not much can be concluded about the presence of lead in the Ohio River in this segment. Because of the different detection limits between the laboratories, no comparisons of data from upstream to downstream can be made.

Lead is believed to be nonpoint source related, therefore levels would not be expected to be high during the dry weather sampling period. Discharge sampling identified several point sources of lead to the main stem. Two of the larger sources were Ohio Power - Kammer Plant Sanitary Outfall and Marietta Wastewater Treatment Plant. In Captina Creek at M.P. 109.5 (Ohio side), no lead was found in the water samples; however, sediment data indicated 315 μg/L.

Chloroform

Figure 3 and Table 11 show the instream chloroform concentrations for the Wheeling to Parkersburg segment. All concentrations detected in this segment exceeded the human health criterion at 10^{-6} CRL of 0.19 μg/L. The detection limit for chloroform is 0.20 μg/L.

There is a large input to the river upstream of M.P. 86.8 as indicated by the detection at mid-stream. There are no detections until 30.5 miles downstream at M.P. 117.3, where a detection occurs on the right descending bank. There are significant detections of chloroform at M.P. 126.4 and 203.9. However, since discharger sampling did not occur at the same time, no conclusions can be drawn about influences of chloroform concentrations in the river and it is not appropriate to attempt to perform a mass balance for chloroform.

FIGURE 3

IN-STREAM CHLOROFORM CONCENTRATION

Ohio River MP 86.8-203.9, 10/20/87

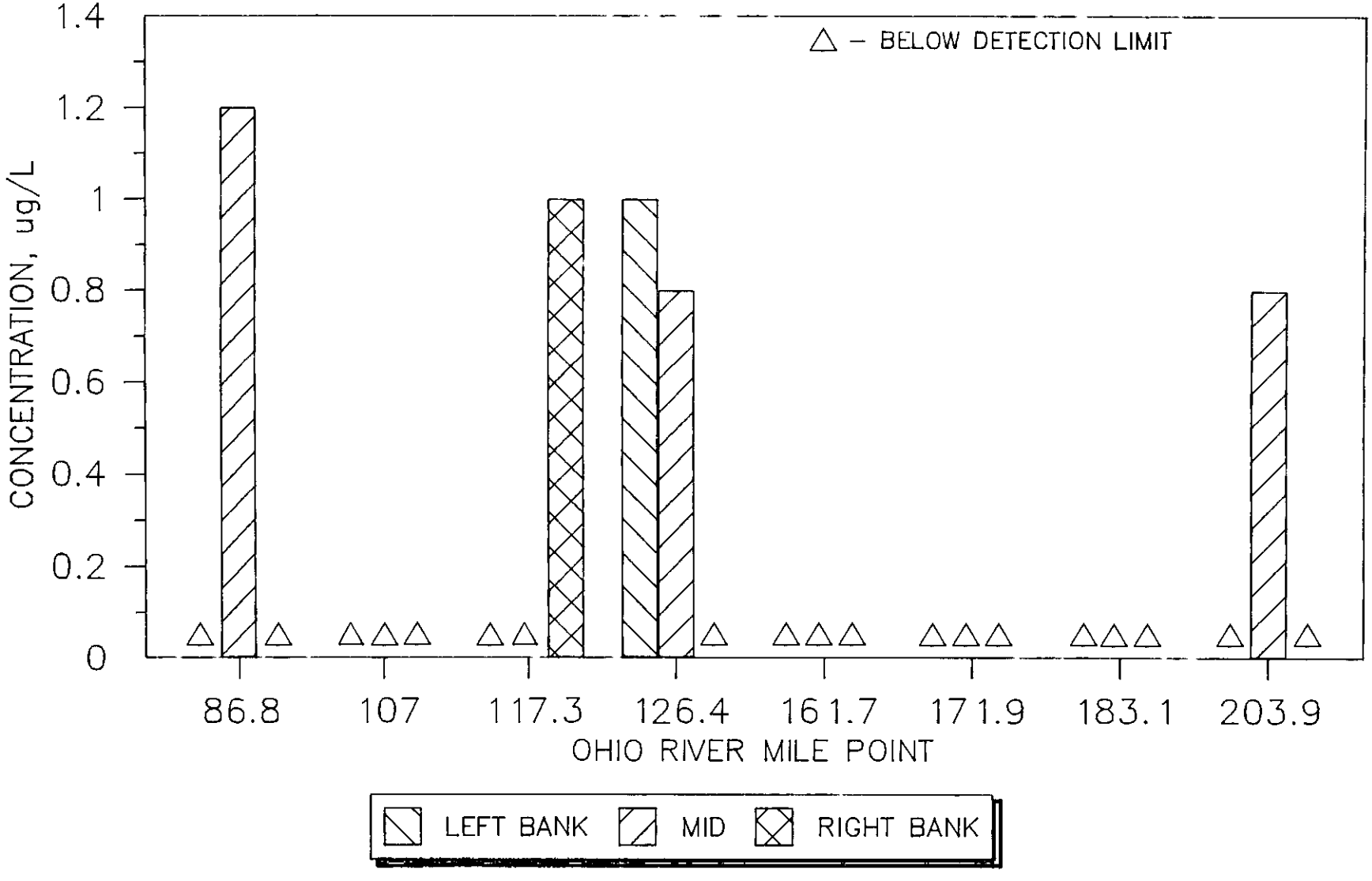


TABLE 11

CONCENTRATIONS FOR CHLOROFORM AND DICHLOROBENZENE

WHEELING TO PARKERSBURG SEGMENT
Toxic Substances Control Program

OHIO RIVER MILE POINT	FLOW (CFS)	CHLOROFORM CONC. (ug/L) LEFT	MID	RIGHT	AGENCY COLLECTING SAMPLE	LAB PERFORMING ANALYSIS
86.8	16,500	ND	1.2	ND	WEST VIRGINIA DNR	HOWARD LABORATORIES
117.3	17,050	ND	ND	1.0	WEST VIRGINIA DNR	HOWARD LABORATORIES
126.4	17,060	1 0	0.8	ND	WEST VIRGINIA DNR	HOWARD LABORATORIES
203.9	19,600	ND	0.8	ND	OHIO EPA	HOWARD LABORATORIES

OHIO RIVER MILE POINT	FLOW (CFS)	DICHLOROBENZENE CONC. (ug/L) LEFT	MID	RIGHT	AGENCY COLLECTING SAMPLE	LAB PERFORMING ANALYSIS
86.8	16,500	ND	ND	ND	WEST VIRGINIA DNR	HOWARD LABORATORIES
107.0	16,940	ND	ND	ND	WEST VIRGINIA DNR	HOWARD LABORATORIES
117.3	17,050	ND	ND	ND	WEST VIRGINIA DNR	HOWARD LABORATORIES
126.4	17,060	0.8	1.3	ND	WEST VIRGINIA DNR	HOWARD LABORATORIES
171.9	18,150	ND	2.5	2.9	OHIO EPA	HOWARD LABORATORIES
183.1	19,315	ND	3.6	3.7	OHIO EPA	HOWARD LABORATORIES

ND = No Detection

Dichlorobenzene

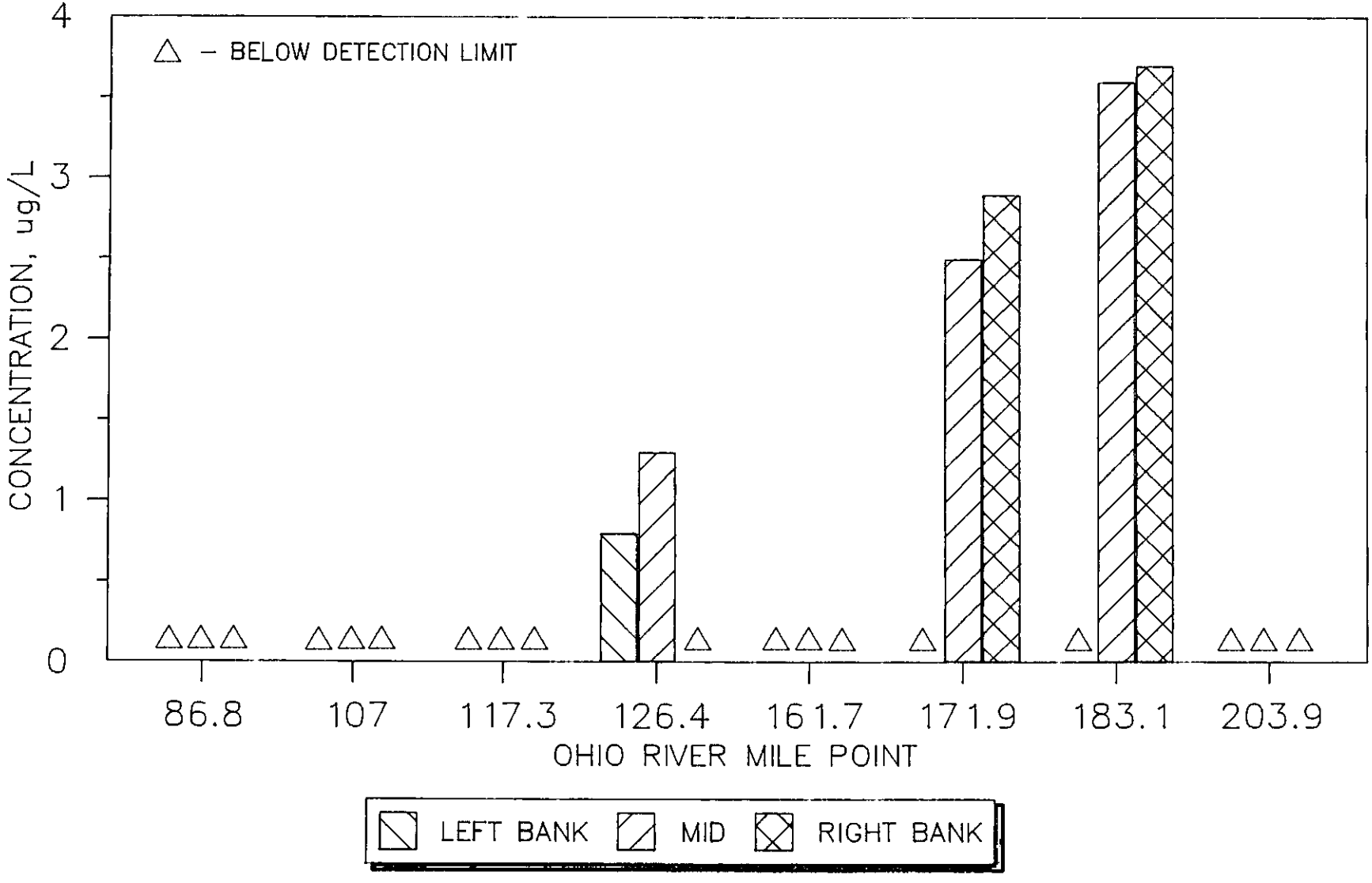
Instream concentrations for total dichlorobenzene are listed in Table 11 and shown in Figure 4. However, concentrations did not exceed the human health criterion of 400 μg/L. Total dichlorobenzene consists of three isomers: ortho, meta, and para. Dichlorobenzene is detected only at M.P. 126.4, 171.9 and 183.1 in this segment. PPG Industries (M.P. 119.6) is a discharger in the upper part of the segment that contributes dichlorobenzene to the river. At outfall 009, PPG releases approximately 38 pounds of dichlorobenzene to the river the day of sampling. In 1989 the discharge permit for PPG Industries, Inc. was revised to include discharge limits for dichlorobenzenes.

The two other detections of dichlorobenzene in the water column of the Ohio River can be attributed to two RCRA facilities in Ohio. One facility is on Duck Creek and water column samples from this tributary indicate the presence of dichlorobenzene. Duck Creek enters the Ohio River at M.P 170.7 and dichlorobenzene is detected in water column samples at M.P. 171.9. The second RCRA facility is upstream of M.P. 183.1 where dichlorobenzene is detected, and is known to have contaminated ground water with dichlorobenzene.

FIGURE 4

IN-STREAM DICHLOROBENZENE CONCENTRATION

Ohio River MP 85.8-203.9, 10/20/87



IV. CONCLUSIONS

The data collected during the survey of M.P. 86.8 to 203.9 show locations where instream criteria were exceeded for mercury and chloroform. Dichlorobenzene was also detected in water column samples, but did not exceed instream human health criterion. Analysis of dichlorobenzene was included because suspect dischargers were known. Significant sources of contributing toxic substances to the Ohio River include Captina Creek (lead) and the reach from M.P. 86.8 to 126.4 (mercury).

V. FOLLOW-UP ACTIONS

Actions Underway

In 1989, ORSANCO entered into a contract with the Pennsylvania Department of Natural Resources to apply a toxic screening model to waterbodies in the upper Ohio River Basin. As part of the arrangement, ORSANCO would apply the model to the upper 200 miles of the Ohio River to determine the applicability of the method to ORSANCO's programs. Refer to Appendix H for the modeling concepts of the toxic screening model.

Discharge data collected as part of the 85-200 toxic substances segment investigation were used to evaluate the effects of these discharges on the Ohio River under design flow conditions ($Q_{7\,10}$ and harmonic mean). The discharges and tributaries listed in Table 12 were identified by the model as contributing loads of toxic substances which may cause violations of stream criteria. The table also shows those discharges and tributaries which are interacting to cause criteria violations.

A comparison of the data collected on October 20, 1987 and the results of the toxic modeling show a strong correlation. All parameters identified by the model were parameters of concern for this segment except cyanide and arsenic. Areas identified in the model as contributing to an instream criterion violation are shown to increase instream loading in the respective cluster. Again, discharger sampling did not occur on the same day as the water column sampling.

TABLE 12

PA DER TOXIC SCREENING MODEL PARAMETERS AND LOCATIONS

WHEELING TO PARKERSBURG SEGMENT
TOXIC SUBSTANCES CONTROL PROGRAM

FACILITY	OHIO RIVER MILE POINT	PARAMETER	INTERACTION
Wheeling	90.9	Mercury	With Wheeling POTW
Wheeling POTW	91.2	Mercury	See Wheeling Creek
LCP Chemical	106.8	Chloroform Mercury	With Ohio Power-Kammer, Ohio Power-Mitchell, PPG-Natrium
Ohio Power-Kammer	111.1	Cadmium Lead	With Ohio Power-Mitchell, PPG-Natrium
Ohio Power-Mitchell	112.6	Lead Mercury	See Ohio Power-Kammer See LCP Chemical
PPG-Natrium	119.6	Chloroform Lead Mercury	See Ohio Power See LCP Chemical
CONALCO	123.7	Cyanide	
Marietta POTW	171.0	Lead	With Muskingum River
Muskingum River	172.2	Arsenic Lead Mercury	With the Marietta POTW
Elkem Metals	176.9	Copper	
Little Kanawha River	184.6	Mercury	
DuPont	190.5	Mercury	

Remaining Actions

Overall analysis of water column and sediment samples do not show any gross contamination from toxic substances in the Ohio River in this segment. The following are recommended follow-up actions for the study areas:

1. This study included only chemical analysis. Although some criteria exceedances occurred, there is no indication of toxic effects, if any, on aquatic life. A suitable methodology for demonstrating instream toxic effects in large rivers such as the Ohio is needed.

2. Sediment samples were collected for tributary streams only, and were analyzed for metals. Further studies should include sediment analysis at selected main stem sites, all sediment samples should include analysis for pesticides and PCBs.

3. Detection levels should be consistent among laboratories if more than one laboratory is used for analysis. This is an unfortunate shortcoming of this study because conclusions cannot be drawn.

4. Additional nonpoint sources to the study area, particularly sources of copper, lead and nickel, should be investigated further. Captina Creek, which had an extremely high sediment level of lead, appears to be a candidate for special investigation.

5. Commission groundwater studies should address potential sources of mercury and dichlorobenzene in the study area.

APPENDIX A

APPENDIX A

NPDES PERMITTED FACILITIES TO THE OHIO RIVER BETWEEN MILE POINT 85 AND 200

RIVER MILE	STATE	FACILITY NAME	PLANT
85.0	OH	MARIETTA COAL CO.	
86.4	WV	WARWOOD TOOL CO.	
86.8	WV	WHEELING CITY OF	WHEELING WTP
87.2	WV	WHEELING STAMPING CO.	
87 8	OH	WHEELING-PITTSBURGH STEEL CORP	MARTINS FERRY PLANT
88 3	WV	UNION OIL CO	WHEELING BULK PLANT
89 0	WV	WHEELING-PITTSBURGH STEEL CORP	BENWOOD PLANT
90.2	OH	BRIDGEPORT. CITY OF	BRIDGEPORT WTP
90.6	WV	L. NIEBERGALL ICE AND FREEZER STORAGE	
91 2	WV	WHEELING. CITY OF	WHEELING WWTP
92.7	OH	R&F COAL CO	BELLEAIRE TERMINAL
93 1	WV	BENWOOD. CITY OF	
93.8	WV	CONSOLIDATION COAL CO.	OHIO VALLEY DIVISION - SHOEMAKER MINE
94 0	OH	BELMONT COUNTY SEWER AUTHORITY	WWTP
94 3	WV	CONSOLIDATION COAL CO.	OHIO VALLEY DIVISION - SHOEMAKER MINE
95 5	WV	BALTIMORE & OHIO RAILROAD CO.	BENWOOD YARD
96.5	WV	McMECHEN. CITY OF	McMECHEN WWTP
113 0	WV	LIQUIFIED COAL DEVELOPMENT CO.	
114 5	WV	COLUMBIAN CHEMICALS CO.	
115.6	OH	QUARTO MINING CO.	MINE NO. 4
119.7	WV	PPG INDUSTRIES INC	NATRIUM PLANT
121.3	WV	MOBAY CHEMICAL CORP.	
123.5	OH	ORMET CORP.	HANNIBAL PLANT
123 7	OH	CONSIDATED ALUMINUM CORP.	
124.7	WV	NEW MARTINSVILLE. CITY OF	NEW MARTINSVILLE NORTH WWTP

APPENDIX A

NPDES PERMITTED FACILITIES TO THE OHIO RIVER BETWEEN MILE POINT 85 AND 200

(Continued)

RIVER MILE	STATE	FACILITY NAME	PLANT
126.0	OH	OHIO & LEE TWP WATER SEWER AUTH.	LEE TOWNSHIP WWTP
127.8	OH	OHIO DEPT OF TRANSPORTATION	DUFFY OUTPOST BLDG.
128.4	WV	BALTIMORE & OHIO RAILROAD CO.	BROOKLYN JCT.
128.7	WV	NEW MARTINSVILLE, CITY OF	NEW MARTINSVILLE SOUTH WWTP
133.2	WV	PADEN CITY, CITY OF	PADEN CITY WWTP
137.1	WV	SISTERSVILLE, CITY OF	SISTERSVILLE WWTP
142.5	OH	FRONTIER BOARD OF EDUCATION	FRONTIER HIGH SCHOOL WWTP
145.3	WV	UNION CARBIDE CORP.	SISTERSVILLE FACILITY
146.9	WV	FRIENDLY PUBLIC SERVICE DIST	FRIENDLY WWTP
176.9	OH	ELKEM METALS COP.	MARIETTA PLANT
179.2	OH	CHEVRON ASPHALT CO.	MARIETTA TERMINAL
180.3	WV	MANVILLE BUILDING MATERIALS CORP	
180.9	WV	TEXACO INC.	
181.4	WV	VIENNA, CITY OF	VIENNA WWTP
181.5	WV	DIAMOND GLASS CO	
183.2	WV	PARKERSBURG, CITY OF	PARKERSBURG WTP
183.3	WV	PENNZOIL CO.	
184.9	WV	WEST VIRGINIA DEPT OF HIGHWAYS	WWTP
185.5	WV	BURDETTE OXYGEN CO.	
185.7	OH	BELPRE, CITY OF	BELPRE WWTP
188.7	OH	SHELL CHEMICAL CO.	MARIETTA PLANT
189.7	OH	OHIO POWER CO.	BELPRE COAL TERMINAL
190.5	WV	E.I. duPONT deNEMOURS & CO.	WASHINGTON WORKS
191.5	WV	BORG-WARNER CHEMICALS INC.	MARBON DIVISION
192.5	WV	OHIO RIVER SAND AND GRAVEL	
192.9	WV	E.I. duPONT deNEMOURS & CO.	WAREHOUSE FACILITY
193.0	WV	AMERICAN METAL CLIMAX INC.	AMAX SPECIALTY METALS

APPENDIX B

APPENDIX B

SITES WITH POTENTIAL FOR GROUNDWATER CONTAMAINATION
RIVER MILE 85.0 TO 200.0

RIVER MILE	SITE NAME	STATE	CONTAMINATION TYPE
85.5	UNKNOWN	WV	UNKNOWN
87 8	WHEELING PITT STEEL MARTINS FERRY	OH	ORGANICS, METALS
88.3	UNION OIL	WV	ORGANICS
89 0	WHEELING PITT STEEL BENWOOD	WV	ORGANICS, METALS
92.6	MARIETTA COAL CO	OH	METALS
94 3	CONSOLIDATED COAL CO	WV	METALS
95.5	BALTIMORE & OHIO RAILYARD BENWOOD	WV	ORGANICS, FREE PRODUCT
96 5	McMECHEN WWTP	WV	SANITARY, NUTRIENTS
99 5	GLENDALE AIRPORT	WV	ORGANICS
100.5	TRIANGLE PWC	WV	ACIDS, SOLVENTS
101 3	ALEXANDER MINE REFUSE PILE	WV	METALS
102.5	R.E. BURGER POWER PLANT	OH	INORGANICS
104.9	OLIN CORPORATION	WV	C6H6, ANALINE, TDI, PHOSGENE
106.1	LCP CHEMICALS	WV	MERCURY
110 5	POWHATAN POINT MINE	OH	METALS
112.1	MOUNTAINEER CARBON	WV	UNKNOWN
112 3	CONSOLIDATION COAL CO	WV	METALS, INORGANICS
112.6	MITCHELL POWER PLANT	WV	INORGANICS
114 5	COLUMBIAN CHEMICALS	WV	UNKNOWN
115 6	OUARTO MINE	OH	METALS, INORGANICS
118.5	UNKNOWN	WV	UNKNOWN
119 7	PPG INDUSTRIES	WV	MERCURY, ORGANICS
121 3	MOBAY CHEMICAL	WV	MERCURY, ORGANICS
123.5	ORMET CORPORATION	OH	ORGANICS, METALS, CYANIDE
123.7	CONSOLIDATED ALUMINUM	OH	METALS, INORGANICS, ORGANICS
145.3	UNION CARBIDE	WV	ORGANICS, RCRA
155.4	MID ATLANTIC FUELS	WV	ORGANICS
159.5	UNKNOWN	OH	ORGANICS

APPENDIX B

SITES WITH POTENTIAL FOR GROUNDWATER CONTAMAINATION
RIVER MILE 85.0 TO 200.0
(CONTINUED)

RIVER MILE	SITE NAME	STATE	CONTAMINATION TYPE
160.5	MONONGAHELA POWER	WV	INORGANICS, METALS
161 6	AMERICAN CYANAMID	WV	ORGANICS. RCRA
163.7	CABOT CORPORATION	WV	ORGANICS
175 0	BYERLYTE COMPANY	OH	ORGANICS
175 1	GULF OIL	OH	ORGANICS
175.3	PAR AMR OIL COMPANY	OH	ORGANICS
176.0	UNKNOWN	WV	METALS. CHLORIDES. ORGANICS
176 0	UNION CARBIDE	OH	CL-BENZENES. OTHER ORGANICS
176.9	ELKEM METALS	OH	ORGANICS. METALS
178.2	VIENNA TIRE DUMP	WV	METALS
182.0	VIENNA-UNIVERSAL GLASS LF	WV	UNKNOWN
184 7	MARRTOWN DUMP	WV	UNKNOWN
188.7	SHELL CHEMICAL	OH	ORGANICS
190.5	E.I. duPONT	WV	ORGANICS
191.5	BORG WARNER CHEMICALS	WV	ORGANICS
191.5	AMAX SPECIALITIES	WV	ORGANICS

APPENDIX C

APPENDIX C

RCRA FACILITIES LOCATED IN THE COUNTIES ADJACENT TO THE OHIO RIVER BETWEEN MILE POINTS 85 AND 200

OHIO:

1984 GENERATOR ANNUAL REPORT HAZARDOUS WASTE GENERATED AND SENT OFF-SITE

1.	Eastern Plating, Martins Ferry	Spent Cyanide Sludge Cyanide Waste Acid	203 tons 31 tons 253 tons 487 tons
2	Imperial Clevite, Inc . Bridgeport	Nickel & Lead Solution Waste Trichloroethylene	129 tons 14 tons 143 tons
3.	Picoma Industries, Inc., Martins Ferry	Spent Acid Spent Alkaline Cleaner	25 tons 38 tons 63 tons
4.	Wheeling-Pittsburgh Steel Corp , Martins Ferry	Galvanizing Waste Water/ Sludge	4,149 tons 4,149 tons
5.	Aerolite Co., Marietta	Paint Residuals Total Waste	4.1 tons 4 1 tons
6.	American Cyanamid Co., Marietta	Clarification Cake Hazardous Trash By-Product Distillate	14 tons 38 tons 7 tons 59 tons
7.	B.F. Goodrich Co., Marietta	Waste Solvent Ink 1,1,1-Trichloroethane	44 tons 0.3 tons 44.3 tons
8.	Elkem Metals Co., Marietta	ELCR Tank Dig-Out ELCR Lead Sludge Cyanide Contaminated Waste	80 tons 17 tons 0.1 tons 97.1 tons
9.	Gulf Oil Products Co., Marietta	Thin Film Evaporator Bottoms Badger Column Bottoms Rubber Syrup Polymerized Styrene Contaminated Wood, Paper, Plastic Spent Aluminum Oil Contaminated Soil Styrene Contaminated Soil	9 tons 4 tons 12 tons 35 tons 2 tons 54 tons 8 tons 17 tons 141 tons

All units in tons generated per year

APPENDIX C

RCRA FACILITIES LOCATED IN THE COUNTIES ADJACENT TO THE OHIO RIVER BETWEEN MILE POINTS 85 AND 200

(Continued)

OHIO:
1984 GENERATOR ANNUAL REPORT HAZARDOUS WASTE GENERATED AND SENT OFF-SITE

10.	Huntsman Chemical Corp., Belpre	Styrene Manomer Toluene Polymer Mix Mineral Oil Styrene Mixture Mercaptan Water Mix	58 tons 1 ton 3 tons 62 tons
11.	Kaiser Aluminum & Chemical Corp., Belpre	Waste Solvent Mixture Total Waste	49 tons 49 tons
12.	Kardex Systems, Inc., Reno	Waste Solvent Paint Waste Solids	60 tons 2 tons 62 tons
13.	Shell Chemical Co., Belpre	Spent Descaling Acid Cyclohexane mixed with Rubber, Oil & Water Styrene, Toluene, Oil Absorb Pads Tetrahydrofuran Rubber Solution Toluene Oils Mix Chloroform Synthetic Rubber Mix	4 1 tons 4 1 tons
14.	Union Carbide Special Polymers Co. Marietta	Waste Residue Solvents	91 tons 91 tons
15.	Vanguard Paints & Finishes, Inc., Marietta	Spent Nonhalogenated Solvent Caustic Sludge	3 tons 0.7 tons 3.7 tons

APPENDIX C

RCRA FACILITIES LOCATED IN THE COUNTIES ADJACENT TO
THE OHIO RIVER BETWEEN MILE POINTS 85 AND 200

(Continued)

WEST VIRGINIA:
GENERATOR BIENNIAL HAZARDOUS WASTE REPORT FOR 1985*

1	American Cyanamid Co., Willow Island	Mercury Waste Stored Spent Toluene, Methanol and Other Nonhalogenated Solvents	45 tons 765 tons 813 tons
2	Blue Ribbon Paint Co., Wheeling	Spent Solvent from Paint Manufacturing	32 tons 32 tons
3	Corning Glass Works, Paden City	Lead and Silicon Sludge	130 tons 130 tons
4	Fostoria Glass Co.	Lead and Silicon Sludge	2 tons 2 tons
5.	Koppers Co., Inc, Follansbee	Soil Contaminated with Phenol, Naphthalene, Cresote, and Ethylene Benzene	4,678 tons 4,678 tons
6.	Ames Co, Parkersburg	Spent Nonhalogenated Solvents Spent Chromic Acid Spent Alkaline Paint Stripper Spent Lead Chromate Pigments Total Waste	5 tons 21 tons 18 tons 1 ton 45 tons
7.	L.C.P. Chemicals, Inc., Moundsville	No Data	
8.	Mobay Co., Natrium	Toluene Wastes Sludges Solvents Waste Oil Total Waste Stored Wastes	4,829 tons 10 tons 34 tons 52 tons 4,925 tons 601,581 tons
7.	L.C.P. Chemicals Inc., Moundsville	No Data	

APPENDIX C

RCRA FACILITIES LOCATED IN THE COUNTIES ADJACENT TO
THE OHIO RIVER BETWEEN MILE POINTS 85 AND 200

(Continued)

WEST VIRGINIA:
GENERATOR BIENNIAL HAZARDOUS WASTE REPORT FOR 1985*

8.	Mobay Co., Natrium	Toluene Wastes Sludges Solvents Waste Oil Total Waste Stored Wastes	4,829 tons 10 tons 34 tons 52 tons 4,925 tons 601,581 tons
9.	Olin Corp., Moundsville	Toluene Dichlorobenzene/Carbon Tetrachloride	23 tons 65 tons 88 tons
10.	PPG Industries, Inc., Natrium Plant	1,1,1-Trichloroethane/Oil Lead Wastes Organic Contaminated Soils Mercury Contaminated Soils Chlorobenzene Product Residuals Total Waste Stored Wastes	46 tons 205 tons 7 tons 13 tons 100 tons 371 tons 248 tons
11.	Union Carbide Corp., Sistersville	Waste Toluene Stored Wastes	1,066 tons 9,181 tons

APPENDIX D

APPENDIX D

MUNICIPAL AND INDUSTRIAL RIVER INTAKES BETWEEN MILE POINT 85 AND 200

MILE POINT	STATE	INTAKE FACILITY
86.6	WV	WARWOOD TOOL COMPANY
86.8	WV	WHEELING, CITY OF
87.8	OH	WHEELING-PITTSBURGH STEEL CORPORATION
89.0	WV	WHEELING-PITTSBURGH STEEL CORPORATION
90.1	OH	BALTIMORE & OHIO RAILROAD COMPANY
102.5	OH	OHIO EDISON COMPANY
104 0	OH	NORTH AMERICAL COAL COMPANY
105.9	WV	ALLIED CHEMICAL AND DYE CORPORATION
111 1	WV	OHIO POWER COMPANY
112.3	WV	CONSOLIDATION COAL COMPANY
112.6	WV	OHIO POWER COMPANY
119.7	WV	PPG INDUSTRIES, INCORPORATED
121.3	WV	MOBAY CHEMICAL CORPORATION
123.6	OH	OLIN MATHESON CHEMICAL CORPORATION
137.1	WV	SISTERSVILLE, CITY OF
145.3	WV	UNION CARBIDE COMPANY
160.6	WV	MONONGAHELA POWER COMPANY
161.9	WV	AMERICAN CYANAMID COMPANY
175.9	OH	UNION CARBIDE CORPORATION
190.5	WV	E.I. DUPONT DENEMOURS AND COMPANY

APPENDIX E

APPENDIX E

PUBLIC WATER SUPPLIES ALONG THE MAIN STEM USING GROUND WATER

RIVER MILE	PUBLIC WATER SUPPLY	STATE	AVERAGE PRODUCT GPD
89.0	MARTINS FERRY	OH	3000000
90.5	BRIDGEPORT	OH	700000
92.3	CRABAPPLE - JOE DUDEK	OH	3000
94.0	BELMONT COUNTY SANITARY DIST. 3	OH	16000000
96.0	McMECHEN MWD	WV	584000
97 5	SHADYSIDE	OH	404000
99.4	GLEN DALE MWW	WV	200000
101 7	MOUNDSVILLE	WV	1400000
109 8	POWHATEN POINT	OH	266000
117 8	CLARINGTON	OH	145000
128.2	NEW MARTINSVILLE	WV	1420000
131 0	OHIO AND LEE TOWNSHIP WA	OH	140000
133.5	PADEN CITY WW	WV	563000
142.0	MATAMORAS	OH	100000
142 6	FRIENDLY PDS	WV	56000
151 5	COLIN ANDERSON	WV	67000
155 0	ST. MARYS WATER WORKS	WV	342000
156.2	NEWPORT W&S ASSOCIATION	OH	49000
165 2	UNION WILLIAMS PSD	WV	527000
172 0	WILLIAMSTOWN	WV	164000
172.0	MARIETTA	OH	3656000
180.0	VIENNA	WV	1082000
184.5	PARKERSBURG	WV	6400000
187.0	BELPRE	OH	1043000
191.0	LUBECK PSD	WV	67000
192.0	LITTLE HOCKING WS	OH	4500
TOTAL USE OF GROUND WATER AS POTABLE WATER MGD:			24.8
TOTAL NUMBER OF PUBLIC WATER SUPPLIES:			26

APPENDIX F

OHIO RIVER VALLEY WATER SANITATION COMMISSION

TOXIC CONTROL PROGRAM

FOLLOW-UP PROGRAM FOR M.P. 85-200

- Quality Assurance Project Plan -

Signatures:

Project Coordinator, ORSANCO Valerie Brinker

QA Officer, ORSANCO Laurie A. Kadyjewski

Project Coordinator, OHIO EPA Harold E. Stackpole

Project Coordinator, WV DNR Donald G. Kain

Toxic Control Program
Final Revision
September 1987

TABLE OF CONTENTS

1. Project Description

This sampling project is designed to further identify sources of toxics in the Ohio River between Wheeling and Parkersburg, West Virginia (Mile Point 85-200). The data collected from this field study will be combined with existing data to confirm the presence and sources of toxic substances in the Ohio River. A source-specific control program to reduce toxic substances in the Ohio River will be developed based upon the information gathered in this field study and previously collected from state files.

