WASTELOAD ALLOCATIONS FOR VOLATILE ORGANICS AND TOXICITY: PHASE I TMDLs FOR TOXIC POLLUTANTS IN THE DELAWARE RIVER ESTUARY

ESTUARY TOXICS MANAGEMENT PROGRAM
DELAWARE RIVER BASIN COMMISSION
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EXECUTIVE SUMMARY

In October 1996, the Delaware River Basin Commission adopted amendments to Articles 3 and 4 of its Water Quality Regulations regarding the control of toxic pollutants from point sources discharges to the Delaware River between Trenton, NJ and Delaware Bay (Zones 2 - 5). Section 4.30.7.B.2. of these regulations allows the Commission to establish wasteload allocations where necessary to meet the stream quality objectives for toxic pollutants. This report culminates Phase 1 of a phased Total Maximum Daily Load (TMDL) approach to controlling toxic pollutants in this section of the river. Phase 2 of this approach will focus on loadings from both point and non-point sources.

This report presents wasteload allocations for five parameters: three volatile organic chemicals (1,2 - Dichloroethane, Tetrachloroethene, and Trichloroethene), chronic toxicity and acute toxicity. These parameters were selected based upon their mass loading to the estuary, minimal interaction with estuary sediments, and the availability of a calibrated and validated water quality models that could be used to develop the wasteload allocations. 76 continuous point source discharges were considered in each of the wasteload allocation exercises, although the number of discharges included in any allocation varied from 26 to 55.

The procedure used to develop the wasteload allocations is called Equal Marginal Percent Reduction or EMPR. EMPR is a two step process in which a discharge is first considered independently of all other discharges to the estuary. In this step called Baseline Analysis, each discharge must meet stream quality objectives in and of itself. In the second step called Multiple Discharge Analysis, the cumulative impact of all discharges, discharging at the baseline loading established during step one, is evaluated against the stream quality objectives. If the analysis indicates that an objective is exceeded, then the baseline loads of all discharges significantly contributing to the violation are reduced by an equal percentage until the stream quality objective is met.

For 1,2 - Dichloroethane, 51 discharges were included in the wasteload allocation. Loadings from eleven of these discharges were adjusted in order to meet the stream quality objectives. For tetrachloroethene, 40 discharges were included in the wasteload allocation. Loadings from seven of these discharges were adjusted in order to meet the stream quality objectives. For trichloroethene, 26 discharges were included in the wasteload allocation. No reductions from initial loadings were necessary to meet the stream quality objectives for trichloroethene.

For chronic toxicity, 55 discharges were included in the wasteload allocation. Ten of the 55 discharges were reduced from their initial loading during the baseline analysis portion of the wasteload allocation. In this phase of the TMDL development, the multiple discharge analysis portion of the procedure will not be implemented so that additional data on the relationship between the concentration of specific chemicals and toxicity of both wastewater and ambient samples can be obtained. The multiple discharge analysis will be deferred until Phase 2 of the

TMDL is completed.

For acute toxicity, the ten discharges that were assigned a wasteload allocation for chronic toxicity were evaluated to determine the dilution factor at the edge of an area of mixing near the outfall structure. This factor was then used to establish a wasteload allocation for acute toxicity in toxic units. Eight of the ten discharges were reduced from their initial wasteload allocation concentration during the baseline analysis portion of the allocation. As with chronic toxicity, the multiple discharge analysis which will determine the total surface area of the estuary assigned to mixing areas will be deferred until Phase 2 of the TMDL is completed.

As specified in the Commission s regulations, wasteload allocations issued by the Executive Director will be referred to the permit-issuing agency of the signatory parties for use, as appropriate, in establishing NPDES permit limitations.

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INTRODUCTION

The term "wasteload allocation" (WLA) refers to a situation in which two or more point source discharges that are in sufficiently close proximity to one another, influence the level of treatment each must provide to comply with water quality criteria (PADER, 1987). A WLA provides a quantitative relationship between the wasteload and the achievement of an instream concentration which is represented by the respective water quality criteria. The establishment of a WLA requires a fundamental understanding of the factors affecting water quality in the receiving water in question, and the representation of the significant processes in a conceptual or mathematical model which will determine the appropriate allocation of load.

The strategy for allocating the loading of toxic pollutants to the Delaware Estuary utilizes a two phased approach based upon the concept of Total Maximum Daily Loads (TMDLs). The TMDL process considers four components: WLAs for point sources, load allocations (LAs) for non-point sources, a specified margin of safety, and a reserve capacity for future growth. Point sources are generally industrial or municipal facilities that discharge to the estuary through outfall structures (or pipes) located in or adjacent to the estuary. These sources are usually regulated through the National Pollutant Discharge Elimination System (NPDES) permits issued by state agencies. Non-point sources include stormwater runoff from urban, agricultural, and industrial areas; groundwater infiltration and runoff from Superfund sites; atmospheric deposition; combined sewer overflows (CSOs); groundwater infiltration and natural background. Some of these sources may discharge via an outfall structure and have an NPDES permit (such as a CSO, landfill or Superfund site), but are still considered non-point sources for the purposes of this strategy. The TMDL represents the maximum allowable loading of a pollutant to the estuary, and is allocated to point and non-point sources. The TMDL must also include a margin of safety to reflect scientific uncertainty. The margin of safety may be incorporated through the use of conservative design conditions. For a phased TMDL approach, the U.S. EPA recommends that the margin of safety should reflect the adequacy of the data and the degree of uncertainty about the relationship between the allocations and receiving water quality (U.S. EPA, 1991).

Phase 1 of the strategy focuses on the loading of toxic pollutants from point sources, while Phase 2 would include loadings from non-point as well as point sources. Loading from non-point sources is limited in Phase 1 to the contributions from sediments (if necessary), and the tributaries to the estuary. The loading from tributaries is set to actual data or the respective water quality criterion, whichever is lower. Sediment concentrations attributable to non-point sources can be established as the difference between actual sediment concentrations and concentrations attributable to point sources which are obtained from model simulations. In Phase 1, the water quality objective would be set to the higher of the water quality criterion for a pollutant or the background concentration of the pollutant. The latter objective is needed in order not to penalize point sources for impacts attributable to non-point sources. In Phase 1, a portion of the TMDL is not allocated to a margin of safety (i.e., the margin of safety is set to zero). The use of minimum performance standards for those discharges where effluent data is not of sufficient quality and quantity, and calibrated and validated water quality models to establish the wasteload allocations support this approach.

This report contains wasteload allocations for point sources for five parameters that are likely to exceed water quality criteria for Zones 2 to 5 of the tidal Delaware River: three volatile organic chemicals, chronic toxicity, and acute toxicity. The three volatile organic chemicals are 1,2 - Dichloroethane, Tetrachloroethene, and Trichloroethene. Chronic toxicity refers to adverse effects of the effluent as a whole resulting from exposure over an extended time, while acute toxicity refers to adverse effects of the effluent as a whole due to short-term exposure. Chronic effects include effects on growth, reproduction, survival, and behavior as well as biochemical and cellular changes. Acute effects are generally associated with, but are not limited to, lethality. Both acute and chronic toxicity consider not only the effects of the individual chemicals in the effluent, but also the interactions of the pollutants. Wasteload allocations were developed for these parameters since they are not strongly associated with sediment, and a calibrated and validated version of the far-field model of the Delaware River Estuary is available for calculating ambient concentrations (DRBC, 1999). Parameters whose transport and fate are strongly associated with sediment such as metals, PCBs, and chlorinated pesticides will require the far-field model to incorporate a sediment transport component before wasteload allocations can be developed.

Wasteload Allocation Procedure

The procedure used to establish wasteload allocations must achieve the following objectives as specified in Section 4.30.7.B.2.c.2). of the Commission s regulations:

1. Assure compliance with applicable water quality criteria;

2. Provide maximum equity, or fairness, between competing discharges; and

3. Minimize, within institutional and legal constraints, the overall cost of compliance.

The first objective is fundamental to the protection of water quality and public health, and is mandated by the federal Clean Water Act and the statutes of the basin states. The second objective is a social statement that embodies the governing principle of wasteload allocation procedures. The desirability of equity among individual (and potentially competing) members of society, especially in a regulatory program, is a reasonably well-accepted goal of society. The third objective is a statement of the desirability of economic efficiency. An effective water quality management program should attempt to achieve water quality management goals with maximum economic efficiency (i.e., least cost).

The procedure selected is the Equal Marginal Percent Reduction (EMPR) procedure. This procedure was developed by the Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management with goal of achieving the above objectives (PADER, 1987). This procedure is based on the premise that all discharges, whether they are part of a wasteload allocation scenario or not, should provide treatment of their wastewater to achieve the applicable water quality standard. In addition, some discharges must provide additional treatment due to the cumulative impact of all discharges on the receiving water body. EMPR is thus a two-step process incorporating both applicable technology-based requirements and, where necessary, water quality-based requirements.

In the first step, known as the **Baseline Analysis**, each discharge included in the wasteload allocation process is evaluated independently, as if it was the only point source discharge to the estuary. If the quality of the discharge at the initial loading results in a violation of the water quality criterion (or other policy constraints), the discharge is assigned a baseline water quality-based allocation. If the quality of the discharge at the initial loading does not cause a violation, the baseline load is set equal to the initial loading.

In the second step, **Multiple Discharge Analysis**, the cumulative impact of all discharges, discharging at the levels established during Baseline Analysis, is evaluated. If the analysis indicates the water quality criteria (or other policy constraint) will be violated, then the Baseline Discharge loads of all discharges significantly contributing to the violation are reduced by an equal percentage until the violation is eliminated.

Procedures for Carcinogen Criteria

Compliance with the stream quality objectives for carcinogens must be assessed with consideration of the duration of the criterion, the allowable frequency of exceedance, tidal hydrodynamics, and the hydrodynamics and pollutant loadings of sources. Section 3.10.3.D.5. of the regulations specifies that the duration of exposure for carcinogens is a lifetime of 70 years. The frequency of exceedance of the criteria is accounted for in the selection of the design tributary flows. Section 4.30.7.B.2.c.b). specifies the harmonic mean flow as the design tributary flow to be used for carcinogens. Average tidal conditions were selected for use in model simulations, and design effluent flows (see Section 4.30.7.A.8.) and initial pollutant loadings were calculated for each of the point sources evaluated for inclusion in a wasteload allocation exercise. Carcinogen criteria were then compared to tidally-averaged concentrations computed by the model at steady state design conditions assuming complete vertical and lateral mixing in order to assess compliance.

The following specific procedures were followed in determining wasteload allocations for carcinogen criteria for volatile organic chemicals.

Baseline Analysis

1. Identify those discharges that have effluent limitations for the parameter, or for which effluent data indicates the presence of the parameter, or that have a reasonable potential to discharge the pollutant of concern according to the requirements of Section 4.30.7.B.2.c.3).

2. For each discharge identified in step 1., establish an initial loading using the criteria contained in Section 4.30.7.B.2.c.4).b). Since the duration of the criteria is 70 years, the initial loading is assumed to represent the long-term average concentration of the parameter in the discharge. The effluent concentration of all other discharges is set to the water quality criteria for the parameter.

3. Set the loading of one discharge to its initial loading, and set the loadings of all other discharges to the water quality criteria for the parameter. Establish a pollutant concentration profile for the estuary using the mathematical model. This profile will include loadings from tributaries and the bay.

4. If the pollutant profile exceeds the applicable water quality criteria at any point, reduce the loading of the discharge until the criterion is met. This loading is the water quality-based load for the discharge.

5. For each parameter, select the more stringent of the initial loading or water quality-based load as the BASELINE DISCHARGE LOAD for that discharge.

6. Repeat steps 3 to 5 for all discharges identified in step 1.

Multiple Discharge Analysis

7. For each parameter, determine the estuary pollutant concentration profile with each discharge discharging at their respective BASELINE DISCHARGE LOAD; or, for those discharges not evaluated in the baseline analysis, a load corresponding to the applicable water quality criterion.

8. Identify (any) locations where the estuary pollutant concentration is expected to exceed the human health criterion.

9. Beginning with the location that shows the most significant violation, determine which discharges are significantly contributing to the exceedance. Make appropriate adjustments to the discharge loads of the contributing discharges.

10. Repeat steps 8 and 9 until all exceedances have been eliminated and the water quality criterion is met throughout the estuary for each parameter.

Procedures for Chronic Aquatic Life Criteria

Compliance with the stream quality objectives for the protection of aquatic life from chronic effects must be assessed with consideration of the duration of the criterion, the allowable frequency of exceedance, tidal hydrodynamics, and the hydrodynamics and pollutant loadings of sources. Section 3.10.3.C.1. of the regulations specifies that the duration of exposure for chronic stream quality objectives is 4 days. The frequency of exceedance of the criteria is accounted for in the selection of the design tributary flows. Section 4.30.7.B.2.c.b). specifies the 7Q10 flow for tributaries and a flow of 2500 cfs at Trenton for the Delaware River as the design tributary flow to be used for carcinogens. Average tidal conditions were selected for use in model simulations, and design effluent flows (see Section 4.30.7.A.8.) and initial pollutant loadings were calculated for each of the point sources evaluated for inclusion in a wasteload allocation exercise. The chronic toxicity criterion was then compared to tidally-averaged concentrations computed by the model at steady state design conditions assuming complete vertical and lateral mixing in order to assess compliance.

The following specific procedures were followed in determining wasteload allocations for aquatic life protection from chronic toxicity.

Baseline Analysis

1. Identify those discharges that have effluent limitations for the parameter, or for which effluent data indicates the presence of the parameter, or that have a reasonable potential to discharge the pollutant of concern according to the requirements of Section 4.30.7.B.2.c.3).

2. For each discharge identified in step 1., establish an initial loading using the criteria contained in Section 4.30.7.B.2.c.4).b). Since the duration of the criteria is 4 days, the initial loading is converted to a 4 day value to determine the wasteload allocation. The effluent concentration of all other discharges is set to the water quality criteria for the parameter.

3. Set the loading of one discharge to its initial loading, and set the loadings of all other discharges to the water quality criteria for the parameter. Establish a pollutant concentration profile for the

estuary using the mathematical model. This profile will include loadings from tributaries and the bay.

4. If the pollutant profile exceeds the applicable water quality criteria at any point, reduce the loading of the discharge until the criterion is met. This loading is the water quality-based load for the discharge.

5. For each parameter, select the more stringent of the initial loading or water quality-based load as the BASELINE DISCHARGE LOAD for that discharge.

6. Repeat steps 3 to 5 for all discharges identified in step 1.

Multiple Discharge Analysis (deferred to Phase 2)

7. For each parameter, determine the estuary pollutant concentration profile with each discharge discharging at their respective BASELINE DISCHARGE LOAD; or, for those discharges not evaluated in the baseline analysis, a load corresponding to the applicable water quality criterion.

8. Identify (any) locations where the estuary pollutant concentration is expected to exceed the aquatic life criterion for chronic toxicity.

9. Beginning with the location that shows the most significant violation, determine which discharges are significantly contributing to the exceedance. Make appropriate adjustments to the discharge loads of the contributing discharges.

10.Repeat steps 8 and 9 until all exceedances have been eliminated and the water quality criterion is met throughout the estuary for each parameter.

Procedures for Acute Aquatic Life Criteria

Compliance with the stream quality objectives for the protection of aquatic life from acute effects must be assessed with consideration of the duration of the criterion, the allowable frequency of exceedance, tidal hydrodynamics, and the hydrodynamics and pollutant loadings of sources. Section 3.10.3.C.1. of the Commission s water quality regulations specifies that the duration of exposure for acute stream quality objectives is 1 hour. The allowable frequency of exceedance of the criteria is usually accounted for in the selection of the design tributary flows. Section 4.30.7.B.2.c.b). specifies the 7Q10 flow for tributaries and a flow of 2500 cfs at Trenton for the Delaware River as the design tributary flow to be used for aquatic life objectives. An additional consideration regarding the frequency of exceedance in the Delaware River Estuary is the tidal frequency. In free-flowing streams and rivers, the maximum extent of the mixing area occurs at minimum flows and ambient velocities. In tidal bodies of water, however, ambient velocities are affected to a greater extent by the tides which in turn affects the extent of the mixing area. In the tidal Delaware River, maximum flood and ebb velocities of 1 meters per second alternate with near zero velocities at slack tide. Since a complete tidal cycle occurs every 12.53 hours, critical ambient velocities which generally occur near slack water may persist for substantial periods of time at a high frequency. Consequently, Section 4.20.5.A.1. of the regulations allows exceedance of acute stream quality objectives near outfall structures, but provides strict controls on the dimensions and location of these mixing areas.

The following specific procedures were followed in determining wasteload allocations for aquatic life protection from acute toxicity.

Baseline Analysis

1. Identify those discharges that have effluent limitations for acute toxicity, or for which effluent data indicates the presence of acute toxicity, or that have a reasonable potential to discharge the parameter of concern according to the requirements of Section 4.30.7.B.2.c.3).

2. For each discharge, establish reference pollutant concentration profiles using the far-field model for the estuary. For acute toxicity, this reference concentration was assumed to be the stream quality objective of 0.3 TU_a.

3. Using the tidal CORMIX model appropriate to the outfall design for each discharge, describe the wastefield (isopleths of dilution factors) for each discharge using the tidal velocities which occur in the vicinity of the discharge location over a complete tidal cycle. Use the post-processor to integrate the results of the model simulations to produce a graphical visualization and statistical summary of the mixing area over a complete tidal cycle.

4. For each discharge, determine the minimum and average dilution factors that correspond to the most stringent of the distances specified in Section 4.20.5.A.1.a.

5. Assess whether the wastefield impinges on critical habitat or exposed benthic substrate, and meets the requirements for zones of passage for free-swimming and drifting organisms (Section 4.20.5.A.1.b. - d.). Dischargers whose plumes impinge on exposed benthic habitat will have their wasteload allocations for all parameters set equal to the respective acute water quality criterion. Determine the dilution factor which corresponds to the most stringent of ecologically-based requirements.

6. For each parameter of concern, select the more stringent of the dilution factors based upon the distance or ecologically-based requirements, and determine the BASELINE DISCHARGE ALLOCATION in $TU_{a.}$

Multiple Discharge Analysis (deferred to Phase 2)

7. Determine the cumulative surface area of the estuary that is allocated acute criteria dispersion area. If the allocated areas exceed the maximum allowable total dispersion area for the estuary specified in Section 4.20.5.A.1.e., make further adjustments to the significant discharges to assure overall compliance with this requirement.

MATHEMATICAL MODELING

Far-Field Model

Given the hydrodynamic complexity of the estuary, the numerous point source discharges, and the various fate processes affecting toxic pollutants, mathematical models are needed to allocate wasteloads under the appropriate design conditions. The model selected for use in allocating wasteloads for the protection of aquatic life from chronic toxicity and the protection of human health is the Water Quality Analysis Simulation Program developed by the U.S. Environmental Protection Agency (U.S. EPA, 1988a). This model has been adapted for the tidal Delaware River between Trenton, NJ (River Mile 133.4) and the head of Delaware Bay (RM 48.2) by specifying physical, hydrodynamic and chemical characteristics for the estuary, and is called DELTOX.

The DELTOX model consists of two linked submodels, DYNHYD5 and the TOXI portion of WASP4. DYNHYD5 solves the one-dimensional equations of continuity and motion for a link-node (branching) system such as a tidal river. The Delaware River Basin Commission has developed a DYNHYD5 model for the tidal Delaware River. This model contains 94 nodes; and incorporates 11 tributaries, the headwaters of the Delaware River, the C&D Canal and a seaward boundary. The model calculates the unsteady hydrodynamics at time steps on the order of 30 seconds and averages these values over 5 minutes intervals for use by the TOXIWASP model. The DYNHYD5 model has been successfully calibrated and validated for the Delaware River Estuary (DRBC, 1995a).

The baseline analysis portion of the wasteload allocation procedure requires that each discharge be considered as if they were the only discharge to the estuary. While this can be implemented in a free-flowing river, the large withdrawals by the City of Philadelphia at Torresdale and just above the head of tide on the Schuylkill River for drinking water significantly alter the hydrodynamics in the estuary and must be included in the model simulations. Furthermore, the volume of flow contributed by industrial and municipal discharges equals the tributary inflow during low flow conditions and also affects the hydrodynamics in the estuary. Therefore, both the drinking water withdrawals and NPDES discharges were included in the hydrodynamic model simulations that were used in the baseline analyses. Since this additional flow will provide assimilation capacity, the concentration of the pollutant in the NPDES discharges was set to the applicable water quality criterion for the zone of the river receiving the discharge.

The TOXIWASP portion of the model incorporates the transport and applicable fate processes for toxic substances which may include sorption, settling, resuspension, scour, volatilization, ionization, photolysis, oxidation, hydrolysis and bacterial degradation. The specific fate processes included in the model runs is dependent on the toxic pollutant being simulated. Loadings from tributaries and the seaward boundary are included in the model, and the concentration of toxic pollutants (e.g., metals) in the river sediments can also be specified in the model.

In the case of volatile organic chemicals that are the subject of this wasteload allocation exercise, the principal fate processes incorporated in the model include volatilization, oxidation, biodegradation and hydrolysis. Since volatile organics do not sorb strongly to sediment, and modeling studies indicate that sediment interactions are not an important process affecting the fate of these chemicals, sediment interactions were not included in the model (Ambrose, 1987; DRBC, 1999). Volatilization, the movement of a chemical across the air-water interface, is the principal process affecting the fate of these chemicals. TOXIWASP calculates the volatilization rate constant (Kv) for each segment of the model using the conductivity of the chemical through the segment, the average depth of the segment, and the dissolved fraction of the chemical. Conductivity is calculated from the liquid and gas phase transfer coefficients with the liquid phase transfer coefficient computed using Covar's method (Covar, 1976). In conjunction with the ambient water temperature, the molecular weight of the chemical, Henry's Law constant for the chemical, the model calculates the loss of the chemical due to volatilization during each time step in the simulation period (Ambrose et al, 1991). The TOXIWASP model has been successfully calibrated and validated for several volatile organics for the Delaware River Estuary (DRBC, 1999).

Chronic toxicity is an indicator parameter much like biochemical oxygen demand (BOD) in that it measures the effect of all chemicals present in a wastewater discharge as well as their interactions. Indicator parameters such as BOD have long been the focus of and impetus for modeling exercises. As with specific chemicals, the data required to model chronic toxicity includes transport, loading and transformation terms. Transport is assumed to be similar to a dissolved constituent such that the model for toxicity includes only the water column component. Loading rates for toxicity at the model boundaries and point sources must be specified. Loading rates are determined by multiplying the toxicity of the source in toxic units by the flow to obtain a toxic emission rate. The units will be converted both within the model and during data interpretation to be consistent with the WASP model framework. Transformation of toxicity is implemented in the model as a generalized first order decay coefficient using the extra reaction rate available in WASP. This coefficient represents the various processes affecting the individual components contributing to the observed toxicity and their interactions. During the calibration and validation of the model for chronic toxicity, this variable was used as an tuning parameter to adjust the model predictions to the levels of chronic toxicity observed in field studies. As a result of this process, a value of 0.001/day was selected for the decay rate for toxicity (DRBC, 1999).

Near-Field Model

Regulations adopted by the Commission for protecting aquatic life from acutely toxic effects allows exceedances of the stream quality objectives for these effects in small areas near outfall structures (Section 4.20.5.A.1.). The size of these areas is limited by the water depth, the dimensions of the outfall structure, and the width of the river at the point of discharge (subsections a. and d.). In addition, these areas may not impinge on critical habitat, include exposed benthic habitats, or cumulatively exceed 5% of the total surface area of the estuary (subsections b., c. and e.). Hydrodynamically, these areas are influenced by outfall structure design, depth of the discharge, water depth at the point of discharge, the jet momentum of the discharge, the buoyancy momentum of the discharge, and the ambient velocity of the receiving stream. In the Delaware River Estuary, the latter factor is even more complex since the magnitude and direction of the ambient velocity changes significantly over a tidal cycle (12.53 hours).

The model selected for use in allocating wasteloads for the protection of aquatic life from acute toxicity is the Cornell Mixing Zone Expert System (CORMIX) (Doneker and Jirka, 1991). This system is a series of programs developed to predict the dilution and trajectory of a submerged single port discharge (CORMIX1), a multiport diffuser (CORMIX2), and a surface discharge (CORMIX3) into a stratified or uniform density environment. This modeling system, however, was developed for free-flowing riverine systems with unidirectional flow, and did not consider the reversing flows and changing water depths of tidal systems. The Commission, therefore, engaged a contractor to develop a tidal version of the CORMIX models which would consider the changes in the magnitude and direction of the ambient velocity of the receiving water, and the water depth over a tidal cycle. Furthermore, a post-processor was developed to analyze the results of the simulations and graphically display the discharge plume and calculate the dilution factors at the distances specified in the Commission s regulations.

Tidal CORMIX consists of the basic CORMIX models (Version 2.1) with the addition of a module that requests the user for specific tidal data including the tidal height range (meters), the maximum amplitude of the tidal current (meters per second), the phase difference between the maximum tidal height and the maximum tidal velocity (typically 90°), and the number of steps through the tidal cycle to evaluate the discharge (typically 24 steps, ~every 30 minutes). The model then automatically performs the number of simulation requested, varying the magnitude and direction of the ambient velocity and water depth for each simulation. The data is then stored for post-processing. The model, a user s guide, and a report describing model are available from the Commission (DRBC, 1995b).

DESIGN EFFLUENT FLOWS

Design effluent flows for each of the 37 municipal and 39 industrial discharges evaluated for inclusion in wasteload allocations were determined using the criteria specified in Section 4.30.7.A.8. This section contains specifications for establishing the effluent flows of industrial discharges (subsection a. and b.) and municipal discharges (subsection c.). Monthly average flows were obtained from the U.S. EPA s Permit Compliance System for the period January 1, 1993 to September 30, 1998. This period was sufficient to cover the five year period used to derive the design flows for industrial discharges and the three year period used to derive design flows for municipal discharges. Production-based flows were obtained, where available, from NPDES permit applications or the NPDES permitting staffs of the Delaware Department of Natural Resources & Environmental Control, New Jersey Department of Environmental Protection, and Pennsylvania Department of Environmental Protection.

The regulations provide that the production-based flow be used for industrial discharges that are covered by Effluent Limitations Guidelines promulgated by the U.S. EPA. Where such flow data is lacking, the discharge is not covered by the guidelines, or the wastewater discharge is mixed with cooling water or stormwater, the design flow is the average daily flow associated with the month having the highest monthly flow rate of the previous 12 months or, if greater, the year having the highest annual flow rate of the previous five years. Table 1 lists the flow data for each of the 39 discharges evaluated for inclusion in wasteload allocations, and indicates the design effluent flow used in the model simulations and wasteload allocations.

For municipal discharges, the regulations provide that the design flow be the higher of the average daily flow for the previous three years including a growth factor, or the capacity of the treatment plant that was used in establishing NPDES permit limitations. A default growth factor of 5% was used in selecting the design flow. Table 2 lists the flow data for each of the 37 discharges evaluated for inclusion in wasteload allocations, and indicates the design effluent flow used in the model simulations and wasteload allocations.

Table 1: Design Effluent Flows for Wasteload Allocations for Delaware River Estuary Industrial Discharges.

PERMITTEE	NPDES #	ELG FACILITY	DSN	PRODUCTION-BASED FLOW (MGD)	MAXIMUM MONTHLY FLOW - Oct 1997- Sep 1998 (MGD)	MAXIMUM ANNUAL FLOW - 1993-1997 (MGD)	EFFLUENT DESIGN FLOW (m^3/s)
STAR ENTERPRISES	DE0000256	Yes	601	NA	12.0	10.727	0.526
FORMOSA PLASTICS	DE0000612	Yes	001	0.49	0.43	0.47	0.021
KANEKA DELAWARE	DE0000647	Yes	001	NA	0.160	0.225	0.010
STANDARD CHLORINE	DE0020001	Yes	001	0.68	0.43	0.421	0.030
OCCIDENTAL CHEMICAL	DE0050911	Yes	001	NA	0.250	0.208	0.011
DUPONT - CHAMBERS WORKS	NJ0005100	Yes	009	NA	0.00	0.111	0.005
DUPONT - CHAMBERS WORKS	NJ0005100	Yes	011	NA	0.00	0.030	0.001
DUPONT - CHAMBERS WORKS	NJ0005100	Yes	013	NA	12.00	4.675	0.526
DUPONT - CHAMBERS WORKS	NJ0005100	Yes	662	47.8[b]	16.90	22.844	1.001
DUPONT-EDGEMOOR	DE0000051	Yes	001	NA	3.90	3.53	0.171
IKO MANUFACTURING	DE0050857	No	001	NA	0.01	0.003	0.0004
GENERAL CHEMICAL CORP.	DE0000655	No	001	NA	32.3	26.517	1.415
GEON	NJ0004286	Yes	001	NA	0.800	0.902	0.040
SOLUTIA	NJ0005045	Yes	001	NA	1.030	1.161	0.051
BAYWAY REFINING	PA0012637	Yes	201	NA	3.250	3.113	0.142
DEGUSSA CORP.	PA0051713	No	001	NA	0.504	0.529	0.023
SAFETY-KLEEN BRIDGEPORT	NJ0005240	No	001	NA	0.980	0.994	0.044
BOEING HELICOPTERS	PA0013323	Yes	001	NA	0.476	0.501[c]	0.022
BOEING HELICOPTERS	PA0013323	Yes	002	NA	0.082	0.095[c]	0.004
DUPONT - REPAUNO	NJ0004219	No	001	NA	8.840	14.702	0.644
AIR PRODUCTS & CHEMICALS	NJ0004278	No	001	NA	0.151	0.191	0.008
HERCULES - GIBBSTOWN	NJ0005134	Yes	001	NA	0.318	0.323	0.014
VALERO REFINING	NJ0005029	Yes	001	NA	10.407	10.155	0.456
AUSIMONT	NJ0005185	Yes	001	NA	0.701	0.661	0.031
SUN COMPANY - GIRARD POINT	PA0011533	Yes	015	NA	4.660	5.867	0.257
SUN COMPANY - BREEZE	PA0012629	Yes	002	NA	5.650	4.595	0.247
COASTAL EAGLE POINT	NJ0005401	Yes	001	NA	3.670	2.70	0.161
GEORGIA PACIFIC	NJ0004669	Yes	001	NA	0.047	0.190	0.008
ROHM & HAAS - PHILADELPHIA	PA0012777	No	001	NA	5.630	6.030	0.264
ROHM & HAAS - PHILADELPHIA	PA0012777	No	003	NA	0.640	1.012	0.044

PERMITTEE	NPDES #	ELG FACILITY	DSN	PRODUCTION-BASED FLOW (MGD)	MAXIMUM MONTHLY FLOW - Oct 1997- Sep 1998 (MGD)	MAXIMUM ANNUAL FLOW - 1993-1997 (MGD)	EFFLUENT DESIGN FLOW (m^3/s)
ROHM & HAAS - PHILADELPHIA	PA0012777	No	007	NA	0.060	0.386	0.017
HOEGANAES CORP.	NJ0004375	Yes	001	NA	0.103[d]	0.178[d]	0.008
COLORITE POLYMERS	NJ0004391	Yes	001A	NA	0.280	0.284	0.012
ROHM & HAAS - BRISTOL	PA0012769	Yes	009	1.67	1.786	1.915	0.084
USX	PA0013463	Yes	103	12.73	10.160	8.708	0.558
G.R.O.W.S.	PA0043818	No	001	NA	0.074[a]	0.067[a]	0.003
CIRCUIT FOIL USA	NJ0004332	Yes	001B	NA	0.043	0.035	0.002
PRE-FINISH METALS	PA0045021	Yes	001	0.02	0.048	0.156	0.007
RHONE-POULENC BASIC CHEMICALS	PA0011720	No	001	NA	0.022	0.017[c]	0.001

a - Recommendation by PADEP.
b - Recommendation by NJDEP.
c - Data available only from 1996.
d - Data obtained from quarterly report.
NA - Data not available.

Table 2: Design Effluent Flows for Wasteload Allocations for Delaware River Estuary Municipal Discharges.

