U.S. ENVIRONMENTAL PROTECTION AGENCY

A WATER QUALITY MODEL~~L~~ING STUDY OF THE DELAWARE ESTUARY

January 1978

Technical Report No. 62
Annapolis Field Office
Region III
Environmental Protection Agency

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ABSTRACT

Recent data acquisition, analysis, and mathematical modelling studies were undertaken to improve the understanding of water quality interactions, particularly as they impact DO, in the Delaware Estuary. A version of the Dynamic Estuary Model, after undergoing considerable modification, was applied in an iterative process of hypothesis formation and testing. Both model parameters and model structure were updated and improved through this process until five intensive data sets gathered in the estuary between 1968 and 1976 were satisfactorily simulated. The major processes treated in this study were the advection and dispersion of salinity and dye tracers, nitrification, carbonaceous oxidation, sediment oxygen demand, reaeration, algal photosynthesis and respiration, and denitrification. The major product of this study is a calibrated and verified "real time" hydraulic and water quality model of the Delaware Estuary between Trenton and Liston Point. Among the conclusions of general importance are: (1) algae exert a variable, but generally positive influence on the DO budget; (2) non-linear reactions (such as denitrification and reduction of effective sediment oxygen demand) become significant when DO levels drop below 2 mg/l; and (3) nitrification, which experiences inhibition in a zone around Philadelphia, and sediment oxygen demand rival carbonaceous oxidation as DO sinks throughout much of the estuary. One implication of this study is that earlier forecasts of DO improvements with a simpler, linear model were somewhat optimistic.

FOREWORD

In all probability, the Delaware Estuary has been the subject of more modelling studies during the past two decades than any other estuarine water body in the United States. While it is hoped that the modelling study documented in this report will help advance the state-of-the-art, recognition should also be given to these early pioneering efforts, since they provided a solid foundation upon which one could build. Without them, and similar attempts at model application elsewhere, this report would not have materialized. It is encouraging that mathematical modelling techniques are gaining increased acceptance and legitimacy by water quality managers, since they represent a valuable tool to assist in the decision making process. Used with intelligence, mathematical models can help frame relevant options with greater precision and explore the implications of alternate decisions with greater objectivity than methods available in the not too distant past. It is toward this end that our efforts are ultimately directed.

TABLE OF CONTENTS

LIST OF FIGURES

Number		Page

LIST OF TABLES

ERRATA SHEET

A WATER QUALITY MODELLING STUDY
OF THE
DELAWARE ESTUARY

January 1978

Technical Report No. 62

U. S. Environmental Protection Agency
Region III
Annapolis Field Office

Page	
I-12	k = frictional resistance coefficient ($k = gn^2/2.208\ R^{4/3}$)
I-12	Last sentence through line 9, page I-13 should read:

The term on the left hand side of Equation (1) represents local acceleration which results from the unsteady motion of fluid particles. The first term on the right hand side represents convective or field acceleration created by the physical (linear or rotational) deformation of fluid particles with respect to space. Both of these terms correspond to the inertial forces, and can be derived by Newton's Second Law which states that

$$\vec{F} = M \frac{\partial \vec{u}}{\partial t}$$

Since the velocity is both time and space dependent, the following identity relating total and partial derivatives can be applied

$$du \equiv \frac{\partial u}{\partial t} dt + \frac{\partial u}{\partial x} dx$$

This translates to

$$\frac{du}{dt} \equiv \frac{\partial u}{\partial t} + \left(\frac{\partial u}{\partial x}\right) \left(\frac{dx}{dt}\right)$$

where $u = \frac{dx}{dt}$. The second term . . . .

ERRATA SHEET

Page	
II-11	Last Paragraph should read:
	The varying waste input section now reads varying waste flows and concentrations from the same card. For each junction . . . .
II-12	The last two paragraphs should read:
	Under the new system, each output table is specified, including the quality cycle number, the high or low slack indicator, and the plotting option, It must be determined external to the model when a given slack water occurs at the seaward boundary.
	The tidal cycle summary printouts tabulated in subroutine QUALEX have been alerted so that the summaries can cover any specified time interval.
	Printer plotting routines have been added which will provide profile plots of all slack water tables and time history plots at specified model nodes.
III-106	First new paragraph, fifth line: "reasonable" should read "reasonably".

I. INTRODUCTION

A. SCOPE OF STUDY

The free-flowing Delaware River water spills over the fall line at Trenton, New Jersey into its tidally influenced estuary. Subjected to vigorous ebb and flood tidal currents, this fresh water slowly makes its way past the large metropolitan center of Philadelphia-Camden-Chester where thousands of tons of municipal sewage and industrial wastewater degrade it dramatically. Widening into a broad, brackish estuary near Wilmington, its pollutants are being assimilated and diluted even as the estuary receives new wastewater loads. The water's salinity increases rapidly as the estuary merges into the Delaware Bay near Liston Point, some 90 miles in distance and 1 to 3 months in time below the fall line at Trenton.

The water quality problem of particular concern in the estuary has been low dissolved oxygen (DO) concentrations between late spring and early fall when temperatures are elevated. Dissolved oxygen is an important indicator of general water quality. High DO levels permit the existence of a diversity of life forms and hence are generally associated with healthy and stable aquatic environments. Low DO levels, on the other hand, often result from abnormally high organic pollution levels in a body of water, and can upset or totally destroy the natural clean water aquatic communities. The high diversity of these communities is usually reduced, leading to a precarious or unstable balance with the changing aquatic environment. If low DO levels persist or worsen, whole communities can be replaced by less desirable pollution tolerant families, such as tubificid or sludge worms. High quality fish having economic and recreational value, such as bass or perch, are first replaced by lesser quality fish, such as carp; finally as DO levels plunge much below 3 mg/l, no species of fish will remain viable. Summer DO concentrations in the Delaware Estuary often remain below 3 mg/l between the Ben Franklin Bridge at Philadelphia and the Delaware Memorial Bridge at Wilmington. Minimum daily DO concentrations immediately below Philadelphia are frequently less than 1.0 mg/l during the summer.

The three primary goals guiding this study were (1) to better understand and define the significant mechanisms affecting the water quality behavior of the estuary; (2) to provide a more reliable deterministic tool for accurately predicting the effects of alternative waste control strategies on the estuary's water quality; and (3) to establish a sound data and knowledge base which would be a valuable reference for planning future water quality studies. Major emphasis was placed on defining those factors which affect dissolved oxygen, due to its widespread acceptance as a water quality standard by planning and regulatory agencies in the Delaware Basin.

This report documents the modifications to the Dynamic Estuary Model performed by the Annapolis Field Office (AFO) and the subsequent application of the revised model to the Delaware Estuary.

The final tangible results of this work are the calibrated and verified hydraulic and water quality models DYNHYD2T and DYNDELA. These mathematical computer models are now available for use in further studies of the water quality of the estuary, including forecasts of the water quality response to hypothetical wastewater control strategies. A user's manual will provide the details necessary for operating the models. Ongoing tests and studies with these models will be documented in future technical papers and reports.

B. HISTORY OF THE DYNAMIC ESTUARY MODEL

The Dynamic Estuary Model (DEM) was originally developed during the mid 1960's by Water Resources Engineers, a consultant engineering firm located in Walnut Creek, California, under contract to the Division of Water Supply and Pollution Control, U. S. Public Health Service [1]. The principal individuals associated with the development of this model were Drs. Gerald Orlob and Robert Shubinski. Estuarine modelling was still in its infancy at that point in time, and the DEM was innovative in considering a "real time" computerized tidal solution of the hydrodynamic behavior of estuaries. Prior to the development of the DEM, the few estuary models already in existence relied on a net flow or plug flow analysis and attempted to reproduce tidal effects through the inclusion of an artificial dispersion coefficient. Since these models were non-tidal in nature, the time step for computations was normally equal to the tidal period (12.5 hrs.) or, for convenience, one day, and consequently they could not handle short term pertubations in water quality.

The DEM was initially applied to the Sacramento-San Joaquin Delta area in California [1]. Other early applications were to the Suisun, San Pablo and San Francisco Bays [2], [3]. The DEM was first brought to the attention of the Annapolis Field Office (AFO) by Mr. Kenneth Feigner. Mr. Feigner was the USPHS project officer during the early developmental and application studies in California and was the author of the basic model documentation report [4]. Staff at AFO (with the assistance of Mr. Feigner) tested the model rigorously and performed extensive modifications to the reaction kinetics in the quality program during its multi-year application to the Potomac Estuary [5], [6], [7]. The Potomac study was primarily directed towards refining the model's ability to treat nutrient cycles (including uptake by phytoplankton) and towards incorporating algal effects within the DO budget. In addition, the DEM was also applied to the upper Chesapeake Bay during 1972-73 for the development of allowable nutrient loadings from the Susquehanna Basin and the Baltimore Metropolitan Area [8].

C. THEORY

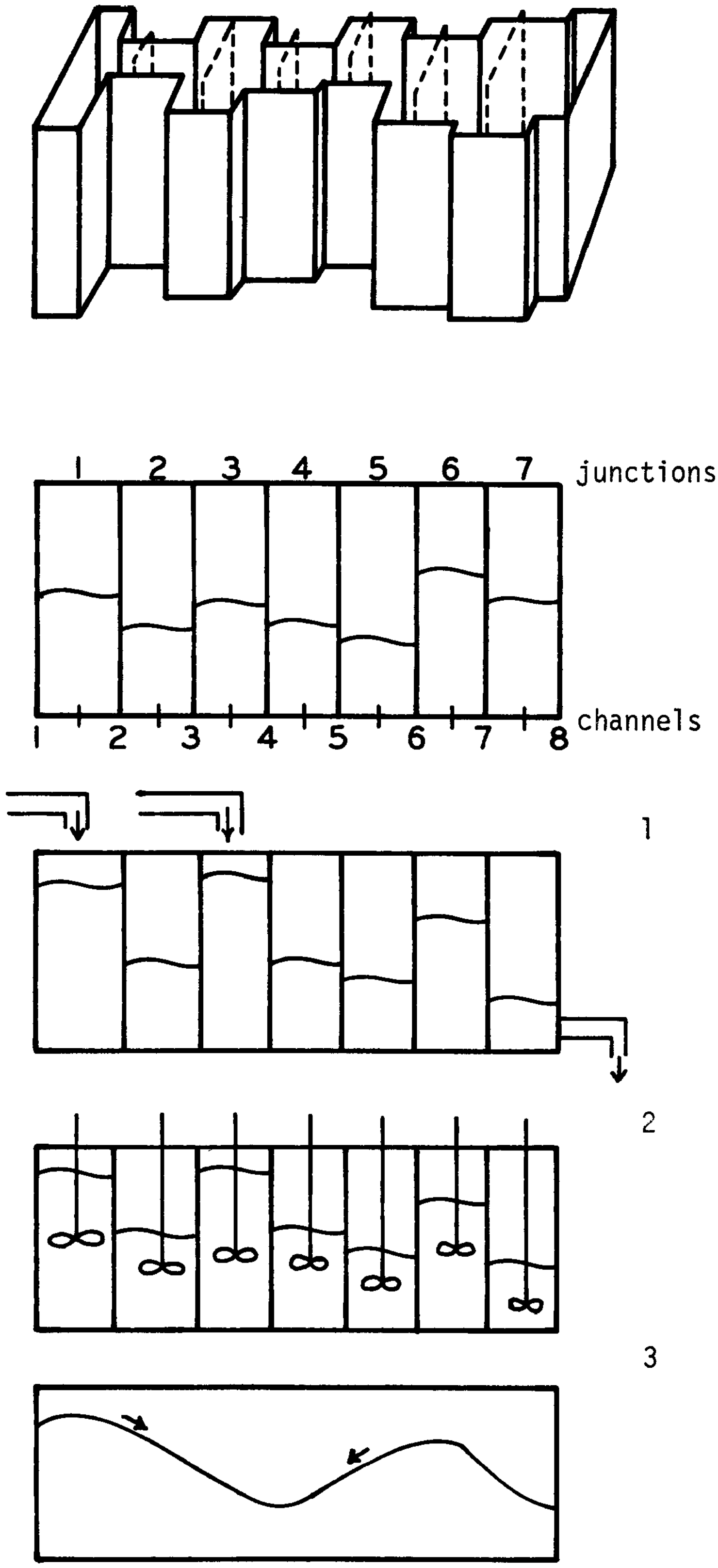
The DEM consists of two separate but interrelated components: (1) a hydraulic program, dealing with water motion, and (2) a quality program, dealing with mass transport and chemical and biological reactions. The hydraulic program predicts water movement by solving the equations of momentum and continuity, while the quality program predicts the movement, buildup, and decay of water-borne material by solving the conservation of mass equations. The numerical solution of the hydraulic and mass equations is accomplished on the same network, which represents the geometrical configuration of the estuary. The following sections will discuss in detail the network and the equations used in the hydraulic and quality models.

1. NETWORK PROPERTIES

The DEM utilizes a channel-junction (sometimes called a link-node) network approach, whereby, either through branching or looping, the pertinent hydraulic and mass balance equations are applied to uniform segments of the estuary and then solved in a sequential fashion. The model can accommodate a range of time and space scales suitable to the dynamic and physical characteristics of a particular estuary.

Two analogies which are useful in better understanding the channel-junction network concept and its application to an estuary are (1) a series of pots connected by hoses, and (2) a partitioned irregular fish tank. In the first case, the pots are analogous to model junctions while the hoses are analogous to model channels. "Tidal currents" are created by raising one of the end pots, thereby creating water movement through the series of pots. The hoses serve as transport media where physical characteristics governing the movement of water are defined. The pots serve as receptacles for the fluid transported where the addition of pollutants and their dilution, decay, and chemical and/or biological transformation are defined. The rhythmical raising and lowering of the pot at one end of the series is analogous to the input of a tidal wave at the seaward boundary of the model. The difference in elevation of the water surface is the primary hydraulic driving force in the pot-hose analogy, the DEM, and an estuary subject to tidal action such as the Delaware.

The second analogy is that of a long irregular fish tank, divided internally into sections or "junctions" by many glass partitions, as illustrated in Figure I-1. Water is poured into various junctions (representing fresh water inflow and wastewater discharge); water is removed from other junctions (representing river water diversion). The water is stirred until well mixed. The partitions are then lifted simultaneously, allowing waves to travel through the tank. The configuration of the fish tank confines water movement along pre-determined paths, or "channels". After a short time interval,



Fish tank with partitions.

Channels describe the geometry of the fish tank; junctions describe the volumes of water separated by partitions.

Water is poured into some junctions (representing fresh water inflow, wastewater inflow, or flooding tide) and removed from other junctions (representing river water withdrawal or ebbing tide).

The volume of water in each junction is well mixed.

Partitions are removed; fluid travels as waves moving through channels. When partitions are reinserted, Step 1 begins again.

FISH TANK ANALOGY FOR
LINK-NODE MODEL NETWORK

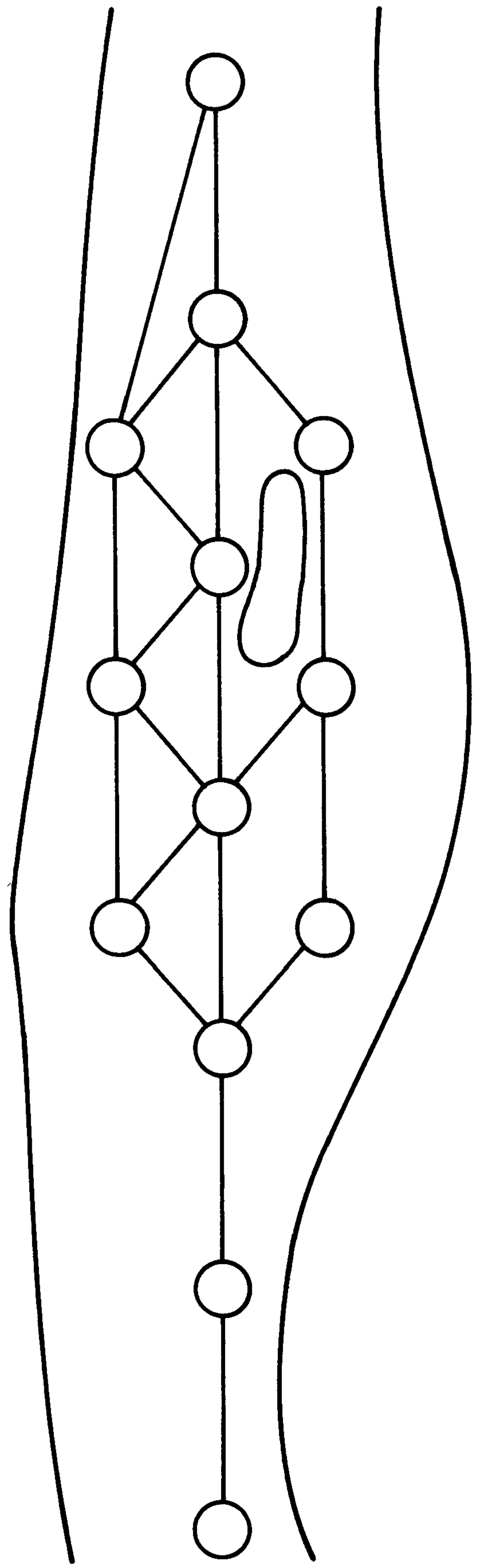
Figure I-1

the partitions are re-inserted, more water is poured into or drained from the junctions, and the process is repeated.

The channels provide for fluid motion. They function as transfer units between the junctions. The tidal wave, river flow and wastewater flow are all propagated from their initial points by means of the channels. The junctions function as mass and volume containers. As Figure I-1 shows, the fish tank, as a whole, is irregular; each channel, however, has a rectangular shape depending on the configuration of the area it represents. The junctions, since they occupy the same space as half of two neighboring channels, will (usually) be rectangular except where branching or looping channels are employed. Since the geometry of the river itself varies continuously, the more channels in the model, the more closely the model will approximate the river.

The linear nature of the model implies certain restrictions, which are easily understood by reference to the fish tank analogy. The model cannot handle flows normal to the x-axis. The acceleration caused by a sloping channel or by wind or Coriolis forces must be negligible. The analogy of the fish tank is, however, overly restricted in that it does not conserve momentum from one period of flow to the next, while the DEM does. The fish tank and the model also differ in that the fish tank is fully three dimensional, while the model is essentially one dimensional. The model does take width and depth into account by entering them as functions: width as a function of longitudinal distance along the river (distance along the x-axis) and depth as a function of distance and time. Nevertheless, the equations and their results are one dimensional. For a given channel or junction, the model outputs one set of results: one flow, one wave height, one DO prediction, one BOD prediction, etc. A pseudo-two-dimensional effect can be achieved by branching more than two channels from a single junction (see Figure I-2). This is done by subdividing the river into smaller parts, which yields greater accuracy and precision in the results, but not true two dimensionality since the equations used are still in a one dimensional form. A three dimensional effect might be similarly achieved, though with considerably more difficulty, since problems arise concerning interaction between different vertical layers.

The more stratified a body of water is either vertically or horizontally, the more difficult and complicated the modelling problem becomes for the DEM. Shallow bodies of water, such as the California deltas and bays or the Delaware Estuary, with little vertical stratification and with the primary flow linearly along the axis of the river, are most suited to this model.



2-D NETWORK WITH BRANCHING CHANNELS

FIGURE I-2

2. HYDRAULIC MODEL

The basic task of the hydraulic model is to solve the equations describing the propagation of a long wave through a shallow water system, while conserving both momentum and volume. The two equations involved are:

$$\frac{\partial u}{\partial t} = -u \frac{\partial u}{\partial x} - (k \cdot |u| \cdot u) - g \frac{\partial H}{\partial x} \quad (1)$$

and

$$\frac{\partial H}{\partial t} = -\frac{1}{b} \cdot \frac{\partial Q}{\partial x} \quad (2)$$

where:

u = velocity along the x-axis

t = time

x = distance along the x-axis

k = frictional resistance coefficient
($k = gn^2/2.208\, R^{4/3}$)

n = Manning's roughness coefficient

R = hydraulic radius

g = gravitational acceleration

H = height of the wave (above arbitrary datum)

b = mean channel width

Q = flow

Equation (1) is associated with the channels and is the equation of motion expressed in a one dimensional form where velocity along the x-axis replaces the flow. The first term on the right hand side represents flow convergence or divergence: for a given quantity of water in motion, its velocity will vary with the cross-sectional area of the channel through which it flows. Convergence and divergence depend directly on the water velocity and the change of the cross-sectional area along the river, such that $\frac{\partial u}{\partial t} = -u \left(\frac{\partial u}{\partial A} \right) \left(\frac{\partial A}{\partial x} \right)$. Since the cross-sectional area is entered in the model in terms of distance along the x-axis, then A = f(x) and, consequently, $\frac{\partial A}{\partial x}$ are known. Multiplying $\frac{\partial u}{\partial A}$ by this known $\frac{\partial A}{\partial x}$ gives the $\frac{\partial u}{\partial x}$ shown in equation 1 $\left(\frac{\partial u}{\partial x} = \frac{\partial u}{\partial A} \times \frac{\partial A}{\partial x}\right)$. The second term represents the frictional resistance: the greater the velocity, the greater will be the friction. The absolute value sign ensures that the resistance opposes the direction of flow. Perhaps the most elusive network input is the Manning roughness coefficient, n, upon which k depends. Since this parameter is virtually undefinable, even through empirical methods, it serves as a "knob" to turn in order to achieve a satisfactory agreement between the actual and predicted tidal data. The third term represents gravitational acceleration: the greater difference in the water surface elevations, the greater will be the gravitational force exerted. The negative signs on the right hand side of the equation result from the sign convention governing flow in the channels. Flow is defined as positive in the positive x direction, that is, in the direction of the channels which (in the Delaware model) are numbered up the river from Artificial Island (channel 9) to Trenton (channel 84).

Channels 1 through 8 are located in the C&D Canal.

Equation (2), the equation of continuity, is used to compute the water surface elevations after appropriate flow transfers are made and is associated with the junction elements of the network. The height of the wave is inversely proportional to the width of the channel for a given flow. Likewise, for a given channel width, the height will vary as a function of the flow.

Equations (1) and (2) must be converted to finite difference forms before they can be used in the model. They therefore become:

$$\frac{\Delta u_i}{\Delta t} = -u_i \frac{\Delta u_i}{\Delta x_i} - k \cdot |u_i| \cdot u_i - g \frac{\Delta H_i}{\Delta x_i} \qquad (3)$$

$$\frac{\Delta H_j}{\Delta t} = -\frac{\Sigma Q_{in} - \Sigma Q_{out}}{b_j \Delta x_j} \qquad (4)$$

where i indicates the channel and j the junction in question.

ΣQ_j is used instead of ΔQ_j since there will usually be several different flows to be considered (waste discharges, accretions, transfers, diversions, etc.). At this point, the equations are now tractable only if there is no branching in the model. If there is branching, the velocity gradient $\frac{\Delta u_i}{\Delta x_i}$ can no longer be used in the form $\frac{u_{i+1} - u_i \text{[redacted]}}{x_{i+1} - x_i \text{[redacted]}}$ since there may be several i+1 channels.

Equation (2) can be used to solve this problem:

$$\frac{\partial H}{\partial t} = -\frac{1}{b} \cdot \frac{\partial Q}{\partial x} \tag{2}$$

$$b \cdot \frac{\partial H}{\partial t} = \frac{-\partial \ (uA)}{\partial x}$$

$$= -u \frac{\partial A}{\partial x} - A \frac{\partial u}{\partial x}$$

$$\frac{\partial u}{\partial x} = -\frac{b}{A} \frac{\partial H}{\partial t} - \frac{u}{A} \frac{\partial A}{\partial x}$$

In finite difference form:

$$\frac{\Delta u_i}{\Delta x_i} = -\frac{b_i}{A_i} \frac{\Delta H_i}{\Delta t} - \frac{u_i}{A_i} \frac{\Delta A_i}{\Delta x_i} \tag{5}$$

($\Delta H_i/\Delta t$ and $\Delta A_i/\Delta x_i$ are computed from the predicted water surface elevations of the junction at both ends of the channel i). Substituting (5) in Equation (3):

$$\frac{\Delta u_i}{\Delta t} = u_i \frac{b_i}{A_i} \frac{\Delta H_i}{\Delta t} + \left(\frac{u_i^2}{A_i} \frac{\Delta A_i}{\Delta x_i}\right) - k|u_i| \cdot u_i - \left(g \frac{\Delta H_i}{\Delta x_i}\right) \tag{6}$$

To solve equations (6) and (4) everything except $\Delta u_i/\Delta t$ and $\Delta H_j/\Delta t$ must have assigned values. River geometry is entered in the model as discretely varying constants. A value for b_j and Δx_j (or their product, surface area) is entered for each junction and a value for Δx_i (length), b_i (width), A_i (cross sectional area) or d_i (depth), and k_i (roughness) for each channel. At the beginning of the run, values for channel velocity and water surface elevations at the junctions must be entered to start the solution procedure (initial conditions). All waste discharges, flow diversions or accretions, tidal height variations, and tributary flows must also be specified (boundary conditions). The equations are then solved, using a modified Runge-Kutta procedure. A step by step solution of equations (6) and (4) proceeds as follows:

(1) The mean velocity for each channel is predicted for the middle of the next time interval using the values of channel velocities and cross-sectional areas and the junction heads at the beginning of the time interval.

(2) The flow in each channel at the middle of next time interval is computed based on the above velocity and the cross-sectional area at the beginning of the interval.

(3) The head at each junction at the middle of the next time interval is predicted based on the above predicted flows.

(4) The cross-sectional area of each channel is adjusted to the middle of the next time interval based on the above predicted heads.

(5) The mean velocity for each channel is predicted for the end of the next time interval using the values of channel velocities and cross-sectional areas and junction heads at the middle of the interval.

(6) Steps (2), (3), and (4) are repeated for the end of the time interval. Computation proceeds through a specified number of Δt time intervals.

The solution will converge, for a given set of boundary conditions, to a dynamic equilibrium condition wherein the velocities and flows in each channel and the heads at each junction repeat themselves at intervals equal to the period of the tide imposed at the seaward boundary of the system. The time required for this convergence will vary from about 1 to 4 tidal periods, depending on the accuracy of the initial conditions.

When applying the model, the tide and flow should be relatively steady over the time period being modelled. The model's predictions are based on the original constant freshwater flow and tidal characteristics, since it is expensive to simulate a transient condition having significantly varying flow or tidal characteristics.

The tidal wave at the seaward boundary is described by a series of coefficients, A_j. These coefficients are obtained from the equation:

$$Y = A_1 + A_2 \sin(\omega t) + A_3 \sin(2\omega t) + A_4 \sin(3\omega t) + A_5 \cos(\omega t) + A_6 \cos(2\omega t) + A_7 \cos(3\omega t) \quad (7)$$

where: ω = 12.5 hrs.

The coefficients A_1 through A_7 are actually solved in a special harmonic analysis program requiring tidal heights as a function of time as input, which must be run once for every hydraulic pattern of interest, such as spring tide, neap tide, or average tide. The tidal data should be referenced to some convenient datum such as mean sea level (MSL).

The selection of the computational time step is an important consideration since stability must be maintained throughout the solution process. Its length is dictated by the refinement of the network in accordance with the stability criterion given below:

$$\chi_i \geq (\alpha_i \pm U_i)\,\Delta t$$

where: χ_i = channel length

α_i = wave celerity ($\sqrt{gy}$)

U_i = tidal velocity

Δt = time step

As can be seen, the more detailed the model network, the shorter the time step and vice versa. Normally, a time step on the order of a few minutes is sufficient for most applications; however, one must pay special attention to the physical configuration of an estuary when deciding upon the network design and the associated time step.

Physical data pertaining to the individual channel and junction elements must be obtained either from navigation charts or from actual field measurements. This data is extremely important for both the hydraulic and quality components and should be estimated with some degree of accuracy. The specific parameters that must be defined are as follows:

Channel Elements

1) Length
2) Width
3) Cross-Sectional Area
4) Hydraulic Radius (depth)
5) Frictional Resistance Coefficient

Junction Elements

1) Surface Area

2) Volume

3) Inflows/Outflows

3. QUALITY MODEL

The task of the quality model is to solve the equations describing the movement, decay and transformation of material in a water system by performing a mass balance (conservation of mass) at each junction element during each time step of the solution. The quality model utilizes the identical network employed in the hydraulic model and requires the hydrodynamic solution, which is extracted and stored onto magnetic tape, as input. Five constituents, either conservative or non-conservative, can be handled simultaneously. The computational time step must be a whole multiple of the time step used in the hydraulic program and evenly divisible into the tidal period. A time step between 1/2 hour and 2 hours will suffice for most applications.

The quality component is concerned with constituents that are introduced to or already contained in the water in either a dissolved or particulate form, such as salinity, dissolved oxygen, BOD, algae, and nutrients (i.e., nitrogen or phosphorus species). The concentration of such a constituent at any point along the river will be modified by the following processes: advection, diffusion, longitudinal dispersion, decay, reaeration, exportation and importation. These processes will be discussed below.

ADVECTION

When a constituent enters the water with a given concentration c, the tidal wave and river flow will cause it to be carried up or down the river at the same velocity at which the water itself moves (disregarding for the moment the effects of diffusion). The greater the constituent's concentration, of course, the more of it will be transported. Thus, the basic transport equation for advection is:

$$T_a = u * c \qquad (8)$$

where: T_a = advective transport of a given mass through a unit area in a unit time (mass/area/time)

u = velocity

c = the concentration of the constituent with respect to the water in which it is carried

Applying this equation to a control volume and shrinking it to infinitesimal size will yield the following one dimensional concentration equation:

$$\frac{\partial c}{\partial t} = u \frac{\partial c}{\partial x} \qquad (9)$$

Multiplying both sides by $A \cdot \delta x$ will yield the following mass equation:

$$\frac{\partial M}{\partial t} = u \, A \, \frac{\partial c}{\partial x} \quad \delta x \qquad (10)$$

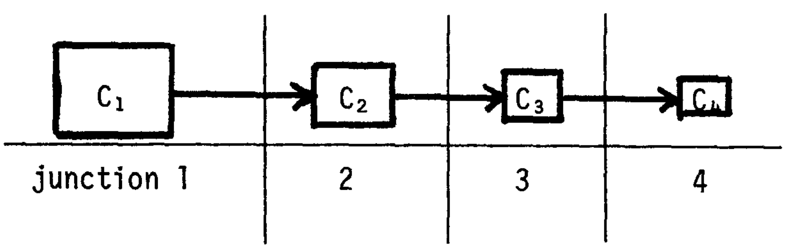
which describes the instantaneous advection of mass at cross-section A. In finite difference form, the equation becomes:

$$\frac{\Delta M_{a,j}}{\Delta t} = u_{i+1} \; A_{i+1} \; c_{j+1} \; - \; u_i \; A_i \; c_j \qquad (11)$$

where j is the junction under consideration and i+1 and i refer to the upstream and downstream channels, respectively. This difference equation describes the net advection of mass into or out of the control volume (or model junction j) during the interval Δt. Even in this form, however, the equation can still be troublesome to use in the model for reasons discussed below.