Sampling activities will be completed in three phases: (1) ambient water quality analysis at eight main stem and 18 tributary stream locations, (2) sediment analysis at the 18 tributary streams, and (3) end-of-pipe effluent analysis at twenty-two permitted dischargers.

The ambient water quality samples will be equal depth grab samples, collected at stream quarter points for the eight main stem stations and midstream for the 18 tributary stream stations. The sediment samples will be collected midstream at each of the identified tributaries. End-of-pipe effluent sampling and analysis will be done in conjunction with the next scheduled compliance sampling inspection and consist of grab samples and/or 24-hour composite samples, when possible.

All ambient water and end-of-pipe effluent samples will be analyzed for suspended solids, alkalinity, total hardness, cyanide, volatile organics and the following metals: aluminum, arsenic, barium, chromium, cadmium, copper, iron, lead, manganese, nickel, mercury, selenium, silver, and zinc. Base/neutral fraction organics will be analyzed at one main stem water sampling location downstream of a Superfund waste site.

The sediment samples will be analyzed for metals: aluminum, arsenic, barium, chromium, cadmium, copper, iron, lead, manganese, nickel, mercury, selenium, silver, and zinc.

2. Project Organization and Responsibility

The field study is a cooperative effort by the State of West Virginia DNR, the State of Ohio EPA, and ORSANCO. ORSANCO is responsible for overall project coordination and on-site assistance. ORSANCO will provide all sample containers, preservatives, shipping materials, and field data sheets for the organic analysis. U.S. EPA-Wheeling field office will provide the sampling boat for the State of Ohio personnel. Ohio and West Virginia will provide sampling personnel as well as sample collection devices, field test equipment, and field data sheets for the inorganic parameters.

The main stem sampling locations (see attached Table 1 and Map) are divided into two sections. West Virginia is responsible for the upper section extending from Hannibal Lock and Dam to Wheeling Water Works. Ohio is responsible for the lower section extending from Willow Island Lock and Dam to Belleville Lock and Dam. Each state will sample their respective tributaries (Table 3) and targeted permitted discharges (Table 4) entering the Ohio River between M.P. 85-200.

Analysis for the inorganic parameters on the sediment and water samples will be performed by the respective collecting state's laboratory. All volatile organic (VOC) analyses will be performed by Howard Laboratory, Dayton, Ohio. Base neutral analysis of one main stem site will also be done by Howard Laboratory.

Valerie Brinker, ORSANCO, is the sampling project coordinator. Don Kain, WV DNR, is the coordinator for West Virginia and Jerry Knapp, Ohio EPA, is the coordinator for Ohio.

3. Quality Assurance Objectives

Data quality requirements are parameter specific and shall conform to

those stated in EPA approved analytical methods. Accuracy and precision criteria for each analyte can be found in Method 624 (VOCs), Method 625 (Base Neutrals), and Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020 (inorganics). All sampling and analysis procedures will be performed as outlined in this QA plan to ensure sample validity and representativeness and minimize sample loss and contamination problems.

4. Sampling Procedures

A. Main Stem Sampling

The sampling sites for the Ohio River main stem are described in Table 1. At the lock and dam locations (Hannibal, Willow Island, Belleville) the samples will be collected immediately upstream of the lock and dam, perpendicular to the river bank. At the other five sampling locations, the samples will be collected perpendicular to the identified landmark. At each site three samples will be collected, (1) the West Virginia side quarter point, (2) midstream, (3) the Ohio side quarter point. Sample numbers for each sample are shown in Table 2.

Grab samples will be collected with a pump through teflon tubing at a depth of one meter. The collection device will be flushed with river water for approximately two minutes prior to filling the sample containers. The samples collected for organic parameters will be pumped to a beaker before transfer to 2 oz. amber glass. If required, preservative is then added to the sample container.

Cleaned labeled sample bottles will be provided as follows:

Volatile Organics	- 2 oz. amber glass
Metals/Total Hardness	- 32 oz. plastic

Cyanide	- 16 oz. plastic
Alkalinity, Suspended Solids	- 16 oz. plastic
Base Neutrals	- 64 oz. glass

Bottle labels will specify analyte, date, time, river mile point, location description (WV, MID, OH) including sample number, preservatives, and collector's initials. A field sample report will also be prepared for each sampling point. Each state will use their own form (Attachments 1 and 2) and the ORSANCO form for the organic analysis (Attachment 3). Sampling personnel will record date, time, stream name, mile point, location (WV, MID, OH) and any landmarks, river and weather conditions, stream temperature, pH, conductivity, and dissolved oxygen.

Each state will provide their own field instruments for the on-site tests. The completed sample report will accompany the samples to the laboratory, and be returned with the results to ORSANCO. Samples will be iced (4°C) and transported to the laboratory within 48 hours.

B. Tributary Stream Sampling

The Ohio River tributary streams to be sampled are listed in Table 3. The streams should be sampled at a location representative of tributary flow. Where possible this will be at the first free flowing point above the mouth. Exact sampling location will be determined by state personnel in the field, and documented in the field notes. A copy of the field notes will be forwarded to ORSANCO.

At each tributary stream site grab water samples will be collected in midstream at a depth of one meter or at mid-depth when the stream depth is less than 2 meters. The sediment grab sample will be collected in the same location according to procedures provided by Ohio EPA (Attachment 4). For the State of

Ohio tributary streams, two sediment samples will be collected. One sediment sample to be sent to the contract lab for mercury analysis, the other to be sent to the state lab for metals analysis.

Cleaned, labeled bottles will be provided for water samples as described under main stem sampling procedures (Section 4A). Sediment sample containers will be 16 oz. wide mouth plastic and/or glass bottles. Field sample reports will be prepared by sampling personnel for each tributary sediment and water sample collected as described previously. Sample numbers to be assigned as shown in Table 2. Samples will be iced (4°C) and transported to the laboratory within 48 hours.

C. Discharge Sampling

Discharges selected for sampling are listed in Table 4. End-of-pipe effluent from all outfalls at each facility will be analyzed for metals and VOCs using 24 hour composites and/or grab samples. Effluent sampling and analysis will be done in conjunction with the next regularly scheduled compliance monitoring inspection or sooner if necessary.

5. Sample Custody

All pertinent information will be documented on field sample reports and sample bottle labels at the time of collection. The sample collector attests to the validity of the sample by signature on the bottle and log sheet. The log sheets are submitted with the samples to the laboratory and can be used to report the test results to ORSANCO. A chain of custody form will be used for the organic parameters and for the state laboratory samples where desired. State personnel will be responsible for transporting those samples requiring metals/hardness, cyanide, and alkalinity/suspended solids analysis. ORSANCO will be responsible for transporting the volatile organics and base neutrals water samples to the contract laboratory.

6. Analytical Procedures

Analytical Procedures

Parameter	Sample Matrix	EPA Approved Method	Sample Preservative	Hold Tir
Volatile Organics	River Water	624-GC/MS	Cool 4°C	14 d
Base Neutrals	River Water	625-GC/MS	Cool 4°C	7 d
Metals	River Water/ Sediment	200 Methods* (Atomic Absorption)	HNO_3, Cool 4°C	6 m
Cyanide	River Water	335.3*	NaOH, Cool 4°C	14 d
Alkalinity	River Water	*	Cool 4°C	28 d
Total Hardness	River Water	*	HNO_3, Cool 4°C	6 m
Suspended Solids	River Water	*	Cool 4°C	7 d

Detailed description of these analytical methods are found in:

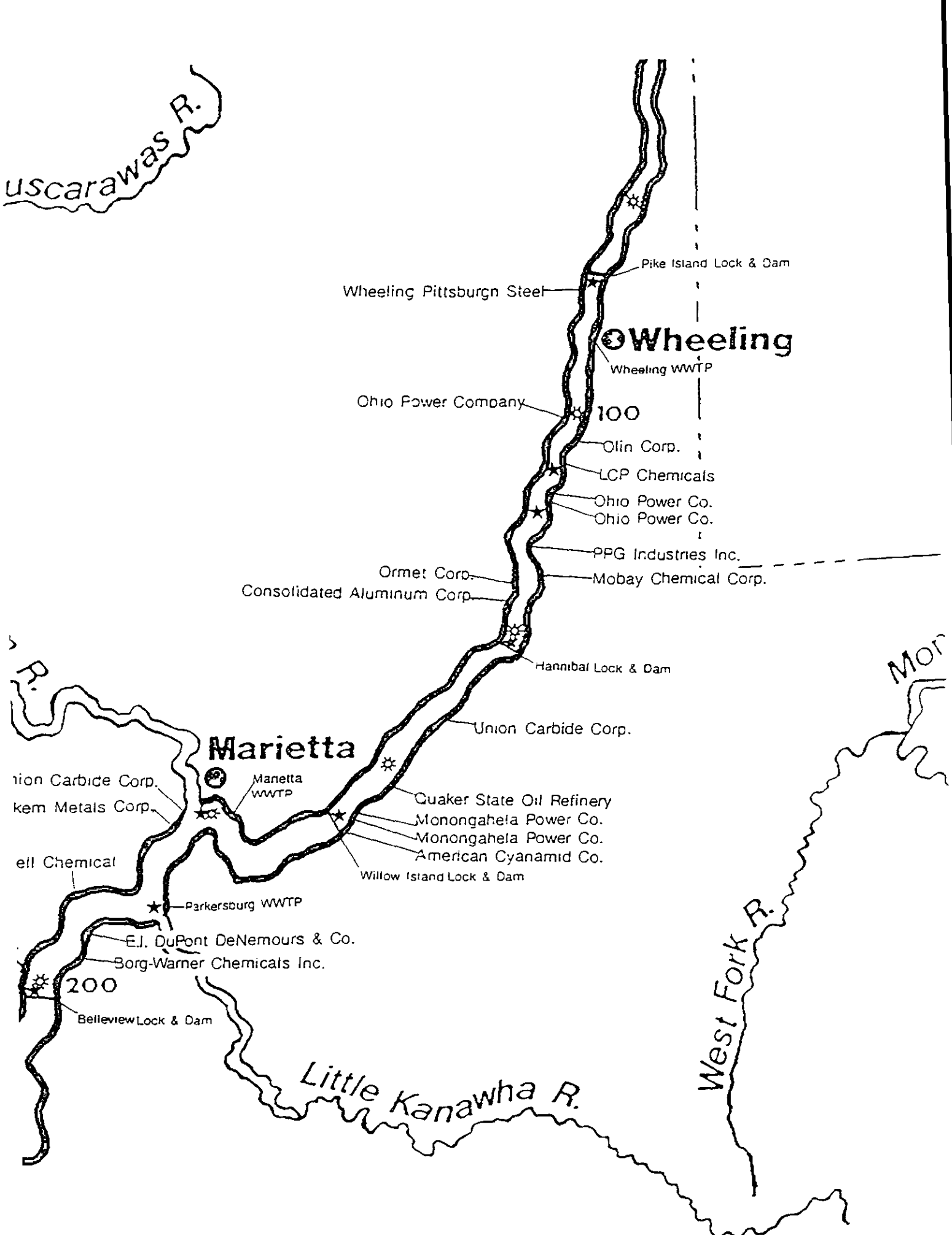
*Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020

Method 624 - Purgeables by Purge and Trap GC/MS

Method 625: Base Neutrals and Acids by GC/MS

7. Calibration Procedures and Frequency

Field instrumentation to measure pH, temperature, conductivity, and dissolved oxygen should be calibrated prior to sampling according to the manufacturer's directions. A copy of the calibration procedures will be submitted to ORSANCO. Calibration of laboratory instruments should conform to EPA protocol for the specific method used.


uscarawas R.
Pike Island Lock & Dam
Wheeling Pittsburgh Steel
Wheeling
Wheeling WWTP
Ohio Power Company
100
Olin Corp.
LCP Chemicals
Ohio Power Co.
Ohio Power Co.
PPG Industries Inc.
Ormet Corp.
Mobay Chemical Corp.
Consolidated Aluminum Corp.
Hannibal Lock & Dam
Union Carbide Corp.
Marietta
Marietta WWTP
ıion Carbide Corp.
kem Metals Corp.
ell Chemical
Quaker State Oil Refinery
Monongahela Power Co.
Monongahela Power Co.
American Cyanamid Co.
Willow Island Lock & Dam
Parkersburg WWTP
E.I. DuPont DeNemours & Co.
Borg-Warner Chemicals Inc.
200
Belleview Lock & Dam
Little Kanawha R.
West Fork R.
★ Sampling Point

10. Data Reduction, Validation and Frequency

Documentation of test results, review of calculations, and data reporting will be conducted by each laboratory according to standard operating procedures. The data will be reviewed for completeness and consistency and entered into STORET and ORSANCO's toxics data base which was established to manage all data collected on this Ohio River segment.

Modeling and statistical analysis of this data and existing data will allow identification of specific toxic pollutant sources. This identification of sources will determine the type of control program necessary to reduce toxic load to the Ohio River.

11. Corrective Action

In the field, spare sampling containers will be available in case of sample loss or contamination. State personnel are responsible for sample collection devices and test equipment supplies. In the event of unfavorable weather conditions or major conflicts with personnel scheduling, an alternative samoling date will be established.

Corrective action in the laboratory should follow established analytical operating procedures and any action taken reported to ORSANCO's project coordinator.

12. Quality Assurance Reports

A status report will be prepared by ORSANCO staff to review progress and discuss any quality assurance problems following the field sampling effort. An estimation of analytical precision and accuracy should be included in the test results reported by each laboratory. The final project report will include a summary of quality control objectives achieved during the project.

TABLE 1

-- INSTREAM SAMPLE SITES --

Mile Point	Sampling Location Description	State Responsible for Sampling
86.8	1. Wheeling Water Treatment Plant intake	West Virginia
107.0	2. Downstream of Olin and LCP Chemicals perpendicular to daymark located on West Virginia bank	West Virginia
117.4	3. Wells Bottom downstream of Quarto Mining perpendicular to daymark located on Ohio bank	West Virginia
126.4	4. Hannibal Lock & Dam*	West Virginia
161.7	5. Willow Island Lock & Dam	Ohio
171.9	6. Downstream of Buckley Island and Marietta Wastewater Treatment Plant before Muskingum R. perpendicular to Tom green light located on Ohio bank	Ohio
183.1	7. Upstream of Parkersburg Wastewater Treatment Plant and immediately below the confluence of Congress Run	Ohio
203.9	8. Belleville Lock & Dam	Ohio

*Base/neutral analysis to be completed at this site in conjunction with other analyses

TABLE 2

SAMPLE IDENTIFICATION NUMBERS

Main Stem Ohio River Sites

Number	Location
1A	Wheeling water plant 86.8 West Virginia quarter point
1B	Wheeling water plant 86.8 midstream
1C	Wheeling water plant 86.8 midstream split
1D	Wheeling water plant 86.8 Ohio quarter point
2A	Downstream of Olin/LCP 107 West Virginia quarter point
2B	Downstream of Olin/LCP 107 midstream
2C	Downstream of Olin/LCP 107 midstream split
2D	Downstream of Olin/LCP 107 Ohio quarter point
3A	Wells Bottom 117.3 West Virginia quarter point
3B	Wells Bottom 117.3 midstream
3C	Wells Bottom 117.3 midstream split
3D	Wells Bottom 117.3 Ohio quarter point
4A	Hannibal 126.4 West Virginia quarter point*
4B	Hannibal 126.4 midstream*
4C	Hannibal 126.4 midstream split
4D	Hannibal 126.4 Ohio quarter point*
5A	Willow Island 161.7 West Virginia quarter point
5B	Willow Island 161.7 midstream
5C	Willow Island 161.7 midstream split
5D	Willow Island 161.7 Ohio quarter point
6A	Buckley Island 171.9 West Virginia quarter point
6B	Buckley Island 171.9 midstream
6C	Buckley Island 171.9 midstream split
6D	Buckley Island 171.9 Ohio quarter point

*Base/neutral analysis also

TABLE 2 (Continued)

Main Stem Ohio River Sites

Number	Location
7A	Upstream of Parkersburg 183.1 West Virginia quarter point
7B	Upstream of Parkersburg 183.1 midstream
7C	Upstream of Parkersburg 183.1 midstream split
7O	Upstream of Parkersburg 183.1 Ohio quarter point
8A	Belleville 203.9 West Virginia quarter point
8B	Belleville 203.9 midstream
8C	Belleville 203.9 midstream split
8O	Belleville 203.9 Ohio quarter point

Tributary Sites

T1	Nixon Run, Ohio
T2	Wheeling Run, Ohio
T3	Wheeling Creek, West Virginia
T4	McMahon Creek, Ohio
T5	Weegee Creek, Ohio
T6	Grave Creek, West Virginia
T7	Captina Creek, Ohio
T8	Fish Creek, West Virginia
T9	Sunfish Creek, West Virginia
T10	Fishing Creek, West Virginia
T11	Middle Island Creek, West Virginia
T12	Little Muskingum River, Ohio
T13	Duck Creek, Ohio
T14	Muskingum River, Ohio
T15	Pond Run, WV
T16	Little Kanawha River, OH
T17	Little Hocking River, OH
T18	Hocking River, OH

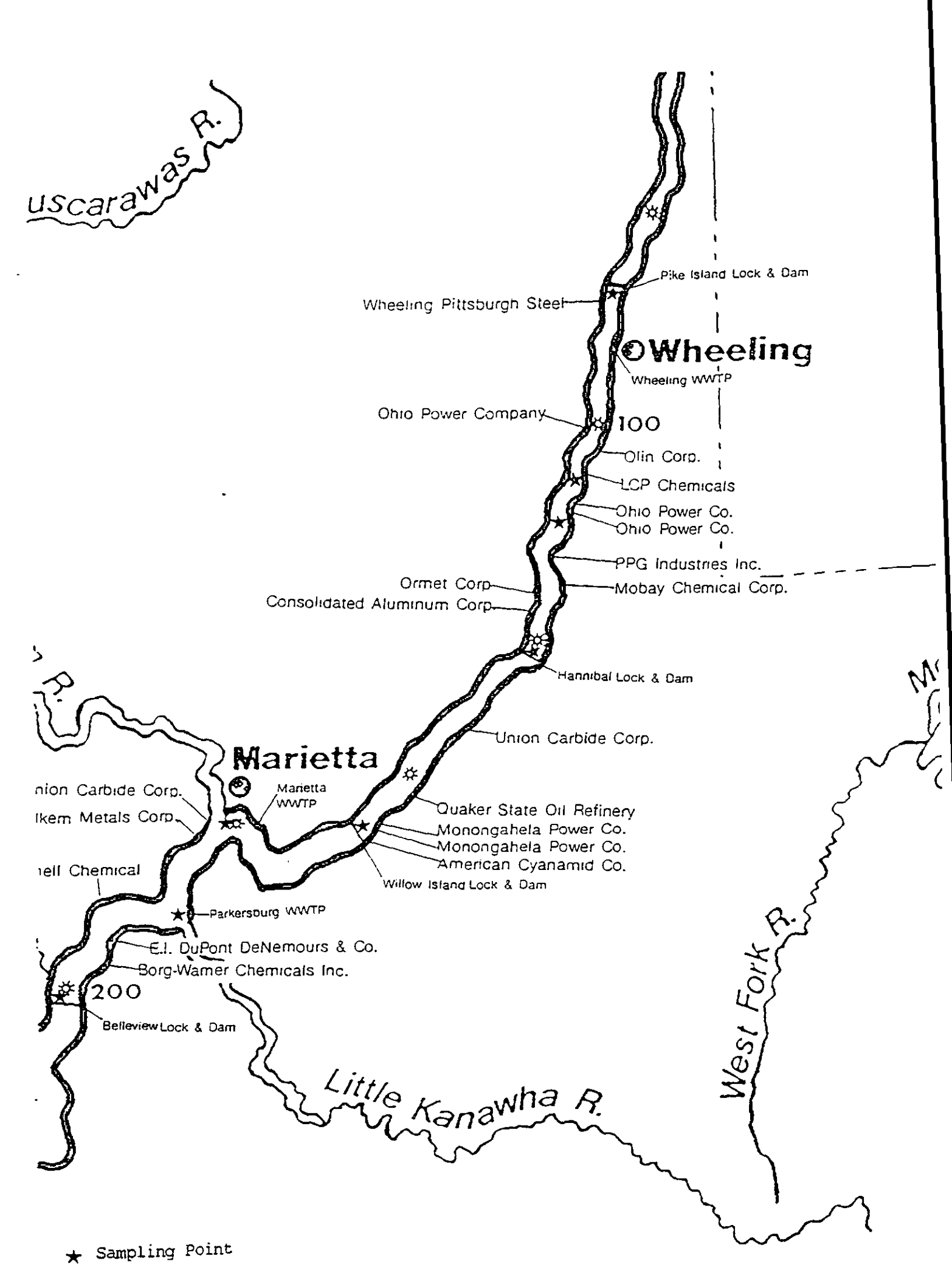

uscarawas R.
Pike Island Lock & Dam
Wheeling Pittsburgh Steel
Wheeling
Wheeling WWTP
Ohio Power Company
100
Olin Corp.
LCP Chemicals
Ohio Power Co.
Ohio Power Co.
PPG Industries Inc.
Ormet Corp
Consolidated Aluminum Corp
Mobay Chemical Corp.
Hannibal Lock & Dam
Union Carbide Corp.
Marietta
nion Carbide Corp.
Ikem Metals Corp.
Marietta WWTP
Quaker State Oil Refinery
Monongahela Power Co.
Monongahela Power Co.
American Cyanamid Co.
Willow Island Lock & Dam
ıell Chemical
Parkersburg WWTP
E.I. DuPont DeNemours & Co.
Borg-Warner Chemicals Inc.
200
Belleview Lock & Dam
Little Kanawha R.
West Fork R.
★ Sampling Point

TABLE 3

TRIBUTARY STREAMS SAMPLING SITES

Mile Point	Tributary Name
86.6	1. Nixon Run, OH
90.1	2. Wheeling Run, OH
90.7	3. Wheeling Creek, WV
94.7	4. McMahon Creek, OH
98.7	5. Weegee Creek, OH
102.4	6. Grave Creek, WV
109.5	7. Captina Creek, OH
113.8	8. Fish Creek, WV
118.0	9. Sunfish Creek, OH
128.3	10. Fishing Creek, WV
154.0	11. Middle Island Creek, WV
168.3	12. Little Muskingum River, OH
170.7	13. Duck Creek, OH
172.2	14. Muskingum River, OH
182.4	15. Pond Run, WV
184.7	16. Little Kanawha River, WV
191.8	17. Little Hocking River, OH
199.3	18. Hocking River, OH

TABLE 4

DISCHARGES TO BE SAMPLED

Facility Name	Plant	State
Wheeling Pittsburgh Steel	Martins Ferry Plant	OH
City of Wheeling	Wastewater Treatment Plant	WV
Ohio Power Company	Burger Plant	OH
Olin Corp.	Moundsville Plant	WV
LCP Chemicals	Moundsville Plant	WV
Ohio Power Co.	Kammer Plant	WV
Ohio Power Co.	Mitchell Plant	WV
PPG Industries Inc.	Natrium Plant	WV
Mobay Chemical Corp.	New Martinsville Plant	WV
Ormet Corp.	Hannibal Plant	OH
Consolidated Aluminum Corp.		OH
AMOCO Corp.	Sistersville Plant	WV
Quaker State Oil Refinery		WV
Monongahela Power Co.	Pleasant Power Station	WV
Monongahela Power Co.	Willow Island Station	WV
American Cyanamid Co.	Willow Island Facility	WV
City of Marietta	Wastewater Treatment Plant	OH
Union Carbide Corp.	Marietta Plant	OH
Elkem Metals Corp.		OH
City of Parkersburg	Wastewater Treatment Plant	WV
Shell Chemical Corp.	Marietta Plant	OH
E.I. DuPont DeNemours & Co.	Washington Works	WV
Borg-Warner Chemicals Inc.	Marbon Division	WV

W. VA. DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER RESOURCES
Analysis Request and Result Form

Permit No. _____ Outfall No _____ Sample No. _____ Lab No. _____

Facility _____ Basin _____

Sample Point Location. _____ No. of Containers _____

Sample . Water _____ Sedmt. _____ Inflnt. _____ Eff. _____

Branch/Div. _____ Program. _____ Sampler _____ Witness _____

Field Meter No.: pn _____ Cond. _____ D. O. _____ Flow _____

CHAIN OF CUSTODY

Date	Time	From (Name)	To (Name)

STORET Station No: SC. _____ ☐ Depth: D _____. (Date-Time as YYMMDDTTTT)

☐ Grab. Date-Time _____. ☐ Comp. (2) _____ _____

ANALYSIS	RESULT	✓	ANALYSIS		RESULT	✓	ANALYSIS	RESULT
00010 Temp (Water) °C			P31673, FEC. Strep./100				P929 Tot Na mg/1	
00400 pH, S.U.			P500, Total, mg/1	S			P1105 Tot. Al ug/1	
00095, Cond., umnos/cm			P70300, Dissol mg/1	O L			P1097 Tot Sb ug/1	
00300 D O, mg/1			P530, Suspend. mg/1	I O			P1002, Tot As, ug/1	
00301, D O, SAT			P505, Vol., mg/1	S			P1007, Tot Ba, ug/1	
00061, Flow, cfs			P38260, MBAS mg/1				P1027, Tot Cd, ug/1	
00058, Flow gpm			P32730, Phenols, ug/1				P1034 Tot Cr, ug/1	
70508, Acidity mg/1 (H)			P720, Cyanide, mg/1				P1042, Tot Cu, ug/1	
00435, Acidity, mg/1			P1032, Hex Cr, ug/1				P1045 Tot. Fe, ug/1	
00436, (Mineral) Acidity, mg/1			P550, Oil-Grease, mg/1				P1051, Tot Pb, ug/1	
00410, Alkalinity mg/1			P950, Fluoride mg/1				P1055, Tot Mn, ug/1	
00900 Hardness mg/1			P665, Total, mg/1	P			P71900, Tot Hg, ug/1	
00945, Sulfate, mg/1			P666 Dis., mg/1	H O			P1067, Tot Ni, ug/1	
00080, Color PT-CO U			P660 Ortho, PO_4, mg/1	S			P1147, Tot Se, ug/1	
00070, Turbidity, JCU			P625, TKN, mg/1				P1077, Tot Ag, ug/1	
00940, Chloride mg/1			P610, NH_3-N, mg/1				P1087, Tot V ug/1	
00310 BODs, mg/1			P605, ORG. -N, mg/1				P1092, Tot Zn, ug/1	
00324 BOD_{20}, mg/1			P620, NO_3-N, mg/1				P80126 BOD_5CARB, mg/1	
00335, COD mg/1			P615, NO_2-N, mg/1					
00680, TOC, mg/1			P916, Tot. Ca., mg/1					
31501, Tot Coli/100			P927, Tot. Mg, mg/1					
31616, FEC. Coli/100			P937, Tot. K, mg/1					

Chemist Review _____ Laboratory Chief Signature _____

Comments:

The sampler should note the analysis requested by placing the appropriate code for preservative used in the checked column:

1. None - determine on site
2. None
3. None iced
4. H_2SO_4 to pH ≤2 iced

(SKETCH ON BACK)

5. HNO_3/to pH≤ 2
6. NaOH to pH>12, iced
7. Sterile + .008% $Na_2S_2O_3$, iced
8. Other (specify)_____

OhioEPA DIVISION OF WASTEWATER POLLUTION CONTROL

Report – Chemistry La.

ite Received _____

ite Reported _____

ation _____

mple Type ☐ Monthly ☐ Compliance ☐ Litigation ☐ WQPA Survey ☐ Complaint ☐ B-WC Survey ☐

mple Collected By _____

port Analysis To _____
☐ NEDO ☐ NWDO ☐ SEDO ☐ SWDO ☐ CDO ☐ WQPA ☐

Laboratory Number _____

Approved By: _____ SC. ☐☐☐☐

Sample Type: Grab ☐ Composite ☐

Date & Time of Sample — Y Y M M D D H H
Begin ☐☐☐☐☐☐ ☐☐
End ☐☐☐☐☐☐ ☐☐

Frequency & Duration of Composite Sample _____

ARAMETER	STORET CODE	RESULTS	DATE ANALYZED	ANALYST	METHOD CODE
ELD EASUREMENTS					
Chlorine, Free Avl. mg/l	P50064				
Chlorine, Total Resd. mg/l	P50060				
Conductivity umhos/cm	P94				
Dissolved Oxygen mg/l	P299				
Flow CFS	P61				
pH SU	P400.				
Temperature Water °C	P10				
Gage Height ft	P65.				
ETALS					
Aluminum, Total Al, ug/l	P1105				
Arsenic, Total As ug/l	P1002				
Barium, Total Ba ug/l	P1007				
Cadmium, Total Cd ug/l	P1027				
Calcium, Total Ca, mg/l	P916				
Chromium, Hex Cr, ug/l	P1032.				
Chromium, Total Cr, ug/l	P1034				
Copper, Total Cu, ug/l	P1042				
Iron, Diss. Fe, ug/l	P1046.				
Iron, Total Fe, ug/l	P1045				
Lead, Total Pb, ug/l	P1051.				
Magnesium, Total Mg, mg/l	P927				
Manganese, Total Mn, ug/l	P1055.				
Mercury, Total Hg, ug/l	P71900.				
Nickel, Total Ni, ug/l	P1067.				
Potassium, Total K, mg/l	P937				
Selenium, Total Se, ug/l	P1147				
Silver, Total Ag, ug/l	P1077				
Sodium, Total Na, mg/l	P929.				
Strontium	P1082.				
Zinc, Total, ug/l	P1092.				

