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ASSESSMENT OF PROJECTED WATER QUALITY BENEFITS FROM IMPLEMENTATION OF THE REGULATIONS DEFINING BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE FOR THE ORGANIC CHEMICALS, PLASTICS, AND SYNTHETICS INDUSTRY

OFFICE OF WATER REGULATIONS AND STANDARDS
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This report is a compilation and summary of information from the following documents:

Environmental Assessment of Fifty Facilities in the Organic Chemicals, Plastics, and Synthetics Industry Using a Simplified Water Quality Dilution Model.
U.S. E.P.A., Office of Water Regulations and Standards, Washington, D.C., Draft Report,
Monitoring and Data Support Division. January 1983.

Environmental Assessment of Indirects Dischargers in the Organic Chemicals, Plastics, and Synthetics Industry.
U.S. E.P.A., Office of Water Regulations and Standards,
Washington, D.C., Draft Report, Monitoring and Data Support Division
January 1983

Detailed Water Quality Analysis for the Organic Chemicals and Plastics Industry on the Greens Bayou and Houston Ship Channel.
U.S. E.P.A., Office of Water Regulations and Standards,
Washington, D.C., Draft Report, Monitoring and Data Support Division
January 1983

Detailed Water Quality Analysis for the Organic Chemicals and Plastics Industry on the Kanawha River.
U.S. E.P.A., Office of Water Regulations and Standards,
Washington, D.C., Draft Report, Monitoring and Data Support Division
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EXECUTIVE SUMMARY

The water quality assessment presented in this report indicates that implementation of the proposed regulation defining best practicable control technology currently available (BPT) and best available technology economically achievable (BAT) for the organic chemicals, plastics, and synthetics industry will likely result in significant improvements in water quality and are likely to result in increased recreational opportunities and reduced health risks.

Analytical Approaches

The assessment includes two levels of analysis for direct dischargers. The first level consists of simplified water quality modeling of the impact of discharges from 50 organic chemical facilities on receiving stream concentrations of each facility's major toxic pollutants. This analysis provides a general indication of the extent to which the 41 stream segments receiving wastes from those 50 facilities will be affected under different control alternatives.

The second level of analysis consists of a summary of more comprehensive water quality studies of two streams: the Houston Ship Channel in Texas and the Kanawha River in West Virginia. These studies included more complex water quality modeling efforts and evaluations of biological conditions in each of the streams.

Indirect dischargers are assessed by modeling the impacts of organic chemicals discharges on receiving stream water quality after treatment by POTWs, both with and without pretreatment. Actual plant flow, POTW flow, and receiving stream flow were obtained for three facilities, while four model plants were used to provide the range of potential impacts for indirects.

Results of the Analyses

The simplified modeling analysis of 41 stream segments indicates that the projected number of violations of EPA water quality criteria will be substantially reduced if BAT controls are implemented. For example, at current discharge levels, 25 of 50 organic chemical facilities would cause violations of EPA water quality criteria under low flow conditions. At BPT discharge levels, 17 facilities would cause violations, and at BAT discharge levels, only 5 facilities would cause violations of water quality criteria.

The results from the two more comprehensive assessments are limited in scope. In the Houston Ship Channel the organic chemicals industry does not represent the major source of pollution within the area. Simple dilution calculations predict that instream water quality criteria violations to both freshwater and saltwater aquatic life will decrease as the degree of treatment is improved (current, BPT, BAT). For the Kanawha River system water quality improvements have been observed in the past decade; however direct correlation between improvements in water quality and upgraded treatment levels for the organic chemical and plastics industry cannot be proven. Although present biological quality of the area appears to be relatively good, further reductions in pollution loads from all sources including organic chemicals facilities will likely result in further increases in the number of high preference game fish.

The models of both the actual indirect dischargers and the possible ranges of indirect dischargers indicate that the application of pretreatment before discharge to a POTW will benefit both the POTW and the receiving stream.

INTRODUCTION

The following analysis is an assessment of the water quality benefits which are projected to result from implementation of the proposed effluent guidelines regulations for the organic chemicals industry. This type of assessment is part of the requirement for a Regulatory Impact Analysis, which Executive Order 12291 directs be prepared for all major regulations.

The BAT regulations cover primarily the specific toxic priority pollutants identified by the 1977 Clean Water Act. Therefore, this analysis focuses on those pollutants, although reduction in other pollutants such as total suspended solids (TSS) and biochemcial oxygen demand (BOD) have also been considered in some cases.

The water quality benefits assessment included two analyses for direct dischargers. The first analysis provides projections of ambient water quality conditions corresponding to different treatment levels for organic chemicals industry discharges. These projections, which are made using simplified modeling procedures, cover 41 stream segments and 50 organic chemicals plants. These plants, which account for approximately 11 percent of the total U.S. organic chemicals production, were selected on the basis of having adequate stream flow data and sufficient facility data to predict discharge levels. This analysis provides projections for the "Best Available Technology (BAT) discharge levels, for the "Best Practicable Control Technology" (BPT) discharge levels, and current effluent levels.

The second analysis consists of detailed water quality analyses of two stream segments under different treatment technology assumptions. These stream segments (the Houston Ship Channel in Texas and the Kanawha River in West Virginia) are evaluated in terms of current water quality conditions, including biological conditions, and in terms of the changes which are projected to occur in those two segments with implementation of higher treatment levels for organic chemical industry discharges. In addition, these analyses provide qualitative discussions of what the changes in water quality conditions might mean in terms of increased recreational opportunities, improved aesthetics, and reduced human health impacts. The targeted BAT limitations used in both analyses are long term averages ranging from 25 to 75 ppb for all pollutants, and are not the exact BAT limitations proposed. All updates to these analyses will include the proposed BAT limitations.

The agency anticipates expanding the scope of this report for promulgation of the regulation to include the potential impact on drinking water sources, the comparison of in-stream concentrations with state standards, and an informal survey of the state and local officials familiar with the streams studied for their perceptions of how the organic chemicals industry discharges are affecting water quality.

The assessment of indirect discharges provides a comparison of the potential impacts of organic chemical plants discharging their effluents to POTWs, both with and without treatment. The benefits derived from the application of pretreatment technologies are only presented in terms of the reduced impact of this industry on the receiving stream, but it is also likely that reduced inhibition problems would provide secondary benefits from more efficient treatment of the total POTW discharge to the receiving stream.

In a separate study now underway, EPA is attempting to express the environmental benefits of this regulation in monetary terms. The study will attempt to place dollar values on the specific benefits described in the two detailed water quality analyses discussed above.

AMBIENT DILUTION ANALYSIS

Introduction

To project the environmental benefits from the implementation of the effluent guidelines regulations, a simplified water quality model was used to determine the potential impacts of priority pollutants discharged from 50 organic chemicals and plastics facilities in terms of increases in receiving stream pollutant concentrations. This analysis provided a general indication of the extent to which the 41 stream segments receiving the wastes from those facilities could be affected under different control alternatives. The facilities for this analysis were selected on the basis of available facility data to predict discharge levels and adequate stream flow data. Since this analysis requires stream dilution calculations, facilities on hydrologically complex waters such as bays, estuaries, lakes, and oceans are not included. This analysis provides projections for the BAT discharge level, for the BPT discharge level, for current effluent levels, and for base case or raw waste levels.

Modeled Plant Concentration Data

For the plants studied (see Table 2.1), the concentration data for raw waste, current discharge, BPT discharge, and BAT discharge were projected using a computer model. The computer model estimates the concentration of the priority pollutants in each plants' total effluent based on the products and processes for each plant and on the assumed treatment level.

The model was developed from the Generalized Plant Configurations (GPCs) for major sectors of the organic chemicals, plastics, and synthetics industry. The GPCs provide a typical process configuration, material and pollutant flow, and manufacturing cost structure for average manufacturing facilities which can then be combined and tailored to describe specific plants.

The model also includes data which describes the removal efficiency and cost for a variety of effluent control devices, including single and double stage activated sludge systems, filtration, ion exchange, steam stripping, carbon adsorption and others. The model can place these controls, both alone and in various feasible combinations, into process-specific, multi-process, or total plant effluent streams. The exact configuration of controls can be specified or the model can determine the most cost effective controls to use in order to meet specified effluent mass or concentration limits. Information about the current

Table 2-1

The Fifty Plants Assessed Using the
Simplified Water Quality Dilution Model

Plant NPDES Number	Plant Name
AL0003026	Courtauldo N. America - Mobile
CT0000086	American Cyanamide Co.
CT0003131	DOW Chemical - Allyn's Point
IA0000191	Chemplex Co. - Clinton
IA0000205	Monsanto Co. - Muscatine
IL0001929	Borg-Warner Corp. - Linbar Plant
KY0001112	Borden Chem. - Louisville
KY0002305	Rohm and Haas - Louisville
KY0002780	Stauffer Chem. Co. - Louisville
KY0024643	Custom Resins - Henderson
LA0000191	Union Carbide - Hahnville
LA0000281	Borden Chem. - Geismar
LA0000761	PPG Inc. - Lake Charles
LA0000892	Rubicon Chem.
LA0002933	Vulcan Materials
LA0003689	Hercules Inc. - Lake Charles
LA0005762	Shell Norco
LA0005924	Dupont - La Place
LA0029963	Gulf Oil
MI0000540	BASF - Wyandotte
MI0000868	DOW - Midland
MO0003140	Cook Paint & Varnish Co. - KC
NC0003760	Dupont - Kinston
NJ0000256	Union Carbide Corp.
OH0002283	General Tire Rubber Co.
PA0012769	Rohm and Haas - Bristol
SC0001791	American Hoechst Corp.
SC0002305	Fiber Industries - Greenville
SC0004162	Fiber Industries - Palmetto
TN0000442	Alpha Chem - Colliersville
TX0004669	E.I. Dupont DeNemours - Beaumont
TX0004839	Gulf Oil - Orange
TX0005835	Texaco Inc. - Port Arthur
TX0006068	Arco/Polymers Inc. - Houston
TX0006297	Arco/Polymers Inc. - Port Arthur
TX0007536	Phillips Petroleum Co. - Sweeny
TX0053813	Shintech

Table 2-1
(continued)

The Fifty Plants Assessed Using the
Simplified Water Quality Dilution Model

Plant NPDES Number	Plant Name
TX0059447	DOW Chemical - Freeport
VA0001601	Dupont - Martinsville
VA0001856	Thiokol Fibers Div.
VA0002208	Avtex Fibers, Inc.
VA0005312	Allied Chem. Corp. - Chesterfield
WV0000132	Goodyear Tire & Rubber Co. - Point Pleasant
WV0000370	Pantasote Co. of New York Inc.
WV0000787	American Cyanamide - Willow Pl.
WV0001112	Novamont Corp.
WV0001678	Avtex Fibers, Inc.
WV0002313	Diamond Shamrock - Belle
WV0002399	Dupont - Belle
WV0005169	Mobay Chem. Co. - New Martin

controls in place at the actual plants of interest was obtained from EPA permit files and from discussions with EPA and state personnel.

<u>Receiving Stream Flow, Plant Discharge Flow, and Ambient Water Quality Data for Reaches Studied</u>

Receiving stream flow data were obtained from a W.E. Gates study which contains calculated mean and low flow statistics based on best available flow data for reaches throughout the United States.

The discharge flow for the plants studies in this analysis were obtained from the Industrial Facilities Discharge (IFD) data base.

Water quality data were obtained from EPA's STORET water quality data base. All available monitoring data for priority pollutants, hardness, pH, and temperature were obtained from the water quality stations located upstream and/or downstream of the studied plants. The water quality data obtained from the upstream stations of the plants under study were used to determine the ambient background concentration of the priority pollutants detected in the effluents.

Decay Rates for Selected Priority Pollutants

Decay constants (or coefficients) were developed for 18 priority pollutants as shown in Table 2-2. These decay constants were based on the estimated or measured half-lives for the dominant processes affecting the pollutant's fate and distribution in an industrialized reach into which effluents from more than one source are discharged. The data for the half-lives and the information for deriving the dominant processes in an industrialized reach were obtained from the document "Water-Related Environmental Fate of 129 Priority Pollutants" by Callahan et. al (1979).

In projecting the decay constants for a selected pollutant it was assumed that, in a polluted industrial reach, molecular sites of sorption for the pollutants on suspended and bed sediments will have been saturated; thus, preventing any further effect that the bed sediment would have in removing the pollutants. Other processes such as photolysis and oxidation will be negligible in their effect on the environmental fate in a polluted industrial river, and hydrolysis for all the organic pollutants selected would be a very slow process.

Water Quality Criteria

Ambient water quality criteria (WQC) for the protection of aquatic life from both acute and chronic effects and for the

Table 2-2

Estimated Decay Constants (K) for Nineteen Priority Pollutants

Pollutant	Dominant Fate Process (Industrialized Reach)	Half-lives (days)	Decay Constant	Degree of Confidence
Arsenic	Dilution	4.7	0.15	Medium
Cadmium	Dilution	4.7	0.15	Medium
Chromium	Precipitation	0.01-1.0	0.69-69	Low
Copper	Dilution/Sorption to Detritus	4.7	0.15	Low
Cyanide	Volatilization	0.5-1.2	0.58-1.39	High
Lead	Dilution/Sorption to Detritus	4.7	0.15	Low
Mercury	Sorption to Suspended and Bed Sediment	2.4-4.7	0.15-0.29	Low
Nickel	Dilution	4.7	0.15	Medium
Zinc	Sorption to Suspended and Bed Sediment	2.4-4.7	0.15-0.29	Low
Phenol	Biodegradation	0.09-0.17	4.1-7.7	Medium
2,4,6-Trichlorophenol	Dilution/Sorption to Detritus	4.7	0.15	Low
1,2,4-Trichlorobenzene	Volatilization	0.04	17.3	Medium
Bis(2-ethylhexyl)phthalate	Dilution	4.7	0.15	High
Di-n-butyl phthalate	Dilution	4.7	0.15	Medium
Tetrachloroethylene	Volatilization	0.02	34.6	Medium
Trichloroethylene	Volatilization	0.014	49.5	Medium
Chloroform	Volatilization	0.014	49.5	Medium
1,1,1-Trichloroethane	Volatilization	0.04	17.3	Medium
Acenaphthylene	Dilution	0.02	34.6	Low

protection of human health were developed and published by the Criteria and Standards Division (CSD) in November 1980. For mercury and beryllium, revised ambient water quality criteria, as listed in 46 FR 40919 (August 13, 1981), were used. The ambient water quality criteria may be subject to revision on a local, site-specific basis; however, the national criteria were used in this assessment as the basis for determining the environmental significance of each pollutant. Where the criteria levels vary with hardness, local hardness data were used to establish the appropriate level.

If a pollutant had no established ambient water quality criteria, then toxicity level values based on the lowest acute and chronic toxic concentrations for freshwater organisms reported in the November 1980 Ambient Water Quality Document were used to assess the potential toxic effect on aquatic life.

Calculations and Assumptions Used in Stream Dilution Analysis

The priority pollutants discharged from the organic chemicals, plastics, and synthetics industry were analyzed using a simplified stream dilution computer model for the following scenarios at both mean and low stream flow conditions:

- raw waste
- current discharge
- BPT discharge
- BAT discharge

The following calculations and assumptions were used in the simplified dilution model:

1. It is assumed that there is complete mixing of discharge flow and stream flow across the stream at the discharge point. This results in calculation of an "average stream" concentration even though actual concentrations vary across the width of the stream.