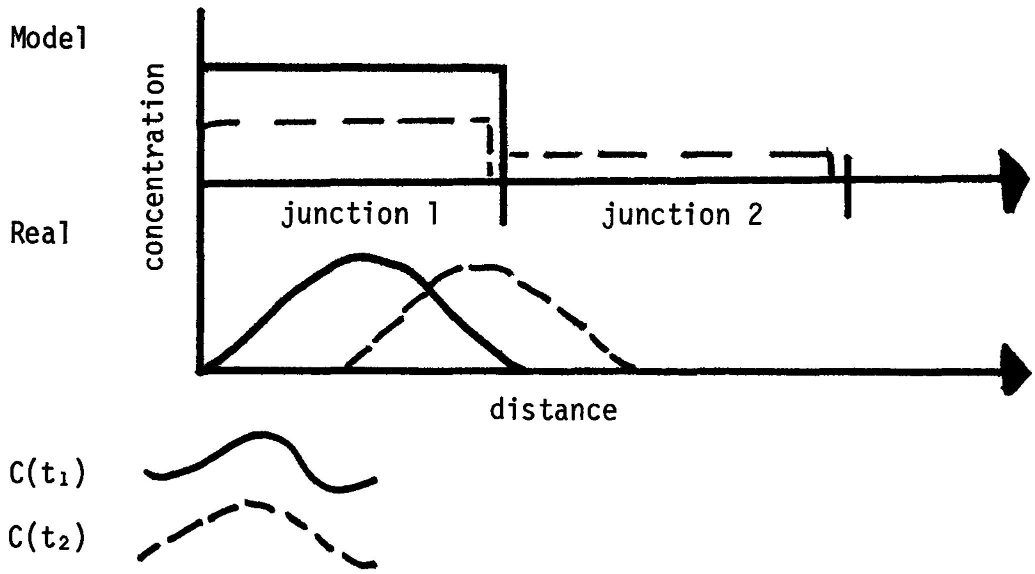
NUMERICAL MIXING

At every quality time step, some portion of the concentration must be advanced one unit: that is, one junction, forward. Thus, in the drawing below, part of the concentration in junction 1 will advance to the center of junction 2 in the first time step; likewise, some of the concentration in junction 2 will advance to the center of junction 3 in time step 2, and so on.



This occurs because the model assumes the complete mixing within each junction of any mass entering that junction. In reality, however, the concentration in junction 1 at time step 1 may only advance to the boundary between junctions 1 and 2.

In other words, while the model concentrations must move in unit steps whose distance is dictated by the junction sizes, the real concentrations are not so constrained. The effect of this unit motion is called numerical mixing.



Certain adjustments must be made in order to insure that the discrepancy between model and river will not be large and will not accumulate because of numerical mixing problems.

The greatest difficulty will arise when there is a high concentration gradient between two junctions. If c_1 is much greater than c_2 then the error involved in advancing c_1 one unit step ahead to junction 2 will be numerically large. The solution is to choose a c_1 or concentration in the advected water, which is in between the "actual" values of c_1 and c_2. The early modelling studies by Feigner [4] showed that, for the San Francisco Bay System, acceptable values for c_1 can be achieved by the Quarter Point Method:

$$c^* = (3c_1 + c_2)/4$$

where c^* = the concentration substituted in the model for c_1. This method also appeared to work satisfactorily in the Potomac, with the exception of salinity, which exhibited steeper concentration gradients and necessitated the use of a Third Point Method:

$$c^* = (2c_1 + c_2)/3$$

The Upper Chesapeake Bay model, on the other hand, was able to utilize the actual upstream concentrations for advection purposes with no apparent problems. With the proper substitution, the advection equation becomes:

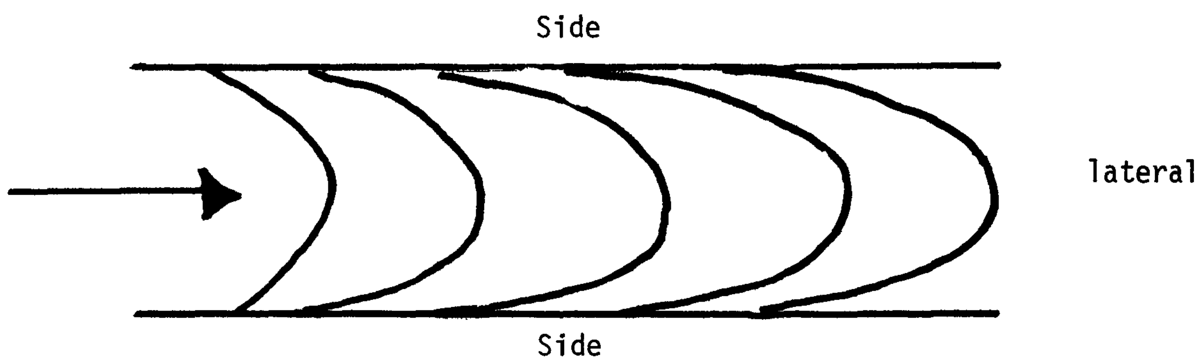
$$\frac{\Delta M_{a,j}}{\Delta t} = A_{i+1} \; u_{i+1} \; c_1^* \; - \; A_i \, u_i \, c_2^* \qquad (12)$$

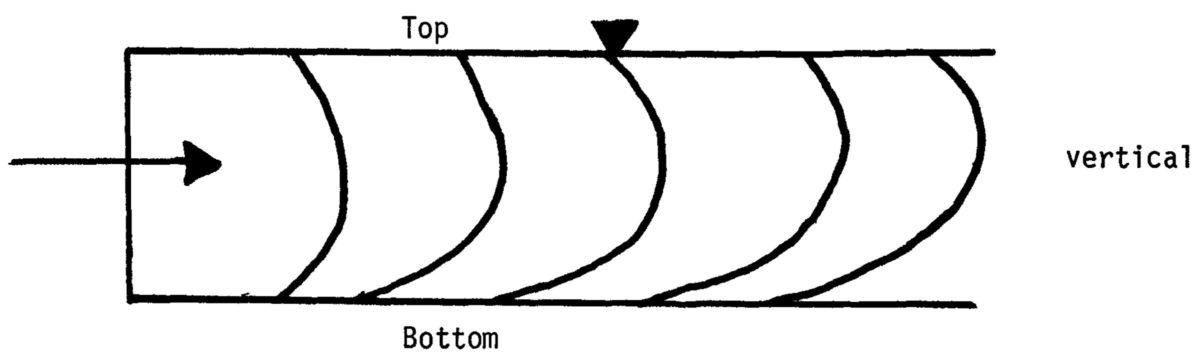
where c_1^* represents the upstream concentration entering the junction and c_2^* represents the concentration leaving the junction. Since the model will actually calculate the individual accretions and depletions separately, the advection equation used is:

$$\frac{\Delta M_a}{\Delta t} = A \; u \; c^* \qquad (13)$$

LONGITUDINAL DISPERSION

The velocity of a river varies laterally and vertically. These variations result in longitudinal dispersion, by which constituents in the center of the river move forward faster than those at the side or bottom. Because the model is one-dimensional in form, this phenomenon cannot be directly accounted for in the model. However, it so happens that the effects of numerical mixing accidentally produce a somewhat similar effect, although it is only partially controllable. Therefore, c* may also be manipulated to help compensate for the effects of longitudinal dispersion. In addition, the turbulent (or eddy) diffusion coefficient, discussed in the next section, can be manipulated to encompass the effects of longitudinal dispersion.





TURBULENT DIFFUSION

In a calm body of water, molecular diffusion will slowly operate to bring constituents from regions of high concentrations to regions of low concentrations. In turbulent bodies of water, however, this relatively slow process can be neglected, and only the effects of turbulent diffusion need to be considered. Turbulent diffusion, the stirring or mixing of the water by eddy currents due to tidal action or some other energy field such as density gradients, is essentially a complex form of advection, which must at present be treated as a separate process since the velocities and directions of the eddy currents are not yet predictable. The transport equation for turbulent diffusion is:

$$T_d = K_d \frac{\partial c}{\partial x} \qquad (14)$$

where T_d is the transport by turbulent diffusion through a unit area in a unit time, K_d is an empirically determined coefficient which describes the rate of transfer (dimensions length^2/time) and $\partial c/\partial x$ is the concentration gradient over the space scale. Applying this equation to a control volume and shrinking it to infinitesimal size will yield a partial differential equation describing the time rate of change of a constituent's concentration due to turbulent or eddy diffusion:

$$\frac{\partial c}{\partial t} = K_d \frac{\partial^2 c}{\partial x^2} \qquad (15)$$

Multiplying this equation by a volumetric term, $A\delta x$, yields a differential equation which relates turbulent diffusion at cross-section A on a mass flux basis.

$$\frac{\partial M}{\partial t} = K_d \; A \; \frac{\partial^2 c}{\partial x^2} \; \delta x \qquad (16)$$

Again, converting the mass transfer equation to finite difference form and expressing distance in terms of a channel element's length results in:

$$\frac{\Delta M_{K,j}}{\Delta t} = K_d \; A_{i+1} \; \frac{\Delta c_{i+1}}{\Delta x_{i+1}} - K_d \; A_i \; \frac{\Delta c_i}{\Delta x_i} \qquad (17)$$

where j is the junction under consideration, i+1 and i refer to the upstream and downstream channels, respectively, and Δc_{i+1} and Δc_i are the concentration differences along the upstream and downstream channels, respectively. This difference equation describes the net dispersion of mass into or out of the control volume (or model junction j) during the interval Δt.

The DEM does not utilize K_d directly but rather computes this rate based upon a simplification of the energy dissipation relationship and a spatial approximation of the eddy size [4]. The actual equation employed by the model is as follows:

$$K_d = c_4 \; |u| R \qquad (18)$$

where c_4 is a dimensionless diffusion coefficient assumed to be constant, u is mean channel velocity, and R is the hydraulic radius of the channel.

DECAY

Both conservative (such as salinity) and non-conservative (such as DO or BOD) constituents may be considered in the quality program. For non-conservative constituents, a further mechanism, decay, must be considered.

For the first order decay process, the quantity of a constituent that decays is a function of (1) the amount of the constituent that is present and (2) its decay rate constant, which at times must be determined empirically. Expressed in differential form, the first order equation for decay is:

$$\frac{dc}{dt} = -K \quad C \tag{19}$$

where K equals the rate constant and c the constituent's concentration. The negative sign indicates that this is a process of decay and not growth. Unlike the other equations so far discussed, this one may be easily and usefully integrated:

$$C_t = C_o e^{-K\,(t - t_o)} \tag{20}$$

where C_o equals concentration at time zero (t_o). This expression is then converted to a difference form for a junction element (j) and time step Δt.

$$\Delta C_{j,t} = C_t - C_{t-1} = C_{t-1}\,(e^{-K\Delta t} - 1) \tag{21}$$

and then to a mass equation by multiplying both sides by the volume:

$$\frac{\Delta M_{D,j}}{\Delta t} = V_j\, C_{t-1}\,(e^{-K\Delta t} - 1) \tag{22}$$

where $\Delta M_{D,j}$ equals total mass decayed in junction j during the time step Δt, and C_{t-1} equals initial concentration in junction j and V_j equals junction volume.

REAERATION

Dissolved oxygen is involved in a fifth process, namely, reaeration. This formula, similar to the formula for decay, is:

$$\frac{dD}{dt} = -K_D D \qquad (23)$$

where D = DO deficit (saturation DO minus actual DO) and K_D = reaeration rate (1/time). The mass equation is:

$$\frac{\Delta M_{R,j}}{\Delta t} = K_D \; D_{j,t-1} \; V_j \qquad (24)$$

where $\Delta M_{R,j}$ equals mass of oxygen added in time step Δt to junction j by reaeration and $D_{j,t-1}$ equals initial dissolved oxygen deficit in junction j.

IMPORT AND EXPORT

The final method by which the concentration in a junction may be changed is by import (tributary inflow, waste discharge, etc.) or export (industrial or municipal use, etc.). The equation for this is:

$$\frac{\Delta M_{e,j}}{\Delta t} = \Sigma \, Q_\ell \, c_\ell \qquad (25)$$

where ΔM equals total mass of constituent added (or subtracted) from the junction in time Δt. Q_ℓ equals separate inflows (or outflows) to junction j during time Δt. For exportation, the concentration c_ℓ is taken to be that in junction j at time t-1, while for importation, the concentration of the inflow must be specified.

SOLUTION OF MASS BALANCE EQUATION

Combining the previous equations which describe the various processes governing mass transport and distribution yields the following:

$$\frac{\Delta M_j}{\Delta t} = \frac{\Delta M_{a,j} + \Delta M_{K,j} + \Delta M_{D,j} + \Delta M_{R,j} + \Delta M_{e,j}}{\Delta t} \quad (26)$$

where ΔM_j represents the change in mass occurring in junction j during the time step Δt for a given constituent.

The solution of this quality equation is a relatively straight-forward and sequential process involving an explicit, finite difference technique. The initial and boundary concentrations as well as waste loading data are entered as input. The solution then proceeds as follows:

1) The hydraulic extract tape is used to provide values for velocity and flow (both direction and quantity) for each channel element in the network, and water surface elevations at each junction element for the appropriate time step. The latter is required to compute junction volumes, which are necessary for mass determination ($M = V*c$).

2) All constituent masses are transported via advection and dispersion.
3) Non-conservative constituent masses are decayed. The reaeration equation for dissolved oxygen is applied here.
4) Wastewater loads and other inflows are added.
5) Water diversions are subtracted.
6) Steps 1-5 are repeated for every junction and channel as necessary.
7) Steps 1-6 are repeated for each quality time step.

All reaction rates must be entered as constants, but they are corrected for temperature and time step internally. It should also be noted that a mathematical discrepancy exists in the quality program in that certain equations retain their "differential" or finite difference form while others are of an integrated form. While this does present certain programming problems, no errors in the final solution are introduced.

II. MAJOR MODEL MODIFICATIONS PERFORMED BY AFO

A. HYDRAULIC MODEL

The hydraulic model described in the preceding chapter underwent a single modification before it was applied to the Delaware Estuary. That modification, the ability to input two separate and independent tidal waves, was precipitated by the uncertain effects, particularly in terms of the hydrodynamics, that the C&D Canal exerts in the lower portion of the Delaware. The western end of the canal is primarily driven by the Chesapeake tides, hence the need for two inputs. Two sets of coefficients, one describing the Delaware wave and the other describing the Chesapeake wave, must be generated by applying the harmonic regression analysis to a set of data describing tidal elevation versus time. Tidal elevations should be referenced to a common datum such as local mean sea level. Junction 1 accepts the Chesapeake wave and junction 2 the Delaware wave in the present program.

B. QUALITY MODEL

The modifications performed to the quality model by AFO can be grouped into two categories: (1) those pertaining to the basic transport mechanisms, i.e., advection and dispersion as well as seaward boundary transfers which are directly related to transport of mass through the model network and (2) those expanding the various reaction kinetics by mathematical formulations and enhancing the flexibility of the model to consider a myriad of combinations with a minimum amount of effort directed towards reprogramming and redefining input parameters. The former group of changes was necessitated by the location of the seaward boundary in the model and the salinity characteristics that this region of the estuary exhibits. Unfortunately, it was not feasible to extend the model network to the ocean thereby eliminating much of the problem. The second group of changes was done primarily to ease tasks associated with a potentially complex calibration/verification.

1. ADVECTION

The very steep salinity concentration gradient which exists in the Delaware Estuary near the model's seaward boundary greatly accentuated the stability and numerical mixing problems in the model. There was a tendency for the "stacking up" of mass to occur in particular junctions during either the ebb or flood phase of the tide. Obviously, this caused the model to produce erroneous predictions. One of the things which was done to overcome these problems was to alter the method by which advective mass transfers were computed. The C* value, or the concentration of the advected water (see previous chapter), was not assumed constant; program changes were made to allow for spatial variation of this term. Moreover, another option was introduced in the model that would permit two values of C* to be read in for each channel element; one would apply to the ebbing phase of the tide and the other, which may or may not be different, would apply when a flooding tide occurred. It is difficult if not impossible to explain, in a physical sense, why C* will or should vary either with time or space. Attempts were made to relate C* to a combination of factors such as tidal velocity, channel length, concentration gradients and other physical characteristics, but nothing conclusive ever evolved from this exercise. One thing is certain: while none of the advective methods contained in the original model documentation report [4] worked for the Delaware, the spatially varied and intra-tidal cycle varied C* computations did produce the first major breakthrough in minimizing both the stability problems and the numerical mixing, which had prevented solution accuracy. The reduction of numerical mixing could be deduced by the fact that the model was now predicting a much steeper concentration gradient, similar to observed gradients.

2. DISPERSION

The coefficient used to compute mass transfers through the turbulent dispersion process, C_4, was required to be a constant in the original model. This did not appear to be realistic in the Delaware and consequently a modification was performed to permit C_4 to vary spatially. Unlike the estimation of the advection concentration, C*, the justification of varying dispersion rates can be explained in the physical sense. It is a well known fact that high salinity gradients produce density currents [9], [10], [11], which constitute a further driving force for dispersion. Practically all previous modelling studies with the DEM have indicated this phenomenon in high salinity areas and have required adjustments to the magnitude of dispersion. Through the use of a spatially varying C_4 term, it was possible to relate dispersion to salinity and achieve a more realistic representation of an actual process which is usually quite significant.

3. SEAWARD BOUNDARY TRANSFERS

There was an inherent problem in the original DEM's handling of the seaward boundary which contributed to the problems discussed under advection. Although this contribution was restricted to only a couple of junctions adjacent to the seaward boundary, it was in these particular junctions where most of the advective problems were arising. The basic defects in the original DEM were (1) the boundary concentration over the entire tidal cycle, assuming that it varied, was virtually unknown but had to be specified, and (2) these concentrations could not be varied on an inter-tidal cycle or long-term basis. This created the situation where the user had to surmise what the final results would be before he started.

Additional flexibility was added to the model's procedure for transferring mass across the seaward boundary in the Delaware Estuary (the Chesapeake Bay boundary was excluded since it was not critical) by eliminating restrictions on concentration variations. During the ebb portion of the tidal cycle, the concentration predicted to be in the seaward junction of the model network was used as the actual concentration of the water advected across the boundary and out of the system. During a flooding tide, the concentration of the incoming water was incremented between the minimum value achieved at the end of the preceding ebb tide and a maximum value, CINMAX, which should theoretically occur at the very end of flood. Checks were made within the program to determine when ebb tide ends and when flood tide ends so that appropriate strategies could be followed. The value assigned to CINMAX can also be temporally varied in any fashion to reproduce the actual observed intrusion process occurring during the simulation period.

As can be seen, the method by which seaward boundary transfers are made is truly dynamic in nature and logical, since it more accurately represents what is actually taking place in the prototype. The model's ability to predict salinity distributions in the Delaware, and especially to achieve the tremendous intra-tidal cycle fluctuations that normally occur near the seaward boundary based upon several observations, was greatly enhanced by this modification to the DEM.

4. REACTION KINETICS

The original version of the DEM could handle five separate constituents which were either conservative or nonconservative (first order decay). However, with the exception of BOD-DO, none of the constituents could be coupled to one another mathematically. This effort was to modify the program so that (1) constituents could be linked in any conceivable fashion, (2) a more complete representation of the DO budget including photosynthesis and respiration by phytoplankton could be included, and (3) reactions other than first order could be specified if the data so warranted. Besides addressing the above items to a satisfactory degree, it was imperative that the model retain as much of its flexibility as possible and be general enough to treat most foreseeable situations.

A unique "linear matrix" type of solution was employed in the model to accommodate the coupling of constituents. Any constituent(s) may be decayed through first order kinetics and the portion decayed may be transferred to any other desired constituent; a mass conversion coefficient can be applied so that the units of mass are compatible. In no case will the conservation of mass theory be violated. An ideal example of the possible constituent couplings is nitrification, or the conversion of ammonia nitrogen to nitrate nitrogen. Nutrient uptake by phytoplankton would be another example where a mass conversion factor to equate the two is necessary. In short, any depletion or accretion of material including any transfer associated with first order reactions may be considered in the model for any constituent given the proper specification of input coefficients.

The other major modification to the program involved the addition of several function operators to the basic mass balance equation. A brief description of these is given below:

FUNC1	Reaeration (three separate formulations)
FUNC2	Sediment (or Benthic) Oxygen Demand
FUNC3	Algal photosynthesis as related to model's predicted chlorophyll concentrations

FUNC4	Algal respiration as related to model's predicted chlorophyll concentrations
FUNC5	Algal photosynthesis as related to user-specified chlorophyll concentrations
FUNC6	Algal respiration as related to user-specified chlorophyll concentrations
FUNC7	n^{th} order reaction kinetics where $n \neq 1$
FUNC8	Uptake of ammonia nitrogen by algae
FUNC9	Uptake of phosphorus by algae
FUNC10 & 11	Any additional first order reaction - i.e., settling
FUNC12	Denitrification rate linked to DO.

As can be seen, these function operators provide a diverse array of reactions, all of which strengthen the model's capability to treat DO and nutrient budgets. Specifying a non-zero value for a particular function operator activates that reaction and requires the input of a rate and other relevant information. It is important to note that all reaction rates may be varied spatially by reading in separate values for different groups of junctions numbered sequentially. This demonstrates an extremely significant improvement in the model's usefulness, since it is highly doubtful that rates such as benthic oxygen demand, nitrification, and algal death would be constant over an 80 mile stretch of estuary. Appropriate temperature corrections are also performed on all rates internally.

Three formulations for the reaeration rate have been employed in the model. The O'Connor-Dobbins Equation, the Churchill Equation, or the USGS (Langbein) Equation can be used to compute a reaeration rate for each channel at each quality time step. If desired, constant reaeration rates can also be read in directly at the junctions. If an equation is used, the reaeration rate for a junction having multiple channels is computed by prorating the individual channel rates according to the magnitude of the flow in each channel during the time step. Other methods for computing reaeration rates can be inserted into the program without much difficulty.

Another modification to the DEM affecting reaction kinetics involved adding a variable temperature option. New temperatures can be read at desired intervals along with the time period, in quality cycles, that each temperature is applied. When a new temperature value is read, all reaction rates (except higher-order rates) will be corrected for this temperature before utilizing them in the mass balance equation.* The convenience of this option will become apparent when longer, inter-seasonal runs are considered.

Final modifications to the reaction linkages and feedback (non-linear in some instances) systems in the model were performed as a result of model testing during the DO calibration and verification phase. Literature material proved helpful during this

* If a simulation requires the specification of chlorophyll concentrations and euphotic depths, these can also be varied by reading in new values whenever the temperature is changed.

endeavor. The most notable of these modifications involved (1) the inclusion of localized settling of organic material (Org N & BOD) which is handled by FUNC10 and FUNC11 according to first order kinetics; (2) the feedback of predicted DO concentrations on the denitrification rate (FUNC12) and the subsequent replenishment of oxygen through the reduction of the NO_3 molecule; and (3) the attenuation of the sediment oxygen demand rate when the DO falls below the 2.0 mg/l level. A further discussion of the modifications specific to the DO model is presented in the next chapter.

5. CONSTITUENT NUMBERING

Several options have been included in the quality model to permit a considerable degree of flexibility in assigning actual constituents to the constituent numbers utilized by the program. The basic purpose of these options was to create the ability to simultaneously consider in a single model run several of the same constituents, each having a different reaction rate or some other distinctive characteristic, without having to repunch the entire set of junction cards. The junction cards contain initial and waste load concentrations for each constituent. It became evident at the outset of the model calibration study that this ability would substantially reduce the number of runs (and the cost) required to intelligently appraise the various reaction rates on an individual basis.

Each of the options added to the model are briefly described below:

Option 1 — Constituent numbers 1 through 5 in the model represent the first water quality parameter.

Option 2 — Constituent 1 in the model represents one parameter; other constituents between 2 and 5 represent the second parameter.

Option 3 — Constituent 1 in the model represents one parameter, constituent 2 another parameter. Constituents 3 through 5 represent the third parameter.

Option 4 — Constituents 1, 2 and 3 in the model each represents a different parameter. The fourth parameter is assigned to constituents 4 and 5.

Option 5 — Similar to option 3 but the parameter treated as constituent 5 is also assigned to constituents 3 and 4. Option 3 sets constituents 4 and 5 equal to constituent 3.

Option 6 — Each constituent in the model represents a different water quality parameter. Normally used for DO program.

6. VARYING WASTE INPUTS

The model as originally programmed allowed constant waste loadings only. In its application to the Potomac Estuary, reprogramming allowed one varying waste source. A proper analysis of the Delaware Estuary, however, required the ability to consider multiple varying waste sources for at least three reasons:

(1) There are numerous major waste sources whose varying loadings could affect stream quality significantly; daily flow periodicities in sewage treatment plants, for example, could be important.

(2) An understanding of stream quality changes during spring and fall fish migrations was desired; these periods are characterized by regular changes in tributary loadings (for both flow and quality) and in sewage loadings (mainly quality).

(3) An understanding of stream quality response to such transient loadings as stormwater runoff was desired; these loadings are characterized by rapid changes in both flow and quality.

The reprogrammed varying waste load section, then, had to be flexible enough to allow periodic, long-term transient, and spike loadings. Furthermore, changes in the quantity of waste flows had to be independent of changes in quality.

The varying waste input section is divided into two logically similar subsections which treat varying waste flows and varying waste concentrations. For each junction with a varying input, the flow periodicity and number of flow increments per period are first required. For a sewage flow that changes hourly over a daily cycle, for example, the periodicity is 24 hours and the number of flow increments is 24. For a spike load (such as stormwater) in the middle of a simulation, the periodicity is set equal to the length of the run, and the number of flow increments is three (before, during and after). The program then reads the flow rate and duration for each flow increment. Next, the varying quality subsection reads in the quality periodicity, number of quality increments, and quality levels and durations for the junction. All varying waste parameters are stored in arrays and recalled when necessary throughout the simulation period.

7. OUTPUT

It will be noticed in the following chapter that all comparisons of model and observed data apply when a slack water tidal condition occurred. All historical water quality data presented in this report were collected during a particular slack tide. Knowing the precise tidal condition during data collection eases considerably some of the problems associated with model verification. The original printout options did not lend themselves to the situation where output is required at numerous consecutive cycles for different groups of junctions. In essence, this represents the following of a slack tide up the estuary. Consequently, a modification was made to the model's printout section.

Under the new system the total number of printout cycles is specified along with the junction numbers to be printed out for each cycle and the particular slack tide being represented. It must be determined, external of the model, when a given slack water occurs at each junction, which is dependent upon starting conditions, and then translated to computational cycle numbers used in the model. In this manner no extraneous printout is obtained.

The tidal cycle summary printouts tabulated in Subroutine QUALEX have not been altered.

The Annapolis Field Office will prepare and publish a complete users manual for the basic model described in this report, with some updated streamlining. The manual, as presently envisioned, will enumerate the various input data and format requirements, output options and examples as well as a rudimentary coverage of the program logic and operation.

III. MODEL APPLICATION TO THE DELAWARE ESTUARY

A. OVERVIEW

The application of the Dynamic Estuary Model to the Delaware Estuary involved the following five major steps: (1) compilation of the data base, (2) establishment of the model network, (3) calibration of the hydraulic model, (4) calibration and verification of the quality model, and (5) definition of the model's sensitivity to various parameters. Steps (2) through (5) were accomplished in order, while step (1) required continuous updating throughout the model application. These five steps are discussed in sections B through F of this chapter.

Although these general steps are followed in most studies utilizing the DEM, the scope of each step and its relationship to the others depends on the overall goals of the study. The basic structure of the quality model which evolved in Step (4) was predicated on the three primary goals enunciated in Chapter I: (1) to better understand and define the significant mechanisms affecting the water quality behavior of the estuary; (2) to provide a more reliable deterministic tool for accurately predicting the effects of alternative waste control strategies on the estuary's water quality; and (3) to establish a sound data and knowledge base which would be a valuable reference for planning future studies. Emphasis was placed on those interactions affecting dissolved oxygen, due to its widespread acceptance as a water quality standard by planning and regulatory agencies in the Delaware Basin. Although the DO budget was the ultimate aim, this study also stressed the crucial importance of first defining the water movement and the resulting basic transport mechanisms through careful application of the hydraulic model and the quality model to salinity and dye tracer data.

B. COMPILATION OF DATA BASE

The single most important data need for this study was water quality. Three primary sources of water quality sampling data were utilized during different phases of the modelling study.

1. State of Delaware

Periodic slack water runs up the Delaware Estuary between Reedy Island and Fieldsboro, N. J. have been performed by the State of Delaware under contract to the Delaware River Basin Commission (DRBC) since 1967. Salinity, nitrogen and DO data collected during some of these surveys, when conditions approached steady-state, were used for model calibration and verification.

2. AFO

Starting in late 1972, AFO has been conducting a considerable amount of sampling in the Delaware Estuary between Artificial Island and Trenton. Both intensive surveys, comprised of several slack water longitudinal runs interspersed with transect sampling or other special studies, and individual runs up the estuary have been performed several times during the past five years. In terms of mathematical model application, the intensive data, normally collected within a week's period, is exceptionally valuable if representative of steady-state conditions. Various fractions of nitrogen and phosphorus were analyzed during all surveys, along with DO, BOD_5, Chlorophyll a, and light penetration (Secchi Disk). Occasionally, long term carbonaceous and nitrogenous oxygen demand, heavy metals, and other parameters of concern were measured in the laboratory.

In addition to this water quality monitoring, AFO performed a special dye study in July-August, 1974, for estimating dispersion, dilution and transport characteristics of the Delaware Estuary in the vicinity of Philadelphia. Dye was released continually at a rate of 1.4 lbs/hr or 25 ppb over a four day period (8 complete tidal cycles) via the outfall pipe at the City of Philadelphia's N.E. wastewater treatment plant. Three weeks of monitoring were conducted in order to track the dye cloud's movement laterally, vertically, and longitudinally over time.

3. 1975 and 1976 Co-Op Studies (208 Program)

Two very intensive, two week monitoring programs were initiated by DRBC for the purpose of calibrating and verifying either a one or two dimensional model. These surveys were conducted during moderate flow, high-temperature periods in August 1975 and July 1976. Major participants included AFO, the City of Philadelphia, and the States of Delaware, Pennsylvania, and New Jersey. Numerous slack water runs were made from Artificial Island to Trenton, N. J.

with three boats running abreast as far as Torresdale, Pa. In addition, a considerable amount of transect sampling was included in the 1975 survey. Sampling of significant tributary inflows and waste discharges was conducted during both surveys. Composite samples were collected at the Trenton water supply intake to establish input loadings to the estuary from the upper Delaware Basin. Among the laboratory analyses were BOD_5, BOD_{20}, DO, NH_3, TKN, NO_2, NO_3, TPO_4, inorg P, chlorophyll a, fecal coliform, total solids, suspended solids, turbidity, and chlorides.

After water quality, the most important data needs were municipal and industrial wastewater loads, tidal conditions, and freshwater inflows. Data pertaining to tides and flows were obtained from the U.S. Coast and Geodetic Survey and the U.S. Geological Survey, respectively. A strenuous effort was made to determine wastewater loadings, particularly from the most significant sources. Nevertheless, many of the individual water quality data sets lacked complete information on wastewater flows and pollutant concentrations. In lieu of wastewater data taken during the water quality surveys, wastewater loads had to be estimated from NPDES and Corps of Engineers permit applications, water and waste quality reports, self-monitoring reports, and special surveys by state and federal agencies. The August 1975 and July 1976 co-op surveys were the only exceptions, where some data were obtained at every major wastewater source while estuary sampling was underway.

As might be expected, the quality and completeness of wastewater data varied among waste dischargers and over time. Recent data from all dischargers tended to be more complete (particularly the flow rates) due to the self-monitoring requirements of the NPDES program. An additional report documenting all of the recent wastewater analyses and trends is planned by AFO for the near future. A summary of wastewater loadings used for the model simulations of the five data sets in this report is tabulated in the Appendix.

C. ESTABLISHMENT OF MODEL NETWORK

A network comprised of 76 junctions and 82 channels was designed for the Delaware Estuary between Trenton, N. J. and Liston Point, Delaware, a distance of about 80 statute miles. A map containing the network is shown in Figure III-1. The network includes not only the main stem of the Delaware, but the entire C&D Canal and the major tidal tributaries as well. Excepting areas where large islands occur, the configuration of the network can be classified as one-dimensional. A hydraulic time step of 5 minutes and a quality time step of 30 minutes are used when running the model with this network.

Caution was exercised in designing the network grid so that the actual channels which convey most of the flow in the prototype are well represented in the model. Channel elements were oriented to minimize the variations in their widths and depths and to keep their lengths relatively uniform and compatible with the stability criteria relationship shown in Chapter I. For the most part, channel lengths ranged between 1 and 3 miles.