NON-METALS	STORET CODE	RESULTS	DATE ANALYZED
☐ Acidity, Total CaCO3, mg/l	P70508		
☐ Alkalinity, Total CaCO3, mg/l	P410		
☐ BOD, 5 day, mg/l	P310		
☐ cBOD, 5 Day, mg/l	P80082.		
☐ BOD, 20 Day, mg/l	P324		
☐ cBOD, 20 Day, mg/l	P80087.		
☐ MBAS, mg/l	P38260.		
☐ Carbon, Total Org., mg/l	P680		
☐ COD, mg/l	P335.		
☐ Chloride, Cl, mg/l	P940.		
☐ Conductivity at 25°C umhos/cm	P95.		
☐ Cyanide, Total, mg/l	P720.		
☐ Fluoride, F, mg/l	P951		
☐ Hardness, Total as CaCO3, mg/l	P900		
☐ Nitrate-Nitrite as N, mg/l	P620		
☐ Nitrite as N, mg/l	P615.		
☐ Nitrogen, Ammonia as N, mg/l	P610.		
☐ Nitrogen, Total Kjeldahl, mg/l	P625.		
☐ Oil and Grease, mg/l	P556.		
☐ pH, SU	P403.		
☐ Phenolics, ug/l	P32730.		
☐ Phosphorus, Diss. P, mg/l	P666.		
☐ Phosphorus, Total P, mg/l	P665.		
☐ Residue, Total, mg/l	P550.		
☐ Residue, Total Flt, mg/l	P70300.		
☐ Residue, Total Nflt, mg/l	P530.		
☐ Silica, Dissolved, mg/l	P955.		
☐ Sulfate, SO_4, mg/l	P945.		
☐			
☐			
MICROBIOLOGY			
☐ Fecal Coliform, MF, #/100 ml	P31616.		
☐ Fecal Strep, MF #/100 ml	P31679.		
☐			

PRESERVATIVES
☐ NaOH ☐ $K_2Cr_2O_7$ ☐ N/P
☐ H_2SO_4 ☐ $CuSO_4$-H_3PO_4

DISTRIBUTION: WHITE-LAB GREEN-PERMITS CANARY-STORET

mments:

PAGE | CHAIN OF CUSTODY LAB #

RCVD: DUE: KEEP: DISP:

DASH SAMPLE IDENTIFICATION LOCATION

RELEASED BY	DATE	TRANSFERRED TO	DATE	RECEIVED BY	DATE

COLLECTED BY	DATE	FIELD TIME	RATE	CHARGE

FIELD NOTES AND OBSERVATIONS:

inter-office communicati

to: Andy Turner, Chief, DWQMA, CO date: 8/4/87

from: Jerry Knapp, Group Leader, DWQMA/Surface Monitoring, SEDO

subject: SEDIMENT SAMPLING PROCEDURES, OHIO RIVER TRIBUTARIES-METHODOLOG

RECEIVED

AUG 6 1987

ORSANCO

Per your request, I am forwarding for your review, our suggeste methods for sediment sampling of selected Ohio River tributarie during our September Ohio River project (ORSANCO).

Considering that metals only will be analyzed from recovered material, it is important that no metallic instruments be used recovering same. The use of plastic or glass should be employe as not to contaminate recovered material. Storage containers should likewise not contain metal caps/seals and be composed of glass/plastic, preferably of wide mouth with at least a one pin capacity.

If the method of core sampling is employed, the top 2 inches should be considered as representative. Multiple efforts at ea site will be required in order to retrieve the desired one pint sample.

Location of characteristic material can be accomplished by use a sounding pole. A graduated, fiberglass, telescoping pole can be very useful especially when a strip of white cloth is affixe (taped) to the lower 12".

Sites most characteristic and representative of Ohio River tributaries will most often not be found at the mouth. Althoug material will be abundant, it will mearly reflect the dropout occurring in the mainstem. Tributary samples should be obtaine upstream, usually below the first upstream free flow location. case by case assessment will be required at each site. In the event that streams may be wadable, samples may be obtained directly in container. Care should be taken to remove only the representative portions (top 2").

Handling, transport and identification of collected material should include day, date, and time of collection, location by river mile, and a site description, i.e., highway number, neare bridge and site stream characteristic. The unpreserved materia should be iced (4°C) and transported for analysis within forty-eight (48) hours.

(ATTACHMENT IV)

OHIO EPA WASTEWATER CHEMISTRY LABORATORY

Sample Submission and Chain of Custody Report

Date Received (Year / Month / Day) _____

Date Reported _____

Laboratory Number(s) _____

_____

_____

Station(s) _____

Collected by _____

Date of grab sample _____

Beginning Date of Composite Sample _____

Frequency (No./24 hrs) _____

Station Code(s) _____

_____

_____

_____

Sample Type(s) ☐ Compliance ☐ Ambient ☐ Water Quality Survey ☐ Complaint ☐ Legal Action

Additional Information _____

_____

_____

_____

_____

_____

_____

Number of Samples _____

MILITARY TIME

	Year	Month	Day	Hour	Minute
Received from					
Received by					
Received from					
Received by					
Received from					
Received by					
Received from					
Received by					

EPA 4705

ATTACHMENT V

Distribution
White — Originator
Canary — Laboratory

APPENDIX G

APPENDIX G1

OHIO RIVER MAIN STEM SAMPLING
OCTOBER 19-20, 1987
(units ug/L)

ALUMINUM				CHROMIUM			
M P	OHIO	MID	WV	M.P.	OHIO	MID	WV
86 8	240	200	200	86.8	<10	<10	<10
107.0	160	280	200	107.0	<10	<10	<10
117 3	140	160	160	117.3	<10	<10	<10
126.4	200	160	240	126.4	<10	<10	<10
161 7	320	210	480	161.7	<30	<30	<30
171 9	<200	<200	<200	171 9	<30	<30	<30
183.1	250	250	<200	183.1	<30	<30	<30
204.9	340	<200	330	204.9	<30	<30	<30

ARSENIC				COPPER			
M.P.	OHIO	MID	WV	M P	OHIO	MID	WV
86.8	1 3	0 9	1 3	86.8	<10	<10	<10
107.0	1.0	0.5	1.3	107.0	<10	<10	<10
117 3	0 5	0.5	0.5	117.3	<10	<10	<10
126.4	<0.5	0 5	0 6	126.4	<10	<10	<10
161 7	<2.0	<2.0	<2.0	161.7	<30	<30	<30
171 9	<2 0	<2.0	<2.0	171.9	<30	<30	<30
183.1	<2 0	<2.0	<2 0	183.1	<30	<30	<30
204.9	<2.0	<2.0	<2 0	204.9	<30	<30	<30

BARIUM				CYANIDE			
M P	OHIO	MID	WV	M.P.	OHIO	MID	WV
86 8	1 3	0.9	1 3	86.8	<10	<10	4
107.0	1 0	0.5	1 3	107.0	<10	<10	2
117.3	0 5	0.5	0.5	117.3	<10	<10	1
126.4	<0.5	0.5	0.6	126.4	<10	<10	1
161.7	<2.0	<2.0	<2 0	161.7	<30	<30	<5
171.9	<2.0	<2.0	<2.0	171.9	<30	<30	<5
183.1	<2.0	<2.0	<2.0	183.1	<30	<30	<5
204.9	<2.0	<2.0	<2.0	204.9	<30	<30	<5

APPENDIX G1

OHIO RIVER MAIN STEM SAMPLING
OCTOBER 19-20, 1987
(units ug/L)

(Continued)

CADMIUM				HARDNESS			
M.P.	OHIO	MID	WV	M.P.	OHIO	MID	WV
86.8	<1	<1	<1	86.8	106	106	106
107.0	<1	<1	<1	107.0	114	108	114
117.3	<1	<1	<1	117 3	112	112	114
126.4	<1	<1	<1	126.4	116	120	104
161.7	<0.2	<0.2	<0.2	161.7	116	119	121
171 9	<0.2	<0.2	<0 2	171 9	114	116	119
183.1	<0.2	<0.2	<0.2	183.1	141	136	133
204.9	<0.2	<0 2	<0.2	204.9	130	136	135

IRON				ZINC			
M P.	OHIO	MID	WV	M.P.	OHIO	MID	WV
86.8	440	440	540	86.8	16	16	16
107 0	300	360	420	107.0	16	21	28
117 3	310	350	340	117.3	20	22	22
126.4	340	320	500	126.4	15	14	16
161.7	470	500	560	161.7	<10	<10	10
171.9	340	410	280	171 9	<10	<10	<10
183.1	250	250	230	183.1	<10	<10	<10
204 9'	300	300	270	204.9	<10	<10	<10

LEAD				TEMPERATURE (°C)			
M.P	OHIO	MID	WV	M.P.	OHIO	MID	WV
86.8	10	10	10	86.8	13.6	13.6	13.5
107.0	<10	<10	<10	107.0	13.9	13.9	14
117 3	10	10	10	117.3	14.3	14.3	14.2
126.4	<10	<10	10	126.4	14.1	14.1	14.2
161 7	<2	<2	<2	161.7	15	15	15
171.9	<2	<2	<2	171.9	15	15.5	15
183.1	<2	<2	<2	183.1	14 5	15	15
204.9	3	<2	<2	204.9	15	15	15

APPENDIX G1

OHIO RIVER MAIN STEM SAMPLING
OCTOBER 19-20, 1987
(units ug/L)

(Continued)

MERCURY[1]				TOTAL SUSPENDED SOLIDS (mg/L)			
M.P	OHIO	MID	WV	M.P.	OHIO	MID	WV
86.8	0.15	<0.1	<0.1	86.8		1	7
107.0	0 39	<0 1	0.1	107.0	1	4	2
117 3	0 2	0.19	0.22	117.3	2	5	8
126 4	0 1	0.1	0.11	126.4	<1	<1	1
				161.7	10	56	10
				171.9	10	10	5
				183.1	6	5	7
				204 9	6	9	7

NICKEL				SELENIUM			
M.P	OHIO	MID	WV	M.P	OHIO	MID	WV
86 8	<10	<10	10	86.8	0.5	0.5	0.5
107 0	10	10	10	107.0	0.6	<0.5	0.5
117 3	10	<10	<10	117 3	0.6	0.7	0.7
126.4	14	<10	10	126.4	1.1	1 0	0.6
161 7	<40	<40	<40	161.7	<2	<2	<2
171 9	<40	<40	<40	171 9	<2	<2	<2
183.1	<40	<40	<40	183.1	<2	<2	<2
204.9	<40	<40	<40	204.9	<2	<2	<2

[1] *NOTE: OEPA lab did not test for mercury*

TABLE G2

TRIBURARY INORGANICS DATA
OCTOBER 20-22, 1987
(Results in ug/L)

M.P	NAME	AL	AS	CD	CR	CU	FE	PB	HG	NI	ZN
86.8	NIXON RUN, OH	16900	< 2.0	< 0.2	< 30	< 10	151000	10		< 40	20
90 1	WHEELING RUN, WV	220	< 2.0	< 0.2	< 30	< 10	190	5		< 40	< 10
90 7	WHEELING CREEK, WV	100	< 0 5	< 1 0	10	4	860	16	0 51	10	8
94 7	McMAHON CREEK, OH	390	< 2.0	< 0.2	< 30	< 10	500	< 2		< 40	< 10
98.0	WEEGEE CREEK, OH	340	< 2 0	< 0.2	< 30	15	130	< 2		< 40	< 10
102.4	GRAVE CREEK, WV	260	1 0	< 1 0	< 10	4	620	12	0 24	< 10	12
109.5	CAPTINA CREEK, OH	320	< 2.0	< 0 2	< 30	< 10	210	< 2		< 40	< 25
113 8	FISH CREEK, WV	280	< 0 5	< 1 0	< 10	2	380	< 10	0 12	< 10	6
118.0	SUNFISH CREEK, OH	330	< 2.0	< 0.2	< 30	< 10	-50	< 2		< 40	< 10
128.3	FISHING CREEK, WV	260	1 4	< 1 0	10	< 2	420	< 10	0 13	10	3
154 0	MIDDLE ISLAND CREEK, WV	140	0 9	< 1.0	< 10	3	280	< 10	0 12	10	2
168.3	LITTLE MUSKINGUM R., OH	610	< 2 0	< 0.2	< 30	< 10	640	< 2		< 40	< 10
170 7	DUCK CREEK, OH	660	< 2 0	< 0.2	< 30	< 10	720	< 2		< 40	< 10
172 2	MUSKINGUM RIVER, OH										
182.4	POND RUN, WV	140	2 0	< 1 0	< 10	2	260	< 10	0 10	10	8
184 7	LITTLE KANAWHA RIVER, WV	160	< 0 5	< 1 0	< 10	2	340	< 10	0.19	< 10	5
184 7	LITTLE KANAWHA RIVER, WV	160	1 0	< 1 0	< 10	2	360	< 10	0 15	10	3
191 8	LITTLE HOCKING RIVER, OH	520	< 2 0	< 0 2	< 30	10	520	< 2		< 40	< 10
199.3	HOCKING RIVER, OH	270	< 2 0	< 0 2	< 30	< 10	290	< 2		< 40	< 10

TABLE G3

OHIO RIVER WASTEWATER DISCHARGES - WHEELING TO PARKERSBURG
INORGANICS DATA
(Results in ug/L)

M P	NAME	AL	AS	CD	CR	CU	FE	PB	HG	NI	ZN
87.8	WHEELING PITTSBURGH STEEL	3710	< 2 00	< 0.2	< 30.00	20	190	5		< 40	500
91 2	WHEELING WWTP	40	10	< 1 0	40.00	8		10	< 0.10	< 10	26
102.5	OHIO EOISON BURGER PLT 003	1930	154 00	0 9	30.00	< 10	800	3		< 40	40
104 9	OLIN CHEMICALS CORP 004	100	1 10	< 1.0	10.00	6	460	20	< 0.10	12	18
106 9	LCP CHEMICALS 001	500	1 60	< 2.5	< 25.00	< 10	1300	< 25	1 77	< 25	55
111 1	OHIO POWER CO										
	KAMMER PLT 001	3700	7 10	15 0	68.00	1460	25000	268	2.30	200	1680
	KAMMER PLT 002	240	1 40	2.0	< 10.00	8	520	< 10	0 10	< 10	20
	KAMMER PLT 003	280	1 90	< 1.0	< 10.00	7	1040	10	0 10	< 10	20
112 6	OHIO POWER CO.										
	MITCHELL PLT 001	1280	14 10	< 1.0	10 00	152	2200	12	< 0.10	10	52
	MITCHELL PLT 003	60	14 10	< 1.0	10.00	16	140	24	0.23	< 10	40
	MITCHELL PLT. 004	1000	16.90	5.8	16 00	50	2600	24	< 0.10	50	118
119 7	PPG INDUSTRIES 001	< 40	0 80	< 1.0	< 10.00	6	580	16	0 16	44	6
	PPG INDUSTRIES 002	< 40	0.30	< 1.0	< 10.00	4	50	14	< 0 10	< 10	10
	PPG INDUSTRIES 003	< 40	< 0.20	< 1.0	< 10.00	10	40	22	< 0 10	< 10	8
	PPG INDUSTRIES 004	1460	10 40	< 1 0	< 10.00	5	1800	18	0 21	< 10	46
	PPG INDUSTRIES 006	2080	2 20	< 1 0	< 10.00	24	4900	18	< 0 10	20	104
	PPG INDUSTRIES 007	2160	2 40	< 1 0	20.00	14	5000	24	0 26	36	108
	PPG INDUSTRIES 009	2100	2 40	< 2.5	< 25.00	17	5500	30	0 41	50	130
	PPG INDUSTRIES 013	180	7 00	< 1 0	< 10 00	7	180	12	0 16	< 10	46
	PPG INDUSTRIES 014	60	4 10	< 1 0	< 10 00	8	120	14	0 10	< 10	140
	PPG INOUSTRIES 015	< 100	1 60	< 2 5	< 25.00	10	2350	30	< 0 10	< 25	18
	PPG INOUSTRIES 016	40	0 50	< 1 0	10.00	2	180	14	0 13	< 10	24
121.3	MOBAY CORP 001	500	0.80	< 2.5	100.00	45	2200	35	0 10	275	60
123.5	ORMET 001	< 200	< 2.00	< 0.2	< 30.00	10	120	2		< 40	< 10
	ORMET 002	860	< 2.00	0.4	< 30.00	25	170	8		< 40	< 10
	ORMET 004	1490	6 00	< 1.0	< 30.00		3860	6		< 40	35
123.7	CONALCO 001	< 200	< 2.00	< 0.2	< 30.00	10	240	4		< 40	35
	CONALCO 001	290	< 2.00	0 3	< 30.00	20	260	< 2		< 40	25
124.7	NEW MARTINSVILLE	80	1.20	< 1 0	< 10.00	20	160	20	< 0.10	< 10	35
145.3	UNION CARBIDE										
	SISTERSVILLE 001	150	0.60	< 2.5	< 25.00	10	100	25	0.10	< 25	22
	SISTERSVILLE 002	< 100	0.50	< 2.5	< 25.00	5	150	25	0.20	< 25	10
	SISTERSVILLE 003	250	0.50	< 2.5	< 25.00	150	250	25	< 0.10	125	290

TABLE G3

OHIO RIVER WASTEWATER DISCHARGES - WHEELING TO PARKERSBURG
INORGANICS DATA
(Results in ug/L)

(Continued)

M.P.	NAME	AL	AS	CD	CR	CU	FE	PB	HG	NI	ZN
155.4	MID ATLANTIC FUELS INC. 001	120	0.20	<1.0	0.01	10	520	10	<0.10	<20	66
160.5	MONONGAHELA POWER										
	PLEASANTS 001	750	7.50	<2.5	25.00	10	1250	30	0.20	125	120
	PLEASANTS 002	60	1.30	<1.0	10.00	18	220	24	<0.10	10	88
160.6	MONONGAHELA POWER										
	WILLOW ISLAND 101	1140	5.80	<1.0	<10.00	8	1320	12	<0.10	10	38
	WILLOW ISLAND 401	50	0.50	<1.0	10.00	60	180	12	<0.10	12	68
	WILLOW ISLAND INTAKE	280		1.0	14.00	8	580	<10		10	14
161.9	AMERICAN CYANAMID										
	WILLOW ISLAND	180	1.20	<1.0		7	80	26	<0.10	120	280
171.0	MARIETTA WWTP	650	<2.00	0.5	20.1	7	840	175		<40	475
175.9	ARMCO CORP 001	240	5.00	<0.2	<30.00	<10	1880	<2		<40	25
	ARMCO CORP 002	260		<0.2	<30.00	10	1850	<2		<40	25
176.9	ELKEMS METALS 001	<200	7.00	0.4	<30.00	<10	90			<40	60
	ELKEMS METALS 002		4.00	<0.2	60.00	<10	6710	<2		<40	
	ELKEMS METALS 003	400		<0.2	120.00	<10	900	2		<40	
	ELKEMS METALS 004	420	<2.00	<0.2	<30.00	<10	1210	<2		<40	
	ELKEMS METALS 005	510	<2.00	0.4	<30.00	15	80	<2		<40	
188.7	SHELL CHEMICAL CO.										<10
	BELPRE 001	510	2.00	<0.2	<30.00	<10	670	2		<40	<10
	BELPRE 002	260	75.00	0.4	<30.00	<10	230	3		<40	35
	BELPRE 003	<200	<2.00	0.2	70.00	<10	100			50	
190.5	DUPONT WASHINGTON										
	001	60	<0.50	1.2	10.00	6	200	12	<0.10	<10	104
	002	200	0.80	3.0	16.00	20	620	60	0.25	16	46
	003	80	0.50	<1.0	<10.00	5	200	12	0.10	<10	14
	005	240	1.00	<1.0	<10.00	6	500	10	0.15	12	14
	006	200	1.30	<1.0	<10.00	4	240	10	<0.10	<10	26
	007	60	<0.50	1.0	<10.00	56	200	280	0.10	260	320
	105	60	0.50	<1.0	<10.00	4	140	<10	0.17	10	42
	INTAKE	220	0.60	1.8	10.00	4	420	10	0.10	10	18
191.5	BORG WARNER CHEMICALS 001	<100	0.50	<2.5	<25.00	10	75	55	<0.10	30	15
	BORG WARNER CHEMICALS 002	80	0.50	1.0	10.00	9	180	14	0.10	<10	17

TABLE G4

TRIBUTARY SEDIMENT SAMPLE RESULTS
OCTOBER 20-22, 1987
(Results in ug/g)

M.P	NAME	AL	AS	CD	CR	CU	FE	PB	HG	NI	ZN
86 8	NIXON RUN OH	17100	11 00	0 800	15.0	58 0	110000.0	55.0	0.24	73.0	244
90.1	WHEELING RUN OH	9260	6.90	0 392	9.0	28.0	30100.0	49 0	0 18	36.0	126
90.7	WHEELING CREEK WV	7970	20 80	<0 400	31 0	33 0	53900 0	45 0	0 23	20.0	133
94 7	McMAHON CREEK OH	12000	8.76	0.453	14.0	31.0	34100.0	46 0	0 11	33.0	130
98 0	WEEGEE CREEK OH	22700	17 50	1 400	16.0	39.0	27600.0	65.0	0 16	93.0	273
102 4	GRAVE CREEK WV	8720	26 20	<0 300	26.0	26 0	47700 0	29 0	0 22	23.0	128
109 5	CAPTINA CREEK OH	11800	5.52	0 277	17.0	26 0	24300.0	315.0	0 11	25.0	93
113 8	FISH CREEK WV	7500	12.40	<0 300	23 0	20.0	32200.0	20.0	0 25	16 0	59
118.0	SUNFISH CREEK OH	5870	6 46	0.228	14.0	23.0	22000.0	25.0	0 08	25.0	70
128 3	FISHING CREEK WV	6210	10 90	<0 400	14 0	13 0	24200.0	14.0	0.33	11.0	46
154 0	MIDDLE ISLAND CREEK WV	12300	8 40	<0 500	25.0	25.0	26000.0	24.0	0 37	20.0	85
168 3	L. MUSKINGUM RIVER OH	5710	6 90	0 256	13 2	20 0	19000.0	26.0	0 07	20.0	70
170 7	DUCK CREEK OH	5770	8 96	0.395	13.5	25.0	20400.0	27.0	0 12	38.0	113
172 2	MUSKINGUM RIVER OH			0.575 0 416	25 8 18.7	31.7 32.5	29400.0 23900 0	33.3 24 4		53.1 43 2	14 123
182.4	POND RUN WV	9340	22.40	<0.400	22.0	21 0	29400 0	35.0	0 30	18 0	88
184 7	LITTLE KANAWHA RIVER WV	7920 11480	5 80 8.30	<0 400 <0 400	17.0 27 0	13.0 27.0	13800.0 26600.0	15.0 30.0	0.25 0.31	17.0 27.0	58 105
191 8	LITTLE HOCKING RIVER OH	4680	6.75	0.197	124 0	15.0	14600.0	<21. 0	0 12	18.0	58
199 3	HOCKING RIVER OH	6630	8 39	1 010	15 0	25.0	24000.0	33.0	0 12	40.0	127

TABLE G5

FLOW DATA FROM NATIONAL WEATHER SERVICE FOR OCTOBER 15-23, 1987 WHEELING TO PARKERSBURG

ALL UNITS IN 1000 CUBIC FEET PER SECOND

DATE	WHEELING MP 86.6	HANNIBAL MP 126.4	WILLOW ISL. MP 161.8	PARKERSBURG MP 183.1	MUSKINGUM RIVER
10/15	26.4	27.7	27.6	29.6	1.9
10/16	24.0	24.9	24.7	26.4	1.7
10/17	21.9	23.3	22.6	24.3	1.6
10/18	20.2	21.3	20.8	22.5	1.6
10/19	18.1	18.9	18.6	20.9	1.6
10/20	16.5	17.0	17.1	19.8	1.6
10/21	16.9	17.2	16.4	18.8	1.7
10/22	16.1	16.6	16.6	18.2	1.2
10/23	15.8	16.2	16.9	18.5	1.6

CRITICAL FLOW: FROM MONTGOMERY DAM (M.P. 32.4) TO WILLOW ISLAND (M.P. 161.8) 5,800 CFS

FROM WILLOW ISLAND (M.P. 161.8) TO GALLIPOLIS DAM (M.P. 279.2) 6,800 CFS

TABLE G6a

SUMMARY OF ARSENIC DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988

NAME DISCHARGERS.	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	ARSENIC	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87 8	OH			<2	0.000
WHEELING WWTP	91 2	WV	234	5.69	10	0.474
OHIO EDISON BURGER 003	102 5	OH			154	0.000
OLIN CHEMICALS CORP 004	104.9	WV	328	0.526	1 1	0.005
LCP CHEMICAL 001	106 1	WV	252	12.07	1 6	0.161
LCP CHEMICAL 001	106 1	WV		12 07		0.000
OH POWER-KAMMER PLT 001	111 1	WV	604	0.005	7 1	0 000
OH POWER-KAMMER PLT 003	111 1	WV	100	648	1 4	7 557
OH POWER-KAMMER PLT 004	111 1	WV	126	5.76	1 9	0.091
OH POWER-MITCHELL PLT 001	112.6	WV	160	4 65	14 1	0 546
OH POWER-MITCHELL PLT 003	112.6	WV	584	0.0099	14 1	0 001
OH POWER-MITCHELL PLT 004	112.6	WV	426	8.2	16 9	1 154
PPG INDUSTRIES INC. 001	119 7	WV	260	0.02	0 8	0 000
PPG INDUSTRIES INC. 002	119 7	WV	234	0 95	0 3	0 002
PPG INDUSTRIES INC 003	119 7	WV	376	0 004	<0 2	<0 000
PPG INDUSTRIES INC. 004	119 7	WV	148	0 88	10 4	0 076
PPG INDUSTRIES INC 006	119 7	WV	118	75 6	2 2	1 385
PPG INDUSTRIES INC 007	119 7	WV	120	0.029	2 4	0.001
PPG INDUSTRIES INC. 009	119 7	WV	256	29.9	2 4	0 598
PPG INDUSTRIES INC. 013	119 7	WV	190	0 02	7	0.001
PPG INDUSTRIES INC 014	119 7	WV	320	0 006	4 1	0.000
PPG INDUSTRIES INC. 015	119 7	WV	240	0.036	1.6	0 000
PPG INDUSTRIES INC. 016	119 7	WV	164	0.0038	0 5	0.000
MOBAY CORP 001	121.3	WV	214	4 9	0.8	0.033
ORMET 001	123.5	OH	202		<2	0.000
ORMET 002	123.5	OH	198		<2	0.000
ORMET 004	123.5	OH	180		6	0.000
CONALCO 001	123.7	OH	123		<2	0.000
CONALCO 002	123.7	OH	214		<2	0.000

TABLE G6a

SUMMARY OF ARSENIC DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	ARSENIC	
					UG/L	#/DAY
NEW MARTINSVILLE	124.7	WV	270	0.462	1.2	0.005
UNION CARBIDE-SISTERSVILLE 001	145.3	WV	240	4.89	0.6	0.024
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1.11	0.5	0.005
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0.002	0.5	0.000
MID ATLANTIC FUELS, INC. 001	155.4	WV	264	0.35	0.196	0.001
MONONGAHELA POWER CO PLEASANTS 001	160.5	WV	874	1.26	1.26	0.078
MONONGAHELA POWER CO PLEASANTS 002	160.5	WV	406	0.01	1.3	0.000
MONONGAHELA POWER CO WILLOW ISL INTAKE	160.6	WV				0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160.6	WV	168	0.001	0.5	0.000
MONONGAHELA POWER CO WILLOW ISLAND 101	160.6	WV	170	2.3	5.8	0.111
AMERICAN CYANAMID CO WILLOW ISLAND	161.9	WV	392	3.763	1.2	0.038
MARIETTA WWTP	171.0	OH	223		<2	0.000
AMOCO CORP 001	175.9	OH	390			0.000
AMOCO CORP 001	175.9	OH			5	0.000
ELKEMS METALS 001	176.9	OH	1170		7	0.000
ELKEMS METALS 002	176.9	OH	1060		4	0.000
ELKEMS METALS 003	176.9	OH	138		<2	0.000
ELKEMS METALS 004	176.9	OH	139		<2	0.000
ELKEMS METALS 005	176.9	OH	1500			0.000
PARKERSBURG WWTP 001	183.3	WV	172	8.18	1.6	0.109
SHELL CHEMICAL CO BELPRE 001	188.7	OH	131		2	0.000
SHELL CHEMICAL CO BELPRE 002	188.7	OH	151		75	0.000
SHELL CHEMICAL CO BELPRE 003	188.7	OH	131		<2	0.000
DUPONT WASHINGTON 001	190.5	WV	126	0.046	<0.5	<0.000
DUPONT WASHINGTON 002	190.5	WV	750	8.16	0.8	0.054
DUPONT WASHINGTON 003	190.5	WV	168	2.916	0.5	0.012
DUPONT WASHINGTON 005	190.5	WV	124	14.3	1	0.119
DUPONT WASHINGTON 006	190.5	WV	96	0.004	1.3	0.000
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	<0.5	<0.000
DUPONT WASHINGTON 105	190.5	WV	76	1.7	0.5	0.005