2. To calculate the diluted in-stream concentrations below the first discharge or the only discharger studied on a reach, the analysis considered two scenarios: a) the upstream concentrations for all the pollutants analyzed equal to zero, and b) the upstream concentrations for the pollutant analyzed equal to the ambient concentration data where available or equal to zero.

3. For all plants studied, it was assumed that the process water was obtained from a source other than the receiving stream.

4. The in-stream dilution concentration at mean and low stream flow was calculated as follows:

$$CD_x = \frac{(CS_x)\ (Q_l)\ +\ (CP_x)\ (Q_p)}{(Q_l\ +\ Q_p)} \qquad (2\text{-}1)$$

CD_x = instream concentration (ug/l) of pollutant x,

CS_x = ambient concentration (ug/l) of pollutant x upstream of outfall

Q_l = stream flow (low or mean in MGD)

CP_x = plant concentration of (ug/l) pollutant x

Q_p = plant flow (MGD)

5. For multi-plant stream reaches, the initial background concentration is either equal to the ambient data available or equal to zero. The in-stream dilution concentration for the initial plant is calculated as shown in equation 2-1. For all subsequent plants on the stream reach, the in-stream values for the upstream plant are used

as the background values in the next downstream plant (unless a decay coefficient is available in which case it is applied) and the stream flow (mean or low) is increased by the previous plant's discharge flow.

6. If the decay coefficient is not available for a pollutant, the pollutant is assumed to remain in the water column for the length of the evaluated stream reach.

7. If the decay coefficient value is available, a secondary calculation involving exponential decay is used to determine background concentrations for all downstream plants on a river reach. The equation used for determining the background concentration at the downstream plant for the pollutants with decay coefficient data is as follows:

$$CR_x \text{ (ug/l)} = CD_x \text{ e exp } (-K \ (\Delta \text{ miles/velocity}) \qquad (2\text{-}2)$$

where, CR_x = the decayed in-stream concentration (ug/l) at a specific distance from the point of outfall,

CD_x = the initial in-stream concentration (ug/l) of the pollutant x as determined by equation 2-1.

K = decay coefficient (Table 2-2)

Δ miles = the distance between the initial outfall of pollutant x and the point at which the decayed in-stream concentration of pollutant x is to be determined.

Velocity = velocity of river (miles/day). For this study, the velocity of all reaches studied was assumed to be 8 miles/day.

Summary of Results

Table 2-3 summarizes the number of pollutants which exceed criteria in the individual plant studies and in the multi-plant reach studies, respectively. Tables 2-4 and 2-5 summarize the results of the dilution analysis model for the individual plant studies and for the multi-plant reach studies.

The water quality projections indicate that the reduction in effluent concentrations achieved by going from current to BPT and from BPT to BAT discharge levels will result in substantially reduced violations of EPA water quality criteria. Violations have been calculated on an individual plant basis to indicate the number of situations where a single facility is projected to exceed the water quality criteria. For example, at current discharge levels, 25 of 50 organic chemical facilities would cause violation of EPA water quality criteria under low flow conditions. At BPT discharge limits, 17 facilities would cause violations, and at BAT discharge limits, only 5 facilities would cause violations of water quality criteria.

In addition to the priority pollutants studied, there are a large number of other toxic pollutants found in the effluents of the organic chemicals, plastics, and synthetics plants; however, these were not included in this analysis because they were generally found only in low concentrations or because there was insufficient toxicity data to evaluate their potential effects on human health or aquatic life.

The simplified water quality dilution model requires stream dilution calculations; therefore, facilities on hydrologically complex waters such as bays, estuaries, and lakes were not included.

TABLE 2-3

Number of Pollutants Which Exceeded Criteria in the Dilution Analysis Study Completed with the Initial Background Concentrations Equal to Zero for the Fifty Plants in the Organic Chemicals, Plastics, and Synthetics Industry

Plant Code	Number of Pollutants Which Exceed Criteria					
	CURRENT		BPT		BAT	
	Mean	Low	Mean	Low	Mean	Low
7-01	1	1	-	-	-	-
2-02	1	1	-	-	-	-
3-10	1	1	-	-	-	-
3-12	-	2	-	1	-	-
3-15	-	3	-	1	-	1
3-16	-	2	-	2	-	-
7-18	-	1	-	-	-	-
5-19	3	4	3	4	1	2
5-20	-	1	-	1	-	-
3-22	1	3	1	3	-	-
7-31	1	1	-	-	-	-
7-33	-	1	-	-	-	-
7-36	1	2	-	1	-	-
1-37	2	3	1	2	-	-
7-40	1	4	-	2	-	-
5-41	-	2	-	2	-	-
7-47	3	8	-	4	-	1
7-50	2	5	1	4	-	-
6-51	1	3	-	2	-	-
7-53	-	2	-	-	-	-
1-55	-	3	-	1	-	-
7-56	5	13	-	5	-	1
3-59	2	4	2	4	-	-
6460	2	4	1	2	-	1
1675	2	5	-	-	-	-

[1]The following twenty-five plants did not have any pollutants which exceeded criteria: 6-03, 2-05, 7-08, 3-09, 3-11, 3-13, 5-17, 7-21, 7-23, 3-24, 2-25, 2-26, 1-27, 3-30, 6-32, 3-34, 2-38, 1-61, 1-62, 1-69, 3-70, 6771, 5-72, 1-73, 1674.

Table 2-4

Summary of the Pollutants Which Exceeded Water Quality Criteria in the Dilution Analysis Study Completed with the Initial Background Concentrations Equal to Zero for the Thirty-Seven Individual Plant Reaches in the Organic Chemicals, Plastics, and Synthetics Industry

		Number of Times Pollutant Exceeded Water Quality Criteria at Each Treatment Level																							
		CURRENT								BPT								BAT							
		Water Quality Criteria								Water Quality Criteria								Water Quality Criteria							
	Number	Aquatic				Human Health				Aquatic				Human Health				Aquatic				Human Health			
	of Times	Acute		Chronic		Water & Org.		Org. Only		Acute		Chronic		Water & Org.		Org. Only		Acute		Chronic		Water & Org.		Org. Only	
Pollutant	Detected in Raw	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low
Antimony	13						2								1										
Arsenic	3					1	3	1	1					1	3	1	1					1	1		1
Cadmium	6			2	4							2	4												
Chromium	22				3								3												
Copper	22	1	2	1	5						1		4						1		2				
Lead	8				3								3												
Nickel	5			1	1	1	2	1	1			1	1	1	2	1	1						1		
Silver	3				1								1												
Zinc	16	1	3	2	4					1	3	2	4												
Chloroform	17						2								2										
1,2-Dichloroethane	6						1																		
Chloroethene	15						1																		
1,1-Dichloroethene	7						3								2								2		
Benzene	20					1	4		2						2										
Bis(2-ethylhexyl) phthalate	13				2																				
Acenaphthylene	4					3	3	2	3																
Anthracene	3					1	2		2																
Benzo(a)anthracene	1						1		1																
Benzo(ghi)perylene	1						1																		
Benzo(a)pyrene	1					1	1		1					1	1		1								
Fluorene	3					2	2	1	2																
Indeno(1,2,3-cd)pyrene	1						1																		
Pyrene	3						1																		
Phenanthrene	3					2	2	1	2																
Acrylonitrile	16					4	7	1	3																

Table 2-5

Summary of the Pollutants Which Exceeded Water Quality Criteria in the Dilution Analysis Study for the Five Multi-plant Reaches Assessing Thirteen Plants in the Organic Chemicals, Plastics, and Synthetics Industry

Plant Code	POLLUTANT	Number of Times Pollutant Exceeded Water Quality Criteria at Each Treatment Level																							
		CURRENT								BPT								BAT							
		Water Quality Criteria								Water Quality Criteria								Water Quality Criteria							
		Aquatic				Human Health				Aquatic				Human Health				Aquatic				Human Health			
		Acute		Chronic		Water & Org.		Org. Only		Acute		Chronic		Water & Org.		Org. Only		Acute		Chronic		Water & Org.		Org. Only	
		Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low
	Reach Case 1 - with initial background equal to zero																								
2-26 2-25	No Pollutants Exceeded Criteria																								
	Reach Case 1 - with initial background equal to water quality data																								
2-26	Bis(2-ethylhexyl)phthalate			1	1							1	1						1	1					
2-25	Bis(2-ethylhexyl)phthalate			1	1							1	1						1	1					
	Reach Case 2 - with initial background equal to zero																								
1-37	Cyanide				1								1												
	Chloroform					1	1		1					1	1										
	1,2-Dichloroethane					1	1																		
7-36	Cyanide				1								1												
	1,2-Dichloroethane					1	1																		
	Reach Case 3 - with initial background equal to zero																								
6-51	Chromium				1								1												
	Zinc		1		1						1		1												
	Acenaphthylene					1	1	1	1																
7-50	Copper				1								1												
	Chromium				1								1												
	Zinc		1		1						1		1												
	Acenaphthylene					1	1	1	1																
	Benzo(a)pyrene					1	1		1					1	1		1								

Table 2-5
(Continued)

Summary of the Pollutants Which Exceeded Water Quality Criteria in the Dilution Analysis Study for the Five Multi-plant Reaches Assessing Thirteen Plants in the Organic Chemicals, Plastics, and Synthetics Industry

Plant Code	POLLUTANT	Number of Times Pollutant Exceeded Water Quality Criteria at Each Treatment Level																							
		CURRENT								BPT								BAT							
		Water Quality Criteria								Water Quality Criteria								Water Quality Criteria							
		Aquatic				Human Health				Aquatic				Human Health				Aquatic				Human Health			
		Acute		Chronic		Water & Org.		Org. Only		Acute		Chronic		Water & Org.		Org. Only		Acute		Chronic		Water & Org.		Org. Only	
		Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low	Mean	Low
	Reach Case 3 - with initial background equal to water quality data																								
6-51	Chromium				1								1												
	Zinc		1	1	1						1	1	1												
	Acenaphthylene					1	1	1	1																
7-50	Copper				1								1												
	Chromium				1								1												
	Zinc		1	1	1						1	1	1												
	Acenaphthylene					1	1	1	1																
	Benzo(a)pyrene					1	1		1					1	1		1								
	Reach Case 4 - with initial background equal to zero																								
1-69 1-73 5-72 6-71 3-70	No Pollutants Exceeded Criteria																								
	Reach Case 5 - with initial background equal to zero																								
1674	No Pollutants Exceeded Criteria																								
1675	Benzene						1																		
	Acenaphthylene						1																		
	Phenanthrene					1	1																		
	Anthracene						1																		
	Fluorene					1	1		1																

EXPANDED WATER QUALITY ANALYSIS

Two stream segments (the Houston Ship Channel in Texas and the Kanawha River in West Virginia) were selected for analysis in a detailed assessment. The major criteria for selection were based upon the availability of an adequate data base and the number of modeled organic chemical plants within the study area. The general approach followed in these analyses was to assess the impacts of the organic chemical industry within the study areas, and included effects on water quality conditions, biological conditions, human health, and recreational activity based upon current, BPT, and BAT scenario results.

The Houston Ship Channel

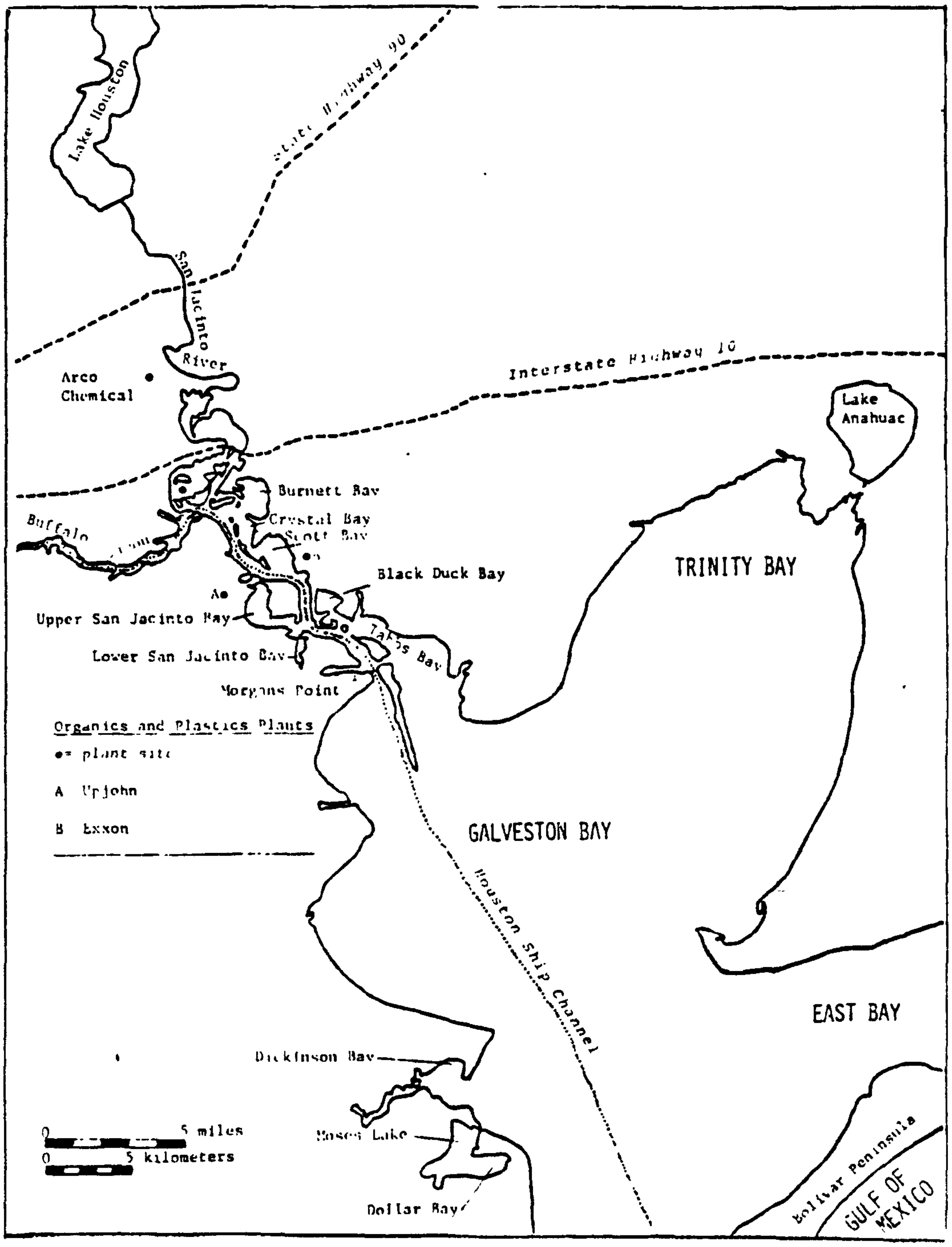
Background

The general study area consists of the lower Houston Ship Channel, (the segment extending from Morgans Point (RM 0) to the confluence with the San Jacinto River), and the bays lateral to the lower 9 miles of the channel (Scott, Tabbs, the upper and lower San Jacinto River (Figure 1). The entire area lies in the east central Texas coastal prairies with the channel and bays located in Chambers and Harris Counties and the San Jacinto River in Harris County.