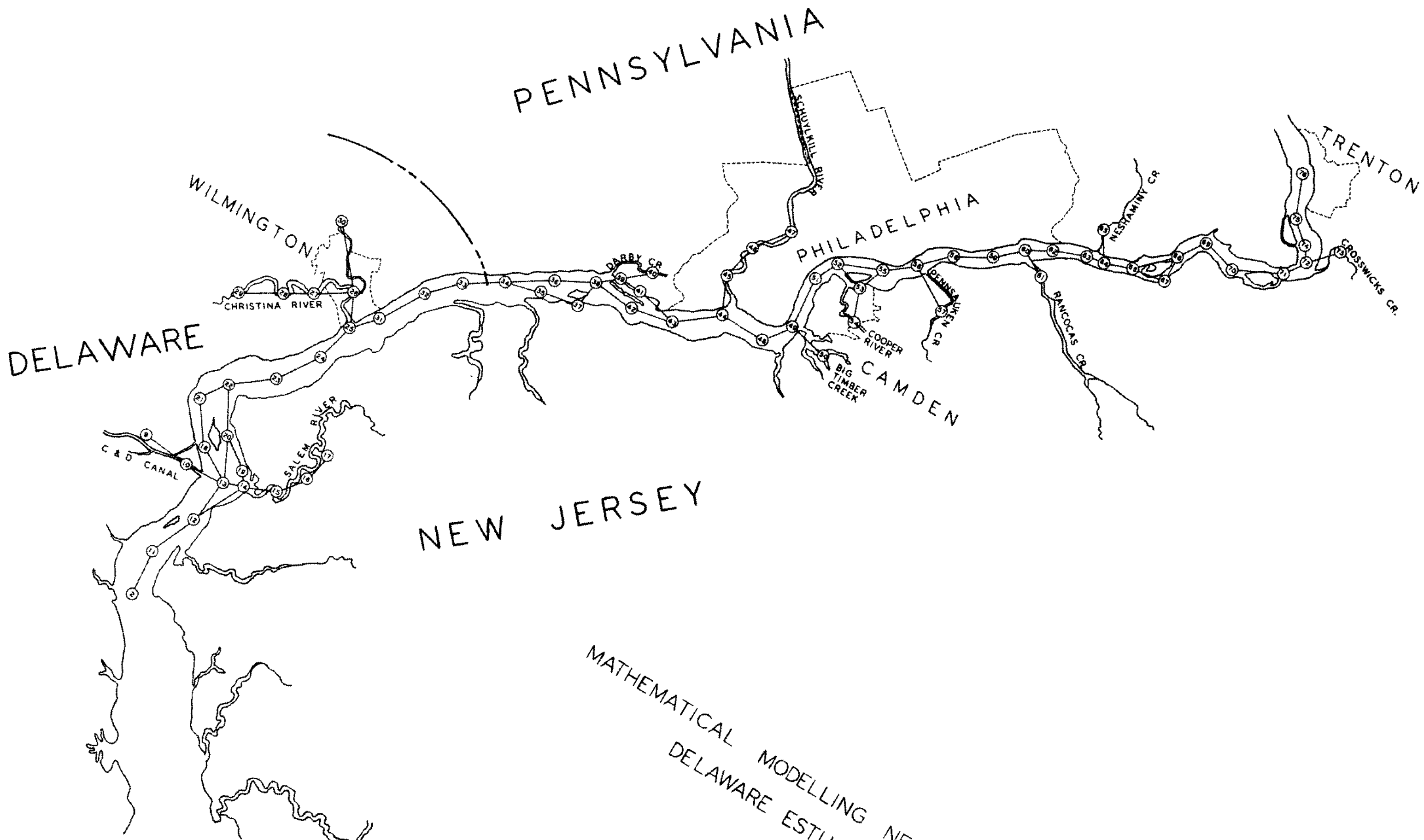


FIGURE III-1

MATHEMATICAL MODELLING NETWORK
DELAWARE ESTUARY

Although any geometrical design can be employed for the junction elements, the one-dimensionality of this network dictated primarily a rectangular type of grid pattern. In general, a sampling station corresponded to about every other junction, which is adequate coverage for most model verification studies. A diagram showing the relative position of sampling station, model junctions, bridges and other landmarks, major waste sources, etc., is included in the Appendix.

All of the required physical data for this network were obtained from the most currently available sets of USC&GS navigation charts.

D. CALIBRATION OF HYDRAULIC MODEL

Several simulations were made with the hydraulic model in an attempt to reproduce the actual tidal wave movement in the Delaware under an average flow condition. The only variable that was altered during these runs was the Manning channel roughness coefficient, which controlled energy losses and thus influenced both the speed of the wave and the tidal ranges. The waves imposed at the seaward boundaries of the model were typical for the areas, based upon one year of tidal records.

The results of the final calibration run, along with actual prototype data for most USC&GS tidal prediction stations are shown in Table III-1. Included in this table are both tidal range data and phasing data which indicate times of high and low water as referenced to Liston Pt., the seaward boundary of the model on the Delaware. An examination of the data shown in Table III-1 reveals that the model does indeed simulate fairly accurately the tidal wave motion in the Delaware Estuary. Actual and predicted tidal velocities at various locations in the estuary were not included in the table because of limited data, but some comparisons were made and they did appear acceptable. The final roughness coefficients are shown in Table III-2.

Table III-1

Comparison of USC&GS Tidal Data and Hydraulic Model Predictions
Delaware Estuary

Station	Model Junction	Ranges (feet) Actual	Ranges (feet) Predicted	Phasing* (min) Actual H.W.	Phasing* (min) Actual L.W.	Phasing* (min) Predicted H.W.	Phasing* (min) Predicted L.W.
Trenton	75	6.8	6.6	+304	+381	+280	+375
Bordentown	72	6.7	6.8	+301	+360	+275	+360
Florence	69	6.6	6.6	+299	+350	+265	+340
Bristol	68	6.5	6.5	+289	+336	+260	+330
Torresdale	60	6.2	6.1	+258	+302	+235	+295
Philadelphia, Bridesburg	56	6.0	6.0	+226	+268	+205	+265
Philadelphia, Pier 11	51	5.9	5.9	+200	+240	+190	+245
Gloucester City	49	5.8	5.8	+187	+227	+180	+240
Schuylkill River @ Fairmount Br.	47	5.8	5.8	+194	+236	+180	+245
Schuylkill River @ Point Breeze	54	5.7	5.7	+179	+220	+170	+235
Fort Mifflin	44	5.7	5.7	+171	+210	+160	+220
Billingsport	43	5.7	5.6	+161	+200	+150	+210
Chester	36	5.7	5.6	+141	+180	+130	+180
Oldmans Pt.	32	5.6	5.6	+118	+153	+100	+145
Christina River	25	5.6	5.6	+106	+135	+ 85	+125
New Castle	23	5.6	5.4	+ 85	+108	+ 70	+110
Reedy Pt.	13	5.5	5.4	+ 55	+ 59	+ 40	+ 50
C&D Canal @ Biddle Pt.	9	5.1	4.4	+ 50	+ 60	+ 35	+ 35
C&D Canal @ Summit Br.	6&7	3.5	3.4	+ 21	+ 04	+ 30	+ 5
C&D Canal @ Chesapeake City	4&5	2.6	2.5	- 20	- 53	-25	-40

* Referenced to Liston Pt.

Table III-2

Final Manning Roughness Coefficients
Delaware Estuary Hydraulic Model

Channels	River Mile	Manning n
1 - 14	87 - 74	0.010
15 - 17	74 - 74 (trib)	0.015
18 - 27	74 - 64	0.010
28 - 32	64 - 64 (trib)	0.015
33 - 36	64 - 54	0.016
37 - 62	54 - 28	0.020
63 - 72	28 - 13	0.035
73 - 82	13 - 0	0.040

E. CALIBRATION AND VERIFICATION OF QUALITY MODEL

1. Chloride Simulations

The chloride ion is a conservative substance which is advected and dispersed upstream from the ocean. It is a convenient measure of salinity and is used interchangeably with that parameter. Five separate and independent data sets were used to calibrate and verify the Delaware model for chloride movement. Of special importance was the confirmation that the transport modifications discussed in Chapter II could, in fact, handle the steep salinity wedge observed in the Delaware, and the proper estimation of input coefficients would permit the model to be predictive rather than descriptive. Three different flow conditions were considered in order to develop a relationship between chloride concentrations, which are a function of freshwater flow, and dispersion coefficients. The fact that chloride data were not available downstream from Reedy Island created a problem when specifying conditions at the model's seaward boundary, which is located 5 miles downstream from Reedy Island. Extrapolations had to be performed based upon observed local gradients during each simulation period.

Initially, a data set representing approximately an average flow condition (11,000 cfs) was selected for model calibration (all flows here refer to the freshwater flow at Trenton). The time period was May 14-28, 1970, when flow was extremely steady. Numerous runs with different assumptions were performed to analyze model sensitivity and thus to acquire insight on model behavior. The following table exhibits the advection factors (C*) and dispersion coefficients (C_4) used in the final calibration run for 11,000 cfs; the results of the calibration are shown in Figure III-2.

TABLE III-3

Advection Factors and Dispersion Coefficients
DEM's Initial Chloride Calibration
(Flow = 11,000 cfs)

Channel	River Mile	C* (Flood)	C* (Ebb)	C_4
1		1.0	0	20
2		1.0	0	30
3		1.0	0	40
4		1.0	0	50
5		1.0	0	60
6		1.0	0	70
7		1.0	0	80
8		1.0	0	90
9	83	.6	0	100
10	80	.33	0	50
11	77	.3	0	10
12		1.0	.33	10
13		.2	0	10
14		.2	0	10
15		.5	0	1
16		.5	0	1
17		.5	0	1
18		.5	0	10
19		.5	0	10
20	74	.5	.1	10
21		.5	0	10
22		.5	0	10
23		.5	0	10
24	72	.5	.25	10
25	69	.67	.33	1
26-82	67-1	.67	.33	1

The agreement between observed and predicted high water salinity profiles is surprisingly good, considering the initial difficulties in maintaining both stability and accuracy of the solution. As can be seen, predicted gradients were extremely steep except for the network between junctions 13 and 20, a highly variable and hydraulically complex area near the C&D Canal. The low water profile, which is not shown in the figure, appeared to be very reasonable, based upon other data sets; this indicated that tidal transport and seaward boundary transfers were functioning properly in the model.

Data collected during a comparable flow period (12,000 cfs) were used to verify the advective and dispersive inputs shown in the table above. The results from this verification simulation of the May 7-22, 1968, chlorides movement are shown in Figure III-3. Again, a satisfactory agreement was obtained, even though the concentration gradients were more severe here than in the data set used for calibration.

The second condition investigated was characteristic of a typical late summer - early fall Delaware hydrograph when flow rates average about 5,000 cfs. It was apparent that the greater salinity intrusion under this lower flow condition would necessitate a dramatic increase in the dispersion coefficients. The original advection factors were, however, left intact since there was no valid justification for changing them. The revised dispersion coefficients yielded by the final calibration run (5,600 cfs - July 6 to August 1, 1967) are presented below for the major channel elements in the model network. The model predictions are shown in Figure III-4 along with observed data.

Channel	River Mile	C_4
9	83	100
10	80	100
11	77	100
20	74	75
24	72	50
25	69	25
26	67	25
27	64	25
33	62	10
34	60	10
35 and above	58-1	1

The next model run was to verify the advection factors and the dispersion values used in the 5,600 cfs calibration run. The observed data represented a steady state period between October 8 and November 6, 1969. The freshwater flow during this period was about 4,800 cfs. The excellent agreement between observed and predicted data exhibited in Figure III-5 indicated that the model was capable of accurately forecasting the salinity intrusion process during a representative low flow situation. It is interesting to note that the calibration was performed with low slack data whereas the verification used high slack data. This demonstrates the versatility of the model in considering significantly varying situations.

The third verification data set represented an extremely low flow period which occurred between July and October 1964. In fact, the 2,400 cfs at that time represented one of the lowest sustained flow periods on record. The salinity profiles at the beginning and end of this time period were obtained from a DRBC report [12]. The primary reason for attempting another verification was to dispel any doubts about whether the model was "predictive" or "descriptive." Up until this point either position could have been argued since the dispersion coefficients were not defined a priori. In this case, however, an estimation of the applicable dispersion coefficients for 2,400 cfs was made based upon the values required for the two higher flow conditions. This extrapolative approach would thereby subject the model to a true test of its predictiveness. The flow-dispersion coefficient relationship used for this verification analysis is presented in Table III-4; it has been subsequently programmed into the model. The model results based upon this set of dispersion coefficients are shown in Figure III-6 along with observed data. An inspection of these salinity profiles will reveal the excellent response of the model in predicting prototype behavior when salinity intrusion rates were at a maximum. It is believed that this favorable agreement, along with others previously discussed, represented a good model verification for salinity subject to the limitations of the data base and the model's seaward boundary location.

2. Dye Simulations

Data collected during and after the July 1974 dye release at the Philadelphia N.E. wastewater treatment plant (see III.B.2) provided a valuable opportunity to assess the model's advection and dispersion inputs in a predominately freshwater region of the estuary. These transport parameters, of course, could not be adequately validated through the salinity simulation studies discussed in the above section. This dye data was considered to be even more valuable because of unique distinctions associated with this tracer. Dye is quasiconservative and, unlike salinity, will be advected and dispersed primarily in a downstream direction; due to a common point source, dye should closely approximate the mixing and transport characteristics of the wastewater itself.

Table III-4

Dispersion Coefficient (C_4) vs Flow

Delaware Estuary Model

River Mile	Channel	Flow (cfs x 1000) 11-12	10-11	9-10	8-9	7-8	6-7	5-6	4-5	3-4	2-3	1-2
83	9	100	100	100	100	100	100	100	100	100	100	100
80	10	50	75	100	100	100	100	100	100	100	100	100
77	11	10	25	50	75	75	100	100	100	100	100	100
74	20	10	10	25	50	50	75	75	75	75	75	75
72	24	10	10	10	25	25	50	50	50	50	50	50
69	25	1	1	1	10	25	25	25	25	25	25	25
67	26				1	10	25	25	25	25	25	25
64	27					1	10	25	25	25	25	25
62	33						1	10	25	25	25	25
60	34							10	10	25	25	25
58	35							1	10	10	25	25
55	36								10	10	25	25
53	37								1	10	10	25
50	39									10	10	25
48	43									1	10	25
46	47										10	10
43	48										10	10
40	52										10	10
38	53										1	10
36	55											10
33	56											10
31	59											10
29	61											10
27	63											10
28	64											1

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
MAY 1970	—	11,000 cfs	CHLORIDES

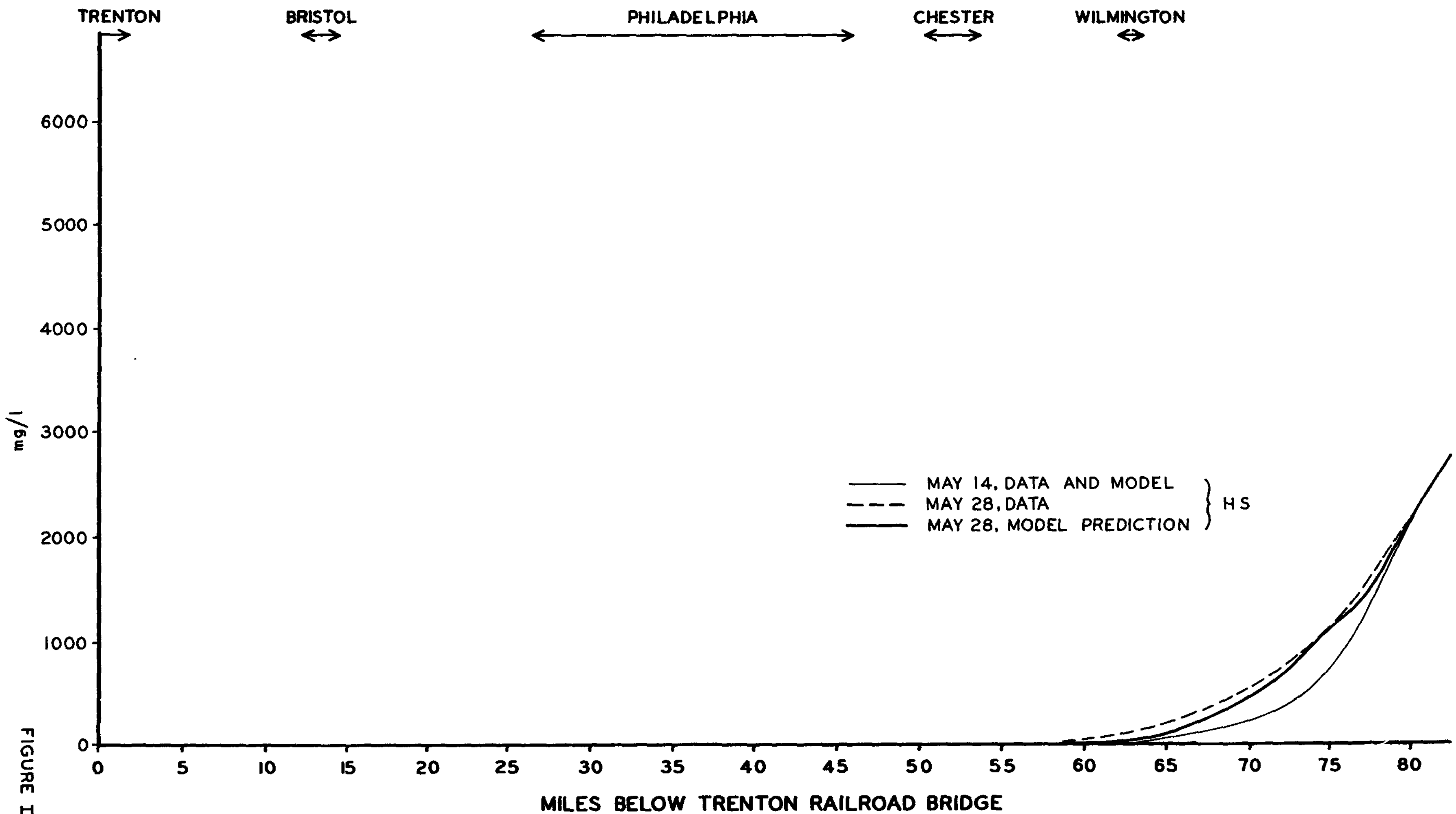


FIGURE III-2

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
MAY, 1968	—	12,300 cfs	CHLORIDES

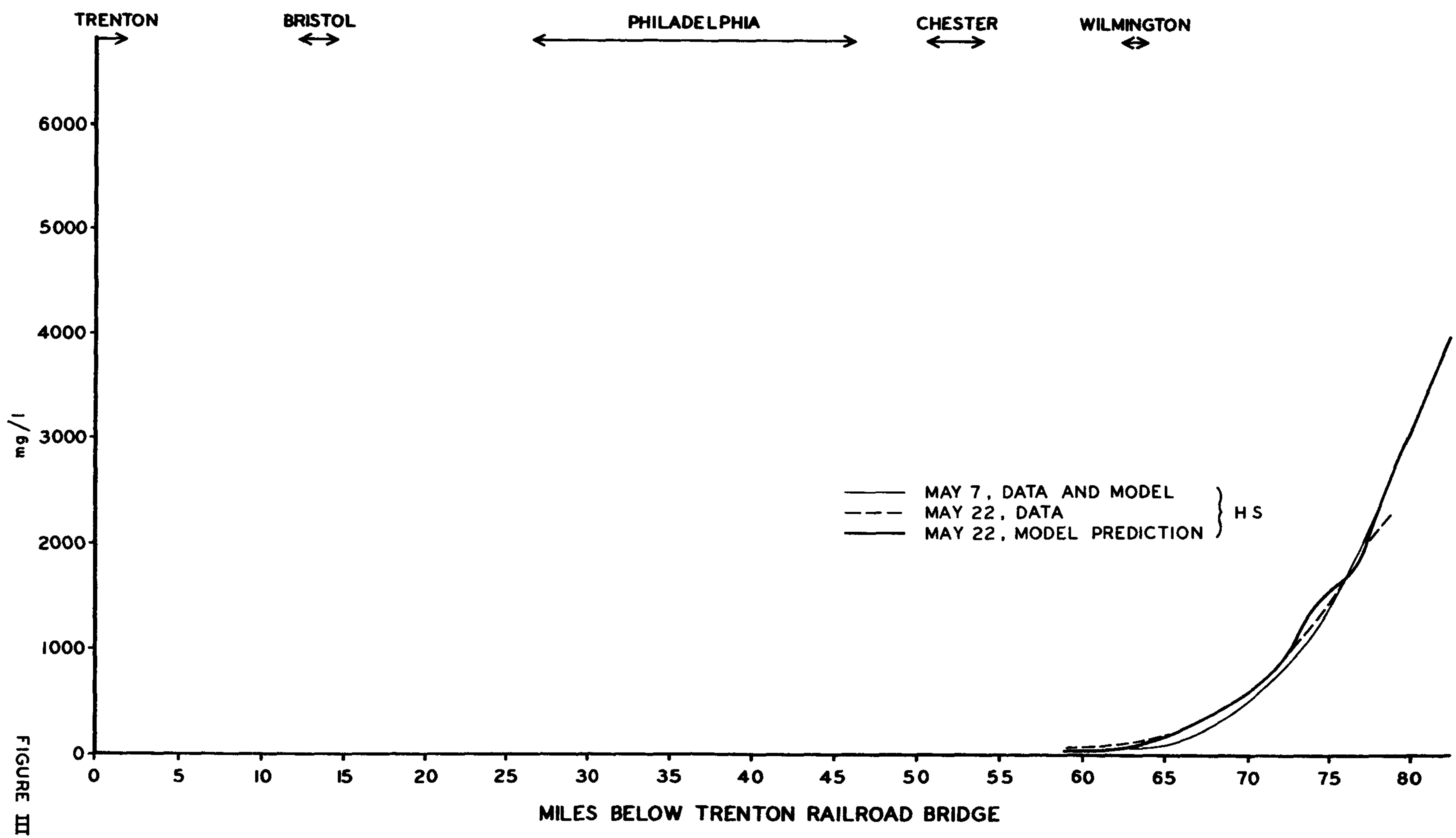
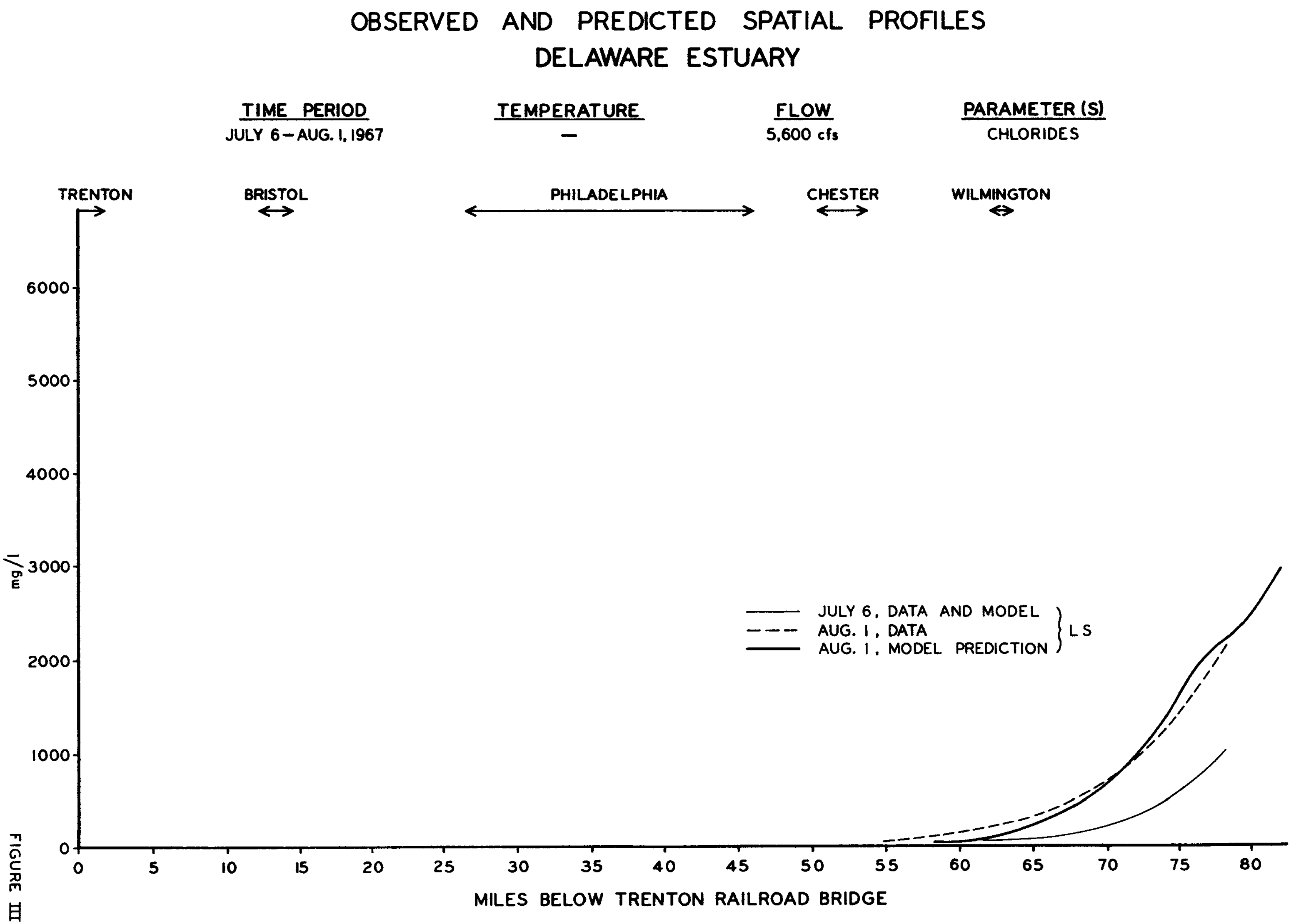


FIGURE III-3



OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY
TIME PERIOD
JULY 6 – AUG. 1, 1967
TEMPERATURE
—
FLOW
5,600 cfs
PARAMETER (S)
CHLORIDES
TRENTON
BRISTOL
PHILADELPHIA
CHESTER
WILMINGTON
mg/l
6000
5000
4000
3000
2000
1000
0
JULY 6, DATA AND MODEL
AUG. 1, DATA
AUG. 1, MODEL PREDICTION
LS
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
MILES BELOW TRENTON RAILROAD BRIDGE

FIGURE III-4

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
OCT. 8–NOV. 6, 1969	—	4,800 cfs	CHLORIDES

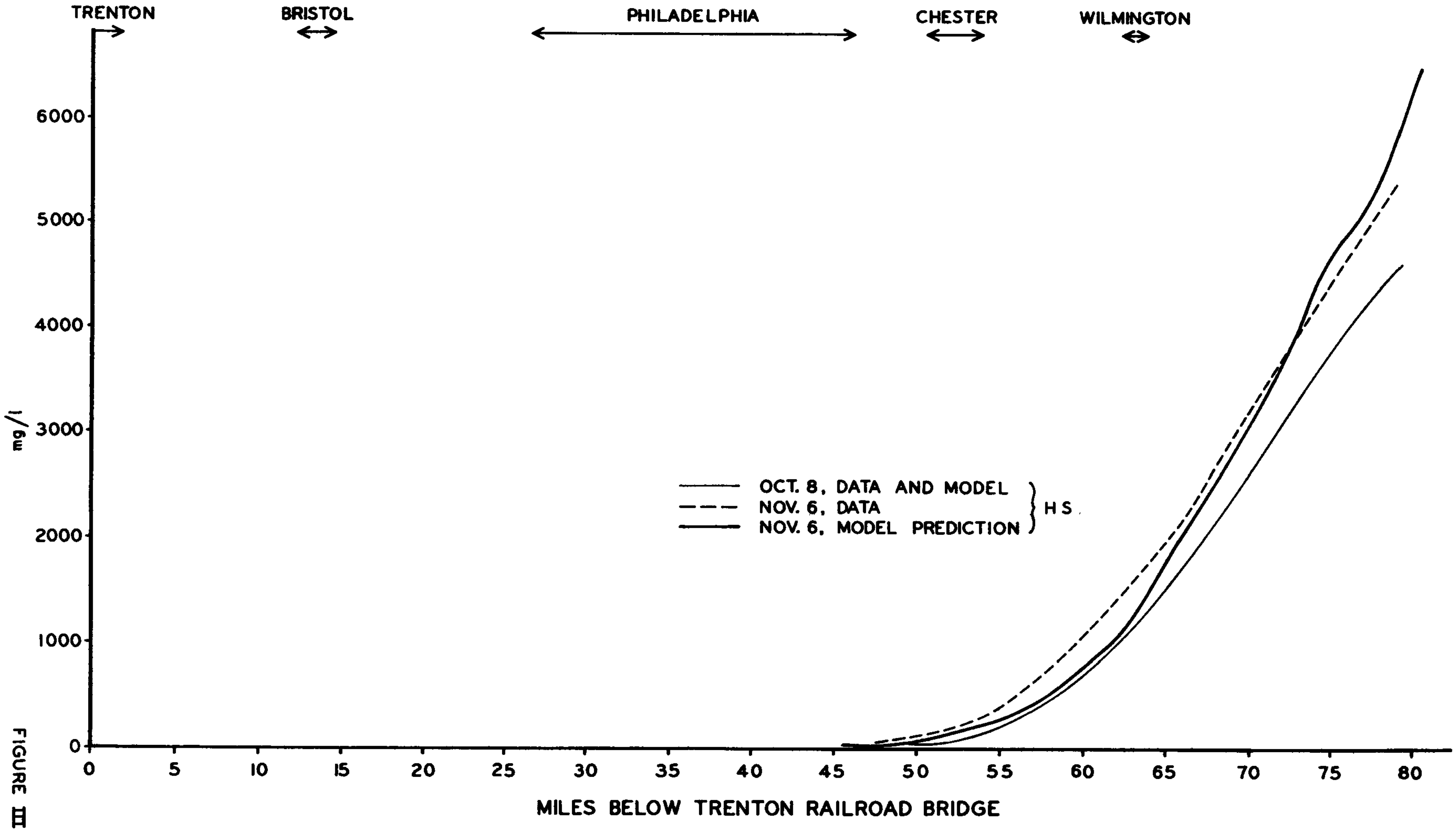


FIGURE III-5

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 10-OCT. 20, 1964	—	2,450 cfs	CHLORIDES

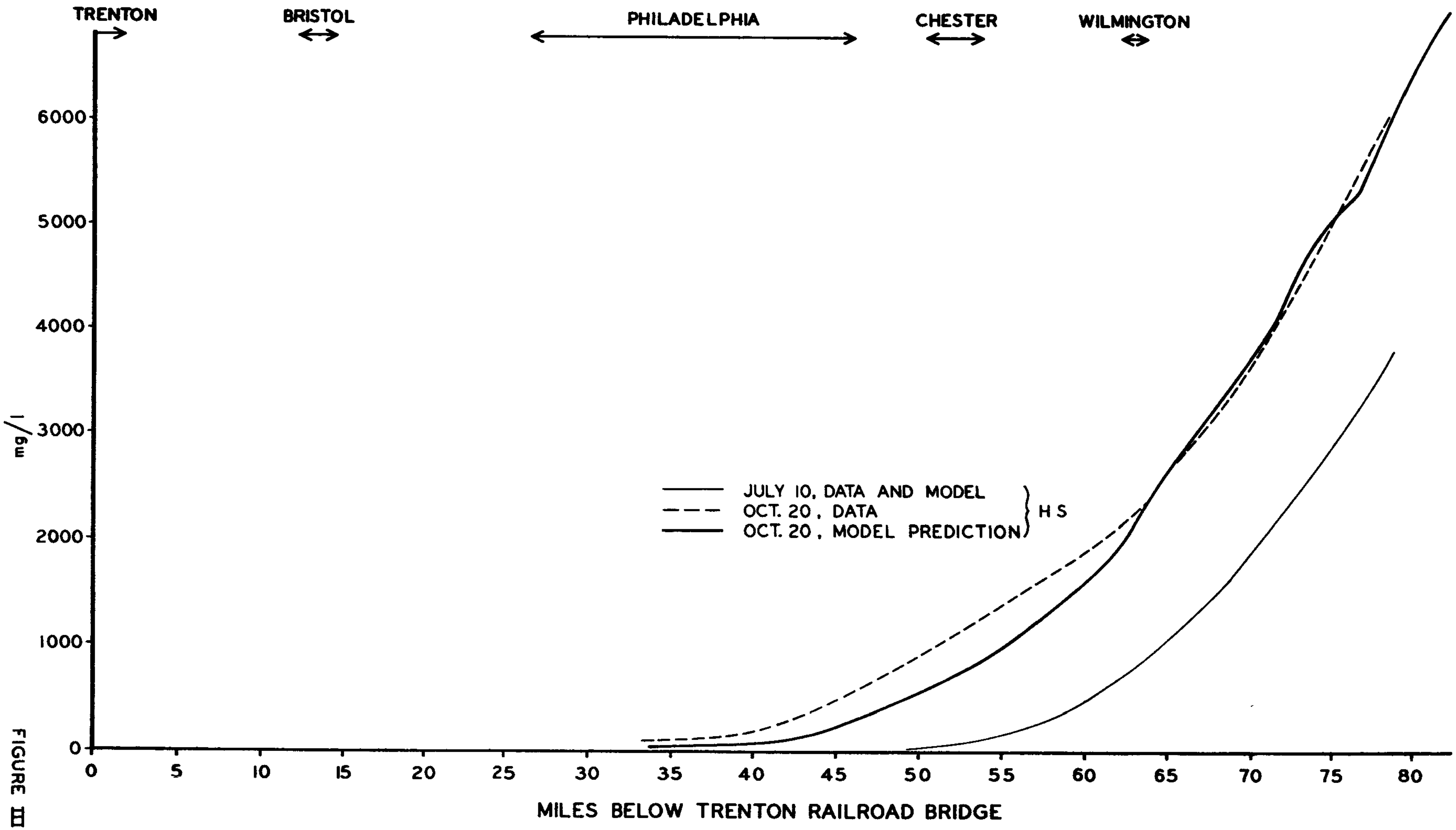


FIGURE III-6

Four separate hydrodynamic solutions, each representing a discrete flow between 3,900 cfs and 8,800 cfs, were required for the dye simulation. The appropriate sets of dispersion coefficients from Table III-4 were used, as well as a theoretical first order dye loss rate computed from a mass balance of field data. This loss rate was estimated to be 0.02/day. Other than the inclusion of a loss rate, the original model employed for salinity was left intact, including all inputs relative to advection. The results of this dye simulation and the actual dye distributions observed in the Delaware Estuary during the study period are presented in Figures III-7 through III-20. Both profiles correspond to either a high or low water slack condition as indicated. Since the model is based on a real time system, the predictions closely approximate the particular time period represented by the different data sets. It should be noted that appropriate corrections were made to some of the measured concentrations, especially during the initial few days of the study, to reflect significant differences between mid-channel values and those representative of the entire cross-section. These differences were identified by extensive transect sampling which was interspersed with the longitudinal monitoring of the dye cloud. Prior to the dye injection, a sampling run was made to define background concentrations throughout the study area. These concentrations were normally quite low ($\approx$ 0.1 ppb) but were nevertheless taken into account when analyzing the dye data for model verification purposes.