PERMITTEE	NPDES #	DSN	GROWTH FACTOR (%)	PERMITTED CAPACITY (MGD)	1995 - 1997 AVERAGE ANNUAL FLOW (MGD)	EFFLUENT DESIGN FLOW (m^3/s)
PORT PENN STP	DE0021539	001	5%	0.05	0.03	0.002
CITY OF SALEM	NJ0024856	001	5%	1.40	0.85	0.061
DELAWARE CITY STP	DE0021555	001	5%	0.55	0.42	0.024
PENNSVILLE SEWAGE AUTHORITY	NJ0021598	001	5%	1.875	1.48	0.082
CARNEYS PT. SEWAGE AUTHORITY	NJ0021601	001	5%	1.3	0.62	0.057
CITY OF WILMINGTON	DE0020320	001	5%	90.0	93.75	4.312
PENNS GROVE SEWAGE AUTHORITY	NJ0024023	001	5%	0.75	0.60	0.033
FORT DIX/PEDRICKTOWN FACILITY	NJ0024635	001	5%	0.03	0.01	0.001
LOGAN TOWNSHIP MUA	NJ0027545	001	5%	1.0	0.53	0.044
DELCORA	PA0027103	001	5%	44.0[a]	27.09	1.927
SWEDESBORO	NJ0022021	001	5%	0.35	0.24	0.015
TINICUM TOWNSHIP	PA0028380	001	5%	1.4[a]	1.06	0.061
GREENWICH TOWNSHIP	NJ0030333	001	5%	1.0	0.60	0.044
GLOUCESTER COUNTY UA	NJ0024686	001	5%	24.1	17.97	1.056
PHILADELPHIA - SOUTHWEST STP	PA0026671	001	5%	200.0[a]	175.77	8.760
CAMDEN COUNTY MUA	NJ0026182	001	5%	80.0	56.91	3.504
PHILADELPHIA - SOUTHEAST STP	PA0026662	001	5%	112[a]	107.86	4.960
PHILADELPHIA - NORTHEAST STP	PA0026689	001	5%	210[a]	191.24	9.198
PALMYRA BOROUGH	NJ0024449	001	5%	0.79	0.48	0.035
RIVERTON BOROUGH	NJ0021610	001	5%	0.22	0.19	0.010
CINNAMINSON	NJ0024007	001	5%	2.0	1.22	0.088
DELRAN SEWAGE AUTHORITY	NJ0023507	001	5%	2.5	1.75	0.110
RIVERSIDE SEWAGE AUTHORITY	NJ0022519	001	5%	1.0	0.71	0.044
WILLINGBORO MUA	NJ0023361	001	5%	5.22	4.61	0.229
MOUNT LAUREL TOWNSHIP	NJ0025178	001A	5%	6.0	3.76	0.263
MOUNT HOLLY SEWAGE AUTHORITY	NJ0024015	001	5%	5.0	2.78	0.219
BEVERLY SEWAGE AUTHORITY	NJ0027481	001	5%	1.00	0.44	0.044
BURLINGTON TOWNSHIP	NJ0021709	001	5%	3.65	1.21	0.160
CITY OF BURLINGTON	NJ0024660	001	5%	2.70	2.34	0.118

PERMITTEE	NPDES #	DSN	GROWTH FACTOR (%)	PERMITTED CAPACITY (MGD)	1995 - 1997 AVERAGE ANNUAL FLOW (MGD)	EFFLUENT DESIGN FLOW (m^3/s)
BRISTOL TOWNSHIP	PA0026450	001	5%	2.25[a]	1.58	0.099
BRISTOL BOROUGH	PA0027294	001	5%	2.7[a]	2.10	0.118
LOWER BUCKS COUNTY JMUA	PA0026468	001	5%	10.0[a]	8.27	0.438
FLORENCE TOWNSHIP	NJ0023701	001	5%	1.5	1.02	0.066
BORDENTOWN TWNSHP (BLACKS CR.)	NJ0024678	001	5%	3.0	1.74	0.131
HAMILTON TOWNSHIP	NJ0026301	001	5%	16.0	9.59	0.701
CITY OF TRENTON	NJ0020923	001	5%	20.0	13.96	0.876
MORRISVILLE BOROUGH	PA0026701	001	5%	7.1[a]	4.39	0.311

a - Data provided by PADEP.

ASSIGNMENT OF INITIAL LOADINGS

Each of the discharges included in a wasteload allocation must be assigned an initial loading based upon the requirements of Section 4.30.7.B.2.c.4).b). The initial loading is the product of the initial concentration and the design effluent flow. This section states that the initial loading for each discharge will be based upon the following information/data in order of preference:

1. Effluent Guideline Limitations published by the U.S. Environmental Protection Agency for the point source category applicable to the discharge,

2. The average monthly limitation for the parameter in the current NPDES permit,

3. Monitoring data of sufficient quantity and quality to characterize the concentration of the parameter in the discharge, or

4. Minimum performance standards established by the Commission for industrial and municipal wastewater treatment discharges to the tidal Delaware River.

This section also provides that the coefficient of variation (CV) derived from the monitoring data or a default value of 0.6 in the absence of sufficient monitoring data shall be used to calculate the concentration used in the initial loading.

Effluent concentrations for the industrial and municipal discharges included in a wasteload allocation for any parameter were retrieved from the U.S. EPA s Permit Compliance System for the years period January 1, 1991 to September 30, 1998, and from the Commission s Toxic Substance Data Base (DRBC, 1991). Mean effluent concentration and coefficient of variation were then calculated for each discharge. In general, sufficient data was defined as a minimum of 6 measurements with the associated coefficient of variation less than or equal to 60%. Specific data quality requirements are presented in the respective discussion of the wasteload allocation for each parameter.

DESIGN TRIBUTARY FLOWS

The frequency that water quality criteria for the protection of aquatic life and human health are exceeded is determined by the hydrological processes that affect the dilution of the effluent. In the tidal river, freshwater inflow is one of the principal processes influencing the transport and fate of pollutants in effluents. The Commission s regulations specify the flow of the mainstem Delaware River and tributary flows that are to be used in establishing wasteload allocations (Section 4.30.7.B.2.c.b).). In establishing wasteload allocations for the protection of aquatic life, a flow of 2500 cfs at Trenton, NJ for the Delaware River and the 7Q10 flow for other tributaries is specified. For the protection of human health from carcinogens, the harmonic mean flow for both the Delaware River at Trenton and all tributaries is specified.

11 tributaries to the tidal Delaware River are included in the mathematical model that is used to develop wasteload allocations. Flow data from 18 gauging stations maintained by the U.S. Geological Survey were obtained for the years 1970 to 1995 in order to calculate the design flows for the mainstem Delaware River and the 11 tributaries. Two of the gages (Little Mill Creek at Elsmere, DE, and the Salem River at Woodstown, NJ) did not have a complete 25 year period of record due to termination.

A computer program developed by the U.S. EPA entitled DFLOW was used to calculate the design flow values at each gauging station (Rossman, 1990). Table 3 lists the design flows for each of the 18 gauging station and the resultant flows for each of the 11 tributaries.

Table 3: Design Freshwater Flows for the Period 1970 to 1995 for the Delaware River at Trenton and Tributaries to the Estuary.

LOCATION	7Q10		30Q5		Harmonic Mean Flow	
	CFS	CMS	CFS	CMS	CFS	CMS
Delaware River at Trenton	-	-	3236.40	91.65	7208.20	204.11
Schuylkill River at Philadelphia[1]	98.00	2.78	301.00	8.52	1236.70	35.02
Brandywine Creek at Wilmington[2]	94.78	2.68	127.28	3.60	298.63	8.46
Christina River[3]	36.13	1.02	54.51	1.54	124.27	3.52
Christina River at Coochs Bridge[2]	1.82	0.05	3.97	0.11	9.72	0.28
Little Mill Creek at Elsmere[4]	0.45	0.01	1.38	0.04	3.18	0.09
Red Clay Creek at Wooddale[2]	12.90	0.37	18.07	0.51	40.08	1.13
White Clay Creek near Newark[2]	20.96	0.59	31.09	0.88	71.29	2.02
Salem River at Woodstown[5]	1.26	0.04	4.15	0.12	9.35	0.26
Darby Creek at Waterloo Mills	1.68	0.05	2.71	0.08	5.19	0.15
Raccoon Creek	9.06	0.26	12.20	0.35	26.18	0.74
Cooper River	8.11	0.23	12.65	0.36	22.63	0.64
South Br. Pennsauken Cr. at Cherry Hill	3.38	0.10	4.98	0.14	9.13	0.26
Rancocas Creek[3]	44.96	1.27	64.66	1.83	164.83	4.67
South Br. Rancocas Creek at Vincentown[6]	8.40	0.24	14.72	0.42	46.03	1.30
North Br. Rancocas Creek at Pemberton	36.56	1.04	49.94	1.41	118.80	3.36
Neshaminy Cr.	21.07	0.60	36.31	1.03	106.57	3.02
Crosswicks Creek	22.91	0.65	34.94	0.99	81.23	2.30

[1] Values were determined by subtracting the average daily withdrawal by the City of Philadelphia (255 cfs) from the gage values. The 7Q10 value was recommended by the Pennsylvania Department of Environmental Protection.
[2] Data from 1970 to 1994.
[3] Sum of data from stations listed below.
[4] Gage terminated in 1981. Value includes data from 1970 - 1980.
[5] Gage terminated in 1989. Value includes data from 1970 - 1989.
[6] Available period of record: 1962 - 1975.

1,2 - Dichloroethane

1,2 -Dichloroethane also known as DCE is one of the chlorinated ethanes that are produced in large quantities for the production of vinyl chloride, as industrial solvents, and as intermediates in the production of other organochlorine compounds (U.S. EPA, 1980a). Based upon data collected in 1990 and 1991 by the Commission, approximately 50 kilograms per day is released to the estuary in wastewater discharges from point sources.

Identification of Permittees

A discharge is included in the wasteload allocation study if it meets one of the following criteria [Section 4:30.7.B.2.c.3)]:

1. The discharge has an existing permit limit for the parameter.
2. Effluent data indicates the presence of the parameter, or
3. The reasonable potential exists for the parameter to occur in the discharge.

If the discharge is not included in the wasteload allocation exercise, its flow will be included in the hydraulic simulations, but its loading will be set to the water quality criteria.

By reviewing the Discharge Monitoring Reports (DMR) from 1992 to September 30, 1998, the Toxic Substance Data Base, and monitoring data collected in the fall of 1992, 51 discharges were identified meeting the criteria provided above. Among them, there were eight discharges which have existing permit limits for DCE, and eighteen discharges that are covered by effluent guidelines that have DCE limitations. The identified discharges and their respective DCE concentrations are listed in Table 4 for industrial discharges and Table 5 for municipal discharges.

Assignment of Initial Loadings

Each of the 51 discharges included in the allocation was assigned an initial loading based upon Section 4.30.7.B.2.c.4).b). 18 discharges were assigned initial loadings based upon the effluent limitations guideline of 68 μg/L. 19 discharges were assigned a value of 68 μg/L (the minimum performance standard) due to insufficient or highly variable monitoring results ($N<6$ or $CV \geq 60$ %).

Wasteload Allocation Procedure

Establishing human health-based wasteload allocations is a two-step process which includes baseline and multiple discharge analyses. A one-dimensional model system WASP5, which consists of DYNHYD5 and TOXI5 models were utilized for this study, as well as, the Equal Marginal Percent Reduction (EMPR) procedure.

Hydraulic Simulations

The DYNHYD5 Model was utilized for simulating the water movement in the Delaware Estuary. The model's segmentation is comprised of two seaward boundaries, 11 tributaries, and the mainstem of the tidal Delaware River. One set of spatially-variable Manning coefficients which were determined as a result of the calibration/verification study of the DYNHYD5 Model was used for the model's input file in the wasteload allocation study. Average tidal coefficients were developed by using non-linear regression analysis on the actual tide data collected by NOAA between August 5 and September 4, 1986. The average flow at Trenton during this one month period was 6300 cfs. It was close to the harmonic mean flow of Delaware River at Trenton (7208 cfs). In addition, this period covered a complete lunar cycle (spring and neap tides). The generated tidal coefficients therefore represent average tidal conditions under the harmonic mean flows.

The design effluent flows were determined according to Section 4.30.7.A.8. The design effluent flows are listed in Tables 1 and 2, and were used by the DYNHYD5 model as constant inflows. The Commission s carcinogen water quality criteria for DCE is the most stringent. Therefore, harmonic mean flows for all tributaries were used in the model simulations. One of the output files from DYNHYD5 containing hydraulic information would be used by the TOXI5 model for water quality simulations.

Water Quality Simulations

A TOXI5 model that was previously calibrated and validated for 1,2 - Dichloroethane in the Delaware Estuary (DRBC, 1998) was utilized to establish wasteload allocations. Several parameters were determined during the calibration/verification process. The dispersion coefficients for average conditions were determined by running the model for chlorides under harmonic mean flow conditions.

A variety of methods have been proposed to compute the liquid and gas phase transfer coefficients which determine the fate of volatile organics. Several of these methods are included in TOXI5, and may be invoked through the user's selection of one of the six volatilization options. In this study, option 4 was selected. Under this option, volatilization rates in flowing systems are calculated using reaeration rates calculated from Covar's method and a gas transfer rate of 100 m/day. The input data required for option 4 are listed in Table 6. In addition to volatilization, three other fate constants (hydrolysis, biodegradation, and oxidation) were also considered. Their constant loss rates were specified as $1x10^{-8}$, $1x10^{-4}$, and $1x10^{-6}$ (day^{-1}), respectively (Ambrose, 1987). The model's calibration/verification results indicate that sediment transport does not influence the transport and the fate of DCE, because DCE does not adsorb strongly to the sediment. Therefore, sediment transport was not considered in this WLA study. The available data showed no detectable DCE in the tributaries, therefore no tributary loadings were specified. A constant temperature of 18 °C was applied for all segments.

Baseline Analysis

To ensure that the model achieved a stable condition, a 60 day simulation period was used. It was determined that the numerical stability of the model was obtained after about 40 days.

There are seventy-six continuous point source discharges to the Delaware River estuary. Fifty-one out of them are included in the 1,2-Dichloroethane wasteload allocation study. Because the model achieves numerical stability after forty days, the last four days of a sixty day simulation were averaged in both the baseline and multiple analysis portions, and compared to the applicable stream quality objective to determine if there is any water quality violation.

In the baseline analysis portion of the EMPR procedure, each discharge is evaluated as if it was the only discharge to the estuary. In this analysis, each discharger is set to its initial loading while the other discharges are set to the applicable stream quality objective for the zone in which they discharge. Since the criteria for DCE vary widely between Zones 3, 4 and 5 (0.383, 98.6 and 17.2 μg/L, respectively), ambient concentrations that exceed the criterion result when discharges are set to the applicable stream quality objective, particularly in the lower portions of Zone 3. Since the objective of using the criteria is to remove the assimilative capacity provided by the discharge flows that are included in the model, discharge concentrations were established for discharges of DCE to Zones 4 and 5 that will not result in exceedances of the water quality criterion in Zone 3. These concentrations were then used in the baseline analysis for the discharges to Zones 4 and 5 that were included in the exercise. A value of 17.3 μg/L was determined to be the appropriate concnetration for discharges to Zones 4 and 5. Discharges to Zones 2 and 3 were set to the applicable water quality criterion (0.383 μg/L).

If the discharge results in a water quality violation, the loading is reduced from the initial loading until the water quality criterion is met. Only 2 of the 51 discharges were reduced from their initial loading during the baseline analysis portion of the wasteload allocation (Table 7). The two discharges were Camden County MUA (78% reduction) and Philadelphia - NE (91% reduction) (Figures 1 and 2).

Multiple Analysis

The baseline loading of each of the 51 dischargers was used for the first run of multiple analysis. At baseline loading, water quality criterion is violated around river mile 95. To find out which zones contribute significantly to the violation, the next step was to reduce the loading of one zone at a time and keep the baseline loading of other zones unchanged. From Figures 3 - 6, it is evident that the discharges in Zone 5 don t have any significant contribution to water quality violation even though some large discharges like Dupont-Chambers Works, Star Enterprise, and City of Wilmington are in Zone 5.

Based upon this sensitivity analysis of loading reduction in different zones, eleven significant dischargers were selected for multiple analysis. In Zone 4, 85.73% of total baseline loadings are from Delcora (11.889 kg/day), Gloucester County (6.512 kg/day), Philadelphia - SW STP (1.272 kg/day), Sun Company - Point Breeze (1.527 kg/day), and Sun Company - Girard Point (1.585 kg/day). In Zone 2 and 3, 92.55% of total baseline loadings are from Camden County (4.756 kg/day), Philadelphia - NE STP (5.107 kg/day), Rohm & Hass - Philadelphia (DSN:001, 1.629 kg/day), Mount Holly Sewage Authority (1.351 kg/day), USX (3.440 kg/day), and Morrisville Borough (1.918 kg/day). By appling Equal Marginal Percent Reduction (EMPR), 58% of the baseline loading of each significant discharger was required to meet the stream quality objectives (Figure 7).

Conclusion

The wasteload allocations for 1,2 - Dichloroethane to protect human health from carcinogenic effects were established by following the procedures specified in Section 4.30.7 of the Commission s Water Quality Regulations. Fifty-one discharges were identified and evaluated in the wasteload allocation study. Philadelphia - NE STP and Camden County were the only two out of the fifty-one discharges whose initial loading was reduced by 91% and 78% respectively during the baseline analysis. The baseline load of each discharger is listed in Table 7. After the multiple analysis portion of the Equal Marginal Percent Reduction (EMPR) procedure was applied, the final multiple discharger loads for the selected discharges were established and listed in Table 7. A 58% reduction of baseline loading of each significant discharger in Zone 2,3 and 4 was required to meet the water quality criterion.

Table 4: Supporting Data for Industrial Dischargers Included in the Wasteload Allocation Study for 1,2-Dichloroethane.

PERMITTEE	NPDES #	ELG	DSN	g/L					DESIGN FLOW (m^3/s)
				G[1]	P[1]	C[1]	M[1]	Assigned Conc.	
STAR ENTERPRISES	DE0000256	Yes	601	68.00				68.00	0.526
FORMOSA PLASTICS	DE0000612	Yes	001	68.00	65.50	1.50[a] 24[b] 57.94[c]		68.00	0.021
KANEKA DELAWARE	DE0000647	Yes	001	68.00	68.00	0.30 6 34.99		68.00	0.010
STANDARD CHLORINE	DE0020001	Yes	001	68.00	180.00	1.92 26 78.68		68.00	0.030
OCCIDENTAL CHEMICAL	DE0050911	Yes	001	68.00				68.00	0.011
DUPONT - CHAMBERS WORKS	NJ0005100	Yes	662	68.00	8.75 kg/day 108.74 g/L	17.27[e] 78 119.30		68.00	1.001
DUPONT-EDGEMOOR	DE0000051		001			0.40 [d] 3 109.00	68.00	68.00	0.171
IKO MANUFACTURING	DE0050857		001			0.30 [d] 1	68.00	68.00	0.0004
GEON	NJ0000008 (NJ0004286)	Yes	001	68.00	0.19 kg/day 66.82 g/L	1.74[f] 17 48.20		68.00	0.040
BAYWAY REFINING	PA0012637	Yes	201	68.00				68.00	0.142
BOEING HELICOPTERS	PA0013323	Yes	001	68.00				68.00	0.022
BOEING HELICOPTERS	PA0013323	Yes	002	68.00				68.00	0.004
HERCULES - GIBBSTOWN	NJ0005134	Yes	001	68.00	0.18 lb/day 70.80 g/L	0.002[g] 4 35.29		68.00	0.014
AUSIMONT	NJ0005185	Yes	001	68.00		22.33 [d] 3 74.16		68.00	0.031
SUN COMPANY - POINT BREEZE	PA0012629	Yes	002	68.00				68.00	0.247
SUN COMPANY - GIRARD POINT	PA0011533	Yes	015	68.00				68.00	0.257

PERMITTEE	NPDES #	ELG	DSN	g/L					DESIGN FLOW (m^3/s)
				G[1]	P[1]	C[1]	M[1]	Assigned Conc.	
ROHM & HAAS - PHILADELPHIA	PA0012777		001			4.30 76 511.98	68.00	68.00	0.264
ROHM & HAAS - PHILADELPHIA	PA0012777		003				68.00	68.00	0.044
ROHM & HAAS - PHILADELPHIA	PA0012777		007				68.00	68.00	0.017
COLORITE POLYMERS	NJ0004391	Yes	001C	68.00	0.10 kg/day 95.04 g/L	0.48[h] 3 71.96		68.00	0.012
ROHM & HAAS - BRISTOL	PA0012769	Yes	009	68.00	68.00	0.30 80 201.12		68.00	0.084
USX	PA0013463	Yes	103	68.00				68.00	0.558
PRE-FINISH METALS	PA0045021	Yes	001	68.00				68.00	0.007

1 G: Effluent Limitations Guideline P: Monthly Permit Limit C: Average Concentration from PCS
M: Minimum Performance Standard.

a. Average Concentration.
b. Number of Observations.
c. Coefficient of Variation.
d. Toxic Substance Data base.
e. 21.259 MGD is used for calculation of concentration.
f. 0.757 MGD is used for calculation of concentration.
g. 0.312 MGD is used for calculation of concentration.
h. 0.275 MGD is used for calculation of concentration

Table 5: Supporting Data for Municipal Discharges Included in the Wasteload Allocation Study for 1,2 Dichloroethane.

PERMITTEE	NPDES #	DSN	g/L				DESIGN FLOW (m^3/s)
			P[1]	C[1]	M[1]	Assigned Conc.	
CITY OF SALEM	NJ0024856	001		1.94[a] 8[b] 40.07[c]		1.94	0.061
PENNSVILLE SEWAGE AUTHORITY	NJ0021598	001		1.42 12 33.09		1.42	0.082
CARNEYS PT. SEWAGE AUTHORITY	NJ0021601	001		1.55 10 44.20		1.55	0.057
CITY OF WILMINGTON	DE0020320	001		5.37[d] 3 84.00	68.00	68.00	4.310
PENNS GROVE SEWAGE AUTHORITY	NJ0024023	001		5.00 4 0.00	68.00	68.00	0.033
LOGAN TOWNSHIP MUA	NJ0027545	001		1.27 7 16.82		1.27	0.044
DELCORA	PA0027103	001		36.20 60 748.73	68.00	68.00	1.927
GREENWICH TOWNSHIP	NJ0030333	001		1.09 8 68.58	68.00	68.00	0.044
GLOUCESTER COUNTY UA	NJ0024686	001		16.14 19 411.02	68.00	68.00	1.056
PHILADELPHIA - SOUTHWEST STP	PA0026671	001		1.60 48 54.00		1.60	8.760
CAMDEN COUNTY MUA	NJ0026182	001		1.22 17 100.93	68.00	68.00	3.504
PHILADELPHIA - SOUTHEAST STP	PA0026662	001		1.60 49 56.05		1.60	4.960
PHILADELPHIA - NORTHEAST STP	PA0026689	001		6.90 54 298.18	68.00	68.00	9.198
PALMYRA BOROUGH	NJ0024449	001		2.72 3 74.22	68.00	68.00	0.035

PERMITTEE	NPDES #	DSN	g/L				DESIGN FLOW (m^3/s)
			P[1]	C[1]	M[1]	Assigned Conc.	
CINNAMINSON	NJ0024007	001		1.44 9 47.22		1.44	0.088
RIVERTON BOROUGH	NJ0021610	001		3.402	68.00	68.00	0.010
DELRAN SEWAGE AUTHORITY	NJ0023507	001		1.84 25 102.20	68.00	68.00	0.110
MOUNT HOLLY SA	NJ0024015	001		0.032 (mg/kg[2])	68.00	68.00	0.219
WILLINGBORO	NJ0023361	001		1.68 18 47.20		1.68	0.229
RIVERSIDE SEWAGE AUTHORITY	NJ0022519	001		1.50 5 40.82	68.00	68.00	0.044
MT. LAUREL TOWNSHIP	NJ0025178	001		2.28 20 62.36		2.28	0.263
BEVERLY SEWAGE AUTHORITY	NJ0027481	001		0.58 16 36.75		0.58	0.044
BURLINGTON TOWNSHIP	NJ0021709	001		1.43 15 61.65		1.43	0.160
FLORENCE TOWNSHIP	NJ0023701	001		1.56 16 43.52		1.56	0.066
BORDENTOWN	NJ0024678	001		0.50 16 0.00		0.50	0.137
HAMILTON TOWNSHIP	NJ0026301	001		0.83 16 60.19		0.83	0.701
MORRISVILLE BOROUGH	PA0026701	001		77.50 13 357.84	68.00	68.00	0.311
SWEDEBORO	NJ0022024	001		0.40 1	68.00	68.00	0.015

1 P: Monthly Permit Limit C: Average Concentration from PCS M: Minimum Performance Standard
a. Average Concentration.
b. Number of Observations.
c. Coefficient of Variation.
d Toxic Substance Data Base.

Table 6: Input data required for volatilization option 4.

Variable	Input Values
Water Body Type (0 = flowing; 1 = quiescent)	0
Molecular Weight of 1,2 - Dichloroethane	99.0
Volatilization Options	4
Henry's Law constant, atm-m^3/mole	0.00914
Volatilization Temperature Correction Factor	1.024

Table 7: Results of Baseline and Multiple Discharges Analysis for 1,2-Dichloroethane.

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (µg/L)
CITY OF SALEM	NJ0024856	001	0.0610	1.94	0.011	0.00	0.011	0.00	0.011	1.94
STAR ENTERPRISES	DE0000256	601	0.5260	68.00	3.242	0.00	3.242	0.00	3.242	68.00
FORMOSA PLASTICS CORP.	DE0000612	001	0.0210	68.00	0.132	0.00	0.132	0.00	0.132	68.00
KANEKA DELAWARE	DE0000647	001	0.0100	68.00	0.061	0.00	0.061	0.00	0.061	68.00
STANDARD CHLORINE	DE0020001	001	0.0300	68.00	0.184	0.00	0.184	0.00	0.184	68.00
OCCIDENTAL CHEMICAL CORP.	DE0050911	001	0.0110	68.00	0.068	0.00	0.068	0.00	0.068	68.00
DUPONT - CHAMBERS WORKS	NJ0005100	662	0.9530	68.00	5.879	0.00	5.879	0.00	5.879	68.00
PENNSVILLE SEWAGE AUTHORITY	NJ0021598	001	0.0820	1.42	0.011	0.00	0.011	0.00	0.011	1.42
CARNEYS POINT SEWAGE AUTHORITY	NJ0021601	001	0.0570	1.55	0.008	0.00	0.008	0.00	0.008	1.55
DUPONT-EDGEMOOR	DE0000051	001	0.1710	68.00	1.054	0.00	1.054	0.00	1.054	68.00
CITY OF WILMINGTON	DE0020320	001	4.3120	68.00	26.598	0.00	26.598	0.00	26.598	68.00
IKO MANUFACTURING INC.	DE0050857	001	0.0004	68.00	0.003	0.00	0.003	0.00	0.003	68.00
PENNS GROVE SEWAGE AUTHORITY	NJ0024023	001	0.0330	68.00	0.203	0.00	0.203	0.00	0.203	68.00
GEON	NJ0004286	001	0.0400	68.00	0.244	0.00	0.244	0.00	0.244	68.00
LOGAN TOWNSHIP MUA	NJ0027545	001	0.0440	1.27	0.005	0.00	0.005	0.00	0.005	1.27

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (μg/L)
BAYWAY MANUFACTURING	PA0012637	201	0.1420	68.00	0.878	0.00	0.878	0.00	0.878	68.00
DELCORA	PA0027103	001	1.9270	68.00	11.889	0.00	11.889	58.00	4.993	28.56
BOEING HELICOPTERS	PA0013323	001	0.0220	68.00	0.135	0.00	0.135	0.00	0.135	68.00
BOEING HELICOPTERS	PA0013323	002	0.0040	68.00	0.026	0.00	0.026	0.00	0.026	68.00
GREENWICH TOWNSHIP	NJ0030333	001	0.0440	68.00	0.270	0.00	0.270	0.00	0.270	68.00
HERCULES - GIBBSTOWN	NJ0005134	001	0.0140	68.00	0.087	0.00	0.087	0.00	0.087	68.00
GLOUCESTER COUNTY UA	NJ0024686	001	1.0560	68.00	6.512	0.00	6.512	58.00	2.735	28.56
AUSIMONT	NJ0005185	001	0.0310	68.00	0.189	0.00	0.189	0.00	0.189	68.00
PHILADELPHIA - SOUTHWEST STP	PA0026671	001	8.7600	1.60	1.272	0.00	1.272	58.00	0.534	0.67
SUN CO. - POINT BREEZE	PA0012629	002	0.2470	68.00	1.527	0.00	1.527	58.00	0.641	28.56
SUN CO. - GIRARD POINT	PA0011533	015	0.2570	68.00	1.585	0.00	1.585	58.00	0.666	28.56
CAMDEN COUNTY MUA	NJ0026182	001	3.5040	68.00	21.616	78.00	4.756	58.00	1.997	6.28
PHILADELPHIA - SOUTHEAST STP	PA0026662	001	4.9600	1.60	0.720	0.00	0.720	0.00	0.720	1.60
PHILADELPHIA - NORTHEAST STP	PA0026689	001	9.1980	68.00	56.742	91.00	5.107	58.00	2.145	2.57
ROHM & HAAS - PHILADELPHIA	PA0012777	007	0.0170	68.00	0.104	0.00	0.104	0.00	0.104	68.00
ROHM & HAAS - PHILADELPHIA	PA0012777	001	0.2640	68.00	1.629	0.00	1.629	58.00	0.684	28.56

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (μg/L)
ROHM & HAAS - PHILADELPHIA	PA0012777	003	0.0440	68.00	0.273	0.00	0.273	0.00	0.273	68.00
PALMYRA BOROUGH	NJ0024449	001	0.0350	68.00	0.213	0.00	0.213	0.00	0.213	68.00
CINNAMINSON	NJ0024007	001	0.0880	1.44	0.011	0.00	0.011	0.00	0.011	1.44
RIVERTON BOROUGH	NJ0021610	001	0.0100	68.00	0.059	0.00	0.059	0.00	0.059	68.00
DELRAN SEWAGE AUTHORITY	NJ0023507	001	0.1100	68.00	0.676	0.00	0.676	0.00	0.676	68.00
MOUNT HOLLY SEWAGE AUTHORITY	NJ0024015	001	0.2190	68.00	1.351	0.00	1.351	58.00	0.567	28.56
WILLINGBORO MUNICIPALITY	NJ0023361	001	0.2290	1.68	0.035	0.00	0.035	0.00	0.035	1.68
RIVERSIDE SEWAGE AUTHORITY	NJ0022519	001	0.0440	68.00	0.270	0.00	0.270	0.00	0.270	68.00
MOUNT LAUREL TOWNSHIP	NJ0025178	001	0.2630	2.28	0.054	0.00	0.054	0.00	0.054	2.28
BEVERLY SEWAGE AUTHORITY	NJ0027481	001	0.0440	0.58	0.002	0.00	0.002	0.00	0.002	0.58
BURLINGTON TOWNSHIP	NJ0021709	001	0.1600	1.43	0.021	0.00	0.021	0.00	0.021	1.43
COLORITE POLYMERS	NJ0004391	001	0.0120	68.00	0.077	0.00	0.077	0.00	0.077	68.00
ROHM & HAAS - BRISTOL	PA0012769	009	0.0840	68.00	0.517	0.00	0.517	0.00	0.517	68.00
FLORENCE TOWNSHIP	NJ0023701	001	0.0660	1.56	0.009	0.00	0.009	0.00	0.009	1.56
USX	PA0013463	103	0.5580	68.00	3.440	0.00	3.440	58.00	1.445	28.56
BORDENTOWN	NJ0024678	001	0.1310	0.50	0.006	0.00	0.006	0.00	0.006	0.50

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (µg/L)
HAMILTON TOWNSHIP	NJ0026301	001	0.7010	0.83	0.053	0.00	0.053	0.00	0.053	0.83
PRE-FINISH METALS	PA0045021	001	0.0070	68.00	0.042	0.00	0.042	0.00	0.042	68.00
MORRISVILLE BOROUGH	PA0026701	001	0.3110	68.00	1.918	0.00	1.918	58.00	0.806	28.56
SWEDESBORO	NJ0022021	001	0.0150	68.00	0.095	0.00	0.095	0.00	0.095	68.00