The Houston Ship Channel is a narrow ship passage about 50 miles long, 400 feet wide and 40 feet deep. The ship canal is a man-made seaport which was originally a 12 foot channel dredged through Galveston Bay to the San Jacinto River by the Army Corps of Engineers. It is currently ranked as the third largest seaport in the United States behind New Orleans and New York. The dimensions of the lateral bays vary in area and little in depth. Upper San Jacinto Bay has a surface area of 1,174 acres and mean depth of 5.84 feet. The lower San Jacinto Bay is smaller with an area of 185 acres and depth of 5.58 feet. Burnett Bay has the largest surface area and is also the deepest, estimated to be about 1,276 acres and 8.67 feet respectively. The lower and upper Black Duck Bays range in area from 183 to 205 acres, with an average depth of 5.58 feet.

Figure 1

Houston Ship Channel General Study Area



Tabbs Bay is 806 acres in area and is 4.75 feet deep.

The San Jacinto River flows 19.1 miles from its origin at Lake Houston to its confluence with the Houston Ship Channel. Over this distance, the river has a surface area of approximately 2,880 acres and an average depth of approximately 12 feet. There is no saltwater barrier (dams) protecting the river from the channel, thereby causing saline water to run freely into the river.

It is reported that the San Jacinto River, for most of the year, provides 60% of the total fresh water discharge to the lower channel. The flow on the river averages 2,609 cubic feet per second and is almost entirely from Lake Houston. The lake's discharge to the river is regulated by a dam which accommodates fluctuations in precipitation, evaporation and drawdown.

The major point source discharges influencing water quality in the channel, major tributaries, and lateral bays are presented in Table 1 and summarized in Table 2. The channel and its tributaries above the confluence with the San Jacinto River (the upper channel) receive most of the point source flow to the channel. In the upper channel and tributaries the municipal flow is greater than industrial flow. In the lower channel, the opposite occurs and industrial flow is much greater than municipal flow.

Table 1. Major Dischargers to the Houston Ship Channel and its Tributaries

Reach #	NPDES #	Facility Name	Total Process and Combined Facility Flow (TGD)[a]	Industrial Category	River Mile[b]
		GREENS BAYOU			
12040104-016	TX0071994	North Belt Regional Sewage	2,000	POTW	34.63
12040104-016	TX0063053	City of Houston (#0023)	2,160	POTW	26.27
12040104-016	TX0058424	North Forest Municipal Utility Dist.	300	POTW	25.61
12040104-016	TX0072001	City of Houston (#69)	900	POTW	25.40
12040104-016	TX0083381	North Green Municipal Utility Dist.	1,500	POTW	25.40
12040104-016	TX0083836	Gator Hawk, Inc.	30	Metal Finishing	25.40
12040104-016	TX0084361	Willow Chase Municipal Utility Dist.	600	POTW	25.40
12040104-016	TX0063037	City of Houston-Northeast	3,000	POTW	20.88
12040104-016	TX0007439	Diamond Shamrock[c]	620 (1,640)	Organic Chemicals	18.43
12040104-016	TX0005584	Merichem Corporation	100	Organic Chemicals	18.22
12040104-016	TX0007064	Pennwalt Corporation	200	Organic Chemicals	18.22
12040104-016	TX0005576	Reichold Chemicals[c]	80	Organic Chemicals	17.00
		UPPER HOUSTON SHIP CHANNEL			
12040104-018	TX0006424	Houston Light & Power	280	Steam Electric	29.39
12040104-018	TX0046884	City of Houston-Northside	130,000	POTW	27.22
12040104-018	TX0006254	Reed Tool Company	60	Metal Finishing	26.30
12040104-018	TX0007021	Exxon Corporation	175	Paint	25.16
12040104-017	TX0007072	Stauffer Chemical Corporation	750	Inorganic Chemicals	23.20
12040104-017	TX0035106	City of Houston-Clinton Park	2,000	POTW	22.82
12040104-017	TX0084409	Denka Chemical Corporation	4,200	Organic Chemicals	22.30
12040104-017	TX0002976	Charter International Oil	50	Petroleum Refining	21.83
12040104-017	TX0007056	U.S. Gypsum Co.	410	Pulp and Paper	21.23
12040104-017	TX0003247	Atlantic Richfield	7,404	Petroleum Refining	20.58
12040104-017	TX0005860	Chemical Exchange Process	65	Organic Chemicals	20.29
12040104-017	TX0006360	Houston Light & Power	320	Steam Electric	19.99
12040104-017	TX0047902	City of Pasadena	4,600	POTW	19.89
12040104-017	TX0063410	City of Pasadena	2,600	POTW	19.89
12040104-017	TX0004262	Crown Central Petroleum Corp.	860	Petroleum Refining	19.35
12040104-017	TX0008524	Armco Steel Corp.	760	Iron and Steel	18.62
12040104-015	TX0004731	Ethyl Corporation[c]	2,090	Organic Chemicals	15.30
12040104-015	TX0006335	Tenneco Chemical Inc.[c]	1,250	Organic Chemicals	14.10
12040104-015	TX0006084	Rohm & Haas	4,320 (4,560)	Organic Chemicals	13.76
12040104-015	TX0004871	Shell Oil Co.	4,504	Petroleum Refining	13.57
12040104-015	TX0007048	Lubrizol Corporation	435	Organic Chemicals	12.98
12040104-015	TX0004863	Shell Oil Co.[c]	3,850 (7,340)	Organic Chemicals	11.50
12040104-015	TX0007412	Diamond Shamrock[c]	70,930	Inorganic Chemicals	11.50
12040104-015	TX0056529	Rohm & Haas[c]	1,400	Organic Chemicals	10.90
12040104-015	TX0007161	Dresser Packaging Division	360	Metal Finishing	10.92
12040104-015	TX0077585	Air Products and Chemicals	175	Inorganic Chemicals	10.79

(Continued)

Table 1. Continued

Reach #	NPDES #	Facility Name	Total Process and Combined Facility Flow (TGD)[a]	Industrial Category	River Mile[b]
		LOWER HOUSTON SHIP CHANNEL AND LATERAL BAYS			
12040104-028	TX0006033	Soltex (Celanese)[c]	109	Organic Chemicals	7.00
12040104-028	TX0070416	Diamond Shamrock	1,570	Organic Chemicals	6.75
12040104-028	TX0077593	Syngas Co.	1,005	Organic Chemicals	5.66
12040104-028	TX0074276	Noramont Corp.	352	Organic Chemicals	5.66
12040104-028	TX0004944	Air Products & Chemicals	310	Inorganic Chemicals	4.89
12040104-028	TX0007293	E. I. DuPont	5,400	Inorganic Chemicals	4.43
12040104-028	TX0008001	P. Grief Brothers	100	Metal Finishing	2.51
12040104-004	TX005160	Diamond Shamrock - Battleground	800	Inorganic Chemicals	--
12040104-028	TX0002863	National Distillers[c]	1,270	Organic Chemicals	2.90
12040104-028	TX0002933	Upjohn Co.[c]	2,520 (860)	Organic Chemicals	2.90
12040203-003	TX0077887	Exxon Chemical Co.[c]	-- (26,000)	Organic Chemicals	2.90
12040203-003	TX0006271	Exxon Corporation	25,600	Petroleum Refining	2.90
12040203-003	TX0020109	City of Baytown	4,700	POTW	1.20

[a] From the Industrial Facilities Database (IFD), Effluent Guidelines Division (EGD) flow estimates in parentheses.

[b] Morgan's Point on Reach 12040104-028 is considered the most downstream point (river mile 0.00) of the Houston Ship Channel. All mileages are calculated upstream from this point.

[c] Plants modeled for this analysis.

Table 2. Summary of Municipal and Industrial Process Flow (MGD) in the Area of the Houston Ship Channel [a]

Source	Tributaries to Upper Channel (019, 020, 025, 016, 010)[b]	Percent total flow	Upper Channel (018, 017, 015, 009)	Percent total flow	San Jacinto River (008)	Percent total flow	Lower Channel, bays, and tributaries (004, 007, 029, 005, 006, 028, 003[c])	Percent total flow
POTW	436.44	98.18	139.20	57.08	3.43	37.98	11.71	20.61
Inorganic chemicals	0.55	0.12	71.86	29.47	--	--	6.51	11.46
Organic chemicals	5.86	1.32	17.61	7.22	5.60	62.02	12.47	21.95
Petroleum refining	--	--	12.82	5.26	--	--	25.60	45.06
Iron and steel	0.05	0.01	0.76	0.31	--	--	--	--
Steam electric	--	--	0.60	0.25	--	--	0.03	0.05
Metal finishing	0.03	<0.01	0.42	0.17	--	--	0.19	0.33
Pulp and paper	--	--	0.41	0.17	--	--	--	--
Paint	--	--	0.18	0.07	--	--	--	--
Other	1.62	0.36	--	--	--	--	0.3	0.53
Total industrial flow	8.11	1.82	104.66	42.92	5.60	62.02	45.10	79.39
Total municipal and industrial flow	444.55		243.86		9.03		56.81	

[a] Source: EPA IFD data base.

[b] Reach segment numbers in 12040104 cataloging unit, except as noted in footnote c.

[c] Reach segment in 12040203 cataloging unit.

The inorganic chemical industry is the largest industrial point source discharger in the upper channel (29% of the total industrial source) while the organic chemical industry accounts for only seven percent of the total industrial point source in the upper channel (see Table 2). In the lower portion of the channel the petroleum refining and the organic chemical industries dominate with forty-five and twenty-two percent of the total point source flow, respectively.

Based upon organic chemicals and metals loadings along the channel, the organic chemical industry does not appear to be the major source of pollution within the area. Table 3 illustrates the discharge loadings under various treatment levels for the organic chemical industry versus the total industrial sources along the channel. In general, this industry accounts for 12-15% of the organic discharge and 7-12% of the metals and inorganics.

Sufficient data were available to model the water quality impact for nine of the eighteen organic chemical plants in the area. Table 4 illustrates the end of pipe treatment under current, BPT and BAT control for these nine plants. The location of these nine facilities are shown in Figure 2. Table 5 indicates the plant type, the type of facility and the number of waste streams at each plant.

TABLE 3

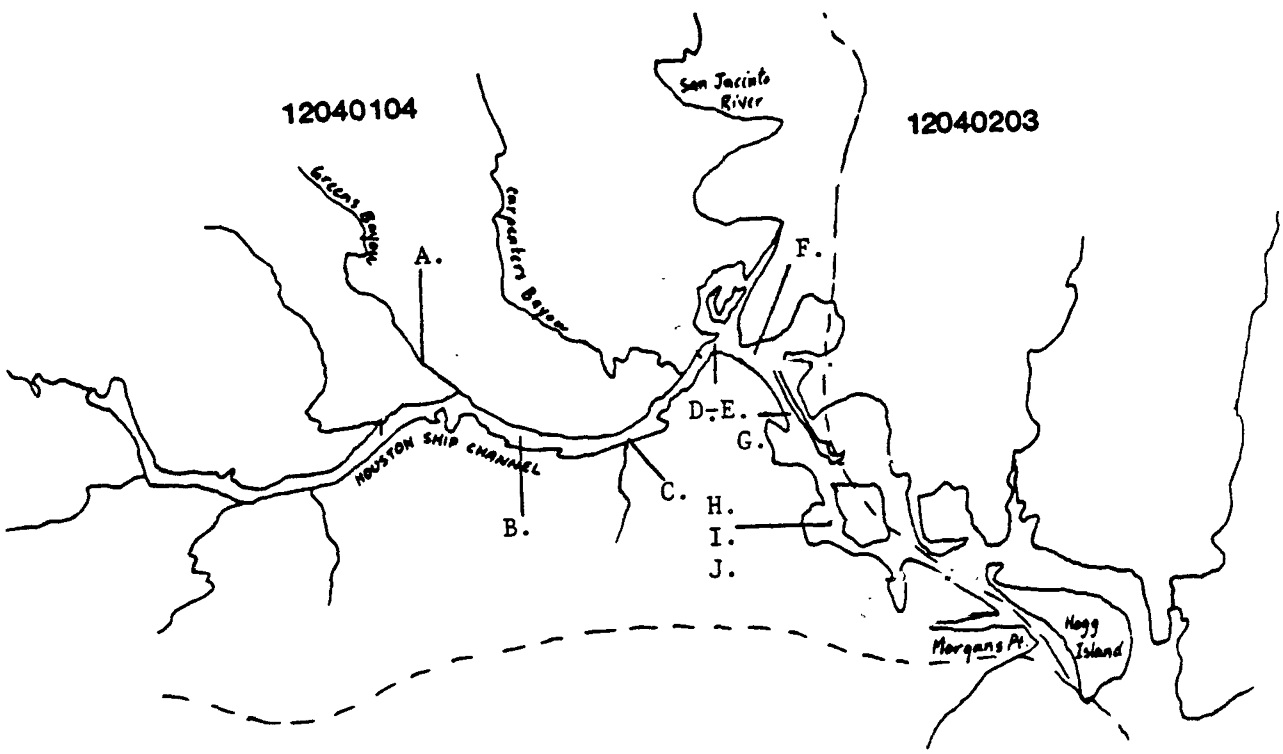
Organics & Phenol (kg/day)

	Treatment Levels		
	Current	BPT	BAT
OC & P	972	262	242
Total Industry	6570	2180	2050
%	15	12	12

Metals & Inorganics (kg/day)

	Treatment Levels		
	Current	BPT	BAT
OC & P	312	304	9
Total Industry	2960	2560	140
%	10	12	7

FIGURE 2. Location of Modeled Organic Chemical and Plastics Plants on the Houston Ship Channel and Greens Bayou.



MODELED ORGANIC CHEMICAL PLANTS	RIVER MILE*
A. Reichold Chemicals, Inc.	17.0
B. Ethyl Corporation	15.3
C. Tenneco Chemicals, Inc.	14.1
D. Shell Chemical Company	11.5
E. Diamond Shamrock Corporation	11.5
F. Rohm and Haas-Texas, Inc.	10.9
G. Celanese (Soltex Polymers)	7.0
H. The Upjohn Company	2.9
I. Exxon Corporation	2.9
J. National Distillers	2.9

*River Mile defined as miles upstream of Morgans Point.