TABLE G6a

SUMMARY OF ARSENIC DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	ARSENIC	
					UG/L	#/DAY
DUPONT WASHINGTON INTAKE	190.5	WV			0.6	0.000
BORG WARNER CHEMICALS INC. 001	191.5	WV	914	2.06	<0.5	<0.009
BORG WARNER CHEMICALS INC. 002	191.5	WV	224	1.3	0.5	0.005

ARSENIC MAIN STEM DATA. UG/L	M P.	OHIO SIDE	MID POINT	WV SIDE
WHEELING	86.8	1 3	0 9	1.3
BUTTER RUN	107 0	1.0	0.5	1 3
WELLS BOTTOM	117.3	0 5	0 5	0.5
HANNIBAL	126 4	<0.5	0.5	0.6
WILLOW ISLAND	161.7	<2.0	<2.0	<2.0
BUCKLEY ISLAND	171 9	<2.0	<2.0	<2.0
PARKERSBURG	183.1	<2.0	<2.0	<2.0
BELLEVILLE	203.9	<2.0	<2.0	<2.0

TRIBUTARY WATER DATA.	M.P.	STATE	HARDNESS (MG/L)	ARSENIC (UG/L)
NIXON RUN	86 8	OH	646	<2
WHEELING RUN	90.1	OH	1030	<2
WHEELING CREEK	90.7	WV	240	<0.5
MCMAHON CREEK	94 7	OH	515	<2
WEEGEE CREEK	98.0	OH	425	<2
GRAVE CREEK	102.4	WV	196	1
CAPTINA CREEK	109 5	OH	291	<2
FISH CREEK	113.8	WV	116	0.5
SUNFISH CREEK	118.0	WV	193	<2
FISHING CREEK	128.3	WV	94	1 4
MIDDLE ISLAND CREEK	154 0	WV	68	0 9
LITTLE MUSKINGUM RIVER	168.3	OH	121	<2
DUCK CREEK	170.7	OH	192	<2
MUSKINGUM RIVER	172.2	OH	310	109

TABLE G6a
(Continued)

TRIBUTARY WATER DATA:	M P	STATE	HARDNESS (MG/L)	ARSENIC (UG/L)
POND RUN	182.4	WV	144	2
LITTLE KANAWHA RIVER	184.6	WV	60	1
LITTLE KANAWHA RIVER	184.7	WV	70	<0.5
LITTLE HOCKING RIVER	191.8	OH	125	<2
HOCKING RIVER	199.3	OH	239	<2

ARSENIC SEDIMENT DATA	M P	STATE	ARSENIC UG/G
NIXON RUN	86.8	OH	11
WHEELING CREEK	90.1	OH	6.9
WHEELING CREEK	90.7	WV	20.8
MCMAHON CREEK	94.7	OH	8.76
WEEGEE CREEK	98.0	OH	17.5
GRAVE CREEK	102.4	WV	26.2
CAPTINA CREEK	109.5	WV	5.52
FISH CREEK	113.8	WV	12.4
SUNFISH CREEK	118.0	OH	6.46
FISHING CREEK	128.3	WV	10.9
MIDDLE ISLAND CREEK	154.0	WV	8.4
LITTLE MUSKINGUM RIVER	168.3	OH	6.9
DUCK CREEK	170.7	OH	8.96
MUSKINGUM RIVER	172.2	OH	
MUSKINGUM RIVER		OH	
POND RUN	182.4	WV	22.4
LITTLE KANAWHA RIVER	184.7	WV	5.8
LITTLE KANAWHA RIVER		WV	8.3
LITTLE HOCKING RIVER	191.8	OH	6.75
HOCKING RIVER	199.3	OH	8.39

TABLE G6b

SUMMARY OF CADMIUM DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	CADMIUM	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87.8	OH			<0.2	0.000
WHEELING WWTP	91.2	WV	234	5.69	<1	<0.047
OHIO EDISON BURGER 003	102.5	OH			0.9	0.000
OLIN CHEMICALS CORP 004	104.9	WV	328	0.526	<1	<0.004
LCP CHEMICAL 001	106.1	WV	252	12.07	<2.5	<0.251
LCP CHEMICAL 001	106.1	WV		12.07		0.000
OH POWER-KAMMER PLT 001	111.1	WV	604	0.005	15	0.001
OH POWER-KAMMER PLT 003	111.1	WV	100	648	2	10.796
OH POWER-KAMMER PLT 004	111.1	WV	126	5.76	<1	<0.048
OH POWER-MITCHELL PLT 001	112.6	WV	160	4.65	<1	<0.039
OH POWER-MITCHELL PLT 003	112.6	WV	584	0.0099	<1	<0.000
OH POWER-MITCHELL PLT 004	112.6	WV	426	8.2	5.8	0.396
PPG INDUSTRIES INC. 001	119.7	WV	260	0.02	<1	<0.000
PPG INDUSTRIES INC. 002	119.7	WV	234	0.95	<1	<0.008
PPG INDUSTRIES INC. 003	119.7	WV	376	0.004	<1	<0.000
PPG INDUSTRIES INC. 004	119.7	WV	148	0.88	<1	<0.007
PPG INDUSTRIES INC 006	119.7	WV	118	75.6	<1	<0.630
PPG INDUSTRIES INC 007	119.7	WV	120	0.029	<1	<0.000
PPG INDUSTRIES INC. 009	119.7	WV	256	29.9	<2.5	<0.623
PPG INDUSTRIES INC. 013	119.7	WV	190	0.02	<1	<0.000
PPG INDUSTRIES INC 014	119.7	WV	320	0.006	<1	<0.000
PPG INDUSTRIES INC. 015	119.7	WV	240	0.036	<2.5	<0.001
PPG INDUSTRIES INC 016	119.7	WV	164	0.0038	<1	<0.000
MOBAY CORP 001	121.3	WV	214	4.9	<2.5	<0.102
ORMET 001	123.5	OH	202		<0.2	0.000
ORMET 002	123.5	OH	198		0.4	0.000
ORMET 004	123.5	OH	180		<1	0.000
CONALCO 001	123.7	OH	123		<0.2	0.000
CONALCO 002	123.7	OH	214		0.3	0.000

TABLE G6b

SUMMARY OF CADMIUM DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS:	M.P	STATE	HARDNESS MG/L	FLOW MG/L	CADMIUM	
					UG/L	#/DAY
NEW MARTINSVILLE	124.7	WV	270	0.462	< 1	<0.004
UNION CARBIDE-SISTERSVILLE 001	145.3	WV	240	4.89	< 2.5	<0.102
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1.11	< 2.5	<0.023
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0.002	<2.5	<0.000
MID ATLANTIC FUELS, INC 001	155.4	WV	264	0.35	< 1	<0.003
MONONGAHELA POWER CO PLEASANTS 001	160.5	WV	874	1.26	< 2.5	<0.026
MONONGAHELA POWER CO PLEASANTS 002	160.5	WV	406	0.01	< 1	<0.000
MONONGAHELA POWER CO WILLOW ISL INTAKE	160.6	WV			1	0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160.6	WV	168	0.001	< 1	<0.000
MONONGAHELA POWER CO WILLOW ISLAND 101	160.6	WV	170	2.3	< 1	<0.019
AMERICAN CYANAMID CO WILLOW ISLAND	161.9	WV	392	3.763	< 1	<0.031
MARIETTA WWTP	171.0	OH	223		0.5	0.000
AMOCO CORP 001	175.9	OH	390		<0.2	0.000
AMOCO CORP 001	175.9	OH			<0.2	0.000
ELKEMS METALS 001	176.9	OH	1170		0.4	0.000
ELKEMS METALS 002	176.9	OH	1060		<0.2	0.000
ELKEMS METALS 003	176.9	OH	138		<0.2	0.000
ELKEMS METALS 004	176.9	OH	139		<0.2	0.000
ELKEMS METALS 005	176.9	OH	1500		0.4	0.000
PARKERSBURG WWTP 001	183.3	WV	172	8.18	<0	<0.068
SHELL CHEMICAL CO BELPRE 001	188.7	OH	131		<0.2	0.000
SHELL CHEMICAL CO BELPRE 002	188.7	OH	151		0.4	0.000
SHELL CHEMICAL CO BELPRE 003	188.7	OH	131		0.2	0.000
DUPONT WASHINGTON 001	190.5	WV	126	0.046	1.2	0.000
DUPONT WASHINGTON 002	190.5	WV	750	8.16	3	0.204
DUPONT WASHINGTON 003	190.5	WV	168	2.916	< 1	<0.024
DUPONT WASHINGTON 005	190.5	WV	124	14.3	< 1	<0.119
DUPONT WASHINGTON 006	190.5	WV	96	0.004	< 1	<0.000
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	1	0.000
DUPONT WASHINGTON 105	190.5	WV	76	1.7	<1	<0.014

TABLE G6b

SUMMARY OF CADMIUM DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	CADMIUM	
					UG/L	#/DAY
DUPONT WASHINGTON INTAKE	190.5	WV			1 8	0.000
BORG WARNER CHEMICALS INC. 001	191.5	WV	914	2.06	< 2.5	<0.043
BORG WARNER CHEMICALS INC 002	191 5	WV	224	1.3	1	0.011

CADMIUM MAIN STEM DATA. UG/L	M P	OHIO SIDE	MID POINT	WV SIDE
WHEELING	86.8	< 1	< 1	< 1
BUTTER RUN	107 0	< 1	< 1	< 1
WELLS BOTTOM	117 3	< 1	< 1	< 1
HANNIBAL	126.4	< 1	< 1	< 1
WILLOW ISLAND	161 7	< 0 2	< 0 2	< 0.2
BUCKLEY ISLAND	171 9	< 0 2	< 0.2	< 0 2
PARKERSBURG	183.1	< 0.2	< 0.2	< 0.2
BELLEVILLE	203.9	< 0.2	< 0.2	< 0.2

TRIBUTARY WATER DATA.	M P	STATE	HARDNESS (MG/L)	CADMIUM (UG/L)
NIXON RUN	86 8	OH	646	< 0 2
WHEELING RUN	90 1	OH	1030	< 0.2
WHEELING CREEK	90.7	WV	240	< 1
MCMAHON CREEK	94 7	OH	515	< 0.2
WEEGEE CREEK	98 0	OH	425	< 0.2
GRAVE CREEK	102.4	WV	196	< 1
CAPTINA CREEK	109.5	OH	291	< 0.2
FISH CREEK	113.8	WV	116	< 1
SUNFISH CREEK	118.0	WV	193	< 0.2
FISHING CREEK	128.3	WV	94	< 1
MIDDLE ISLAND CREEK	154.0	WV	68	< 1
LITTLE MUSKINGUM RIVER	168.3	OH	121	< 0.2
DUCK CREEK	170.7	OH	192	< 0 2
MUSKINGUM RIVER	172.2	OH	310	< 1

TABLE G6b
(Continued)

TRIBUTARY WATER DATA:	M.P.	STATE	HARDNESS (MG/L)	CADMIUM (UG/L)
POND RUN	182.4	WV	144	< 1
LITTLE KANAWHA RIVER	184 6	WV	60	< 1
LITTLE KANAWHA RIVER	184 7	WV	70	< 1
LITTLE HOCKING RIVER	191 8	OH	125	<0.2
HOCKING RIVER	199 3	OH	239	<0.2

CADMIUM SEDIMENT DATA	M.P.	STATE	CADMIUM UG/G
NIXON RUN	86 8	OH	0.8
WHEELING CREEK	90.1	OH	0.392
WHEELING CREEK	90 7	WV	<0 4
MCMAHON CREEK	94 7	OH	0 453
WEEGEE CREEK	98 0	OH	1 4
GRAVE CREEK	102 4	WV	<0 3
CAPTINA CREEK	109 5	WV	0.277
FISH CREEK	113 8	WV	<0.3
SUNFISH CREEK	118 0	OH	0.228
FISHING CREEK	128.3	WV	<0.4
MIDDLE ISLAND CREEK	154.0	WV	<0.5
LITTLE MUSKINGUM RIVER	168.3	OH	0.256
DUCK CREEK	170 7	OH	0.395
MUSKINGUM RIVER	172.2	OH	0 575
MUSKINGUM RIVER		OH	0.416
POND RUN	182.4	WV	<0.4
LITTLE KANAWHA RIVER	184.7	WV	<0.4
LITTLE KANAWHA RIVER		WV	<0.4
LITTLE HOCKING RIVER	191.8	OH	0.197
HOCKING RIVER	199.3	OH	1.01

TABLE G6c

SUMMARY OF COPPER DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988

NAME DISCHARGERS	M P	STATE	HARDNESS MG/L	FLOW MG/L	COPPER	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87.8	OH			20	0.000
WHEELING WWTP	91.2	WV	234	5.69	8	0.379
OHIO EDISON BURGER 003	102.5	OH			<10	0.000
OLIN CHEMICALS CORP 004	104 9	WV	328	0 526	6	0 026
LCP CHEMICAL 001	106.1	WV	252	12.07	<10	<1 005
LCP CHEMICAL 001	106 1	WV		12 07		0 000
OH POWER-KAMMER PLT 001	111 1	WV	604	0 005	460	0.061
OH POWER-KAMMER PLT 003	111 1	WV	100	648	8	43.183
OH POWER-KAMMER PLT 004	111 1	WV	126	5.76	7	0 336
OH POWER-MITCHELL PLT 001	112 6	WV	160	4 65	152	5.888
OH POWER-MITCHELL PLT 003	112 6	WV	584	0 0099	16	0.001
OH POWER-MITCHELL PLT 004	112.6	WV	426	8 2	50	3.415
PPG INDUSTRIES INC. 001	119 7	WV	260	0 02	6	0.001
PPG INDUSTRIES INC. 002	119 7	WV	234	0.95	4	0 032
PPG INDUSTRIES INC. 003	119 7	WV	376	0 004	10	0.000
PPG INDUSTRIES INC 004	119 7	WV	148	0 88	5	0.037
PPG INDUSTRIES INC 006	119 7	WV	118	75 6	24	15.114
PPG INDUSTRIES INC 007	119 7	WV	120	0 029	14	0.003
PPG INDUSTRIES INC. 009	119.7	WV	256	29 9	17	4 234
PPG INDUSTRIES INC 013	119.7	WV	190	0.02	7	0.001
PPG INDUSTRIES INC. 014	119 7	WV	320	0.006	8	0.000
PPG INDUSTRIES INC. 015	119 7	WV	240	0.036	10	0.003
PPG INDUSTRIES INC 016	119 7	WV	164	0 0038	2	0.000
MOBAY CORP 001	121 3	WV	214	4 9	45	1.837
ORMET 001	123.5	OH	202		10	0.000
ORMET 002	123.5	OH	198		25	0.000
ORMET 004	123.5	OH	180			0.000
CONALCO 001	123.7	OH	123		10	0.000
CONALCO 002	123.7	OH	214		20	0.000

TABLE G6c

SUMMARY OF COPPER DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS.	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	COPPER	
					UG/L	#/DAY
NEW MARTINSVILLE	124 7	WV	270	0.462	20	0.077
UNION CARBIDE-SISTERSVILLE 001	145 3	WV	240	4 89	10	0 407
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1 11	5	0.046
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0.002	150	0.002
MID ATLANTIC FUELS, INC. 001	155.4	WV	264	0.35	10	0.029
MONONGAHELA POWER CO PLEASANTS 001	160.5	WV	874	1.26	10	0 105
MONONGAHELA POWER CO PLEASANTS 002	160.5	WV	406	0 01	18	0.001
MONONGAHELA POWER CO WILLOW ISL INTAKE	160.6	WV			8	0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160.6	WV	168	0.001	60	0.000
MONONGAHELA POWER CO WILLOW ISLAND 101	160.6	WV	170	2.3	8	0.153
AMERICAN CYANAMID CO WILLOW ISLAND	161.9	WV	392	3.763	7	0.219
MARIETTA WWTP	171.0	OH	223		<30	0.000
AMOCO CORP 001	175.9	OH	390		< 10	0.000
AMOCO CORP 001	175.9	OH			10	0.000
ELKEMS METALS 001	176.9	OH	1170		< 10	0.000
ELKEMS METALS 002	176 9	OH	1060		< 10	0.000
PARKERSBURG WWTP 001	183.3	WV	172	8.18	15	1.022
SHELL CHEMICAL CO BELPRE 001	188 7	OH	131		< 10	0 000
SHELL CHEMICAL CO . BELPRE 002	188.7	OH	151		< 10	0.000
SHELL CHEMICAL CO . BELPRE 003	188.7	OH	131		< 10	0.000
DUPONT WASHINGTON 001	190.5	WV	126	0.046	6	0.002
DUPONT WASHINGTON 002	190.5	WV	750	8.16	20	1 359
DUPONT WASHINGTON 003	190.5	WV	168	2 916	5	0.121
DUPONT WASHINGTON 005	190 5	WV	124	14 3	6	0.715
DUPONT WASHINGTON 006	190.5	WV	96	0.004	4	0.000
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	56	0.000
DUPONT WASHINGTON 105	190.5	WV	76	1 7	4	0 057
DUPONT WASHINGTON INTAKE	190.5	WV			4	0.000
BORG WARNER CHEMICALS INC 001	191.5	WV	914	2.06	10	0.172
BORG WARNER CHEMICALS INC 002	191.5	WV	224	1.3	9	0.097

TABLE G6c
(Continued)

COPPER SEDIMENT DATA	M.P.	STATE	COPPER UG/G
NIXON RUN	86.8	OH	58
WHEELING CREEK	90.1	OH	28
WHEELING CREEK	90.7	WV	33
MCMAHON CREEK	94.7	OH	31
WEEGEE CREEK	98.0	OH	39
GRAVE CREEK	102.4	WV	26
CAPTINA CREEK	109.5	WV	26
FISH CREEK	113.8	WV	20
SUNFISH CREEK	118.0	OH	23
FISHING CREEK	128.3	WV	13
MIDDLE ISLAND CREEK	154.0	WV	25
LITTLE MUSKINGUM RIVER	168.3	OH	20
DUCK CREEK	170.7	OH	25
MUSKINGUM RIVER	172.2	OH	31.7
MUSKINGUM RIVER		OH	32.5
POND RUN	182.4	WV	21
LITTLE KANAWHA RIVER	184.7	WV	13
LITTLE KANAWHA RIVER		WV	27
LITTLE HOCKING RIVER	191.8	OH	15
HOCKING RIVER	199.3	OH	25

TABLE G6c (cont.)

COPPER MAIN STEM DATA: UG/L	M P.	OHIO SIDE	MID POINT	WV SIDE
WHEELING	86.8	4	4	4
BUTTER RUN	107 0	4	4	3
WELLS BOTTOM	117.3	3	4	4
HANNIBAL	126.4	4	3	4
WILLOW ISLAND	161 7	< 10	< 10	< 10
BUCKLEY ISLAND	171 9	< 10	< 10	< 10
PARKERSBURG	183.1	< 10	< 10	< 10
BELLEVILLE	203 9	< 10	< 10	< 10

TRIBUTARY WATER DATA	M P	STATE	HARDNESS (MG/L)	COPPER (UG/L)
NIXON RUN	86.8	OH	646	< 10
WHEELING RUN	90 1	OH	1030	< 10
WHEELING CREEK	90 7	WV	240	4
MCMAHON CREEK	94 7	OH	515	< 10
WEEGEE CREEK	98.0	OH	425	15
GRAVE CREEK	102.4	WV	196	4
CAPTINA CREEK	109 5	OH	291	< 10
FISH CREEK	113 8	WV	116	2
SUNFISH CREEK	118.0	WV	193	< 10
FISHING CREEK	128.3	WV	94	< 2
MIDDLE ISLAND CREEK	154 0	WV	68	3
LITTLE MUSKINGUM RIVER	168.3	OH	121	< 10
DUCK CREEK	170.7	OH	192	< 10
MUSKINGUM RIVER	172.2	OH	310	7
POND RUN	182 4	WV	144	7
LITTLE KANAWHA RIVER	184.6	WV	60	2
LITTLE KANAWHA RIVER	184.7	WV	70	2
LITTLE HOCKING RIVER	191.8	OH	125	10
HOCKING RIVER	199.3	OH	239	< 10

TABLE G6d

SUMMARY OF CYANIDE DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988

NAME DISCHARGERS.	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	CYANIDE	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87.8	OH			42	0.000
WHEELING WWTP	91 2	WV	234	5 69	29	1.375
OHIO EDISON BURGER 003	102.5	OH			< 5	0.000
OLIN CHEMICALS CORP 004	104.9	WV	328	0.526	26	0.009
LCP CHEMICAL 001	106.1	WV	252	12 07	< 1	<0.101
LCP CHEMICAL 001	106.1	WV		12.07		0.000
OH POWER-KAMMER PLT 001	111 1	WV	604	0.005	6	0.000
OH POWER-KAMMER PLT 003	111 1	WV	100	648	5	26.989
OH POWER-KAMMER PLT 004	111.1	WV	126	5 76		0 000
OH POWER-MITCHELL PLT 001	112.6	WV	160	4 65	23	0.891
OH POWER-MITCHELL PLT 003	112.6	WV	584	0 0099	6	0 000
OH POWER-MITCHELL PLT 004	112 6	WV	426	8 2	1	0.068
PPG INDUSTRIES INC 001	119.7	WV	260	0 02	1	0.000
PPG INDUSTRIES INC. 002	119 7	WV	234	0 95	1	0.008
PPG INDUSTRIES INC 003	119 7	WV	376	0.004	< 1	<0.000
PPG INDUSTRIES INC. 004	119 7	WV	148	0 88	4	0.029
PPG INDUSTRIES INC 006	119 7	WV	118	75.6	4	2.519
PPG INDUSTRIES INC. 007	119 7	WV	120	0 029	5	0.001
PPG INDUSTRIES INC. 009	119.7	WV	256	29.9	3	0 747
PPG INDUSTRIES INC. 013	119.7	WV	190	0.02	16	0.003
PPG INDUSTRIES INC 014	119.7	WV	320	0 006	2	0 000
PPG INDUSTRIES INC. 015	119 7	WV	240	0.036	2	0.001
PPG INDUSTRIES INC. 016	119 7	WV	164	0 0038	3	0.000
MOBAY CORP. 001	121.3	WV	214	4 9	49	2.000
ORMET 001	123.5	OH	202		107	0.000
ORMET 002	123.5	OH	198		78	0.000
ORMET 004	123.5	OH	180		2230	0.000
CONALCO 001	123.7	OH	123		< 5	0.000
CONALCO 002	123.7	OH	214		11	0.000

TABLE G6d

SUMMARY OF CYANIDE DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS.	M.P	STATE	HARDNESS MG/L	FLOW MG/L	CYANIDE	
					UG/L	#/DAY
NEW MARTINSVILLE	124.7	WV	270	0.462	5	0.019
UNION CARBIDE-SISTERSVILLE 001	145.3	WV	240	4 89	<0.001	<0.000
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1 11	0.002	0.000
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0.002	<0.001	<0.000
MID ATLANTIC FUELS. INC 001	155 4	WV	264	0 35	0 01	0.000
MONONGAHELA POWER CO PLEASANTS 001	160 5	WV	874	1 26	4	0.042
MONONGAHELA POWER CO PLEASANTS 002	160 5	WV	406	0 01	4	0 000
MONONGAHELA POWER CO WILLOW ISL INTAKE	160 6	WV				0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160.6	WV	168	0.001	13	0.000
MONONGAHELA POWER CO WILLOW ISLAND 101	160 6	WV	170	2 3	3	0 057
AMERICAN CYANAMID CO WILLOW ISLAND	161.9	WV	392	3.763	0.215	0.007
MARIETTA WWTP	171.0	OH	223		14	0 000
AMOCO CORP 001	175.9	OH	390		<5	0.000
AMOCO CORP 001	175.9	OH				0.000
ELKEMS METALS 001	176 9	OH	1170		15	0.000
ELKEMS METALS 002	176 9	OH	1060		<5	0.000
ELKEMS METALS 003	176 9	OH	138		<5	0.000
ELKEMS METALS 004	176.9	OH	139		<5	0.000
ELKEMS METALS 005	176.9	OH	1500		<5	0.000
PARKERSBURG WWTP 001	183.3	WV	172	8.18		0.000
SHELL CHEMICAL CO.. BELPRE 001	188.7	OH	131		<5	0.000
SHELL CHEMICAL CO.. BELPRE 002	188.7	OH	151		<5	0 000
SHELL CHEMICAL CO.. BELPRE 003	188.7	OH	131		<5	0.000
DUPONT WASHINGTON 001	190.5	WV	126	0.046	2	0.001
DUPONT WASHINGTON 002	190.5	WV	750	8.16	2	0.136
DUPONT WASHINGTON 003	190.5	WV	168	2.916	3	0.073
DUPONT WASHINGTON 005	190.5	WV	124	14.3	9	0.072
DUPONT WASHINGTON 006	190.5	WV	96	0.004	<1	<0.000
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	<1	<0.000
DUPONT WASHINGTON 105	190.5	WV	76	1.7	26	0.368
DUPONT WASHINGTON INTAKE	190.5	WV			2	0.000

TABLE G6d

SUMMARY OF CYANIDE DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS.	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	CYANIDE	
					UG/L	#/DAY
BORG WARNER CHEMICALS INC. 001	191.5	WV	914	2.06	42	0.721
BORG WARNER CHEMICALS INC. 002	191.5	WV	224	1.3	3	0.032

CYANIDE MAIN STEM DATA UG/L	M.P.	OHIO SIDE	MID POINT	WV SIDE
WHEELING	96.8	3	4	4
BUTTER RUN	97.0	2	2	2
WELLS BOTTOM	117.3	2	2	1
HANNIBAL	126.4	< 1	2	1
WILLOW ISLAND	161.7	< 5	< 5	< 5
BUCKLEY ISLAND	171.9	< 5	< 5	< 5
PARKERSBURG	183.1	< 5	< 5	< 5
BELLEVILLE	203.9	< 5	< 5	< 5

TRIBUTARY WATER DATA	M.P.	STATE	HARDNESS (MG/L)	CYANIDE (UG/L)
NIXON RUN	86.8	OH	646	< 5
WHEELING RUN	90.1	OH	1030	< 5
WHEELING CREEK	90.7	WV	240	< 1
MCMAHON CREEK	94.7	OH	515	< 5
WEEGEE CREEK	98.0	OH	425	< 5
GRAVE CREEK	102.4	WV	196	< 1
CAPTINA CREEK	109.5	OH	291	< 5
FISH CREEK	113.8	WV	116	< 1
SUNFISH CREEK	118.0	WV	193	< 5
FISHING CREEK	128.3	WV	94	< 1
MIDDLE ISLAND CREEK	154.0	WV	68	< 1
LITTLE MUSKINGUM RIVER	168.3	OH	121	< 5
DUCK CREEK	170.7	OH	192	< 5
MUSKINGUM RIVER	172.2	OH	310	< 1
POND RUN	182.4	WV	144	1

TABLE G6d
(Continued)

TRIBUTARY WATER DATA:	M.P.	STATE	HARDNESS (MG/L)	CYANIDE (UG/L)
LITTLE KANAWHA RIVER	184.6	WV	60	< 1
LITTLE KANAWHA RIVER	184.7	WV	70	< 1
LITTLE HOCKING RIVER	191.8	OH	125	< 5
HOCKING RIVER	199.3	OH	239	< 5

TABLE G6e

SUMMARY OF LEAD DATA
FROM INTENSIVE FIELD STUDY
OCTOBER 20-22, 1988

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	LEAD	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87.8	OH			5	0.000
WHEELING WWTP	91.2	WV	234	5.69	10	0.474
OHIO EDISON BURGER 003	102.5	OH			3	0.000
OLIN CHEMICALS CORP 004	104.9	WV	328	0.526	20	0.088
LCP CHEMICAL 001	106.1	WV	252	12.07	<25	<2.514
LCP CHEMICAL 001	106.1	WV		12.07		0.000
OH POWER-KAMMER PLT 001	111.1	WV	604	0.005	268	0.011
OH POWER-KAMMER PLT 003	111.1	WV	100	648	<10	<53.978
OH POWER-KAMMER PLT 004	111.1	WV	126	5.76	10	0.480
OH POWER-MITCHELL PLT 001	112.6	WV	160	4.65	12	0.465
OH POWER-MITCHELL PLT 003	112.6	WV	584	0.0099	24	0.002
OH POWER-MITCHELL PLT 004	112.6	WV	426	8.2	24	1.639
PPG INDUSTRIES INC. 001	119.7	WV	260	0.02	16	0.003
PPG INDUSTRIES INC. 002	119.7	WV	234	0.95	14	0.111
PPG INDUSTRIES INC. 003	119.7	WV	376	0.004	22	0.001
PPG INDUSTRIES INC. 004	119.7	WV	148	0.88	18	0.132
PPG INDUSTRIES INC 006	119.7	WV	118	75.6	18	11.335
PPG INDUSTRIES INC 007	119.7	WV	120	0.029	24	0.006
PPG INDUSTRIES INC. 009	119.7	WV	256	29.9	30	7.472
PPG INDUSTRIES INC 013	119.7	WV	190	0.02	12	0.002
PPG INDUSTRIES INC. 014	119.7	WV	320	0.006	14	0.001
PPG INDUSTRIES INC 015	119.7	WV	240	0.036	30	0.009
PPG INDUSTRIES INC. 016	119.7	WV	164	0.0038	14	0.000
MOBAY CORP. 001	121.3	WV	214	4.9	35	1.429
ORMET 001	123.5	OH	202		2	0.000
ORMET 002	123.5	OH	198		8	0.000
ORMET 004	123.5	OH	180		6	0.000
CONALCO 001	123.7	OH	123		4	0.000
CONALCO 002	123.7	OH	214		<2	0.000

TABLE G6e

SUMMARY OF LEAD DATA
FROM INTENSIVE FIELD STUDY
OCTOBER 20-22, 1988
(Continued)