Figure 1 - Baseline Analysis for Camden County

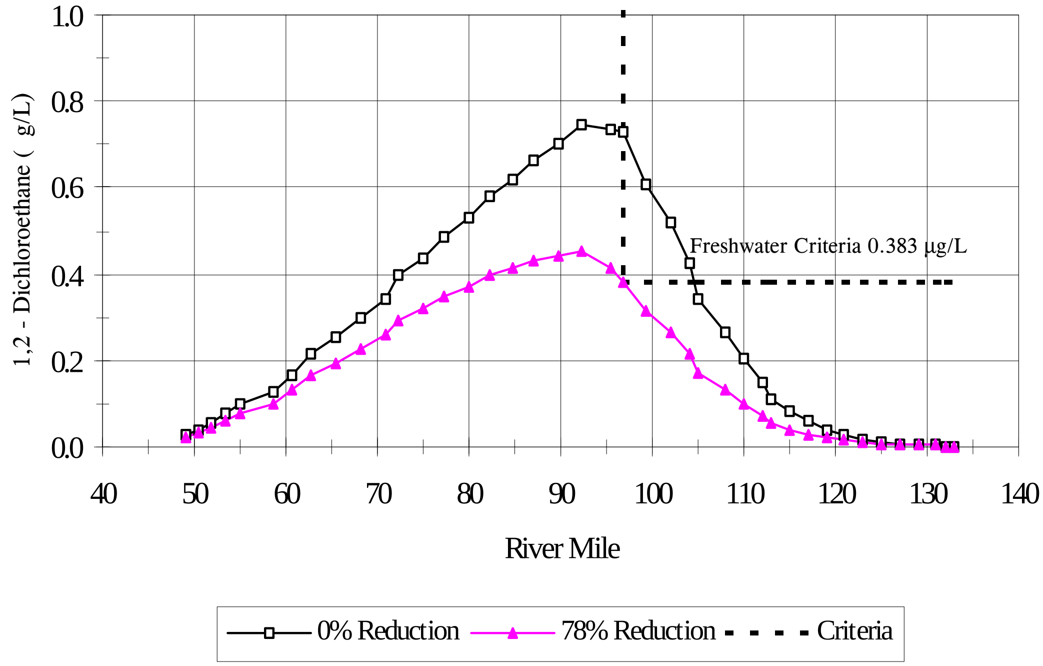


Figure 2- Baseline Analysis for Philadelphia - NE STP

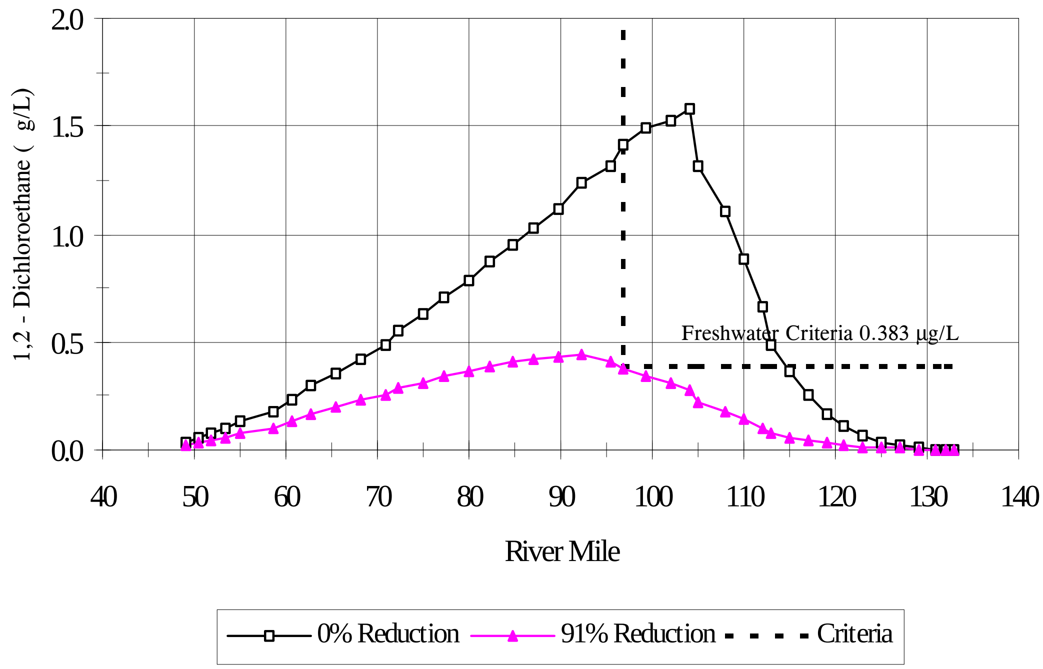


Figure 3 - Multiple Analysis - Reduction of Loading in Zone 5

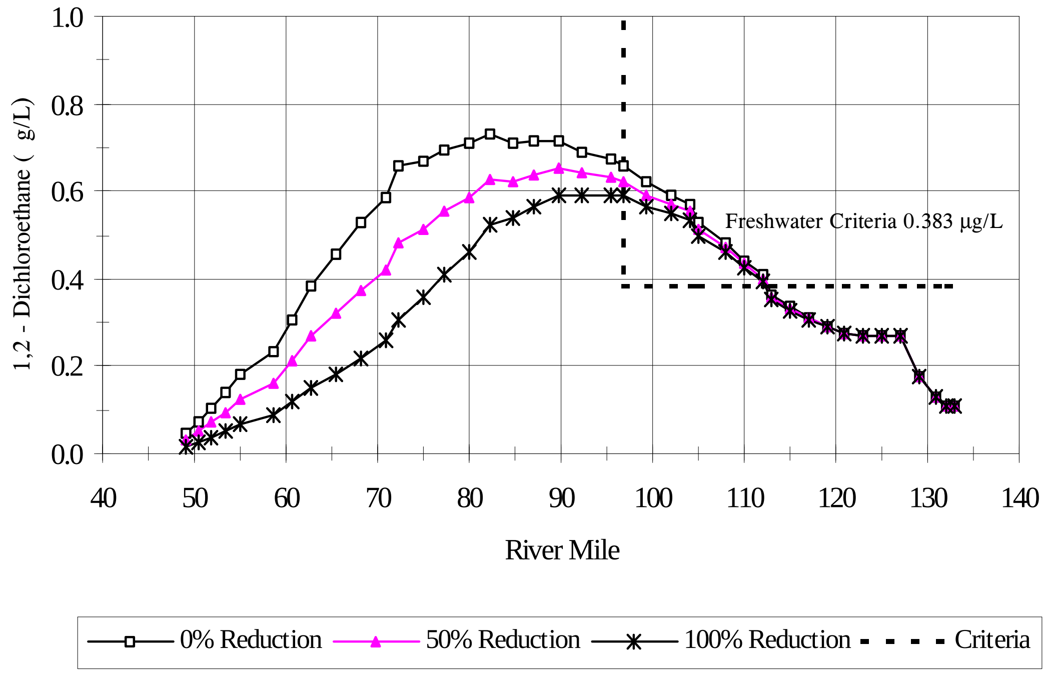


Figure 4 - Multiple Analysis - Reduction of Loading in Zone 4

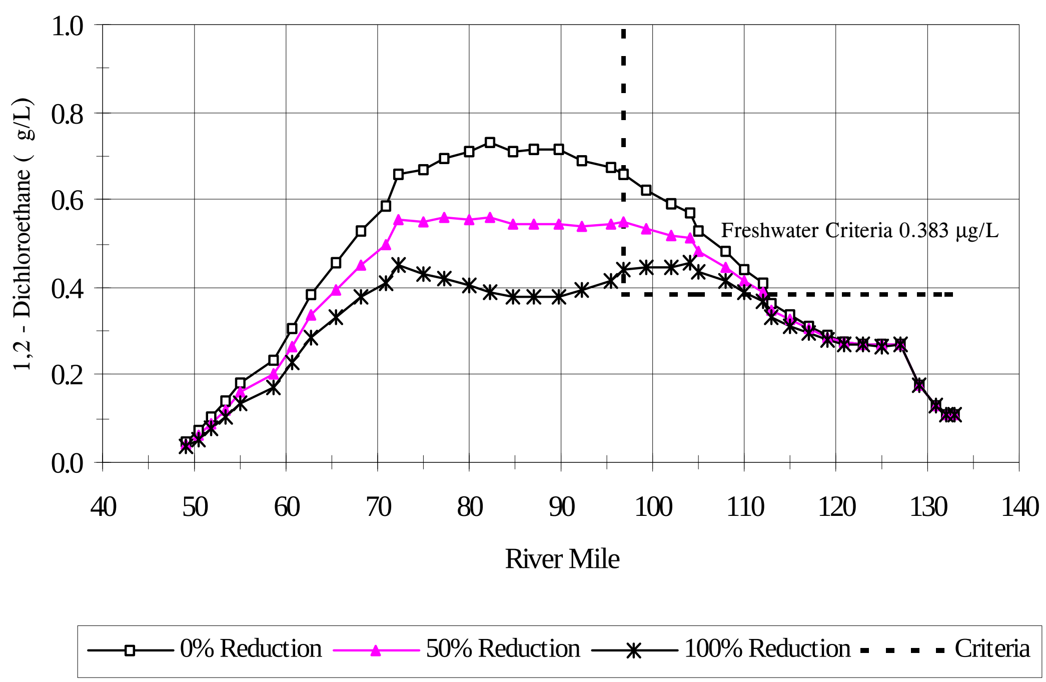


Figure 5 - Multiple Analysis - Reduction of Loading in Zone 2& 3

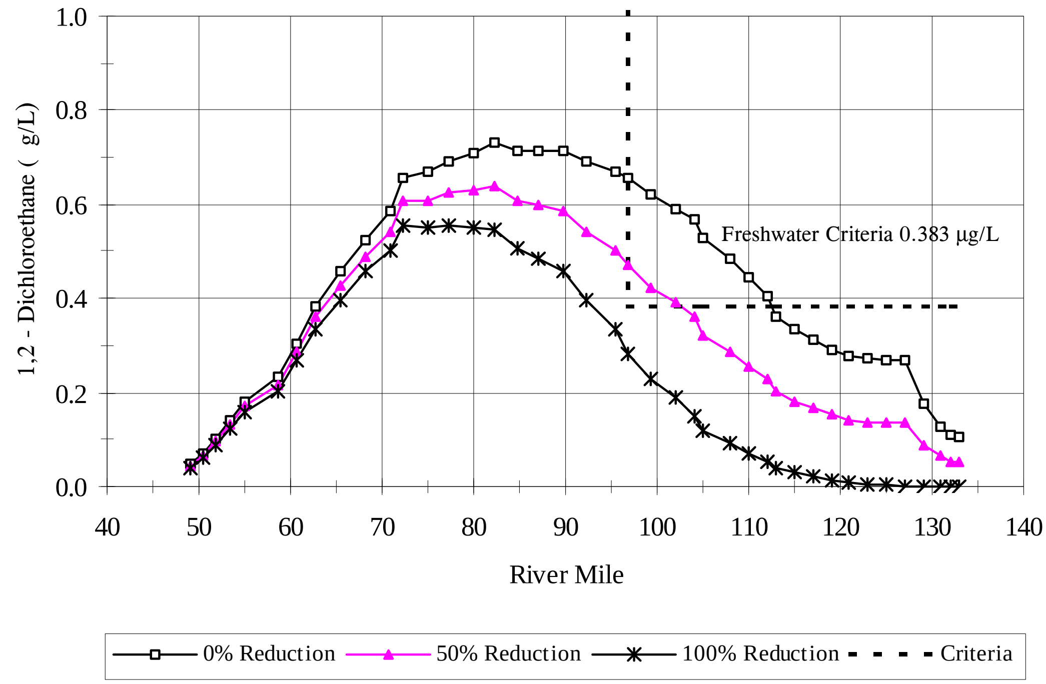


Figure 6 - Effect of Reduction of Baseline Load

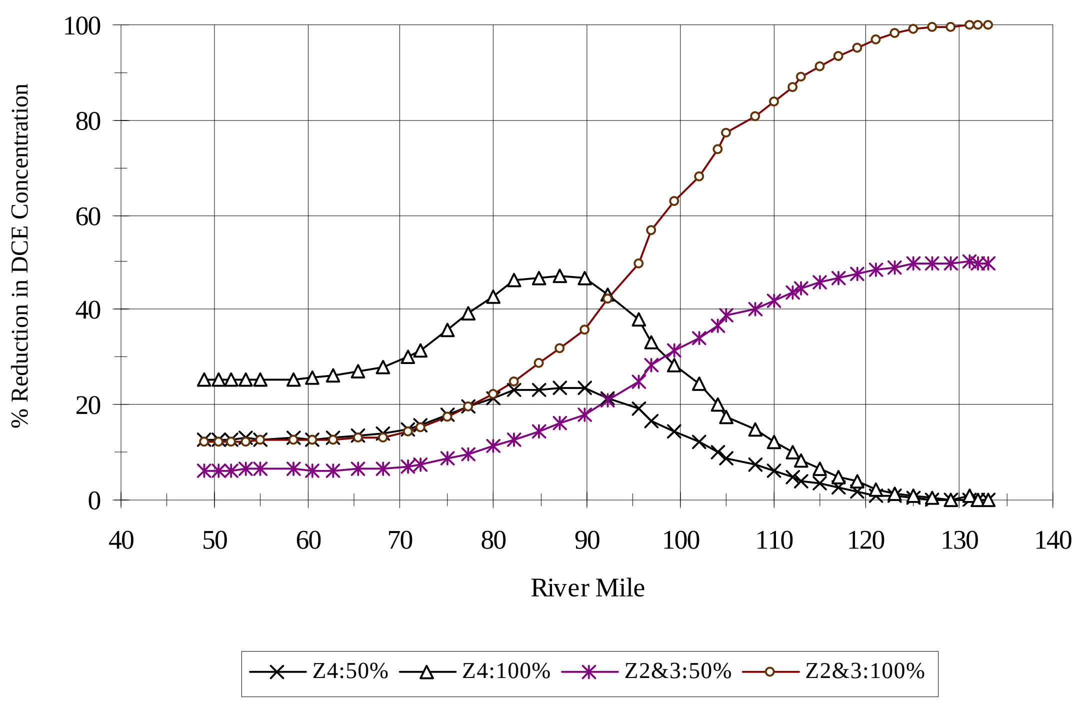
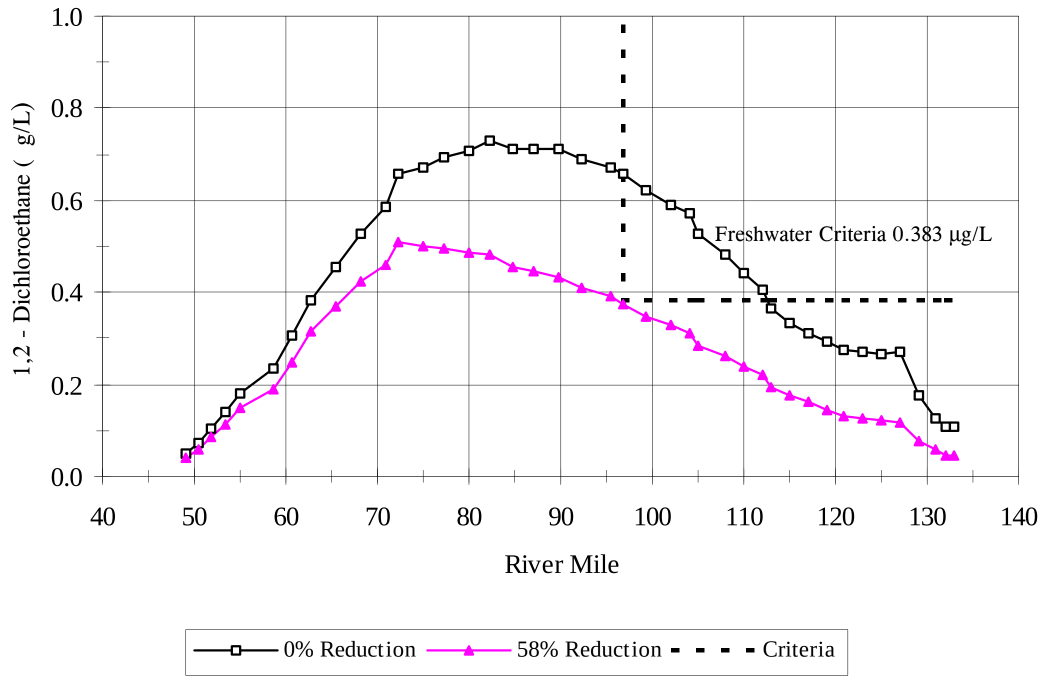


Figure 7 - Multiple Analysis - Reduction of Significant Loads



Tetrachloroethene

Tetrachloroethene, also known as perchloroethylene or PCE, is used primarily as a solvent in the dry cleaning industry, and also as an industrial solvent (U.S. EPA, 1980b). Based upon data collected in 1990 and 1991 by the Commission, approximately 34 kilograms per day is released to the estuary in wastewater discharges from point sources.

Identification of Permittees

Forty out of seventy-six discharges were identified that meet the criteria specified in Section 4:30.7.B.2.c.3) (Table 8). There were five discharges that have existing permit limits for PCE, and ten industrial discharges that are covered by effluent guidelines.

Assignment of Initial Loadings

Each of the forty discharges included in the allocation was assigned an initial loading based upon Section 4.30.7.B.2.c.4).b) (Table 8). Ten discharges were assigned initial loadings based upon the effluent limitations guideline of 22 μg/L. Seven discharges were assigned loadings based upon actual effluent data. Twenty-three discharges were assigned a value of 22 μg/l (the minimum performance standard) due to insufficient or highly variable monitoring results ($N<6$ or $CV \geq 60$ %). The loading of the discharges not included in the wasteload allocation were assigned the stream quality objectives for PCE according to its location.

Wasteload Allocation Procedure

A two-step process including baseline and multiple discharge analyses was used to establish human health-based wasteload allocations for PCE. The parameters used for hydraulic simulations were the same as those used for DCE. The DYNHYD5 model was set to simulate a 60-day run under the harmonic mean flows. The predominant transformation rate is the volatilization rate. It is calculated by the TOXI5 model for each segment throughout the simulation. The fate constants of biodegradation and oxidation were also considered in the simulations, and they were specified as $1x10^{-4}$ and $1x10^{-6}$, respectively (Ambrose, 1987). A constant temperature of 18 °C was utilized for all river segments. The TOXIWASP model parameters are listed in Table 9.

Baseline Analysis

In both the baseline and multiple analysis portions of the wasteload allocation, the last four days of a sixty day simulation are averaged and compared to the applicable stream quality objectives to check for any water quality violation.

Every discharge included in the wasteload allocation study has its own baseline analysis in which the loading listed in Table 8 is assigned to the discharge and the other discharges are set to the stream quality objective according to its location. For example, in the baseline analysis of Philadelphia - NE STP, the concentration used in calculating this discharge s loading is 22.0 μg/l (Table 8), 1.55 μg/l is assigned to the discharges located in Zone 5 below RM 68.75, 8.85 μg/L is assigned to the discharges located in Zone 5 above RM 68.75 and in Zone 4, and 0.8 μg/L is assigned to the discharges located in Zones 2 and 3. If there is water quality violation, the loading of the individual discharge is reduced until no violation

occurs.
Table 10 list the results of the baseline analysis. Only 1 of the 39 discharges (Hamilton Township) was reduced from its initial loading (40% reduction) during this portion of the wasteload allocation (Figure 14).

Multiple Analysis

The baseline loading of each of the 40 discharges was used for the first run of the multiple discharge analysis. With the discharges set at baseline loading, the stream quality objective is violated in lower Zone 3 between river miles 95 and 105 (Figure 15). To find out which zones contributes significantly to the violation, the next step was to reduce the loading of one zone at a time and keep the baseline loading of other zones constant. From Figures 15 - 18, it is evident that only the discharges in Zones 2 & 3 significantly contribute to the water quality violation. Seven significant discharges to Zones 2 and 3 were selected for the multiple analysis: Camden County (6.993 kg/day), Philadelphia - SE (0.945 kg/day), Philadelphia - NE (18.358 kg/day), Lower Bucks County JMUA (0.874 kg/day), USX (1.113 kg/day), Hamilton Township (0.839 kg/day), and Morrisville Borough (0.621 kg/day). A 45% reduction of each of the seven discharges is required to meet the stream quality objective. The loading of each discharger resulting from the multiple analysis is listed in Table 10.

Conclusions

The wasteload allocations for Tetrachloroethene to protect human health from carcinogenic effects are established by following the procedures specified in Section 4.30.7 of the Commission s Water Quality Regulations. Forty discharges were identified and evaluated in the wasteload allocation study. Hamilton Township was the only discharger whose loading was reduced by 40% during the baseline analysis. An additional reduction of 45% was required of seven significant discharges located in Zones 2 and 3 in order to meet the stream quality objective.

Table 8: Supporting Data for Dischargers Included in the Wasteload Allocation Study for Tetrachloroethene.

PERMITTEE	NPDES #	ELG	DSN	g/L					DESIGN FLOW (m^3/s)
				G[1]	P[1]	C[1]	M[1]	Assigned Conc.	
CITY of SALEM	NJ0024856		001			2.01[a] 8[b] 77.68[c]	22.00	22.00	0.061
FORMOSA PLASTICS CORP.	DE0000612	Yes	001	22.00	20.10	0.85 7 28.46		22.00	0.021
KANEKA DELAWARE	DE0000647	Yes	001	22.00	22.00	0.60 6 28.06		22.00	0.012
STANDARD CHLORINE	DE0020001	Yes	001	22.00	22.00	1.93 26 91.09		22.00	0.030
DUPONT-CHAMBER WORKS	NJ0005100	Yes	662	22.00		0.094[f] 63 144.28		22.00	1.001
PENNSVILLE SEWERAGE AUTHORITY	NJ0021598		001			1.667 12 61.79		1.67	0.082
CARNEYS PT. SEWAGE AUTHORITY	NJ0021601		001			1.50 10 70.27	22.00	22.00	0.057
CITY OF WILMINGTON	DE0020320		001			0.13[d] 3	22.00	22.00	4.310
PENNS GROVE SEWERAGE AUTHORITY	NJ0024023		001			6.84 5 111.37	22.00	22.00	0.033
GEON	NJ0000008 (NJ0004286)	Yes	001	22.00	0.062 kg/day	0.0044[f] 17 58.06		22.00	0.040
LOGAN TOWNSHIP MUA	NJ0027545		001			1.285 7 37.95		1.29	0.044
DUPONT-REPAUNO	NJ0004219		001			1.40[e] 3	22.00	22.00	0.644
GREENWICH TOWNSHIP	NJ0030333		001			1.209 8 37.24		1.21	0.044
HERCULES-GIBBSTOWN	NJ0005134	Yes	001	22.00	0.059 lb/day	0.0013 4 23.09		22.00	0.014
GLOUCESTER COUNTY UTILITIES AUTHORITY	NJ0024686		001			1.334 19 47.67		1.33	1.056
AUSIMONT	NJ0005185	Yes	001	22.00		1.31 2 4.31		22.00	0.031
PHILADELPHIA - SW	PA0026671		001			9.70 52 388.56	22.00	22.00	8.760

PERMITTEE	NPDES #	ELG	DSN	g/L					DESIGN FLOW (m^3/s)
				G[1]	P[1]	C[1]	M[1]	Assigned Conc.	
CAMDEN COUNTY M.U.A.	NJ0026182		001			1.51 17 75.34	22.00	22.00	3.504
PHILADELPHIA - SE	PA0026662		001			2.10 53 59.00		2.10	5.241
PHILADELPHIA - NE	PA0026689		001			3.50 48 156.42	22.00	22.00	9.198
PALMYRA BOROUGH	NJ0024449		001			2.58 3 82.31	22.00	22.00	0.035
CINNAMINSON	NJ0024007		001			1.667 9 94.87	22.00	22.00	0.088
RIVERTON BOROUGH	NJ0021610		001			0.5 2	22.00	22.00	0.010
DELRAN SEWERAGE AUTHORITY	NJ0023507		001			1.35 26 90.47	22.00	22.00	0.110
MOUNT HOLLY SEWAGE AUTHORITY	NJ0024015		001			0.013 13 148.52	22.00	22.00	0.219
WILLINGBORO MUN.	NJ0023361		001			0.45 5 24.85	22.00	22.00	0.229
RIVERSIDE STP	NJ0022519		001			1.70 5 64.44	22.00	22.00	0.044
MT. LAUREL TOWNSHIP	NJ0025178		001			2.73 21 72.50	22.00	22.00	0.263
BEVERLY SEWERAGE AUTHORITY	NJ0027481		001			0.491 16 7.64		0.49	0.044
BURLINGTON TWP	NJ0021709		001			1.03 15 88.59	22.00	22.00	0.160
COLORITE POLYMERS COMPANY	NJ0004391	Yes	001	22.00		0.0002[f] 3		22.00	0.012
ROHM & HAAS-BRISTOL	PA0012769	Yes	009	22.00		0.33 81 195.14		22.00	0.084
LOWER BUCKS COUNTY JMUA	PA0026468		001			600.00	22.00	22.00	0.438
FLORENCE TOWNSHIP	NJ0023701		001			1.50 16 68.85	22.00	22.00	0.066
USX	PA0013463	Yes	403	22.00		0.2 1		22.00	0.558

PERMITTEE	NPDES #	ELG	DSN	g/L					DESIGN FLOW (m^3/s)
				G[1]	P[1]	C[1]	M[1]	Assigned Conc.	
BORDENTOWN	NJ0024678		001			0.67 16 83.12	22.00	22.00	0.131
HAMILTON TOWNSHIP	NJ0026301		001			2.86 16 300.59	22.00	22.00	0.701
CITY OF TRENTON	NJ0020923		001			0.563 16 57.38		0.56	0.876
MORRISVILLE BORO	PA0026701		001			0.118 13 353.38	22.00	22.00	0.311
SWEDEBORO	NJ0022024		001			1.10 1	22.00	22.00	0.015

1 G: Effluent Limitations Guideline P: Monthly Permit Limit C: Average Concentration from PCS
M: Minimum Performance Standard.

a. Average Concentration.
b. Number of Points.
c. Coefficient of Variation.
d. DRBC Monitoring Program data (µg/L) collected in September and October 1992.
e. Toxic Substance Data Base.
f. kg/day.

Table 9: Input data required for volatilization option 4.

Variable	Input Values
Water Body Type (0 = flowing; 1 = quiescent)	0
Molecular Weight of Tetrachloroethene	165.8
Volatilization Options	4
Henry's Law constant, atm-m^3/mole	0.0153
Volatilization Temperature Correction Factor	1.024

Table 10: Wasteload Allocations for Tetrachloroethene for Delaware River Estuary Discharges.

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (μg/L)
CITY OF SALEM	NJ0024856	001	0.06132	22.00	0.122	0.00	0.122	0.00	0.122	22.00
FORMOSA PLASTICS CORP.	DE0000612	001	0.02146	22.00	0.043	0.00	0.043	0.00	0.043	22.00
KANEKA DELAWARE	DE0000647	001	0.00986	22.00	0.020	0.00	0.020	0.00	0.020	22.00
STANDARD CHLORINE	DE0020001	001	0.02978	22.00	0.059	0.00	0.059	0.00	0.059	22.00
DUPONT - CHAMBERS WORKS	NJ0005100	662	0.95292	22.00	1.902	0.00	1.902	0.00	1.902	22.00
PENNSVILLE SEWAGE AUTHORITY	NJ0021598	001	0.08213	1.67	0.012	0.00	0.012	0.00	0.012	1.67
CARNEYS POINT SEWAGE AUTHORITY	NJ0021601	001	0.05694	22.00	0.114	0.00	0.114	0.00	0.114	22.00
CITY OF WILMINGTON	DE0020320	001	4.31156	22.00	8.605	0.00	8.605	0.00	8.605	22.00
PENNS GROVE SEWAGE AUTHORITY	NJ0024023	001	0.03285	22.00	0.066	0.00	0.066	0.00	0.066	22.00
GEON	NJ0004286	001	0.03951	22.00	0.079	0.00	0.079	0.00	0.079	22.00
LOGAN TOWNSHIP MUA	NJ0027545	001	0.04380	1.29	0.005	0.00	0.005	0.00	0.005	1.29
DUPONT - REPAUNO	NJ0004219	001	0.64395	22.00	1.285	0.00	1.285	0.00	1.285	22.00
GREENWICH TOWNSHIP	NJ0030333	001	0.04380	1.21	0.005	0.00	0.005	0.00	0.005	1.21
HERCULES - GIBBSTOWN	NJ0005134	001	0.01415	22.00	0.028	0.00	0.028	0.00	0.028	22.00

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (μg/L)
GLOUCESTER COUNTY UA	NJ0024686	001	1.05558	1.33	0.127	0.00	0.127	0.00	0.127	1.33
AUSIMONT	NJ0005185	001	0.03070	22.00	0.061	0.00	0.061	0.00	0.061	22.00
PHILADELPHIA - SOUTHWEST STP	PA0026671	001	8.76000	22.00	17.484	0.00	17.484	0.00	17.484	22.00
CAMDEN COUNTY MUA	NJ0026182	001	3.50400	22.00	6.993	0.00	6.993	45.00	3.846	12.10
PHILADELPHIA - SOUTHEAST STP	PA0026662	001	4.96048	2.10	0.945	0.00	0.945	45.00	0.520	1.16
PHILADELPHIA - NORTHEAST STP	PA0026689	001	9.19800	22.00	18.358	0.00	18.358	45.00	10.097	12.10
PALMYRA BOROUGH	NJ0024449	001	0.03460	22.00	0.069	0.00	0.069	0.00	0.069	22.00
CINNAMINSON	NJ0024007	001	0.08760	22.00	0.175	0.00	0.175	0.00	0.175	22.00
RIVERTON BOROUGH	NJ0021610	001	0.00964	22.00	0.019	0.00	0.019	0.00	0.019	22.00
DELRAN SEWAGE AUTHORITY	NJ0023507	001	0.10950	22.00	0.219	0.00	0.219	0.00	0.219	22.00
MOUNT HOLLY SEWAGE AUTHORITY	NJ0024015	001	0.21900	22.00	0.437	0.00	0.437	0.00	0.437	22.00
WILLINGBORO	NJ0023361	001	0.22864	22.00	0.456	0.00	0.456	0.00	0.456	22.00
RIVERSIDE SEWAGE AUTHORITY	NJ0022519	001	0.04380	22.00	0.087	0.00	0.087	0.00	0.087	22.00
MOUNT LAUREL TOWNSHIP	NJ0025178	001	0.26280	22.00	0.525	0.00	0.525	0.00	0.525	22.00

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (μg/L)
BEVERLY SEWAGE AUTHORITY	NJ0027481	001	0.04380	0.49	0.002	0.00	0.002	0.00	0.002	0.49
BURLINGTON TOWNSHIP	NJ0021709	001	0.15987	22.00	0.319	0.00	0.319	0.00	0.319	22.00
COLORITE POLYMERS	NJ0004391	001	0.01244	22.00	0.025	0.00	0.025	0.00	0.025	22.00
ROHM & HAAS - BRISTOL	PA0012769	009	0.08388	22.00	0.167	0.00	0.167	0.00	0.167	22.00
FLORENCE TOWNSHIP	NJ0023701	001	0.06570	22.00	0.131	0.00	0.131	0.00	0.131	22.00
LOWER BUCKS COUNTY JMUA	PA0026468	001	0.43800	22.00	0.874	0.00	0.874	45.00	0.481	12.10
USX	PA0013463	103	0.55757	22.00	1.113	0.00	1.113	45.00	0.612	12.10
BORDENTOWN	NJ0024678	001	0.13140	22.00	0.262	0.00	0.262	0.00	0.262	22.00
HAMILTON TOWNSHIP	NJ0026301	001	0.70080	22.00	1.399	40.00	0.839	45.00	0.462	7.26
CITY OF TRENTON	NJ0020923	001	0.876	0.56	0.045	0.00	0.045	0.00	0.045	0.56
MORRISVILLE BOROUGH	PA0026701	001	0.31098	22.00	0.621	0.00	0.621	45.00	0.341	12.10
SWEDESBORO	NJ0022021	001	0.01533	22.00	0.031	0.00	0.031	0.00	0.031	22.00