TABLE 4. WATER POLLUTION CONTROL TECHNOLOGY FOR ORGANIC CHEMICALS & PLASTICS PLANTS LOCATED IN THE HOUSTON SHIP CHANNEL STUDY AREA

PLANT	CONTROL	TREATMENT LEVEL*			IN PROCESS CONTROLS							
		AS1	AS2	FILT	SS	IE	CA	COA	FLO	LIM	AMS	OS
1	Current		X	X								
	BPT		X	X								
	BAT		X	X	X							
2	Current		X	X								
	BPT		X	X								
	BAT		X	X	X	X				X	X	
3	Current	X		X								
	BPT		X	X								
	BAT		X	X	X	X		X	X			X
4	Current	X		X								
	BPT		X	X								
	BAT		X	X	X							
5	Current	X		X								
	BPT	X		X								
	BAT	X		X		X		X	X			
6	Current		X	X								
	BPT		X	X								
	BAT		X	X		X						
7	Current		X	X								
	BPT		X	X								
	BAT		X	X								
8	Current		X	X								
	BPT		X	X								
	BAT		X	X	X	X	X	X	X			
9	Current	X		X								
	BPT	X		X								
	BAT		X	X								

* - all three controls have clarification and neutralization @ end of pipe

SS - Steam stripper
IE - Ion Exchange
CA - Carbon Absorption

COA - coagulation
FLO - Flocculation
LIM - Liming

FILT - Filtration
AMS - Ammonia stripper
OS - Oil separation

AS1 - single stage activated sludge
AS2 - double stage activated sludge

TABLE 5

Plant	Company	Plant Type*	Discharge	Waste Treatment Facility	# of Waste Streams
B	Diamond Shamrock	CEM, PP/TR	Direct	ASL	1
C	Ethyl	CEM	Direct	ALA	1
D	Exxon	E/BTX, PP/TR	Direct	ALA	1
E	National Distillers	PP/TR	Direct	ASL SSK	2
F	Reichold	PP/TR	Direct Zero	ASL BRN	2
G	Rohm & Haas	PP/TR	Direct	ASL	1
H	Shell	CEM, E/BTX, PP/TR	Direct	ASL	1
I	Tenneco	PP/TR	Direct	ASL	1
J	UpJohn	U	Direct	ALS	1

*CEM - Chloroethanes/Methanes

E/BTX - Ethylene/BTX Complex

ASL - Activated Sludge

ALA - Aeration Lagoon

PP/TR - Polymer Plastics/Thermoset Resins

U - Urethanes

SSK - Skimmer, ditch clay filter

BRN - Incineration

Chemical Water Quality Conditions

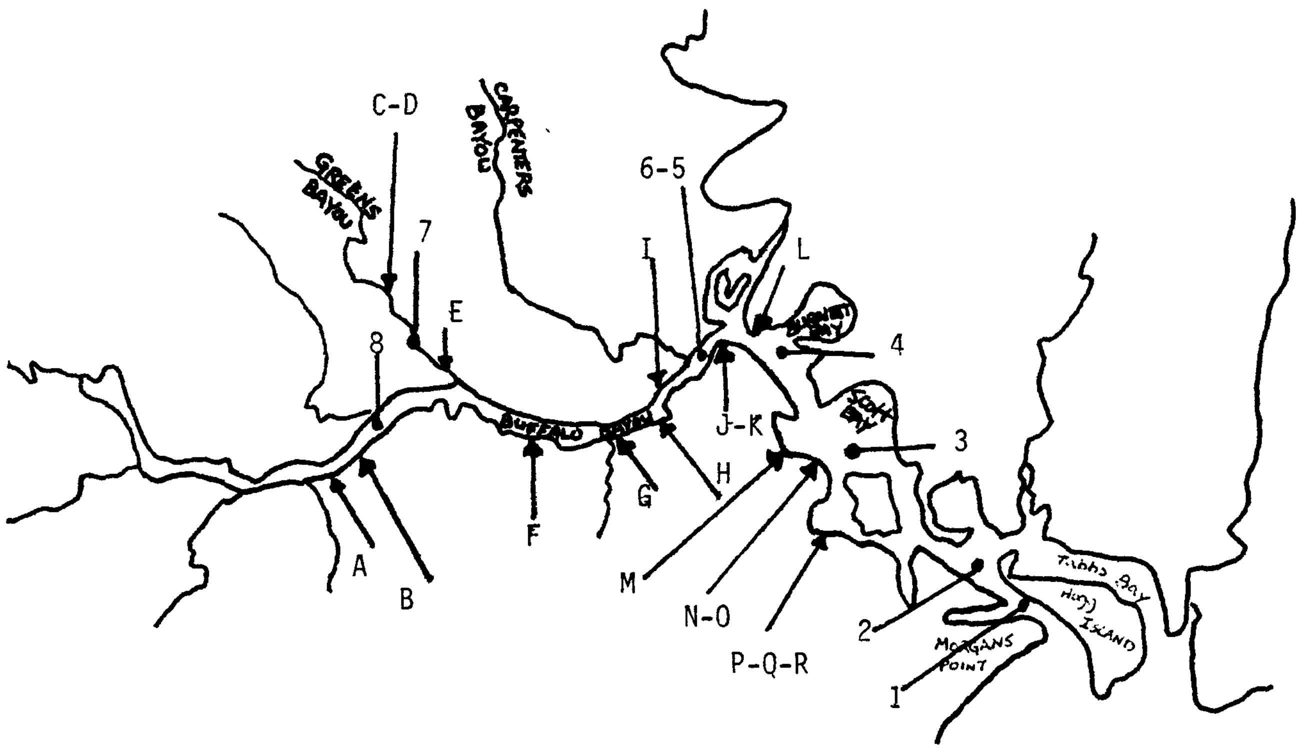
The Houston Ship Channel area has had a long history of pollution problems from the two primary point pollution sources-industrial and municipal. Non-point source waste loads except for dredging and sediment bed load present no significant water quality problems in the channel.

In terms of a general water quality indicator, point source discharges in the lower channel contribute significantly less flow than the point source dischargers in the upper channel. However, in the lower segment, the industrial flow is greater than the municipal flow.

Figure 3 illustrates the location of the 18 Organic Plants and the eight available STORET ambient water quality stations along the Houston Ship Channel. Within the study area, three organic plants and one monitoring station are located on Greens Bayou (RM 18.22-16.1), eight organic plants and three monitoring stations along Buffalo Bayou (RM 22.3-11.5), and seven organic plants and four monitoring stations along the lower Houston Ship Channel (RM 10.9-2.9).

Tables 6, 7, and 8 report the exceedances of EPA water quality criteria for both freshwater and saltwater organisms

Figure 3. Location of the Organic Chemical and Plastics Plants and Ambient Water quality Monitoring Stations on the Houston Ship Channel and Greens Bayou



Monitoring Stations	River Mile*
1. 21TXWQB/10050100	1.7
2. 11POX06/TOX004	1.8
3. 11POX06/TOX001	3.2
4. 21TXWQB/10050200	8.3
5. 21TXWQB/10060100	10.2
6. 21TEXWR/10060100	10.2
7. 21TXWQB/10060200	16.1
8. 21TXWQB/10060220	19.8

Organic Chemical Plants	River Mile*
A. Denka Chemical Corporation	22.3
B. Chemical Exchange Process	20.29
C. Merichem Corporation	18.22
D. Pennwalt Corporation	18.22
E. Reichold Chemicals, Inc.	17.0**
F. Ethyl Corporation	15.3**
H. Rohm & Haas,Inc.	13.76
G. Tenneco Chemicals,Inc.	14.1**
I. Lubrizol Corporation	12.98
J. Shell Chemical Company	11.5**
K. Diamomd Shamrock Corporation	11.5**
L. Rohm and Haas-Texas, Inc.	10.9**
M. Diamond Shamrock Corporation	6.75
N. Syngas Company	5.66
O. Noramont Corporation	5.66
P. The Upjohn Company	2.9**
Q. Exxon Corporation	2.9**
R. National Distillers	2.9**

*-River Mile defined as miles upstream of Morgans Point
**- Modeled Organic Chemical Plants

Table 6. EXCEEDANCES OF EPA WATER QUALITY CRITERIA AND LOWEST REPORTED TOXICITY LEVELS FOR FRESHWATER AQUATIC ORGANISMS BASED ON STORET MONITORING DATA AT LOW FLOW

Pollutant	Station 21TXWQB/ 10050100 (river mile 1.7) Actual	21TXWQB/ 10050200 (river mile 8.3) Actual	21TXWQB/ 10060100 (river mile 10.2) Actual	21TXWQB/ 10060200 (river mile 16.1) Actual	21TXWQAB/ 10060220 (river mile 19.8) Actual
Cadmium	FA FC	FA FC	FA FC	FA FC	FA FC
Chromium (III)	FC(L)	FC(L)	FC(L)	FC(L)	--
Copper	FA FC	FA FC	FA FC	FA FC	FA FC
Lead	FC	FC	FC	FC	FC
Selenium	ND	ND	ND	ND	ND
Silver	FA FC(L)	-- ND	-- ND	-- ND	-- ND
Zinc	FC	ND	—	ND	ND

FC/FC(L) - Freshwater chronic criterion or lowest reported chronic toxicity level.
FA - Freshwater acute criterion.
ND - No data.

Table 7. EXCEEDANCES (OF EPA WATER QUALITY CRITERIA AND LOWEST REPORTED TOXICITY LEVELS FOR FRESHWATER AQUATIC ORGANISMS) BASED ON STORET MONITORING DATA AT MEAN FLOW

Pollutant	Station 21TXWQB/ 10050100 (river mile 1.7) Actual	11POX06/ TOX004 (river mile 1.8) Actual	11POX06/ TOX001 (river mile 3.2) Acutal	21TXWQB/ 10060100 (river mile 8.3) Actual	21TXWQB, 21TEXWB/ 10060100 (river mile 10.2) Acutal		21TXWQB/ 10060200 (river mile 16.1) Actual	21TXWQAB 10060220 (river mile 19.8) Actual
					Acutal	Acutal		
Cadmium	FA FC	FA FC	FA FC	FA FC	FA FC	FA FC	FA FC	FA FC
Chromium	FC(L)	--	--	FC(L)	--	--	--	--
Copper	FA FC	FA FC	FA FC	FA FC	-- FC FA	FA FC	-- FC	FA FC
Lead	-- FC	FA FC	-- FC	-- FC	-- FC	-- FC	-- FC	-- FC
Nickel	ND	FC	--	ND	ND	--	ND	ND
Silver	FA FC(L)	FA FC(L)	FA FC(L)	-- ND	-- ND	-- ND	-- ND	-- ND
Zinc	FC	FC	FC	FC	FC	ND	FC	FC

FC/FC(L) - Freshwater chronic criterion or lowest reported chronic toxicity level.
FA - Freshwater acute criterion.
ND - No data.

Table 8. EXCEEDANCES OF EPA WATER QUALITY CRITERIA AND LOWEST REPORTED TOXICITY LEVELS FOR SALTWATER AQUATIC ORGANISMS BASED ON STORET MONITORING DATA AT LOW FLOW

Pollutant	Station 21TXWQB/ 10050100 (river mile 1.7) Actual	21TXWQB/ 10050200 (river mile 8.3) Actual	21TXWQB/ 10060100 (river mile 10.2) Actual	21TXWQB/ 10060200 (river mile 16.1) Actual	21TXWQAB/ 10060220 (river mile 19.8) Actual
Cadmium	SC	SC	SC	SC	SC
Copper	SA SC	SA SC	SA SC	SA SC	SA SC
Lead	SC(L)	SC(L)	SC(L)	SC(L)	--
Nickel	ND	ND	ND	ND	ND
Selenium	ND	ND	ND	ND	ND
Silver	SA	ND	ND	ND	ND
Zinc	SC	ND	ND	ND	ND

SC/SC(L) - Saltwater chronic criterion or lowest reported chronic toxicity level.
FA - Saltwater acute criterion.
ND - No data.

based upon the available inorganic metals data for five of the eight STORET stations. For all five data stations worst case assumptions were made, that is, data reported as less than a certain value were set equal to that value. For all stations there were exceedances of the criteria.

Assuming downstream river flow within the channel (especially at mean flow conditions), water quality criteria violations upstream along Buffalo and Greens Bayou are certain to affect or increase water quality impacts along the downstream areas (upper and lower San Jacinto Bay and Morgans Point). Under low flow periods where tidal action (flushing) is more predominant, discharged pollutants in the water column could remain within the discharge zone for longer periods of time causing greater localized (near plant discharge sites) pollution problems.

Sufficient ambient data are not available to determine whether or not potential water quality impacts from current level discharges of toxic organic chemicals are actually occurring in the channel. Based upon other available data sources [the State of Texas Water Quality Inventory, 1982, 305(b)], the entire study area is classified as water quality limited. Along the upper portions of the channel (Buffalo Bayou) organic carbon levels and fecal coliform bacteria levels are high. Elevated levels of nickel, mercury, lead, cadmium, arsenic, and manganese, as well as the insecticide lindane, have been reported in the water column. Sediments contain elevated levels of lead, cadmium, copper, chromium, nickel, silver, zinc, and oil and grease, as well as aldrin, DDT, DDE, DDD, and PCB.

Along the lower portion of the channel from the San Jacinto River to Morgans Point, elevated concentrations of nickel, mercury, lead, arsenic, and manganese have occurred in the water. High levels of silver, nickel, lead, zinc, and cadmium have been reported in the sediments, as well as aldrin, DDT, and DDE. No specific locations regarding these toxic problems were mentioned in the 305(b) report; however, Burnett Bay has been reported to have a toxic sediment problem. No organic plants discharge within Burnett Bay.

Dilution Analysis

Information provided on process wastewater discharges from nine direct discharging plants served as a basis for assessing impacts of toxic pollutants discharged by the Organic Chemicals and Plastics Industry on water quality in the study area. This information consists of pollutant loadings and effluent concentrations resulting from modeling plant product-processes at raw (Base Case) and three levels of wastewater treatment: current, proposed BPT, and proposed BAT. The results of the model plant study are shown in detail in the report entitled

"Detailed Water Quality Analysis for the Organics Chemicals & Plastics Industry on the Greens Bayou and Houston Ship Channel", January, 1983.

The "base case" represents raw untreated process wastewater, which is not normally discharged to receiving water. This level is included for comparison purposes only. "Current" represents the treatment technology currently in place at a plant. Proposed BPT and BAT technology levels represent additional treatment required to bring effluent concentrations in line with proposed BPT and BAT limitations for this industry.

Comparisons between the modeled current discharge concentrations and proposed BPT effluent limitations are presented in Table 9. Based on these comparisons, all but the Diamond Shamrock and Shell plants are treating effluents to levels more stringent than that proposed for BPT BOD and BPT TSS limitations. Current treatment at the remaining seven plants achieves a discharge concentration level better than the proposed BPT effluent limitations for conventional pollutants. Based on model projections of current discharges, only the Tenneco plant complies with proposed BAT longterm average concentrations for toxic pollutants (50 ug/l for volatile organic compounds, 25 ug/l for acid toxic organic compounds, 50 ug/l for base/neutral toxic organic compounds, and 75 ug/l for toxic metals).

Table 9. Evaluation of Modeled Current Discharge Concentrations from Nine Organic Chemical and Plastics Manufacturing Plants which Discharge to the Houston Ship Channel and Greens Bayou

Plant	Applicable BPT BOD limitation (μg/l)	Model current BOD discharge conc. (μg/l)	Percentage of BOD limitation %	Applicable BPT TSS limitation (μg/l)	Model current TSS discharge conc. (μg/l)	Percentage of TSS limitation %	Compliance with proposed BPT effluent limitations for both conventional pollutants	Compliance with proposed BAT effluent limitations for all toxic pollutants[a]	Level of treatment currently achieved by plant
Diamond Shamrock	15.5	95.37	615	25	64.69	259	No	--	Less than BPT
Ethyl	24	20.17	84	42	8.2	19	Yes	No	Better than BPT, less than BAT
Exxon	24	5.07	21	42	NA	--	Yes	No	Better than BPT, but less than BAT
National Distillers	36	24.7	69	42	31.44	75	Yes	No	Better than BPT, but less than BAT
Reichold	24	21.72	90	42	18.45	44	Yes	No	Better than BPT, but less than BAT
Rohm & Haas	24	2.27	9	42	29.69	71	Yes	No	Better than BPT, but less than BAT
Shell	24	149.48	623	42	5.23	12	No	--	Less than BPT
Tenneco	36	4.28	12	42	34.95	83	Yes	Yes	BAT
UpJohn	24	13.39	56	42	0	0	Yes	No	Better than BPT, but less than BAT

[a] This evaluation only applicable to plants whose effluents currently meet proposed BPT effluent limitations on BOD and TSS.