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	LEAD	
					UG/L	#/DAY
NEW MARTINSVILLE	124.7	WV	270	0.462	20	0.077
UNION CARBIDE-SISTERSVILLE 001	145.3	WV	240	4.89	25	1.018
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1.11	25	0.231
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0 002	25	0.000
MID ATLANTIC FUELS, INC 001	155 4	WV	264	0.35	18	0.052
MONONGAHELA POWER CO PLEASANTS 001	160.5	WV	874	1 26	30	0.315
MONONGAHELA POWER CO PLEASANTS 002	160.5	WV	406	0 01	24	0 002
MONONGAHELA POWER CO WILLOW ISL INTAKE	160.6	WV			< 10	0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160.6	WV	168	0 001	12	0.000
MONONGAHELA POWER CO WILLOW ISLAND 101	160 6	WV	170	2.3	12	0.230
AMERICAN CYANAMID CO WILLOW ISLAND	161.9	WV	392	3.763	26	0.815
MARIETTA WWTP	171.0	OH	223		840	0 000
AMOCO CORP. 001	175.9	OH	390		<2	0.000
AMOCO CORP 001	175.9	OH			<2	0.000
ELKEMS METALS 001	176.9	OH	1170			0.000
PARKERSBURG WWTP 001	183.3	WV	172	8.18	16	1.090
SHELL CHEMICAL CO BELPRE 001	188.7	OH	131		2	0.000
SHELL CHEMICAL CO BELPRE 002	188.7	OH	151		3	0.000
SHELL CHEMICAL CO BELPRE 003	188.7	OH	131			0.000
DUPONT WASHINGTON 001	190.5	WV	126	0 046	12	0.005
DUPONT WASHINGTON 002	190.5	WV	750	8.16	60	4 078
DUPONT WASHINGTON 003	190.5	WV	168	2.916	12	0.291
DUPONT WASHINGTON 005	190.5	WV	124	14.3	10	1.191
DUPONT WASHINGTON 006	190.5	WV	96	0.004	10	0.000
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	280	0.002
DUPONT WASHINGTON 105	190.5	WV	76	1.7	< 10	<0.142
DUPONT WASHINGTON INTAKE	190.5	WV			10	0.000
BORG WARNER CHEMICALS INC. 001	191.5	WV	914	2.06	55	0.944
BORG WARNER CHEMICALS INC. 002	191.5	WV	224	1.3	14	0.152

TABLE G6e
(Continued)

LEAD MAIN STEM DATA: UG/L	M.P	OHIO SIDE	MID POINT	WV SIDE
WHEELING	86.8	10	10	10
BUTTER RUN	107.0	< 10	< 10	< 10
WELLS BOTTOM	117.3	10	10	10
HANNIBAL	126.4	< 10	< 10	10
WILLOW ISLAND	161.7	< 2	< 2	< 2
BUCKLEY ISLAND	171.9	< 2	< 2	< 2
PARKERSBURG	183.1	< 2	< 2	< 2
BELLEVILLE	203.9	3	< 2	< 2

TRIBUTARY WATER DATA	M.P.	STATE	HARDNESS (MG/L)	LEAD (UG/L)
NIXON RUN	86.8	OH	646	10
WHEELING RUN	90.1	OH	1030	5
WHEELING CREEK	90.7	WV	240	16
MCMAHON CREEK	94.7	OH	515	< 2
WEEGEE CREEK	98.0	OH	425	< 2
GRAVE CREEK	102.4	WV	196	12
CAPTINA CREEK	109.5	OH	291	< 2
FISH CREEK	113.8	WV	116	< 10
SUNFISH CREEK	118.0	WV	193	< 2
FISHING CREEK	128.3	WV	94	< 10
MIDDLE ISLAND CREEK	154.0	WV	68	< 10
LITTLE MUSKINGUM RIVER	168.3	OH	121	< 2
DUCK CREEK	170.7	OH	192	< 2
MUSKINGUM RIVER	172.2	OH	310	20
POND RUN	182.4	WV	144	< 10
LITTLE KANAWHA RIVER	184.6	WV	60	< 10
LITTLE KANAWHA RIVER	184.7	WV	70	< 10
LITTLE HOCKING RIVER	191.8	OH	125	< 2
HOCKING RIVER	199.3	OH	239	< 2

TABLE G6e
(Continued)

LEAD SEDIMENT DATA	M.P.	STATE	LEAD UG/G
NIXON RUN	86.8	OH	55
WHEELING CREEK	90.1	OH	49
WHEELING CREEK	90.7	WV	45
MCMAHON CREEK	94.7	OH	46
WEEGEE CREEK	98.0	OH	65
GRAVE CREEK	102.4	WV	29
CAPTINA CREEK	109.5	WV	315
FISH CREEK	113.8	WV	20
SUNFISH CREEK	118.0	OH	25
FISHING CREEK	128.3	WV	14
MIDDLE ISLAND CREEK	154.0	WV	24
LITTLE MUSKINGUM RIVER	168.3	OH	26
DUCK CREEK	170.7	OH	27
MUSKINGUM RIVER	172.2	OH	33.3
MUSKINGUM RIVER		OH	24.4
POND RUN	182.4	WV	35
LITTLE KANAWHA RIVER	184.7	WV	15
LITTLE KANAWHA RIVER		WV	30
LITTLE HOCKING RIVER	191.8	OH	<21
HOCKING RIVER	199.3	OH	33

TABLE G6f

SUMMARY OF MERCURY DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	MERCURY	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87.8	OH				0.000
WHEELING WWTP	91.2	WV	234	5.69	<0.1	<0.005
OHIO EDISON BURGER 003	102.5	OH				0.000
OLIN CHEMICALS CORP 004	104.9	WV	328	0.526	<0.1	<0.000
LCP CHEMICAL 001	106.1	WV	252	12.07	1.77	0.178
LCP CHEMICAL 001	106.1	WV		12.07	1.55	0.156
OH POWER-KAMMER PLT 001	111.1	WV	604	0.005	2.3	0.000
OH POWER-KAMMER PLT 003	111.1	WV	100	648	0.1	0.540
OH POWER-KAMMER PLT 004	111.1	WV	126	5.76	0.1	0.005
OH POWER-MITCHELL PLT 001	112.6	WV	160	4.65	<0.1	<0.004
OH POWER-MITCHELL PLT 003	112.6	WV	584	0.0099	0.23	0.000
OH POWER-MITCHELL PLT 004	112.6	WV	426	8.2	<0.1	<0.007
PPG INDUSTRIES INC. 001	119.7	WV	260	0.02	0.16	0.000
PPG INDUSTRIES INC. 002	119.7	WV	234	0.95	<0.1	<0.001
PPG INDUSTRIES INC. 003	119.7	WV	376	0.004	<0.1	<0.000
PPG INDUSTRIES INC 004	119.7	WV	148	0.88	0.21	0.002
PPG INDUSTRIES INC. 006	119.7	WV	118	75.6	<0.1	<0.063
PPG INDUSTRIES INC. 007	119.7	WV	120	0.029	0.26	0.000
PPG INDUSTRIES INC 009	119.7	WV	256	29.9	0.41	0.102
PPG INDUSTRIES INC. 013	119.7	WV	190	0.02	0.16	0.000
PPG INDUSTRIES INC. 014	119.7	WV	320	0.006	<0.1	<0.000
PPG INDUSTRIES INC. 015	119.7	WV	240	0.036	<0.1	<0.000
PPG INDUSTRIES INC. 016	119.7	WV	164	0.0038	0.13	0.000
MOBAY CORP. 001	121.3	WV	214	4.9	<0.1	<0.004
ORMET 001	123.5	OH	202			0.000
ORMET 002	123.5	OH	198			0.000
ORMET 004	123.5	OH	180			0.000
CONALCO 001	123.7	OH	123			0.000
CONALCO 002	123.7	OH	214			0.000

TABLE G6f

SUMMARY OF MERCURY DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	MERCURY	
					UG/L	#/DAY
NEW MARTINSVILLE	124.7	WV	270	0.462	<0.1	<0.000
UNION CARBIDE-SISTERSVILLE 001	145.3	WV	240	4.89	0.1	0.004
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1.11	0.2	0.002
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0.002	<0.1	<0.000
MID ATLANTIC FUELS, INC. 001	155.4	WV	264	0.35	<0.1	<0.000
MONONGAHELA POWER CO PLEASANTS 001	160.5	WV	874	1.26	0.2	0.002
MONONGAHELA POWER CO PLEASANTS 002	160.5	WV	406	0.01	<0.1	<0.000
MONONGAHELA POWER CO WILLOW ISL INTAKE	160.6	WV				0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160.6	WV	168	0.001	<0.1	<0.000
MONONGAHELA POWER CO WILLOW ISLAND 101	160.6	WV	170	2.3	<0.1	<0.002
AMERICAN CYANAMID CO WILLOW ISLAND	161.9	WV	392	3.763	<0.1	<0.003
MARIETTA WWTP	171.0	OH	223		175	0.000
AMOCO CORP 001	175.9	OH	390			0.000
AMOCO CORP 001	175.9	OH				0.000
ELKEMS METALS 001	176.9	OH	1170			0.000
ELKEMS METALS 002	176.9	OH	1060			0.000
ELKEMS METALS 003	176.9	OH	138			0.000
ELKEMS METALS 004	176.9	OH	139			0.000
ELKEMS METALS 005	176.9	OH	1500			0.000
PARKERSBURG WWTP 001	183.3	WV	172	8.18	<0.1	<0.007
SHELL CHEMICAL CO., BELPRE 001	188.7	OH	131			0.000
SHELL CHEMICAL CO., BELPRE 002	188.7	OH	151			0.000
SHELL CHEMICAL CO., BELPRE 003	188.7	OH	131			0.000
DUPONT WASHINGTON 001	190.5	WV	126	0.046	<0.1	<0.000
DUPONT WASHINGTON 002	190.5	WV	750	8.16	0.25	0.017
DUPONT WASHINGTON 003	190.5	WV	168	2.916	0.1	0.002
DUPONT WASHINGTON 005	190.5	WV	124	14.3	0.15	0.018
DUPONT WASHINGTON 006	190.5	WV	96	0.004	<0.1	<0.000
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	0.1	0.000
DUPONT WASHINGTON 105	190.5	WV	76	1.7	0.17	0.002
DUPONT WASHINGTON INTAKE	190.5	WV			0.1	0.000

TABLE G6f

SUMMARY OF MERCURY DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	MERCURY	
					UG/L	#/DAY
BORG WARNER CHEMICALS INC. 001	191.5	WV	914	2.06	<0.1	<0.002
BORG WARNER CHEMICALS INC. 002	191.5	WV	224	1.3	0.1	0.001

MERCURY MAIN STEM DATA. UG/L	M.P.	OHIO SIDE	MID POINT	WV SIDE
WHEELING	86.8	0.15	<0.1	<0.1
BUTTER RUN	107.0	0.39	<0.1	0.1
WELLS BOTTOM	117.3	0.2	0.19	0.22
HANNIBAL	126.4	0.1	0.1	0.11

NOTE: OEPA lab did not test for mercury

TRIBUTARY WATER DATA	M.P.	STATE	HARDNESS (MG/L)	MERCURY (UG/L)
NIXON RUN	86.8	OH	646	
WHEELING RUN	90.1	OH	1030	
WHEELING CREEK	90.7	WV	240	0.51
MCMAHON CREEK	94.7	OH	515	
WEEGEE CREEK	98.0	OH	425	
GRAVE CREEK	102.4	WV	196	0.24
CAPT'NA CREEK	109.5	OH	291	
FISH CREEK	113.8	WV	116	0.12
SUNFISH CREEK	118.0	WV	193	
FISHING CREEK	128.3	WV	94	0.13
MIDDLE ISLAND CREEK	154.0	WV	68	0.12
LITTLE MUSKINGUM RIVER	168.3	OH	121	
DUCK CREEK	170.7	OH	192	
MUSKINGUM RIVER	172.2	OH	310	0.2
POND RUN	182.4	WV	144	0.1
LITTLE KANAWHA RIVER	184.6	WV	60	0.19
LITTLE KANAWHA RIVER	184.7	WV	70	0.15
LITTLE HOCKING RIVER	191.8	OH	125	
HOCKING RIVER	199.3	OH	239	

TABLE G6f (cont.)

MERCURY SEDIMENT DATA	M.P.	STATE	MERCURY UG/G
NIXON RUN	86.8	OH	0.237
WHEELING CREEK	90.1	OH	0.176
WHEELING CREEK	90.7	WV	0.23
MCMAHON CREEK	94.7	OH	0.107
WEEGEE CREEK	98.0	OH	0.162
GRAVE CREEK	102.4	WV	0.22
CAPTINA CREEK	109.5	WV	0.114
FISH CREEK	113.8	WV	0.25
SUNFISH CREEK	118.0	OH	0.08
FISHING CREEK	128.3	WV	0.33
MIDDLE ISLAND CREEK	154.0	WV	0.37
LITTLE MUSKINGUM RIVER	168.3	OH	0.066
DUCK CREEK	170.7	OH	0.121
MUSKINGUM RIVER	172.2	OH	
MUSKINGUM RIVER		OH	
POND RUN	182.4	WV	0.3
LITTLE KANAWHA RIVER	184.7	WV	0.25
LITTLE KANAWHA RIVER		WV	0.31
LITTLE HOCKING RIVER	191.8	OH	0.12
HOCKING RIVER	199.3	OH	0.116

TABLE G6g

SUMMARY OF NICKEL DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	NICKEL	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87.8	OH			<40	0.000
WHEELING WWTP	91.2	WV	234	5.69	<10	<0.474
OHIO EDISON BURGER 003	102.5	OH			<40	0.000
OLIN CHEMICALS CORP 004	104.9	WV	328	0.526	12	0.053
LCP CHEMICAL 001	106.1	WV	252	12.07	<25	<2.514
LCP CHEMICAL 001	106.1	WV		12.07		0.000
OH POWER-KAMMER PLT 001	111.1	WV	604	0.005	200	0.008
OH POWER-KAMMER PLT 003	111.1	WV	100	648	<10	<53.978
OH POWER-KAMMER PLT 004	111.1	WV	126	5.76	<10	<0.480
OH POWER-MITCHELL PLT 001	112.6	WV	160	4.65	10	0.387
OH POWER-MITCHELL PLT 003	112.6	WV	584	0.0099	<10	<0.001
OH POWER-MITCHELL PLT 004	112.6	WV	426	8.2	50	3.415
PPG INDUSTRIES INC. 001	119.7	WV	260	0.02	44	0.007
PPG INDUSTRIES INC. 002	119.7	WV	234	0.95	<10	<0.079
PPG INDUSTRIES INC. 003	119.7	WV	376	0.004	<10	<0.000
PPG INDUSTRIES INC. 004	119.7	WV	148	0.88	<10	<0.073
PPG INDUSTRIES INC. 006	119.7	WV	118	75.6	20	12.595
PPG INDUSTRIES INC 007	119.7	WV	120	0.029	36	0.009
PPG INDUSTRIES INC. 009	119.7	WV	256	29.9	50	12.453
PPG INDUSTRIES INC. 013	119.7	WV	190	0.02	<10	<0.002
PPG INDUSTRIES INC. 014	119.7	WV	320	0.006	<10	<0.000
PPG INDUSTRIES INC 015	119.7	WV	240	0.036	<25	<0.007
PPG INDUSTRIES INC. 016	119.7	WV	164	0.0038	<10	<0.000
MOBAY CORP. 001	121.3	WV	214	4.9	275	11.225
ORMET 001	123.5	OH	202		<40	0.000
ORMET 002	123.5	OH	198		<40	0.000
ORMET 004	123.5	OH	180		<40	0.000
CONALCO 001	123.7	OH	123		<40	0.000
CONALCO 002	123.7	OH	214		<40	0.000
NEW MARTINSVILLE	124.7	WV	270	0.462	<10	<0.038
UNION CARBIDE-SISTERSVILLE 001	145.3	WV	240	4.89	<25	<1.018

TABLE G6g

SUMMARY OF NICKEL DATA FROM INTENSIVE FIELD STUDY OCTOBER 20-22, 1988 (Continued)

NAME DISCHARGERS.	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	NICKEL	
					UG/L	#/DAY
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1 11	<25	<0.231
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0.002	125	0.002
MID ATLANTIC FUELS. INC. 001	155.4	WV	264	0 35	<20	<0.058
MONONGAHELA POWER CO PLEASANTS 001	160.5	WV	874	1 26	125	1 312
MONONGAHELA POWER CO PLEASANTS 002	160.5	WV	406	0.01	10	0.001
MONONGAHELA POWER CO WILLOW ISL INTAKE	160.6	WV			10	0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160 6	WV	168	0.001	12	0.000
MONONGAHELA POWER CO WILLOW ISLAND 101	160.6	WV	170	2.3	10	0.192
AMERICAN CYANAMID CO WILLOW ISLAND	161 9	WV	392	3 763	120	3 761
MARIETTA WWTP	171 0	OH	223			0.000
AMOCO CORP 001	175.9	OH	390		<40	0.000
AMOCO CORP 001	175.9	OH			<40	0.000
ELKEMS METALS 001	176 9	OH	1170		<40	0.000
ELKEMS METALS 002	176.9	OH	1060		<40	0.000
ELKEMS METALS 003	176.9	OH	138		<40	0.000
ELKEMS METALS 004	176.9	OH	139		<40	0.000
ELKEMS METALS 005	176.9	OH	1500		<40	0 000
PARKERSBURG WWTP 001	183 3	WV	172	8.18	<10	<0.681
SHELL CHEMICAL CO . BELPRE 001	188.7	OH	131		<40	0.000
SHELL CHEMICAL CO . BELPRE 002	188.7	OH	151		<40	0.000
SHELL CHEMICAL CO.. BELPRE 003	188.7	OH	131		50	0.000
DUPONT WASHINGTON 001	190.5	WV	126	0.046	<10	<0.004
DUPONT WASHINGTON 002	190.5	WV	750	8.16	16	1.088
DUPONT WASHINGTON 003	190.5	WV	168	2.916	<10	<0.243
DUPONT WASHINGTON 005	190.5	WV	124	14 3	12	1.429
DUPONT WASHINGTON 006	190.5	WV	96	0 004	<10	<0.000
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	260	0.002
DUPONT WASHINGTON 105	190.5	WV	76	1 7	10	0.142
DUPONT WASHINGTON INTAKE	190.5	WV			10	0.000
BORG WARNER CHEMICALS INC. 001	191.5	WV	914	2.06	30	0.515
BORG WARNER CHEMICALS INC. 002	191.5	WV	224	1.3	<10	<0.108

TABLE G6g

NICKEL MAIN STEM DATA: UG/L	M.P.	OHIO SIDE	MID POINT	WV SIDE
WHEELING	86.8	<10	<10	10
BUTTER RUN	107.0	10	10	10
WELLS BOTTOM	117.3	10	<10	<10
HANNIBAL	126.4	14	<10	10
WILLOW ISLAND	161.7	<40	<40	<40
BUCKLEY ISLAND	171.9	<40	<40	<40
PARKERSBURG	183.1	<40	<40	<40
BELLEVILLE	203.9	<40	<40	<40

TRIBUTARY WATER DATA.	M.P	STATE	HARDNESS (MG/L)	NICKEL (UG/L)
NIXON RUN	86.8	OH	646	<40
WHEELING RUN	90.1	OH	1030	<40
WHEELING CREEK	90.7	WV	240	10
MCMAHON CREEK	94.7	OH	515	<40
WEEGEE CREEK	98.0	OH	425	<40
GRAVE CREEK	102.4	WV	196	<10
CAPTINA CREEK	109.5	OH	291	<40
FISH CREEK	113.8	WV	116	<10
SUNFISH CREEK	118.0	WV	193	<40
FISHING CREEK	128.3	WV	94	10
MIDDLE ISLAND CREEK	154.0	WV	68	10
LITTLE MUSKINGUM RIVER	168.3	OH	121	<40
DUCK CREEK	170.7	OH	192	<40
MUSKINGUM RIVER	172.2	OH	310	10
POND RUN	182.4	WV	144	10
LITTLE KANAWHA RIVER	184.6	WV	60	<10
LITTLE KANAWHA RIVER	184.7	WV	70	10
LITTLE HOCKING RIVER	191.8	OH	125	<40
HOCKING RIVER	199.3	OH	239	<40

TABLE G6g (cont.)

NICKEL SEDIMENT DATA	M.P.	STATE	NICKEL UG/G
NIXON RUN	86.8	OH	73
WHEELING CREEK	90.1	OH	36
WHEELING CREEK	90.7	WV	20
MCMAHON CREEK	94.7	OH	33
WEEGEE CREEK	98.0	OH	93
GRAVE CREEK	102.4	WV	23
CAPTINA CREEK	109.5	WV	25
FISH CREEK	113.8	WV	16
SUNFISH CREEK	118.0	OH	25
FISHING CREEK	128.3	WV	11
MIDDLE ISLAND CREEK	154.0	WV	20
LITTLE MUSKINGUM RIVER	168.3	OH	20
DUCK CREEK	170.7	OH	38
MUSKINGUM RIVER	172.2	OH	53.1
MUSKINGUM RIVER		OH	43.2
POND RUN	182.4	WV	18
LITTLE KANAWHA RIVER	184.7	WV	17
LITTLE KANAWHA RIVER		WV	27
LITTLE HOCKING RIVER	191.8	OH	18
HOCKING RIVER	199.3	OH	40

TABLE G6h

SUMMARY OF ZINC DATA
FROM INTENSIVE FIELD STUDY
OCTOBER 20-22, 1988

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	ZINC	
					UG/L	#/DAY
WHEELING PITTSBURGH STEEL	87.8	OH			500	0.000
WHEELING WWTP	91.2	WV	234	5.69	26	1.232
OHIO EDISON BURGER 003	102.5	OH			40	0.000
OLIN CHEMICALS CORP 004	104.9	WV	328	0.526	18	0.079
LCP CHEMICAL 001	106.1	WV	252	12.07	55	5.530
LCP CHEMICAL 001	106.1	WV		12.07		0.000
OH POWER-KAMMER PLT 001	111.1	WV	604	0.005	1680	0.070
OH POWER-KAMMER PLT 003	111.1	WV	100	648	20	107.957
OH POWER-KAMMER PLT 004	111.1	WV	126	5.76	20	0.960
OH POWER-MITCHELL PLT 001	112.6	WV	160	4.65	52	2.014
OH POWER-MITCHELL PLT 003	112.6	WV	584	0.0099	40	0.003
OH POWER-MITCHELL PLT 004	112.6	WV	426	8.2	118	8.060
PPG INDUSTRIES INC. 001	119.7	WV	260	0.02	6	0.001
PPG INDUSTRIES INC. 002	119.7	WV	234	0.95	10	0.079
PPG INDUSTRIES INC. 003	119.7	WV	376	0.004	8	0.000
PPG INDUSTRIES INC. 004	119.7	WV	148	0.88	46	0.337
PPG INDUSTRIES INC. 006	119.7	WV	118	75.6	104	65.494
PPG INDUSTRIES INC. 007	119.7	WV	120	0.029	108	0.026
PPG INDUSTRIES INC. 009	119.7	WV	256	29.9	130	32.379
PPG INDUSTRIES INC. 013	119.7	WV	190	0.02	46	0.008
PPG INDUSTRIES INC. 014	119.7	WV	320	0.006	140	0.007
PPG INDUSTRIES INC. 015	119.7	WV	240	0.036	18	0.005
PPG INDUSTRIES INC. 016	119.7	WV	164	0.0038	24	0.001
MOBAY CORP. 001	121.3	WV	214	4.9	60	2.449
ORMET 001	123.5	OH	202		< 10	0.000
ORMET 002	123.5	OH	198		< 10	0.000
ORMET 004	123.5	OH	180		35	0.000
CONALCO 001	123.7	OH	123		35	0.000
CONALCO 002	123.7	OH	214		25	0.000
NEW MARTINSVILLE	124.7	WV	270	0.462	18	0.069
UNION CARBIDE-SISTERSVILLE 001	145.3	WV	240	4.89	22	0.896

TABLE G6h

SUMMARY OF ZINC DATA
FROM INTENSIVE FIELD STUDY
OCTOBER 20-22, 1988
(Continued)

NAME DISCHARGERS:	M.P.	STATE	HARDNESS MG/L	FLOW MG/L	ZINC	
					UG/L	#/DAY
UNION CARBIDE-SISTERSVILLE 002	145.3	WV	240	1.11	10	0.092
UNION CARBIDE-SISTERSVILLE 003	145.3	WV	224	0.002	290	0.005
MID ATLANTIC FUELS, INC. 001	155.4	WV	264	0.35	66	0.092
MONONGAHELA POWER CO PLEASANTS 001	160.5	WV	874	1 26	120	1.259
MONONGAHELA POWER CO PLEASANTS 002	160 5	WV	406	0 01	88	0.007
MONONGAHELA POWER CO WILLOW ISL INTAKE	160 6	WV			14	0.000
MONONGAHELA POWER CO WILLOW ISLAND 401	160.6	WV	168	0 001	68	0 001
MONONGAHELA POWER CO WILLOW ISLAND 101	160.6	WV	170	2 3	38	0.728
AMERICAN CYANAMID CO WILLOW ISLAND	161 9	WV	392	3 763	280	8.777
MARIETTA WWTP	171 0	OH	223		475	0 000
AMOCO CORP. 001	175 9	OH	390		25	0.000
AMOCO CORP 001	175 9	OH			25	0.000
ELKEMS METALS 001	176.9	OH	1170		10	0 000
ELKEMS METALS 002	176.9	OH	1060		30	0.000
ELKEMS METALS 003	176 9	OH	138		15	0 000
ELKEMS METALS 004	176.9	OH	139		20	0 000
ELKEMS METALS 005	176.9	OH	1500		15	0.000
PARKERSBURG WWTP 001	183 3	WV	172	8 18	46	3.134
SHELL CHEMICAL CO . BELPRE 001	188.7	OH	131		100	0.000
SHELL CHEMICAL CO . BELPRE 002	188 7	OH	151		30	0 000
SHELL CHEMICAL CO.. BELPRE 003	188.7	OH	131		60	0.000
DUPONT WASHINGTON 001	190.5	WV	126	0.046	104	0.040
DUPONT WASHINGTON 002	190.5	WV	750	8.16	46	3.127
DUPONT WASHINGTON 003	190 5	WV	168	2.916	14	0.340
DUPONT WASHINGTON 005	190 5	WV	124	14 3	14	1 668
DUPONT WASHINGTON 006	190.5	WV	96	0.004	26	0.001
DUPONT WASHINGTON 007	190.5	WV	20	0.0007	320	0.002
DUPONT WASHINGTON 105	190.5	WV	76	1 7	42	0.595
DUPONT WASHINGTON 105	190.5	WV			18	0.000
BORG WARNER CHEMICALS INC. 001	191.5	WV	914	2.06	15	0.257
BORG WARNER CHEMICALS INC. 002	191.5	WV	224	1.3	17	0.184

TABLE G6h
(Continued)

ZINC MAIN STEM DATA: UG/L	M.P.	OHIO SIDE	MID POINT	WV SIDE
WHEELING	86.8	16	16	16
BUTTER RUN	107 0	16	21	28
WELLS BOTTOM	117.3	20	22	22
HANNIBAL	126.4	15	14	16
WILLOW ISLAND	161.7	< 10	< 10	10
BUCKLEY ISLAND	171.9	< 10	10	< 10
PARKERSBURG	183.1	< 10	< 10	< 10
BELLEVILLE	203.9	< 10	< 10	< 10

TRIBUTARY WATER DATA	M.P.	STATE	HARDNESS (MG/L)	ZINC (UG/L)
NIXON RUN	86 8	OH	646	20
WHEELING RUN	90.1	OH	1030	< 10
WHEELING CREEK	90.7	WV	240	8
MCMAHON CREEK	94 7	OH	515	< 10
WEEGEE CREEK	98.0	OH	425	< 10
GRAVE CREEK	102.4	WV	196	12
CAPTINA CREEK	109 5	OH	291	< 25
FISH CREEK	113.8	WV	116	6
SUNFISH CREEK	118 0	WV	193	< 10
FISHING CREEK	128.3	WV	94	3
MIDDLE ISLAND CREEK	154 0	WV	68	2
LITTLE MUSKINGUM RIVER	168.3	OH	121	< 10
DUCK CREEK	170 7	OH	192	< 10
MUSKINGUM RIVER	172.2	OH	310	16
POND RUN	182.4	WV	144	8
LITTLE KANAWHA RIVER	184.6	WV	60	5
LITTLE KANAWHA RIVER	184.7	WV	70	3
LITTLE HOCKING RIVER	191.8	OH	125	< 10
HOCKING RIVER	199.3	OH	239	< 10

TABLE G6h
(Continued)

ZINC SEDIMENT DATA	M P.	STATE	ZINC UG/G
NIXON RUN	86.8	OH	244
WHEELING CREEK	90.1	OH	126
WHEELING CREEK	90.7	WV	133
MCMAHON CREEK	94.7	OH	130
WEEGEE CREEK	98.0	OH	273
GRAVE CREEK	102.4	WV	128
CAPTINA CREEK	109.5	WV	93
FISH CREEK	113.8	WV	59
SUNFISH CREEK	118.0	OH	70
FISHING CREEK	128.3	WV	46
MIDDLE ISLAND CREEK	154.0	WV	85
LITTLE MUSKINGUM RIVER	168.3	OH	79
DUCK CREEK	170.7	OH	113
MUSKINGUM RIVER	172.2	OH	147
MUSKINGUM RIVER		OH	123
POND RUN	182.4	WV	88
LITTLE KANAWHA RIVER	184.7	WV	58
LITTLE KANAWHA RIVER		WV	105
LITTLE HOCKING RIVER	191.8	OH	58
HOCKING RIVER	199.3	OH	127

APPENDIX H

PA DER TOXIC SCREENING MODEL MODELING CONCEPTS

November 29, 1989

Part I - Modeling Concepts

A. Technical Overview:

The Water Quality Analysis Template performs TMDL/WLA analysis for point source discharges to free flowing streams using a steady state, first order decay, mass balance model.

The Template considers four different water quality criteria: acute fish and aquatic life (AFC), chronic fish and aquatic life (CFC), threshold human health (THC) and non-threshold human health (carcinogens) (CRL). AFC, CFC, and THC criteria are applied at a Q_{7-10} design stream flow. CRL is applied at a Carcinogen design flow. There are different durations associated with each criteria. The template uses a computational strategy based on treatment plant performance variability to establish a common duration base for comparing Water Quality Based Effluent Limitations (WQBELs) to determine which criteria governs for a particular discharge, or combination of discharges. All criteria must be complied with at design stream flow conditions within policy derived maximum instream travel times.

The model compares the simulated water quality profile with applicable water quality criteria to determine if a violation is occurring. All discharges upstream of a violation that contribute a significant portion of the total pollutant load at the point(s) of maximum violation are considered to be interacting.

Except for CRL based limits, effluent limits are expressed as 30-day average values. They can include a factor of safety specified by the user.

The model can use either a Uniform Treatment (UT) or an Equal Marginal Percent Removal (EMPR) WLA strategy. Whenever more than technology based effluent limitations are needed to meet water quality criteria, a WLA is required. When two or more discharges are in sufficiently close proximity to one another such that they must share the assimilation capacity of the receiving stream, a multiple discharge WLA is required.

Under the UT strategy, all discharge concentrations that are part of the same multiple discharge scenario are reduced by a uniform percentage from their baseline values. The baseline for a UT WLA is technology based effluent limitations or existing discharge quality.