An examination of the observed and predicted dye data indicated that, in general, the model satisfactorily reproduced the basic transport of the dye cloud, as evidenced by the close agreement in spatial position, the bell-shaped characteristics, and the magnitude and location of the peak concentrations. A few significant discrepancies did occur with the dye peaks during the early phase of the study when some of the field data appeared questionable. Mixing problems or unrepresentative sampling points may have partially accounted for this problem. Considering the independence of the dye data and the fact that no manipulations were performed to the model, it is believed that a successful verification of the advective and dispersive transport mechanisms was achieved.

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

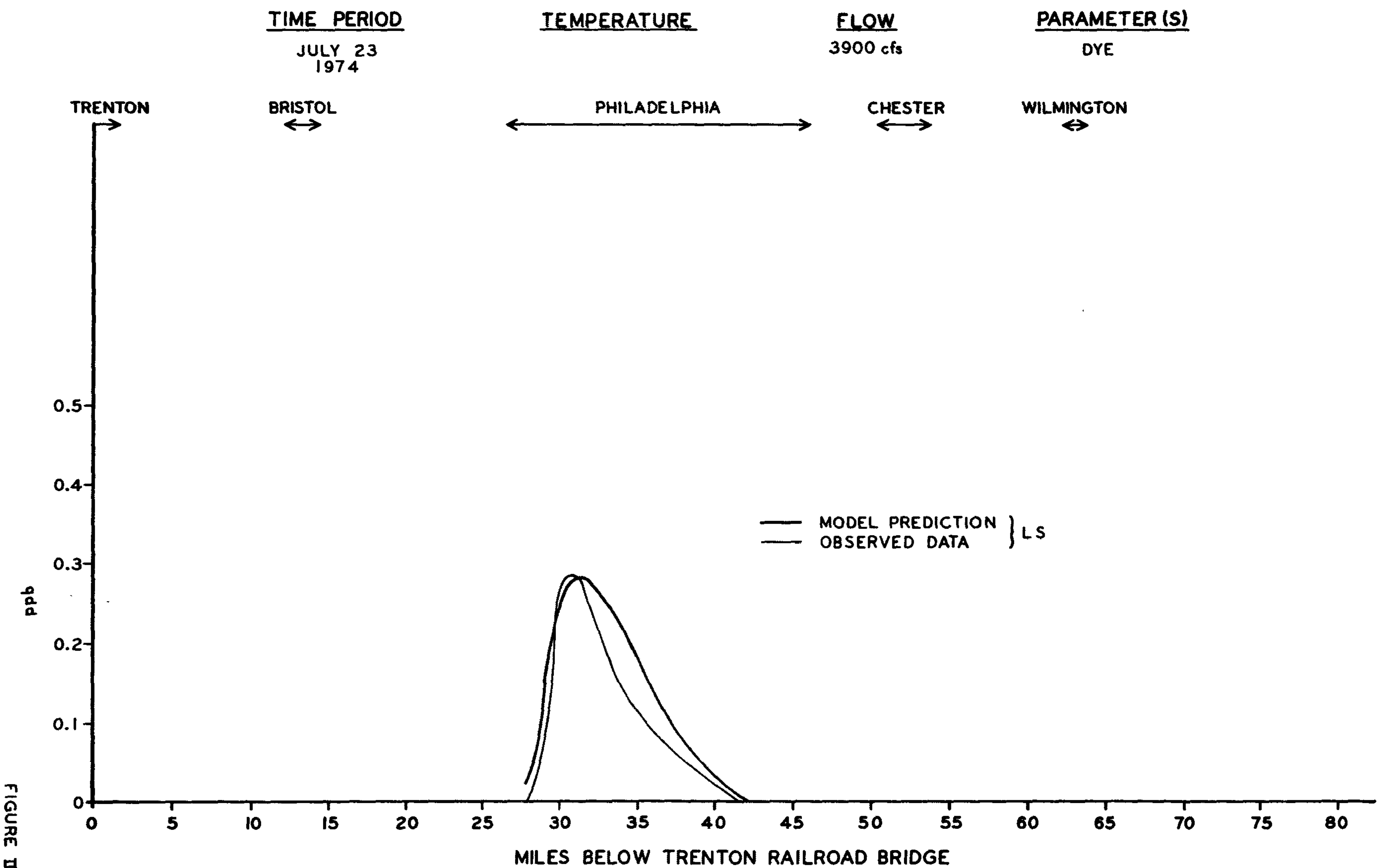


FIGURE III-7

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 24 1974		3900 cfs	DYE

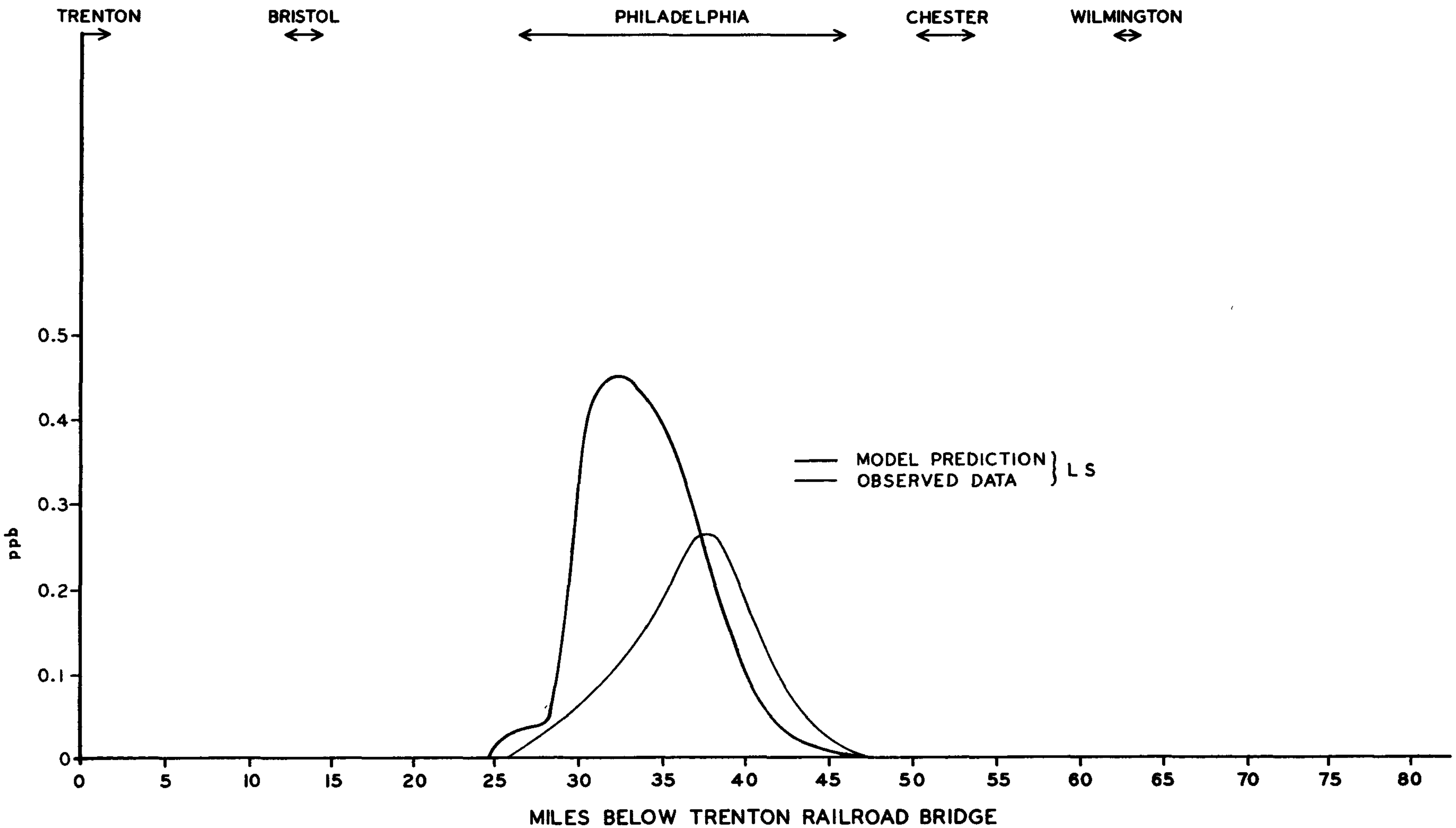


FIGURE III-8

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 25 1974		3900 cfs	DYE

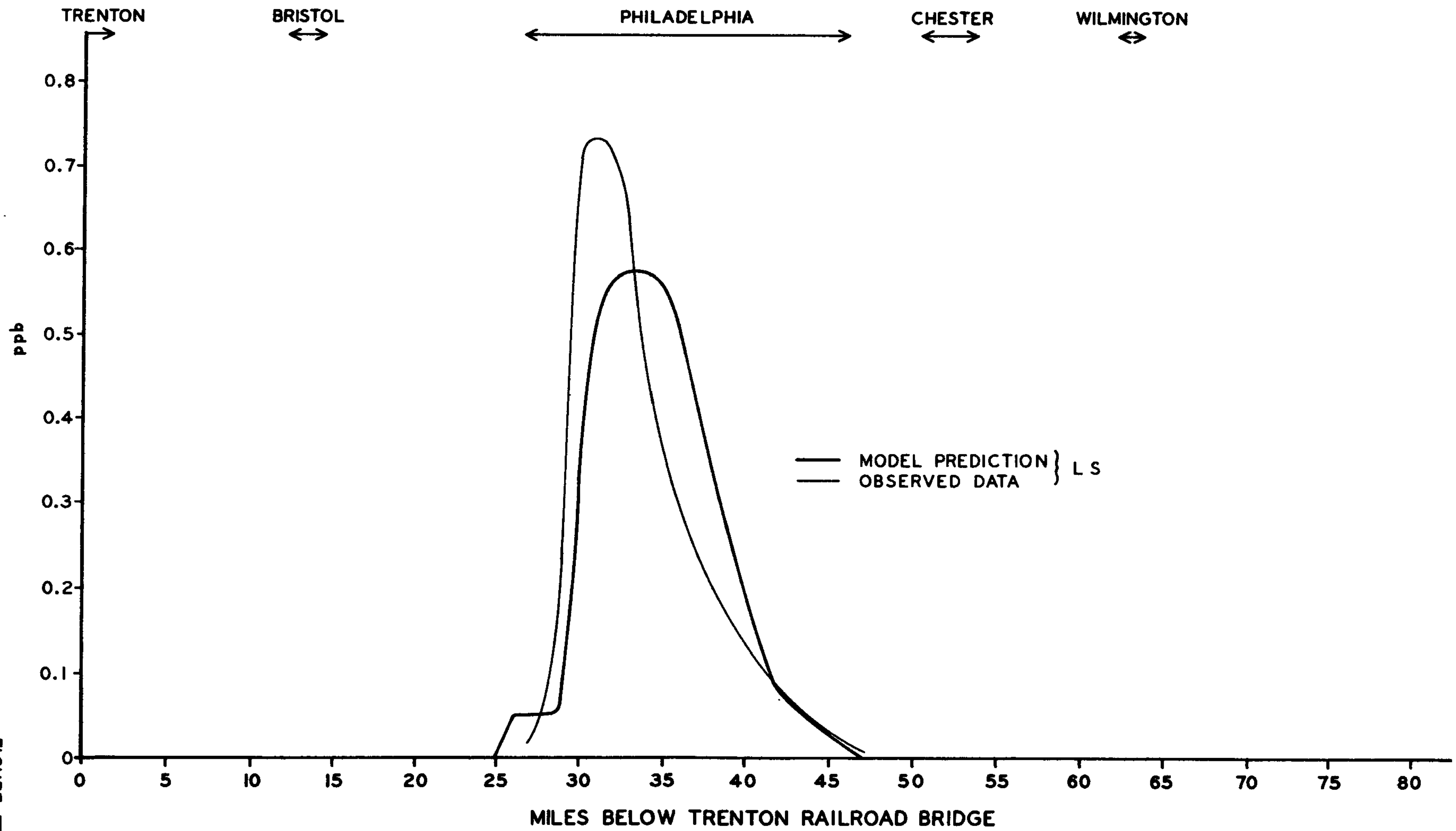


FIGURE III-9

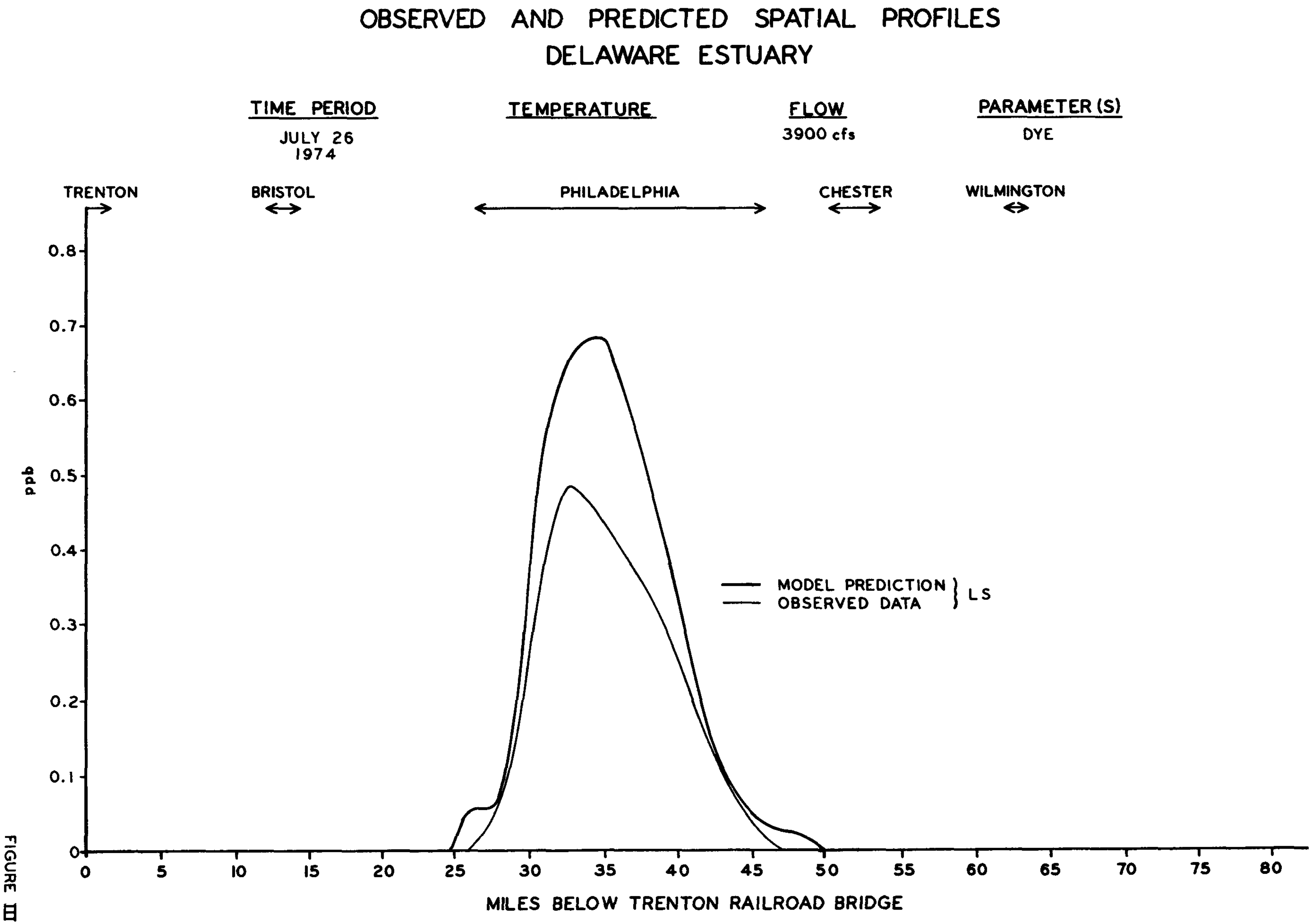


FIGURE III-10

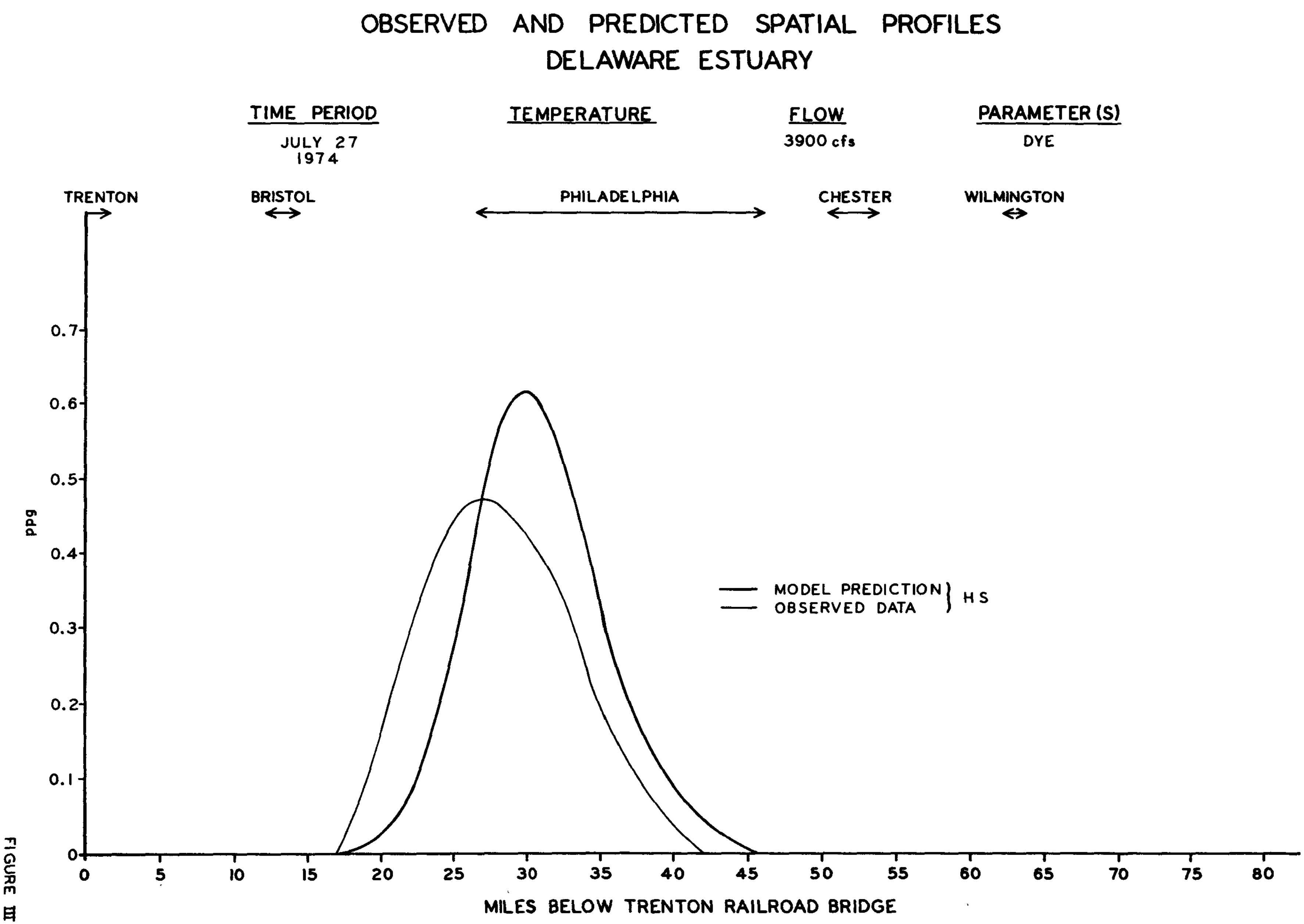


FIGURE III-11

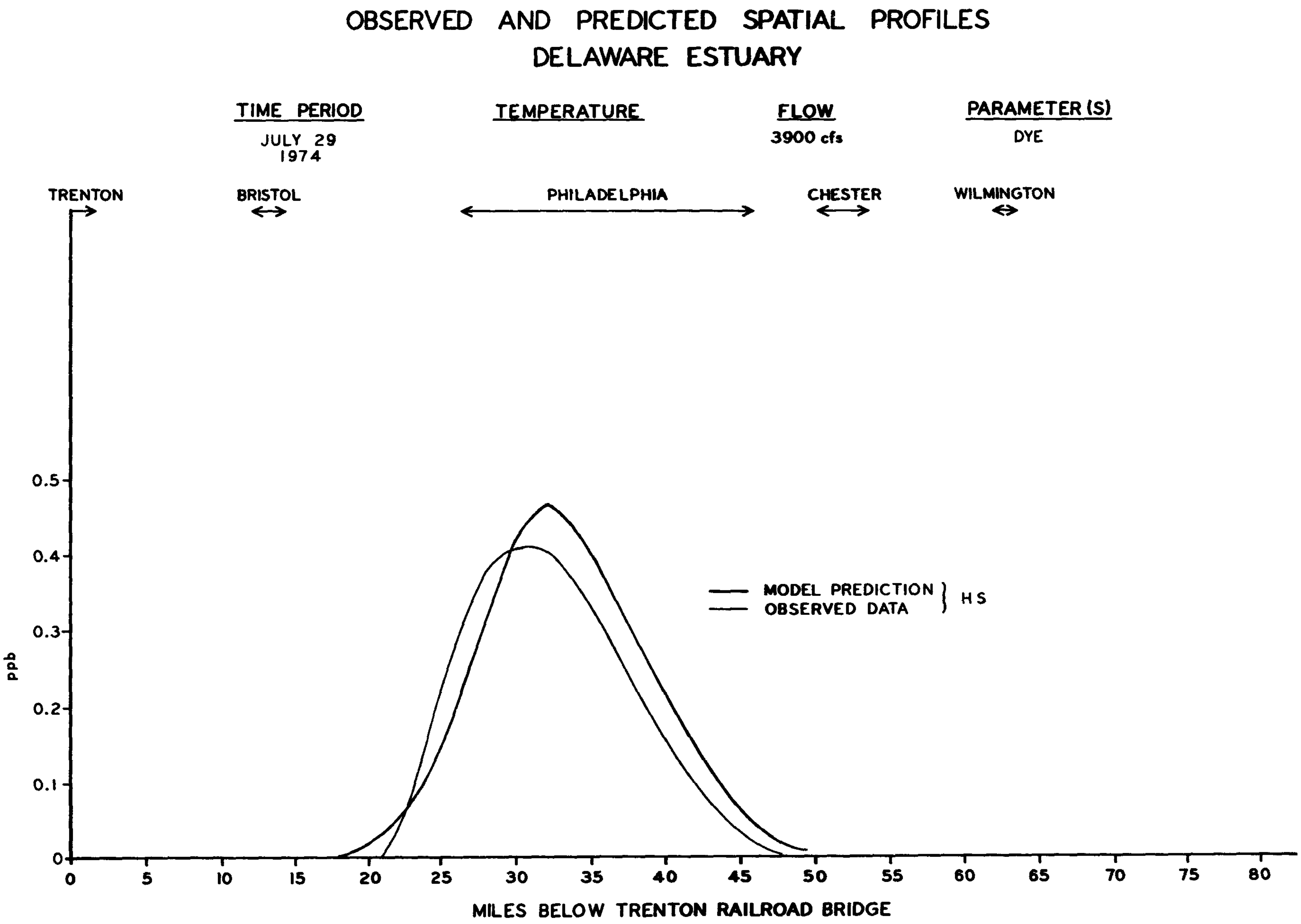


FIGURE III-12

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

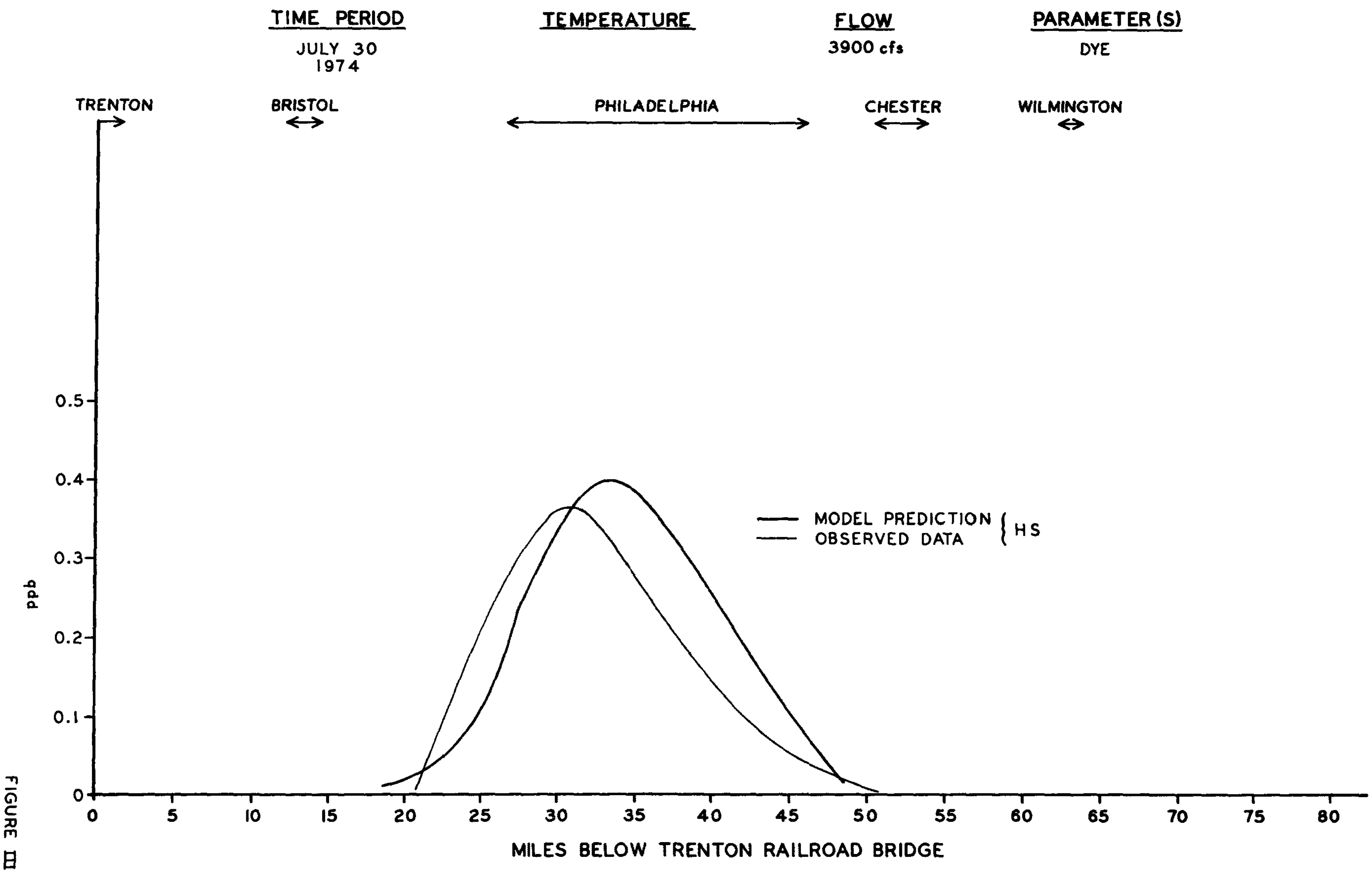


FIGURE III-13

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 31 1974		8850 cfs	DYE

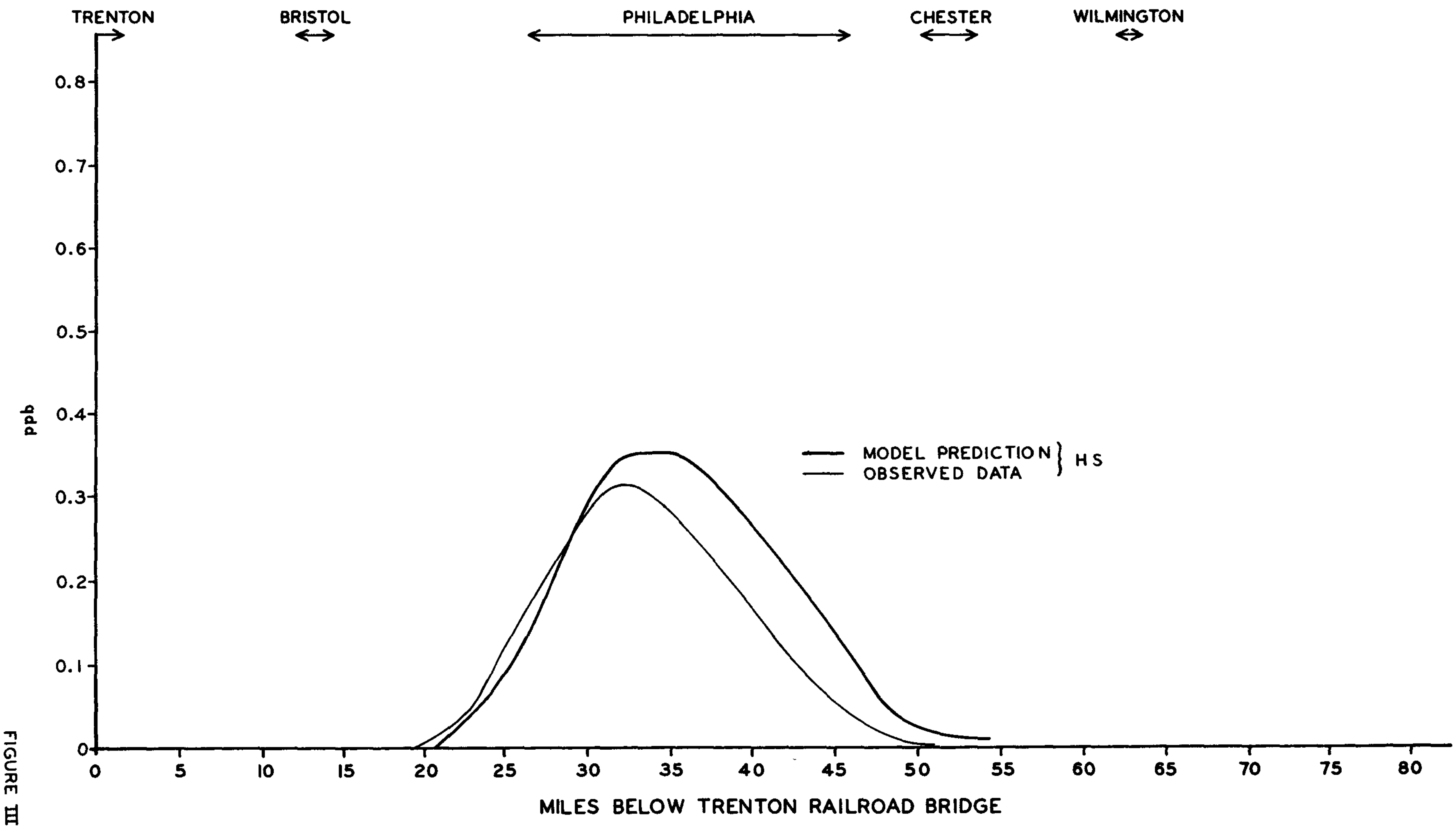


FIGURE III - 14

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

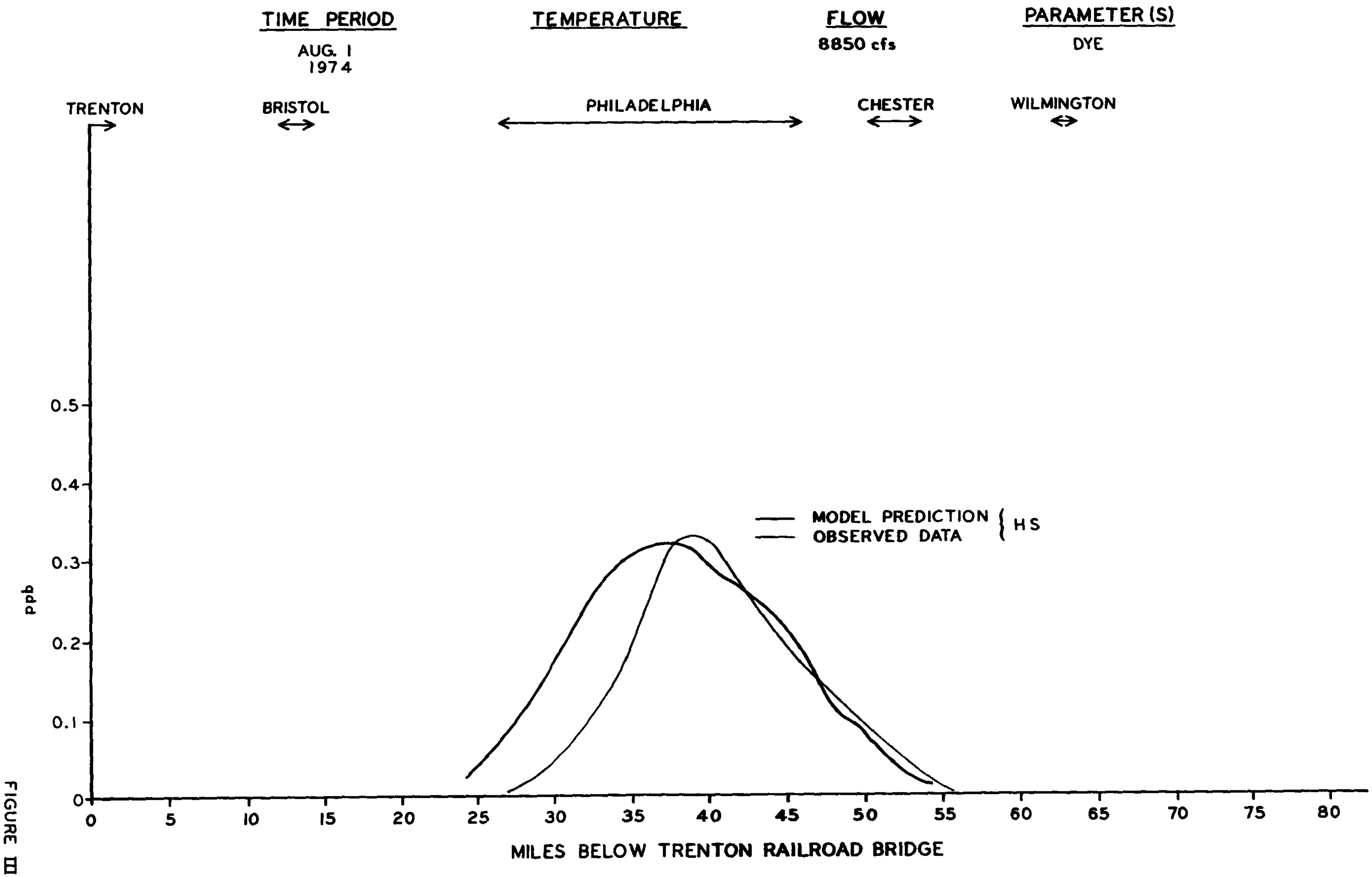


FIGURE III - 15

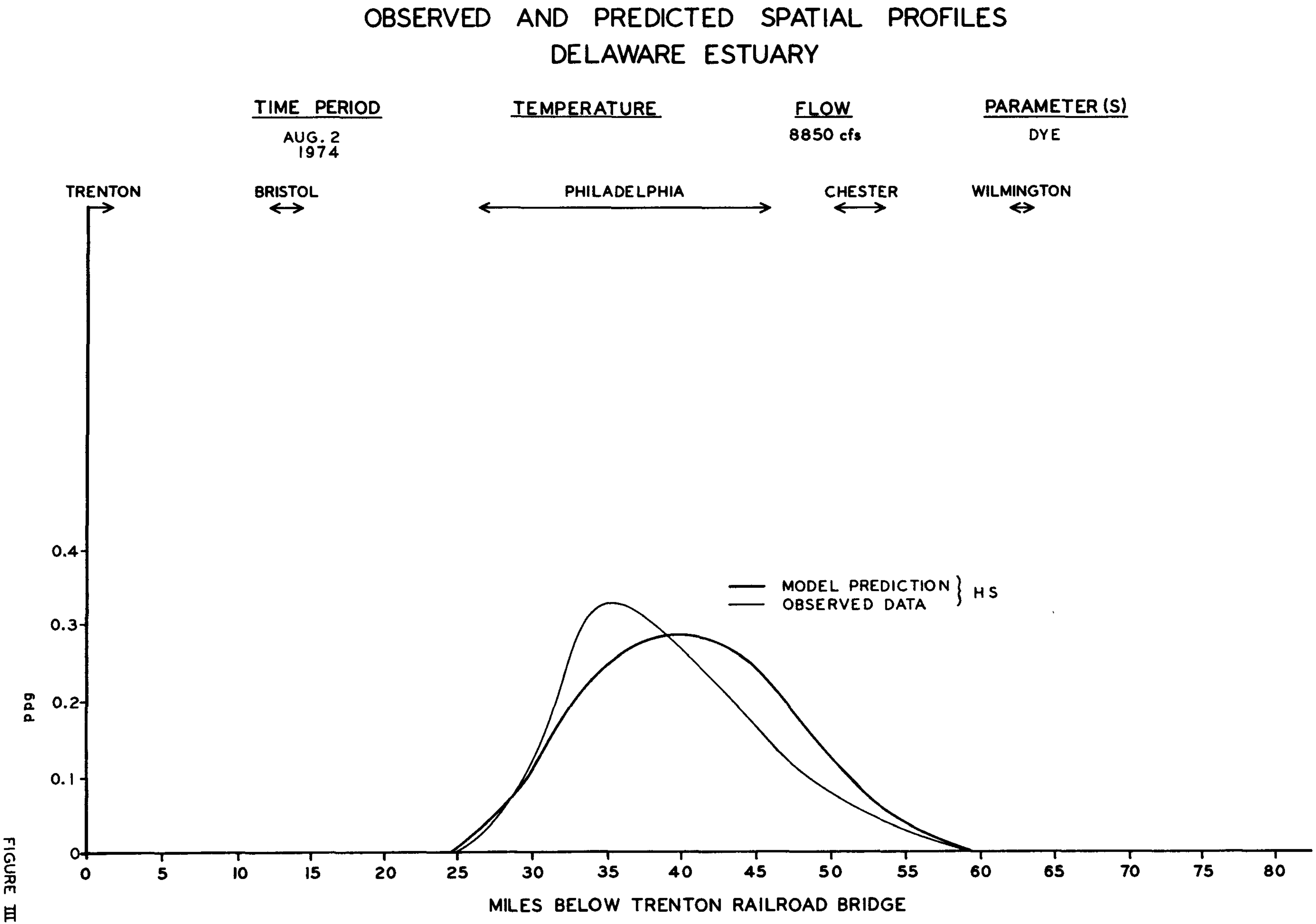


FIGURE III-16

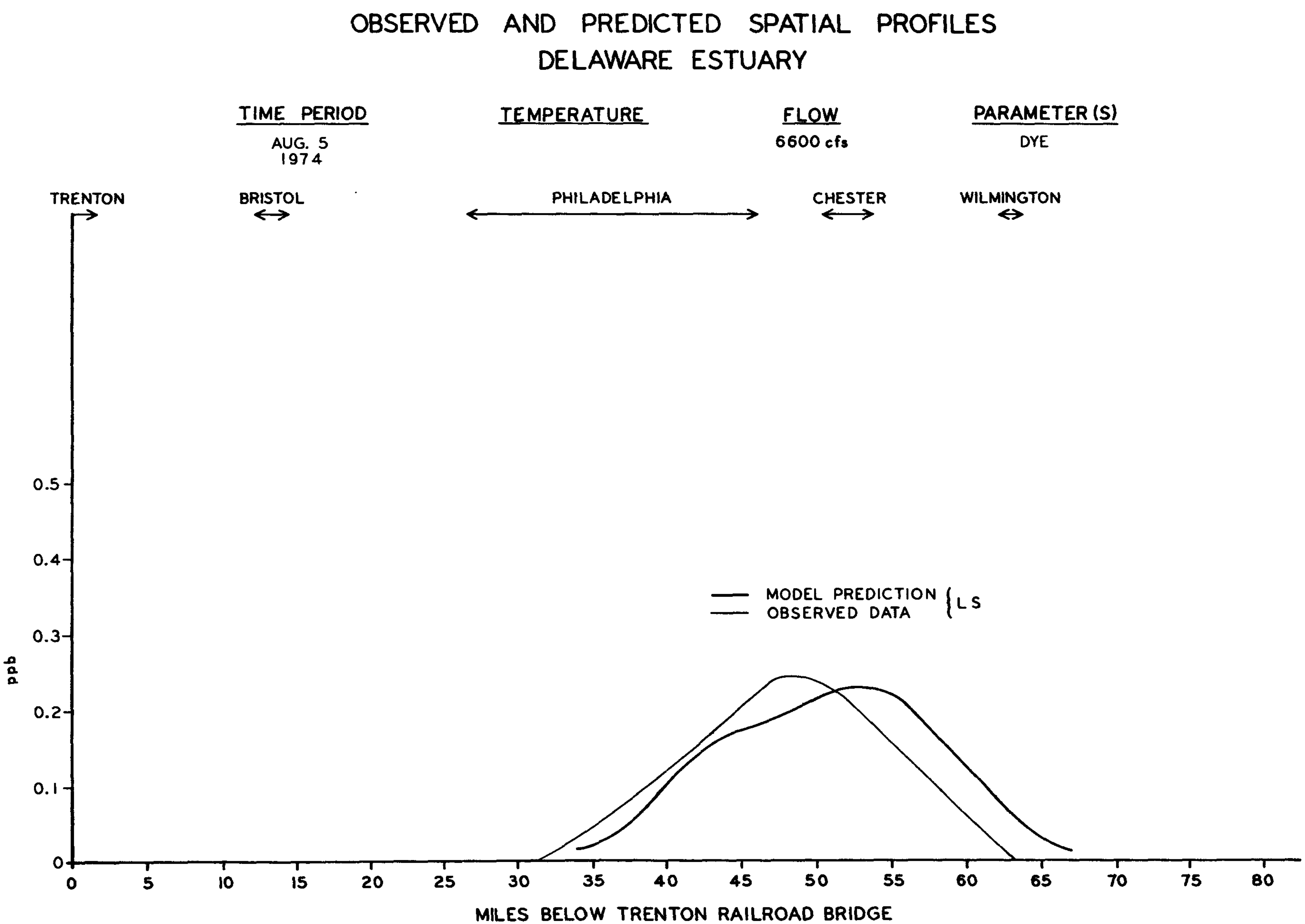


FIGURE III - 17

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG. 6 1974		6600 cfs	DYE

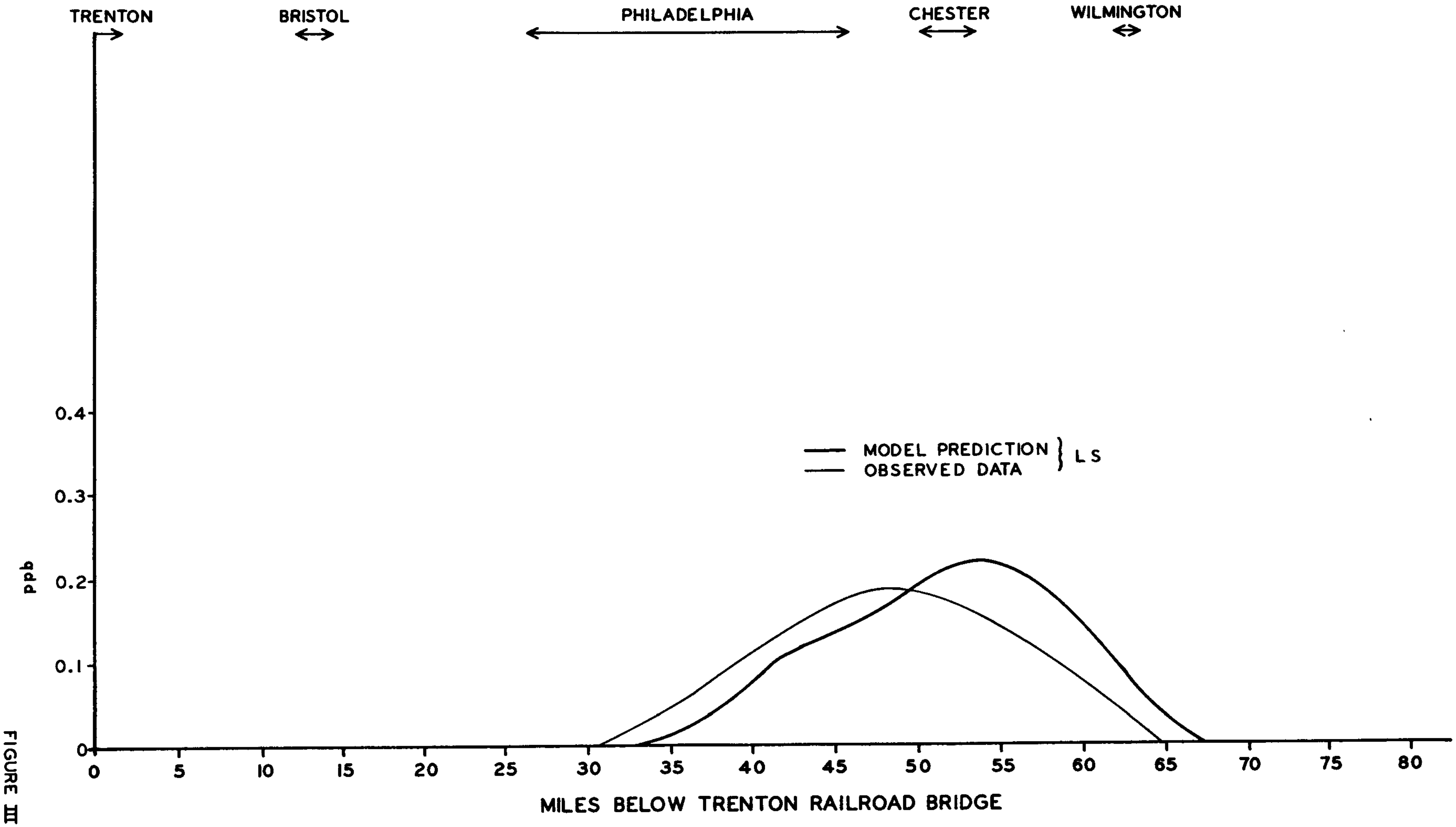


FIGURE III-18

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG. 8 1974		4800 cfs	DYE

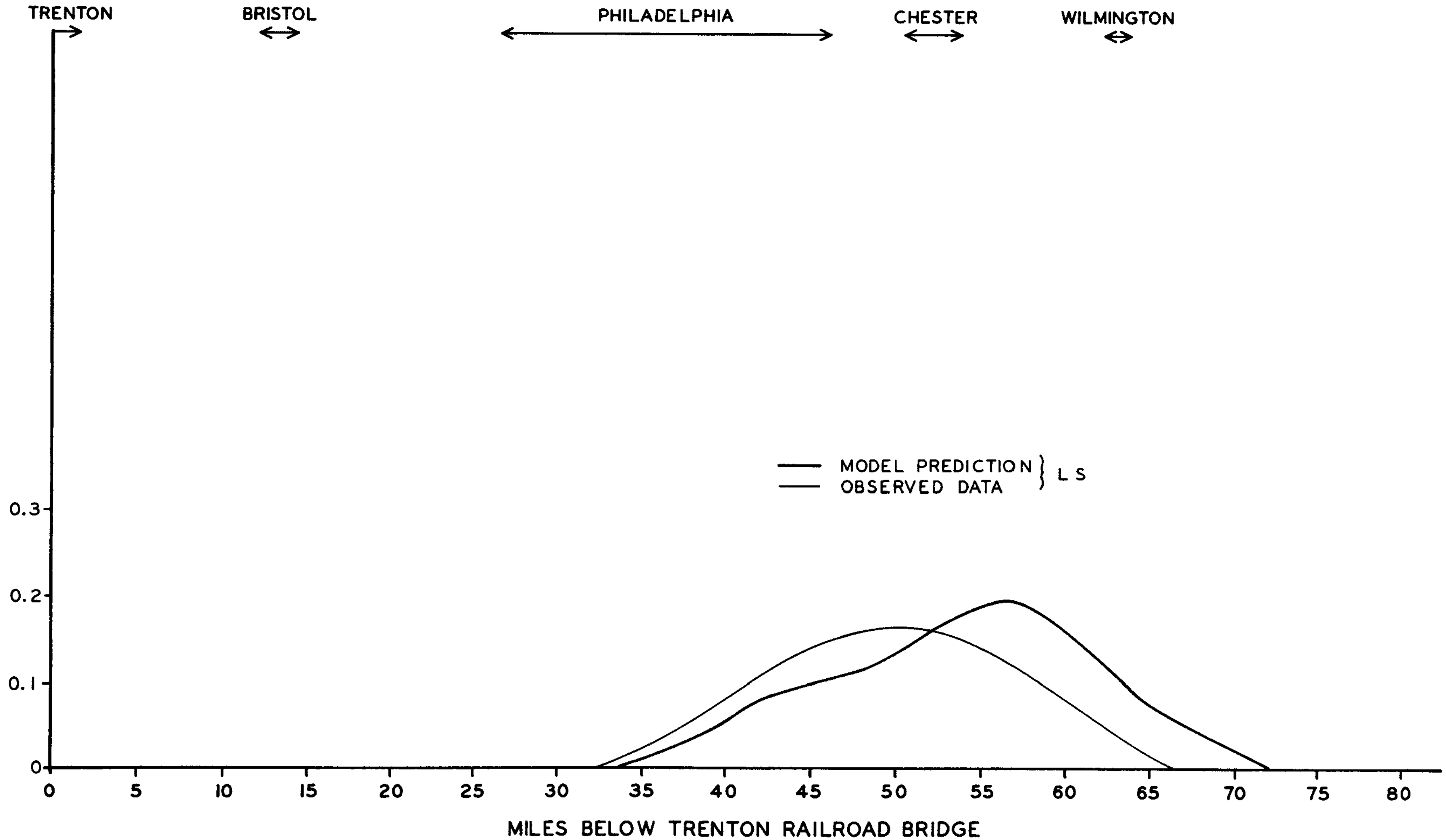


FIGURE III-19

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG. 12 1974		4800 cfs	DYE

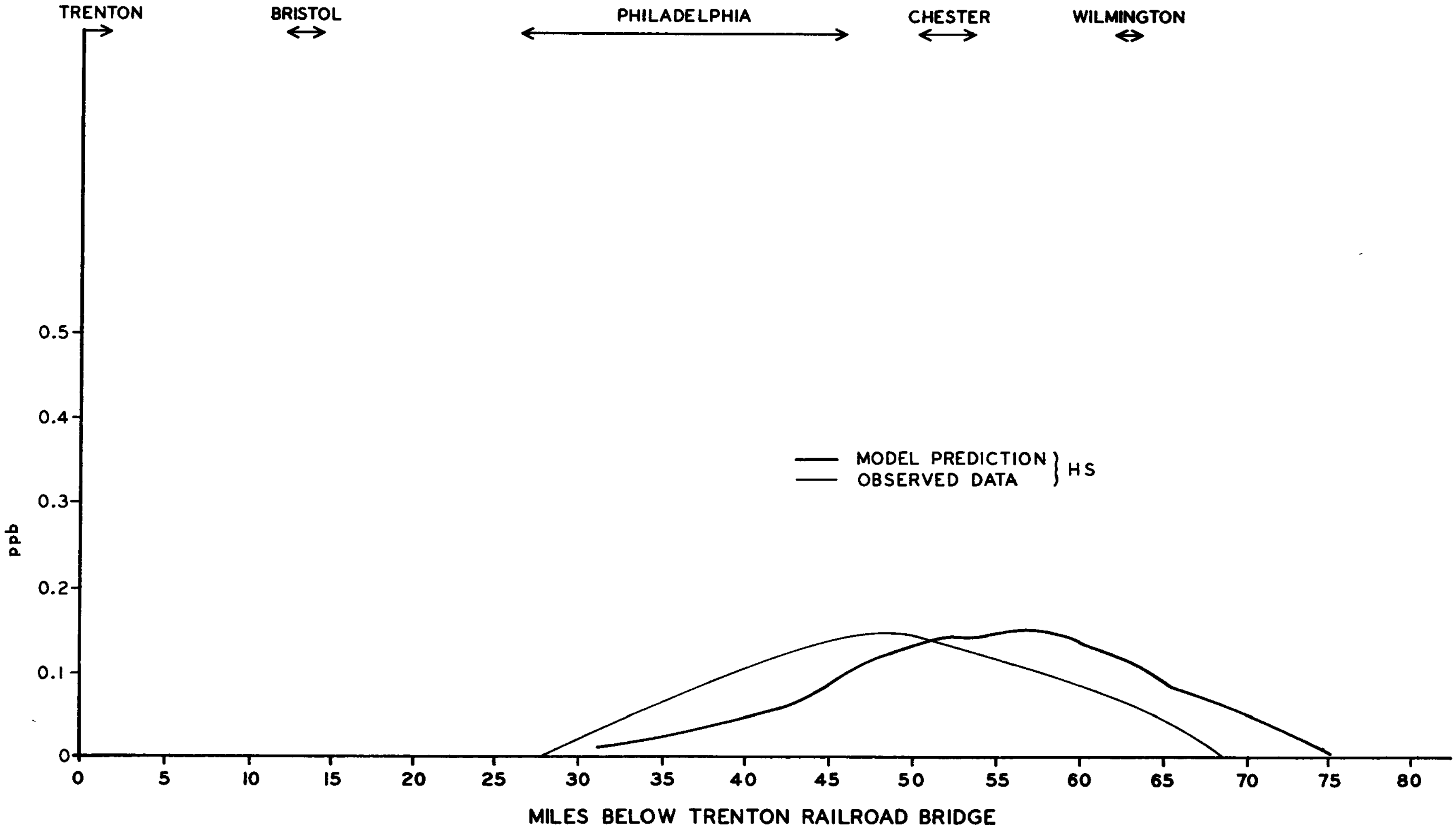


FIGURE III-20

3. Dissolved Oxygen Budget

a) Introduction

Special emphasis was placed on modelling the dissolved oxygen budget, due to its widespread acceptance as a water quality standard. Because of its important role in affecting DO levels in rivers, and particularly estuaries, considerable attention was directed towards the major components of the nitrogen cycle. The majority of the previous models applied to the Delaware Estuary made no attempt to model specific nitrogen fractions, but rather treated nitrogen solely in terms of oxygen demand associated with nitrification.

The strategy followed in the model formulation and calibration studies was essentially one of starting simple, and then progressing in complexity when the data analysis phase so dictated. It could be described by the following three step algorithm:

<u>Step 1</u> Begin with a relatively simple model which includes the principal reactions affecting DO; utilize this approach, along with rates bounded by ranges determined from a literature search, to "explain" the results of a historical water quality data set.

<u>Step 2</u> Test the tentatively calibrated model for other reactions known or suspected to occur based upon comparison of observed data trends with simulation results; include new reactions in a restructured model to better "explain" the historical data.