NA - Not Available

Instream concentrations of toxic pollutants discharged by the plants at each treatment level were also estimated for analysis of ambient (instream) water quality impacts from wastewater discharges. These concentrations were derived as follows. First, the study area was divided into segments based on plant location and river mile position of reach segments (Table 10). These river segments provided a basis for calculation of receiving water flows used to estimate instream concentrations of toxic pollutants from plant discharges.

Receiving stream flows for each segment are derived by adding the model discharge flow from each of the nine plants to the mean and low flow for the segment which receives its discharge, and accumulating the plant flows to the farthest segment downstream. This assumes that process water discharges from the modeled plants are not included in the flow estimates in Table 11. This assumption is suggested because it is unlikely that the plants use the saltwater from the Channel as process water. Furthermore, the primary source of freshwater in the study area is from groundwater wells or Lake Houston. Data were not available at the time this analysis was completed to verify this assumption.

Table 10. FLOWS USED TO ESTIMATE INSTREAM CONCENTRATIONS OF POLLUTANTS DISCHARGED TO GREENS BAYOU AND THE HOUSTON SHIP CHANNEL BY MODELED PLANTS IN THE ORGANIC CHEMICALS AND PLASTICS INDUSTRY

Channel Segment (river miles)	Low flow conditions (CFS)	Mean flow conditions (CFS)
0-2.9	51.64	3,859.64
2.9-7.0	36.15	3,844.15
7.0-8.9	33.25	3,841.25
8.9-9.0	16.45	1,227.25
9.0-10.9	16.25	1,136.25
10.9-11.5	13.06	1,133.06
11.5-14.1	4.59	1,124.59
14.1-15.3	4.38	1,124.38
15.3-15.5	3.85	1,123.85
15.5-17.0	1.55	228.85

Table 11. DISCHARGE FLOW FOR REACHES IN THE HOUSTON SHIP CHANNEL STUDY AREA (W.E. Gates & Associates, 1982)

Reach	Reach number	Mean flow (CFS)	Low flow (CFS)
White Oak Bayou	12040104-019	97	0.5
Buffalo Bayou	12040104-020	480	1.1
Buffalo Bayou/Upper Houston Ship Channel	12040104-018	624	1.7
Upper Houston Ship Channel	12040104-017	855	2.2
Greens Bayou	12040104-016	228	0.7
Upper Houston Ship Channel	12040104-015	1,123	3.0
Carpenters Bayou	12040104-010	83	0.2
Upper Houston Ship Channel	12040104-009	1,214	3.2
San Jacinto River	12040104-008	2,609	16.8
Lower Houston Ship Channel	12040104-007	3,828	20.0
Lower Houston Ship Channel	12040104-004	3,828	20.0
Burnett Bay	12040104-006	--	--
Mouth of Burnett Bay	12040104-005	4.0	0.0
Scotts Bay	12040104-003	--	--
San Jacinto Bay	12040104-028	--	--
San Jacinto River/Lower Houston Ship Channel	12040104-029	--	--
Goose Creek[a]	12040203-002	370	1.3

[a] Discharges to Tabbs Bay on Upper Galveston Bay.

Instream concentrations of pollutants discharged by the nine plants were estimated assuming that no other sources discharged these pollutants to the study area. Detailed effluent data on other point sources in the area were unavailable to test this assumption. Modeled plant flows and discharge concentrations were accumulated in a downstream direction with only simple dilution and plant discharge determining instream concentration.

This "worst case" analysis approach does not take into consideration factors which would tend to reduce ambient pollutant concentrations below levels determined by simple dilution. These fate process factors include volatilization, sedimentation, biodegradation, bioaccumulation, photolysis, and other physical and chemical processes which affect the fate of chemical in a water environment. Decay rate constants associated with these fate processes were unavailable for the study area for use in the development of instream pollutant concentrations used in this analysis.

Calculated instream toxic pollutant concentrations were compared to EPA Water Quality Criteria and lowest reported toxicity concentrations to estimate the extent of water quality impacts from diluted process wastewater discharges from the nine plants.

In this analysis, a number of assumptions were required to use the EPA Water Quality Criteria. The criterion for trivalent chromium was used to evaluate chromium discharges. For hardness-dependent metal criteria, an ambient hardness level of 112 mg/l $CaCO_3$ was used based upon actual data. Since there are no drinking water intakes in the study area, the only human health criteria applicable to this analysis are those for ingestion of aquatic organisms. Finally, where available, lowest reported toxic concentrations were used in the analysis when a water quality criterion had not been developed for a pollutant.

In the case where a water quality criterion was exceeded, the corresponding water quality effect was assumed to occur over the full length of the river segment. Using this assumption, the total length of river miles impacted by a wastewater discharge could be estimated by summing the lengths of the individual river segments where a water quality criterion for a pollutant was exceeded.

Figures 4, 5, and Table 12 summarize the river miles from Morgans Point at the mouth of the Houston Ship Channel affected by discharges by the nine plants under the three levels of treatment.

Figure 4. Freshwater Aquatic Life Impacts Expected from Wastewater Discharges to the Houston Ship Channel Bayou at Low Flow by Nine Modeled Organic Chemical and Plastics Plants

Treatment level	Water quality effect (impact)	Pollutant	River miles impacted
Current	Acute Toxicity Criterion	Copper	8.9–11.5; 15.5–17
	Lowest Reported Acute Toxicity	Acrolein	11.5–17
	Chronic Toxicity Criterion	Cadmium	0–2.9
		Copper	0–17
		Cyanide	0–15.3
		Lead	0–2.9
		Selenium	8.9–11.5
		Zinc	0–2.9
	Lowest Reported Chronic Toxicity	Acrolein	8.9–17
		Chromium*	0–2.9; 8.9–11.5
		Silver	0–2.9
BPT	Acute Toxicity Criterion	Copper	8.9–11.5; 15.5–17
	Lowest Reported Acute Toxicity	Acrolein	11.5–17
	Chronic Toxicity Criterion	Cadmium	0–2.9
		Copper	0–17
		Cyanide	0–15.3
		Lead	0–2.9
		Selenium	8.9–11.5
		Zinc	0–2.9
	Lowest Reported Chronic Toxicity	Acrolein	8.9–17
		Chromium*	0–2.9; 8.9–11.5
		Silver	0–2.9
BAT	Acute Toxicity Criterion	Copper	8.9–11.5; 15.5–17
	Chronic Toxicity Criterion	Cadmium	0–2.9
		Copper	0–17

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Mouth — Houston Ship Channel River Miles — Greens Bayou

Potential impacts based on exceedances of protection/toxicity levels by estimated instream concentrations.

* Trivalent.

Figure 5. Saltwater Aquatic Life Impacts Expected from Wastewater Discharges to the Houston Ship Channel and Greens Bayou at Low Flow by Nine Modeled Organic Chemicals and Plastics Plants

Treatment level	Water quality effect (impact)	Pollutant	River miles impacted
Current	Acute Toxicity Criterion	Copper	8.9 — 11.5; 15.5 — 17
	Lowest Reported Acute Toxicity	Acrolein	11.5 — 17
	Chronic Toxicity Criterion	Chromium*	0 — 11.5
		Copper	0 — 17
		Nickel	0 — 2.9
		Zinc	0 — 2.9
	Lowest Reported Chronic Toxicity	Cyanide	0 — 15.3
		Lead	0 — 2.9
BPT	Acute Toxicity Criterion	Copper	8.9 — 11.5; 15.5 — 17
	Lowest Reported Acute Toxicity	Acrolein	11.5 — 17
	Chronic Toxicity Criterion	Chromium	0 — 11.5
		Copper	0 — 17
		Nickel	0 — 2.9
		Zinc	0 — 2.9
	Lowest Reported Chronic Toxicity	Cyanide	0 — 15.3
		Lead	0 — 2.9
BAT	Acute Toxicity Criterion	Copper	8.9 — 11.5; 15.5 — 17
	Chronic Toxicity Criterion	Copper	0 — 17

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Mouth — Houston Ship Channel River Miles — Greens Bayou

Potential impacts based on exceedances of protection/toxicity levels by estimated instream concentrations.

* Hexavalent.

Table 12. Human Health Impacts Expected from Wastewater Discharges to the Houston Ship Channel and Greens Bayou by Nine Modeled Organic Chemicals and Plastics Plants at Mean and Low Flow

Pollutant	Treatment technology level	Low Flow HC (Risk Levels) 10^{-5}	Low Flow HC (Risk Levels) 10^{-6}	Low Flow HC (Risk Levels) 10^{-7}	Mean Flow HH (o)	Mean Flow HC (Risk Levels) 10^{-5}	Mean Flow HC (Risk Levels) 10^{-6}	Mean Flow HC (Risk Levels) 10^{-7}
Arsenic	Current, BPT	0-2.9 →	→	→			0.2-9 →	→
	BAT			0-2.9				
Methyl chloride	Current			2.9-11.5				
Methylene chloride	Current			2.9-11.5, 15.5-17				
	BPT			15.5-17				
Chloroform	Current, BPT		0-11.5 →	→				
1,2 Dichloroethane	Current			0-11.5				
Vinylidene chloride	Current		0-11.5	11.5-15.3				8.9-11.5
	BPT, BAT		8.9-11.5	11.5-15.3, 0-8.9				
Benzene	Current	10.9-11.5	0-10.9 →	→				8.9-11.5
	BPT			0-2.9 8.9-11.5				
Acrylonitrite	Current	8.9-11.5	0-8.9 →	→				8.9-11.5
Anthracene	Current	0-11.5 →	→	→			8.9-11.5	0-8.9
Benzo(a)anthracene	Current, BPT, BAT	0-11.5 →	→	→				0-11.5
Benzo(k)fluoranthene	Current, BPT, BAT		0-11.5 →	→				
Benzo(ghi)perylene	Current, BPT, BAT		0-2.9, 8.9-11.5 →	→ 2.9-8.9				
Benzo(a)pyrene	Current, BPT	0-11.5 →	→	→				0-11.5
	BAT		0-2.9 →	→				
Chrysene	Current, BPT, BAT		0-2.9 →	→				0-2.9
Fluorene	Current, BPT	0-11.5 →	→	→		0-11.5 →	→	→
Indeno(1,2,3,-cd)pyrene	Current			0-11.5		0-11.5 →	→	→
Phenanthrene	Current	0-11.5 →	→	→		9.0-11.5	0-9.0 →	→
Pyrene	Current	8.9-11.5	0-8.9 →	→				8.9-11.5
Total PAHs	Current, BPT	0-11.5 →	→	→		0-11.5 →	→	→
	BAT		0-2.9 →	→				0-2.9

HH (o) - EPA water quality criterion for human health toxicity protection from ingesting organisms.

HC (risk level) - EPA water quality criterion for carcinogenicity protection from ingesting organisms at a risk level given in parentheses.

Figures 4 and 5 show the types of aquatic life impacts expected in the Houston Ship Channel from wastewater discharges by the nine modeled plants. At current treatment levels, acute impacts on freshwater aquatic organisms are expected under low flow conditions from copper and acrolein discharges. Under the same conditions of flow and treatment level, impacts on freshwater aquatic organisms related to exceedances of chronic toxicity thresholds are expected to occur from cadmium, copper, cyanide, lead, selenium, zinc, acrolein, chromium, and silver.

Impacts on freshwater organisms are likely to be significantly reduced under low flow conditions when plants currently treating their wastewater at less than BPT upgrade their treatment to comply with proposed BPT effluent limitations. Referring to Figure 4, impacts related to acute toxic effects are expected only from copper and acrolein discharges. Expected freshwater aquatic life impacts from chronic toxicity effects at the proposed BPT will be expected from only cadmium, copper, cyanide, lead, zinc, selenium, silver, chromium, and acrolein discharges. The total river miles impacted by both types of effects is also reduced under BPT. Once the plants upgrade wastewater treatment to meet the proposed BAT limitations, all impacts on freshwater organisms under low flow conditions are expected to be eliminated except those from cadmium and copper.

Expected impacts on freshwater organisms under mean flow conditions at current treatment levels do not occur due to additional dilution.

Because the study area may be used for recreational and subsistence fishing, potential human health impacts from ingesting fish are considered in this analysis. Table 12 presents human health impacts expected from wastewater discharges to the Houston Ship Channel and Greens Bayou by the nine plants at low and mean flow conditions.

Current discharges are likely to present the potential for human health due to toxicity from eating fish contaminated with acrolein during low flow conditions. The potential for this impact is eliminated at both BPT and BAT.

The threat of human carcinogenicity from eating contaminated fish is present at current discharge levels from seventeen organic pollutants under low flow conditions, from eleven at BPT levels, and from eight pollutants at BAT levels (Table 13). The extent of the area where the impact may occur also decreases under conditions representing compliance with the more stringent effluent limitations at the proposed BPT and BAT levels.

Biological Conditions

Available data indicate that present fish harvests from Galveston Bay are very high. The Houston Ship Channel has also experienced a significant upswing in the species and abundance of each found there. Species found on the lower segment of the channel between 1973 and 1977 include: croaker, sand seatrout, bass, menhaden, bluegill, butterfish, catfish, sheepshead, drum and flounder. Recent biological survey results (1982) from Scott & Burnett Bay have also found a number of important species (See table 14).

The lower Ship Channel and Galveston Bay have seen a return of fish species that have been absent from this area for many years. A sampling survey two miles above the confluence of the San Jacinto with the channel bears this out. Samples taken in 1972 revealed a total of 18 species but by 1978, the number had almost doubled to 33 species. As a result, sportfishing has increased around the shoreline of the lower channel and the inner bays have developed as productive nursery areas for larval shrimp and crabs.

Several different species of fish including large numbers of blue crabs, white and brown shrimp are observed on the San Jacinto River. Blue crabs are plentiful from Lake Houston to the Houston Ship Channel while the shrimp are most abundant in the lower segment of the river.