EMPR is similar to UT, except for the baseline for the multiple discharge analysis. Under EMPR, the baseline for multiple discharge analysis is the level that each discharge would have to provide if it was the only discharge on the stream. The effect that any upstream discharge(s) selected by the analyst may have on stream hydraulic and assimilation characteristics may be considered in setting this baseline. If a violation exists after the baseline has been established, then all discharges that contribute to the violation are reduced by an (additional) equal percentage.

The model uses a single set of discharge flows, representing expected discharge flows at the planning horizon. These flows can be inputed by the

analyst, or can be estimated using existing and permitted discharge flows in combination with a user defined Reserve Factor (RF).

The template can analyze up to 10 reaches in a single run. Branched or large systems (more than 10 reaches) are analyzed by using a built-in discharge transfer routine that calculates equivalent end-of-segment discharge loads. These discharge loads are transferred to the next segme as an equivalent discharge.

B. Basic Water Quality Model

The basic water quality model used in the template for simulating instrea quality is of the form:

$$C'_t = C'_o * e^{-kt} \quad \text{where,}$$

C'_t = In-stream pollutant concentration at time t,
C'_o = In-stream pollutant concentration at time t = 0,
e = Base e,
k = Aggregate fate coefficient, and
t = Travel time

Advection and aggregate fate are considered as the fate and transport mechanisms. The fate and transport considerations deal only with the wate column. Dissolved and particulate partitioning, exchange with the atmosphere, and sediment bed interaction are not explicitly considered. The fate coefficient (k) embodies the aggregate effect of all in-stream fate processes without discriminating among them. The coefficient is assumed to be constant and is not adjusted for temperature, pH, or other factors. If a substance is susceptible to variable fate processes due to changes in the chemical or physical conditions (such as temperature, flow, etc.). then separate aggregate fate coefficients should be determined if the template is applied at different design conditions.

C. Mixing

Mixing is evaluated in the model under the assumption that the stream channel is rectangular. Unless the information is supplied by the analyst mixing is handled through an adaptation of the EPA Ambient Mixing Model:*

$$X_m = \frac{m\ W^2\ u}{D_y} \quad \text{where,}$$

X_m = Distance to Complete Mix
m = parameter that defines the uniformity required for complete mix and location of discharge (set at .315 in the template)
W = Stream width
u = flow velocity for critical design flow
D_y = lateral dispersion coefficient

If it is not supplied by the analyst, complete mix time is estimated using

the equation:

$$t_m = \frac{0.315 * w'^2}{[.6 * d * (32.2 * d * s)^{.5} * 60]} ,$$

$$w' = w * Q_s/(Q_s+Q_d) \quad \text{where,}$$

t_m = Complete Mix Time in minutes
w' = Adjusted reach width in feet
d = Reach depth in feet
s = Reach slope in feet/feet
Q_s = Stream Flow in cfs
Q_d = Discharge Flow in cfs

The amount of stream flow that mixes with a shore line discharge is a function of downstream travel time and complete mix time. The equation for estimating the amount of stream flow mixed with the discharge plume is:

$$Q'_s = Q_s * (t_i/t_m)^{.5} \quad \text{where}$$

Q'_s = Amount of stream flow mixed with discharge flow at travel time t_i
Q_s = Total stream flow at the point of discharge

If t_i is greater than t_m, then complete mix has occurred and Q'_s is set equal to Q_s. More information on the derivation of the mixing relationships used in the model is presented in Appendix C.

D. Criteria Compliance Times

Toxics criteria have different critical durations. Because of this, an approach that takes criteria duration into consideration has been developed. The approach is based on the general premise that at design conditions, a (relatively) small in-stream zone where water quality criteria may be violated can be tolerated. Using this basic premise, different criteria compliance times have been established for each criteria and criteria duration.

Acute Fish and Aquatic Life Criteria

The EPA Technical Support Document[F] generally appears to suggest that AFC be met at the end-of-pipe. Taken literally, this means that the AFC WQBEL would have to be set equal to the AFC itself. This recommendation, however, is tempered by the incorporation of a recommended steady state design flow (Q_{1-10}) for AFC application, and the suggestion that where mixing is "rapid," or when high rate diffusers are used, a small in-stream zone where the AFC is exceeded may be tolerated. It is tempered further by the fact that EPA has approved a number of State Toxic Management Programs that do not apply the AFC at end-of-pipe.

If a (relatively) small in-stream zone where acute criteria is violated can

be tolerated at design conditions, then it is possible to make use of mixi and dilution to determine an AFC-based WQBEL that is different from the AF itself. This WQBEL would be no more stringent than the AFC, but could, depending on site specific mixing and dilution conditions, be several time greater than the AFC.

On the basis of the EPA guidance and the factors discussed above, a policy that allows an "Acute Criteria Dispersion Zone" (ACDZ), has been incorporated into the template. The limit of the ACDZ is the zone defined by up to 15 minutes travel time from the point of discharge under site specific design flow conditions.

Chronic Fish and Aquatic Life Criteria

An underlying assumption frequently used to conduct chronic toxicity based analyses is that of "complete mix." The actual application of complete mix however, can often vary greatly from case to case. In many cases, dilution analysis is carried out using less than 100 percent of available stream flow, due to the knowledge or professional judgement of the analyst about individual site specific mixing characteristics, or because of a desire to provide an additional "factor of safety" in the water quality impact analysis. Different mixing and dilution assumptions can lead to significantly different results and NPDES permit limitations.

Ambient mixing is a function of several physical variables, including strea width, stream depth, the location of the discharge (i.e., shore line or center of stream channel), stream velocity, and stream slope.(*) For stream in Pennsylvania, it has been determined that mixing is relatively rapid (compared to criteria duration) for practically all small streams with Q_{7-1} flows of less than 50 cfs, and that complete mix will usually occur within 12 hours. For streams in the 50 to 250 cfs range, rapid mixing occurs in circumstances where slopes are moderate (0.5%) to steep (1.0%). For large streams above 250 cfs mixing can seldom, if ever, be considered rapid.

The conclusions presented above are based on ambient mixing considerations only. They do not consider the effects of discharge induced mixing, stream flow augmentations due to groundwater or tributary inflows, or channel irregularities below the point of discharge. All of these factors tend, in general, to increase the rate of mixing, or alternatively, lead to the achievement of predicted in-stream complete mixing concentrations in the diluted discharge plume at a point upstream of the predicted point of complete mix. Field studies conducted by DER staff tend to confirm that, i most cases, mixing will occur more rapidly than predicted using the EPA ambient mixing model.

For purposes of template application, it has been concluded that if complete mix occurs within 12 hours at design flow conditions, then 100 percent of stream flow may be used for the purposes of setting CFC based effluent limitations. If, under design conditions, complete mixing is expected to take more than 12 hours, then only that portion of the stream that mixes with the discharge plume during the first 12 hours should be used for dilution. The 12 hour maximum mixing time for CFC application does not normally have a major impact on NPDES effluent limitations for discharges to larger streams, since in most such cases acute toxicity will govern the

determination of NPDES permit limitations for these discharges.

Threshold and Non-Threshold Human Health Criteria

The maximum criteria compliance time used in the template for THC and CRL criteria is the same as for CFC criteria, or the estimated travel time to the nearest potable water supply intake, whichever is less. This assures that THC and CRL criteria will be complied with either at, or upstream of any water supply intake.

E. Setup and Data Input Requirements

Depending on the analysis mode, up to 27 data inputs are required to operate the template. These data inputs are in addition to the Set-up options that are selected by the analyst to define the model operating profile. The Set-up selections include (a) a reserve factor (RF), (b) a factor of safety (FOS), (c) a multiple discharge wasteload allocation cutoff factor (WF), and (d) a waste load allocation method (WS).

The reserve factor is designed to take potential future growth into consideration. It is normally set at a default value of 0.1 (i.e., a projected 10 percent increase in presently permitted loads). The factor of safety is designed to account for the uncertainty associated with the model inputs. It is normally set at .20. The multiple discharge wasteload allocation cutoff factor defines the level at which a discharge is considered significant in a multiple discharge situation. It is normally set at 0.05.

Many data inputs are optional. If the user does not supply the information, the template estimates the required value, using the equations described in the sections that follow. If, however, the user does not supply a data value identified in Table 10-1 as required, the template will assign a value of zero (0).

The required data input of Cumulative Drainage Area represents the total drainage area at the beginning of each reach being modeled, including the drainage area of any tributaries entering the stream segment at the beginning of the reach. When the template is run using "transferred" loads, care should be taken to verify that the correct cumulative drainage area has been inputed.

The required data inputs of Potable and Industrial Water Supply withdrawal should represent the expected withdrawal rates at Q_{7-10} conditions. Some water supply withdrawal permits contain special conditions that require the adjustment of withdrawal rates when stream flow approaches Q_{7-10}. Failure to input the correct withdrawal rate will result in an erroneous flow balance, which will affect model results.

The optional data input of incremental stream flow should be used to adjust Q_{7-10} flows to account for any required minimum releases upstream or in the first model segment that is being modeled. Failure to account for minimum releases will result in erroneous estimates of both Q_{7-10} and Carcinogen Design Flow, when the model default equations are used to estimate incremental flows.

The optional data inputs of reach width/depth ratio, stream width, and stream depth represent values at Q_{7-10} design flow conditions. The optiona inputs of reach velocity, reach travel time, and complete mix time are assumed to apply at both Q_{7-10} and Carcinogen Design Flow Conditions. If the user wishes to supply different values for these data elements for the two separate design flow conditions, two separate model runs will be required.

It should be noted that the model calls for inputing tributary background pollutant concentration information. The model calculates an in-stream background pollutant concentration by applying mass balance techniques to the pollutant concentration and tributary flow values provided (or calculated). If the user knows the in-stream background concentration, som preliminary data manipulation, exterior to the model itself may be necessar to achieve these values in the model.

The tributary and in-stream pollutant background concentrations should represent concentrations that result from sources that are not subject to manipulation or control in the TMDL/WLA process. These sources may include natural ambient conditions, non-point sources loads, or point sources that are not considered "controllable" in the TMDL/WLA modeling analysis, such a pollutants being discharged through abandoned mine drainage. This means that when Water Quality Network or other similar field data are used to estimate background conditions, the measured values may have to be adjusted to account for controllable point sources.

Although calibration field studies are recommended whenever possible, it ma be possible to use long term Water Quality Network data, in conjunction wit discharge data to estimate aggregate fate coefficients. An example of how this may be done is presented in Appendix _.

Table 10-1
TEMPLATE DATA REQUIREMENTS

Data Element	
Discharge/Tributary Name	X
River Mile Index	X
Elevation	X
Cumulative Drainage Area	X
Existing Discharge Flow	X
Permitted Discharge Flow	X
Potable Water Supply Withdrawal	X
Groundwater Yield	O
Discharge Analysis Flow	O
Incremental Stream Flow	O
Carcinogen Design Stream	O
Reach Length	O
Reach Slope	O
Width/Depth Ratio	O
Stream Width	O
Stream Depth	O
Reach Velocity	O
Reach Travel Time	O
Complete Mix Time	O
Industrial Water Supply Withdrawal	X
Flow Augmentation Factor	X
Pollutant Information	
- Discharge Concentration	X
- Tributary (Incremental Flow) Background Concentration)	X
- Aggregate Fate Coefficient	X
- Acute Fish Criteria	(a)
- Chronic Fish Criteria	(a)
- Human Health Criteria	(a)

X = Required User Input
O = Optional User Input. If input is not provided, value is estimated using built-in default equations.
(a) Criteria Values are obtained from Criteria Look-up Table, which may be modified by the user

F. Overview of Template Calculations and Notation

The calculations carried out by the template are divided into three major phases -- (1) Preliminary Calculations, (2) Baseline Discharge Analysis, a (3) Multiple Discharge Analysis. In the preliminary calculation phase, calculations are carried out to determine reach travel times, complete mix times, and partial mixing factors for both baseline and multiple discharge analysis. In the baseline discharge phase, calculations are carried out t determine baseline pollutant concentrations for use in the EMPR wasteload allocation strategy. (If the Uniform Treatment WLA strategy has been selected under Set-up, this calculation phase is effectively bypassed, except for the determination of the "maximum" effluent limitation.) In the multiple discharge phase, a final set of calculations are carried out to determine final effluent limitations.

Several notations are used in the equations described in Part II. The notation (x) is used to describe the design condition. There are four different design conditions, -- (1) baseline conditions at Q_{7-10} design flow, (2) baseline conditions at carcinogen design flow Q_c, (3) multiple discharge conditions at Q_{7-10} design flow, and (4) multiple discharge conditions at carcinogen design flow Q_c.

The notation (y) describes which criteria value (Acute Fish, Chronic Fish, Threshold Human Health, or Non-Threshold Human Health) is being evaluated.

Finally, most variables are either single or double subscripted using the letters (i) and/or (j). A single subscript (i or j) normally refers to the current reach and/or discharge being evaluated. A subscript (i-1) refers t the reach or discharge immediately upstream of the current reach (i).

A double subscript of the form (i,j) generally means the effect of the current discharge (i) on (or in) some subsequent downstream reach (j).

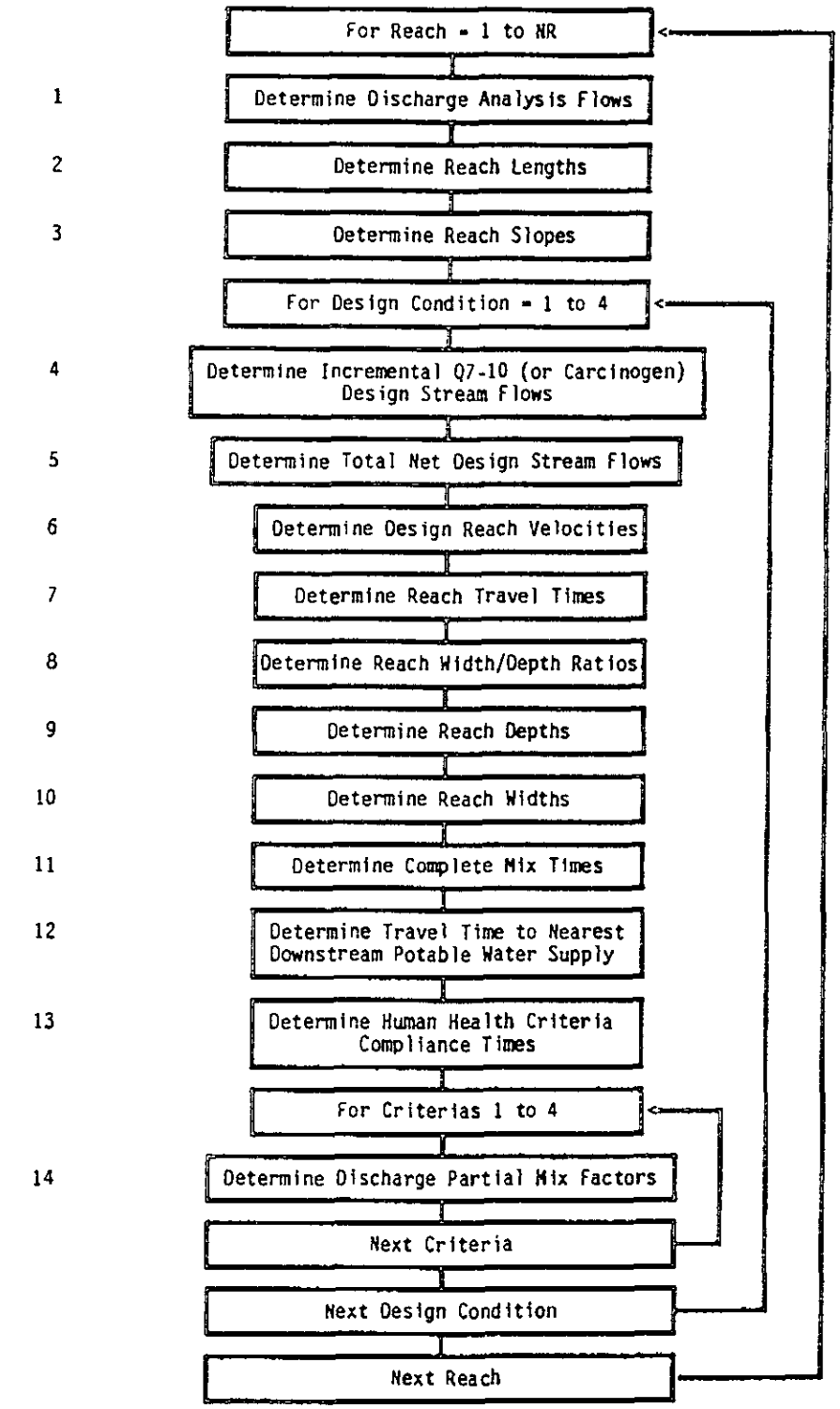
(Note: The equations described below are in general detail and are meant to provide the reader with a basic understanding of how the model computes the effluent limitations. Those interested in the detailed formulas in the template including all of the "what-if" analyses that are performed should refer to Part II of Chapter 10. It is recommended that new readers, continue with Part I, below, in order to get a basic understanding of the template before proceeding to the more detailed Part II.)

G. Preliminary Calculations

Preliminary calculations are designed to determine the physical, hydraulic and mixing characteristics that are used in the subsequent baseline and multiple discharge analyses. Some preliminary calculations are made for the four (4) different design conditions evaluated by the model. The preliminary calculation sequence is shown in flow-chart form in Figure 10-1. The equation numbers shown on the figure refer to the actual equations, which are described below.

Figure 10-1

Preliminary Calculation Sequence



1. Discharge Analysis Flow (MGD)

The Discharge Analysis Flow is the design flow for each discharge. The s Discharge Analysis Flow is used for all design conditions. The Discharge Analysis Flow may be inputed by the user, or may be estimated using exist or permitted discharge flow.

2. Reach Length (Feet)

Reach Length is used to calculate reach slopes and travel times. Reach length is calculated by taking the current river mile index and subtractir the downstream river mile index, then multiplying by 5280 to convert to feet. The general relationship for this computation is:

$$[\ RMI_i - RMI_{(i+1)}\ ] * 5280$$

where,

RMI_i = River mile index in the current reach (i)
$RMI_{(i+1)}$ = River mile index in the next downstream reach (i+1)

3. Reach Slope (FT/FT)

Reach Slopes are used to calculate velocities and complete mix times. Slop is calculated by taking the elevation in the current reach and subtracting the elevation in the downstream reach, then dividing by the reach length. The general relationship for this computation is:

$$\frac{[\ EL_i - EL_{(i+1)}\ ]}{RL}$$

where,

EL_i = Elevation in the current reach (i)
$EL_{(i+1)}$ = Elevation in the next downstream reach (i+1)
RL = Reach length

4. Incremental Stream Flows (CFS)

Incremental Stream Flow may represent an actual tributary stream, a value representing lateral and ground water inflow, or a combination of the two. The incremental flow in the first reach of a problem represents the upstre flow. Although it is identified as an optional data input, it is recommended that Incremental Stream Flows be inputed by the user whenever possible, to improve the accuracy of the analysis. Also, in circumstances where the incremental flow represents a controlled release, it must be entered by the user. When incremental stream flow is not inputed by the user, it is computed by taking the drainage area in the current reach and subtracting the drainage area in the upstream reach, then multiplying by th ground water yield factor. The general relationship for this computation is

$$[\ DA_i - DA_{(i-1)}\ ] * GWY$$

where,

DA_i = Total Drainage Area in the current reach (i)
$DA_{(i-1)}$ = Total Drainage Area in the previous reach (i-1)
GWY = Ground Water Yield Factor

5. Total Net Design Stream Flow (CFS)

The total net design stream flow in each reach is determined separately for each design condition. It is determined by summing incremental stream flows through the current reach, and then deducting any potable or industrial water withdrawals. If both a discharge and water intake are identified as occurring at the beginning of the same reach, it is assumed that the water intake takes place upstream of the discharge. Because of this, it is recommended that intakes and discharges be placed in separate reaches whenever possible to assure proper hydrologic sequencing.

Please note that the total net stream flow may be zero under circumstances where total withdrawals exceed gross stream flow. This condition is most likely to occur at Q_{7-10} multiple discharge design conditions where there are substantial industrial water withdrawals.

6. Stream Velocity (MPD and FPS)

Stream velocities in each reach are determined in both miles per day and feet per second. Stream velocities are computed using the DER velocity equation if not entered by the user. In addition, the total stream flow used in the velocity equation may be adjusted to take into consideration discharge flow augmentation. This occurs if the user inputs a discharge flow augmentation factor in the option reach data input area. The general relationship for this computation is:

If drainage area (DA) is less than or equal to 500 mi^2

$$2.62 * Q_i^{.56} * SL^{.083} * DA^{-.22}$$

If drainage area (DA) is greater than 500 mi^2

$$1.64 * Q_i^{.56} * SL^{.055} * DA^{-.15}$$

where,

Q_i = Total base stream flow
SL = Slope
DA = Drainage Area

7. Reach Travel Times (Days)

Reach travel times are used in the determination of pollutant fate in both the baseline and multiple discharge scenarios. Reach travel time is computed by taking the reach length and dividing by the velocity. Reach travel time can also be entered by the user in the optional reach data input area.

8. Reach Width/Depth Ratios

Reach width/depth ratio is determined for Q_{7-10} design conditions only. It is assumed that reach width is the same for carcinogen design conditions as estimated or inputed for Q_{7-10} conditions. It should be noted that the default equation for estimating the width/depth ratio is only considered to be applicable for design flows of less then 250 cfs. Where Q_{7-10} flows are greater than 250 cfs, it is recommended that the user input the reach width directly under the optional data inputs. Reach width/depth is computed usin the Memon-Vu equation if not inputed by the user. The general relationship for this formulation is:

$$[\ -.073 + .141 * Q_1^{-.077} + .06 * DA^{-.445} + .0001 * SL^{1.075}\ ]^{-1.429}$$

where,

Q_1 = Total base stream flow
SL = Slope
DA = Drainage Area

9. Reach Depths (Feet)

Reach depth is used to estimate complete mix time. Reach depths are different for Q_{7-10} and Q_c conditions because of the assumption that the reach width remains constant for both design conditions. Reach depth is computed by taking the total stream flow and dividing by the velocity multiplied by the width. Reach depth may also be inputed by the user in the optional reach data input area. The general formulation for computing depth is:

For Q_{7-10}:

$$\frac{Q_1}{\{\ V * W\_D\ \}}$$

For Q_c:

$$\frac{Q_1}{\{\ V * W_{7-10}\ \}}$$

where,

Q_1 = Total base stream flow
V = Stream velocity
W_D = Width/Depth Ratio
W_{7-10} = Width computed/inputed at the Q_{7-10} design condition

10. Reach Widths (Feet)

Reach width is used in the determination of complete mix times. Reach width is determined for Q_{7-10} design conditions only. Because of the assumption that the channel is rectangular, it is assumed that reach width is the same at Carcinogen Design Flow Conditions as it is at Q_{7-10} conditions. Reach width is computed by taking the reach depth multiplied by the width/depth. Reach width may also be inputed by the user in the optional reach data input area. The general formulation for computing width is:

[D * W_D]

where,

D = Computed/inputed depth
W_D = Computed/inputed width/depth ratio

11. Complete Mix Times (Minutes)

Complete mix time is used to determine the degree that each discharge plume mixes with upstream flows at the various criteria compliance times. If the user indicates that a discharge is equipped with high rate diffusers, then it is assumed that complete mix takes place within 15 minutes travel time from the point of discharge. The general form of the equation for complete mix is described above in Section C. The user can also enter the complete mix time in the optional reach data input area. If the user designates a discharge as having high-rate diffusers, however, the inputed complete mix time will be ignored.

12. Travel Time to Nearest Downstream Potable Water Supply (Days)

The travel time to the nearest downstream water supply is determined by a search routine that locates each potable water supply withdrawal entered by the user, and then sums the reach travel times from the current discharge to the withdrawal location. Note that since reach travel times may vary by design condition, the travel time to the nearest downstream potable water supply may also vary.

13. Human Health Criteria Compliance Time (Minutes)

Human health criteria compliance time is computed as either 12 hours or the travel time to the nearest downstream potable water supply, whichever is the lesser of the two.

14. Partial Mix Factors

Partial Mix Factors are used to determine the degree of mixing that takes place between the current discharge dispersion plume and the stream. Partial mix factors may vary by design condition, but may never be greater then 1. A partial mix factor of 1 indicates that complete mix has been achieved. When the discharge represents an equivalent end-of-segment transfer from a tributary stream, it is assumed that complete mix has been achieved in the tributary stream. Partial mix factors are computed using the general relationship:

$$(t_i/t_m)^{.5} \quad \text{or} \quad 1$$

where,

t_i = Criteria compliance time
t_m = Complete Mix travel time

H. Baseline Analysis

Once the preliminary calculations described above are completed, the template initiates Baseline Analysis. Baseline analysis does two things -- (1) it determines the baseline effluent limitation(s) that will be used in the multiple discharge analysis, assuming that the EMPR wasteload allocation strategy is selected, and (2) it determines the "maximum" effluent limitation that could theoretically be applied to any given discharge and parameter. This maximum effluent limitation value is useful in helping to determine if additional data about the discharge would be desirable. The baseline calculation sequence is described in flow-chart form in Figure 10-2. The equation numbers shown on the figure refer to the actual equations, which are described below. Note that the calculation sequence described in Figure 10-2 is repeated for each parameter being evaluated.

15. In-stream Background Pollutant Concentrations (µg/l)

The instream background pollutant concentration is used to determine the amount of stream assimilation capacity that must be set aside for non-controllable pollutant sources. The instream background pollutant concentration is estimated on the basis of complete mix between the stream and (any) tributary inflow. There can be different instream background pollutant concentrations for different design conditions. The in-stream background pollutant concentration will also be decayed, if in-stream fate is inputed by the user. The user must input the background and in-stream fate for each parameter in order for it to be used by the model. The general relationship for computing background is:

$$CB = \frac{QS * CB * e^{-k*t} + QI * CT}{\{ QS + QI \}}$$

where,

QS = Total stream flow upstream of the current reach
QI = Tributary Flow
CB = Background pollutant concentrations
k = User supplied aggregate fate coefficient for the previous reach
t = Travel time for the previous reach
CT = User supplied tributary flow pollutant concentration

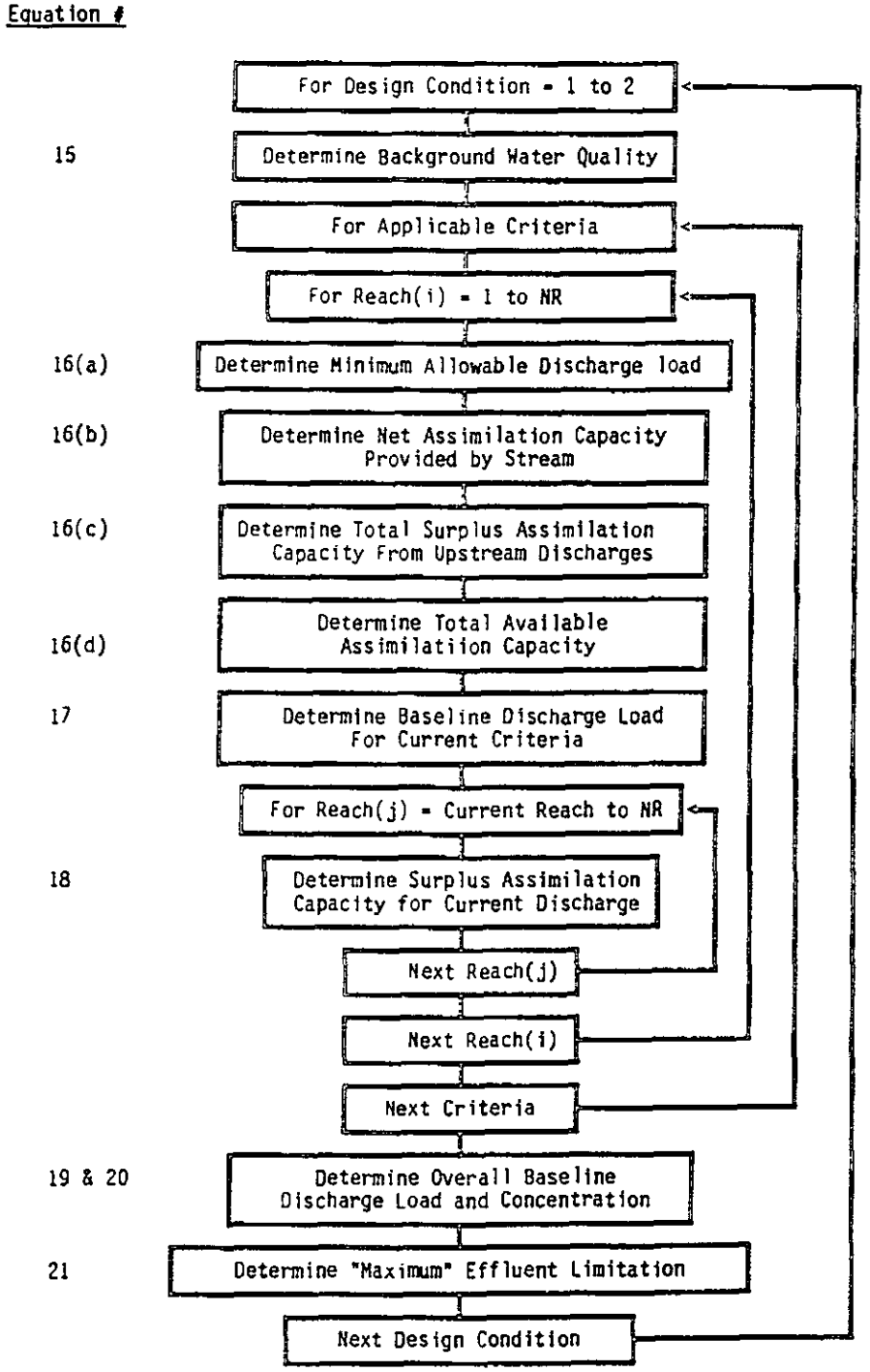
16. Allowable Discharge Loads (mass units)

The allowable discharge load for any discharge under baseline conditions is the sum of (1) the minimum allowable load for the discharge, (2) the net assimilation capacity provided by the stream, and (3) the surplus assimilation capacity provided by any upstream discharge(s) that are considered to be augmenting the stream. The general relationship for this computation is:

$$[MADL + PMF * \{NAC + TSDAC\}]$$

Figure 10-2

Baseline Calculation Sequence



where,

MADL = Minimum Allowable Discharge Load
PMF = Partial Mix Factor for the current reach
NAC = Net Assimilative Capacity Provided by the Stream
TSDAC = Net Surplus Assimilative Capacity Provided by any upstream discharges

17. Individual Discharge Loads for Current Criteria (mass units)

Except when the Uniform Treatment (UT) wasteload allocation strategy is being used, the individual discharge load is the lesser of the original discharge load and the allowable discharge load (computed from Equation 16, above). When the Uniform Treatment wasteload allocation strategy is employed, the individual discharge load is set equal to the original discharge load.