This step of restructuring and recalibrating the model should be repeated, keeping in mind the limitations of the available field and literature data, until adequate confidence in the model's "prowess" is attained commensurate with the goals of the study.

Step 3 Utilize additional independent data sets to verify that the model is indeed satisfactorily recreating what is taking place in the prototype for a variety of conditions totally unrelated to the original data set(s) used for calibration purposes.

b) Description of Data

Five independent sets of water quality data were analyzed during the course of this modelling study. Their source and basic content were described in Section B of this chapter. Data sets collected during July 1974 and October 1973 were used extensively for model construction and calibration, with the exception of algal effects; algal photosynthesis and respiration were addressed in the August 1975 data set, where their effects became prominent. The fourth and fifth data sets, covering the periods July - September 1968 and July 1976, respectively, were used strictly for model verification. The primary criteria that determined which data sets were selected for model simulations were (1) the degree to which steady state conditions prevailed, (2) the intensiveness and completeness of the data, including wastewater information, and (3) the representation of different hydraulic, thermal, chemical or biological conditions to increase the predictive power of the model.

The first major step in data analysis (and a necessary prelude to modelling) is a thorough examination of currently available data in search of common trends and important variations. The following is a summary of the five data sets eventually used in this study.

July, 1974

Four high water slack sampling runs were made up the mid-channel of the Delaware Estuary on July 22, 24, 29 and 31, 1974. During this period the estuary was warm with a relatively steady flow - 27°C ± 0.9°C* and 3906 ± 290* cfs at Trenton (disregarding a high flow of 8,740 cfs on July 31). The daily longitudinal profiles for DO, the nitrogen series, and chlorophyll a are plotted in Figures III-21, III-22-24, and III-25, respectively.

The four DO profiles exhibit common significant trends. There is a steady decline from saturation levels at Trenton to about 3 mg/l below Bristol. This "Bristol sag" is followed by a 1 mg/l recovery in the vicinity of Torresdale. Beginning near Philadelphia's N.E. STP, DO levels decline rapidly to between 1/2 and 1 mg/l below the Walt Whitman Bridge. These conditions persist down to Chester, where a gradual recovery begins. DO concentrations finally reach 5 mg/l below Pea Patch Island near Reedy Point.

The nitrogen profiles also show common trends. The decline in ammonia levels accompanied by similar increases in nitrate strongly indicates nitrification above and below Philadelphia. The rapid buildup of ammonia at Philadelphia might result from an inhibition of nitrification due to the "shock effect" of high organic loading, low DO, or other unknown toxic pollutants. Finally, a slow decay

* Mean ± S.D.

of nitrates can be discerned below Wilmington where the masking effects of nitrification are not present. Organic nitrogen concentrations are fairly stable throughout most of the estuary with some decline occurring in the lower reach.

Chlorophyll a levels were somewhat variable but almost exclusively less than 50 μg/l, a value normally associated with a bloom threshold. Maximum concentrations were measured downstream of Philadelphia.