Figure 8 - Baseline Analysis for DuPont-Chambers Works

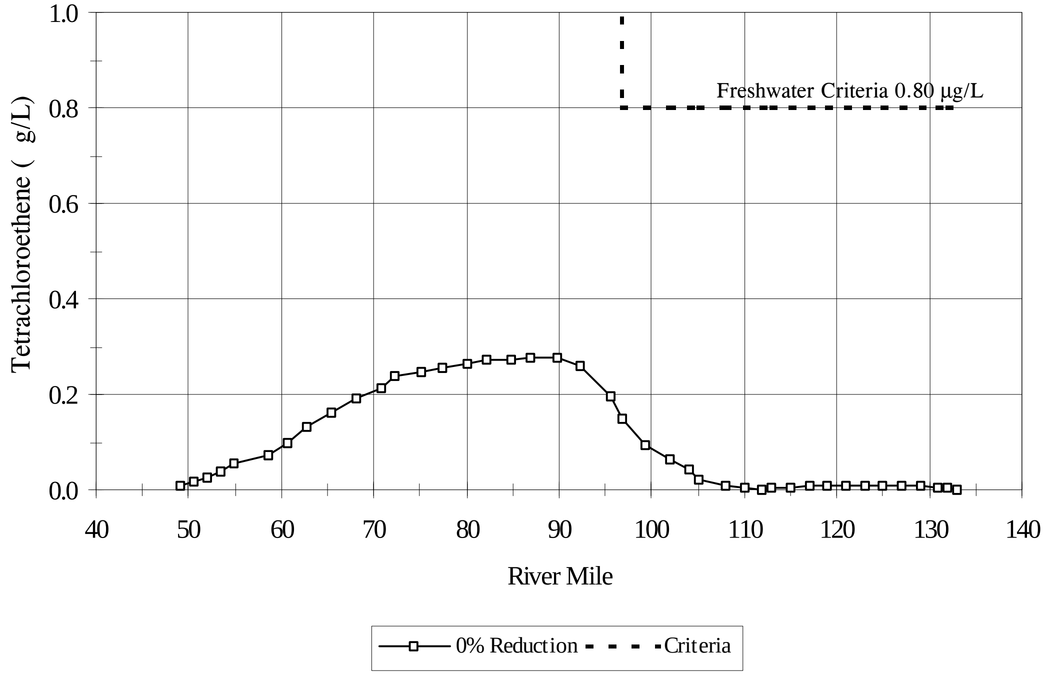


Figure 9 - Baseline Analysis for City of Wilmington

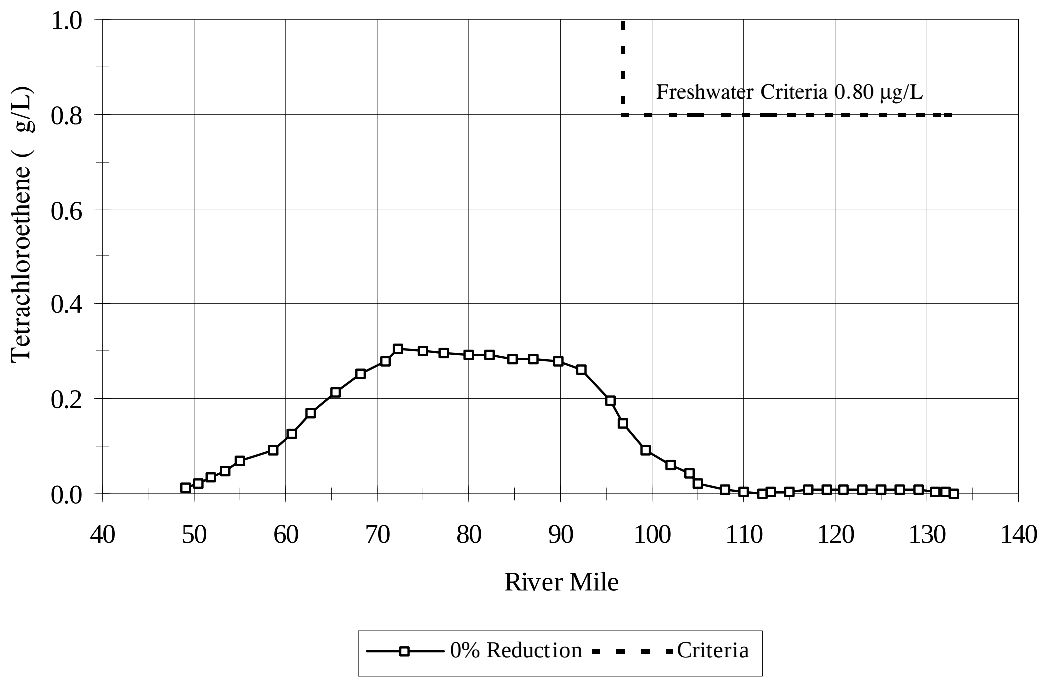


Figure 10 - Baseline Analysis for DuPont - Repauno

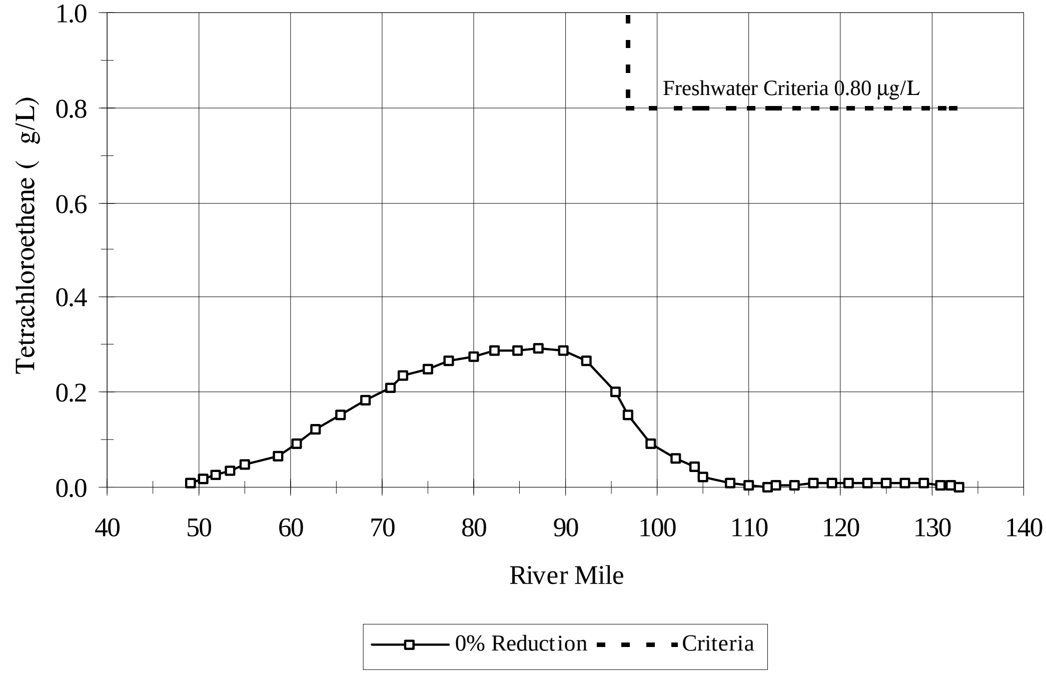


Figure 11 - Baseline Analysis for Philadelphia - SW

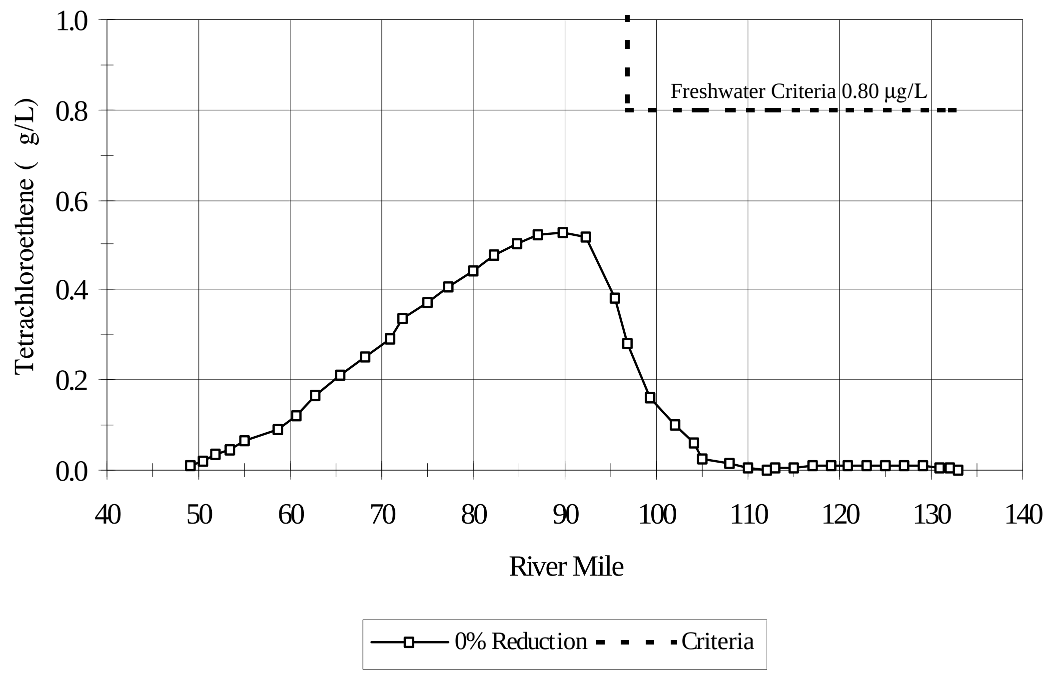


Figure 12 - Baseline Analysis for Philadelphia - NE

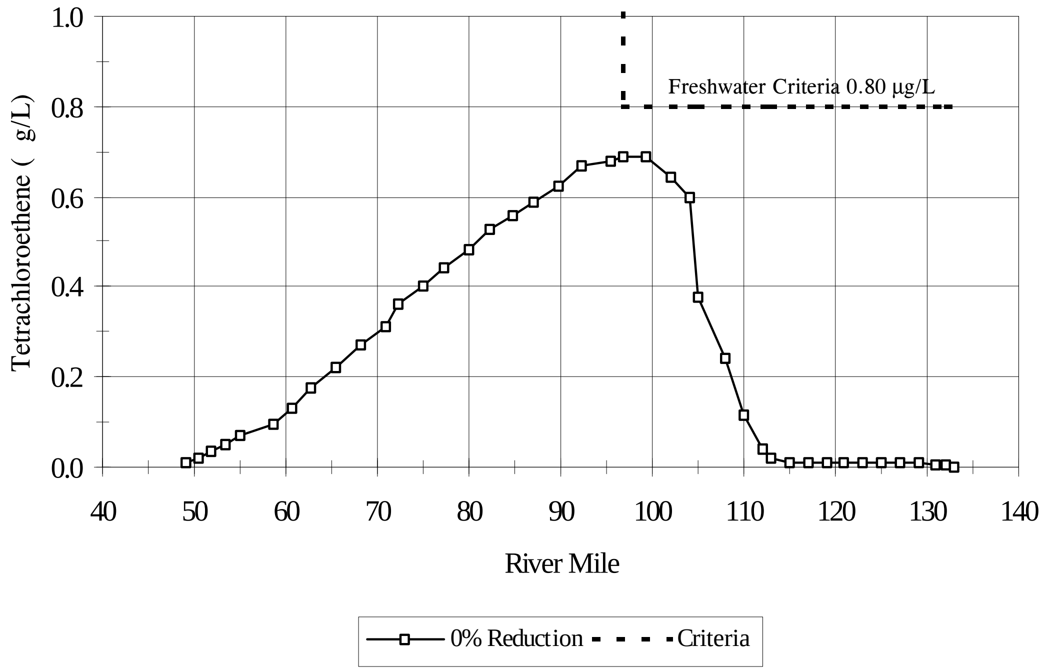


Figure 13 - Baseline Analysis for USX

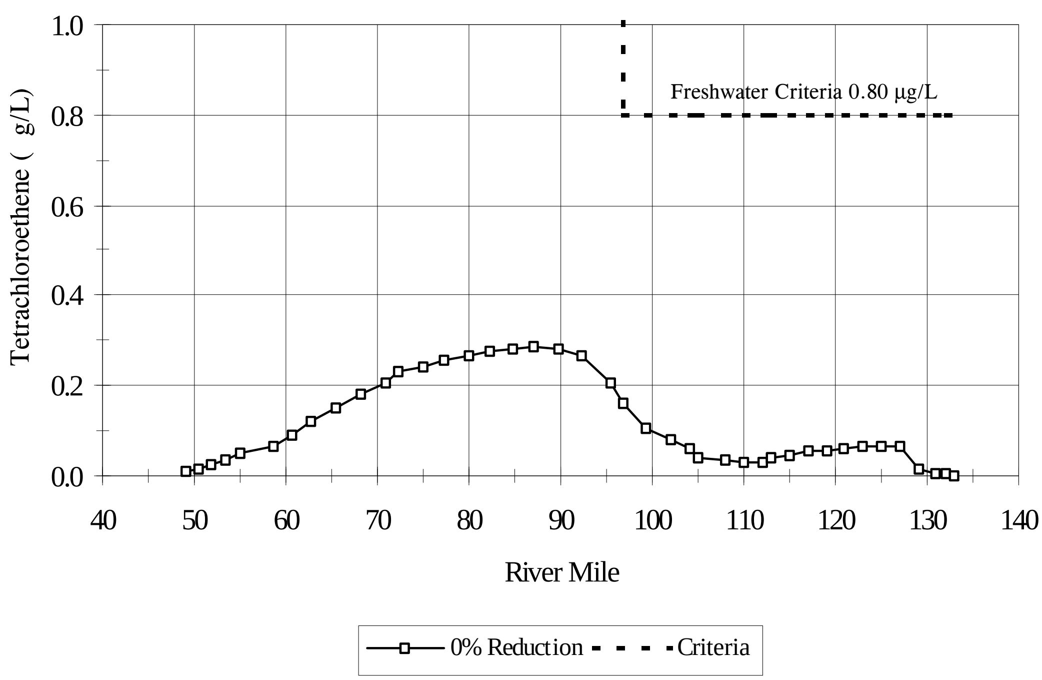


Figure 14 - Baseline Analysis for Hamilton Township

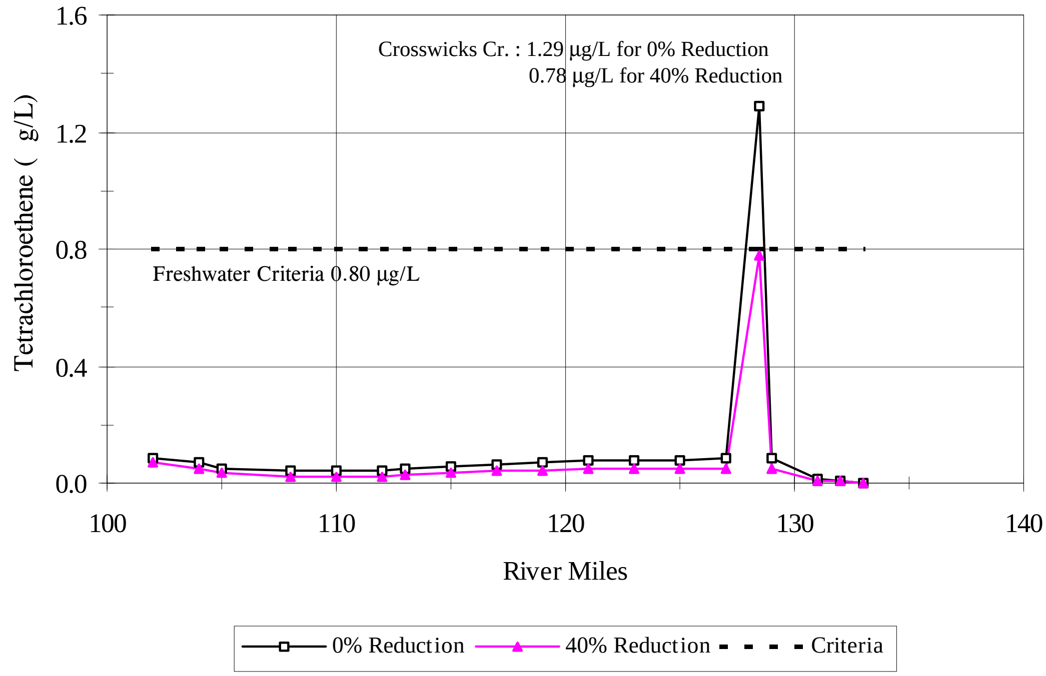


Figure 15 - Multiple Analysis - Reduction of Loading in Zone 5

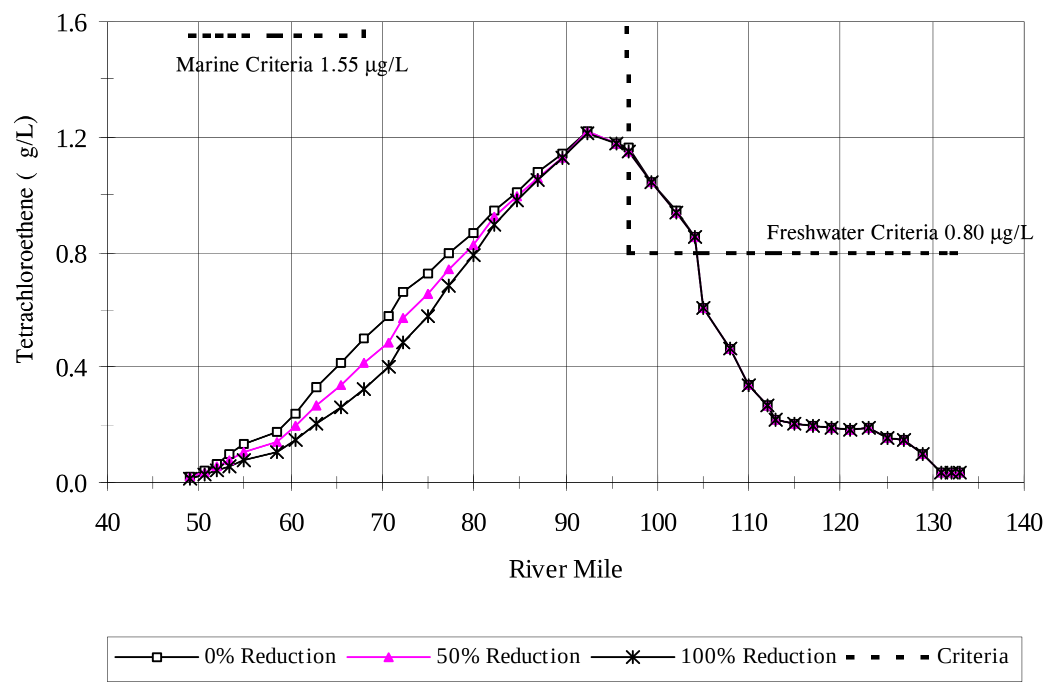


Figure 16 - Multiple Analysis - Reduction of Loading in Zone 4

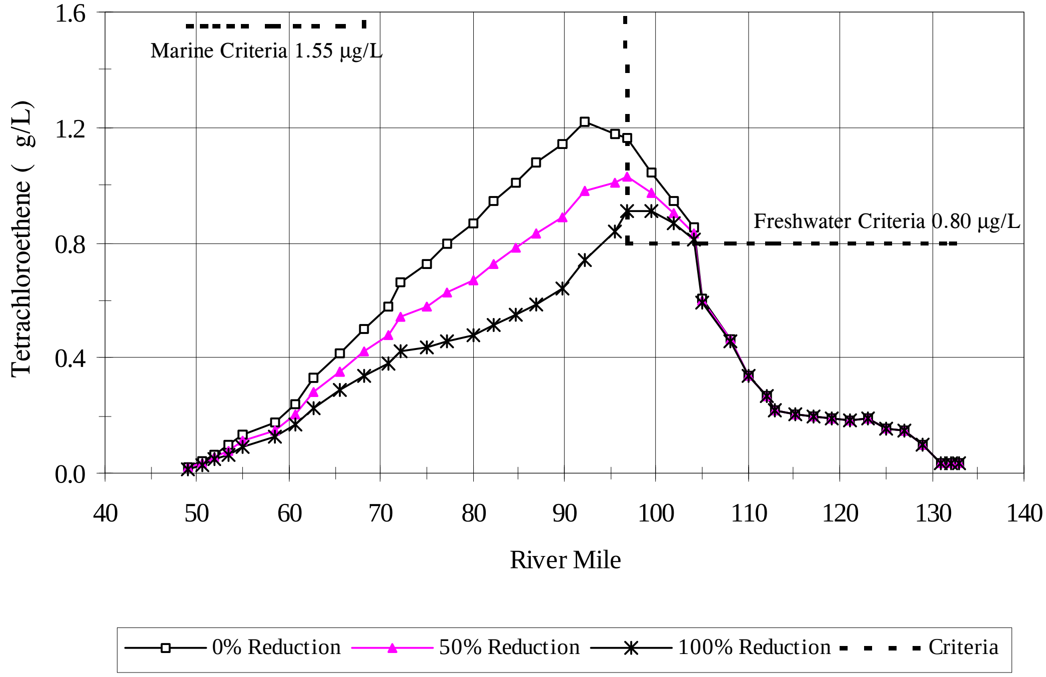


Figure 17 - Multiple Analysis - Reduction of Loading in Zone 2&3

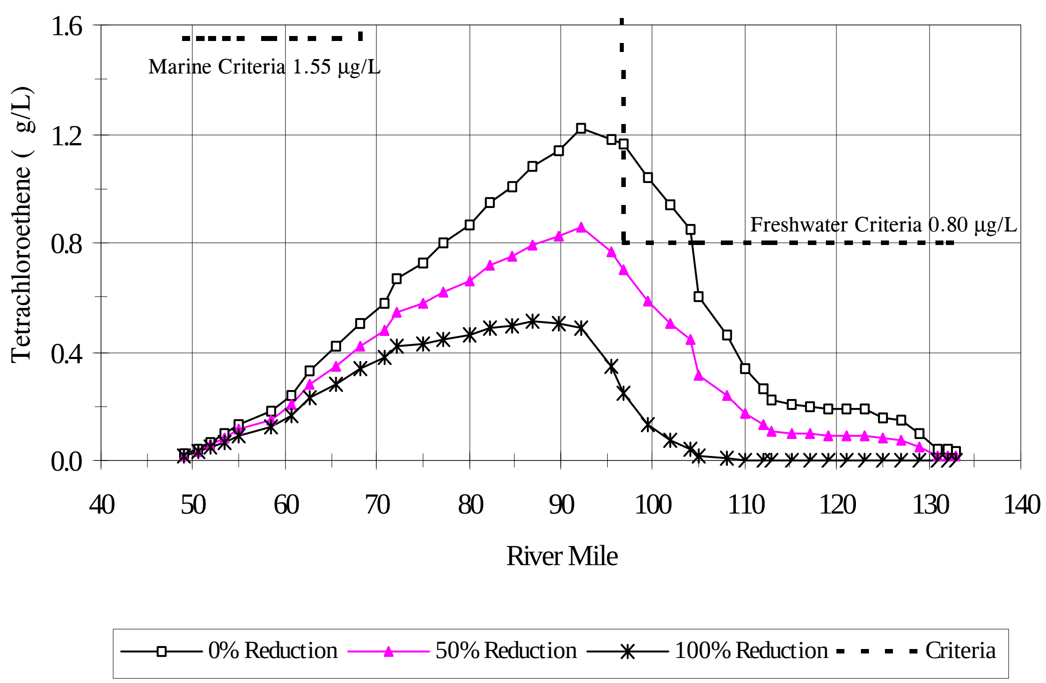


Figure 18 - Effect of Reduction of Baseline Load

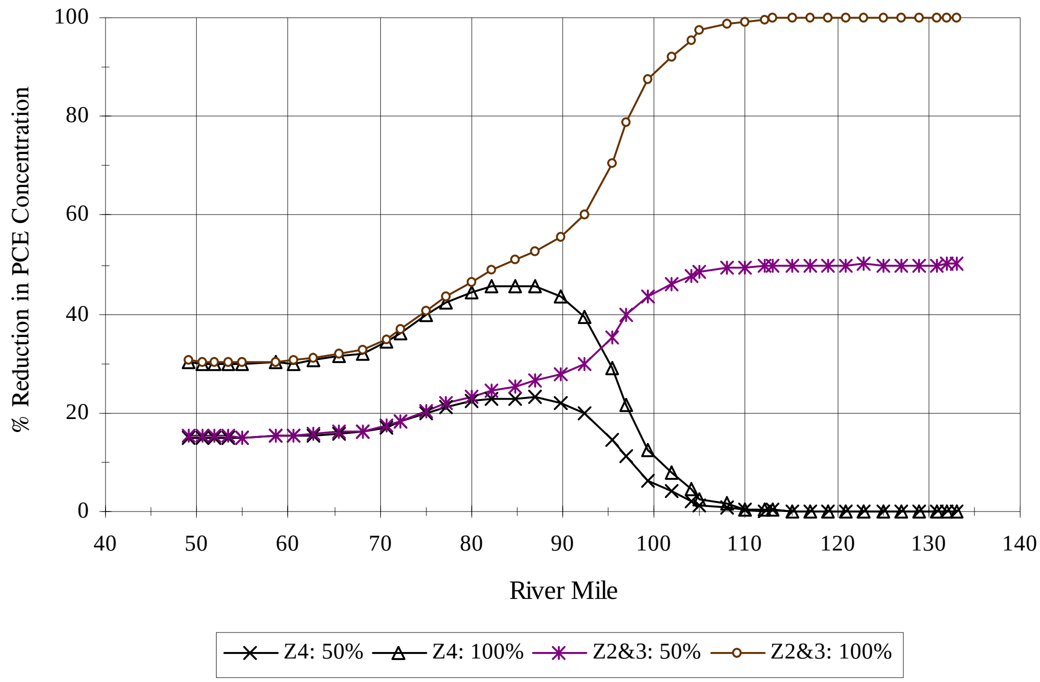
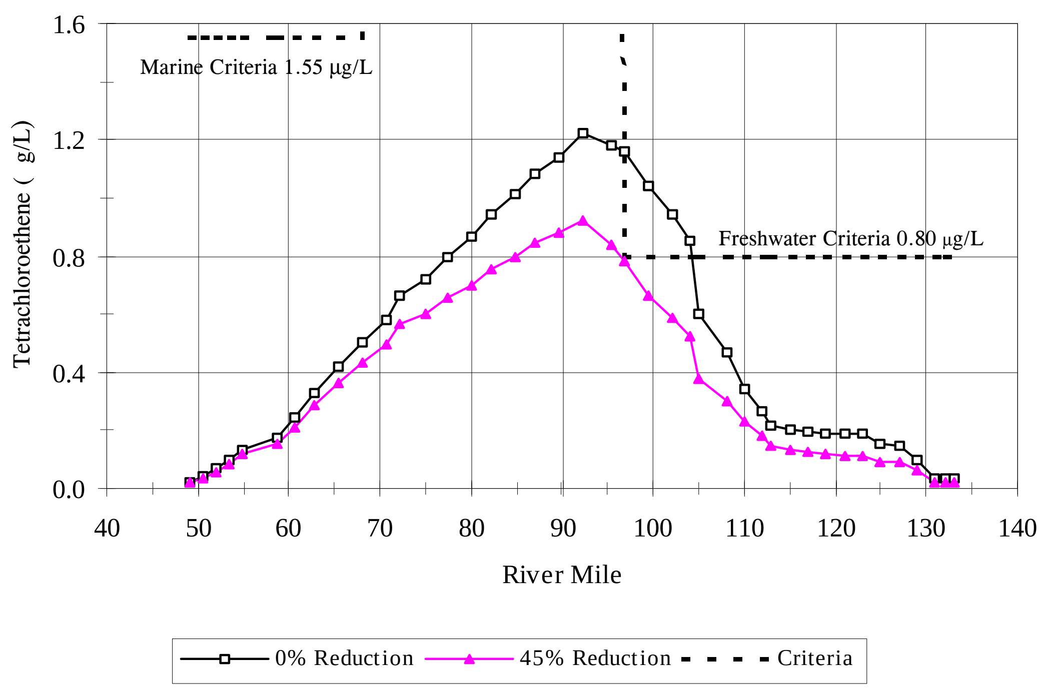


Figure 19 - Multiple Analysis for Tetrachloroethene



Trichloroethene

Trichloroethene (TCE) is used mainly as a degreasing solvent in metal industries, but it has also been used as a dry-cleaning solvent, an extractive solvent in foods, and as an inhalation anesthetic (U.S. EPA, 1980c).

Identification of Permittees

Twenty-six out of seventy-six discharges were identified that meet the criteria specified in Section 4:30.7.B.2.c.3). TCE was detected in the effluent of all identified discharges. Nine dischargers are covered by effluent guidelines that have TCE limitations. The identified discharges and their respective TCE concentrations are listed in Table 11.

Assignment of Initial Loadings

Each of the twenty-six discharges included in the allocation was assigned an initial loading based upon Section 4.30.7.B.2.c.4).b). Nine discharges were assigned initial loadings based upon the effluent guideline limitation of 21 μg/L. Five discharges were assigned loadings based upon actual effluent data. Twelve discharges were assigned a value of 21 μg/L (the minimum performance standard) due to insufficient or highly variable monitoring results ($N<6$ or $CV \geq 60$ %).

Wasteload Allocation Procedure

A two-step process involving baseline and multiple discharge analyses was used to establish human health-based wasteload allocations for TCE. The parameters used for hydraulic simulations were the same as those used for DCE and PCE simulations. The DYNHYD5 model was set to simulate a 60-day run under the harmonic mean flows. TOXIWASP was not calibrated to TCE due to the lack of detectable field data during the model calibration/validation study. However, the model's prediction should be within an acceptable range, since the model can calculate the spatially variable volatilization rates based upon the chemical's properties and water temperatures. The fate constants of biodegradation and oxidation were also obtained from the previous modeling study for the Delaware Estuary conducted by Robert B. Ambrose (1987). These constants were specified as $1x10^{-5}$ and $1x10^{-5}$, respectively. A constant temperature of 18 °C was utilized for all river segments. The TOXIWASP model parameters are listed in Table 12.

Baseline Analysis

The loading is initially set to the concentration listed in Table 11. The model was then run for 60 days. The predicted TCE concentrations for the last four days were averaged and compared to the appplicable stream quality objectives to check for any violation. The loading is then reduced, if necessary, until the predicted ambient concentrations are less than or equal to the stream quality objective. None of the discharges was reduced during the baseline analysis portion of the wasteload allocation exercise. Table 13 lists the baseline loads for all discharges. The assigned concentration for Philadelphia - NE is 1.7 μg/L which is much less that the minimum performance standard, 21 μg/L. Additional model runs were conducted to investigate the ambient TCE concentrations if the assigned TCE concentration for the discharges was set to 21 μg/L. Figure 25 indicates that even if the assigned concentration was changed to 21 μg/L, ambient concentrations do not exceed the water quality criteria.

Multiple Analysis

In the multiple discharge analysis, the identified discharges were set to their baseline discharge loads while other discharges were set to stream quality objective for TCE according to their location. The stream quality objectives were not violated at any point in the estuary, resulting in no further reduction of the baseline loads. The final multiple discharge loads for the discharges are also listed in Table 13.

Procedures for Carcinogen Criteria Conclusion

The wasteload allocations for Trichloroethene to protect human health from carcinogenic effects are established by following the procedures specified in Section 4.30.7 of the Commission s Water Quality Regulations. Twenty-six discharges were identified and evaluated in this study and all of them met the criteria without reduction in their initial loadings in the baseline analysis. All of the discharges set at their baseline loadings did not result in any water quality violation in the multiple discharge portion of the allocation exercise, so no further reductions were necessary.

Table 11: Supporting Data for Dischargers Included in the Wasteload Allocation Study for Trichloroethene.

PERMITTEE	NPDES #	ELG	DSN	g/L					DESIGN FLOW (m³/s)
				G[1]	P[1]	C[1]	M[1]	Assigned Conc.	
CITY of SALEM	NJ0024856		001			1.52[a] 4[b] 77.38[c]	21.00	21.00	0.06
FORMOSA PLASTICS CORP.	DE0000612	Yes	001	21.00		0.788 8 53.20		21.00	0.021
PENNSVILLE SEWERAGE AUTHORITY	NJ0021598		001			1.59 12 62.57		1.59	0.082
STANDARD CHLORINE	DE0020001	Yes	001	21.00		1.89 26 85.27		21.00	0.030
KANEKA DELAWARE	DE0000647	Yes	001	21.00		0.60 6 34.99		21.00	0.010
DUPONT-CHAMBERS WORKS	NJ0005100	Yes	662	21.00		0.134[f] 61 169.66		21.00	1.001
CARNEYS POINT SEWAGE AUTHORITY	NJ0021601		001			0.83 6 97.98	21.00	21.00	0.057
GEON	NJ0000008 (NJ0004286)	Yes	001	21.00		0.0048[e] 15 42.55		21.00	0.040
GREENWICH TOWNSHIP	NJ0030333		001			1.006 5 0.54	21.00	21.00	0.044
HERCULES - GIBBSTOWN	NJ0005134	Yes	001	21.00		0.00125[f] 4 23.09		21.00	0.014
GLOUCESTER COUNTY UA	NJ0024686		001			0.72 9 30.00		0.72	1.056
AUSIMONT	NJ0005185	Yes	001	21.00		3.11 2		21.00	0.031
PHILADELPHIA - SOUTHWEST STP	PA0026671		001			0.35[d] 3	21.00	21.00	8.760
PHILADELPHIA - SOUTHEAST STP	PA0026662		001			0.35[d] 3	21.00	21.00	5.241
CAMDEN COUNTY MUA	NJ0026182		001			0.87 16 93.26	21.00	21.00	3.504
PHILADELPHIA - NORTHEAST STP	PA0026689		001			1.70 46 49.35		1.70	9.198
PALMYRA BOROUGH	NJ0024449		001			2.337 3 98.71	21.00	21.00	0.035

PERMITTEE	NPDES #	ELG	DSN	g/L					DESIGN FLOW (m^3/s)
				G[1]	P[1]	C[1]	M[1]	Assigned Conc.	
RIVERTON BOROUGH	NJ0021610		001			0.50 2	21.00	21.00	0.010
MT. HOLLY SEWAGE AUTHORITY.	NJ0024015		001			0.005 13 93.92	21.00	21.00	0.219
WILLINGBORO MUN.	NJ0023361		001			0.44 4 28.57	21.00	21.00	0.229
MT. LAUREL TOWNSHIP	NJ0025178		001			0.50 5 0.00	21.00	21.00	0.263
ROHM & HAAS COMPANY-Bristol	PA0012769	Yes	009	21.00		0.33 79 159.16		21.00	0.073
COLORITE POLYMERS	NJ0004391	Yes	001	21.00		0.0003[e] 3		21.00	0.012
BORDENTOWN	NJ0024678		001			0.50 16 0.00		0.50	0.131
HAMILTON TOWNSHIP	NJ0026301		001			0.769 16 65.02		0.77	0.701
SWEDESBORO	NJ0022021		001			0.65 1	21.00	21.00	0.015

1 - G: Effluent Limitations Guideline P: Monthly Permit Limit C: Average Concentration from PCS
M: Minimum Performance Standard
a - Average Concentration
b - Number of Point
c - Coefficient of Variation
d - DRBC Monitoring Program data (mg/L) collected in September and October 1992
e - kg/day
f- lbs/day

Table 12: Input data required for volatilization option 4.