18. Surplus Assimilation Capacity for Current Discharge and Criteria (mass units)

In the current reach, a discharge may "create" assimilation capacity if the discharge load is less then the minimum allowable discharge load. In downstream reaches, this assimilation capacity may increase due to aggregat fate. The template computes the surplus assimilative capacity by taking th individual discharge load for each discharge and comparing this value with the minimum allowable load. As you move downstream the individual discharge load is decayed using in-stream fate. If the individual discharge load is less than the minimum allowable load in any reach, then the discharge provides surplus assimilative capacity. This surplus assimilative capacity is made available to all of the downstream discharges in the baseline analysis. The general formula for computing discharge assimilative capacity is:

$$[\ FAF\ *\ MADL - IDL * e^{-k_{i,j-1} * t_{i,j-1}}\ ]$$

where

FAF = Discharge Flow Augmentation Factor
MADL = Minimum Allowable Discharge Load
IDL = Individual Discharge Load

and,

$$e^{-k_{i,j-1}*t_{i,j-1}} = e^{-k_i*t_i} * e^{-k_{i+1}*t_{i+1}} * \cdots * e^{-k_{j-1}*t_{j-1}}$$

19. Baseline Discharge Load (mass units)

For the Q_{7-10} design flow conditions, the baseline discharge load is the minimum of the individual discharge loads for the three separate criteria applied at the design condition. For the Q_{∞} design flow condition, the baseline discharge load is just the individual discharge load. The template does the baseline analysis four times looking at each of the criteria separately and then makes the comparisons here. The template computes

separate allowable loads, individual discharge loads and surplus assimilative capacities for each of the criteria being evaluated.

20. Baseline Discharge Concentration (µg/l)

The baseline discharge concentration for each discharge is equal to the baseline discharge load divided by the design analysis flow.

21. "Maximum" Effluent Limitation (ug/l)

The "maximum" (water quality based) effluent limitation is a reference value. It plays no direct role in the determination of baseline or final effluent limitations. It is useful, however, in judging the sensitivity of model results to the inputed discharge concentration. Normally, if the inputed discharge concentration is more than fifty percent of the "maximum" effluent limitation, a more careful examination, including the collection of additional discharge data, will be made of the discharge concentration. The template computes the "maximum" effluent limitation by comparing the allowable loads for each of the three criteria under the Q_{7-10} design flow condition as selecting the most stringent value. For the Q_e design flow condition, the template uses the allowable load directly and computes the "maximum" effluent concentration. Both values are displayed separately in the output.

I. Multiple Discharge Analysis

When the baseline analysis for a parameter has been completed, the template performs multiple discharge analysis to determine if any (further) reductions in effluent limitations are needed because of cumulative discharge impacts. The baseline discharge loads and baseline effluent limitations are used as the starting effluent values in the multiple discharge analysis.

Multiple discharge analysis involves four (4) basic steps. The first step is to determine the cumulative, unallocated discharge load at the beginning of the current and each downstream reach. Next the available, unallocated assimilation capacity for the current and each downstream reach is determined. The unallocated discharge load and the unallocated assimilation capacity are then compared. If the discharge load is greater than the assimilation capacity in a given reach, a percent reduction for that reach is computed. The maximum percent reduction, considering the current and all subsequent downstream reaches is then applied to the discharge in the current reach to determine the allowable discharge load for the current discharge. The process is then repeated for the next downstream reach, after adjusting the cumulative unallocated discharge load and the available, unallocated assimilation capacity for the amounts allocated in the previous iteration, until all reaches and discharges have been evaluated. This process is repeated for each water quality criteria and parameter.

Multiple discharge analysis is conducted on the basis of net discharge loads and assimilative capacities. The template, therefore, computes a minimum allowable load for each discharge. This minimum allowable load will be a concentration equivalent to the water quality criteria, or the in-stream background water quality (i.e., unaffected by controllable loads) whichever

is the greater value. The results from analysis of the net discharge loads are added to the minimum allowable load to determine the final effluent limit.

An assumption made in multiple discharge analysis is that all discharges ar along the same shore line. This means that where two discharges to a very large stream (i.e., greater than approximately 500 cfs) are located in clos proximity to one another, but on opposite banks of the stream, it is possible that they should not be considered in the same evaluation, because the discharge plumes of these discharges do not interact with one another within the maximum criteria compliance time(s). For these types of situations, preliminary discharge plume analysis, outside the template, may be required to determine the proper discharge configuration that should be modeled.

A second assumption is that (any) upstream discharge(s) has completely mixe with the receiving stream prior to the next downstream discharge, regardless of the estimated complete mix time and the travel time between the discharges.

The multiple discharge calculation sequence is described in flow-chart form in Figure 10-3. The equation numbers shown on the figure refer to the actual equations, which are described below. Note that the calculation sequence described in Figure 10-3 is repeated for each parameter being evaluated.

22. In-stream Background Pollutant Concentration (µg/l)

In-stream background pollutant concentrations are determined using equation 15. Note, however, that multiple discharge travel times are used.

23. Minimum Allowable Discharge Load (mass units)

The minimum allowable discharge load is computed by taking the discharge analysis flow and multiplying by the minimum of the criteria or the in-stream background concentration. The general formulation for this computation is:

$$1.547 * QD * [COV * CV] \quad \text{or} \quad 1.547 * QD * CB$$

whichever is the maximum value, and, where,

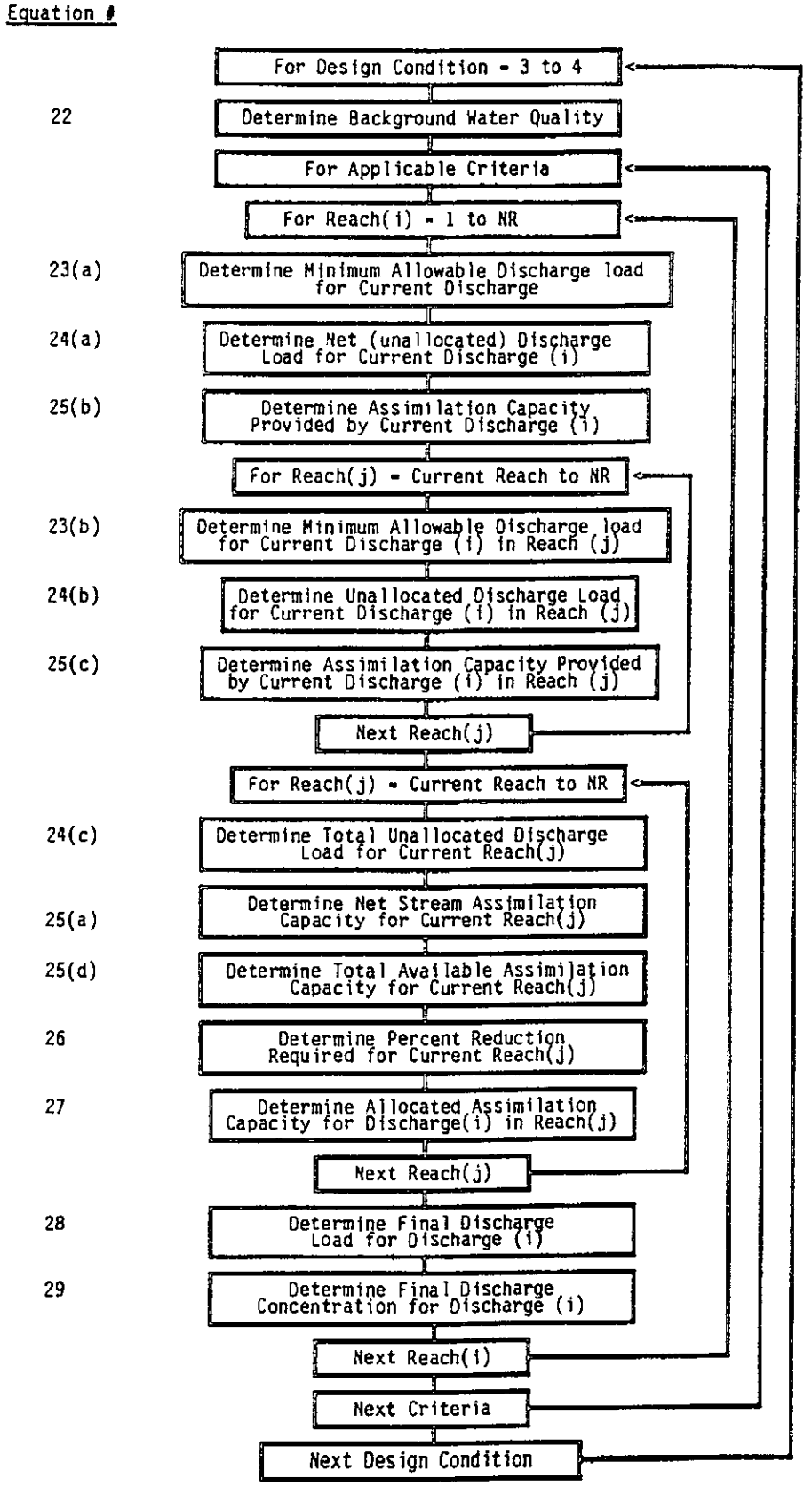
QD = Discharge Analysis Flow
COV = Coefficient of Variability Multiplication Factor
CV = Critieria Value
CB = In-Stream Background Concentration

24. Net Unallocated Discharge Load (mass units)

The unallocated discharge load for any discharge at the point of discharge is computed by taking the total baseline discharge load and subtracting the minimum allowable discharge load. This equation checks to see if there is a need to further allocate the discharge load because the baseline discharge

Figure 10-3

Multiple Discharge Calculation Sequence



load exceeds the minimum allowable load. If this occurs for the discharge, then a further reduction may be required. The general formula for this computation is:

$$PMF * [BDL - MADL * e^{-k_{i,j-1} * t_{i,j-1}}]$$

where,

PMF = Partial Mix Factor in the current reach
BDL = Baseline Discharge Load
MADL = Minimum Allowable Discharge Load

and,

$$e^{-k_{i,j-1}*t_{i,j-1}} = e^{-k_i*t_i} * e^{-k_{i+1}*t_{i+1}} * \cdots * e^{-k_{j-1}*t_{j-1}}$$

25. Net Available Assimilation Capacities (mass units)

The net assimilation capacity is computed in three separate equations. First, the net assimilative capacity provided by the receiving stream is computed. Second, assimilation capacity may also be provided by the current or any upstream discharge. This is also computed. There may also be the potential for assimilation capacity from the current discharge in the downstream reaches. This is computed. Finally, at each reach the total available assimilative capacity is computed by summing the total stream and discharge assimilative capacities from the unallocated loads, and subtracting out the assimilative capacities already allocated upstream. The general concept of this computation is:

$$[SAC + DAC - ADL]$$

where,

SAC = Stream Assimilative Capacity
DAC = Potential Discharge Assimilative Capacity Downstream
ADL = Allocated Assimilative Capacity to the Current Discharge

26. Required Percent Reduction of Current Load

Once the net discharge load and the net available assimilation capacities have been determined for the current and all subsequent downstream reaches, these two values are compared to determine if a reduction of the current load is required. Included in the comparison is a determination of whether or not the current load represents a significant part of the net discharge load, based on the wasteload allocation factor. If there is a reduction required, the template computes the percent reduction required.

27. Allocation of Assimilation Capacity to the Current Discharge (mass units)

The assimilative capacity that is allocated to the current discharge in the current and subsequent downstream reaches is then computed by taking the net unallocated load for the current discharge and multiplying by one minus the

maximum percent reduction. The maximum percent reduction is computed by beginning with the current reach and finding the maximum violation downstream of the current discharge. This reduction is applied to the net unallocated discharge load. The general formula for this computation is:

$$[\ NDL\ *\ \{\ 1\ -\ PR\ \}\ ]$$

where,

NDL = Net Discharge Load for the current discharge
PR = Percent Reduction (calculated by Equation 26)

28. Final Discharge Load (mass units)

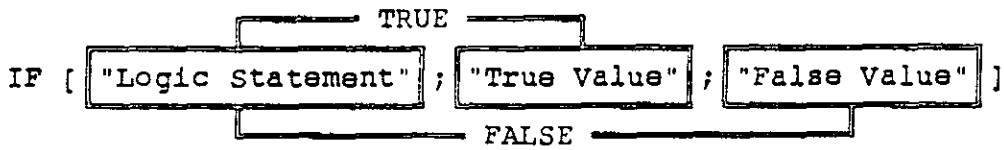
The final discharge load for each discharge is computed by comparing, 1) the minimum allowable discharge load, adding in the allocated load (computed in Equation 27, above, and, 2) the baseline discharge load determined in baseline analysis. Whichever of these values is the more stringent will be final discharge load. The baseline discharge load is further compared with the criteria and the background to protect against WQBELs being computed below the criteria or background value.

29. Final Discharge Concentration (ug/l)

The final discharge concentration is then computed by taking the final discharge load and dividing by the discharge analysis flow. Separate final discharge concentrations are computed for the Q_{7-10} and Q_e design stream flow conditions.

Part II - Detailed Formula Descriptions

Preface. In this section, we provide you with a detailed description of e of the formulas used in WQAT2_04. Since the execution module is written i Lotus 1-2-3, which is a spreadsheet software, the syntax for 1-2-3 formul must be explained. Formulas can be simple addition (+), subtraction (-), multiplication (*) and division (/), and can include exponents and/or val raised to a power. Formulas can also be logical. Logical formulas are ma up of three parts. These are: 1) the logic statement you are testing for 2) the true answer and, 3) the false answer. Logic statements can also b nested, meaning you are testing a series of true/false combinations and returning a different answer for each possible combination. (Note: In 1-2- the components of the logic statements are separated by commas. In this documentation, we are using semicolons.) The syntax for logic statements this documentation is as follows:



When the logical "if" statement being tested is true, the first value to t right of the "if" statement is returned. When the logical "if" statement being tested is false, the second value to the right of the "if" statement is returned. You can also have the following situations:

```
IF [ "Logic Statement A" ; IF [ "Logic Statement B" ; "True Value B" ;
     "False Value B" ] ; "False Value A" ]
```

or,

```
IF [ "Logic Statement A" ; "True Value A" ; IF [ "Logic Statement B" ; "Tr
      Value B" ; "False Value B" ] ]
```

In the first equation, if "Logic Statement A" is true, then "Logic Stateme B" is tested. When "Logic Statement B" is true, "True Value B" is displayed. When "Logic Statement B" is false, "False Value B" is displayed Finally, when "Logic Statement A" is false, "False Value A" is displayed.

In the second equation, the logical order is reversed. This time, if "Logi Statement A" is true, then "True Value A" is displayed. Otherwise, if "Log Statement A" is false, then "Logic Statement B" is tested.

The common operators used in logical "if" statements are greater than (>), less than (<), greater than or equal to (>=), and less than or equal to (<=). All of the formulas in the template use logic statements.

There is also another type of logical formula available in 1-2-3 by using the @MAX and @MIN functions. The @MAX means maximum and the @MIN means minimum. The syntax used in this section is: @MAX {"Value A","Value B"} or @MIN {"Value A","Value B"}.

The @MAX function tests two or more values and returns the maximum of the values in the brackets. Each value in the brackets is separated by a comma. The @MIN function tests two or more values and returns the minimum of the values in the brackets. As with @MAX, each value in the brackets is separated by a comma.

As you can see, by using the logic "if" statement and the @MAX and @MIN functions, some fairly sophisticated tests can be performed. In the following documentation, each equation will be displayed including the logical tests that are performed. The syntax described above will be used i the equations below. Also, each variable in the equations will be defined. Finally, an explanation of what the possible outcomes are for each equation will be provided just below that equation.

Preliminary Calculations:

1. Discharge Analysis Flow (MGD): QD_i

$$IF\ [\ DG\_QD_i > 0\ ;\ DG\_QD_i\ ;\ (1+RF) * @MAX\{\ EX\_QD_i,\ PM\_QD_i\ \}\ ]$$

where,

DG_QD_i = User supplied discharge design flow for discharge i
RF = User supplied reserve factor
EX_QD_i = User supplied existing discharge flow for discharge i
PM_QD_i = User supplied permitted discharge flow for discharge i

Explanation. In this equation, if you input a value for the design discharge flow (DG_QD_i) under the required reach data, the template uses this value directly in the model. If you do not input a design discharge flow, but instead input either an existing or permitted discharge flow, the template takes the maximum of the two inputed flows and multiples this value by one plus the reserve factor. The latter occurs only if you do not input a design discharge flow.

2. Reach Length (Feet): RL_i

$$IF\ [\ RL\_I_i > 0\ ;\ RL\_I_i\ ;\ (\ RMI_i - RMI_{i+1}\ )\ *\ 5280\ ]$$

where,

RL_I_i = User supplied reach length for reach i
RMI_i = User supplied river mile index at reach i

Explanation. In this equation, if you input a value for the length of each reach (RL_I_i) in the optional reach input data area, the template uses this value in the model. If you do not input a value for reach length, the template takes the difference between the current and downstream river mile indices and multiplies this by 5280. Multiplying by 5280 converts the reach length from miles to feet.

3. Reach Slope (FT/): SL_i

IF [$SL\_I_i > 0$; SL_I_i ; $SL_i = (EL_i - EL_{i-1}) / RL_i$]

where,

SL_I_i = User supplied slope for reach i
EL_i = User supplied elevation at the beginning of reach i

Explanation. In this equation, if you input a value for the reach slope (SL_I_i) in the optional reach input data area, the template uses this va in the model. If you do not input a value for slope, the template takes difference between the current and downstream elevations and divides thi the reach length (RL_i) from Equation 2 to compute the slope.

4. Incremental Stream Flows (CFS): $QI(x)_i$

(a) When x = Q_{7-10}

IF [$(QS\_I_i) > 0$; QS_I_i ; $(DA_i - DA_{i-1}) * GWY_i$]

where,

QS_I_i = User supplied incremental Q7-10 flow for reach i
DA_i = User supplied cumulative drainage area for reach i
GWY_i = User supplied minimum ground water yield for reach i

Explanation. In this equation, if you input a value for the incremental stream flow (QS_I_i) in the optional reach input data area, the template u this value in the model. If you do not input a value for incremental stre flow, the template computes the incremental flow by taking the difference between the current and upstream drainage area and multiplying by the gro water yield.

(b) When x = Q_c

IF [$QC\_I_i > 0$; QC_I_i ; $7.43 * \left(\sum_{1}^{i} Q7\text{-}10_i^{0.874} - \sum_{1}^{i-1} Q7\text{-}10_i^{0.874}\right)$]

where,

QC_I_i = User supplied incremental carcinogen design flow for reach
$Q7\text{-}10_i$ = Incremental Q7-10 stream flow, either inputed by the user computed from Equation 4(a).

Explanation. If you input a value for incremental design flow for carcinogens (QC_I_i), the template uses this value directly in the model. you do not input an incremental carcinogen stream flow, the template computes the incremental carcinogen design flow by calculating the total in the current and upstream reaches and then taking the difference of thes values. To compute the incremental Q_c flow, the template must do a summati of the incremental Q7-10 stream flows up to the current and previous reach and raise these summed flows to the power of .874. The template then takes the difference of the summed values and multiplies this by 7.43. In the equation above, i is the current reach, and i-1 is the previous reach. 5.

Total Net Design Stream Flow (CFS): $QS(x)_i$, where $x = Q_{7-10}$ or Q_c

$$@MAX \{ \sum_{1}^{i-1} (QI(x)_{i-1}) + QI(x)_i + 1.547*(FL*IWS_{i-1}-PWS_i-IWS_i) , 0 \}$$

where,

PWS_i = User supplied water supply intake at reach i
IWS^i = User supplied industrial water supply intake at reach i
FL = Baseline/multiple discharge analysis "flag." For baseline analysis, FL = 1. For multiple discharge analysis, FL = 0.

Explanation. In this equation, the template computes the total net stream flow in each reach. This is obtained by taking the sum of the total net stream flow up to the previous reach, adding in incremental stream flow for the current reach, and then subtracting out both the Potable Water Supply and Industrial Water Supply Withdrawals that are occurring in the present reach. The equation is surround by @MAX to prevent the total net stream flow from becoming a negative value. If the total computed net stream flow is a negative value, this equation displays a value of zero. Otherwise, the total computed net stream flow is displayed.

6. Stream Velocity (MPD): $VMPD(x)_i$, where $x = Q_{7-10}$ or Q_c

$$IF [V\_FPS\_I_i > 0 ; V\_FPS\_I_i * 16.36 ; a * Q_i^{.56} * (SL_i * 5280)^b * DA_i^c]$$

and,

$$Q_i = QS(x)_i + (\sum_{1}^{i-1} \{ fa_i * QD_i \} + QD_i) * 1.547$$

where,

$V\_FPS\_I_i$ = User supplied velocity in reach i in feet per second
fa_i = User supplied flow augmentation factor for discharge i
Q_i = Total adjusted design stream flow (cfs)

Explanation. In this equation, if you input a value for reach velocity ($V\_FPS\_I_i$) in the optional reach input data area, the template uses this value directly in the model. The template first, however, converts the velocity you enter to miles per day by multiplying by the constant 16.36. If you do not input a value for velocity, the template computes the velocity using the DER velocity equation. The velocity equation has been modified to take total adjusted stream flow (Q_i) into account. Total adjusted stream flow (Q_i) is the sum of: 1) total net stream flow ($QS(x)_i$) up to the current reach, 2) a summation of all discharges providing flow augmentation up to the current reach ($\sum \{ fa_i * QD_i \}$) and, 3) the current discharge flow (QD_i). (Q_i) is referenced many times in the preliminary calculations including the computation of velocity, width, width/depth ratio and depth.

The user supplied discharge flow augmentation factor is a user input and can be a value from 0 to 1. In baseline calculations the flow augmentation factor (fa_i) for each upstream discharge is set equal to the user specified value, which must be between zero (0) and one (1). In multiple discharge calculations, (fa_i) is equal to one (1).

The constants a,b,c can be one of the following values depending on the total drainage area in the current reach.

	a	b	c
When DA_i <= 500mi²	2.62	0.083	-0.22
When DA_i > 500mi²	1.64	0.055	-0.15

These constants are used in the DER velocity equation.

7. Reach Travel Times (Days) $TT(x)_i$, where x = Q_{7-10} or Q_c

IF [TT_I_i > 0 ; TT_I_i ; RL_i/(5280 * $VMPD(x)_i$)]

where,

TT_I_i = User supplied travel time for reach i

Explanation. In this equation, if you input a value for travel time (TT_I the templates uses this value directly in the model. If you do not input value for travel time in the optional reach data area, the template compu the travel time by taking the reach length (RL_i) and dividing by the velocity in miles per day ($VMPD(x)_i$). This is either the velocity compute at the Q_{7-10} or Q_c design condition. The constant 5280 in the denominator used to convert feet to miles.

8. Stream Velocity (FPS): $VFPS(x)_i$, where x = Q_{7-10} or Q_c

IF [TT_I_i > 0 ; RL_i / (TT_i * 86400) ; $VMPD_i$ / 16.36]

Explanation. In this equation, if you input a value for the travel time, the template takes the reach length (RL_i) and divides by the travel time (TT_i) after applying the conversion factor of 86400 to obtain feet per second. This is because the travel time (TT_i) is in days. If you do not input the travel time, then the template computes the velocity by taking t computed velocity in miles per day ($VMPD_i$) and dividing by 16.36 to conve to feet per second.

9. Reach Width/Depth Ratios: $W\_D(x)_i$, where x = Q_{7-10} or Q_c

IF [$W\_D\_I_i$ > 0 ; $W\_D\_I_i$; [-.073 +.141 * $Q_i^{-.077}$ +.06 * $DA_i^{-.448}$ +.0001 * (5280 * SL_i)$^{1.075}$]$^{-1.429}$]

where,

$W\_D\_I_i$ = User supplied width/depth ratio for reach i

Explanation. If you input the width/depth ratio ($W\_D\_I_i$) in the optional reach data area, then the template uses this value directly in the model. you do not input a width/depth ratio, then the template computes the W/D ratio using the Memon-Vu equation.

10. Reach Depths (Feet): $D(x)_i$

(a) When x = Q_{7-10}

IF [WIDTH_I$_i$ > 0 ; (Q_i/(VFPS$_i$ * WIDTH_I$_i$) ; IF [DEPTH_I$_i$ > 0 ; DEPTH_I$_i$; [Q_i/(VFPS(x)$_i$ * W_D(x)$_i$)] $^{.5}$

where,

WIDTH_I$_i$ = User supplied depth for reach i
DEPTH_I$_i$ = User supplied depth for reach i

Explanation. In the first condition, if you input the width, the template calculates the depth by taking the total stream flow (Q_i) up to the curren reach and dividing by the velocity multiplied by the width: (VFPS$_i$ * WIDTH_I$_i$). This means the depth is derived based on the inputed width. This is simply Q/(A*V), where A is equal to the width multiplied by the depth (A=W*D) and you are solving for depth.

If you do not input the width, but instead choose to input the depth, the template uses the inputed depth directly in the model. Finally, if you choose to input neither the width nor the depth, the template computes the reach depth by taking the total computed stream flow (Q_i) and dividing it by a computed velocity multiplied by the computed width/depth ratio raised to the power of one-half or the square root (Q_i/VFPS(x)$_i$ * W_D(x)$_i$)$^{.5}$. This is also derived from the relationship: Q = (A*V).

(b) When x = Q_c

Q_i/(VFPS(x)$_i$ * W(x)$_i$)

where,

W(x)$_i$ = Stream width determined for Q_{7-10} design conditions (from equation 11 below)

Explanation. When the design flow is at the Q_c condition, the template simply takes the width computed or inputed at the Q_{7-10} design condition and uses this width to compute the depth at Q_c. The width (W(x)$_i$) is determined in the next equation.

11. Reach Widths (Feet): W(x)$_i$, where x = Q_{7-10} and Q_c

IF [WIDTH_I$_i$ > 0 ; WIDTH_I$_i$; D(x)$_i$ * W_D(x)$_i$]

where,

WIDTH_I$_i$ = User supplied width for reach i
D(x)$_i$ = Depth determined for Q_{7-10} design conditions (from equation 10 above)

Explanation. In this equation, if you input the width in the optional reach data area, the template uses this width directly in the model and in Equation 10, above. If you do not input the width, the template computes

the width by taking the depth (computed in Equation 10) and multiplying this depth by the width/depth equation. When you input the width in the optional reach data area, the template uses this width for both the Q_{7-10} and Q_c design stream flow conditions. The depth ($D(x)_i$) is adjusted accordingly.

12. Complete Mix Times (Minutes): $TM(x)_i$, where x = Q_{7-10} or Q_c

$$\text{IF [CMT\_I}_i > 0 \text{ ; CMT\_I}_i \text{ ; IF [TR\_NAME}_i = \text{"d" ; 15 ; } \frac{0.315 * W'(x)_i^2}{[\,0.6 * D(x)_i * (\,32.2 * D(x)_i * SL_i\,)^{.5} * 60]} \text{]]}$$

and,

$$W'(x)_i = W(x)_i * \frac{Q_i - 1.547 * QD_i}{Q_i}$$

where,

CMT_I_i = User supplied complete mix time for discharge at the beginni of reach i

TR_NAME_i = User supplied indicator of discharge having high rate diffusers (*d*)

$W'(x)_i$ = Adjusted width in reach i (see Appendix C)

Explanation. In this equation if you input the complete mix time (CMT_I_i for each reach, the template uses your inputed mix time directly in the model. Secondly, if you wish to turn on high-rate diffusers for the discharge in the current reach, the template overides any user inputed complete mix time and sets the complete mix time to 15 minutes. This mea that all the criteria will be evaluated at the complete mix condition. If you do neither of the two options mentioned here, the template computes t complete mix time using the Ambient Mixing Equation in the model.

This Ambient Mixing Equation has been slightly modified here to take into consideration mixing that occurs when you have a stream that is "discharge dominated". Equation 12(a) modifies the width ($W(x)_i$) by multiplying it by a ratio of total adjusted stream flow minus the discharge flow divided by the total adjusted stream flow. This adjusted width ($W'(x)_i$) is then usec in the mixing equation. By using an adjusted width, mixing occurs more rapidly in "discharge dominated" stream conditions.

13. Travel Time to Nearest Downstream PWS (Days): T_PWS(x)

where x = Q_{7-10} or Q_c,

The travel time to the nearest downstream water supply (T_PWS(x)) is determined by a search routine that locates each potable water supply withdrawal entered by the user, and then sums the reach travel times from the current discharge to the withdrawal location. (Note: Since reach travel times may vary by design condition, the travel time to the nearest downstream potable water supply may also vary.)

14. Human Health Criteria Compliance Time (minutes): $T\_HHC(x)_i$

where $x = Q_{7-10}$ or Q_c,

$$IF \left[\sum_{i}^{nr} PWS(x)_i = 0 \; ; \; 720 \; ; \; @MIN\{ 720, T\_PWS(x)_i * 1440 \} \right]$$

Explanation. In this equation, the template checks each reach from the current reach to the end of the segment and does a summation of potable water supply withdrawals. If there are no potable water supply withdrawals meaning: $\Sigma\ PWS(x)_i = 0$, then the template sets the human health criteria compliance time ($T\_HHC(x)_i$) equal to 720 minutes (12 hrs.). If the template finds potable water supply withdrawals, it determines the human health criteria compliance time by taking the minimum of 720 minutes or the travel time to the nearest downstream water supply ($T\_PWS(x)_i$). The value of 1440 is used to convert the travel time to minutes.

15. Partial Mix Factors: $PMF(x,y)_i$, where $x = Q_{7-10}$ or Q_c

$$IF \left[TR\_NAME_i = \text{"*t*"} \; ; \; 1 \; ; \; @MIN\{ (tc(y)/TM(x)_i)^{.5} , 1 \} \right]$$

where,

tc(y) = Maximum allowable criteria compliance time (minutes):

	AFC	CFC	THH & CRL
tc(y)	15	720	$T\_HHC(x)_i$

Explanations. In this equation, if the current stream reach has been designated as a transfer reach, the partial mix factor is set equal to 1. This means complete mix will be assumed for all transferred equivalent discharge loads. If the current reach is not a transfer reach, the template calculates the partial mix factor by taking the minimum of: 1) the criteria compliance time (tc(y)) divided by the complete mix time ($TM(x)_i$) raised to one-half (.5) power, or, 2) the value of 1. This means that if the discharge plume is not completely mixed at the compliance time (tc(y)), the discharge plume will only be partially mixed with the stream. In this case the partial mix factor will be some value between 0 and 1. If complete mix occurs before the discharge plume reaches the compliance time (tc(y)), the discharge will be completely mixed. The partial mix factor will be set equal to 1. During each modeling analysis, separate partial mix factors are computed for each criteria evaluated.