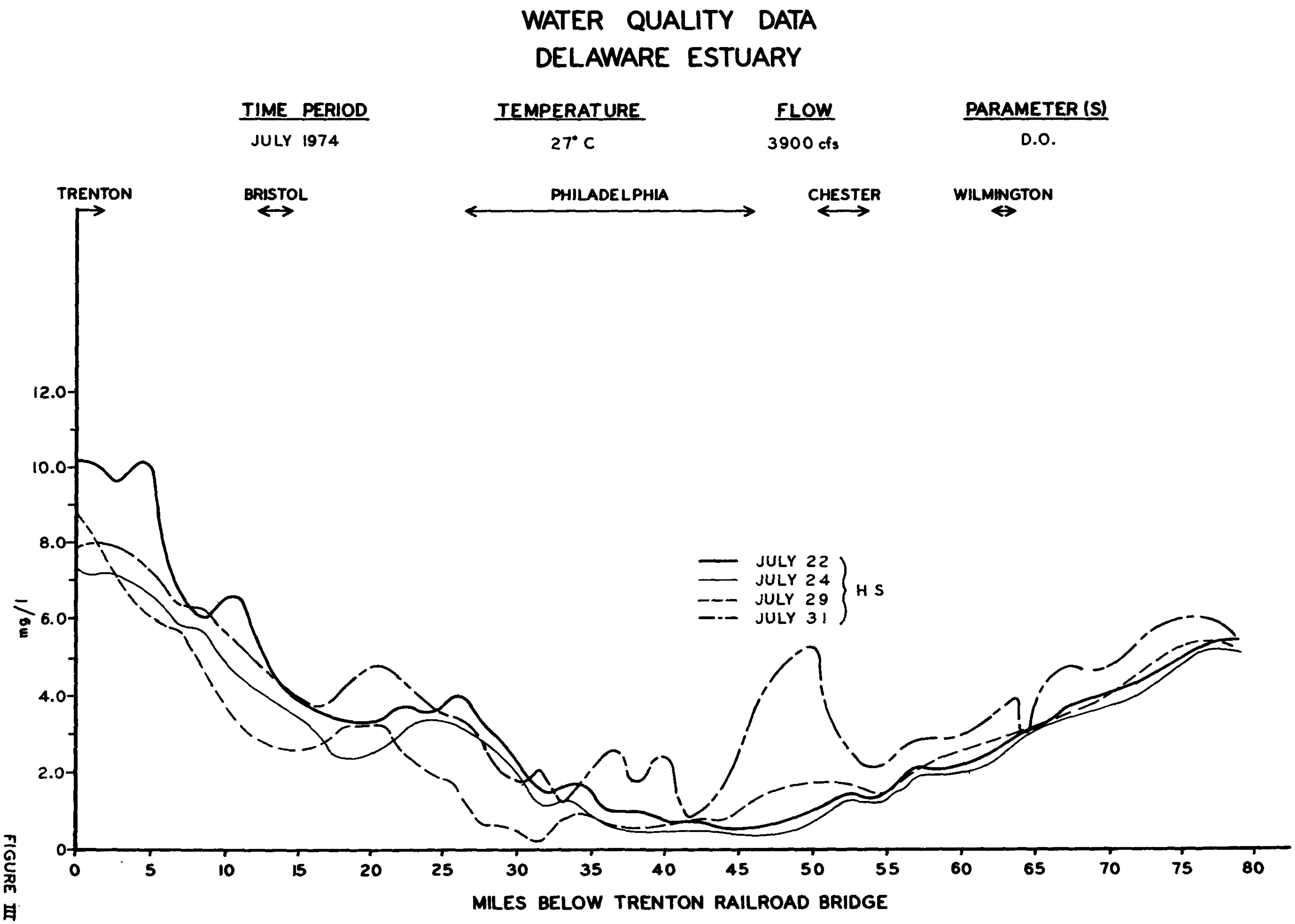


FIGURE III-21

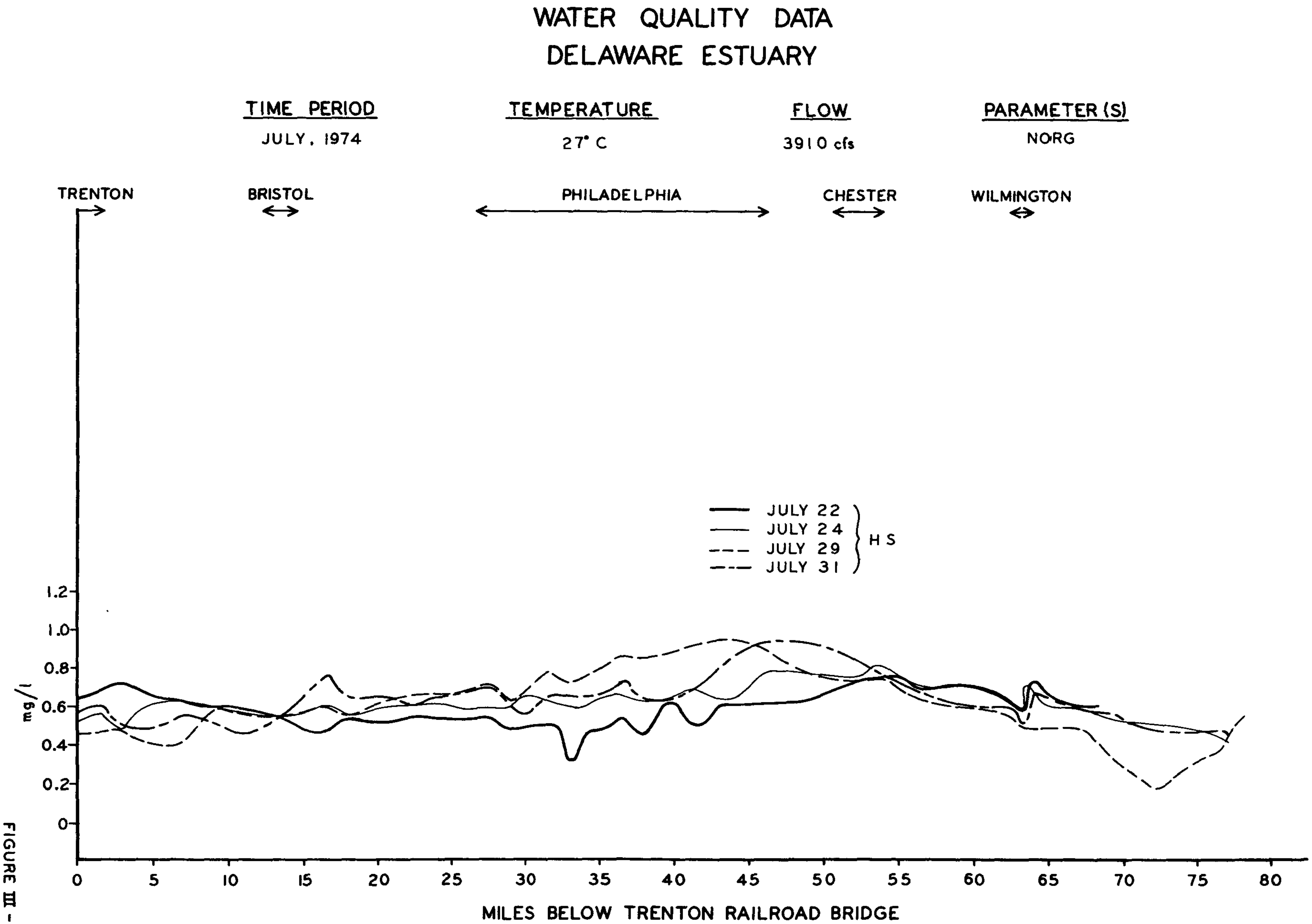


FIGURE III - 22

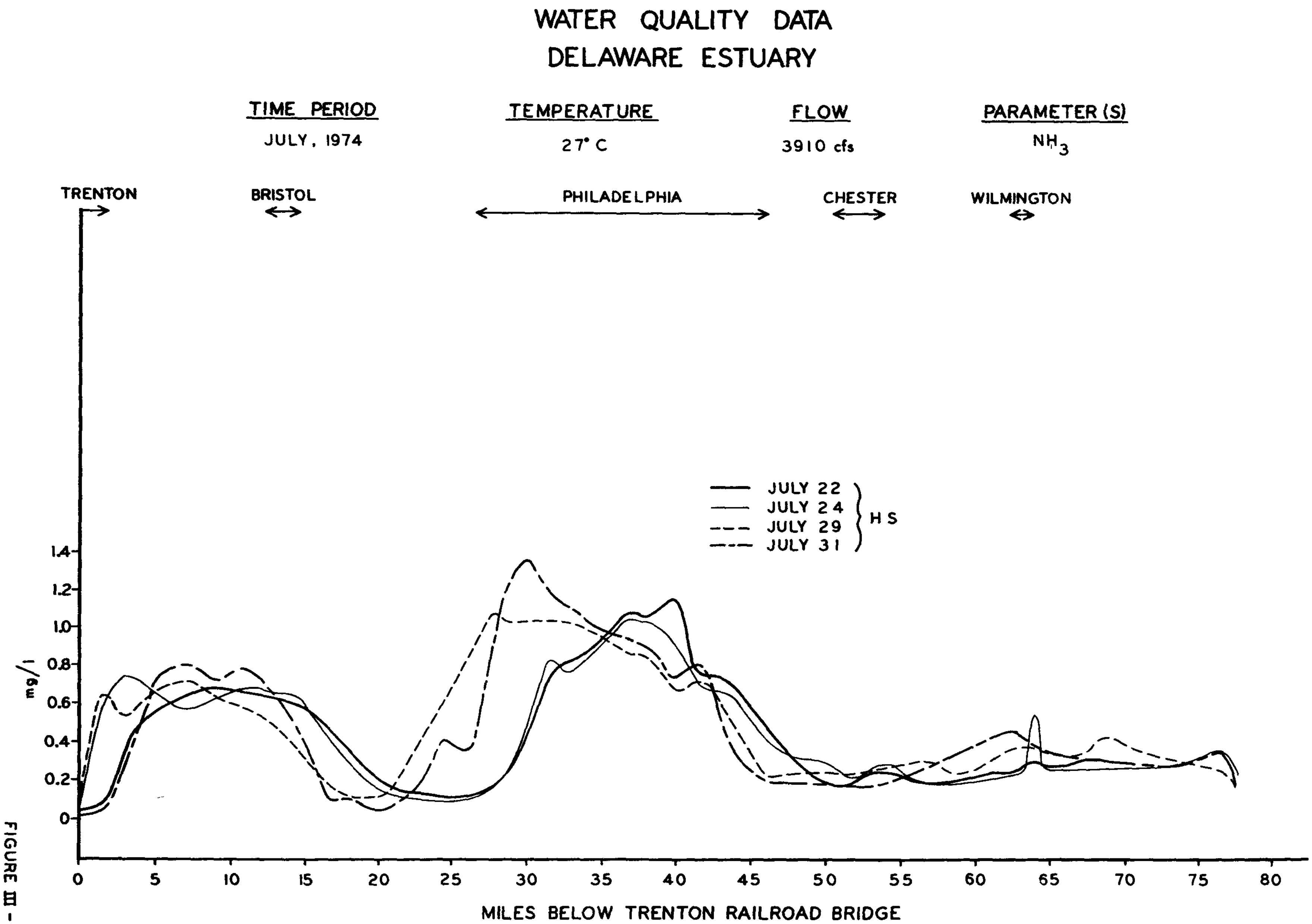


FIGURE III - 23

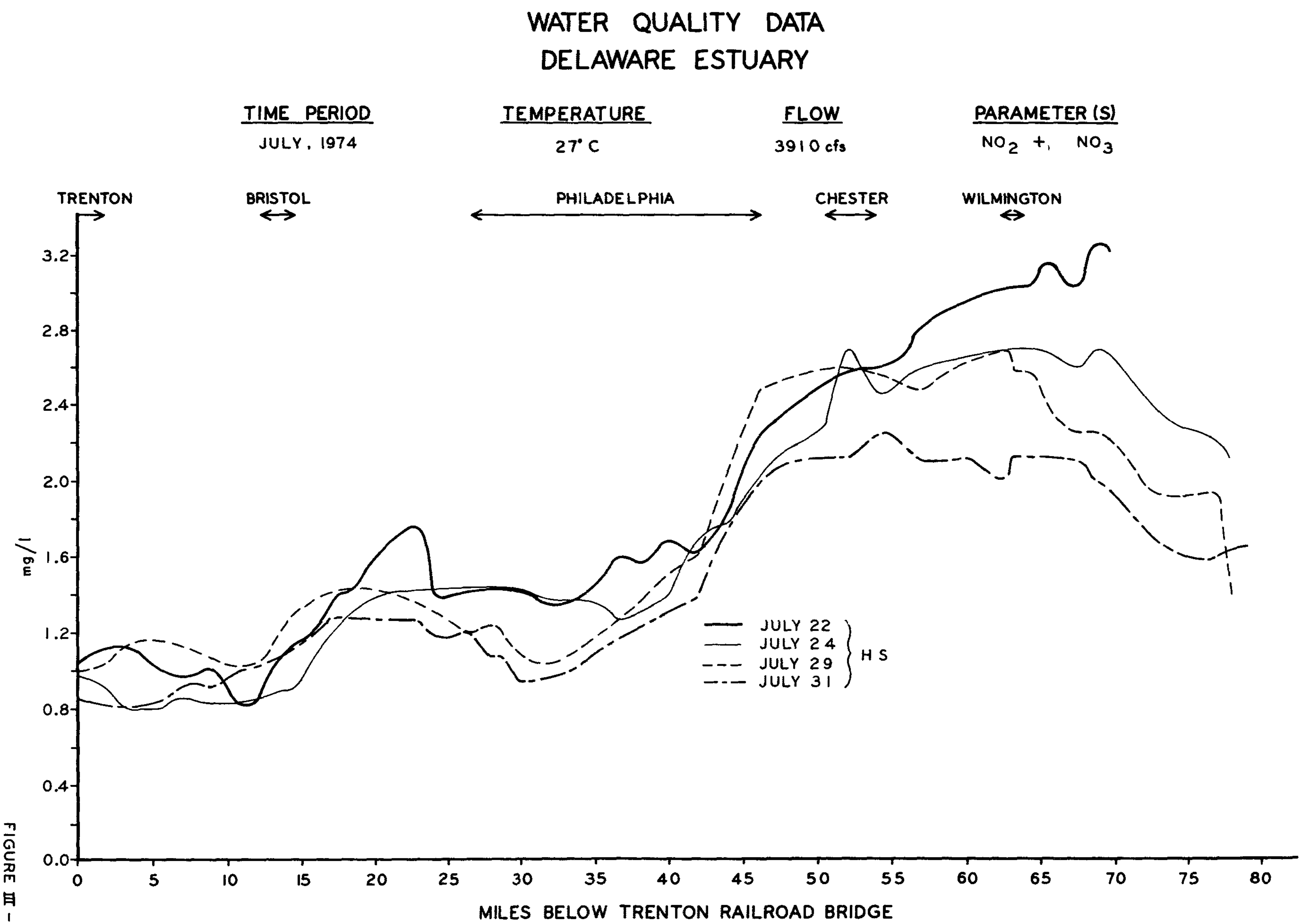


FIGURE III - 24

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY , 1974	27° C	3910 cfs	CHLORO. a

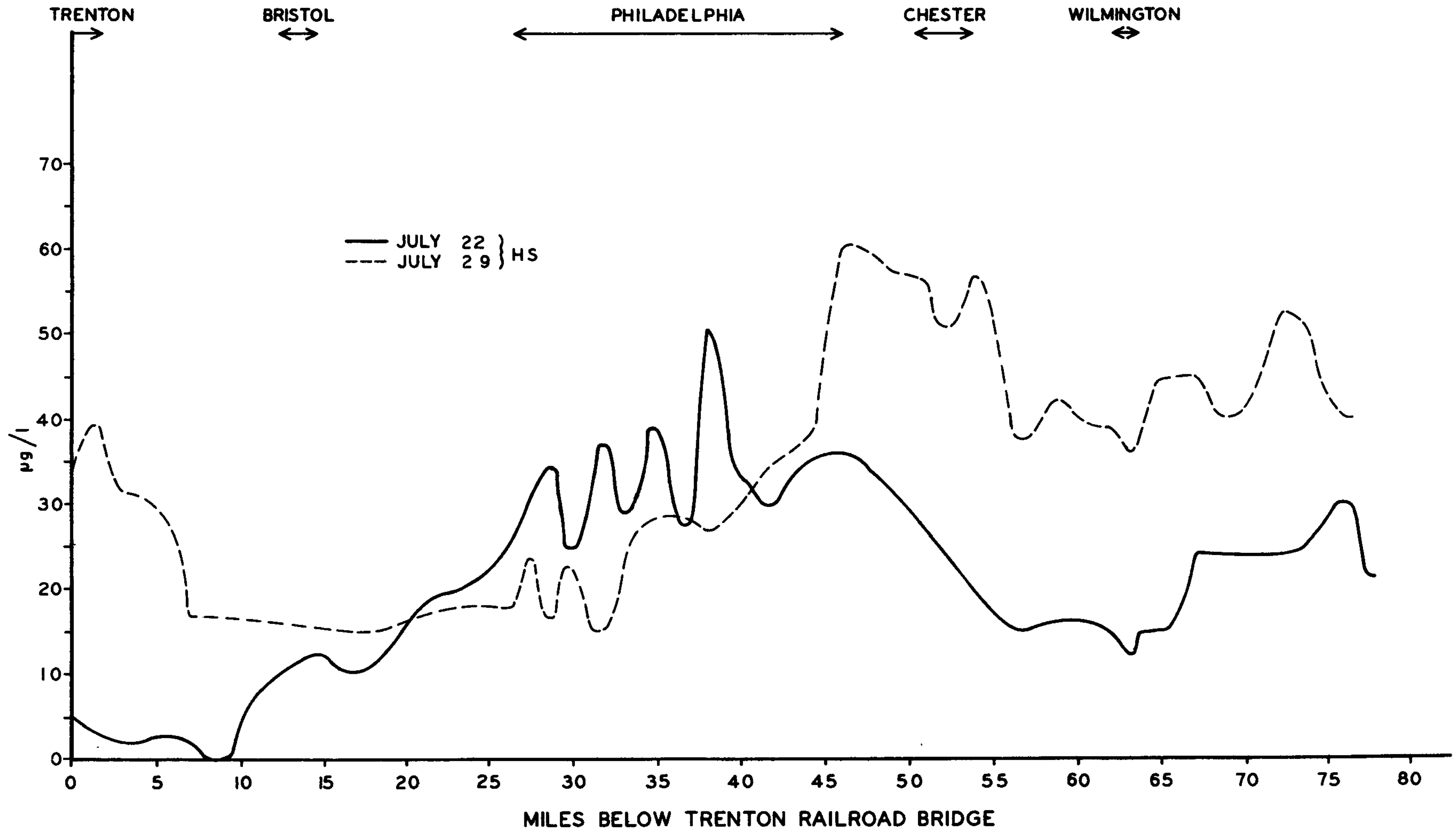


FIGURE III -25

October, 1973

Two high water slack sampling runs on October 15 and 17 accompanied by two transect sampling runs on the 16th and 18th comprised the October, 1973 data set. This was a relatively steady period, with temperatures declining from 20°-19°, and flows averaging 4020 cfs at Trenton. Water quality parameters analyzed were the same as for the July, 1974 data set. During both transect runs, surface and bottom samples were taken near the east and west banks in addition to the mid-channel at ten different stations between Torresdale and Reedy Point. This transect sampling data, which was intended to show whether mid-channel surface water samples were representative of the entire cross-sectional water column, is still undergoing analysis along with other data of a similar nature. Pertinent findings will be included in a future document. Mid-channel surface samples were taken at every station during the two high slack runs. The resulting longitudinal profiles for DO and the nitrogen series are plotted in Figures III-26 through III-29.

The two DO profiles show a steady decline from saturation levels at Trenton to around 5 mg/l just above Philadelphia. No "Bristol sag" is evident. Near Philadelphia's NE STP, DO levels drop rapidly, reaching a minimum of 1 - 1.5 mg/l just below the Walt Whitman Bridge. A gradual recovery, beginning immediately, is interrupted by a secondary sag below Chester. From 2.5 mg/l, oxygen levels improve quickly below Wilmington.

The nitrogen profiles exhibit the same trends as the July 1974 data. The most prominent difference is the increase in magnitude and duration of the ammonia buildup at and below Philadelphia. These high ammonia levels could be caused by larger waste loadings or by longer inhibition of the nitrification process due to the low ambient water temperature. Based on the two data sets described thus far, it does not appear that low DO levels (i.e., <1.0 mg/l) directly reduce nitrification rates.

Unfortunately, a complete set of chlorophyll a data was not obtained during this survey, although some measurements were made in the critical zone between Marcus Hook and Wilmington. Levels were again in the sub-bloom category (20 - 40 μg/l) with an observable difference between the two individual sampling runs.

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
OCT. 1973	18 – 20° C	4020 cfs	D.O.

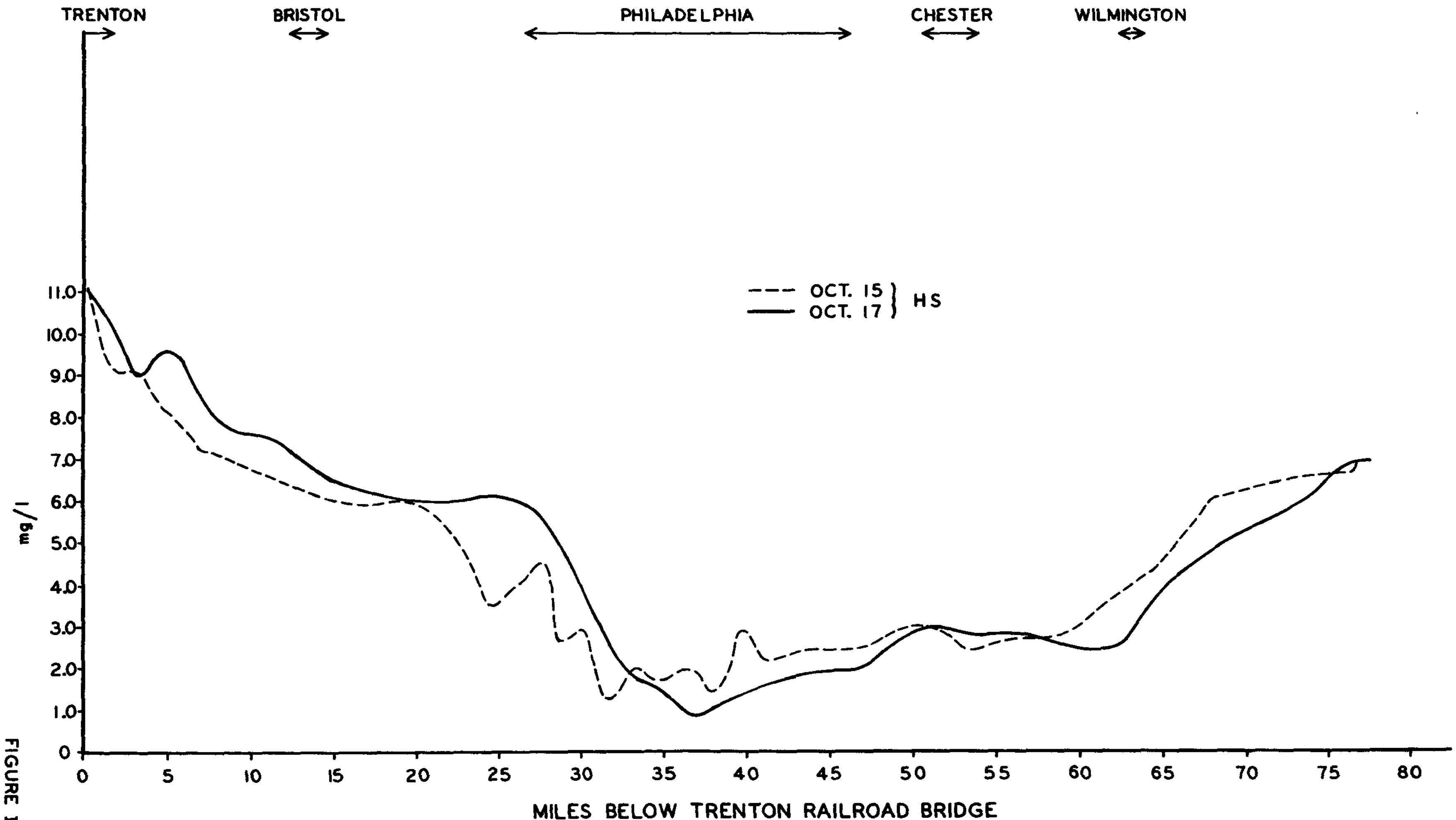


FIGURE III-26

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
OCT., 1973	18 – 20° C	4020 cfs	NORG

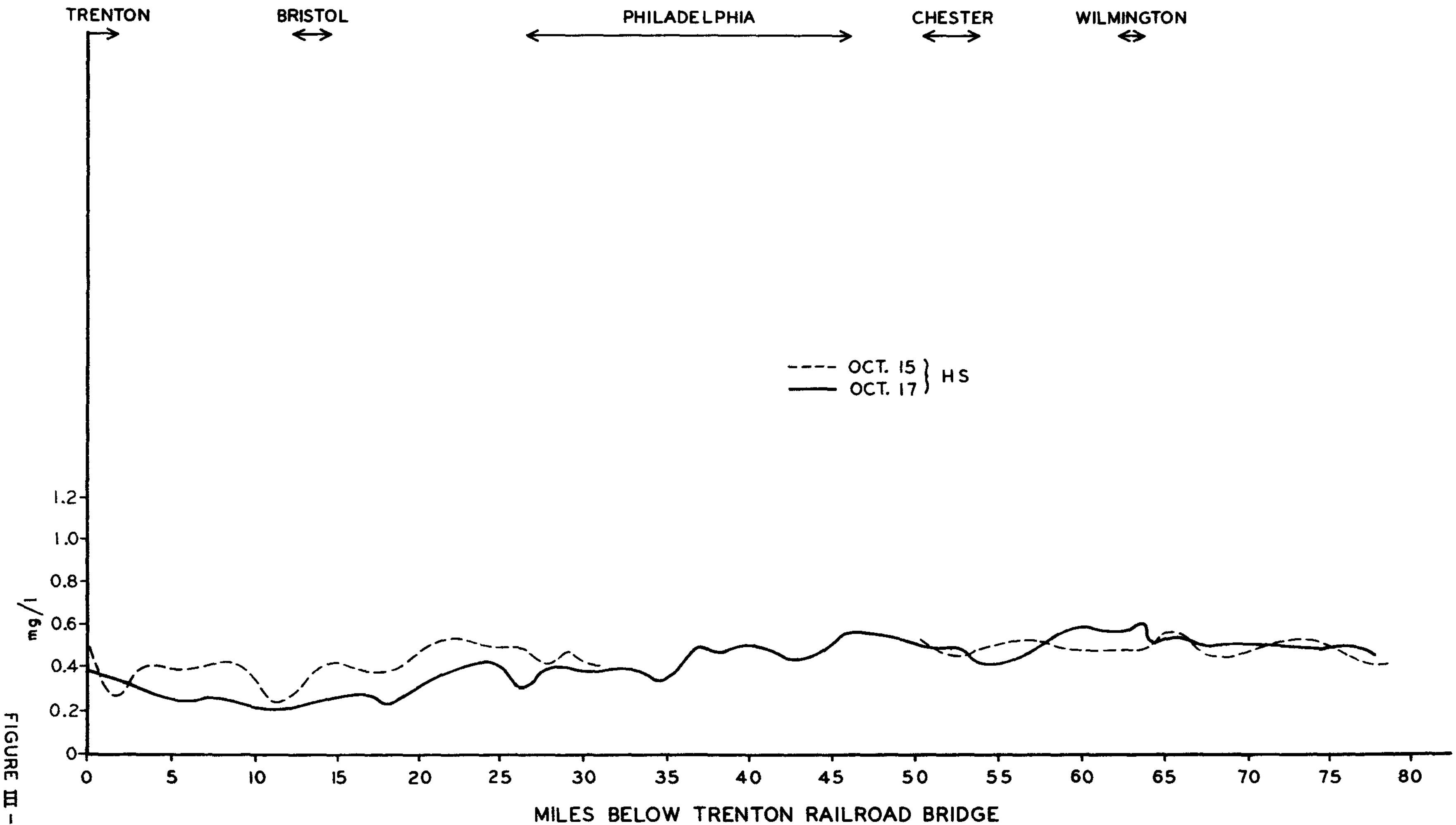


FIGURE III - 27

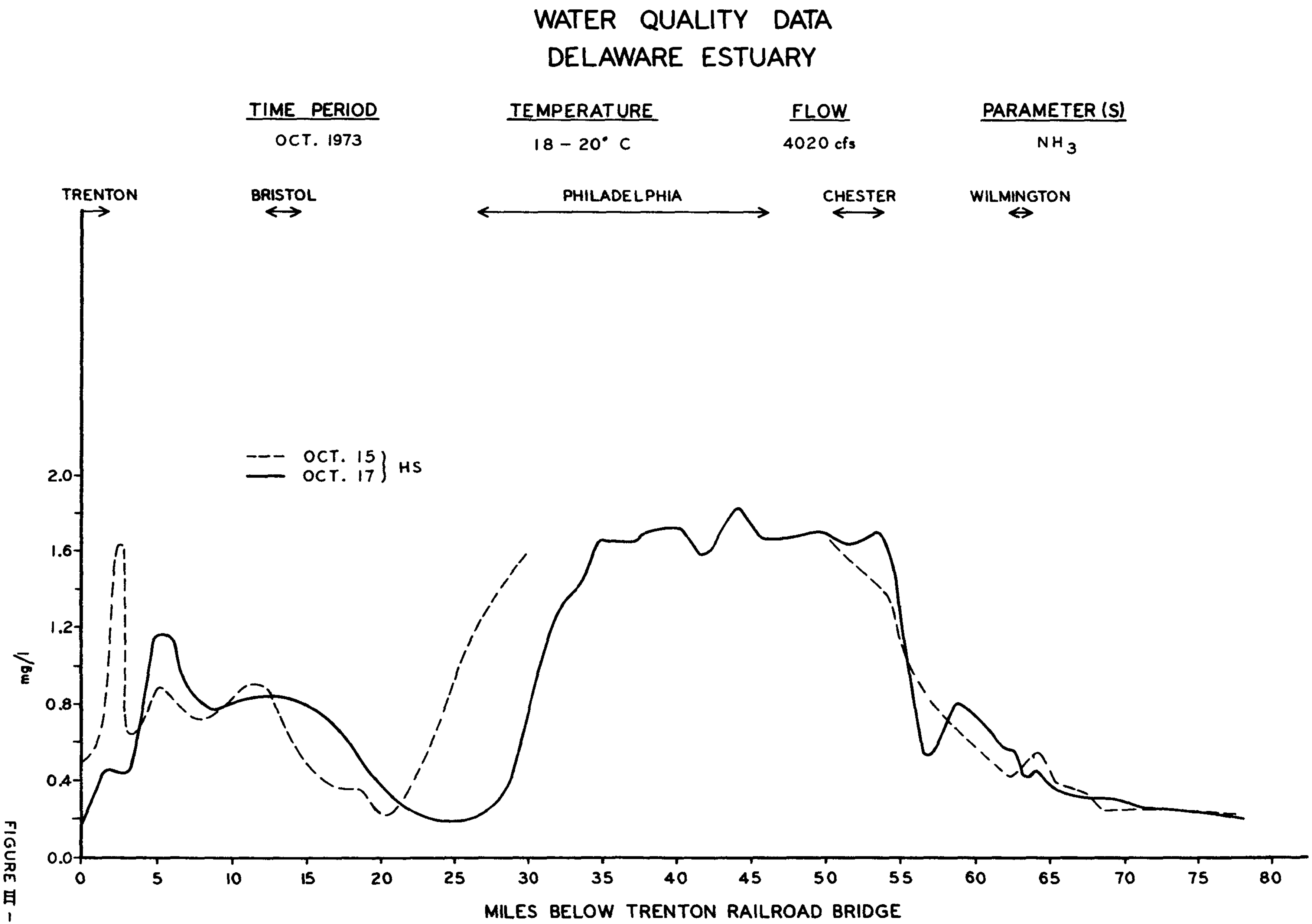


FIGURE III -28

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
OCT., 1973	18 - 20° C	4020 cfs	NO_2 + NO_3

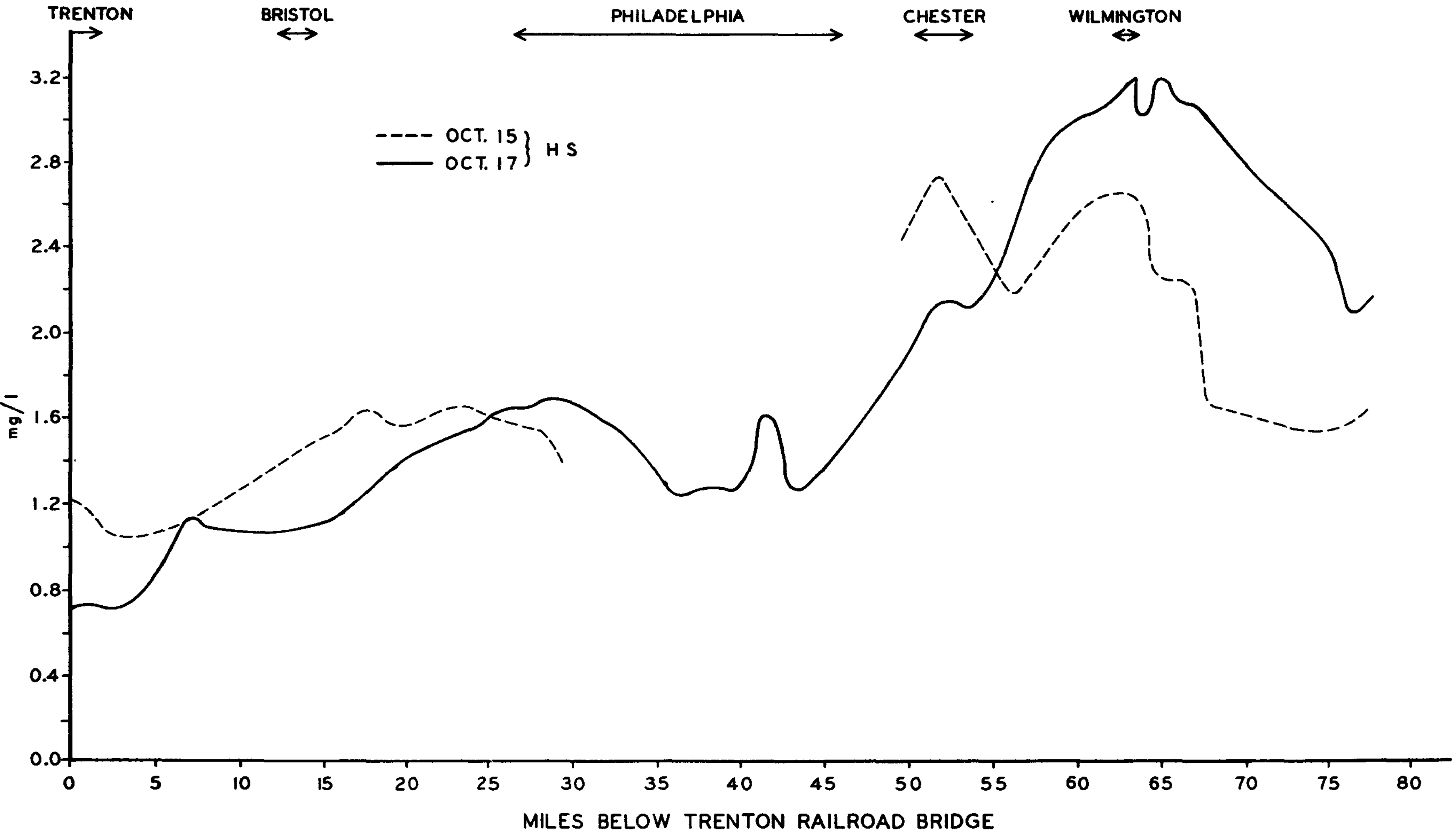


FIGURE III - 29

August, 1975

Perhaps the most comprehensive data set from the Delaware Estuary was gathered between July 31 and August 18, 1975 for the purpose of calibrating a future two-dimensional water quality model. Under the auspices of DRBC, field crews from AFO, USGS, the States of Delaware, Pennsylvania and New Jersey, and the City of Philadelphia sampled 32 water quality stations between Liston Point and Trenton, as well as the major municipal and industrial waste discharges within this reach. Both high and low slack water surface samples were taken from the east bank, mid-channel and west bank of the estuary between Liston Point and Torresdale, and from the mid-channel the rest of the way to Trenton. In addition, transect samples were taken from the same locations on alternate days. Several laboratories, including those of AFO, the State of Delaware, and the City of Philadelphia, contributed to sample analyses. A detailed evaluation of this voluminous body of data has not been accomplished at this writing, in part due to the lengthy process of data quality assurance required in a comprehensive survey with many participants.