Variable	Input Values
Water Body Type (0 = flowing; 1 = quiescent)	0
Molecular Weight of Trichloroethene	131.39
Volatilization Option	4
Henry's Law constant, atm-m^3/mole	0.0091
Volatilization Temperature Correction Factor	1.024

Table 13: Wasteload Allocations for Trichloroethene for Delaware River Estuary Discharges.

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (µg/L)
CITY OF SALEM	NJ0024856	001	0.06132	21.00	0.117	0.00	0.117	0.00	0.117	21.00
FORMOSA PLASTICS CORP.	DE0000612	001	0.02146	21.00	0.041	0.00	0.041	0.00	0.041	21.00
KANEKA DELAWARE	DE0000647	001	0.00986	21.00	0.019	0.00	0.019	0.00	0.019	21.00
STANDARD CHLORINE	DE0020001	001	0.02978	21.00	0.057	0.00	0.057	0.00	0.057	21.00
DUPONT - CHAMBERS WORKS	NJ0005100	662	0.95292	21.00	1.815	0.00	1.815	0.00	1.815	21.00
PENNSVILLE SEWAGE AUTHORITY	NJ0021598	001	0.08213	1.59	0.012	0.00	0.012	0.00	0.012	1.59
CARNEYS PT. SEWAGE AUTHORITY	NJ0021601	001	0.05694	21.00	0.109	0.00	0.108	0.00	0.108	21.00
GEON	NJ0004286	001	0.03951	21.00	0.075	0.00	0.075	0.00	0.075	21.00
GREENWICH TOWNSHIP	NJ0030333	001	0.04380	21.00	0.083	0.00	0.083	0.00	0.083	21.00
HERCULES - GIBBSTOWN	NJ0005134	001	0.01415	21.00	0.027	0.00	0.027	0.00	0.027	21.00
GLOUCESTER COUNTY UA	NJ0024686	001	1.05558	0.72	0.069	0.00	0.069	0.00	0.069	0.72
AUSIMONT	NJ0005185	001	0.03070	21.00	0.059	0.00	0.058	0.00	0.058	21.00
PHILADELPHIA - SOUTHWEST STP	PA0026671	001	8.76000	21.00	16.689	0.00	16.689	0.00	16.689	21.00
CAMDEN COUNTY MUA	NJ0026182	001	3.50400	21.00	6.676	0.00	6.676	0.00	6.676	21.00
PHILADELPHIA - SOUTHEAST STP	PA0026662	001	4.96048	21.00	9.450	0.00	9.450	0.00	9.450	21.00

PERMITTEE	NPDES #	DSN	Design Flow (m^3/s)	Assigned Conc. (g/L)	Initial Load (kg/day) (5% Reserve)	Baseline Analysis % Reduction	Baseline Load (kg/day)	Multiple Analysis % Reduction	Multiple Load (kg/day)	Final WLA Conc. (μg/L)
PHILADELPHIA - NORTHEAST STP	PA0026689	001	9.19800	1.70	1.419	0.00	1.419	0.00	1.419	1.70
PALMYRA BOROUGH	NJ0024449	001	0.03460	21.00	0.066	0.00	0.066	0.00	0.066	21.00
RIVERTON BOROUGH	NJ0021610	001	0.00964	21.00	0.018	0.00	0.018	0.00	0.018	21.00
MOUNT HOLLY SEWAGE AUTHORITY	NJ0024015	001	0.21900	21.00	0.417	0.00	0.417	0.00	0.417	21.00
WILLINGBORO MUNICIPALITY	NJ0023361	001	0.22864	21.00	0.436	0.00	0.436	0.00	0.436	21.00
MOUNT LAUREL TOWNSHIP	NJ0025178	001	0.26280	21.00	0.501	0.00	0.501	0.00	0.501	21.00
COLORITE POLYMERS	NJ0004391	001	0.01244	21.00	0.024	0.00	0.024	0.00	0.024	21.00
ROHM & HAAS - BRISTOL	PA0012769	009	0.08388	21.00	0.160	0.00	0.160	0.00	0.160	21.00
BORDENTOWN	NJ0024678	001	0.13140	0.50	0.006	0.00	0.006	0.00	0.006	0.50
HAMILTON TOWNSHIP	NJ0026301	001	0.70080	0.77	0.049	0.00	0.049	0.00	0.049	0.77
SWEDESBORO	NJ0022021	001	0.01533	21.00	0.029	0.00	0.029	0.00	0.029	21.00

Figure 20 - Baseline Analysis for DuPont Chambers Works

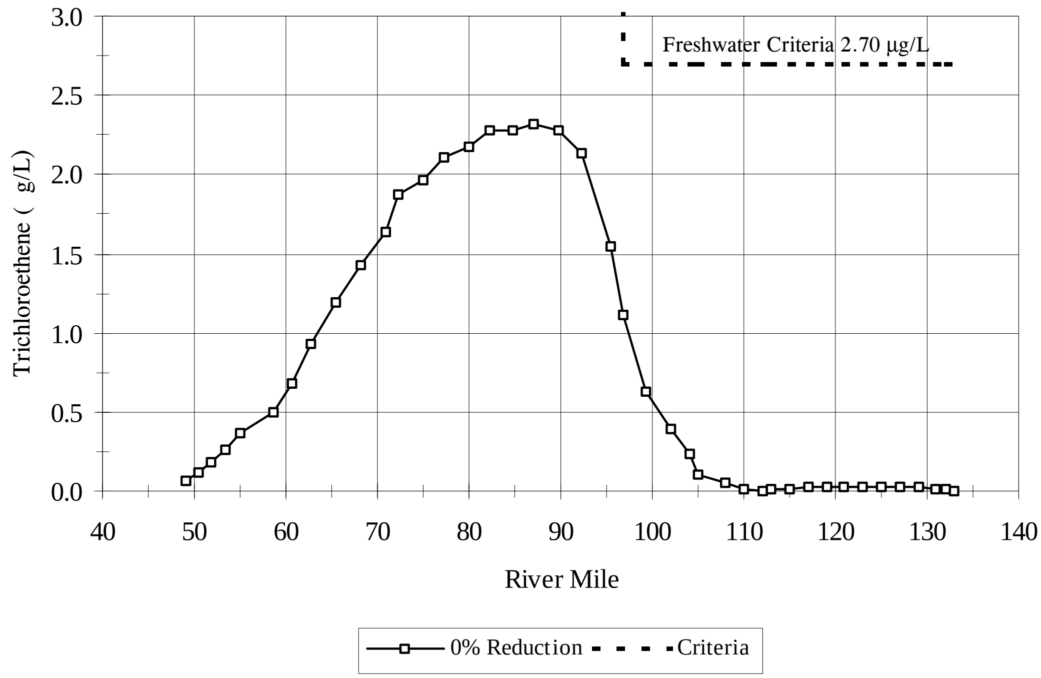


Figure 21 - Baseline Analysis for Gloucester County

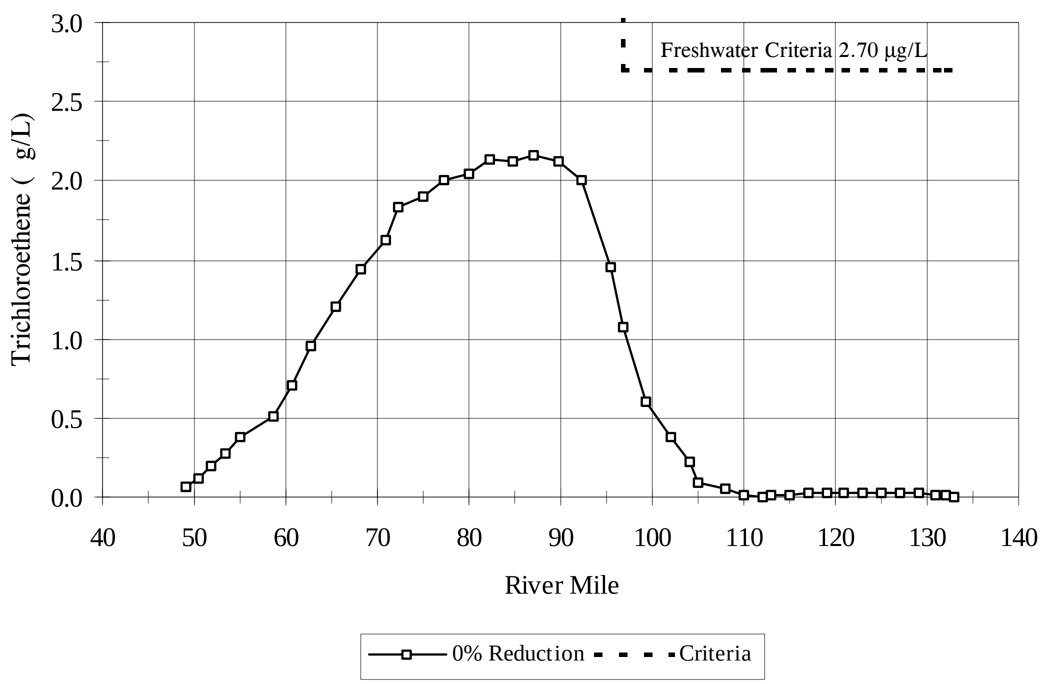


Figure 22 - Baseline Analysis for Philadelphia - SW

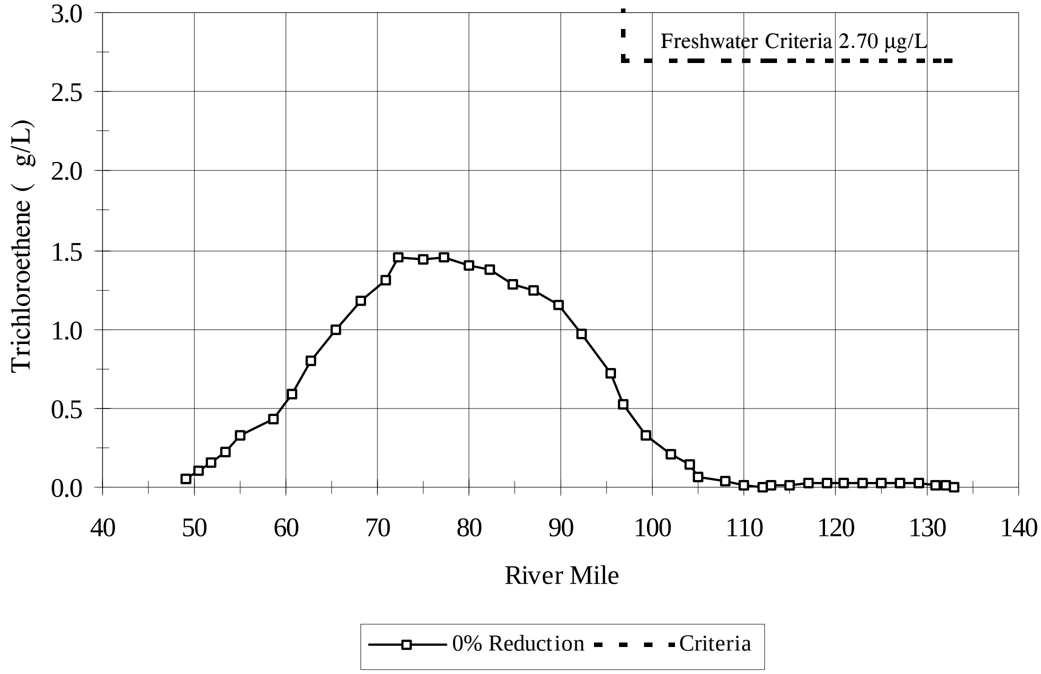


Figure 23 - Baseline Analysis for Philadelphia - SE

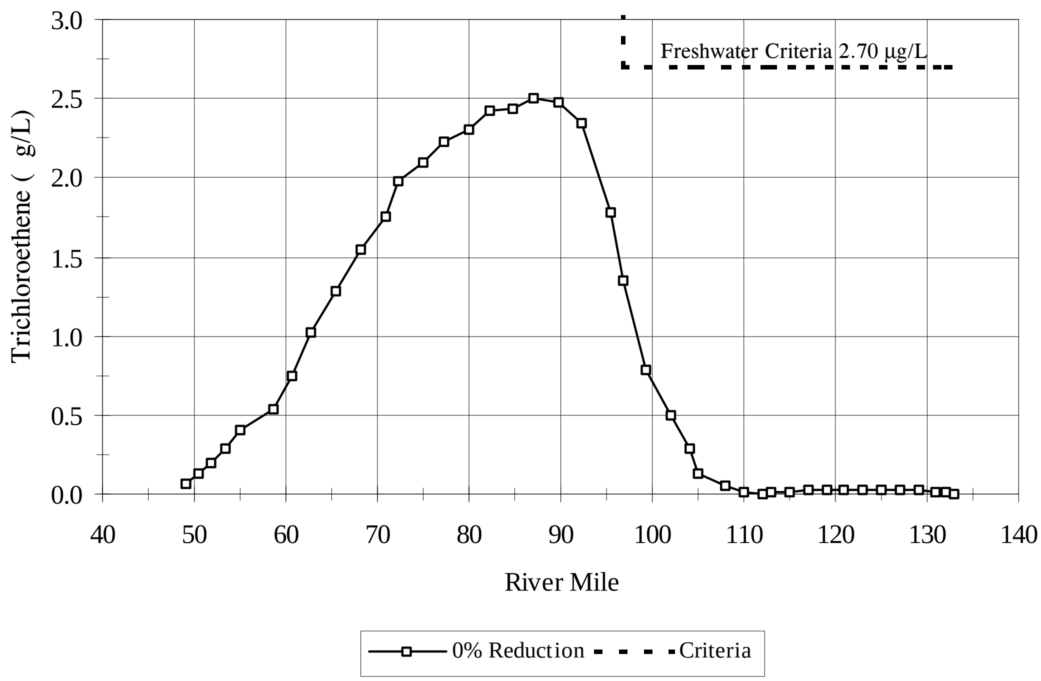


Figure 24 - Baseline Analysis for Camden

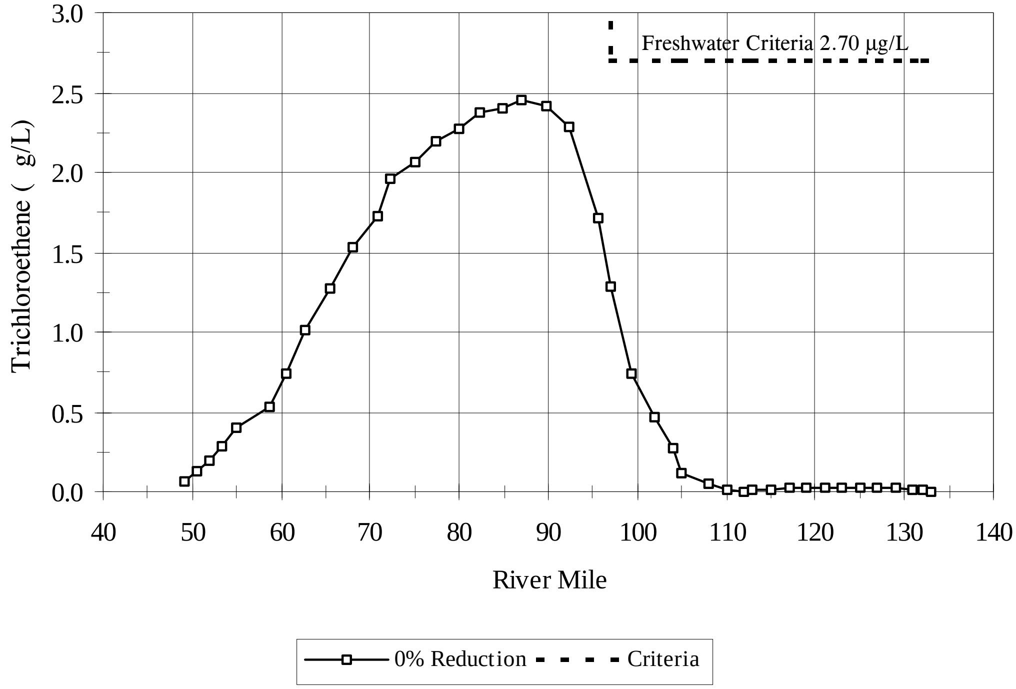


Figure 25 - Baseline Analysis for Philadelphia - NE

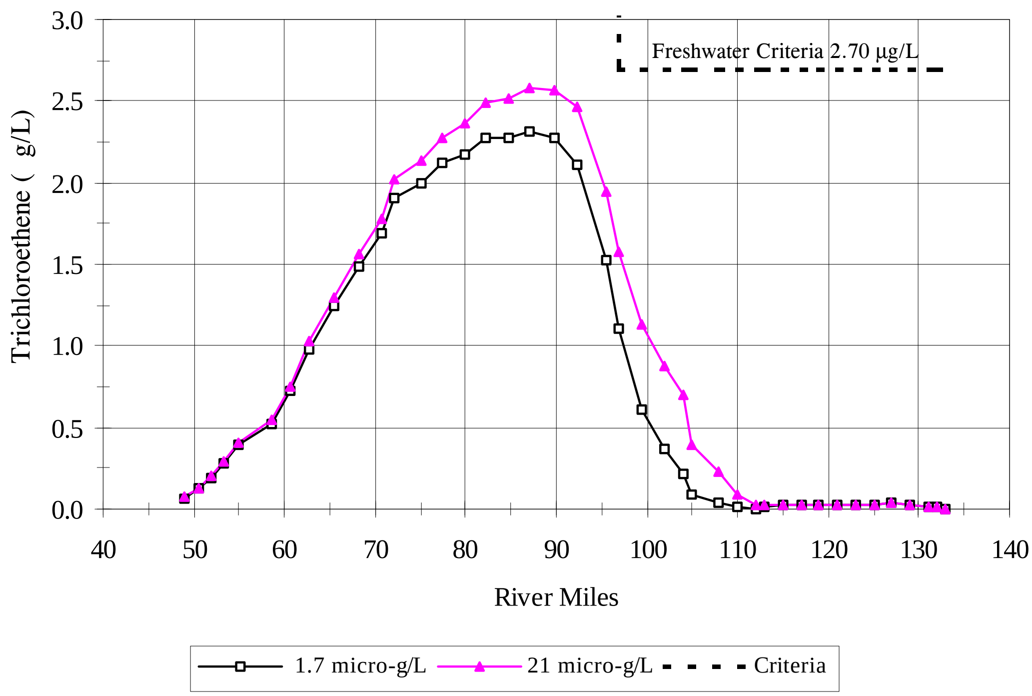
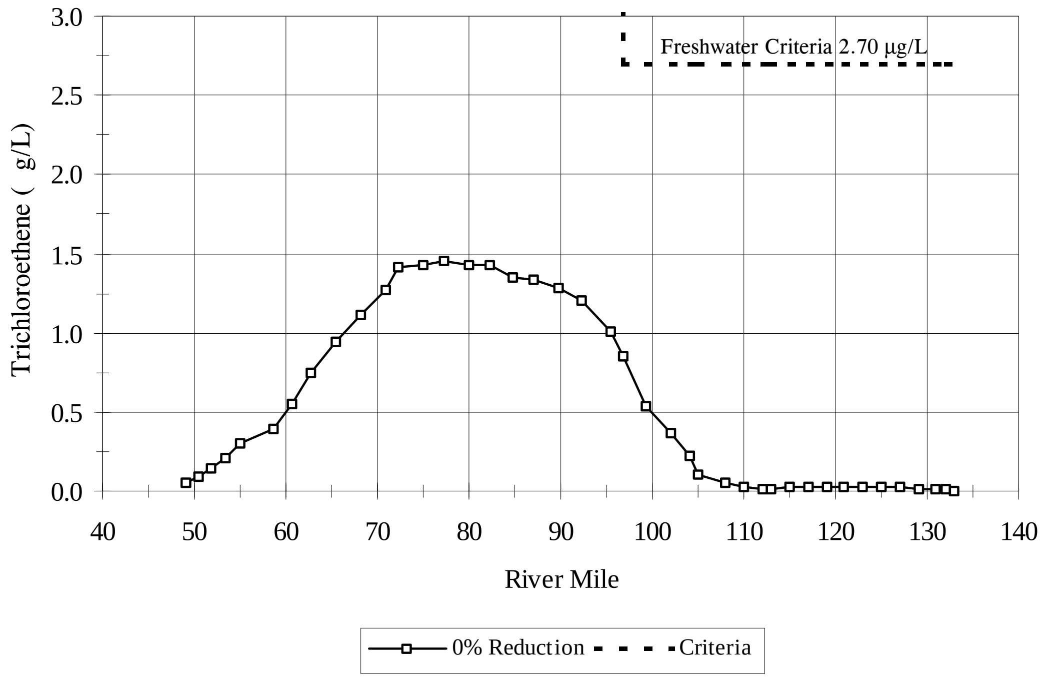


Figure 26 - Multiple Analysis for Trichloroethene



CHRONIC TOXICITY

Chronic toxicity, also known as whole effluent chronic toxicity, is not a specific chemical but rather an integrator of the effects of all chemicals present in an effluent as well as the interactions of those chemicals. In this respect, it is similar to Biochemical Oxygen Demand (BOD) which also measures the effect of multiple chemicals and their interactions. Using this parameter to measure the cumulative impacts of pollutants from discharges to the tidal Delaware River assumes that the source of the observed toxicity is similar in all discharges or that the toxicity contributed by each pollutant is additive. Successful calibration and validation of a water quality model based upon these assumptions supports this concept (DRBC, 1999). Furthermore, analyses conducted by the staff and presented to the Commission s Toxic Advisory Committee indicate that the sum of the toxic units based upon the concentration of several metals is closely correlated with the toxicity of ambient samples. This result together with a low rate of decay used in the model calibration and validation suggests that metals are the likely source of the chronic toxicity observed in ambient water samples.

In view of the need to obtain additional data on the relationship between the concentration of specific chemicals and toxicity of both wastewater and ambient samples, Phase 1 of this TMDL will be limited to establishing wasteload allocations from the Baseline Analysis. These allocations are those necessary for a discharge to meet the applicable water quality criterion without consideration of any other discharge to the estuary. The Multiple Discharge Analysis will be deferred until Phase 2 of the TMDL is completed in 2002. In the interim period, both chemical and toxicity tests must be conducted on the same wastewater samples by NPDES permittees, and additional ambient toxicity surveys need to be conducted by the Commission. This data will allow a determination of the source(s) of the ambient toxicity, the feasibility of establishing wasteload allocations for specific chemicals that contribute to the ambient toxicity, or the necessity for developing wasteload allocations for chronic toxicity.

Identification of Permittees

Fifty-five (55) out of seventy-six discharges were identified that meet the identification criteria specified in Section 4:30.7.B.2.c.3). Three of the discharges have permit limits for chronic toxicity, while the others are included due to the presence of chronic toxicity in their effluent. There are no U.S. EPA effluent guidelines with chronic toxicity as a limiting parameter. The loading of the other discharges is assigned the stream quality objective for chronic toxicity which is 1.0 toxic units (chronic) in all four zones of the estuary. The identified discharges and their respective chronic toxicity data are listed in Table 14.

Assignment of Initial Loadings

Each of the fifty-five discharges included in the allocation was assigned an initial loading based upon Section 4.30.7.B.2.c.4).b). Twenty-one discharges with sufficient quality data were assigned initial loadings based upon actual effluent concentrations. The remaining 34 discharges were assigned a value representing the minimum performance standard for industrial and municipal discharges to the estuary of 3.3 and 2.9 Toxic $\text{Units}_{\text{chronic}}$, respectively, due to insufficient or highly variable monitoring results ($N<6$ or $CV > 100\%$). Since compliance with the Commission s stream quality objectives for chronic toxicity must be assessed at a criteria duration of 4 days (see Section 3.10.3.C.1.), the initial long-term average loadings were converted to equivalent 4 day values using the formula contained in the Technical Support Document for Water Quality-Based Toxics Control (U.S. EPA,1991):

$$WLA_{chronic} = \frac{LTA_{chronic}}{e^{\left(0.5\sigma_4^2 - z\sigma_4\right)}}$$

where:

$LTA_{chronic}$ =	Long-term average chronic toxicity of the discharge.
$WLA_{chronic}$ =	Four day average chronic toxicity of the discharge.
σ_4 =	square of the standard deviation of the chronic toxicity of the discharge [equal to $\log_n (CV^2 / 4 + 1)$].
z =	2.326 for 99^{th} percentage probability of occurrence.

For this conversion, the actual CV of the parameter in each discharge was used where sufficient data was available along with a probability level of 0.01 (DRBC, 1995). If the monitoring data was insufficient, then a default CV of 0.6 was used. The resulting loadings for each discharge are presented in Table 14.

Wasteload Allocation Procedure

Establishing wasteload allocations for the protection of aquatic life from chronic toxicity is a two-step process which includes baseline and multiple discharge analyses. A one-dimensional model system WASP5, which consists of DYNHYD5 and TOXI5 models were utilized for this study, as well as, the equal marginal percent reduction (EMPR) procedure.

Hydraulic Simulations

The DYNHYD5 Model was utilized for simulating the water movement in the Delaware Estuary. The model's segmentation is comprised of two seaward boundaries, 11 tributaries, and the mainstem of the tidal Delaware River. Average tidal coefficients were developed by using non-linear regression analysis on the actual tide data collected by NOAA between August 5 and September 4, 1986 when the river flow at Trenton was 6300 cfs. One set of spatially-variable Manning coefficients which were determined as a result of a calibration/verification study was used for the model's input file in the wasteload allocation study (DRBC, 1995). Since the Manning coefficients selected during the model calibration/validation were found to be acceptable during river flows of approximately 3800 and 5800 cfs, they were used during the wasteload allocation study. The design flow for aquatic life criteria is 2500 cfs at Trenton and 7Q10 for all other tributaries. Therefore, these flows were used in the model simulations.

The design effluent flows were determined according to Section 4.30.7.A.8. The design effluent flows are listed in Tables 4 and 5, and were used by the DYNHYD5 model as constant inflows. One of the output files from DYNHYD5 containing hydraulic information is then used by the TOXI5 model for water quality simulations.

Water Quality Simulations

A TOXI5 model that was previously calibrated and validated for chronic toxicity in the Delaware Estuary (DRBC, 1999) was utilized to establish wasteload allocations. Several parameters were determined during the calibration/verification process. The dispersion coefficients for average conditions were determined during the calibration/validation of the model for chlorides. During the model calibration, the river flow was representative of low flow conditions at approximately 3800 cfs.

The transformation of toxicity was implemented in the model as a single, first order rate constant using the extra reaction rate available in the model. In effect, this is a lumped rate constant representing the various processes affecting the individual components contributing to the observed chronic toxicity and their interactions. A value of 0.001/day was selected for the rate during the calibration/validation of the model for toxicity (DRBC, 1998). The calibration/validation results indicated that chronic toxicity can be simulated as a dissolved constituent, therefore, sediment transport was not included in the model framework. Loading rates for toxicity at the model boundaries and tributaries were set to the water quality criteria for chronic toxicity, 1.0 Toxic Units $_{chronic}$.

Baseline Analysis

To ensure that the model achieved a stable condition, a 60 day simulation period was used. It was determined that the numerical stability of the model was obtained after about 40 days.

There are seventy-eight continuous point source discharges to the Delaware River estuary. Fifty-five of them are included in the wasteload allocation study for chronic toxicity. Since the model achieves numerical stability after forty days, the last four days of the sixty day simulation were averaged during both the baseline and multiple analysis portions of the study, and compared to the stream quality objective to check if there is any water quality violation.

In the baseline analysis portion of the Equal Marginal Percent Reduction procedure, each discharge is evaluated as if it was the only discharge to the estuary. In this analysis, each discharger is set to its initial loading while the other discharges are set to the applicable stream quality objective for the zone in which they discharge. The water quality criterion for chronic toxicity is 1.0 TU_c for all four estuary zones.

If the discharge results in a water quality violation, the loading is reduced from the initial loading until the water quality criterion is met. 10 of the 55 discharges were reduced from their initial loading during the baseline analysis portion of the wasteload allocation (Table 15). The smallest reduction occurred at Dupont - Chambers Works (10%), while the largest reduction occurred at and Philadelphia - NE (71%) (Figures 27 and 28). Reductions were necessary in three areas of the estuary, in upper Zone 5, Zone 3, and in upper Zone 2. Figures 29 - 32 depict the results of the baseline analyses for Wilmington, Philadelphia - SW, Philadelphia - SE and Trenton, respectively.

Multiple Discharge Analysis - Deferred to Phase 2 of TMDL process.

Conclusion

The wasteload allocations for chronic toxicity to protect aquatic life from chronic effects were established by following the procedures specified in Section 4.30.7 of the Commission s Water Quality Regulations. Fifty-five discharges were identified and evaluated in the wasteload allocation exercise. Ten of the 55 discharges were reduced from their initial loading during the baseline analysis portion of the wasteload allocation. It should be noted that the initial loadings assigned to some discharges are less than the available data suggest. Additional analyses are necessary to determine whether the loading of these discharges at levels comparable to the available data will still ensure compliance with the stream quality objective of 1.0 TU_c.

Table 14: Supporting Data for Dischargers Included in the Wasteload Allocation Study for Chronic Toxicity.