Table 13. Projected Human Health Impacts in Upper Galveston Bay

Receiving water flow conditions	Pollutant	Current Treatment Levels Human carcinogenicity from ingesting organisms/ highest risk level	BPT Treatment Level Human carcinogenicity from ingesting organisms/ highest risk level	BAT Treatment Level Human carcinogenicity from ingesting organisms/ highest risk level
Low flow	Arsenic	10^{-5}	10^{-5}	10^{-7}
	Chloroform	10^{-6}	10^{-6}	--
	1,2 Dichloroethane	10^{-7}	--	--
	Vinylidene chloride	10^{-6}	10^{-7}	10^{-7}
	Benzene	10^{-6}	10^{-7}	--
	Acrylonitrile	10^{-6}	--	--
	Anthracene	10^{-5}	--	--
	Benzo(a)anthracene	10^{-5}	10^{-5}	10^{-5}
	Benzo(k)fluoranthene	10^{-6}	10^{-6}	10^{-6}
	Benzo(ghi)perylene	10^{-6}	10^{-6}	10^{-6}
	Benzo(a)pyrene	10^{-5}	10^{-5}	10^{-6}
	Chrysene	10^{-6}	10^{-6}	10^{-6}
	Fluorene	10^{-5}	10^{-5}	--
	Indeno(1,2,3-ed)pyrene	10^{-7}	--	--
	Phenanthrene	10^{-5}	--	--
	Pyrene	10^{-6}	--	--
	Total PAHs	10^{-5}	10^{-5}	10^{-5}
Mean flow	Arsenic	10^{-6}	10^{-6}	--
	Anthracene	10^{-7}	--	--
	Benzo(a)anthracene	10^{-7}	10^{-7}	10^{-7}
	Benzo(a)pyrene	10^{-7}	10^{-7}	--
	Chrysene	10^{-7}	10^{-7}	10^{-7}
	Total PAHs	10^{-7}	10^{-7}	10^{-7}

Table 14. Recent Biological Survey Results from Scott and Burnett Bays (1982)

Species	Scott Bay		Burnett Bay Lower	Burnett Bay Upper
	4/1/82	5/19/82	6/13/82	8/3/82
White shrimp, *Penaeus setiferus*	84	34	8	127
Brown shrimp, *Penaeus aztecus*	1	--	--	45
Blue crab, *Callinectes sapidus*	14	48	33	26
Black drum, *Pogonias cromius*	1	--	--	--
Bay anchovy, *Anchoa mitchilli*	1	--	--	--
Largescale menhaden, *Brevoortia patronus*	4	2	2	--
Atlantic croaker, *Micropogon undulatus*	11	11	17	--
Southern fluke, *Paralichthys lethostigma*	--	1	--	--
Gaff-topsail catfish, *Bagre marinus*	--	--	--	7
Sand seatrout, *Cynoscion arenarius*	--	--	4	4
Blue catfish, *Ictalurus furcatus*	--	--	2	--
River shrimp, *Macrobrachium ohione*	--	--	1	--

Despite these improvements, fish kills caused by a drop in oxygen due to aerobic bacterial decomposition of pollutants still occur in the channel. Further reductions in the BOD loading should result in even greater increases in marine productivity throughout the area. There is no vegetation problem stemming from water quality on the river. However, the low concentrations of dissolved oxygen and high levels of chlorides in the lower stretches (below RM 4.95) are a threat to fish population and have been responsible for fish kills in the past.

Table 15 presents results of benthic macroinvertebrate surveys at three locations on the Houston Ship Channel by the Texas Department of Water Resources. The number of species is highest in the two most recent years of sampling, suggesting improving conditions. The number of species also increases in samples collected downstream at river miles 9.0 (San Jacinto Monument Station) and 0.0 (Morgans Point Station), suggesting reduced pollution impacts as Upper Galveston Bay is approached. This increase in species number may be related to distance from point sources of wastewater discharges, increasing flow and tidal action (increases dilution of wastewaters), reduction in water depth and more habitat which is less impacted by commercial shipping activities.

Table 15. Results of Benthic Macroinvertebrate Sampling on the Houston Ship Channel

BENTHIC MACROINVERTEBRATES COLLECTED IN THE TURNING BASIN (MILE 25.0)

PHYLUM	CLASS/ORDER	SPECIES	YEAR AND MONTH 1974 8	11*	1975 2	5	8	11	1976 2	5	8	11**	1977 2	6	9	11	1978 2	5	8	11
ANNELIDA	OLIGOCHAETA	Tubificid	D	32	D	D	D	D	D	D	D	N	D	N	N	N	N	N	D	D
	(Segmented		E		E	E	E	E	E	E	E	O	E	O	O	O	O	O	E	E
	Aquatic Worms)		V		V	V	V	V	V	V	V	T	V	T	T	T	T	T	V	V
			O		O	O	O	O	O	O	O		O						O	O
ARTHROPODA	INSECTA	<u>Chaoborus punctipennis</u>	I	1	I	I	I	I	I	I	I	S	I	S	S	S	S	S	I	I
		<u>Polypedium</u> sp.	D	1	D	D	D	D	D	D	D	A	D	A	A	A	A	A	D	D
												M		M	M	M	M	M		
												P		P	P	P	P	P		
												L		L	L	L	L	L		
												E		E	E	E	E	E		
												D		D	D	D	D	D		

Table 15. (continued)

BENTHIC MACROINVERTEBRATES COLLECTED NEAR THE SAN JACINTO MONUMENT (MILE 9.0)

PHYLUM	CLASS/ORDER	SPECIES	1974 8	1974 11	1975 2	1975 5	1975 8	1975 11	1976 2	1976 5	1976 8	1976 11	1977 2	1977 6	1977 9	1977 11	1978 2	1978 5	1978 8	1978 11
NEMERTEA	ANOPLA (Unsegmented Marine Worms)	<u>Tubulanus pellucidus</u>				3					D		1		5			3	2	8
											E									
											V									
ANNELIDA	POLYCHAETA (Segmented Marine Worms)	<u>Gyptis vittata</u>	28								O				2					
		<u>Nereis pelagica</u>									I	1		1	1		2	1		
		<u>Streblospio benedicti</u>	438	49	78	7		35	503	112	D	36	117	52	22	51	22		21	11
		<u>Prionospio pinnata</u>														1			8	1
		<u>Polydora socialis</u>											1				2			
		<u>Boccardia hamata</u>													2					
		<u>Capitella capitata</u>								2					1		1			
		<u>Mediomastus californiensis</u>													3				1	
		<u>Amphicteis gunneri</u>	4																	
	OLIGOCHAETA (Segmented Aquatic Worms)	Immature tubificid					1													
ARTHROPODA	AMPHIPODA	<u>Ampellisca vadorum</u>			1															
		Gammarid Species A			1															
	MYSIDACEA	<u>Mysidiopsis bahia</u>	2																	
	INSECTA	<u>Chaoborus punctipennis</u>		1	3		1													
MOLLUSCA	PELECYPODA (Clams)	<u>Brachydontes exustus</u>	11																	
		<u>Congeria leucophaeta</u>										2					2			
		<u>Macoma mitchelli</u>												1						
		<u>Mulinia lateralis</u>							4	3								7		

Table 15. (continued)

BENTHIC MACROINVERTEBRATES COLLECTED AT MORGANS POINT (MILE 0.0)

PHYLUM	CLASS/ORDER	SPECIES	1974 8	1974 11	1975 2	1975 5	1975 8	1975 11	1976 2	1976 5	1976 8	1976 11	1977 2	1977 6	1977 11	1978 2	1978 5	1978 8	1978 11
PLATYHELMINTHES	POLYCLADIA (Flatworms)	Stylochus ellipticus																1	
NEMERTEA	ANOPLA (Unsegmented Marine Worms)	Tubulanus pellucidus	1		3		1				16	1	2		2	4	4	8	1
		Lineus pallidus																1	
		Nemertea Species A			9														
ANNELIDA	POLYCHAETA (Segmented Marine Worms)	Pseudeurythoe ambiqua											1						1
		Eumida sanquinea														3	1		
		Eteone heteropoda															1		
		Gyptis vittata															1	1	
		Neanthes succinea			1			1											
		Nereis pelagica														1			4
		Glycinde solitaria									2	5			5	1	5	1	
		Streblospio benedicti	283	3	6		11		6		454	6	2	22	9	9	3	2	
		Prionospio pinnata	12				2				18	3	1	6	15	6	1	40	33
		Polydora websteri																	1
		Mediomastus californiensis	3	17	4	1					434	9					3	1	
		Heteromastus filiformis							2										
		Capitella capitata									28								
SIPUNCULIDA		Sipunculid Species A			4														
MOLLUSCA	GASTROPODA (Snails)	Cymatium nicobaricum																	2
		Cratena kaoruae											8						
	PELECYPODA (Clams)	Brachidontes exustus														1			
		Macoma mitchelli															3		
		Mulinia lateralis	2						1	3							1		
ARTHROPODA	CUMACEA	Cumacean Species A																1	
	AMPHIPODA	Gammarid Species A		1															
	DECAPODA (Shrimp-like Crustaceans)	Ogyrides limicola														1			2

KANAWHA RIVER

Background

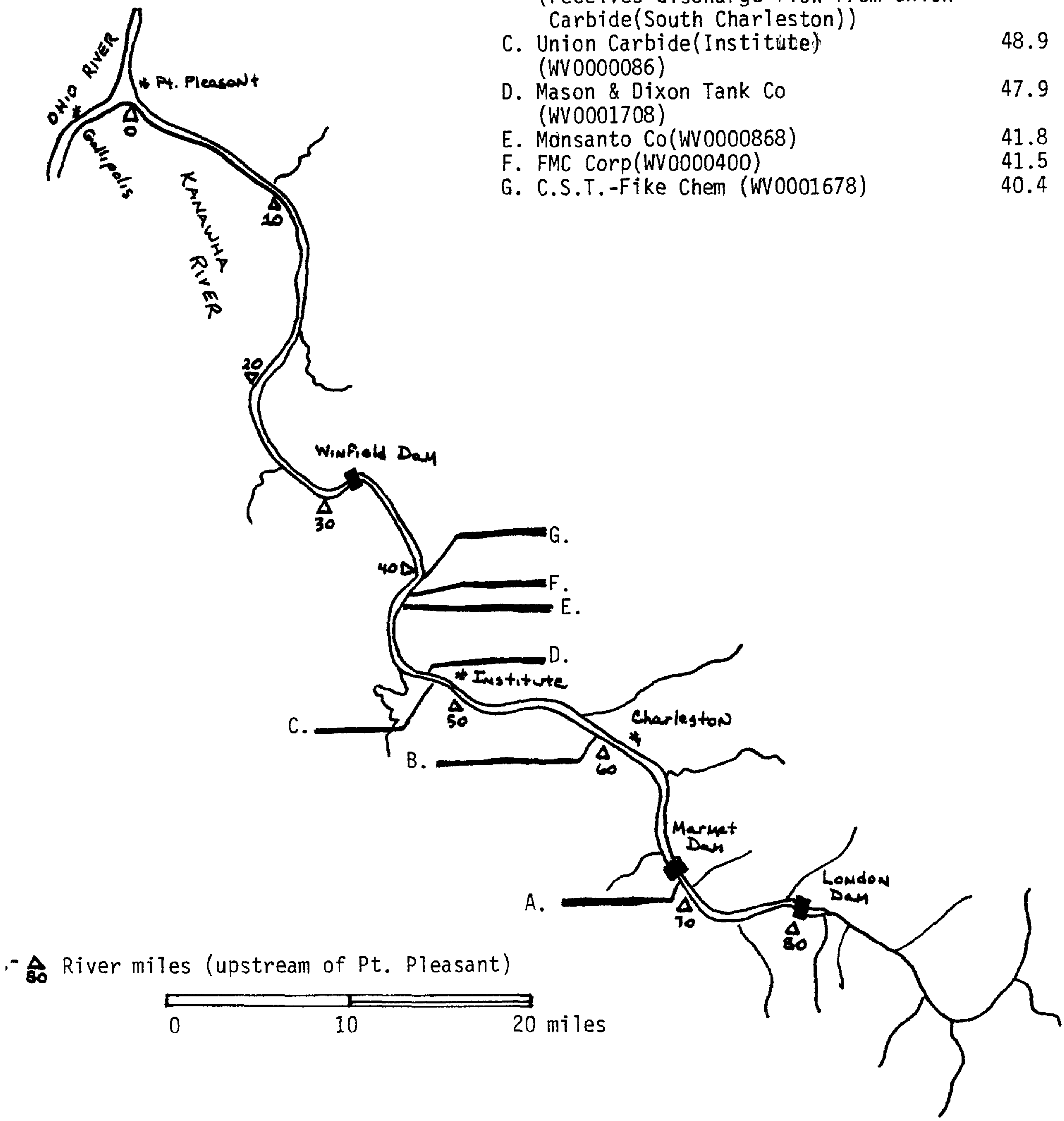
The Kanawha River flows through the southwest region of West Virginia. The main body of the Kanawha River is formed at the confluence of the New and Gauley Rivers at Gauley Bridge, West Virginia. The mainstem flows northwesterly for 97 miles through parts of Fayette, Kanawha, Putnam, and Mason counties where it joins the Ohio River at Point Pleasant, West Virginia. Its major tributaries are the Greenbrier River, Elk River, Coal River and Pocatalico River.

A set of four locks and dams, the London (River Mile (RM) 80), Marmet (RM 67), Winfield (RM 30), and Gallipolis (RM 0), divide the river into four pools designed to maintain a minimum navigational depth for barge traffic. The Kanawha River can be characterized as a large, deep, slow moving, almost lake-like river.

The 74 mile stretch of the Kanawha River from Point Pleasant to Cheylan is the subject of this analysis (figure 6). A total of 34 industrial and municipal direct discharge facilities affect water quality in the study area. Six (6) Organic Chemical and Plastics (OC&P) facilities contribute an estimated 40 percent of the total process wastewater flow to the segment; the dischargers from this industry are concentrated between river miles 69.36 and 40.41.

Figure 6. Location of Organic Chemical and Plastics Plants on the Kanawha River, West Virginia.

ORGANIC CHEMICAL PLANTS	RIVER MILE
A. E.I. DuPont (WV0002399)	69.4
B. South Charleston STP (WV00023116) (receives discharge flow from Union Carbide(South Charleston))	56.3
C. Union Carbide(Institute) (WV0000086)	48.9
D. Mason & Dixon Tank Co (WV0001708)	47.9
E. Monsanto Co(WV0000868)	41.8
F. FMC Corp(WV0000400)	41.5
G. C.S.T.-Fike Chem (WV0001678)	40.4



Publicly Owned Treatment Works (POTWs) and Inorganic Chemicals contribute 31 percent and 29 percent, respectively, of the wastewater to this segment of the river. Coal mining and pesticides plants contribute less than one (1) percent of the total process wastewater flow.

The proportional contribution of OC&P loadings to all industrial loadings of toxic pollutants was estimated on two reaches on the Kanawha River above Winfield Dam. A total of eighteen (18) pollutants (nine organics, two inorganics, seven metals) and the two largest OC&P plants which had data available , FMC Corp. and Union Carbide (Institute), were selected for analysis.

Table 16 summarizes the results under current, proposed BPT, and proposed BAT treatment levels. The two OC&P plants contribute over seventy (70) percent of the total industrial loading of the pollutants to the reaches. An eighty (80) percent loading reduction is estimated in upgrading to BAT levels over current treatment for combined organics, inorganics, and metals removal.

Table 17 lists the six (6) Organic Chemicals and Plastics facilities with discharge flows to the study area. Table 18 shows the two (2) OC&P plants (E.I. DuPont and Union Carbide (Institute)) and their treatment technology for which modeled plant effluent data was available for this study. The two modeled plants in this analysis contribute 86 percent of the total OC&P discharge flow to the Kanawha River.