Baseline Analysis:

16. In-stream Background Pollutant Concentrations (µg/l): $CB(x)_i$

where $x = Q_{7-10}$ or Q_c,

$$CB(x)_i = \frac{@MAX\{\ QS(x)_{i-1} * CB(x)_{i-1} * e^{-k_{i-1}*t_{i-1}}, 0\ \} + QI(x)_i * CT_i}{@MAX\{\ QS(x)_i\ ,\ QI(x)_i\ \}}$$

where,

k_i = User supplied aggregate fate coefficient for reach i
t_i = travel time for reach i
CT_i = User supplied tributary flow pollutant concentration

Explanation. In this equation, the template computes the in-stream background concentration for the current reach (i), by performing the following mass balance: 1) the background load upstream of the current reach is computed, applying any decay (in-stream fate), 2) the tributary flow pollutant load in the current reach is added, and, 3) the total loa is then divided by either the total net stream flow or the tributary flo depending upon which flow is the largest.

The @MAX functions are used to protect against negative background concentrations. If all of the upstream flow has been withdrawn (either d to potable water supplies or an industrial water withdrawal in the curre reach), the template uses only the tributary load in the current reach t compute the background concentration. If there is no tributary pollutant background concentration and the upstream background has been removed (b withdrawals), then the in-stream pollutant concentration in the current reach will be zero. It will remain zero until a new tributary pollutant concentration is added into the stream.

17. Allowable Discharge Load at the current reach (i): $AL(x,y)_i$

(a) Minimum Allowable Discharge Load: $MADL(x,y)_i$

$$QD_i * 1.547 * @MAX\{ COV(y)*CV(y) , CB(x)_i \}$$

(b) Net Assimilation Capacity Provided by the Stream: $NAC(x,y)_i$

$$QS(x)_i * PMF(x,y)_i * [@MAX\{ COV(y)*CV(y) , CB(x)_i \} - CB(x)_i]$$

(c) Assimilation Capacity from Upstream Discharges: $TSDAC(x,y)_i$

$$PMF(x,y)_i * \sum_{1}^{i-1} (SIDAC(x,y)_i)$$

(d) Total Allowable Discharge Load: $AL(x,y)_i$

$$MADL(x,y)_i + NAC(x,y)_i + TSDAC(x,y)_i$$

where, x = Q_{7-10} or Q_c
y = criteria being evaluated, and,

COV(y) = Effluent Variability Factor associated with criteria y. Present factors used in the template are:

	AFC	CFC	THH & CRL
COV(y)	0.39	0.72	1.00

CV(y) = Criteria Value for criteria y

$SIDAC(x,y)_i$ = Discharge Assimilation Capacity Provided by Upstream Discharges at the current reach (i). (See equation 19 below.)

Explanation. In these equations, the template computes the total allowable discharge load for the current reach. To compute this, three separate computations are made. These are: 1) the minimum allowable discharge load ($MADL(x,y)_i$), 2) the net assimilative capacity provided by the stream ($NAC(x,y)_i$), and 3) the total assimilative capacity from any upstream discharges ($TSDAC(x,y)_i$). Once these three values are known, they are added together to obtain the total allowable discharge load ($AL(x,y)_i$).

Equation 17(a). The minimum allowable discharge load ($MADL(x,y)_i$) is computed by taking the discharge flow and multiplying by the maximum of the criteria or the in-stream background concentration ($CB(x)_i$). The criteria is further multiplied by the appropriate effluent variability factor (COV(y)*CV(y)) before comparison with the in-stream background is made.

Equation 17(b). The net assimilative capacity provided by the stream ($NAC(x,y)_i$) is computed by taking:

1) the total net stream flow at the current reach ($QS(x)_i$) and multiplying by the partial mix factor ($PMF(x,y)_i$), then,
2) multiplying by the relationship:

$$[\ @MAX\{\ COV(y)*CV(y)\ ,\ CB(x)_i\ \}\ -\ CB(x)_i\ ].$$

In this part of the equation, if the in-stream background ($CB(x)_i$) is greater than the criteria multiplied by the conversion factor ($COV(y)*\ CV(y)$), then ($NAC(x,y)_i$) will be equal to zero since the ($CB(x)_i$) terms will cancel out.

Equation 17(c). The total assimilative capacity provided by the upstream discharges ($TSDAC(x,y)_i$) is computed and added in at the current reach. (Refer to Equation 19, below for an explanation of how the discharge assimilative capacity ($TSDAC(x,y)_i$) is computed.) Before the ($TSDAC(x,y)_i$) can be computed for the current reach, however, the individual discharge load ($IDL(x,y)_i$) must be computed. Once the ($IDL(x,y)_i$) is known for the current reach, it is used to calculate any assimilative capacity for that reach and this assimilative capacity, if any, is added to the total allowable load for all subsequent downstream discharges.

Equation 17(d). Finally, the total allowable load ($AL(x,y)_i$) is computed by summing: 1) the minimum allowable load ($MADL(x,y)_i$), 2) net assimilativ capacity provided by the stream ($NAC(x,y)_i$), and, 3) the assimilative capacity(ies) from upstream discharges ($TSDAC(x,y)_i$), at the current reach (i).

18. Individual Discharge Load at the current reach (i): $IDL(x,y)_i$

$$IF\ [\ WS = "UT"\ ;\ 1.547\ *\ CD_i\ *\ QD_i\ ;\ @MIN\{\ 1.547\ *\ QD_i\ *\ CD_i,\ AL(x,y)_i\ \}\ ]$$

WS = User specified wasteload allocation method

Explanation. In this equation, if you specified the "uniform treatment" method in your setup file, the template overides all of the baseline calculations, and, instead, computes the individual discharge load using the discharge analysis flow multiplied by the inputed discharge concentration ($1.547 * CD_i * QD_i$). If the wasteload allocation method is "equal marginal percent removal", the template determines the individual discharge load ($IDL(x,y)_i$) by taking the minimum of: 1) the allowable discharge load ($AL(x,y)_i$), or, 2) the discharge analysis flow multiplied b the discharge concentration ($1.547 * QD_i * CD_i$). If the allowable load ($AL(x,y)_i$) is greater than ($1.547 * QD_i * CD_i$), then there is no violation of the criteria in the baseline analysis.

19. Surplus Assimilation Capacity for Current Discharge: $SIDAC(x,y)_i$

In the current reach (i):

$$fa_i * @MAX\{ MADL(x,y)_i - IDL(x,y)_i , 0 \}$$

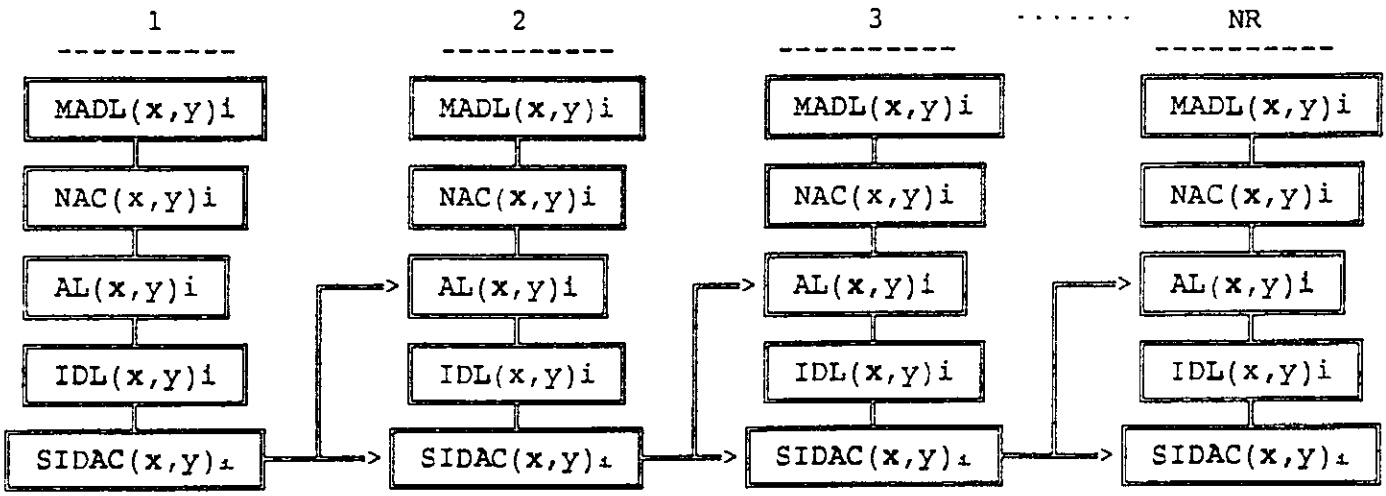
In subsequent downstream reaches, the equation is:

$$fa_j * @MAX\{ MADL(x,y)_i - IDL(x,y)_i * e^{-k_{i,j-1}*t_{i,j-1}} , 0 \}$$

where, x = Q_{7-10} or Q_o and y = criteria being evaluated, and,

$$e^{-k_{i,j-1}*t_{i,j-1}} = e^{-k_i*t_i} * e^{-k_{i+1}*t_{i+1}} * \cdots * e^{-k_{j-1}*t_{j-1}}$$

Explanation. In this equation, we compute the net discharge assimilative capacity, beginning with Discharge No. 1. This is done using the following procedure and illustrated in Figure 10-4, below:



1) For the current reach, the net surplus discharge capacity ($SIDAC(x,y)_i$) is computed and decayed through subsequent downstream reaches. The ($SIDAC(x,y)_i$) is made available for all downstream discharges.
2) The next downstream reach now becomes the current reach. A new (($AL(x,y)_i$) is computed, adding in any surplus assimilative capacity ($SIDAC(x,y)_i$) from the upstream discharge(s) multiplied by the partial mix factor ($PMF(x,y)_i$) in the current reach.
3) A new (IDL(x,y)i) is computed for the current reach.
4) Steps 1) thru 3) are repeated again. This iterative process continues up to the last discharge (NR) begin evaluated.

In Equation 17(c), above, the term (Σ ($SIDAC(x,y)_i$)) is the summation of all upstream discharge assimilative capacities up to the previous reach. This is added to the total allowable discharge load ($AL(x,y)_i$) for each discharge as you move downstream. Another words, the upstream ($SIDAC(x,y)_i$) is made available to all of the downstream discharges.

20. Baseline Discharge Load: $BDL(x)_i$

When $x = Q_{7-10}$

$@MIN\{ IDL(AFC)_i, IDL(CFC)_i, IDL(THH)_i \}$

When $x = Q_c$

$IDL(CRL)_i$

where,

$IDL(AFC)_i$ = Individual Discharge Load computed for AFC criteria
$IDL(CFC)_i$ = " " " " " CFC criteria
$IDL(THH)_i$ = " " " " " THH criteria
$IDL(CRL)_i$ = " " " " " CRL criteria

Explanation. In this equation, if the design stream flow condition is Q_{7-10}, the template takes the minimum of three, separately computed, individual discharge loads ($IDL(x,y)_i$) (from Equation 18, above) and this value becomes the baseline discharge load for the multiple discharge analysis. If the design stream flow condition is Q_c, the template uses the individual discharge load computed for the Q_c flow as the baseline.

21. Baseline Discharge Concentration (ug/l): $BDC(x)_i$, where $x = Q_{7-10}$ or Q_c

$$BDC(x)_i = BDL(x)_i/(QD_i*1.547)$$

Explanation. In this equation, the baseline discharge load ($BDL(x)_i$) is displayed as a concentration. This computation is for information purposes only.

22. "Maximum" Effluent Limitation (ug/l): $WQM(x)_i$

When $x = Q_{7-10}$

$$\frac{@MIN\{ AL(AFC)_i, AL(CFC)_i, AL(THH)_i \}}{QD_i * 1.547}$$

When $x = Q_c$

$$AL(CRL)_i/(QD_i * 1.547)$$

where,

$AL(AFC)_i$ = Total Allowable Load for the AFC criteria analysis
$AL(CFC)_i$ = " " " " CFC " "
$AL(THH)_i$ = " " " " THH " "
$AL(CRL)_i$ = " " " " CRL " "

Explanation. In this equation, the template computes the maximum effluent limitation. For the Q_{7-10} design condition, this value is the minimum of the allowable loads ($AL(x,y)_i$) computed for each of the three criteria

divided by the discharge analysis flow (QD_i * 1.547). For the Q_c stream flow condition, the template merely takes the allowable load for the Q_c criteria and divides this value by the discharge analysis flow. This computation is also for information purposes only.

Multiple Discharge Analysis:

23. In-stream Background Pollutant Concentration (µg/l): $CB(x)_i$

where x = Q_{7-10} or Q_c

In-stream background pollutant concentrations are computed the same as in the Baseline Analysis. Refer to Equation 16, above. However, if you have fate (in-stream decay), the background concentrations here will be different due to the use of multiple discharge travel times, instead of baseline travel times.

24. Minimum Allowable Discharge Load (mass units): $MADL(x,y)_i$

For the current reach (i):

(a) 1.547 * QD_i * @MAX{ COV(y)*CV(y) , $CB(x)_i$ }

For discharge (i) and subsequent downstream reaches (j):

(b) 1.547 * QD_i * maximum{ COV(y)*CV(y) , $CB(x)_j$ }

where, x = Q_{7-10} or Q_c
y = criteria being evaluated, and,

Explanation. In this equation, the template computes the minimum allowable discharge load ($MADL(x,y)_i$) for each discharge beginning with the Discharge No. 1. To compute the minimum allowable discharge load, the template takes the discharge analysis flow (QD_i) and multiplies this by the either the criteria multiplied by the conversion factor (COV(y)*CV(y)) or the in-stream background ($CB(x)_j$), whichever is the larger value. In subsequent downstream reaches, the minimum allowable load is a function of the background water quality in that stream reach.

25. Unallocated Discharge Loads (mass units): $TDL(x,y)_j$

where, x = Q_{7-10} or Q_a
y = criteria being evaluated, and,

(a) Net Discharge Load for current reach (i): $NDL(x,y)_i$

$$@MAX\{ BDL(x,y)_i - MADL(x,y)_i , 0 \}$$

(b) Net Discharge Load for current discharge (i) in downstream reach (j): $NDL(x,y)_{i,j}$

$$PMF(y)_j * @MAX\{BDL(x,y)_i * e^{-k_{i,j-1}*t_{i,j-1}} - MADL(x,y)_{i,j} , 0 \}$$

where,

$$e^{-k_{i,j-1}*t_{i,j-1}} = e^{-k_i*t_i} * e^{-k_{i+1}*t_{i+1}} * \ldots\ldots * e^{-k_{j-1}*t_{j-1}}$$

(c) Total Net Discharge Load for Discharge (i) in any reach (j): TDL(x,y

$$\sum_{j=i}^{nr} (NDL(x,y)_{i,j})$$

where,

i = The current discharge being evaluated, and,
j = The total number of reaches beginning with reach (i)
nr = The total number of reaches

Explanation. In these equations, the template computes the total net unallocated discharge load for which allocation of available assimilation capacity may be necessary. This is done in three steps. These are: 1) determine the net discharge load for each discharge, 2) simulate that discharge load from the current reach (i) to the total number of reaches being evaluated (j), computing a new net discharge load at each point, an 3) take the summation from the current reach to the end of the segment of all net discharge loads.

Equation 25(a). The Net Discharge Load for the Current Reach (i) ($NDL(x,y)_i$) is computed by taking the baseline discharge load ($BDL(x,y)_i$) and subtracting the minimum allowable discharge load ($MADL(x,y)_i$). The purpose for the @MAX function is to see if the result is a value greater than zero. If the ($NDL(x,y)_i$) is greater than zero this means there is additional net load which the discharge is contributing to the system, an this load must be simulated through all reaches, beginning with the next downstream reach, incorporating any fate (in-stream decay) that may be occurring.

Equation 25(b). In this equation, the net discharge load ($NDL(x,y)_{i,j}$) i computed downstream of discharge (i) by applying in-stream decay to the baseline discharge load ($BDL(x,y)_i$) and subtracting the minimum allowable

discharge load ($MADL(x,y)_{i,j}$) in reach (j). In addition, the partial mix factor ($PMF(y)_j$) at reach (j) is also multiplied to the result to take into consideration mixing with the next downstream discharge plume.

This is an iterative procedure similar to the method used in Equation 19, above. The template computes the net loads for each discharge, beginning with the first discharge and moving downstream to the last discharge.

Equation 25(c). After all of the net discharge loads ($NDL(x,y)_{i,j}$) have been computed individually, the template takes a summation of all of the discharge loads beginning at the first reach and ending at the total number of reaches. This is represented by the formula: $TDL(x,y)_j$. The total net discharge load in each reach is represent by: $\Sigma\ (NDL(x,y)_{i,j})$ where j is equal to the current discharge (i) and the summation proceed from j to the total number of reaches being evaluated (nr).

26. Assimilation Capacities (mass units): $TAC(x,y)_j$

where, x = Q_{7-10} or Q_c
y = criteria being evaluated, and,

(a) Stream Assimilation Capacity: $SAC(x,y)_i$

$$PMF(x,y)_i * QS(x)_i * [\ @MAX\{\ COV(y)*CV(y)\ ,\ CB(x)_i\ \} - CB(x)_i\ ]$$

(b) Discharge Assimilation Capacity: $DAC(x,y)_i$

$$- @MIN\{\ BDL(x,y)_i - MADL(x,y)_i\ ,\ 0\ \}$$

(c) Potential Discharge Assimilation Capacity Downstream: $DAC(x,y)_{i,j}$

$$- PMF(x,y)_j * @MIN\{\ BDL(y)_i * e^{-k_{i,j-1}*t_{i,j-1}} - MADL_{i,j}\ ,\ 0\ \}$$

where,

$$e^{-k_{i,j-1}*t_{i,j-1}} = e^{-k_i*t_i} * e^{-k_{i+1}*t_{i+1}} * \ldots\ldots * e^{-k_{j-1}*t_{j-1}}$$

(d) Total Assimilation Capacity at reach (j): $TAC(x,y)_j$

$$SAC(x,y)_j + \sum_{i=1}^{j} DAC(x,y)_{i,j} - \sum_{i=0}^{j-1} ADL(x,y)_{i,j}$$

where,

$ADL(y)_{i,j}$ = Previously allocated assimilation capacity for discharge i at the beginning of reach j for criteria y. The expression for determining $ADL(y)_{i,j}$ is described in equation 28 below.

Explanation. To compute the total assimilation capacity in the stream, the template goes through another series of calculations, each designed to determine a different type of assimilation capacity. At each reach, the template computes: 1) the net stream assimilation capacity ($SAC(x,y)_i$) available at the beginning of each reach (i), 2) the discharge assimilatic capacity ($DAC(x,y)_i$) that may be added by the current discharge in reach (i), and, 3) the potential that each discharge may contribute some assimilation capacity downstream ($DAC(x,y)_{i,j}$) at reach (j).

Equation 26(a). Stream assimilation capacity is determined by taking the total net stream flow ($QS(x)_i$) up to the current reach (i) and multiplying by the partial mix factor ($PMF(x,y)_i$). This is then multiplied to the relationship: [@MAX{ COV(y)*CV(y) , $CB(x)_i$ } -$CB(x)_i$]. If the background concentration ($CB(x)_i$) exceeds the criteria multiplied by the conversion factor (COV(y)*CV(y)) then the assimilation capacity provided b the stream will be equal to zero.

Equation 26(b). The template computes the discharge assimilation capacity ($DAC(x,y)_i$) in the current reach (i) by taking the baseline discharge loac ($BDL(x,y)_i$) and subtracting the minimum allowable discharge load ($MADL(x,y)_i$). If the baseline discharge load is less than the minimum allowable load, then addition assimilation capacity is provided by the discharge. The -@MIN in this equation ensures that the ($DAC(x,y)_i$) is always a positive number or zero.

Equation 26(c). The equation for potential discharge assimilation capacity downstream ($DAC(x,y)_{i,j}$) is similar to ($DAC(x,y)_i$) except here we look at each discharge (i) in the downstream reaches (j). The corresponding partia mix factor: ($-PMF(x,y)_j$) is applied in each downstream reach. In addition fate (in-stream decay) is considered for the baseline discharge load ($BDL(y)_i$). The negative sign in front of the partial mix factor ensures that the result will be a positive number or zero. Again the procedure use to compute the loads is similar to that used in Equation 16, above.

Equation 26(d). Finally, the total assimilation capacity ($TAC(x,y)_j$) at an reach (j) is computed by taking a summation of: 1) the total stream assimilation capacity ($SAC(x,y)_i$), 2) the existing and/or potential discharge surplus assimilation capacity ($DAC(x,y)_{i,j}$), and, 3) subtracting previously allocated assimilation capacity ($ADL(y)_{i,j}$) from upstream discharges. See Equation 28 for an explanation of how the ($ADL(y)_{i,j}$) is derived.

27. Required Percent Reduction of Current Load: $PR_{i,j}$

IF [$TDL(x,y)_j$ < $TAC(x,y)_j$ #OR# $NDL(x,y)_{i,j}$ < WF * $TDL(x,y)_j$: 0 ; ($TDL(x,y)_j$ - $TAC(x,y)_j$) / $TDL(y)_j$

where, x = Q_{7-10} or Q_o
y = criteria being evaluated, and,

Explanation. In this equation, the template computes the percent reduction ($PR_{i,j}$) required for the current discharge load. This is done by doing two comparisons. First, if the total net discharge load ($TDL(x,y)_j$) in reach (j) is less than the total net assimilation capacity ($TAC(x,y)_j$ in reach

(j) then the percent removal computed by the template will be zero. If the net discharge load ($NDL(x,y)_j$) for the current discharge is less than the wasteload allocation factor multiplied by the total net discharge load ($WF * TDL(x,y)_j$), then the percent reduction is also equal to zero. If this is true, then the current discharge is contributing less than a significant portion of the total load at the critical reach. Because the default wasteload allocation factor (WF) is equal to 5%, a discharge would have to be contributing more that 5% of the total load at the critical reach before it would be considered as part of the multiple discharge WLA. Finally, if neither of the conditions tested here is true, then the template computes a percent reduction by taking the total net discharge load and subtracting the total net assimilation capacity, then dividing by the total net discharge load [$(TDL(x,y)_j - TAC(x,y)_j) / TDL(y)_j$].

28. Allocation of Assimilation Capacity to the Current Discharge: $ADL(x,y)_{i,j}$

$$NDL(x,y)_{i,j} * (1 - @MAX\{ PR_{i,i}..PR_{i,nr} \})$$

where, x = Q_{7-10} or Q_c
y = criteria being evaluated, and,

Explanation. In this equation, the template computes the allowable discharge load ($ADL(x,y)_{i,j}$) by taking the net discharge load and multiplying by 1 times the maximum percent reduction. The maximum percent reduction is obtain by looking downstream beginning from the current reach (i) and finding the maximum value up to the number of reaches (nr) being evaluated.

29. Final Discharge Load (mass units): $FDL(x,y)_i$

$$@MIN\{ MADL(x,y)_i + \frac{ADL(x,y)_{i,i}}{(1+FOS)}, IF\{ BDC(x,y)_i <= @MAX\{COV(y)*CV(y)*(1+FOS), CB(x)_i\} ; 1.547*QD_i*@MAX\{COV(y)*CV(y), CB(x)_i\} ; \frac{BDL(x,y)_i}{(1+FOS)}] \}$$

where, x = Q_{7-10} or Q_c
y = criteria being evaluated, and,
FOS = Factor of Safety

Explanation. In this equation, we finally determine the discharge load that can be safely discharged into the stream. To compute final discharge load ($FDL(x,y)_i$), there are a number of comparisons that are done. To obtain the final value, we take the minimum of the results from the baseline discharge analysis and the multiple discharge analysis.

The final multiple discharge allowable load is computed by taking the minimum allowable discharge load ($MADL(x,y)_i$) and adding in any additional allocation of assimilation capacity to the discharge ($ADL(x,y)_{i,i}$). This additional allocated load is divided by (1+FOS).

The final baseline discharge allowable load is computed by determining if the baseline discharge concentration ($BDC(x,y)_i$) is less than maximum of either the criteria multiplied by the conversion factor and the factor of safety ($COV(y)*CV(y)*(1+FOS)$) or the in-stream background ($CB(x)_i$). If th is true, then template computes the final baseline discharge allowable lo as: $1.547*QD_i*@MAX\{COV(y)*CV(y),CB(x)_i\}$. Otherwise, the template simply brings down the baseline discharge load ($BDL(x,y)_i$) (computed in Equation 20) and divides this by (1+FOS).

Once the final baseline and multiple discharge allowable loads are known, the template takes the minimum of these two values to obtain the final discharge load ($FDL(x,y)_i$).

30. Final Discharge Concentration (ug/l): $FDC(x)_i$

where $x = Q_{7-10}$

$$\frac{@MIN\{\ FDL(AFC)_{i,i},\ FDL(CFC)_{i,i},\ FDL(THC)_{i,i}\ \}}{QD_i * 1.547}$$

where $x = Q_e$

$$\frac{@MIN\{\ BDL(x)_i,\ FDL(CRL)_{i,i}\}}{QD_i * 1.547}$$

and,

$FDL(AFC)_{i,i}$ = Final discharge load from the AFC criteria evaluation
$FDL(CFC)_{i,i}$ = " " " " " CFC " "
$FDL(THH)_{i,i}$ = " " " " " THH " "
$FDL(CRL)_{i,i}$ = " " " " " CRL " "

Explanation. In these equations, the template determines the final discharge concentrations for both design stream flow conditions. For the Q_{7-10} design stream flow condition, the template compares the fin allowable discharge loads from the AFC, CFC, an THH criteria and selects the minimum (most stringent of the three values). For the Q_e design strea flow condition, the template compares the baseline and final discharge loads and, again, selects the minimum or most stringent of the values. The results for Q_{7-10} and Q_e are displayed separately in the output reports so that you can determine which value to place in the permit.

Appendices

Appendix A

Explanation of TMDL/WLA Screening Symbols

TECH:XXX

This symbol means that the discharge does not cause a violation of any of the four criteria evaluated. The XXX is the governing criteria which produce the most stringent WQ-Based Effluent Limit, if one was needed.

TECH:XXX > 50%

This symbol means that the discharge does not cause a violation of any of the four criteria evaluated. The XXX is the governing criteria which would produce the most stringent WQ-Based Effluent Limit, if one was needed.
The > 50% means that the initial discharge concentration supplied by the user is within 50% or less of MAX WQ-Based Effluent Limit. You would generally consider this a parameter of concern, and double the discharge concentration, then re-run the template to see if this parameter becomes part of a multiple discharge WLA.

N/A

Not applicable. Either no discharge concentration was inputed for the discharge being evaluated or no criteria exists.

< XXX:0 >

This means a violation of the criteria occurred for the discharge. The :0 means, there is no interaction with other discharges downstream. The XXX is the governing criteria which produced the most stringent WQ-Based Effluent Limit. In this case, a WQ-Based Effluent Limit is needed for the discharge.

< XXX:N >

This means a violation of the criteria occurred for the discharge. It also means that there is a multiple discharge interaction taking place. The :N is the critical reach number where the violation is at a maximum for the discharges being evaluated. The XXX is the governing criteria which produced the most stringent WQ-Based Effluent Limit. In this case, a WQ-Based Effluent Limit is needed for the discharge based on a multiple discharge WLA.

Appendix B - List of WQAT2_04 Program Files

File Name		Size	Date	Time	Description
CRITDAT	WK1	10287	5-15-89	1:53p	Statewide Criteria Data File
CRITFIL	WK1	18393	5-15-89	1:55p	Criteria Table Report
CRITTBL	WK1	21770	5-15-89	1:48p	Criteria Conversion Programs
EXECMAC1	WK1	52093	8-07-89	9:39a	TMDL-WLA Macro Library
EXECMEN1	WK1	14034	7-17-89	10:54a	TMDL-WLA Menu Macro Library
EXECMOD2	WK1	95005	8-17-89	10:07a	Execution Module
EXECSCRP	WK1	7982	8-15-89	8:01a	Script Macro Library
EXECTRF1	WK1	7149	5-28-89	4:30p	Transfer Macro Library
EXEC_2A	WK1	77982	8-16-89	9:01p	Execution Macro Library
FIELD_0	WK1	21359	6-19-89	9:55p	Print Input Data Fields
FIELD_1	WK1	21073	7-30-89	4:41a	Print Data Fields (v1.0)
FIELD_2	WK1	21533	8-16-89	9:27p	Print Data Fields (v2.0)
INDEXTBL	WK1	13912	8-22-88	3:21p	Index Table Library
KEYBAK	WK1	15744	1-23-89	3:00p	Backup Macro Library
KEYIN_1	WK1	102734	8-15-89	8:55a	Keyboard Module
KEYMEN	WK1	19875	8-15-89	8:56a	Keyboard Menu Macro Library
KEYREAD	WK1	7949	3-29-89	8:57p	Keyboard Read Data Macro Library
KEYSAV	WK1	12598	3-29-89	8:58p	Keyboard Save Data Macro Library
MACKEYIN	WK1	40408	8-15-89	8:56a	Keyboard Macro Library
PAGE_1	WK1	10439	5-29-89	11:06a	Report Page 1
PAGE_2	WK1	10508	2-13-89	12:22p	Report Page 2
PAGE_2A	WK1	10439	5-29-89	12:18p	Report Page 2a
PAGE_2B	WK1	10389	5-29-89	12:51p	Report Page 2b
PARAL_1	WK1	14919	3-03-89	9:09a	Parameter Names List
PARANAME	WK1	29970	10-21-88	8:08p	Parameter Names Data
PARATBL	WK1	11570	3-03-89	8:50a	Parameter Table
PRINTMOD	WK1	92553	7-18-89	10:33a	Print Module
TUTORIAL	WK1	24104	8-09-89	10:32a	Tutorial Program
WQATEXE1	WK1	123240	8-07-89	9:33a	TMDL-WLA Module
WQATKEY	WK1	5323	4-06-89	7:40p	Keyboard Database Macro Library (KEY)
WQATMAIN	WK1	23080	8-15-89	10:54p	WQAT2_04 Main Menu Module
WQATNDX	WK1	8927	4-06-89	7:14p	Keyboard Database Macro Library (NDX)
WQAT	TUT	12	8-16-89	9:29p	Tutorial Manager
DEFAULT	SET	897	1-05-89	8:28p	Default Setup File
CRITDAT	PRG	10152	5-15-89	1:49p	Criteria Data Program File (ASCII)
PRINTQ	PRG	102	8-09-89	12:02p	Print Queue File
MASTER	NDX	102	8-15-89	9:01a	Program Master Index
WQAT	DEF	574	8-16-89	9:07p	WQAT2_04 Manager
PARANAME	DAT	5922	3-03-89	8:50a	Parameter Name Data File
INSTALL	BAT	229	8-15-89	10:41p	Installation Program
UPDATE	BAT	462	8-15-89	10:42p	Update Program
WQATINST	BAT	3432	8-15-89	10:40p	Installation Batch File
WQATUP	BAT	3319	8-15-89	10:44p	Update Batch File