PERMITTEE	NPDES #	ELG Facility	DSN	CATEGORIES					Wasteload Allocation - 4 day (TU_c)
				Permit Limit ($_{Tuc}$)	Effluent Data [TU_c (N) CV]		Minimum Performance Standard	Assigned Concentration (TU_c)	
					Fathead Minnow	Ceriodaphnia			
City of Salem	NJ0024856	No	001	-	4.2 (5) 59.3[a]	2.5 (17) 105[a]		4.2	8.0
Star Enterprises	DE0000256	Yes	001	-	1.5 (2) 47.1[a]	1.5 (2) 47.1[a]	3.3		6.3
Kaneka Delaware	DE0000647	Yes	001	-	1.0 (2) 0.0	1.5 (2) 47.1	3.3		6.3
Standard Chlorine	DE0020001	Yes	001	-	1.0 (1) -[a]	6.0 (2) 47.1[a]	3.3		6.3
Occidental Chemical	DE0050911	Yes	001	-	56.3 (4) 89.8[a]	150 (4) 38.5[a]	3.3		6.3
Pennsville	NJ0021598	No	001	-	1.0 (3) 0.0[a]	3.8 (9) 49.1[a]		3.8	6.5
Dupont - Chambers Works	NJ0005100	Yes	662	-	7.8 (18) 72	12.0 (2) 47.1		7.8	16.2
Carney's Point	NJ0021601	No	001	-	1.3 (9) 37.5	-		1.3	2.0
City of Wilmington	DE0020320	No	001	-	3.4 (17) 110	2.5 (17) 67.2	2.9		5.5
Penns Grove	NJ0024023	No	001	5.9	1.0 (2) 0.0	1.3 (3) 43.3		5.9	11.2
Dupont - Edgemoor	DE0000051	Yes	001	-	1.0 (2) 0.0	3.3 (2) 0.0	3.3		6.3
Geon Company	NJ0004286	Yes	001	-	1.0 (4) 0.0	7.5 (4) 82.6	3.3		6.3

PERMITTEE	NPDES #	ELG Facility	DSN	CATEGORIES					Wasteload Allocation - 4 day (TU_c)
				Permit Limit (T_{uc})	Effluent Data [TU_c (N) CV]		Minimum Performance Standard	Assigned Concentration (TU_c)	
					Fathead Minnow	Ceriodaphnia			
General Chemical	DE0000655	No	001	-	1.5 (2) 47.1	4.5 (2) 110	3.3		6.3
Logan Township	NJ0027545	No	001	-	2.0 (1) -	2.0 (1) -	2.9		5.5
Monsanto Corp.	NJ0005045	Yes	001	-	12.0 (2) 47.1	16.0 (2) 0.0	3.3		6.3
Bayway Manufacturing	PA0012637	Yes	201	-	6.7 (2) 70.7	6.7 (2) 70.7	3.3		6.3
Laidlaw Environmental	NJ0005240	No	001	-	3.9 (7) 142	17.5 (7) 117	3.3		6.3
Swedesboro	NJ0022021	No	001	-	-	-	2.9		5.5
DELCORA	PA0027103	No	001	-	10.0 (2) 0.0	2.2 (2) 76.1	2.9		5.5
Boeing Helicopters	PA0013323	Yes	001	-	8.5 (2) 125	9.0 (2) 110	3.3		6.3
Tinicum Township	PA0028380	No	001	-	3.8 (2) 47.1	1.7 (2) 0.0	2.9		5.5
Dupont - Repauno	NJ0004219	No	001	-	7.6 (7) 104	6.7 (7) 106	3.3		6.3
Air Products & Chemicals	NJ0004278	No	001	-	1.0 (2) 0.0	8.0 (2) 0.0	3.3		6.3
Hercules - Gibbstown	NJ0005134	Yes	001	-	1.5 (2) 47.1	4.0 (2) 0.0	3.3		6.3
Mobile Oil	NJ005029	Yes	001	-	8.0 (8) 70.6	4.0 (4) 70.7		8.0	16.6

PERMITTEE	NPDES #	ELG Facility	DSN	CATEGORIES					Wasteload Allocation - 4 day (TU_c)
				Permit Limit ($_{Tuc}$)	Effluent Data [TU_c (N) CV]		Minimum Performance Standard	Assigned Concentration (TU_c)	
					Fathead Minnow	Ceriodaphnia			
Gloucester County UA	NJ0024686	No	001	-	5.1 (14) 75.0	1.9 (5) 9.8		5.1	11.6
Ausimont	NJ0005185	Yes	001	-	19.6 (2) 83.8	21.1 (3) 42.1	3.3		6.3
Philadelphia SW Plant	PA0026671	No	001	-	3.5 (8) 59.1	4.4 (7) 118		3.5	6.6
Sun Co. - Girard Point	PA0011533	Yes	015	-	1.8 (3) 75.8	2.2 (2) 76.1	3.3		6.3
Sun Co. - Point Breeze	PA0012629	Yes	002	-	5.5 (2) 116	34.8 (3) 162	3.3		6.3
Coastal Eagle Point	NJ0005401	Yes	001	-	1.8 (6) 87.4	3.6 (4) 119	3.3		6.3
Philadelphia SE Plant	PA0026662	No	001	-	3.7 (6) 165	1.3 (6) 38.7	2.9		5.5
Camden County MUA	NJ0026182	No	001	-	1.9 (5) 68.0	1.7 (8) 26.1		1.9	4.0
Philadelphia NE Plant	PA0026689	No	001	-	6.3 (7) 106	5.0 (6) 120	2.9		5.5
Georgia Pacific	NJ0004669	Yes	001	-	2.2 (5) 50	13.6 (5) 39.5	3.3		6.3
Cinnaminson	NJ0024007	No	001	-	3.0 (12) 77.9	1.3 (6) 38.7		3.0	6.8
Hoeganaes Corp.	NJ0004375	Yes	001	-	1.0 (3) 0.0	1.8 (4) 28.6	3.3		6.3
Delran	NJ0023507	No	001	10.0	1.7 (7) 65	2.0 (20) 105		10.0	19.0

PERMITTEE	NPDES #	ELG Facility	DSN	CATEGORIES					Wasteload Allocation - 4 day (TU_c)
				Permit Limit ($_{Tuc}$)	Effluent Data [TU_c (N) CV]		Minimum Performance Standard	Assigned Concentration (TU_c)	
					Fathead Minnow	Ceriodaphnia			
Riverside	NJ0022519	No	001	-	2.7 (6) 38.7	-		2.7	4.2
Willingboro UA	NJ0023361	No	001	-	-	-	2.9		5.5
Mount Laurel Township	NJ0025178	No	001A	-	-	-	2.9		5.5
Mount Holly	NJ0024015	No	001	-	1.5 (2) 47.1	1.4 (7) 37.4		1.4	2.2
Bristol Township	PA0026450	No	001	-	5.0 (2) 84.9	4.0 (3) 0.0	2.9		5.5
Colorite Polymers	NJ0004391	Yes	001A	-	2.7 (7) 59.1	5.5 (7) 103	3.3		6.3
Burlington Township	NJ0021709	No	001	-	1.9 (7) 78.8	2.1 (13) 95.2		2.1	5.6
City of Burlington	NJ0024660	No	001	6.3	10.0 (2) 84.8	2.2 (9) 107.4		6.3	12.0
Rohm & Haas	PA0012769	Yes	009	-	1.8 (14) 134	1.3 (14) 64.2	3.3		6.3
Bristol Borough	PA0027294	No	001	-	2.0 (2) 38.6	1.0 (2) 0.0	2.9		5.5
Lower Bucks County JMUA	PA0026468	No	001	-	7.0 (6) 46.9	3.8 (6) 9.1		7.0	12.0
Bordentown	NJ0024678	No	001	-	5.5 (4) 130	4.3 (9) 153	2.9		5.5
Hamilton Township	NJ0026301	No	001	-	3.7 (5) 66.6	2.7 (9) 105	2.9		5.5

PERMITTEE	NPDES #	ELG Facility	DSN	CATEGORIES					Wasteload Allocation - 4 day (TU_c)
				Permit Limit ($_{Tuc}$)	Effluent Data [TU_c (N) CV]		Minimum Performance Standard	Assigned Concentration (TU_c)	
					Fathead Minnow	Ceriodaphnia			
Circuit Foil USA	NJ0004332	Yes	001B	-	-	-	3.3		6.3
Pre-Finish Metals	PA0045021	Yes	001	-	1.5 (2) 47.1	1.0 (2) 0.0	3.3		6.3
City of Trenton	NJ0020923	No	001	-	5.5 (4) 127	3.5 (9) 64.5	2.9		5.5
Morrisville Borough	PA0026701	No	001	-	2.0 (2) 0.0	1.5 (2) 47.1	2.9		5.5

a - Data reported is for the marine species *Mysidopsis bahia* and sheepshead minnow.
b - Actual limit is for IC25.

Table 15: Wasteload Allocations for Chronic Toxicity for Delaware River Estuary Discharges.

PERMITTEE	NPDES #	DSN	Node	Wasteload Allocation - 4 day (TU_c)	Design Flow (m^3/s)	Initial Load (TU_c/day) (5% Reserve)	Baseline Analysis (Percent Reduction)	Baseline Load (TU_c/day)	Final WLA Conc. (TU_c)
City of Salem	NJ0024856	001	15	8.0	0.061	4.43e+04	0%	4.43e+04	8.0
Star Enterprises	DE0000256	601	21	6.3	0.526	3.01e+05	0%	3.01e+05	6.3
Kaneka Delaware	DE0000647	001	22	6.3	0.01	5.72e+03	0%	5.72e+03	6.3
Standard Chlorine	DE0020001	001	22	6.3	0.03	1.71e+04	0%	1.71e+04	6.3
Occidental Chemical	DE0050911	001	22	6.3	0.009	5.14e+03	0%	5.14e+03	6.3
Pennsville	NJ0021598	001	24	6.5	0.082	4.84e+04	0%	4.84e+04	6.5
Dupont - Chambers Works	NJ0005100	662	24	16.2	2.094	3.08e+06	10%	2.77e+06	14.6
Carney's Point	NJ0021601	001	25	2.0	0.057	1.03e+04	0%	1.03e+04	2.0
City of Wilmington	DE0020320	001	31	5.5	4.312	2.15e+06	30%	1.51e+06	3.9
Penns Grove	NJ0024023	001	31	11.2	0.033	3.35e+04	0%	3.35e+04	11.2
Dupont - Edgemoor	DE0000051	001	31	6.3	0.171	9.77e+04	0%	9.77e+04	6.3
Geon Company	NJ0004286	001	33	6.3	0.04	2.29e+04	0%	2.29e+04	6.3
General Chemical	DE0000655	001	33	6.3	1.415	8.09e+05	0%	8.09e+05	6.3
Logan Township	NJ0027545	001	34	5.5	0.044	2.20e+04	0%	2.20e+04	5.5
Monsanto Corp.	NJ0005045	001	34	6.3	0.051	2.91e+04	0%	2.91e+04	6.3
Bayway Manufacturing	PA0012637	201	34	6.3	0.142	8.12e+04	0%	8.12e+04	6.3
Laidlaw Environmental	NJ0005240	001	93	6.3	0.044	2.51e+04	0%	2.51e+04	6.3
Swedesboro	NJ0022021	001	93	5.5	0.015	7.48e+03	0%	7.48e+03	5.5

PERMITTEE	NPDES #	DSN	Node	Wasteload Allocation - 4 day (TU_c)	Design Flow (m^3/s)	Initial Load (TU_c/day) (5% Reserve)	Baseline Analysis (Percent Reduction)	Baseline Load (TU_c/day)	Final WLA Conc. (TU_c)
DELCORA	PA0027103	001	36	5.5	1.927	9.62e+05	0%	9.62e+05	5.5
Boeing Helicopters	PA0013323	001	38	6.3	0.022	1.26e+04	0%	1.26e+04	6.3
Tinicum Township	PA0028380	001	40	5.5	0.061	3.04e+04	0%	3.04e+04	5.5
Dupont - Repauno	NJ0004219	001	42	6.3	0.644	3.68e+05	0%	3.68e+05	6.3
Air Products & Chemicals	NJ0004278	001	42	6.3	0.008	4.57e+03	0%	4.57e+03	6.3
Hercules - Gibbstown	NJ0005134	001	42	6.3	0.014	8.00e+03	0%	8.00e+03	6.3
Mobile Oil	NJ005029	001	43	16.6	0.456	6.87e+05	0%	6.87e+05	16.6
Gloucester County UA	NJ0024686	001	43	11.6	1.056	1.11e+06	0%	1.11e+06	11.6
Ausimont	NJ0005185	001	43	6.3	0.031	1.77e+04	0%	1.77e+04	6.3
Philadelphia SW Plant	PA0026671	001	44	6.6	8.76	5.25e+06	68%	1.68e+06	2.1
Sun Co. - Girard Point	PA0011533	015	45	6.3	0.257	1.47e+05	0%	1.47e+05	6.3
Sun Co. - Point Breeze	PA0012629	002	45	6.3	0.247	1.41e+05	0%	1.41e+05	6.3
Coastal Eagle Point	NJ0005401	001	48	6.3	0.161	9.20e+04	0%	9.20e+04	6.3
Philadelphia SE Plant	PA0026662	001	49	5.5	4.96	2.47e+06	54%	1.14e+06	2.5
Camden County MUA	NJ0026182	001	49	4.0	3.504	1.27e+06	18%	1.04e+06	3.3
Philadelphia NE Plant	PA0026689	001	55	5.5	9.198	4.59e+06	72%	1.29e+06	1.5
Georgia Pacific	NJ0004669	001	55	6.3	0.008	4.57e+03	0%	4.57e+03	6.3
Cinnaminson	NJ0024007	001	59	8.7	0.088	6.95e+04	0%	6.95e+04	8.7
Hoeganaes Corp.	NJ0004375	001	59	6.3	0.008	4.57e+03	0%	4.57e+03	6.3

PERMITTEE	NPDES #	DSN	Node	Wasteload Allocation - 4 day (TU_c)	Design Flow (m^3/s)	Initial Load (TU_c/day) (5% Reserve)	Baseline Analysis (Percent Reduction)	Baseline Load (TU_c/day)	Final WLA Conc. (TU_c)
Delran	NJ0023507	001	60	19.0	0.11	1.90e+05	0%	1.90e+05	19.0
Riverside	NJ0022519	001	61	4.2	0.044	1.68e+04	0%	1.68e+04	4.2
Willingboro UA	NJ0023361	001	61	5.5	0.229	1.14e+05	0%	1.14e+05	5.5
Mount Laurel Township	NJ0025178	001A	61	5.5	0.263	1.31e+05	0%	1.31e+05	5.5
Mount Holly	NJ0024015	001	61	2.2	0.219	4.37e+04	0%	4.37e+04	2.2
Bristol Township	PA0026450	001	64	5.5	0.099	4.94e+04	0%	4.94e+04	5.5
Colorite Polymers	NJ0004391	001A	64	5.5	0.012	5.99e+03	0%	5.99e+03	5.5
Burlington Township	NJ0021709	001	64	6.2	0.16	9.00e+04	0%	9.00e+04	6.2
City of Burlington	NJ0024660	001	64	12.0	0.118	1.28e+05	0%	1.28e+05	12.0
Rohm & Haas	PA0012769	009	64	6.3	0.084	4.80e+04	0%	4.80e+04	6.3
Bristol Borough	PA0027294	001	66	5.5	0.118	5.89e+04	0%	5.89e+04	5.5
Lower Bucks County JMUA	PA0026468	001	69	12.0	0.438	4.77e+05	67%	1.57e+05	4.0
Bordentown	NJ0024678	001	72	5.5	0.131	6.54e+04	0%	6.54e+04	5.5
Hamilton Township	NJ0026301	001	73	5.5	0.701	3.50e+05	65%	1.22e+05	1.9
Circuit Foil USA	NJ0004332	001B	73	6.3	0.002	1.14e+03	0%	1.14e+03	6.3
Pre-Finish Metals	PA0045021	001	74	6.3	0.007	4.00e+03	0%	4.00e+03	6.3
City of Trenton	NJ0020923	001	75	5.5	0.876	4.37e+05	75%	1.09e+05	1.4
Morrisville Borough	PA0026701	001	76	5.5	0.311	1.55e+05	62%	5.90e+04	2.1

Figure 27 - Baseline Analysis for Dupont - Chambers Works

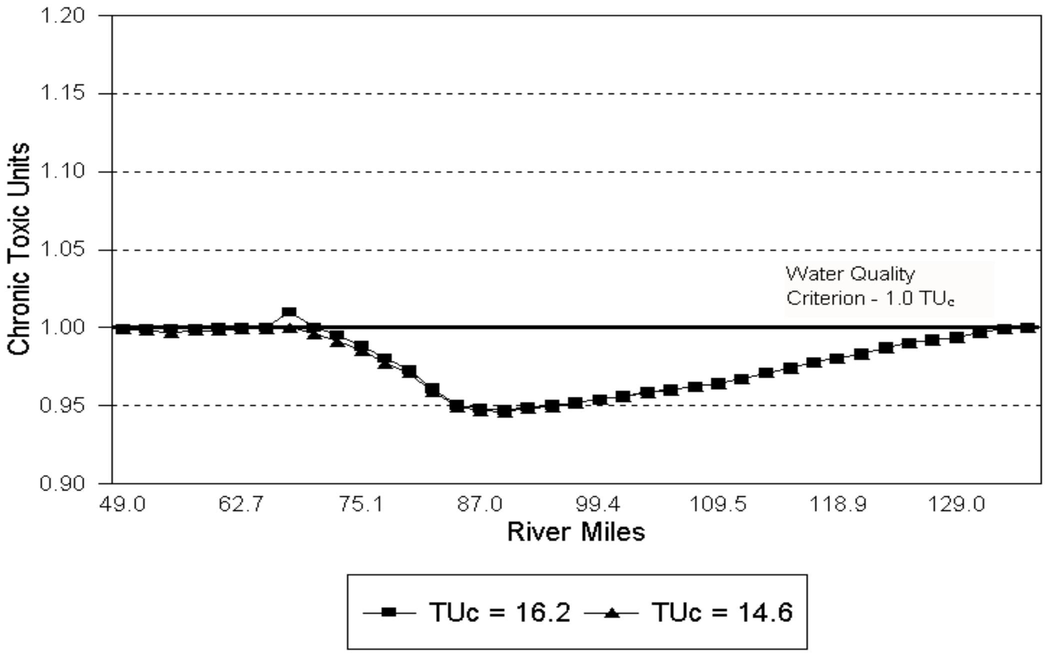


Figure 28 - Baseline Analysis for Philadelphia NE

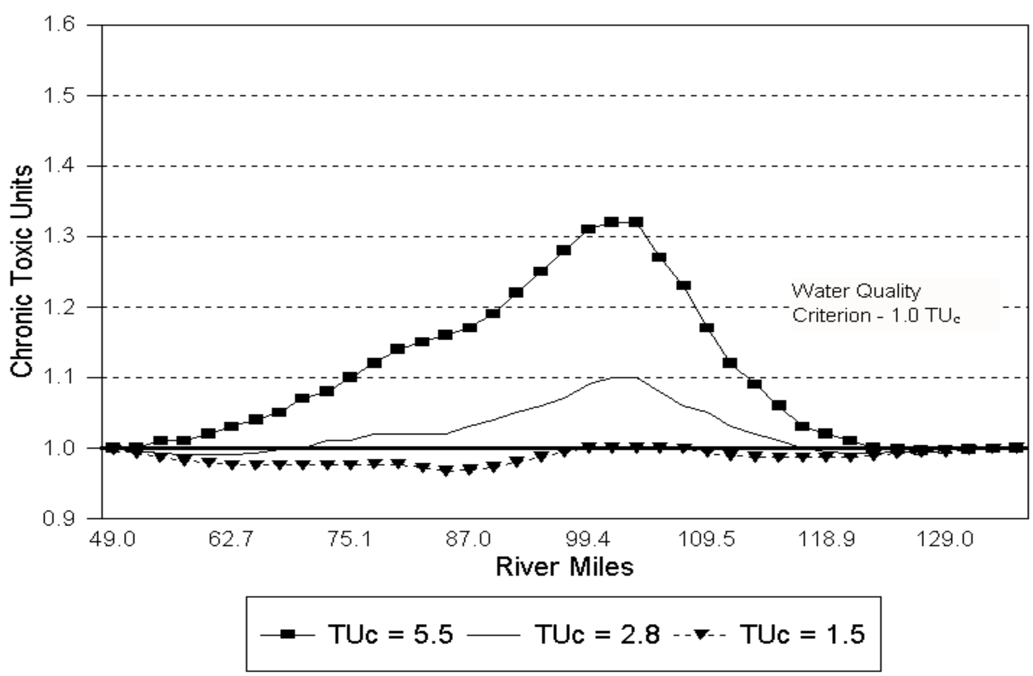


Figure 29 - Baseline Analysis for Wilmington

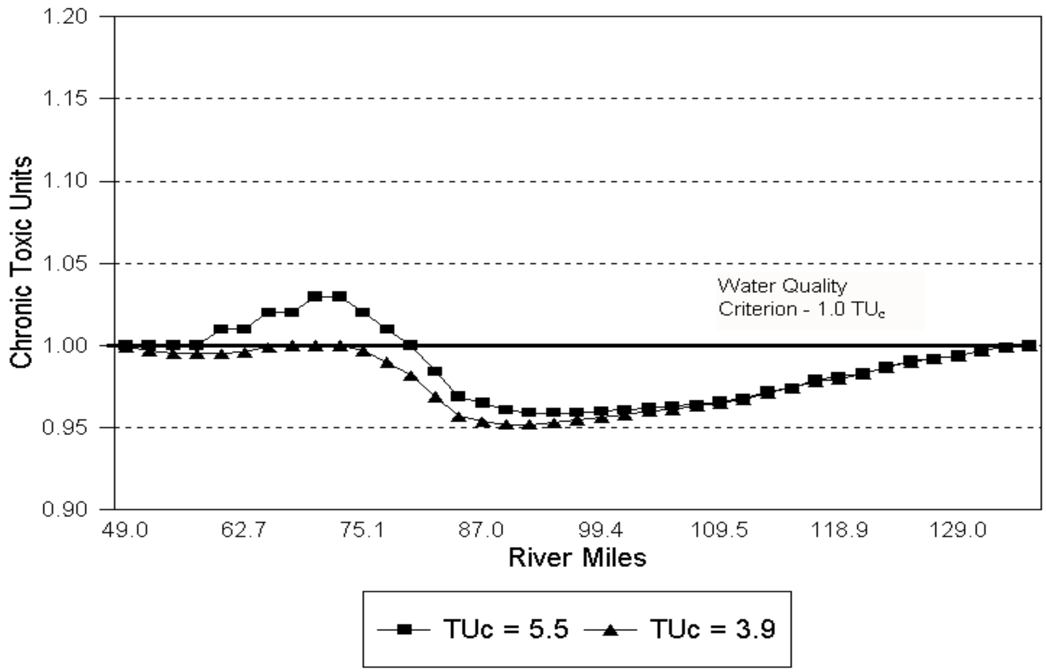


Figure 30 - Baseline Analysis for Philadelphia SW

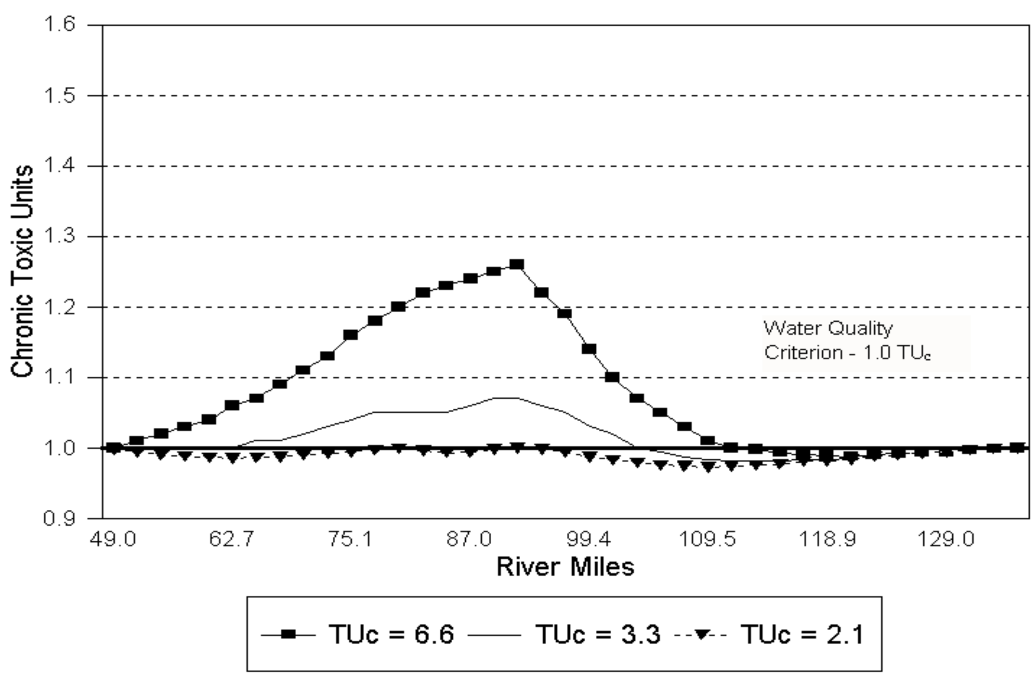


Figure 31 - Baseline Analysis for Philadelphia SE

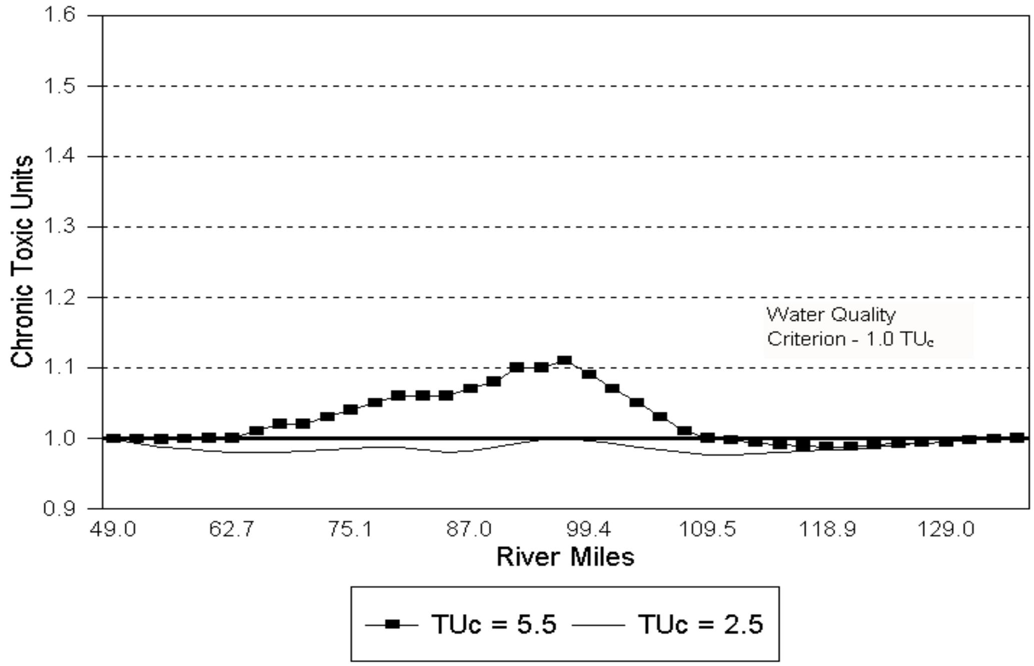
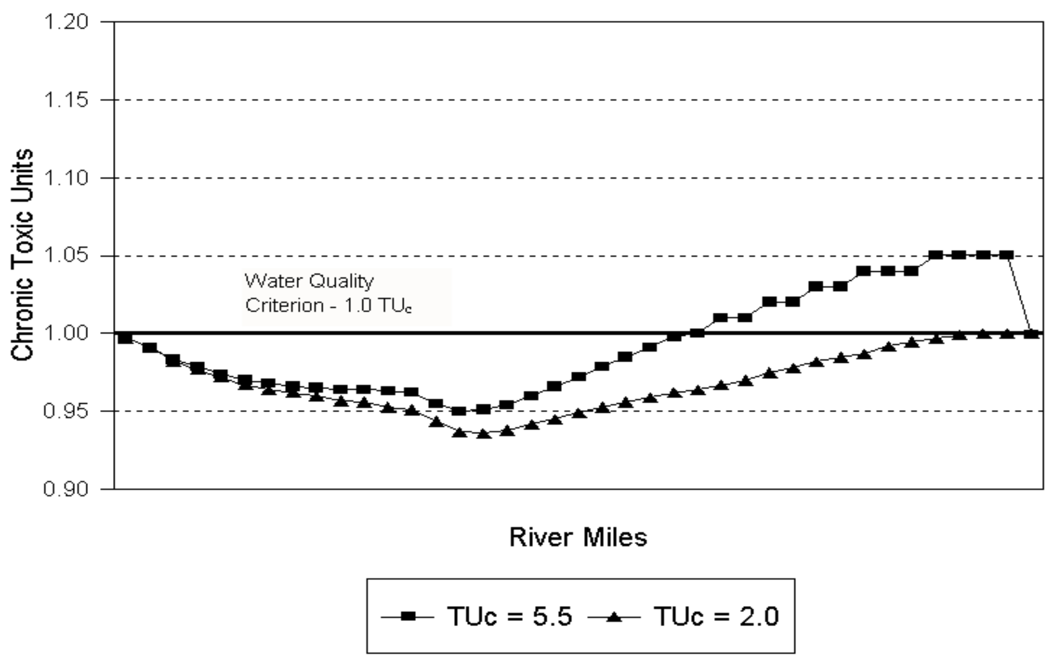


Figure 32 - Baseline Analysis for Trenton



ACUTE TOXICITY

Like chronic toxicity, acute toxicity, also known as whole effluent acute toxicity, is not a specific chemical but rather an integrator of the effects of all chemicals present in an effluent as well as the interactions of those chemicals. It differs from chronic toxicity in that the effect is due to a short-term rather than a long-term exposure.

Phase 1 of this TMDL will be limited to establishing wasteload allocations for acute toxicity only for those discharges that were assigned allocations during the Baseline Analysis for chronic toxicity. This will enable permittees to assess reduction strategies for acute as well as chronic toxicity. The Multiple Discharge Analysis portion of the allocation for this parameter (the assessment of the cumulative area of the estuary that is assigned to mixing areas) will be deferred until Phase 2 of the TMDL is completed in 2002. In the interim period, additional acute wasteload allocations will be developed on a case by case basis, particularly for those discharges that meet the identification criteria specified in Section 4:30.7.B.2.c.3), and where the initial loadings used in the chronic toxicity wasteload allocation were significantly less than the loading suggested by the available data (see page 13).

Identification of Permittees

Ten of the fifty-five discharges that were evaluated in the allocation for chronic toxicity were reduced from initial loadings in the baseline analysis portion of this allocation. These ten discharges were considered as meeting the identification criteria specified in Section 4:30.7.B.2.c.3). Four of the discharges have permit limits for acute toxicity, while the others are included based upon the reasonable potential for acute toxicity to occur in their effluent. There are no U.S. EPA effluent guidelines with acute toxicity as a limiting parameter. The identified discharges and their respective acute toxicity data are listed in Table 16.

Wasteload Allocation Procedure

Establishing wasteload allocations for the protection of aquatic life from acute toxicity is a two-step process which includes baseline and multiple discharge analyses. A near-field hydrodynamic modeling system, specifically modified for tidal water bodies, tidal CORMIX, was utilized for this study, as well as, the equal marginal percent reduction (EMPR) procedure.

Hydraulic Simulations

Information required to simulate the wastefield resulting from each of the discharges includes both ambient data and outfall configuration data. Required ambient data includes the width and depth of the receiving water at the point of discharge, the background ambient velocity (established as 0.117 m/s based upon the design flow for aquatic life criteria of 2500 cfs at Trenton), the tidal range, maximum tidal velocities, and ambient temperature. Required outfall configuration data varies depending on whether the outfall is a surface discharge, a single submerged pipe, or a multiport diffuser. Typical information required for any outfall includes the bank nearest to the discharge point, the water depth at the point of discharge, the diameter of the discharge port, the discharge flow, and effluent temperature. The CORMIX Expert System prompts the user for this data, checks the input against a range of acceptable values, and stores the data for use in model simulations. The modified version of CORMIX also calculates ambient tidal velocities and depths over the tidal cycle using a sinusoidal function, and automatically performs model simulations over the tidal cycle at time steps specified by the user (generally 24 time steps).

Water Quality Simulations

Given the short residence time of pollutants in the effluent plume prior to reaching the edge of the mixing area defined by the regulatory guidelines, no fate processes were considered in the tidal CORMIX simulations. The results of the hydrodynamic simulations for each of the discharges were graphically and statistically analyzed using a post-processor called CMXPOST. This post-processor reads and integrates the dilution predictions from multiple simulations to produce a spatial representation of the dilution contours over a range of tidal conditions. The guideline dimensions specified in Section 4.20.5.A.1.a. of the Commission s regulations are then calculated for the discharge being analyzed and projected in the graphical display. The post-processor also calculates the minimum and average dilution factors at the guideline dimensions.

Baseline Analysis

Ten of the fifty-five discharges that were evaluated in the allocation for chronic toxicity were evaluated in the baseline analysis for acute toxicity. Nine of these discharges had sufficient data to perform tidal CORMIX evaluations. The dilution factors predicted by the tidal CORMIX model over a complete tidal cycle at the most stringent of the distances specified in Section 4.20.5.A.1.a. and d. were then evaluated. For seven of the nine discharges, the minimum and average dilution factors were not significantly different. For these discharges, the tidally-averaged dilution factor was selected as the wasteload allocation dilution factor. For the other two discharges, the average of the minimum and average dilutions factors was selected as the wasteload allocation dilution factor. A dilution factor for the other discharge, Hamilton Township, was calculated from data obtained during a dilution study conducted by the permittee. The WLA factors were then used with the acute toxicity stream quality objective of 0.3 TU_a to calculate an acute toxicity wasteload allocation in TU_a (Table 17). Eight of the ten discharges were reduced from their initial wasteload allocation concentration during the baseline analysis portion of the wasteload allocation. The largest reductions occurred at Philadelphia - NE, Philadelphia - SW and Camden County MUA where the final acute WLAs were 0.7 TU_A. Two of the discharges, City of Trenton and Dupont - Chambers Works were not reduced from their existing permit limit of 2.0 TU_a or existing effluent concentration of 1.2 TU_a, respectively.

Multiple Discharge Analysis - Deferred to Phase 2 of TMDL process.

Conclusion

The wasteload allocations for acute toxicity to protect aquatic life from chronic effects were established by following the procedures specified in Section 4.30.7 of the Commission s Water Quality Regulations. Ten discharges were identified and evaluated in the wasteload allocation exercise. Eight of the ten discharges were reduced from their initial wasteload allocation concentration during the baseline analysis portion of the wasteload allocation.

Table 16: Supporting Data for Dischargers Included in the Wasteload Allocation Study for Acute Toxicity.

PERMITTEE	NPDES #	ELG Facility	DSN	CATEGORIES				Assigned Concentration (TU_a)
				Permit Limit (TU_a)	Effluent Data [TU_a (N) CV]		Minimum Performance Standard	
					Sheepshead Minnow	Fathead Minnow		
Dupont - Chambers Works	NJ0005100	Yes	001	2.0	1.0 (1) -	1.2 (81) 41.61	2.0	1.2
City of Wilmington	DE0020320	No	001	-	-	-	2.0	2.0
Philadelphia SW Plant	PA0026671	No	001	-	-	-	2.0	2.0
Philadelphia SE Plant	PA0026662	No	001	-	-	-	2.0	2.0
Camden County MUA	NJ0026182	No	001	2.0	-	-	2.0	2.0
Philadelphia NE Plant	PA0026689	No	001	-	-	-	2.0	2.0
Lower Bucks County JMUA	PA0026468	No	001	-	-	-	2.0	2.0
Hamilton Township	NJ0026301	No	001	2.0	-	1 (8) 0.00	2.0	2.0
City of Trenton	NJ0020923	No	001	2.0	-	1 (5) 0	2.0	2.0
Morrisville Borough	PA0026701	No	001	-	-	-	2.0	2.0

Table 17: Wasteload Allocations for Acute Toxicity for Delaware River Estuary Discharges.

PERMITTEE	NPDES #	DSN	Mininum Dilution	Average Dilution	Area (m^2)	WLA Dilution Factor	Wasteload Allocation - Tidally Averaged (TU_a)
Dupont - Chambers Works	NJ0005100	001	2.61	3.10	3970	3.1	0.9
City of Wilmington	DE0020320	001	2.74	3.81	8984	3.1	0.9
Philadelphia SW Plant	PA0026671	001	1.20	1.38	2376	1.4	0.4
Philadelphia SE Plant	PA0026662	001	1.25	1.41	4902	1.4	0.4
Camden County MUA	NJ0026182	001	1.08	1.28	284	1.3	0.4
Philadelphia NE Plant	PA0026689	001	1.77	2.07	3848	2.1	0.6
Lower Bucks County JMUA	PA0026468	001	2.36	2.73	754	2.7	0.8
Hamilton Township	NJ0026301	001	Note 1.	Note 1.	-	3.6	1.1
City of Trenton	NJ0020923	001	5.45	6.68	579	6.1	1.8
Morrisville Borough	PA0026701	001	2.06	2.32	705	2.3	0.7

Note 1: Values for Hamilton Township were calculated from data contained in a report prepared for the permittee by HydroQual, Inc. (1987).