The Delaware River at Trenton experienced declining flows throughout the survey, averaging 8330 $\pm$ 1080 cfs from July 31 - August 10 and 5870 $\pm$ 290 cfs from August 11 - 18. Water temperatures during the period averaged about 27^{o}C. The longitudinal DO, nitrogen and chlorophyll a profiles are presented in Figures III-30 through III-38 and constitute the data collected and analyzed by AFO. This partial data set was intended to be used for the initial verification analysis of the one dimensional water quality model presented in this report.

The four low water and two high water DO profiles follow the same trends, but exhibit considerable scatter in some areas of the estuary, particularly near Philadelphia. The gradual decline from saturation levels at Trenton to 4 mg/l at Philadelphia's NE STP shows no sign of a sag and recovery near Bristol, possibly demonstrating the effects of a higher than normal summer flow condition. The DO levels drop off more quickly through Philadelphia, reaching a minimum of about 1.5 mg/l near the mouth of the Schuylkill River. Recovery is unusually fast, with DO levels exceeding 5.0 mg/l above Wilmington and remaining near that level down to Liston Point. This rapid DO recovery is probably the result of a large phytoplankton bloom which produced high chlorophyll a concentrations between Philadelphia and Wilmington.

Although the nitrogen profiles exhibit the same characteristics as in previous data sets, the spatial trends are less pronounced. The buildup of ammonia levels at and below Philadelphia does not reach 0.8 mg/l, and the subsequent decline is gradual. An increase in nitrates below Philadelphia generally matches the decline in ammonia in terms of magnitude and position. Both this area and that above Philadelphia show evidence of nitrification. The organic nitrogen median profile is characteristically flat, ranging between 0.4 and 0.6 mg/l. Individual profiles are more variable, but exhibit no discernible trends.

Particular attention should be paid to the chlorophyll _a_ profiles shown in Figure III-38, since they differ so greatly from the levels encountered in either July, 1974 or October, 1973. Maximum chlorophyll _a_ concentrations between 100 and 200 μg/l were measured in the estuary between Philadelphia and Wilmington during much of the study period. Spatial gradients were rather abrupt both above and below the centroid of the bloom. Daily profiles, while showing the same general trends, were extremely variable, possibly because algal blooms normally occur as discrete patches rather than as a uniform mixture, thereby increasing sampling uncertainty. The impact of this algal bloom on DO concentrations became quite apparent during the initial attempt to verify the model with this data set. That effort was unsuccessful because the effects of algae were not considered, and the speedy DO recovery could not be simulated with existing mechanisms in the model. A vivid quantification of these algal effects on the predicted DO distributions is depicted in the sensitivity analysis section of this chapter.

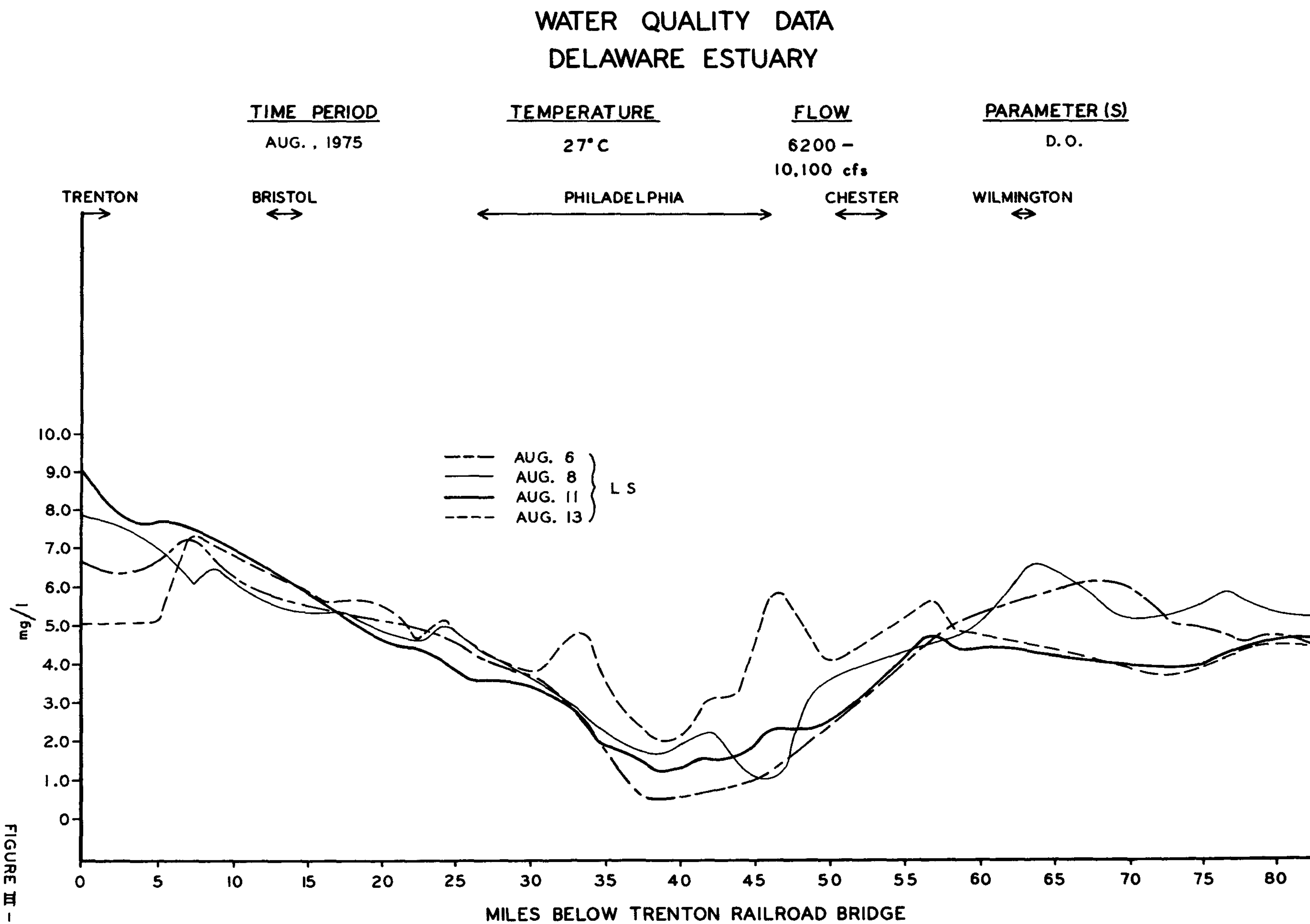


FIGURE III - 30

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., 1975	27°C	6200 – 10,100 cfs	D.O.

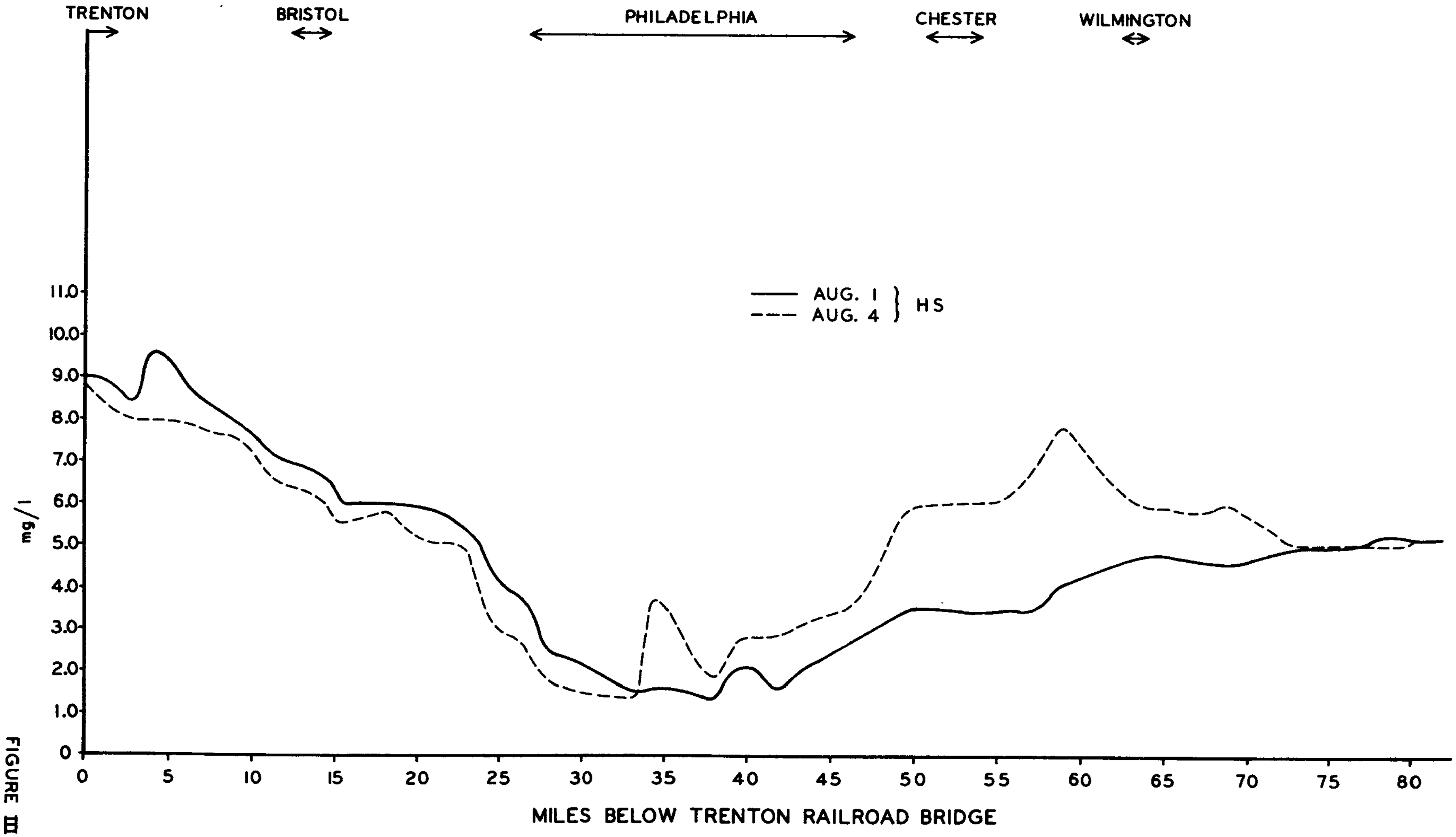


FIGURE III-31

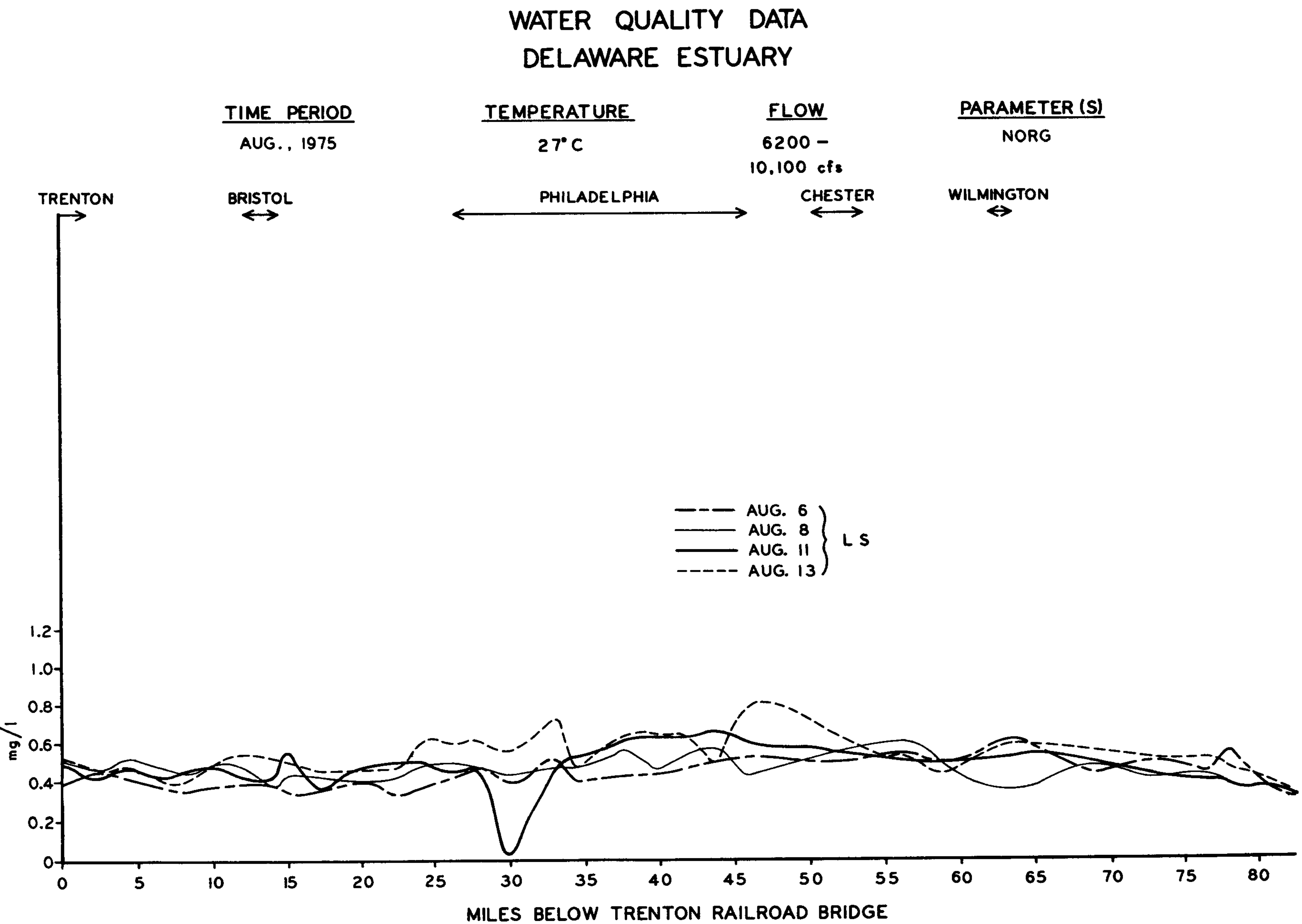


FIGURE III - 32

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG. 1975	27°C	6200 – 10,100 cfs	NH_3

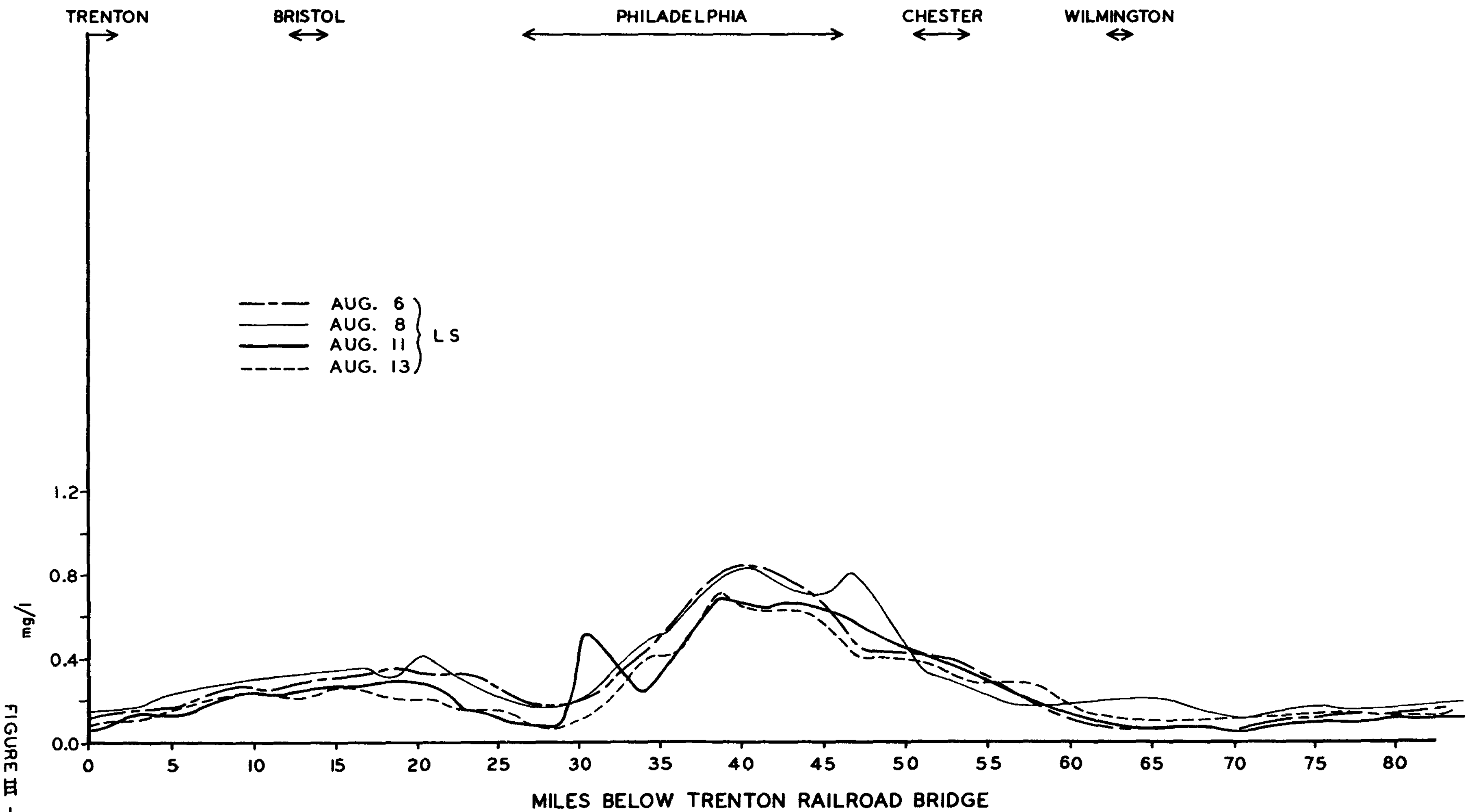


FIGURE III - 33

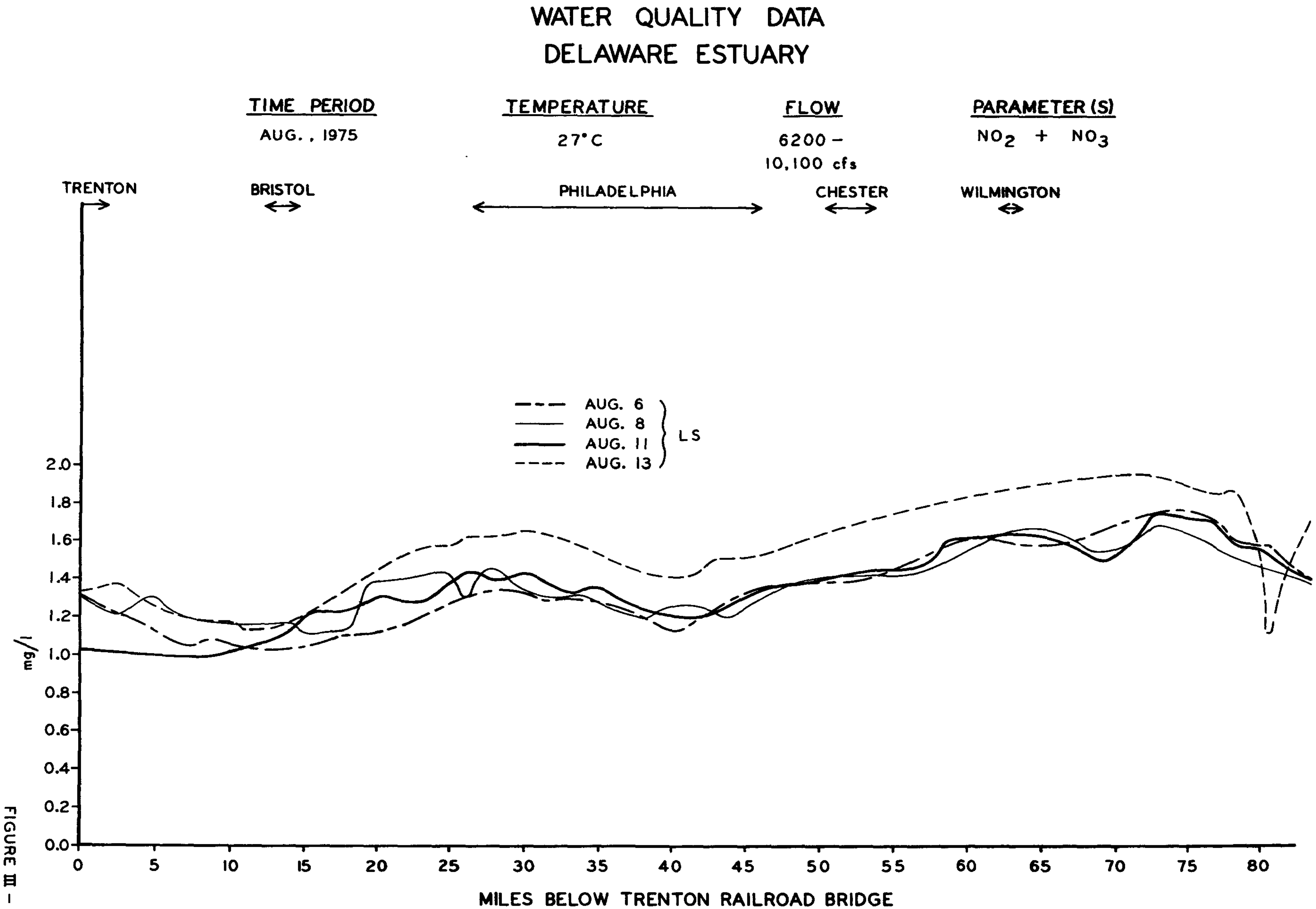


FIGURE III - 34

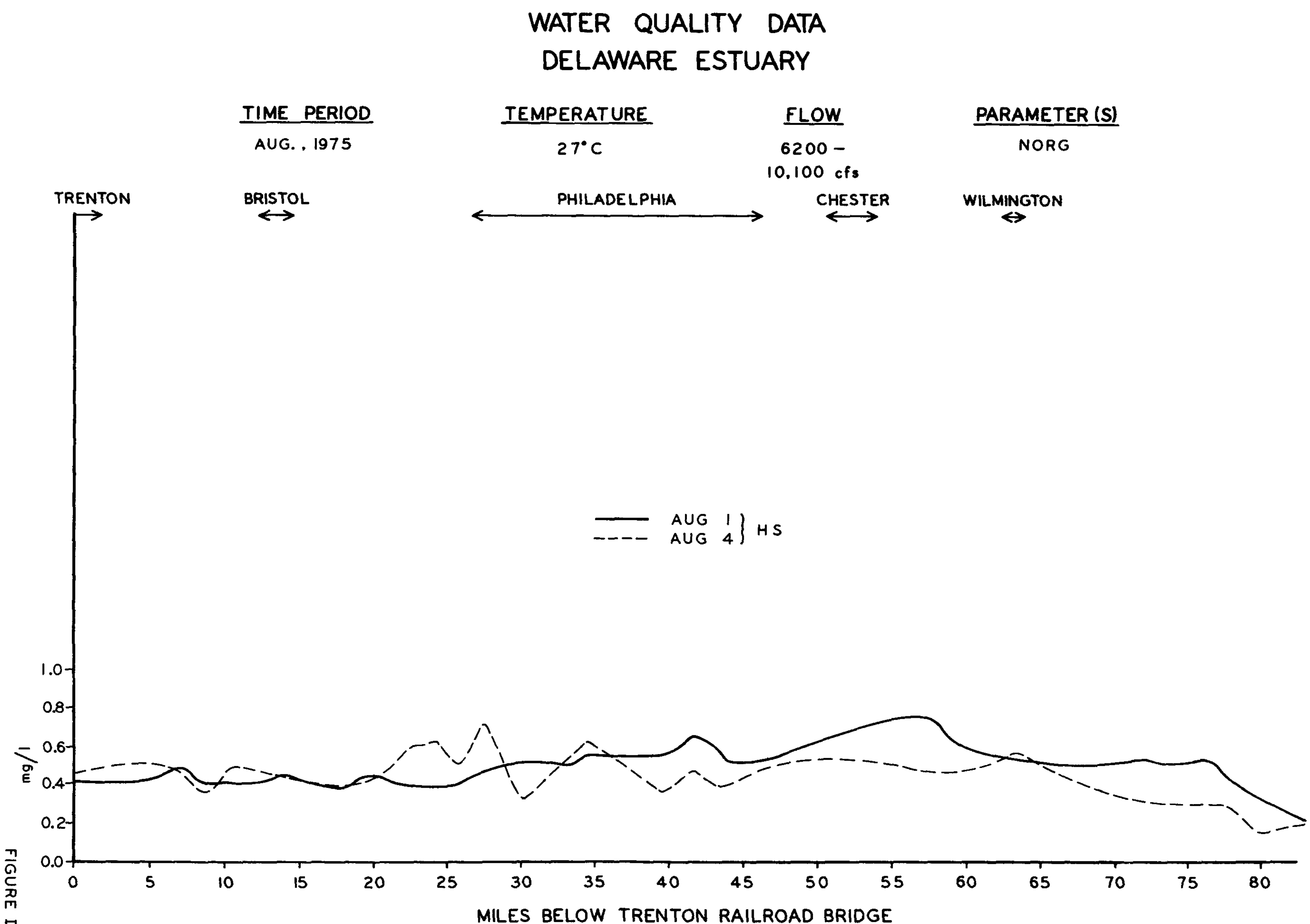


FIGURE III - 35

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., 1975	27°C	6200 – 10,100 cfs	NH_3

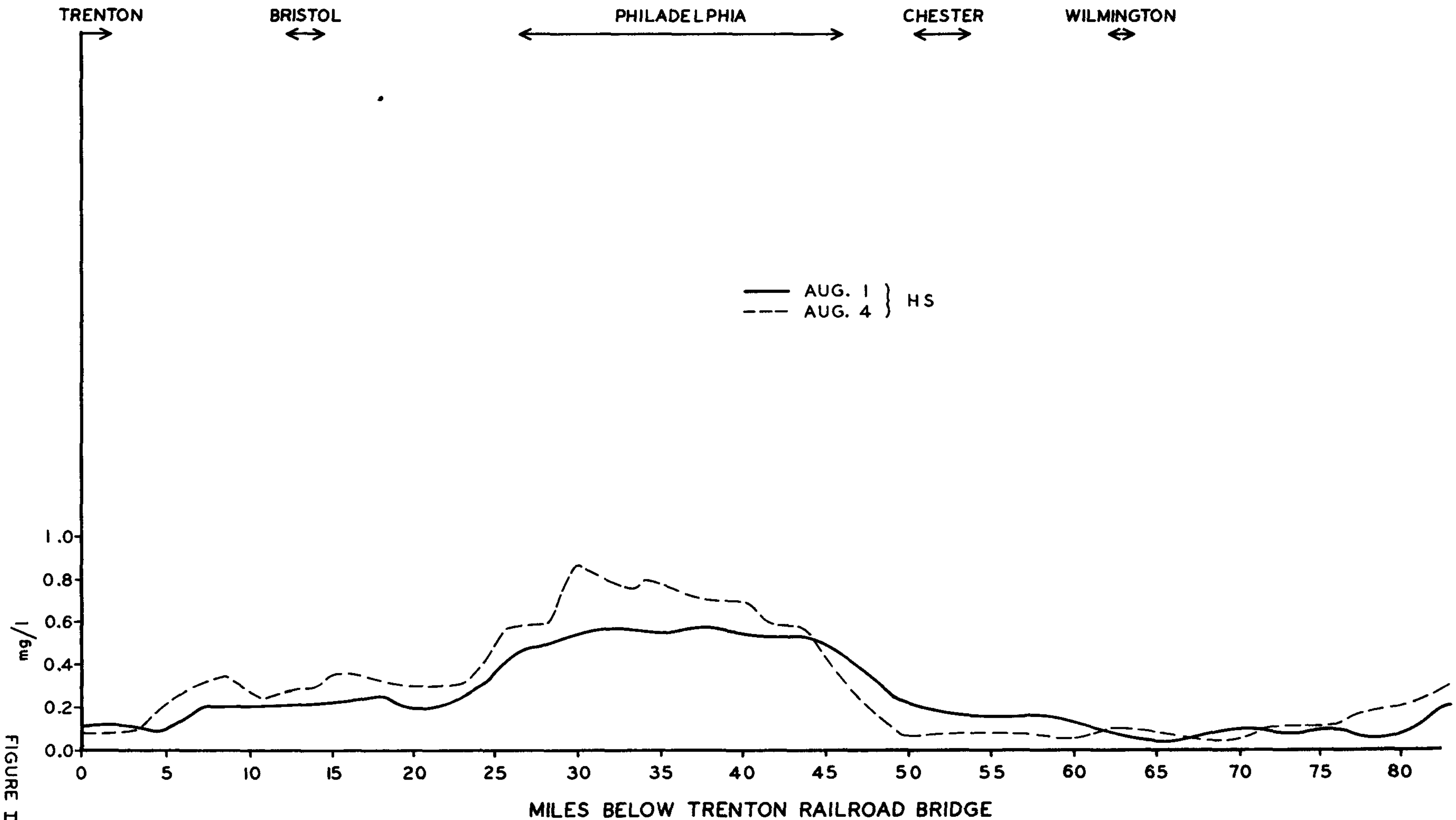


FIGURE III - 36

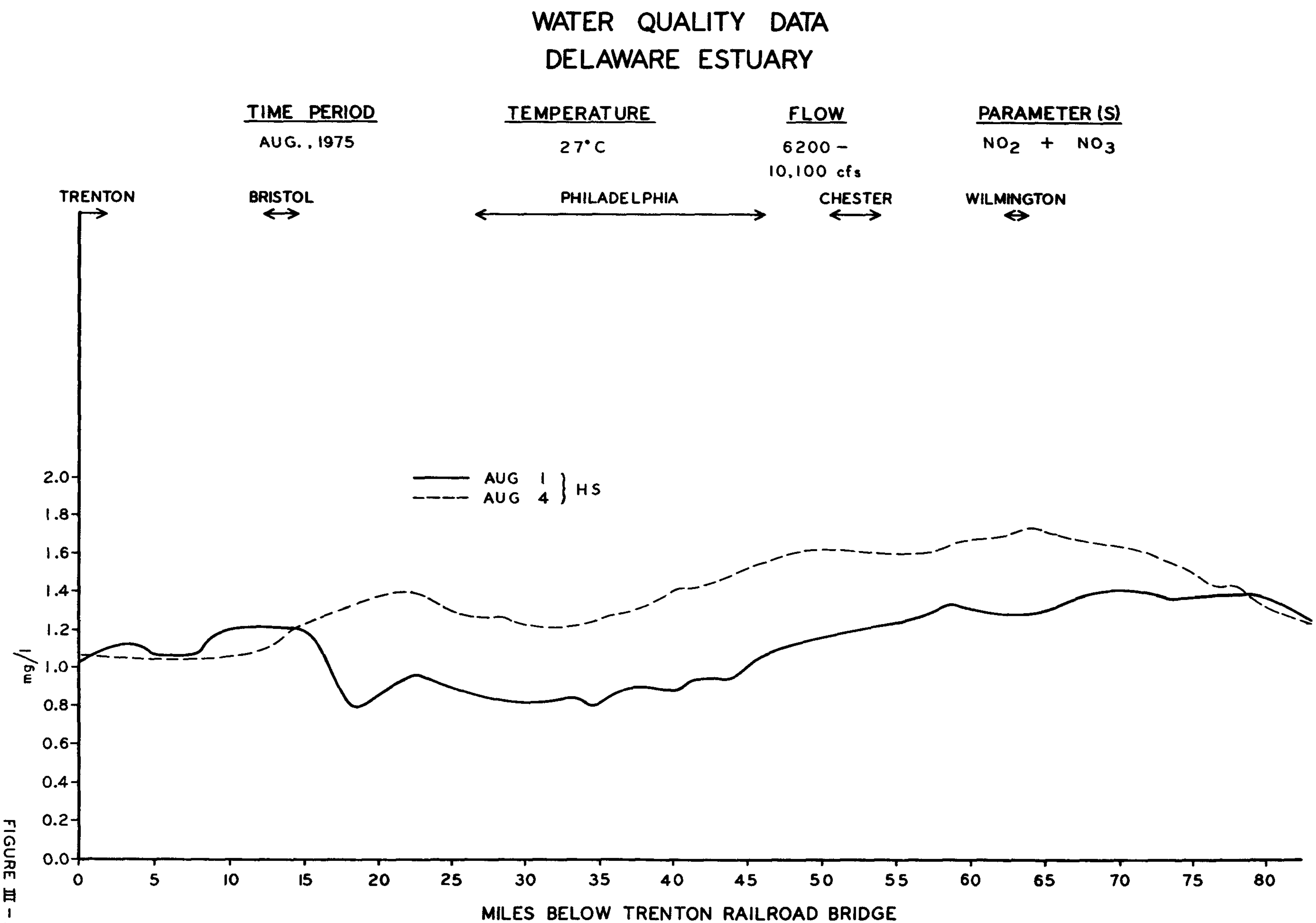


FIGURE III - 37

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., 1975	27°C	6200 - 10,100 cfs	CHLORO. a