TABLE 16. ESTIMATION OF LOADINGS OF SELECTED PRIORITY POLLUTANTS TO THE KANAWHA RIVER FOR TWO PLANTS UNDER VARIOUS TREATMENT CONTROLS

	LOADINGS (Kg/day)		
	Current	BPT	BAT
Total Industry	605.04	275.60	123.21
OC & P	437.10	197.99	87.46
(Percent of Total)	72.2	71.8	71.0

REDUCTIONS IN LOADINGS (Percent) FOR OC & P INDUSTRY

Current BPT	BPT BAT	Current BAT
54.7	55.8	80.0

TABLE 17. NAME, NPDES NUMBER, AND DISCHARGE LOCATION OF DIRECT DISCHARGE ORGANIC CHEMICALS AND PLASTICS PLANTS IN THE STUDY AREA.

River mile	NPDES number	Facility	Total Facility Wastewater flow (TGD)
69.36	WVØØØ2399	E.I. DuPont	26,389
48.9	WVØØØØØ86	Union Carbide Corp.	2,240
47.86	WVØØØ17Ø8	Mason & Dixon Tank Inc.	5
41.79	WVØØØØ868	Monsanto Co.	2,460
41.54	WVØØØØ4ØØ	FMC Corp.	2,150
40.41	WVØØØ1678	C.S.T. Inc. - Fike Chemical	30

TABLE 18. TREATMENT TECHNOLOGY FOR THE MODELED ORGANIC CHEMICALS AND PLASTICS PLANTS ON THE KANAWHA RIVER

PLANT	TYPE	WASTEWATER TREATMENT FACILITY	DISCHARGE	PRODUCT PROCESSES	TREATMENT PROCESS
E.I DuPont	PP/TR	Clarification	Direct	8	PSC, EQUALIZATION, NEUTRALIZATION, SINGLE STAGE ACTIVATED SLUDGE
Union Carbide (Institute)	CEM,U	Activated Sludge	Direct	20	EQUALIZATION, CLARIFICATION, NEUTRALIZATION, SINGLE STAGE ACTIVATED SLUDGE

TYPE: CEM - Chloroethanes/Methanes
PP/TR - Polymer Plastics/Thermoset Resins
U - Urethanes

The State of West Virginia has designated the lower Kanawha River from RM 72 to its mouth (Zone 2) a water quality limited segment due to the presence of significant pollution problems. The segment from RM 72 to the river's origin (Zone 1) is considerably cleaner. Table 19 lists the use classifications designated by the State and actual uses as reported by the Regional Intergovernmental Council.

Chemical Water Quality

The Kanawha River has had a long history of pollution problems from both industrial and municipal sources. Most of the pollution can be attributed to the upsurge in industrial activity that occurred at the beginning of World War II and the concomitant increase in population. In the 40-year period between 1940 and 1980, industry continued to expand and the population along the Kanawha River increased by 44% from 195,192 to 281,446.

During the 1950s and early 1960s the water quality of the Gallipolis, Winfield and Marmet Pools was severely degraded. The dissolved oxygen level dropped to zero during low flow periods and, as a result, fish kills were a frequent occurrence, particularly between Winfield Dam and Charleston. A thick black sludge covered the banks during this period, and oil, untreated sewage and trash floated on the surface of the river. In addition, severely elevated threshold odor levels from sewage and aromatic compounds were reported.

TABLE 19. DESIGNATED AND ACTUAL USES OF THE KANAWHA RIVER MAINSTEM

	Use Category						
	(A)	(B1)	(B2)	(B3)	(C)	(D)	(E)
zone and use status	Water contact recreation	Public water supply	Water supply industrial	Water supply agricultural	Propagation of fish	Water transport, cooling and power	Treated wastes transport and assimilation
Zone 1 (River miles 72 to 97)							
Designated by State	X	X		X	X	X	
Actual Use	X	X	X	X	X	X	X
Zone 2 (River miles 0 to 72)							
Designated by State	X		X		X	X	X
Actual Use	X		X	X	X	X	X

The water quality of the London and Gallipolis Pools was not as severely impacted by industrial and municipal discharges as the Marmet and Winfield Pools. According to an official at the Department of Natural Resources (DNR), industrial discharge into the London Pool has always been minimal and water quality has been good. A power facility discharged heat into the London Pool until the early 1970s; however, the impact was reported to be minimal. The water quality in the Gallipolis Pool, while poor, was generally better than the Winfield and Marmet Pools. This was due to the absence of dischargers and the ability of the river to assimilate some of the wastes as they progressed downstream.

The West Virginia State Water Commission began a three-phase clean-up program in 1957. During Phase I, primary treatment was required as a minimum for municipal dischargers, and chemical manufacturers were required to reduce their BOD_5 loads by 40% by June, 1963. Phase II required municipalities to implement secondary treatment and chemical plants to reduce BOD_5 loads by 50%. Phase III requirements were specified in 1971. BOD_5 reductions to 15% of 1959 levels were required, with as much reduction of nitrogenous waste loads as possible.

Monitoring data at several stations document the degraded water quality conditions prevalent from the early to mid - 1970's throughout the Kanawha River extending from the Elk River to Winfield Dam. A lack of ambient data upstream of the Elk River makes it difficult to state water quality conditions above this point. West Virginia water quality standards were frequently exceeded for fecal coliform levels, copper, and lead. Occassional violations for cyanide, phenols, iron, and zinc were also reported.

With the absence of major dischargers below Winfield Dam and the ability of the river to assimilate wastes progressing downstream, the water quality conditions were not as severely degraded as those upstream of Winfield Dam. At the mouth of the Kanawha River, at Henderson, West Virginia, standards violations, while occurring, were not as numerous compared to those above Winfield Dam. Iron levels were an exception to this trend with concentrations frequently exceeding standard levels.

During the period between 1979 and 1981, the West Virginia Water Quality Status Assessment reported that no standards violations occurred on the Kanawha mainstem for copper or zinc. Cyanide, manganese, iron, cadmium, phenols, and lead levels occasionally exceeded standards. Repeated fecal coliform standard violations have been reported between the Elk River and Winfield Dam. No data were available for other organics. Iron and manganese standards violations have been attributed to the coal mining industry; fecal coliform violations were attributed to agriculture, construction, and silviculture.

Evaluation of Organic Chemicals Plant Effects

Information on modeled process wastewater discharges based on "generalized plant configurations" (GPCs) from two plants served as a basis for assessing impacts of toxic pollutants discharged by the Organic Chemicals and Plastics Industry on Kanawha River water quality. This information consists of pollutant effluent concentrations resulting from modeling plant product-processes at raw discharge (base case) and three levels of wastewater treatment: current, proposed BPT, and proposed BAT. Table 20 lists the specific treatment technology at each level for the two plants, E.I. DuPont and Union Carbide (Institute).

Table 21 compares the GPCs current discharge concentrations and the proposed BPT effluent limitations for DuPont and Union Carbide. Both plants are currently exceeding the proposed BPT limitations for BOD while meeting the BPT TSS limitations. Current discharges from both plants do not meet proposed BAT concentrations for all toxic metals (75 ug/l).

Instream concentrations of toxic pollutants discharged by the plants were estimated for an analysis of water quality impacts using a simple dilution analysis (See "Detailed Water Quality Analysis for the Organic Chemicals and Plastics Industry on the Kanawha River", January, 1983). The dilution analysis was a "worst case" scenario with respect to aquatic life toxicity effects outside of

TABLE 20. TREATMENT TECHNOLOGY FOR MODELED PLANTS ON THE KANAWHA RIVER AT CURRENT, BPT, AND BAT CONTROLS

PLANT	CONTROL	TREATMENT LEVEL*			IN PROCESS CONTROLS				
		AS1	AS2	FILT	IE	COA	FLO	AMS	LIM
1	Current	X		X					
	BPT	X		X					
	BAT	X		X	X	X	X		
2	Current	X		X					
	BPT		X	X					
	BAT		X	X	X			X	X

* - all three controls have clarification and neutralization @ end of pipe

AS1 - single stage activated sludge
AS2 - double stage activated sludge
FILT - filtration
IE - Ion Exchange
COA - Coagulation
FLO - Flocculation
AMS - Ammonia stripping
LIM - Liming

TABLE 21. COMPARISON OF MODELED CURRENT DISCHARGE CONCENTRATIONS AND PROPOSED BPT EFFLUENT LIMITATIONS FOR TWO ORGANIC CHEMICAL AND PLASTICS MANUFACTURING PLANTS WHICH DISCHARGE TO THE KANAWHA RIVER

	Applicable BPT BOD limitation mg/l	Model current BOD conc. mg/l	Percentage of BOD limitation %	Applicable BPT TSS limitation mg/l	Model current TSS conc. mg/l	Percentage of TSS limitation %
E.I. DuPont	36	33.41	93	42	0.75	2
Union Carbide (Institute)	24.0	199.15	829	42	1.72	4

the mixing zone, as it does not take into account factors which would tend to reduce ambient pollutant concentrations below levels determined by simple dilution. These fate process factors include volatilization, sedimentation, biodegradation, bioaccumulation, photolysis, and other physical and chemical processes which affect the fate of a chemical in a water environment.

Instream concentrations within the mixing zones are expected to be higher than those predicted by the simple dilution analysis. Estimations of pollutant levels and water quality impacts within these zones were not performed due to lack of detailed information on the behavior of the discharge plumes. However, elevated toxic pollutant concentrations are likely to have at least some local adverse sublethal, bioaccumulative, physiological, or behavioral effects on any exposed aquatic organisms.

Table 22 summarizes the total river miles impacted by discharges from the two plants under the treatment levels at mean and low flow as a result of the dilution analysis. Seven (7) pollutants exceed EPA Water Quality Criteria under either mean or low flow only under base case treatment. All potential violations occur as a result of discharge from Union Carbide (Institute). Arsenic was the only pollutant that had potential violations at current and BPT treatment. No violations were predicted at BAT treatment.

TABLE 22. TOTAL RIVER MILES ON THE KANAWHA RIVER WHERE WATER QUALITY IMPACTS ARE EXPECTED BASED ON EXCEEDANCES OF EPA WATER QUALITY CRITERIA

Pollutant	Model treatment level	Flow condition	Exceeded EPA Criteria	River miles impacted
Arsenic	B = C = BPT	Mean	HC (10^{-7})	0-48.9
	B = C = BPT	Low	HC (10^{-6})	0-48.9
Cyanide	Base Case	Mean	FC	0-48.9
	Base Case	Low	FA, FC	0-48.9
Methyl chloride	Base Case	Low	HC (10^{-7})	0-48.9
Chloroform	Base Case	Low	HC (10^{-7})	38.4-48.9
Carbon Tetrachloride	Base Case	Low	HC (10^{-7})	0-48.9
Benzene	Base Case	Low	HC (10^{-7})	0-48.9
2,4 Dinitrotoluene	Base Case	Mean	HC (10^{-7})	45.4-48.9
	Base Case	Low	HC (10^{-6})	38.4-48.9
			HC (10^{-7})	0-38.4

FC - Freshwater chronic toxicity
FA - Freshwater acute toxicity
HC - EPA water quality criterion for carcinogenicity protection from ingesting organisms at risk level given in parenthesis
B - Base Case
C - Current
BPT - Best practicable treatment

Ambient arsenic data was retrieved to compare to the current modeled plant discharge concentrations, with discharges assumed to begin at a time corresponding with the beginning of the current NPDES plant permit (November 1, 1981).

All values of arsenic concentrations were reported as less than 2 ug/l, the analytical detection limit, so that meaningful comparisons with the projected levels which range from 0.007 to 0.08 ug/l and the EPA criterion of 0.00175 ug/l for carcinogenicity protection at the 10^{-7} risk level are not possible.

Significant improvements in water quality are projected in going from the base case to current treatment levels. The results shown in Table 22 indicate that, except for arsenic, current treatment removes all toxic pollutants to levels below the EPA criteria. The only potential human health impact expected from discharges by any of the plants is the risk at the 10^{-7} risk level for the occurrence of human carcinogenicity from eating fish contaminated with arsenic. This potential risk is present from below the point of discharge of the Union Carbide (Institute) plant at river mile 48.9 to the mouth of the Kanawha River. Its discharges currently do not meet proposed BAT concentration limitations for all toxic metals (75 ug/l). Modeled BAT effluent concentrations for this plant indicate that the human health risk associated with arsenic discharges will be eliminated when the plant complies with the proposed BAT effluent limitations for metals.

From the dilution analysis, the modeled plant discharge concentrations indicate that the two modeled direct dischargers will not by themselves cause aquatic life effects in the Kanawha River at their current, BPT, or BAT toxic pollutant discharge levels. Potential aquatic life effects may occur within the mixing zone of the effluent plume.

However, although the two modeled plants discussed above account for 86 percent of the discharge flow to the Kanawha River, this may not preclude potential impacts from the remaining 14 percent of the OC&P discharge flow. Since GPC data was not available for plants E, F, and G (figure 7), hypothetical pollutant loadings were computed at RM 41.5. Loadings to the river were calculated using average OC&P effluent data at the various treatment levels for the seven (7) pollutants in Table 22 and the 14 percent discharge flow contributed by plants E, F, and G.

Table 23 shows the results using the previously discussed dilution analysis with the hypothetical OC&P plant added at RM 41.5. At current treatment, all seven (7) pollutants are projected to exceed water quality criteria (particularly at low flow) as a result of the loading from the hypothetical plant. Table 22 showed that without this loading, only arsenic was estimated to exceed the criterion level. Projections in going to BPT treatment show that in addition to the previous potential arsenic criterion violations,

TABLE 23. IMPACT PROJECTIONS WITH A HYPOTHETICAL OC&P PLANT LOCATED ON THE KANAWHA RIVER AT RIVER MILE 41.5

Pollutant	Model treatment level	Flow condition	Exceeded EPA Criteria	River miles impacted
Arsenic	Base	Mean	HC(10^{-7})	41.5 - 48.9
		Mean	HC(10^{-6})	0 - 41.5
		Low	HC(10^{-6})	41.5 - 48.9
		Low	HC(10^{-5})	0 - 41.5
	Current	Mean	HC(10^{-7})	41.5 - 48.9
		Mean	HC(10^{-6})	11.6 - 41.5
		Mean	HC(10^{-7})	0 - 11.6
		Low	HC(10^{-6})	41.5 - 48.9
		Low	HC(10^{-5})	9.2 - 41.5
		Low	HC(10^{-6})	0 - 9.2
	BPT	Mean	HC(10^{-7})	41.5 - 48.9
		Mean	HC(10^{-6})	11.6 - 41.5
		Mean	HC(10^{-7})	0 - 11.6
	BAT	Mean	HC(10^{-7})	0 - 41.5
		Low	HC(10^{-6})	0 - 41.5
Cyanide	Base	Mean	FC	0 - 48.9
		Low	FA, FC	0 - 48.9
	Current	Low	FC	0 - 41.5
	BPT	Low	FC	0 - 41.5
Methyl chloride	Base	Low	HC(10^{-7})	0 - 48.9
Chloroform	Base	Mean	HC(10^{-7})	0 - 41.5
		Low	HC(10^{-7})	41.5 - 48.9
		Low	HC(10^{-6})	0 - 41.5
	Current	Low	HC(10^{-7})	0 - 41.5
Carbon Tetrachloride	Base	Low	HC(10^{-7})	0 - 48.9
Benzene	Base	Mean	HC(10^{-7})	0 - 41.5
		Low	HC(10^{-7})	41.5 - 48.9
		Low	HC(10^{-6})	0 - 41.5
	Current	Mean	HC(10^{-7})	0 - 41.5
		Low	HC(10^{-6})	0 - 41.5
	BPT	Low	HC(10^{-7})	0 - 41.5
2,4 Dinitrotoluene	Base	Mean	HC(10^{-7})	45.4 - 48.9
		Mean	HC(10^{-7})	0 - 41.5
		Low	HC(10^{-6})	0 - 48.9
	Current	Low	HC(10^{-7})	0 - 41.5

FC - Freshwater chronic toxicity
FA - Freshwater acute toxicity
HC - EPA water quality criterion for carcinogenicity protection from ingesting organisms at risk level given in parenthesis

estimated water quality impacts for benzene and cyanide at low flow will occur from the hypothetical pollutant loadings. The risk level associated with arsenic increases by an order of magnitude immediately downstream of the hypothetical plant. BAT effluent concentrations for this plant indicate that the impacts associated with the discharge of all pollutants except arsenic will be eliminated with compliance with the proposed BAT effluent limitations.