TRANSLATION OF WLAs TO PERMIT LIMITATIONS

The final step in establishing effluent limitations for toxic pollutants is the translation of the wasteload allocations developed to assure that aquatic and human health water quality criteria for a toxic pollutant are met, into a single effluent limitation. In accordance with Section 4.30.7.B.2.c.6)., the appropriate permit-issuing agency of the signatory parties is responsible for establishing effluent limitations from the wasteload allocations established by the Commission s Executive Director, as appropriate. The following discussion is provided to inform interested parties of the significant factors involved in establishing effluent limitations in NPDES permits. Since the establishment of the limitations is the responsibility of each of the states, differing procedures may be used providing that they ensure that the wasteload allocations are achieved.

NPDES regulations (40 CFR Part 122.45(d)) require all permit limits to be expressed as both average monthly and daily maximum values for all discharges including Publicly-Owned Treatment Works (POTWs) for toxic pollutants. The procedures for calculating these values are contained in Section 5 (Permit Requirements) of the Technical Support Document for Water Quality-Based Toxics Control (U.S. EPA, 1991), and are summarized below.

The first step in the translation process is the determination of the most stringent wasteload allocation (WLA). In the case of the volatile organics that are the subject of this report, the carcinogen-based WLA is the most stringent. For chronic and acute toxicity, the U.S. EPA recommends that the acute WLA be converted into chronic toxicity units for comparison to the chronic toxicity WLA. This approach assumes that similar toxicants with similar ratios between their acute and chronic toxicity values are the source of the toxicity. This assumption is not supported by the experience of the New Jersey Department of Environmental Protection which has effectively controlled the acute toxicity of discharges to the estuary, but continues to observe high levels of chronic toxicity. Furthermore, the lack of a mixing zone for chronic toxicity, and the use of a four day average concentration for comparison to the stream quality objective is not consistent with this assumption. Therefore, WLAs for both chronic and acute toxicity should be used to develop effluent limitations for each parameter.

The WLA is first converted to a long-term average concentration (LTA). In the case of chronic toxicity which is a 4 day WLA, the following formula is used:

$$LTA_{chronic} = WLA_{chronic} \times e^{\left(0.5\,\sigma_4^2 - z\sigma_4\right)}$$

where:

$LTA_{chronic}$ =	Long-term average chronic toxicity of the discharge.
$WLA_{chronic}$ =	Four day average chronic toxicity of the discharge.
σ_4 =	Square of the standard deviation of the chronic toxicity of the discharge [equal to ln $(CV^2 / 4 + 1)$].
z =	2.326 for 99^{th} percentage probability of occurrence.

For a coefficient of variation (CV) of 0.6, the second term of this equation reduces to 0.527.

In the case of acute toxicity which is usually implemented as a 1 day WLA, the following formula is used:

$$LTA_{acute} = WLA_{acute} \times e^{\left(0.5\,\sigma^{2} - z\sigma\right)}$$

where:

LTA_{acute} =	Long-term average acute toxicity of the discharge.
WLA_{acute} =	Four day average chronic toxicity of the discharge.
σ =	Square of the standard deviation of the acute toxicity of the discharge [equal to ln $(CV^2 + 1)$].
z =	2.326 for 99th percentage probability of occurrence.

For a coefficient of variation (CV) of 0.6, the second term of this equation reduces to 0.321.

Permit limits in the form of a Maximum Daily Limit (MDL) and Average Monthly Limit (AML) are calculated from the LTA. For carcinogen-based WLAs, the AML is set equal to the WLA. A Maximum Daily Limit can be calculated from the AML by using a multiplier derived from the following formula:

$$\frac{MDL}{AML} = \frac{e^{\left(z_m\sigma - 0.5\,\sigma^{2}\right)}}{e^{\left(z_a\sigma_n - 0.5\,\sigma_n^{2}\right)}}$$

where:

AML =	Average Monthly Limit for parameter of interest.
MDL =	Maximum Daily Limit for parameter of interest.
σ^2 =	equal to ln $(CV^2 + 1)$].
σ_n^2 =	equal to ln $(CV^2 / n + 1)$].
n =	Number of samples per month.
z_m =	2.326 for 99th percentage probability of occurrence.
z_a =	1.645 for 95th percentage probability of occurrence.

A table of multipliers is presented on page 106 in U.S. EPA (1991). For example, a WLA of 18 μg/l for a volatile organic chemical would result in an AML of 18 μg/l. The MDL would be 31 μg/l if two samples per month were required and the CV of the effluent concentration was 0.6.

For chronic and acute toxicity, the LTA is converted into an average monthly limit (AML) using the following formula:

$$AML = LTA \times e^{\left(z\sigma_n - 0.5\,\sigma_n^{2}\right)}$$

where:

AML =	Average Monthly Limit for parameter of interest.
LTA =	Long-term average concentration of the parameter in the discharge.
σ_n =	Square of the standard deviation of the parameter in the discharge [equal to $\ln (CV^2 / n + 1)$].
n =	Number of samples per month.
z =	1.645 for 95^{th} percentage probability of occurrence.

For a coefficient of variation (CV) of 0.6 and 1 sample per month, the second term of this equation reduces to 2.13. For example, a $WLA_{chronic}$ of 2.0 Toxic Units for a discharge would result in a LTA of 1.1 Toxic Units, and a AML of 2.2 Toxic Units if one sample per month was required and the CV of the discharge was 0.6.

Maximum Daily Limits (MDL) for chronic and acute toxicity can be established using the following formula:

$$MDL = LTA \times e^{\left(z\sigma - 0.5\sigma^2\right)}$$

where:

MDL =	Maximum Daily Limit for parameter of interest.
LTA =	Long-term average concentration of the parameter in the discharge.
σ =	Square of the standard deviation of the parameter in the discharge [equal to $\ln (CV^2 + 1)$].
z =	2.326 for 99^{th} percentage probability of occurrence.

For a coefficient of variation (CV) of 0.6, the second term of this equation reduces to 3.11. For example, a WLA_{acute} of 2.0 Toxic Units for a discharge would result in a LTA of 0.64 Toxic Units, and a MDL of 2.0 Toxic $Units_{acute}$ if the CV of the discharge was 0.6.

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Appendix

Input Data and Graphical Displays for Tidal Cormix Simulations

CORMIX2 -- Submerged multiport diffuser discharges -- CORMIX2

SITE/CASE IDENTIFIER:		Date prepared:
SITE Name	Dupont - Chambers Works	1/27/95 (3/10/95)
Design CASE	Tidal Simulation	Prepared by:
DOS FILE NAME	DUP2-F01	T. Fikslin (SH)

TIDAL DATA:			Is this a tidal simulation?	yes	
Tidal height range (H_r)	1.7	m	Phase difference between tidal current and height	90	°
Maximum amplitude of the tidal current (U_t)	1.54	m/s	Number of STEPS	24	

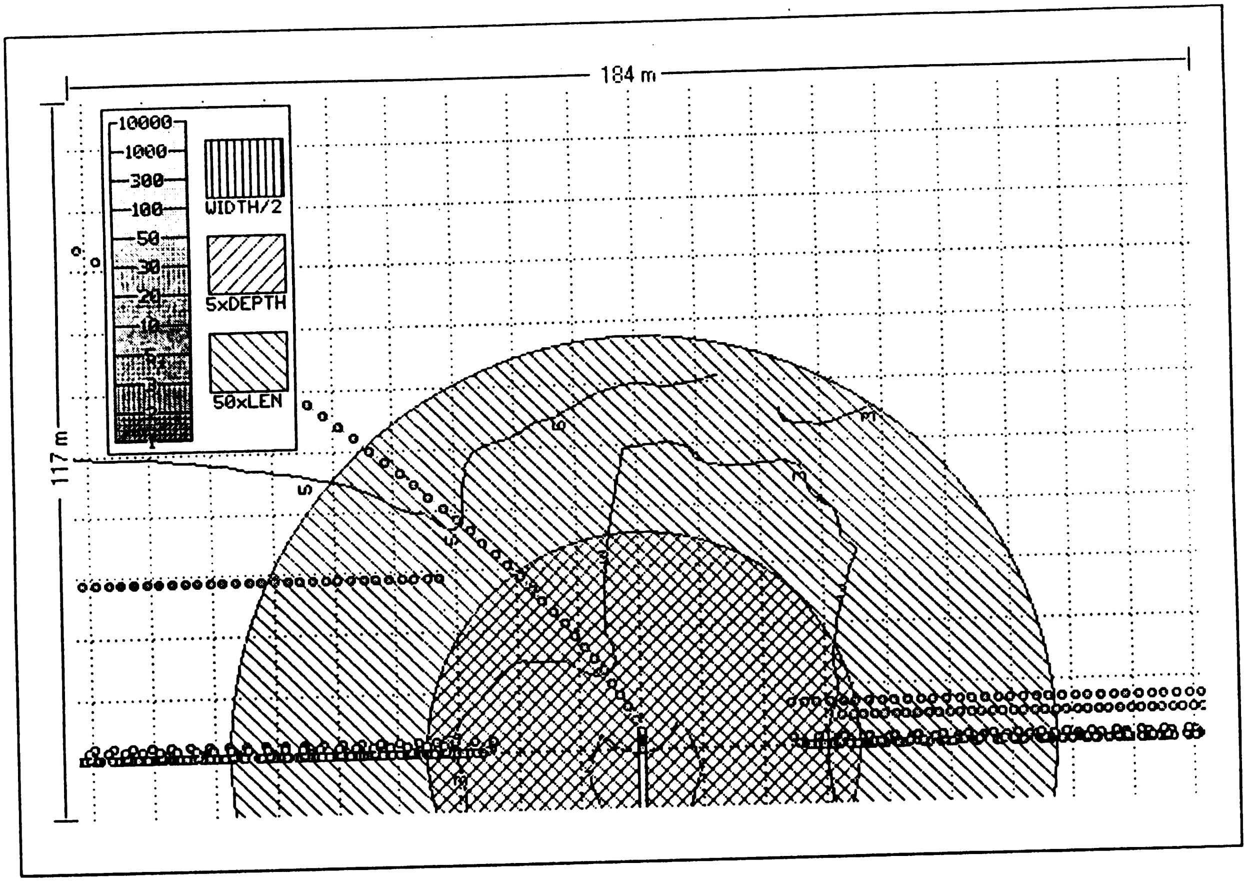
AMBIENT DATA:			Bounded or unbounded	bounded	
Water body depth (H_a)	7.11	m	Water body width (W)	2080	m
Depth at discharge (H_d)	5.1	m	Appearance (1 / 2 / 3)?	1	
Ambient flowrate (Q_a)	---	m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.01		*or:* Darcy-Weisbach f	---	
Wind Speed	2	m/s			

Density data:			UNITS: Density...kg/m^3 / Temperature...°C		
Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density / temp.	20	
If stratified:			Stratification type (A / B / C)?	---	
Density/temp. at surface	---		*If B/C:* Pycnocline height	---	m
Density/temp. at bottom	---		*If C:* Density/temp. jump	---	m

DISCHARGE DATA:					
Geometry data:					
Nearest bank (left / right)?	left		Distance to one endpoint	9.1	m
Diffuser length (L_D)	6.1	m	to other endpoint	9.1	m
Total number of openings	4				
Port diameter (D)	0.76	m	width contraction ratio	1	
Diffuser arrangement / type (unidirectional / staged / alternating or vertical)				unidirect.	
Alignment angle (GAMMA)	0	°	Horizontal angle (SIGMA)	270	°
Vertical angle (THETA)	0	°	Relative orientation (BETA)	90	°
Port height (h_o)	1.4	m			

Effluent data:					
Effluent flow rate	2.92	m^3/s	*or:* Effluent velocity	---	m/s
Effluent density	---	kg/m^3	*or:* Effluent temperature	22	°C
Heated discharge (yes/no)?	no		*If yes:* Heat loss ($W/m^2\cdot°C$)	---	
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no:* Decay coefficient	---	/day

MIXING ZONE DATA:					
Is effluent toxic (yes / no)?	no		*If yes:* CMC value	---	
			CCC value	---	
Is there a WQ standard for conventional pollutant?	no		*If yes:* value of standard	---	
Any mixing zone specified?	yes		*If yes:* distance	---	m
			or width (% or m)	50%	
Region of interest	25000	m	or area (% or m^2)	---	
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info

CORMIX Case Description

Site name:	Dupont - Chambers Works
Design case:	DRBC Tidal Run - 01 Final
File name:	cormix\sim\dup2-f01.cx2
Time of FORTRAN run:	03/14/95–22:28:35

Tidal CORMIX Information

Tidal height range (m):	1.7
Maximum tidal current (m/s):	1.54
Phase difference (degrees):	90
Number of steps:	24

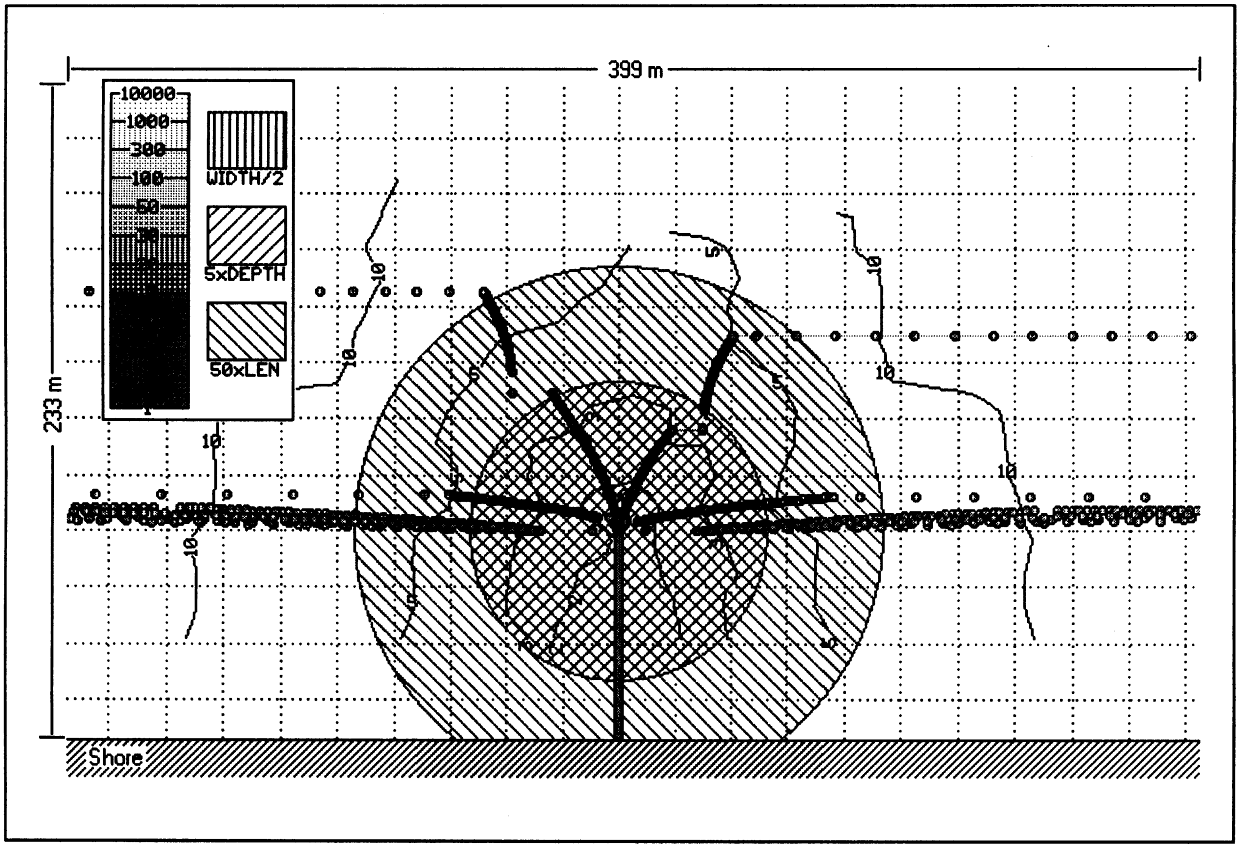
Regulatory Information

	Minimum Dilution	Average Dilution
5 x depth (35.55 m)	2.61	3.10
50 x length (67.50 m)	3.02	4.22
50% x width (1040.00 m)	137.70	146.45

	Minimum Distance	Average Distance
50% x width	11619 m	12040 m

CORMIX1 -- Submerged Single Port Discharges -- CORMIX1

SITE/CASE IDENTIFIER:			Date prepared:		
SITE Name	Wilmington STP			9/26/94 (3/6/95)	
Design **CASE**	Tidal Simulation		Prepared by:		
DOS **FILE NAME**	WIL1-F02			T. Fikslin (SH)	
TIDAL DATA:			Is this a tidal simulation?	yes	
Tidal height range (H_r)	1.67	m	Phase difference between		
Maximum amplitude			tidal current and height	90	°
of the tidal current (U_t)	1.55	m/s	Number of STEPS	23	
AMBIENT DATA:			Bounded or unbounded	bounded	
Water body depth (H_a)	8.3	m	Water body width (W)	2400	m
Depth at discharge (H_d)	10.7	m	Appearance (1 / 2 / 3)?	1	
Ambient flowrate (Q_a)	---	m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.028		*or:* Darcy-Weisbach f	---	
Wind Speed	2	m/s			
Density data:			**UNITS: Density...kg/m³ / Temperature...°C**		
Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density/temp.	20	
If stratified:			Stratification type (A / B / C)?	---	
Density/temp. at surface	---		*If B/C:* Pycnocline height	---	m
Density/temp. at bottom	---		*If C:* Density/temp. jump	---	m
DISCHARGE DATA:					
Geometry data:					
Discharge is on (left / right)	right	bank	Distance to nearest bank	73.2	m
Vertical angle (THETA)	0	°	Horizontal angle (SIGMA)	90	°
Port diameter (D)	2.13	m	*or:* Port area	---	m^2
Port height (h_o)	1.066	m			
Effluent data:					
Effluent flow rate	3.77	m^3/s	*or:* Effluent velocity	---	m/s
Effluent density	---	kg/m^3	*or:* Effluent temperature	22	°C
Heated discharge (yes/no)?	no		*If yes:* Heat loss ($W/m^2 \cdot °C$)	---	
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no:* Decay coefficient	---	/day
MIXING ZONE DATA:					
Is effluent toxic (yes / no)?	no		*If yes:* CMC value	---	
			CCC value	---	
Is there a WQ standard for conventional pollutant?	no		*If yes:* value of standard	---	
Any mixing zone specified?	yes		*If yes:* distance	---	m
			or width (% or m)	50%	
Region of interest	24000	m	or area (% or m^2)	---	
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info	
CORMIX Case Description	
Site name:	Wilmington
Design case:	Tidal
File name:	cormix\sim\WIL1-F02.cx1
Time of FORTRAN run:	01/12/99–15:30:20
Tidal CORMIX Information	
Tidal height range (m):	1.67
Maximum tidal current (m/s):	1.55
Phase difference (degrees):	90
Number of steps:	23

Regulatory Information

	Minimum Dilution	Average Dilution
5 x depth (53.47 m; 8984 m2)	2.82	3.79
50 x length (94.38 m; 26261 m2)	4.61	5.91
50% x width (1200.00 m; 1.2e+08 m2)	99999.00	

	Minimum Distance	Average Distance
50% x width	99999 m	

Interpolation uses a search distance of 50 m.

CORMIX2 -- Submerged multiport diffuser discharges -- CORMIX2

SITE/CASE IDENTIFIER:

SITE Name	Philadelphia SW	Date prepared:	12/13/94 (1/26/95)
Design **CASE**	Tidal Simulation	Prepared by:	T. Fikslin (SH)
DOS **FILE NAME**	PSW2-F01		

TIDAL DATA:

			Is this a tidal simulation?	yes	
Tidal height range (H_r)	1.74	m	Phase difference between tidal current and height	90	°
Maximum amplitude of the tidal current (U_t)	0.93	m/s	Number of STEPS	24	

AMBIENT DATA:

			Bounded or unbounded	bounded	
Water body depth (H_a)	5.5	m	Water body width (W)	1200	m
Depth at discharge (H_d)	4.6	m	Appearance (1 / 2 / 3)?	1	
Ambient flowrate (Q_a)	---	m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.028		*or:* Darcy-Weisbach f	---	
Wind Speed	2	m/s			

Density data: — **UNITS: Density...kg/m^3 / Temperature...°C**

Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density / temp.	20	
If stratified:			Stratification type (A / B / C)?	---	
Density/temp. at surface	---		*If B/C:* Pycnocline height	---	m
Density/temp. at bottom	---		*If C:* Density/temp. jump	---	m

DISCHARGE DATA:

Geometry data:

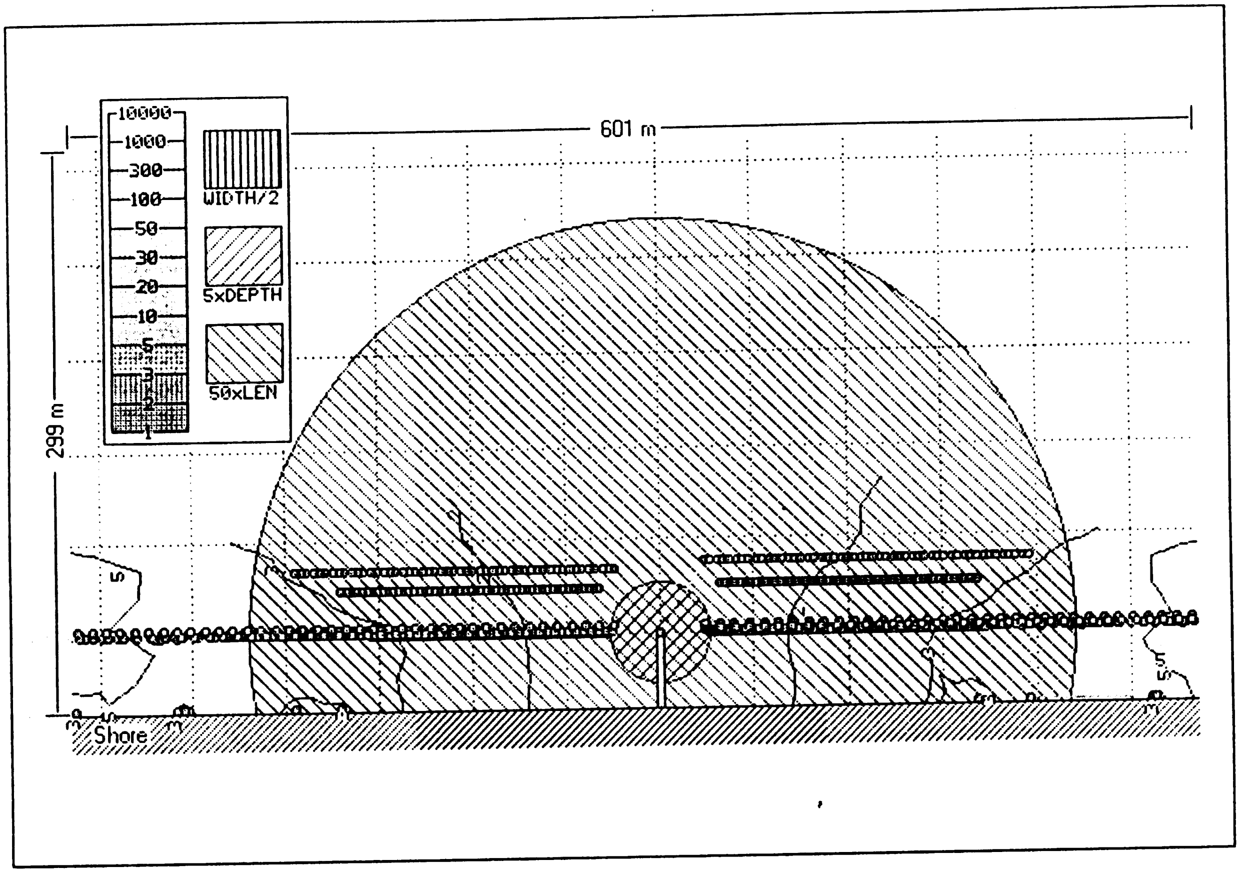
Nearest bank (left / right)?	right		Distance to one endpoint	38.1	m
Diffuser length (L_D)	10.36	m	to other endpoint	38.1	m
Total number of openings	3				
Port diameter (D)	2.88	m	width contraction ratio	1	
Diffuser arrangement / type (unidirectional / staged / alternating or vertical)				unidirect.	
Alignment angle (GAMMA)	0	°	Horizontal angle (SIGMA)	90	°
Vertical angle (THETA)	-45	°	Relative orientation (BETA)	90	°
Port height (h_o)	0.8	m			

Effluent data:

Effluent flow rate	8.76	m^3/s	*or:* Effluent velocity	---	m/s
Effluent density	---	kg/m^3	*or:* Effluent temperature	22	°C
Heated discharge (yes/no)?	no		*If yes:* Heat loss ($W/m^2 \cdot °C$)	---	
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no:* Decay coefficient	---	/day

MIXING ZONE DATA:

Is effluent toxic (yes / no)?	no		*If yes:* CMC value	---	
			CCC value	---	
Is there a WQ standard for conventional pollutant?	no		*If yes:* value of standard	---	
Any mixing zone specified?	yes		*If yes:* distance	---	m
			or width (% or m)	50%	
Region of interest	15000	m	or area (% or m^2)	---	
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info

CORMIX Case Description

Site name: Philadelphia SW
Design case: DRBC Tidal Run - 01 Final
File name: cormix\sim\psw2-f01.cx2
Time of FORTRAN run: 03/14/95–21:39:56

Tidal CORMIX Information

Tidal height range (m): 1.74
Maximum tidal current (m/s): .93
Phase difference (degrees): 90
Number of steps: 24

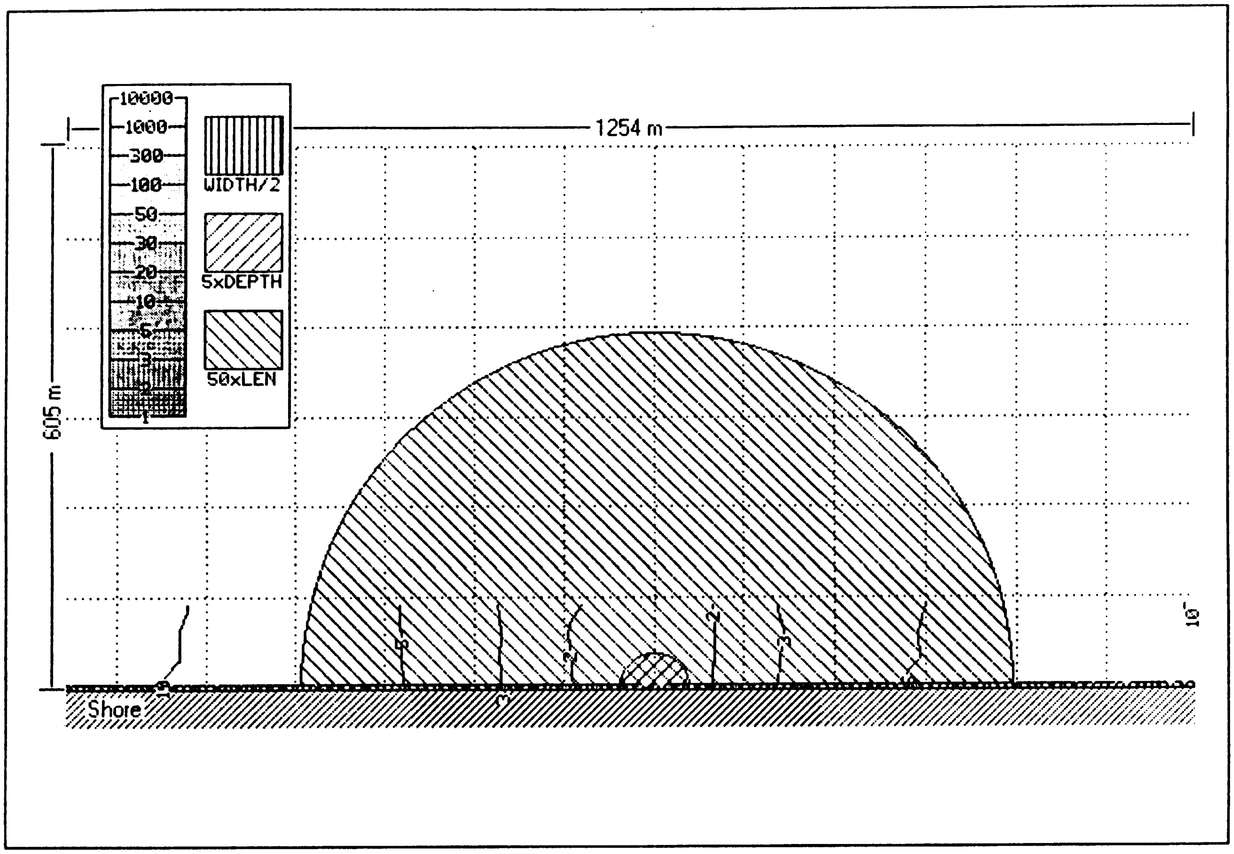
Regulatory Information

	Minimum Dilution	Average Dilution
5 x depth (27.50 m)	1.20	1.38
50 x length (221.00 m)	2.20	3.32
50% x width (600.00 m)	21.70	28.40

	Minimum Distance	Average Distance
50% x width	2862 m	5458 m

CORMIX3 -- Buoyant Surface Discharges -- CORMIX3

SITE/CASE IDENTIFIER:			Date prepared:	9/26/94 (3/6/95)	
SITE Name	Philadelphia SE		Prepared by:	T. Fikslin (SH)	
Design **CASE**	Tidal Simulation				
DOS **FILE NAME**	PSE3-F01				
TIDAL DATA:			Is this a tidal simulation?	yes	
Tidal height range (H_r)	1.6	m	Phase difference between tidal current and height	90	°
Maximum amplitude of the tidal current (U_t)	0.93	m/s	Number of STEPS	24	
AMBIENT DATA:			Bounded or unbounded	bounded	
Water body depth (H_a)	7.9	m	Water body width (W)	805	m
Depth at discharge (H_d)	7.9	m	Appearance (1 / 2 / 3)?	1	
Ambient flowrate (Q_a)	---	m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.02		*or:* Darcy-Weisbach f	---	
Wind Speed	2	m/s			
Density data:			**UNITS: Density...kg/m^3 / Temperature...°C**		
Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density / temp.	20	
If stratified:			Stratification type (A / B / C)?	---	
Density/temp. at surface	---		*If B/C:* Pycnocline height	---	m
Density/temp. at bottom	---		*If C:* Density/temp. jump	---	m
DISCHARGE DATA:					
Geometry data:			Configuration type is		
Discharge is on (left / right)	right	bank	(flush/protruding/co-flowing)	flush	
Horizontal angle (SIGMA)	90	°	*If protruding:* Dist. from bank	na	m
Depth at discharge	7.9	m	Bottom slope	0	°
If rectangular Width (b_o)	45.2	m	*If circular* Diameter (D)	na	m
disch. channel: Depth (h_o)	3.06	m	*pipe:* Bottom invert depth (h_o)	na	m
Effluent data:					
Effluent flow rate	4.91	m^3/s	*or:* Effluent velocity	---	m/s
Effluent density	---	kg/m^3	*or:* Effluent temperature	22	°C
Heated discharge (yes/no)?	no		*If yes:* Heat loss ($W/m^2 \cdot °C$)	---	
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no:* Decay coefficient	---	/day
MIXING ZONE DATA:					
Is effluent toxic (yes / no)?	no		*If yes:* CMC value	---	
			CCC value	---	
Is there a WQ standard for conventional pollutant?	no		*If yes:* value of standard	---	
Any mixing zone specified?	yes		*If yes:* distance	---	m
			or width (% or m)	50%	
Region of interest	10000	m	or area (% or m^2)	---	
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info

CORMIX Case Description

Site name: Philadelphia SE
Design case: DRBC Tidal Run - 01 Final
File name: cormix\sim\pse3-f01.cx3
Time of FORTRAN run: 03/14/95–13:55:47

Tidal CORMIX Information

Tidal height range (m): 1.6
Maximum tidal current (m/s): .93
Phase difference (degrees): 90
Number of steps: 24