Pollutant Fate Analysis

The five (5) organic chemicals that exceeded EPA water quality criteria at base conditions under the two plant dilution analysis (Table 22) were modeled using the EXAMS model using site-specific and chemical-specific data to show the behavior and fate of these compounds from the point of discharge downstream to the Ohio River.

Under mean flow conditions, over 90% or more of the load of 2,4-dinitrotoluene and benzene volatilize or biodegrade before being transported out of the study area. For carbon tetrachloride, methyl chloride, and chloroform these fate processees are not as significant at mean flow. At low flow, volatilization and biodegradation account for over 95% of the fate of all of the above pollutants with five (5) percent or less being transported out of the study area.

Biological Conditions

Biological conditions have generally followed the trend seen in the chemical water quality of the Kanawha River. Severely degraded conditions occurred in the 1950's and 1960's and slow improvement in conditions occurred through the 1970's.

Over the past decade, an improvement in fish population has occurred at the Winfield Dam where the water quality conditions had been severely degraded. To evaluate the changes that have occurred, fish caught were characterized based on angler preference (Table 24). Table 25 shows the changes in the number of individual specimens caught by preference class by year. These data indicate that the quality and quantity of fish species in the area have increased since 1968. By 1976, white bass and sauger had returned to the Winfield Pool and walleye returned to the same area in 1980.

During the same sampling periods, the increase in the number of medium and high preference fish at the London Dam, where water quality has remained in the good range, was of lesser magnitude, i.e., from 56 to 97 species. The species sampled in the London Pool, between 1968 and 1973, included: black and white crappie, bass (smallmouth, Kentucky spotted and white), longear sunfish, bluegill, and muskellunge. In contrast, species that were sampled

TABLE 24

PREFERENCE CLASSES FOR FISH SPECIES SOUGHT BY FRESHWATER ANGLERS

Broad Species Group	Assigned Preference	Principal Species	Secondary Species
I. Rough fish	Low	carp freshwater drum buffalo bullhead catfish	paddlefish, smelt, fallfish, chub goldfish, American eel, goldeye, mooneye,
II. Warm water game fish-panfish	Medium	yellow perch white bass bluegill crappie rock bass pumpkinseed lake herring northern pike	white perch, warmouth orange spotted sunfish, green sunfish, longear sunfish, chain pickerel, grass pickerel
	High (warm water/ cool water)	Kentucky bass largemouth bass smallmouth bass walleye striped bass	spotted bass, sauger, muskellunge
III. Cold water game fish	High (cold water)	rainbow trout brook trout brown trout lake trout	cutthroat trout, Atlantic salmon, steelhead, Pacific salmon(s)

Source: Larry Nielsen, 1980. "Water Criteria and Angler Preference for Important Recreational Fishes." EPA Benefits Project Recreation Working Paper #3. Unpublished. (Washington, D.C., Resources for the Future).

TABLE 25

HISTORICAL FISH SAMPLING AT THE WINFIELD AND LONDON LOCKS

	1968	1969	1970	1973[1]	1976	1977	1978	1979	1980	1968-73	1976-80
Winfield Lock Assigned Preference[2]											
Low	2053	1652	1070	1049	1270	127	1270	249	392	5824	3309
Medium	0	1	6	5	3	7	38	2	9	13	110
High	0	0	0	1	3	8	17	1	22		
London Lock Assigned Preference											
Low	204	428	1445	75	814	219	2579	460	632	2152	4704
Medium	2	17	6	0	4	6	5	0	3	56	97
High	6	1	10	4	9	26	26	10	8		

[1]No data collected for 1974 and 1975

[2]Preference assigned according to Table 10.

Source: Ohio River Fish Population Data, 1968-1980, Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio in the London Pool, between 1976 and 1980, included walleye, sauger, sharpnose darter, logperch, largemouth and rock bass, trout and perch as well as those found between 1968 and 1973.

Therefore, the biological quality of the area, as indicated by the fishery data, appears to be in fairly good condition. Fishery biologists familiar with the area support this conclusion but suggest that additional reductions in pollution loads from all sources will result in further improvement in the gamefish (high preference) population. However, extrapolation to continued improvements in fish populations due to reductions in toxic pollutant loadings from the OC&P industry is difficult. As the Kanawha River is dredged for navigation, habitats available for organisms are limited. Dredging, runoff, and point sources contribute to a high suspended solids load. Consequently, light penetration is reduced, lessening the significance of rooted aquatic vegetagion, and preventing development of a diverse, high quality benthic community available for aquatic organisms. Pollutant loadings from other industrial or municipal sources may also act in limiting the growth and diversity of the fish population on the Kanawha River.

Fish Tissue Analysis

A study completed by the U.S. EPA (1981) summarized arsenic tissue levels in fish caught near Winfield downstream of Union

Carbide (Institute). These data represent conditions in 1978. Results from a STORET retrieval are presented in Table 26.

Arsenic tissue concentrations ranged from 0.05 to 0.23 mg/kg wet weight near Winfield. Reported arsenic tissue levels (U.S. EPA, 1981) in walleye (Stizostedeum vitreum) and channel catfish (Ictalurus punctatus) caught near London, upstream of the Union Carbide (Institute) plant, were 0.10 mg/kg (average) and 0.15 mg/kg (maximum), but they do not differentiate levels between the two species. Comparison of arsenic tissue levels in fish caught at the two locations suggest that downstream specimens carry higher arsenic body burdens than fish inhabiting locations upstream of the plant.

The 1981 EPA study estimated an average daily intake of arsenic through ingestion of fish equal to 0.7 ug/day and a maximum intake level of 46 ug/day. Human health impacts of these intake levels were not addressed. Other information presented by U.S. EPA (1980) indicates that these ingestion rates are well within the range of normal dietary intake values for arsenic.

TABLE 26. TISSUE ARSENIC CONCENTRATIONS IN FISH CAUGHT IN THE KANAWHA RIVER NEAR WINFIELD, WEST VIRGINIA

Species (common name)	STORET agency/station	Arsenic tissue concentration (mg/kg wet weight)
Atractosteus spatula (alligator gar)	310RWUNT/ KR320f	0.15
Catostomus commersoni (white sucker)	310RWUNT/ KR320f	0.10
	11FWS/023	0.05, 0.10
Dorosoma cepedianim (gizzard shad)	310RWUNT/ KR320f	0.23
Ictalurus natalis (yellow bullhead)	11FWS/023	0.05K

K = STORET remark code indicating analytic detection limit.

Indirect Dischargers Analysis

Introduction

To determine potential environmental impacts of indirect dischargers, seven "model" plants were analyzed. There were no actual indirect end-of-pipe pollutant data available; therefore, these model plants were assessed using calculated pollutant concentrations (average industry-wide, flow-weighted) at the raw waste level and at the PSES treatment level. For three of seven "model" plants analyzed, actual plant discharge flow, the discharge flow of the POTW to which they discharge, and the receiving stream flow under mean and low flow conditions were used. For the remaining four "model" plants, it was assumed that the discharge flow was 10, 16, 25, and 50 percent of a 5 MGD POTW with secondary treatment, and that the POTWs discharge flow is 10 percent of the receiving stream's flow.

The industry-wide concentration for raw waste and PSES were obtained by flow-weighting the concentration data available for each of the processes under study. The data and method used to calculate the industry-wide concentrations are presented in the report entitled "Summary of Priority Pollutant Loadings for the Organic Chemicals, Plastics, and Synthetics Industry."

Methodology Used to Determine Potential Impacts from Indirect Dischargers

For the indirect dischargers, the potential impacts of priority pollutants were determined using a computer model to simulate a POTW.

In the POTW computer model, background levels for the priority pollutants are assumed equal to zero. The theoretical POTW influent concentration is calculated by dividing the pollutants concentrations by the sewer dilution factor (i.e., POTW flow divided by plant flow). The theoretical POTW effluent concentration is calculated by multiplying the theoretical POTW influent concentration by the POTW pass-through value for each pollutant. The theoretical POTW effluent concentrations are then divided by the receiving stream dilution factors (i.e., stream flow divided by the POTW flow) to determine the theoretical in-stream concentrations.

To determine the potential impacts on the operation of the POTW, the theoretical POTW influent concentrations were compared to the available inhibition criteria. Pollutants were also evaluated for sludge contamination by comparing the product of the theoretical POTW influent concentration, treatment efficiency, sludge partition factor, and the sludge generation factor with available data for sludge contamination levels.

To determine the potential environmental impacts, the undiluted theoretical POTW effluent concentrations were compared to the available ambient acute water quality criteria for the protection of freshwater aquatic life. Also, the projected in-stream concentrations, based on the diluted POTW effluent concentrations, were compared to the available ambient chronic water quality criteria for the protection of freshwater aquatic life and the human health criteria for ingesting water and organisms.

Summary of Results

Table 4-1 summarizes the pollutants which exceeded the water quality criteria from the three plants for which actual flow data were available. Table 4-2 summarizes the pollutants which exceeded the water quality criteria from the four plants for which a range of representative flow data were assumed. The analysis shows that the application of PSES will reduce water quality criteria violations by between 70 and 100 percent, given the assumptions listed above.

Inhibition of the POTW treatment system by cyanide in the raw waste was projected in all seven plants, and by acrylonitrile in three plants as was sludge contamination by chromium at two plants. These projected problems were eliminated after the application of PSES.

In a review of five case studies of POTWs that receive organic chemicals discharges (including the three actual plants modeled as described above) and that are known to have experienced operating problems, there are strong indications that the organic chemical discharges are at least part of the cause of the POTW's problems. The case studies do not however, provide a clear link between specific priority pollutants and operational problems.

Table 4-1

Summary of Criteria Violations for Three Indirect Dischargers

	Based on Raw Waste Levels	Based on PSES Treatment
American Color and Chemicals Mean Flow	Chromium, S Copper, A Cyanide, I, A Benzene, H 2,4 Dimethyl phenol, A Anthracene, H Phenanthrene, H Pyrene, H Acrylonitrile, I	No violations
American Color and Chemicals Low Flow	Arsenic, H Chromium, S Copper, A Cyanide, I, A, C Dichloromethane, H Trichloromethane, H 1,2-Dichloroethane, H Benzene, H 2,4-Dimethyl phenol, A Bis(2-ethylhexyl) phthalate, C Anthracene, H Phenanthrene, H Pyrene, H Acrylonitrile, I	No violations
Monsanto Mean Flow	Cyanide, I, A	No violations
Monsanto Low Flow	Cyanide, I, A Anthracene, H	No violations

KEY: A - Exceeds Acute Aquatic Water Quality Criteria
C - Exceeds Chronic Aquatic Water Quality Criteria
H - Exceeds Human Health Water Quality Criteria for Ingesting Water and Organisms
I - Exceeds POTW inhibition concentration
S - Exceeds sludge contamination levels

Table 4-1
(Continued)

Summary of Criteria Violations for Three Indirect Dischargers

		Based on Raw Waste Levels	Based on PSES Treatment
Tenneco	Mean Flow	Cyanide, I, A Benzene, H 2,4-Dimethyl phenol, A Anthracene, H Phenanthrene, H Pyrene, H	No violations
Tenneco	Low Flow	Arsenic, H Cyanide, I, A, C Dichloromethane, H Trichloromethane, H 1,2-Dichloroethane, H Benzene, H 2,4-Dimethyl phenol, A Bis(2-ethylhexyl)phthalate, C Anthracene, H Phenanthrene, H Pyrene, H	No violations

KEY: A - Exceeds Acute Aquatic Water Quality Criteria
C - Exceeds Chronic Aquatic Water Quality Criteria
H - Exceeds Human Health Water Quality Criteria for Ingesting Water and Organisms
I - Exceeds POTW inhibition concentration
S - Exceeds sludge contamination levels

Table 4-2

Summary of Criteria Violations for Model Indirect Discharging Plants

	Based on Raw Waste Levels	Based on PSES Treatment
Model Plant for Industry SDF = 10	Arsenic, H Cyanide, I, A, C Dichloromethane, H Trichloromethane, H 1,2-Dichloroethane, H Benzene, H Anthracene, H Phenanthrene, H Pyrene, H	No Violations
Model Plant for Industry SDF = 6.25	Arsenic, H Cyanide, I, A, C Dichloromethane, H Trichloromethane, H 1,2-Dichloroethane, H Benzene, H 2,4-Dimethyl phenol, A Bis(2-ethylhexyl) phthalate, C Anthracene, H Phenanthrene, H Pyrene, H	No Violations
Model Plant for Industry SDF = 4	Arsenic, H Cyanide, I, A, C Dichloromethane, H Trichloromethane, H 1,2-Dichloroethane, H Benzene, H 2,4-Dimethyl phenol, A Bis(2-ethylhexyl) phthalate, C Anthracene, H Phenanthrene, H Pyrene, H Acrylonitrile, I	Arsenic, H

KEY:
- A - Exceeds Acute Aquatic Water Quality Criteria
- C - Exceeds Chronic Aquatic Water Quality Criteria
- H - Exceeds Human Health Water Quality Criteria for Ingesting Water and Organisms
- I - Exceeds POTW inhibition concentration
- S - Exceeds sludge contamination levels

Table 4-2
(Continued)

Summary of Criteria Violations for Model Indirect Discharging Plants

	Based on Raw Waste Levels	Based on PSES Treatment
Model Plant for Industry SDF = 2	Arsenic, H	Arsenic, H
	Chromium, S	Pyrene, H
	Copper, A	
	Cyanide, I, A, C	
	Dichloromethane, H	
	Trichloromethane, H	
	1,2-Dichloroethane, H	
	Benzene, A, H	
	2,4-Dimethyl phenol, A	
	Bis(2-ethylhexyl) phthalate, C	
	Anthracene, H	
	Phenanthrene, H	
	Pyrene, H	
	Acrylonitrile, I	

KEY: A - Exceeds Acute Aquatic Water Quality Criteria
C - Exceeds Chronic Aquatic Water Quality Criteria
H - Exceeds Human Health Water Quality Criteria for Ingesting Water and Organisms
I - Exceeds POTW inhibition concentration
S - Exceeds sludge contamination levels

Agency