Regulatory Information

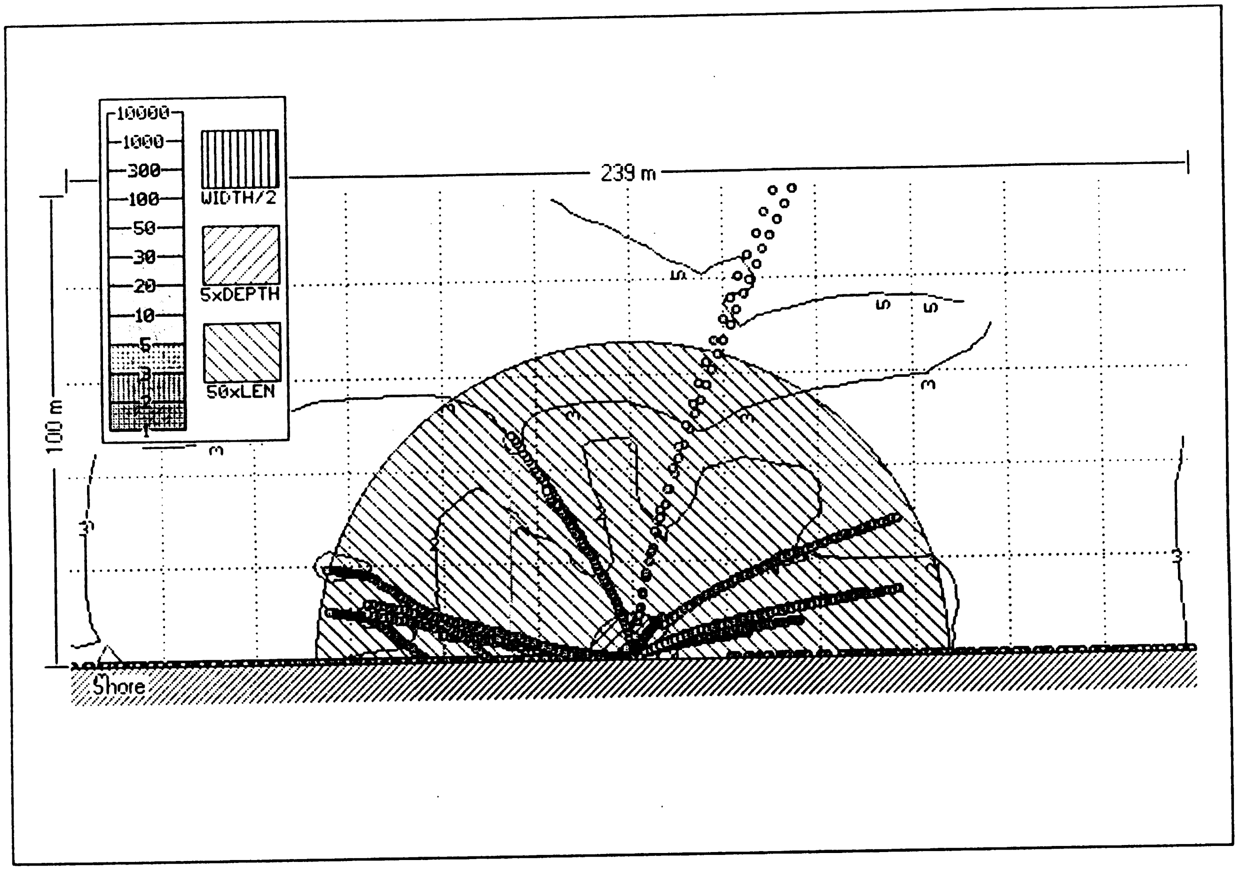
	Minimum Dilution	Average Dilution
5 x depth (39.50 m)	1.25	1.41
50 x length (395.50 m)	6.40	7.17
50% x width (402.50 m)	8.30	9.57

	Minimum Distance	Average Distance
50% x width	2229 m	2315 m

CORMIX3 -- Buoyant Surface Discharges -- CORMIX3

SITE/CASE IDENTIFIER:			Date prepared:	
SITE Name	Camden County MUA			12/14/94 (3/6/95)
Design **CASE**	Tidal Simulation		Prepared by:	
DOS **FILE NAME**	CAM3-F02			R. Wu (SH)

TIDAL DATA:			Is this a tidal simulation?	yes	
Tidal height range (H_r)	0.762	m	Phase difference between		
Maximum amplitude			tidal current and height	90	°
of the tidal current (U_t)	0.67	m/s	Number of STEPS	24	
AMBIENT DATA:			Bounded or unbounded	bounded	
Water body depth (H_a)	1.905	m	Water body width (W)	804.7	m
Depth at discharge (H_d)	1.905	m	Appearance (1 / 2 / 3)?	1	
Ambient flowrate (Q_a)	---	m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.02		*or:* Darcy-Weisbach f	---	
Wind Speed	2	m/s			
Density data:			**UNITS: Density...kg/m³ / Temperature...°C**		
Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density / temp.	20	
If stratified:			Stratification type (A / B / C)?	---	
Density/temp. at surface	---		*If B/C:* Pycnocline height	---	m
Density/temp. at bottom	---		*If C:* Density/temp. jump	---	m
DISCHARGE DATA:					
Geometry data:			Configuration type is		
Discharge is on (left / right)	left	bank	(flush/protruding/co-flowing)	flush	
Horizontal angle (SIGMA)	90	°	*If protruding:* Dist. from bank	na	m
Depth at discharge (H_d)	1.905	m	Bottom slope	0	°
If rectangular Width (b_o)	na	m	*If circular* Diameter (D)	1.524	m
disch. channel: Depth (h_o)	na	m	*pipe:* Bottom invert depth (h_o)	1.524	m
Effluent data:					
Effluent flow rate	1.48	m^3/s	*or:* Effluent velocity	---	m/s
Effluent density	---	kg/m^3	*or:* Effluent temperature	22	°C
Heated discharge (yes/no)?	no		*If yes:* Heat loss ($W/m^2 \cdot °C$)	---	
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no:* Decay coefficient	---	/day
MIXING ZONE DATA:					
Is effluent toxic (yes / no)?	no		*If yes:* CMC value	---	
			CCC value	---	
Is there a WQ standard for conventional pollutant?	no		*If yes:* value of standard	---	
Any mixing zone specified?	yes		*If yes:* distance	---	m
			or width (% or m)	50%	
Region of interest	10000	m	or area (% or m^2)	---	
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info	
CORMIX Case Description	
Site name:	Camden County MUA
Design case:	DRBC Tidal Run - 02 Final
File name:	cormix\sim\cam3-f02.cx3
Time of FORTRAN run:	07/26/95–16:41:46
Tidal CORMIX Information	
Tidal height range (m):	.762
Maximum tidal current (m/s):	.67
Phase difference (degrees):	90
Number of steps:	24

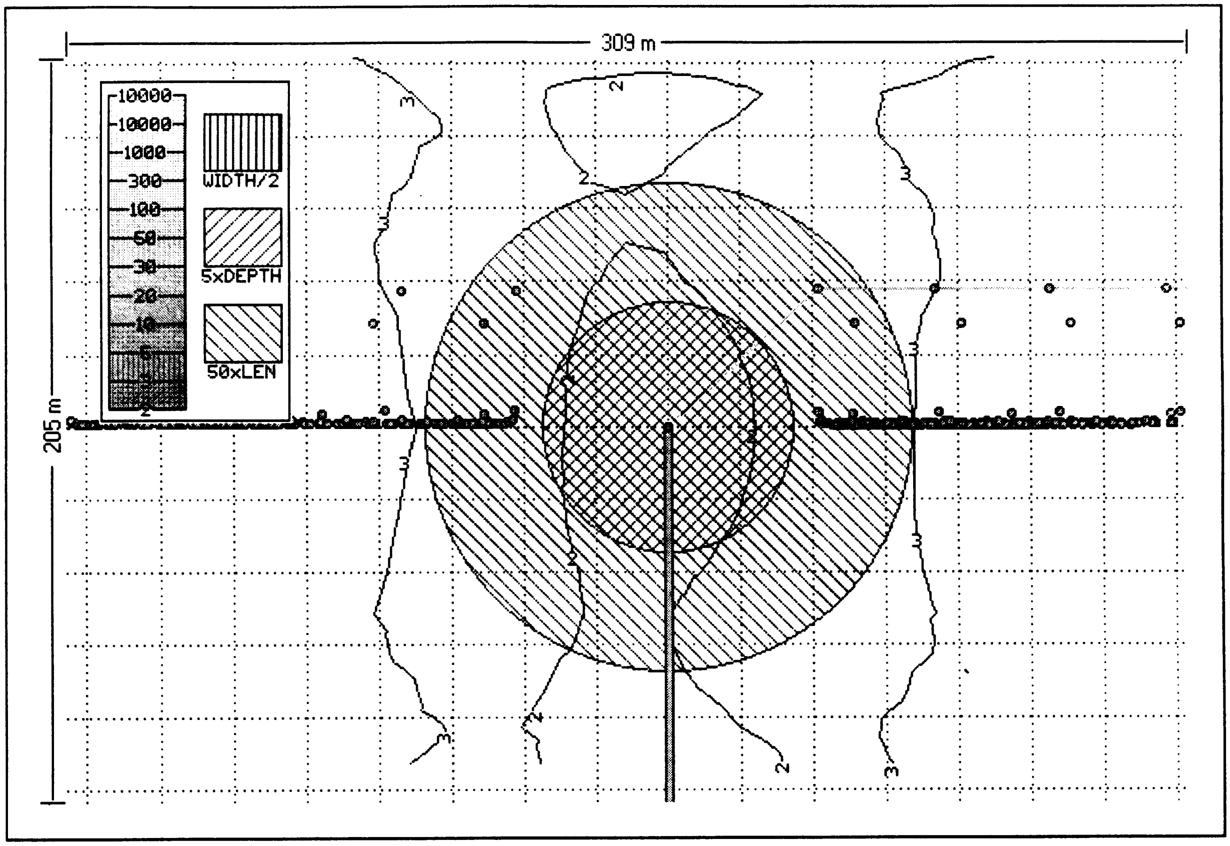
Regulatory Information

	Minimum Dilution	Average Dilution
5 x depth (9.50 m)	1.08	1.28
50 x length (67.50 m)	1.95	2.76
Width	n/a	

	Minimum Distance	Average Distance
Width	n/a	

CORMIX2 -- Submerged multiport diffuser discharges -- CORMIX2

SITE/CASE IDENTIFIER:		Date prepared:	
SITE Name	Philadelphia NE		4/29/96
Design **CASE**	Case 3	Prepared by:	
DOS **FILE NAME**	Cormix\sim\PHIL3-NE.cx2		T. Fikslin
TIDAL DATA:		Is this a tidal simulation?	Yes
Tidal height range (H_r)	1.94 m	Phase difference between	
Maximum amplitude		tidal current and height	90 °
of the tidal current (U_t)	0.93 m/s	Number of STEPS	24
AMBIENT DATA:		Bounded or unbounded	Bounded
Water body depth (H_a)	7.0 m	Water body width (W)	805 m
Depth at discharge (H_d)	7.0 m	Appearance (1 / 2 / 3)?	1
Ambient flow rate (Q_a)	- m^3/s	*or:* Ambient velocity (U_a)	0.12
Manning's n	0.028	*or:* Darcy-Weisbach f	-
Wind speed	0 m/s		
Density data:		**UNITS: Density...kg/m³ / Temperature...°C**	
Water body (fresh / salt)?	Fresh	Specify density or temp. ?	Temp
If uniform		Average density/temp.	20
If stratified:		Stratification type (A / B / C)?	-
Density/temp. at surface	-	*If B/C:* Pycnocline height	- m
Density/temp. at bottom	-	*If C:* Density/temp. jump	- m
DISCHARGE DATA:			
Geometry data:			
Nearest bank (left / right)?	Right	Distance to one endpoint	186 m
Diffuser length (L_D)	23 m	to other endpoint	186 m
Port diameter (D)	1.524 m	width contraction ratio	
Diffuser arrangement / type (unidirectional / staged / alternating or vertical)			Unidirectional
Alignment angle	0 °	Horizontal angle (SIGMA)	90 °
Vertical Angle (THETA)	0 °	Relative orientation (BETA)	90 °
Port height (h_o)	0.762 m		
Effluent data:			
Effluent flow rate	9.2 m^3/s	*or:* Effluent velocity	-
Effluent density	- kg/m^3	*or:* Effluent temperature	25 °C
Heated discharge	No	*If yes:* Heat loss ($W/m^2 \cdot {}^\circ C$)	-
Concentration units	Percent	Effluent concentration	100
Conservative substance?	Yes	*If no:* Decay coefficient	-
MIXING ZONE DATA:			
Is effluent toxic (yes/no)?	No	*If yes:* CMC value	-
		CCC value	-
Is there a WQ standard			
conventional pollutant?	No	*If yes:* value of standard	-
Any mixing zone	No	*If yes:* distance	- m
		or width (% or m)	-
Region of interest	10,000 m	or area (% or m^2)	-
Grid intervals for display	30		



Tidal CORMIX Postprocessor Site Info

CORMIX Case Description

Site name: Philadelphia NE
Design case: Case 3
File name: cormix\sim\PHIL3-NE.cx2
Time of FORTRAN run: 04/29/96–11:46:18

Tidal CORMIX Information

Tidal height range (m): 1.94
Maximum tidal current (m/s): 0.93
Phase difference (degrees): 90
Number of steps: 24

Regulatory Information

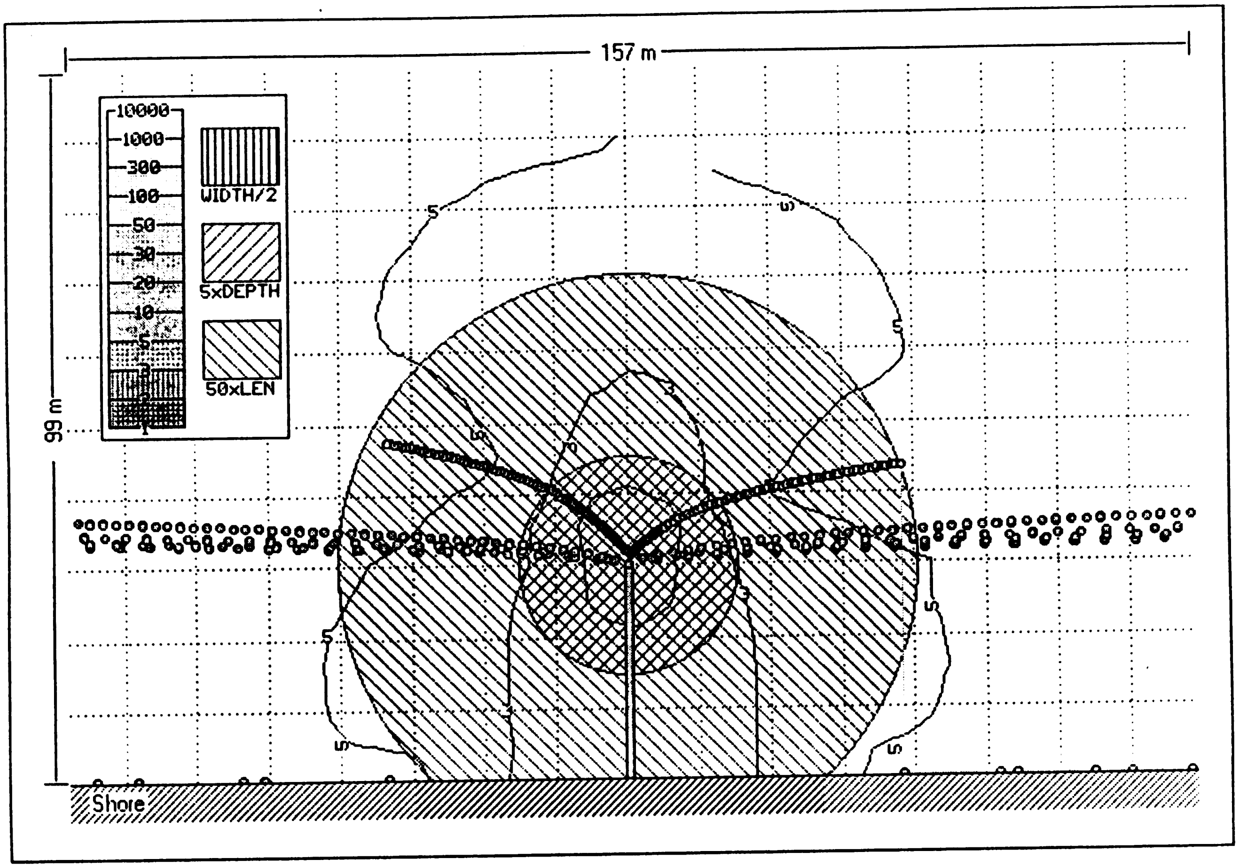
	Minimum Dilution	Average Dilution
5 x depth (35.00 m; 3848 m2)	1.77	2.07
50 x length (67.53 m; 14327 m2)	1.89	2.47
50% x width (402.50 m; 336490 m2)	6.70	7.05

	Minimum Distance	Average Distance
50% x width	836 m	848 m

Interpolation uses a search distance of 100 m.

CORMIX3 -- Buoyant Surface Discharges -- CORMIX3

SITE/CASE IDENTIFIER:			Date prepared:	12/6/94 (5/95)	
SITE Name	Lower Bucks County		Prepared by:	T. Fikslin (SH)	
Design **CASE**	Tidal Simulation				
DOS **FILE NAME**	LBC3-F12				
TIDAL DATA:			Is this a tidal simulation?	yes	
Tidal height range (H_r)	0.455	m	Phase difference between tidal current and height	90	°
Maximum amplitude of the tidal current (U_t)	0.82	m/s	Number of STEPS	24	
AMBIENT DATA:			Bounded or unbounded	bounded	
Water body depth (H_a)	3.0	m	Water body width (W)	300	m
Depth at discharge (H_d)	3.0	m	Appearance (1 / 2 / 3)?	3	
Ambient flowrate (Q_a)	---	m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.028		*or:* Darcy-Weisbach f	---	
Wind Speed	2	m/s			
Density data:			**UNITS: Density...kg/m^3 / Temperature...°C**		
Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density / temp.	20	
If stratified:			Stratification type (A / B / C)?	---	
Density/temp. at surface	---		*If B/C:* Pycnocline height	---	m
Density/temp. at bottom	---		*If C:* Density/temp. jump	---	m
DISCHARGE DATA:					
Geometry data:			Configuration type is (flush/protruding/co-flowing)	protruding	
Discharge is on (left / right)	right	bank	*If protruding:* Dist. from bank	29.3	m
Horizontal angle (SIGMA)	90	°	Bottom slope	10	°
Depth at discharge (H_d)	3.0	m			
If rectangular Width (b_o)	---	m	*If circular* Diameter	0.91	m
disch. channel: Depth (h_o)	---	m	*pipe:* Bottom invert depth (h_o)	0.91	m
Effluent data:					
Effluent flow rate	0.44	m^3/s	*or:* Effluent velocity	---	m/s
Effluent density	---	kg/m^3	*or:* Effluent temperature	22	°C
Heated discharge (yes/no)?	no		*If yes:* Heat loss ($W/m^2 \cdot °C$)	---	
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no* Decay coefficient	---	/day
MIXING ZONE DATA:					
Is effluent toxic (yes / no)?	no		*If yes* CMC value	---	
			CCC value	---	
Is there a WQ standard for conventional pollutant?	no		*If yes* value of standard	---	
Any mixing zone specified?	yes		*If yes* distance	---	m
			or width (% or m)	50%	
Region of interest	10000	m	or area (% or m^2)	---	
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info

CORMIX Case Description

Site name: Lower Bucks County

Design case: DRBC Tidal Run - 12 Final

File name: cormix\sim\lbc3-f12.cx3

Time of FORTRAN run: 04/04/95–13:02:23

Tidal CORMIX Information

Tidal height range (m): .455

Maximum tidal current (m/s): .82

Phase difference (degrees): 90

Number of steps: 24

Regulatory Information

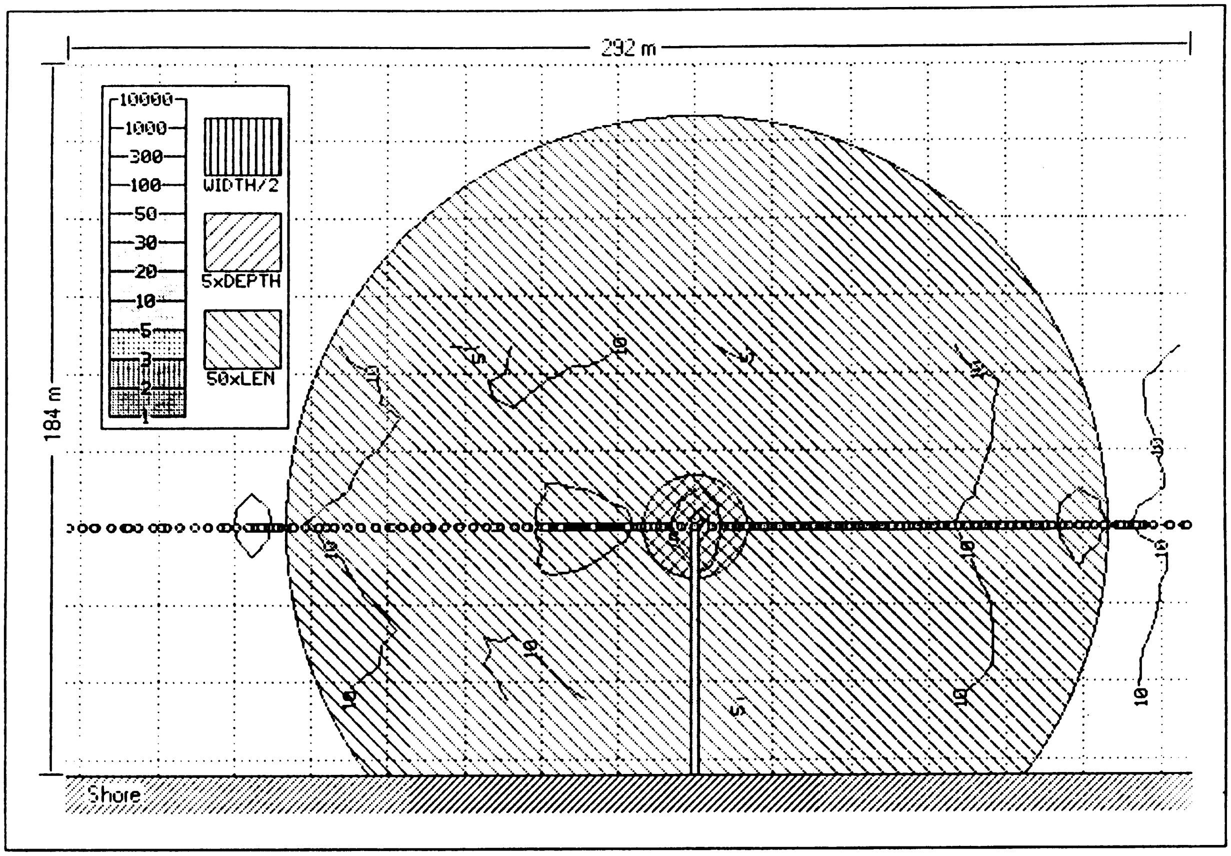
	Minimum Dilution	Average Dilution
5 x depth (15.49 m)	2.36	2.73
50 x length (40.50 m)	3.24	4.47
50% x width (150.00 m)	107.70	107.70

	Minimum Distance	Average Distance
50% x width	5708 m	5708 m

CORMIX2 -- Submerged multiport diffuser discharges -- CORMIX2

SITE/CASE IDENTIFIER:		Date prepared:	12/6/94 (3/9/95)
SITE Name	City of Trenton		
Design **CASE**	Tidal Simulation	Prepared by:	R. Wu (SH)
DOS **FILE NAME**	TRN2-F01		

TIDAL DATA:			Is this a tidal simulation?	yes	
Tidal height range (H_r)	2.07	m	Phase difference between tidal current and height	90	°
Maximum amplitude of the tidal current (U_t)	0.72	m/s	Number of STEPS	24	
AMBIENT DATA:			Bounded or unbounded	bounded	
Water body depth (H_a)	2.72	m	Water body width (W)	265	m
Depth at discharge (H_d)	2.49	m	Appearance (1 / 2 / 3)?	1	
Ambient flowrate (Q_a)	---	m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.04		*or:* Darcy-Weisbach f	---	
Wind Speed	2	m/s			
Density data:			**UNITS: Density...kg/m^3 / Temperature...°C**		
Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density / temp.	20	
If stratified:			Stratification type (A / B / C)?	---	
Density/temp. at surface	---		*If B/C:* Pycnocline height	---	m
Density/temp. at bottom	---		*If C:* Density/temp. jump	---	m
DISCHARGE DATA:					
Geometry data:					
Nearest bank (left / right)?	left		Distance to one endpoint	59.4	m
Diffuser length (L_D)	7.62	m	to other endpoint	67.02	m
Total number of openings	4				
Port diameter (D)	1.2	m	width contraction ratio	1	
Diffuser arrangement / type (unidirectional / staged / alternating or vertical)				unidirect.	
Alignment angle (GAMMA)	90	°	Horizontal angle (SIGMA)	na	°
Vertical angle (THETA)	90	°	Relative orientation (BETA)	na	°
Port height (h_o)	0.48105	m			
Effluent data:					
Effluent flow rate	0.69	m^3/s	*or:* Effluent velocity	---	m/s
Effluent density	---	kg/m^3	*or* Effluent temperature	22	°C
Heated discharge (yes/no)?	no		*If yes* Heat loss ($W/m^2 \cdot °C$)	---	
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no* Decay coefficient	---	/day
MIXING ZONE DATA:					
Is effluent toxic (yes / no)?	no		*If yes:* CMC value	---	
			CCC value	---	
Is there a WQ standard for conventional pollutant?	no		*If yes:* value of standard	---	
Any mixing zone specified?	yes		*If yes:* distance	---	m
			or width (% or m)	50%	
Region of interest	5000	m	or area (% or m^2)	---	
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info

CORMIX Case Description

Site name:	City of Trenton
Design case:	DRBC Tidal Run - 01 Final
File name:	cormix\sim\TRN2-F01.cx2
Time of FORTRAN run:	03/14/95–20:53:35

Tidal CORMIX Information

Tidal height range (m):	2.07
Maximum tidal current (m/s):	.72
Phase difference (degrees):	90
Number of steps:	24

Regulatory Information

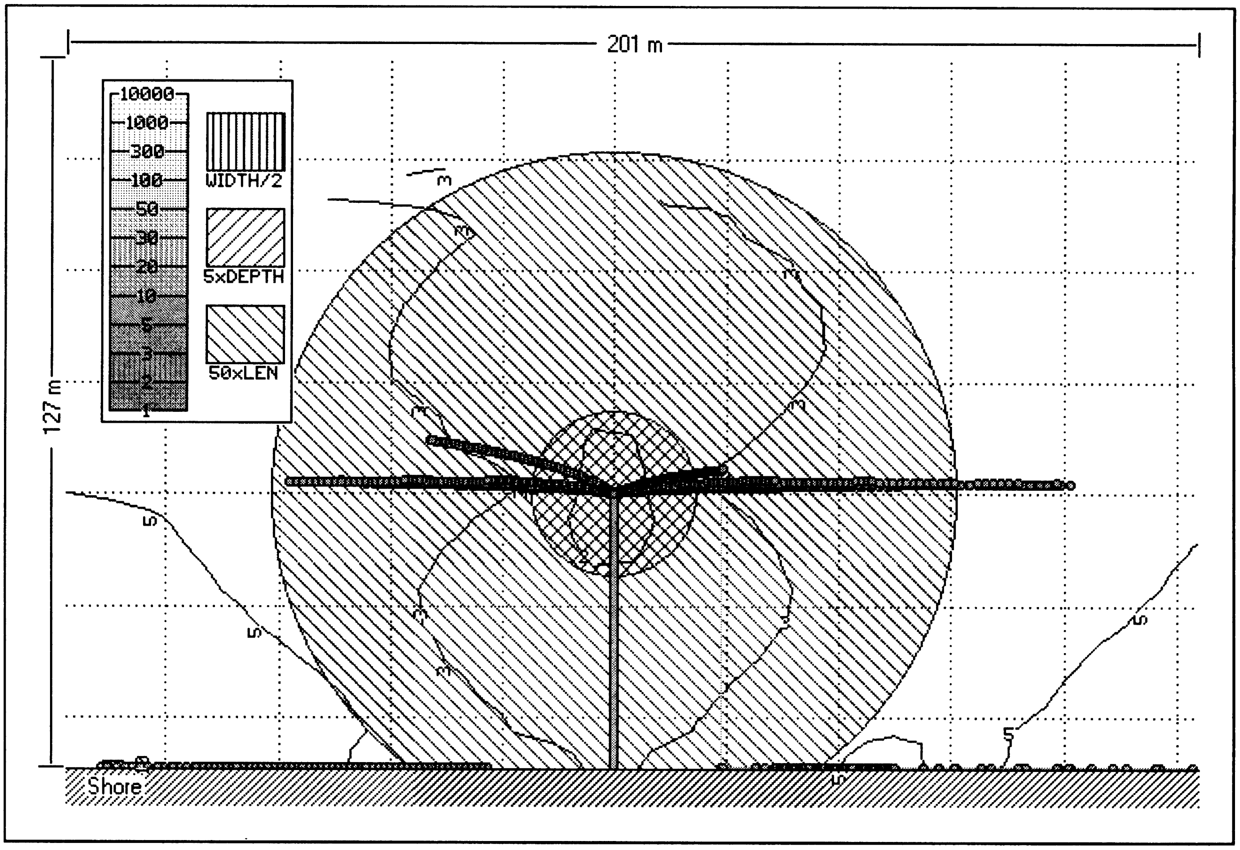
	Minimum Dilution	Average Dilution
5 x depth (13.57 m)	5.45	6.68
50 x length (106.50 m)	5.21	11.54
50% x width (132.50 m)	10.40	11.00

	Minimum Distance	Average Distance
50% x width	232 m	244 m

CORMIX3 -- Bouyant Surface Discharges -- CORMIX3

SITE/CASE IDENTIFIER:		Date prepared:
SITE Name	Morrisville Borough	1/11/99
Design **Case**	Tidal Simulation	Prepared by:
DOS **FILE NAME**	Morr3	JT

TIDAL DATA			Is this a tidal simulation	Yes	
Tidal height range (H_r)	0.69	m	Phase differences between		
Maximum amplitude			tidal current and height	90	°
of the tidal current (U_t)	0.72	m/s	Number of STEPS	24	
AMBIENT DATA:			Bounded or unbounded	bounded	
Water body depth (H_a)	3.0	m	Water body width (W)	244	m
Depth at discharge (H_d)	3.0	m	Appearance (1 / 2 / 3)?	1	
Ambient flow rate (Q_a)		m^3/s	*or:* Ambient velocity (U_a)	0.117	m/s
Manning's n	0.04		*or:* Darcy-Weisbach f		
Wind Speed	2	m/s			
Density data:			**UNITS: Density...kg/m3 / Temperature...°C**		
Water body (fresh / salt)?	fresh		Specify density or temp. ?	temp	
If uniform:			Average density / temp.	20	
If stratified:			Stratification type (A / B / C)?		
Density/temp. at surface			*If B/C:* Pycnocline height		m
Density/temp. at bottom			*If C:* Density/temp. jump		m
DISCHARGE DATA:					
Geometry data:			Configuration type is		
Discharge is on (left / right)	right	bank	(flush/protruding/co-flowing)	protruding	
Horizontal angle (SIGMA)	90	°	*If pertruding:* Dist. from bank	48.8	m
Depth at discharge		m	Bottom slope	10	°
If rectangular: Width (b_o)		m	*If circular:* Diameter (D)	1.38	m
disch. channel: Depth (h_o)		m	*pipe:* Bottom invert depth (h_o)	1.38	m
Effluent data:					
Effluent flow rate	0.31	m^3/s	*or:* Effluent velocity		m/s
Effluent density		kg/m^3	*or:* Effluent temperature	11	°C
Heated discharge (yes/no)?	no		*If yes:* Heat loss ($W/m^2 \cdot °C$)		
Concentration units	percent		Effluent concentration	100	
Conservative substance?	yes		*If no:* Decay coefficient		/day
MIXING ZONE DATA:					
Is effluent toxic (yes / no)?	no		*If yes:* CMC value		
			CCC value		
Is there a WQ standard for conventional pollutant?	no		*If yes:* value of standard		
Any mixing zone specified?	yes		*If yes:* distance		m
			or width (% or m)	50%	
Region of interest	10000	m	or area (% or m^2)		
Grid intervals for display	50				



Tidal CORMIX Postprocessor Site Info

CORMIX Case Description

Site name: Morrisiville

Design case: Surface

File name: cormix\sim\morr3

Time of FORTRAN run: 01/08/99–09:13:41

Tidal CORMIX Information

Tidal height range (m): 0.69

Maximum tidal current (m/s): 0.72

Phase difference (degrees): 90

Number of steps: 24

Regulatory Information

	Minimum Dilution	Average Dilution
5 x depth (14.98 m; 705 m2)	2.06	2.32
50 x length (61.15 m; 11127 m2)	2.84	4.00
50% x width (122.00 m; 76128 m2)	68.50	70.60

	Minimum Distance	Average Distance
50% x width	624 m	1742 m

Interpolation uses a search distance of 50 m.