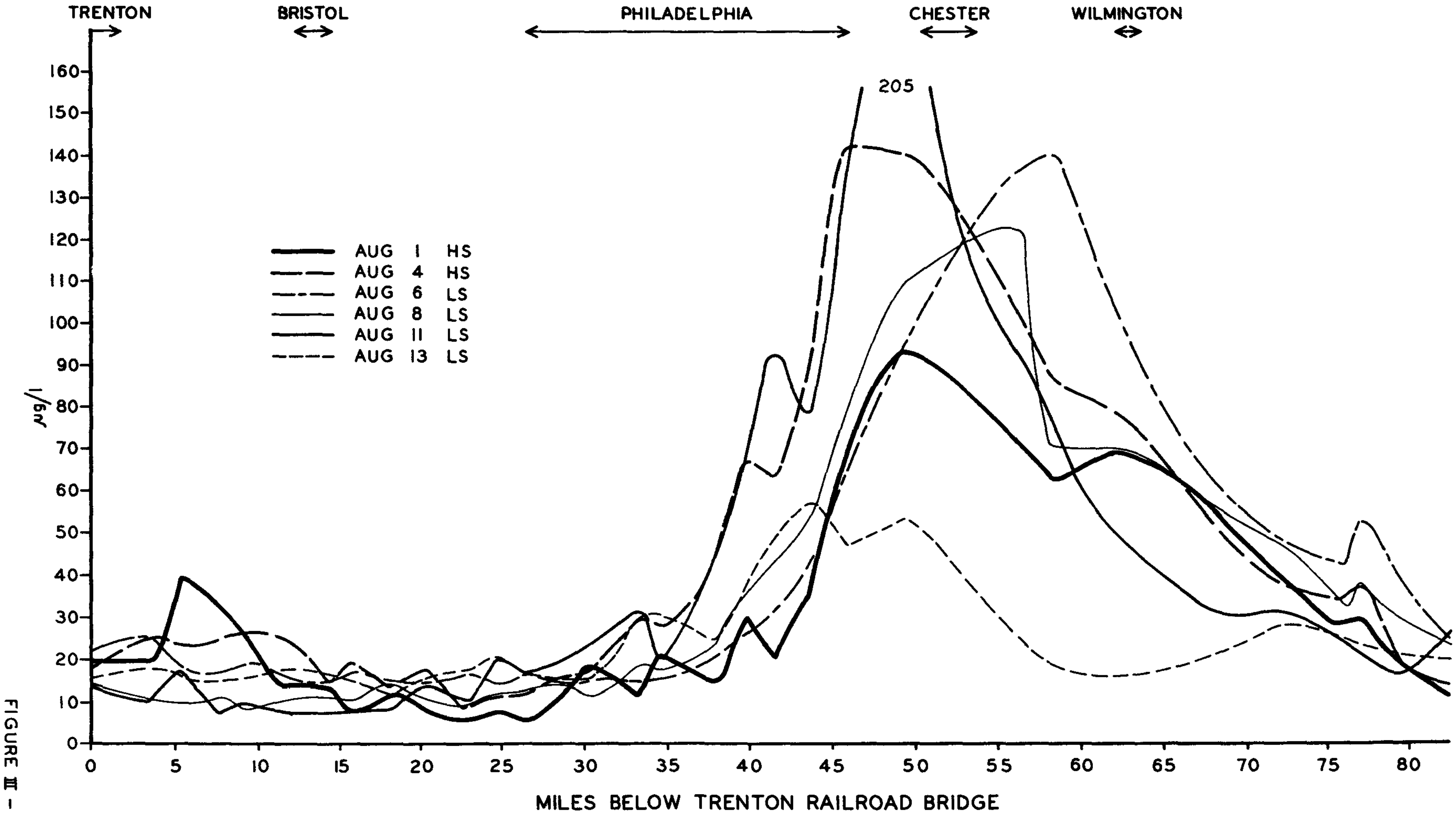


FIGURE III - 38

July - September, 1968

In some respects, this data set offered more value than the others because of its relatively long duration. The fact that both non-bloom and varying algal bloom conditions were represented made it particularly appealing from the standpoint of model verification. Weekly, or in some cases, semi-weekly slack water runs extending from Reedy Island to Fieldsboro, N. J. were performed by the State of Delaware from July 3 to September 9. Unfortunately, the early non-algae phase of the study had very limited value because of the transient nature of the hydrograph and the difficulty associated with conducting a meaningful simulation of such a condition. Figure III-39 presents the variability of temperature, flow, and chlorophyll a concentrations for the entire study period.

The individual DO profiles for the two significant algal bloom periods, July 26 - August 17 and August 18 - September 6, are shown in Figures III-40 through III-42. For the sake of convenience, low water slack and high water slack data are presented on separate graphs. As can be seen, definite similarities exist among these profiles with regards to minimum DO concentrations and the basic configuration of the sag. The spatial displacement of the profiles from one slack to the other can be easily identified. One disturbing feature of these profiles is the lengthy and relatively constant DO minimum, a phenomenon that is seldom experienced. It appears that the sampling procedure prevented the DO concentrations from going below about 1.0 mg/l, as though the introduction of a residual amount of oxygen to the sample, either through pumping or filling the container, was taking place. Data collected by the City of Philadelphia during the same period showed many DO values approaching or actually reaching zero. This data will be presented in the next section in conjunction with the model verification study.

Plots of the nitrogen series data for the same time periods are presented in Figures III-43 through III-51 for both high water and low water conditions. The relatively small amount of scatter among the individual data points within both periods enhance their value for model simulation studies. Examination of the nitrogen profiles reveals that the same basic trends depicted in the other data sets are further corroborated by this 1968 data. Differences between one period and the next relate primarily to concentration levels rather than spatial trends; whether these differences in the inorganic nitrogen concentrations can be attributed to existing algal levels is uncertain because of discrepancies in the data itself.

Maximum chlorophyll a data for the duration of this 1968 study are presented in Figure III-39. Individual profiles for each sampling date within the three separate periods can be seen in Figures III-52 through III-55. To summarize, the period from July 3 to July 25 was of low algal intensity but very transitory; the following period from July 26 to August 17 contained maximum algal blooms with chlorophyll a levels ranging between 100 and 150 μg/l; the last period between August 18 and September 6 exhibited a continued but somewhat lower bloom condition, with maximum chlorophyll a levels ranging between 70 -

100 μg/l. In all three cases, chlorophyll _a_ peaked in the Philadelphia to Marcus Hook reach.

TEMPERATURE, FLOW, CHLOROPHYLL DATA
JULY - SEPTEMBER, 1968 , DELAWARE ESTUARY

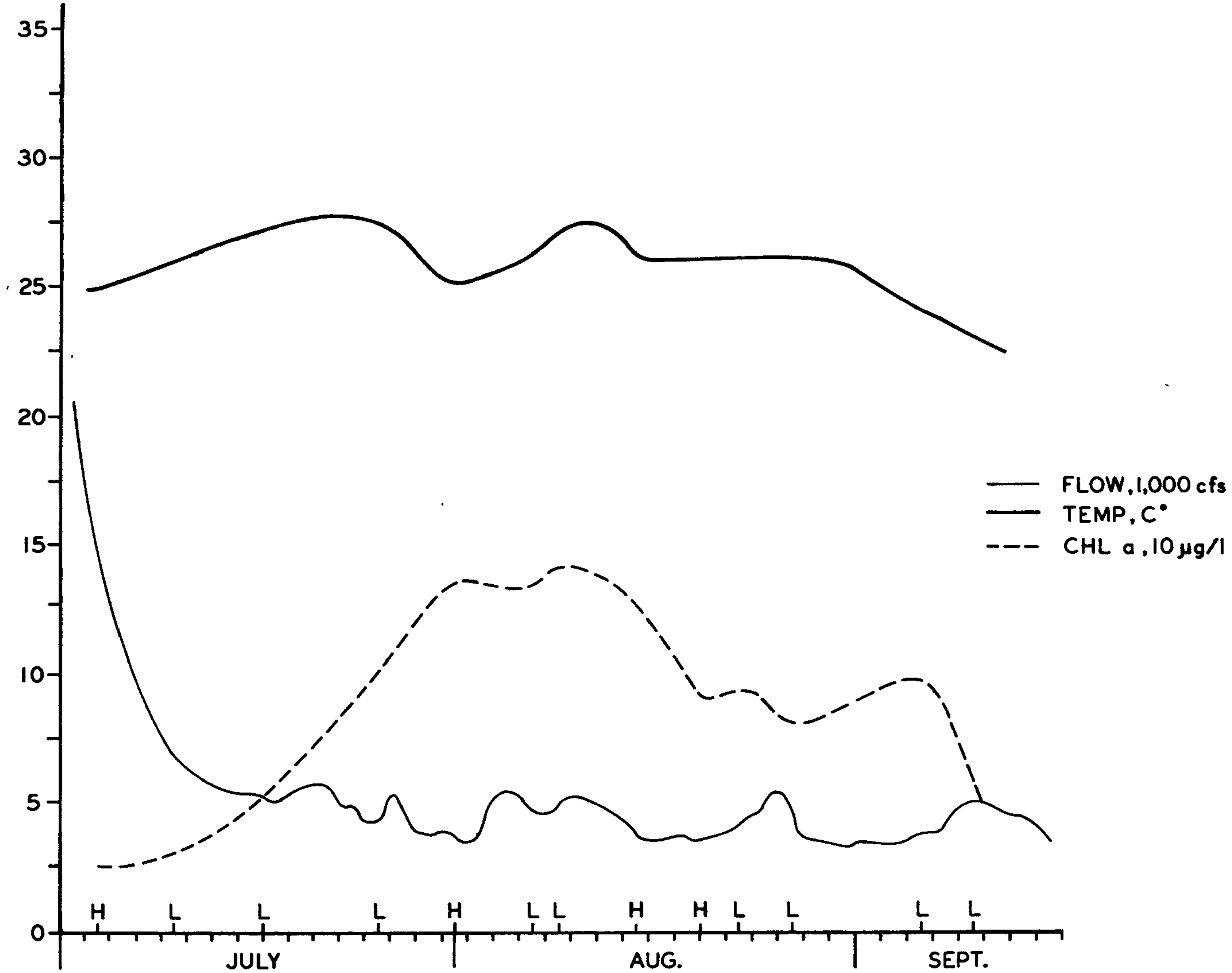


FIGURE III - 39

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, AUG., 1968	28° C	4800 cfs	D.O.

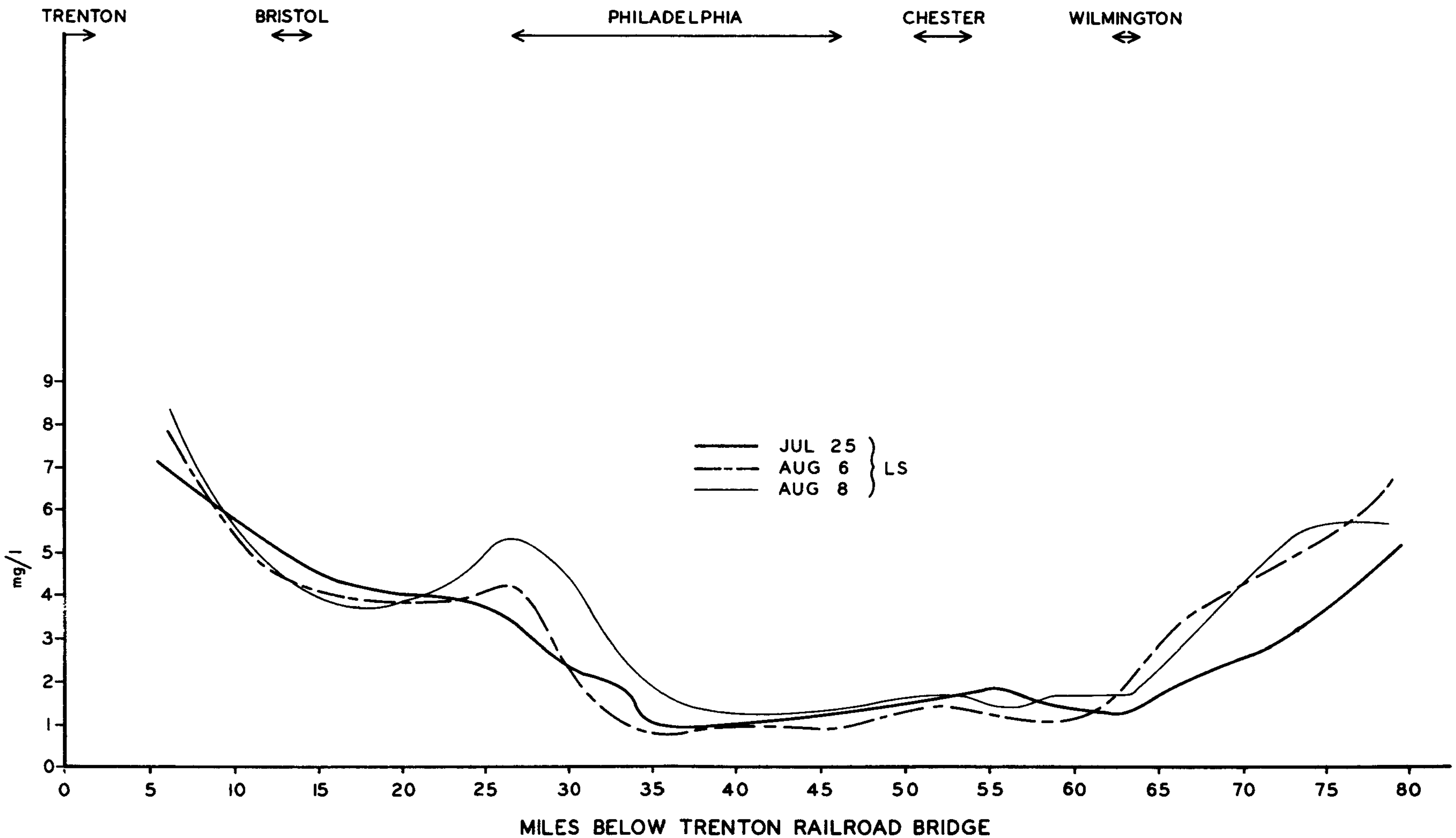


FIGURE III - 40

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, AUG., 1968	28° C	4800 cfs	D.O.

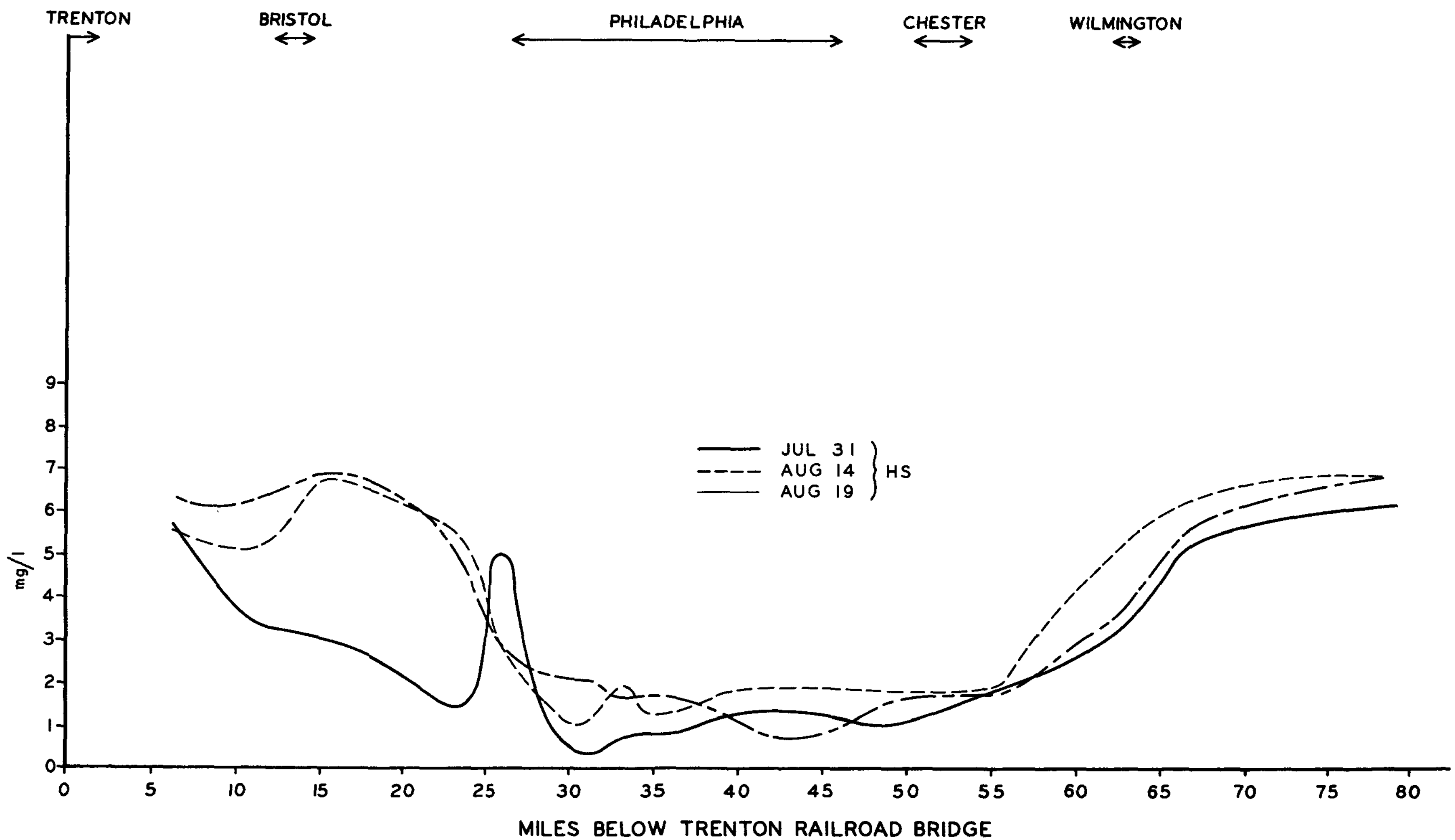


FIGURE III-41

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., SEPT., 1968	27° C	3900 cfs	D.O.

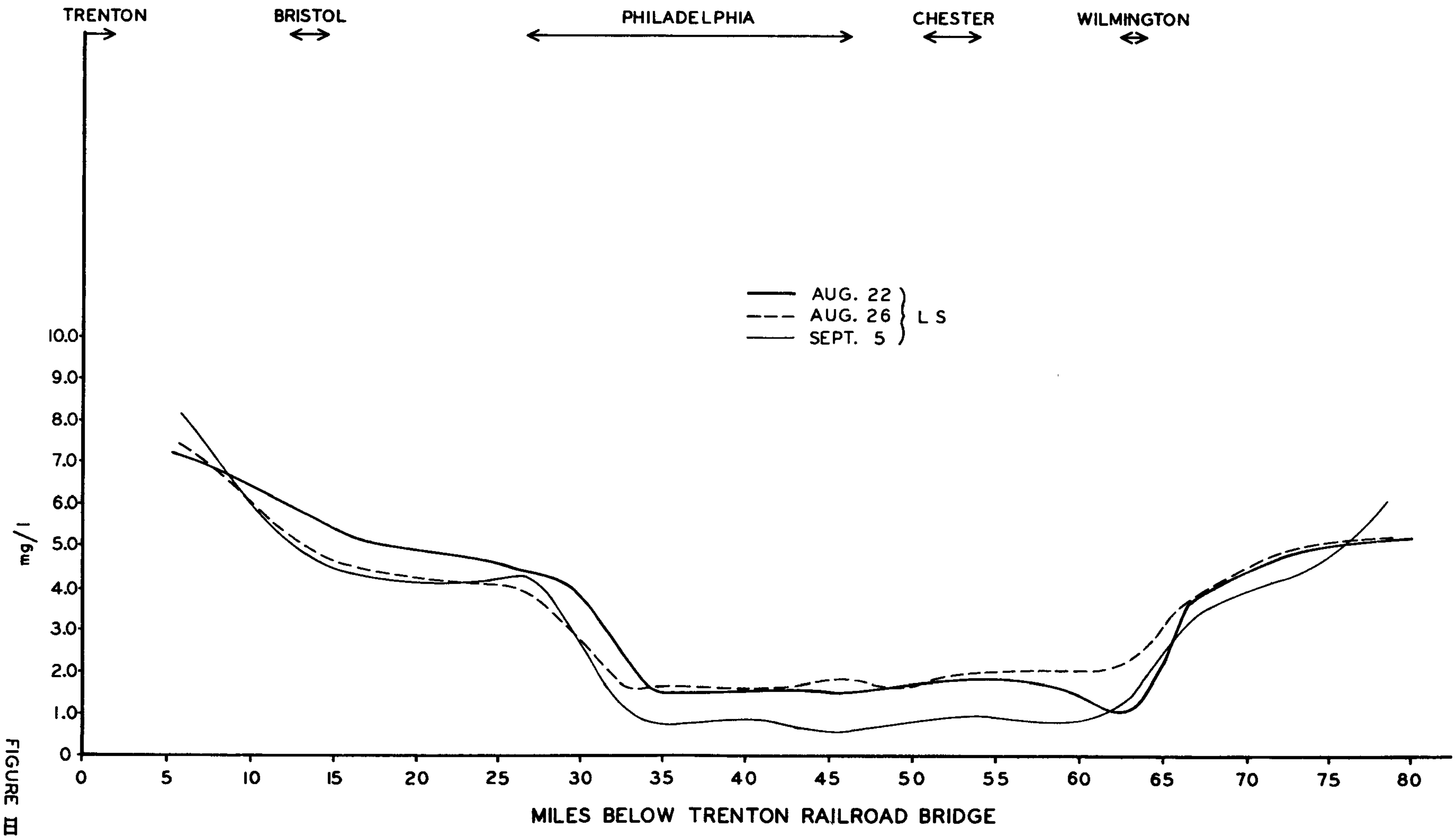


FIGURE III-42

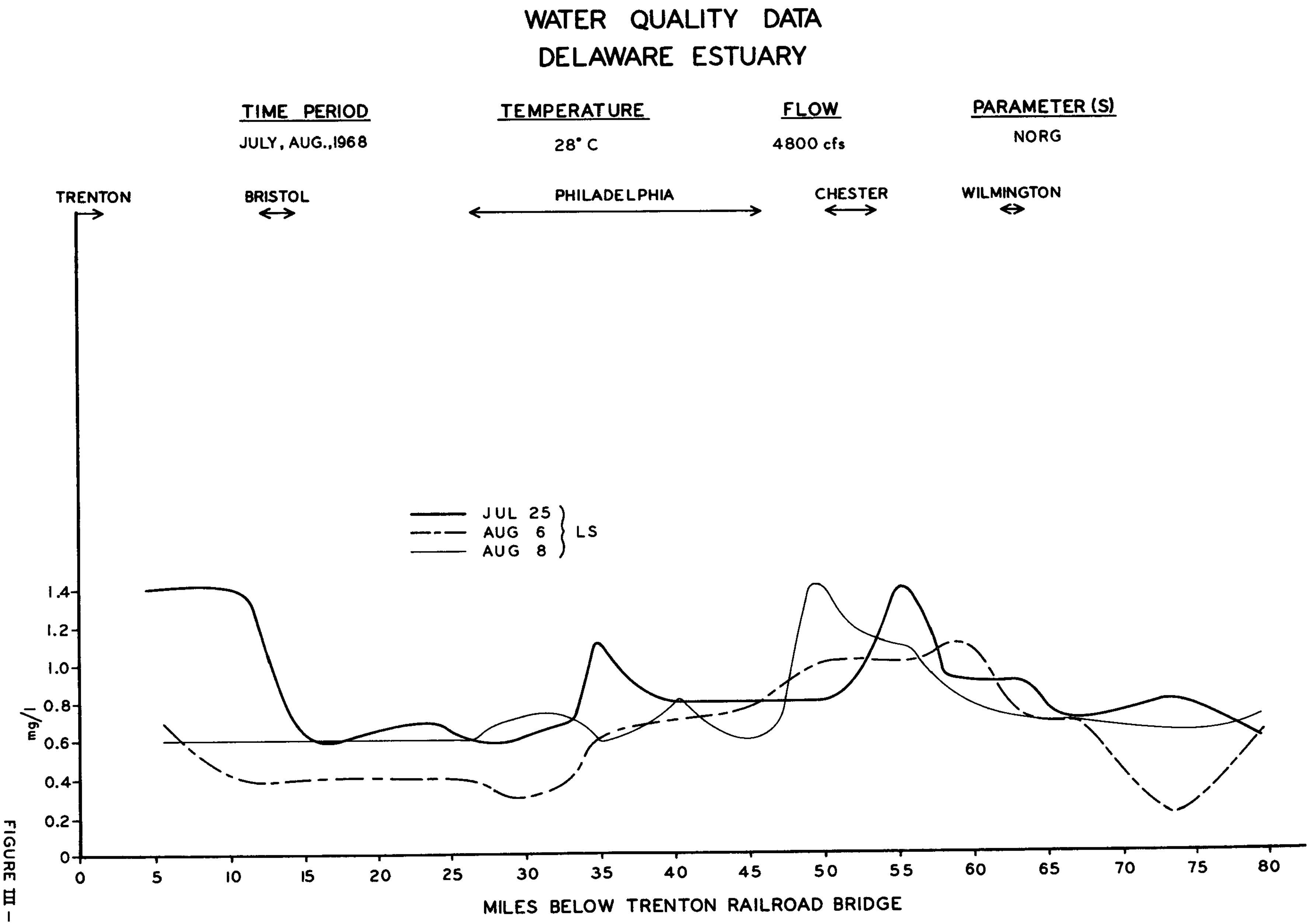


FIGURE III - 43

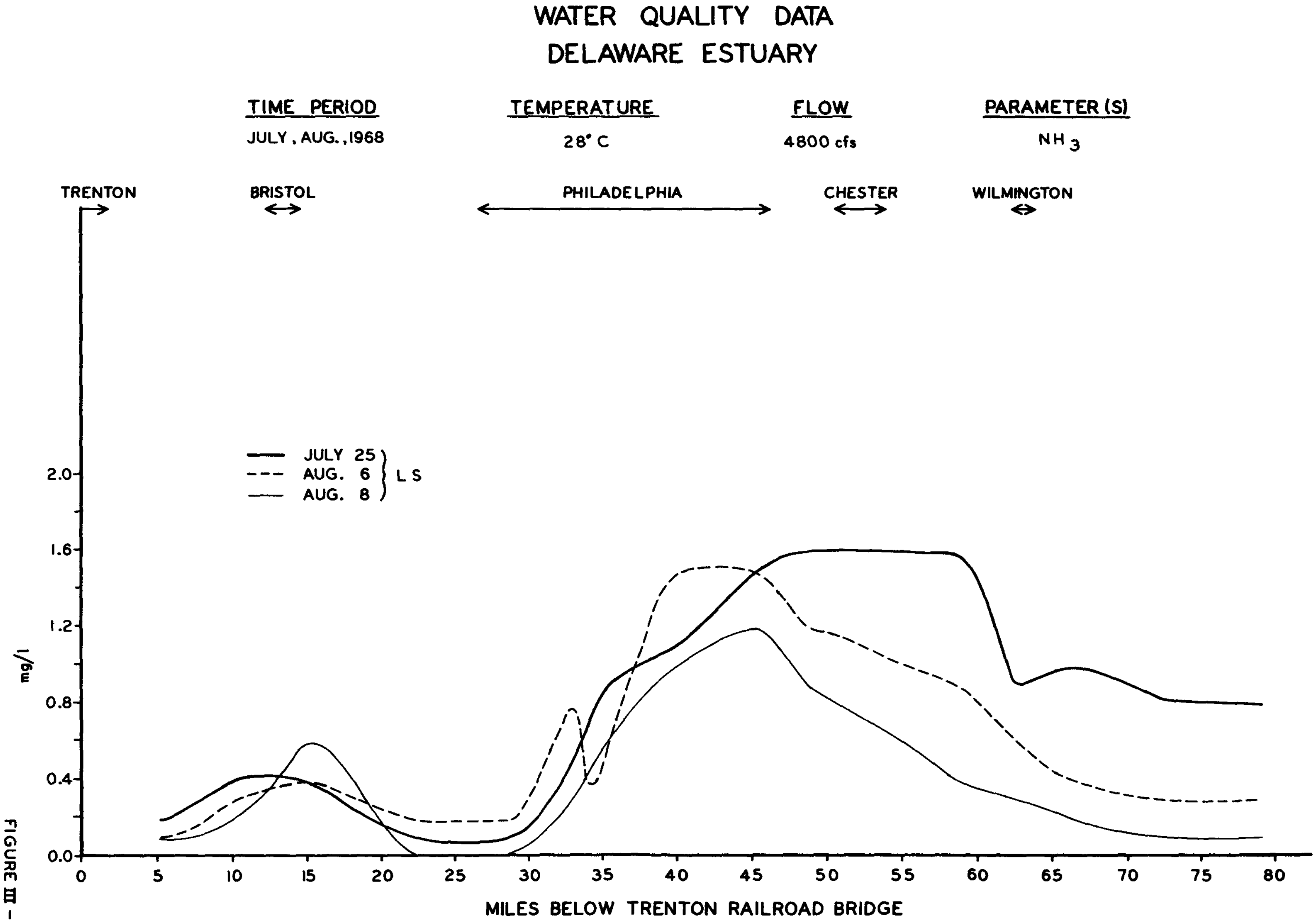


FIGURE III - 44

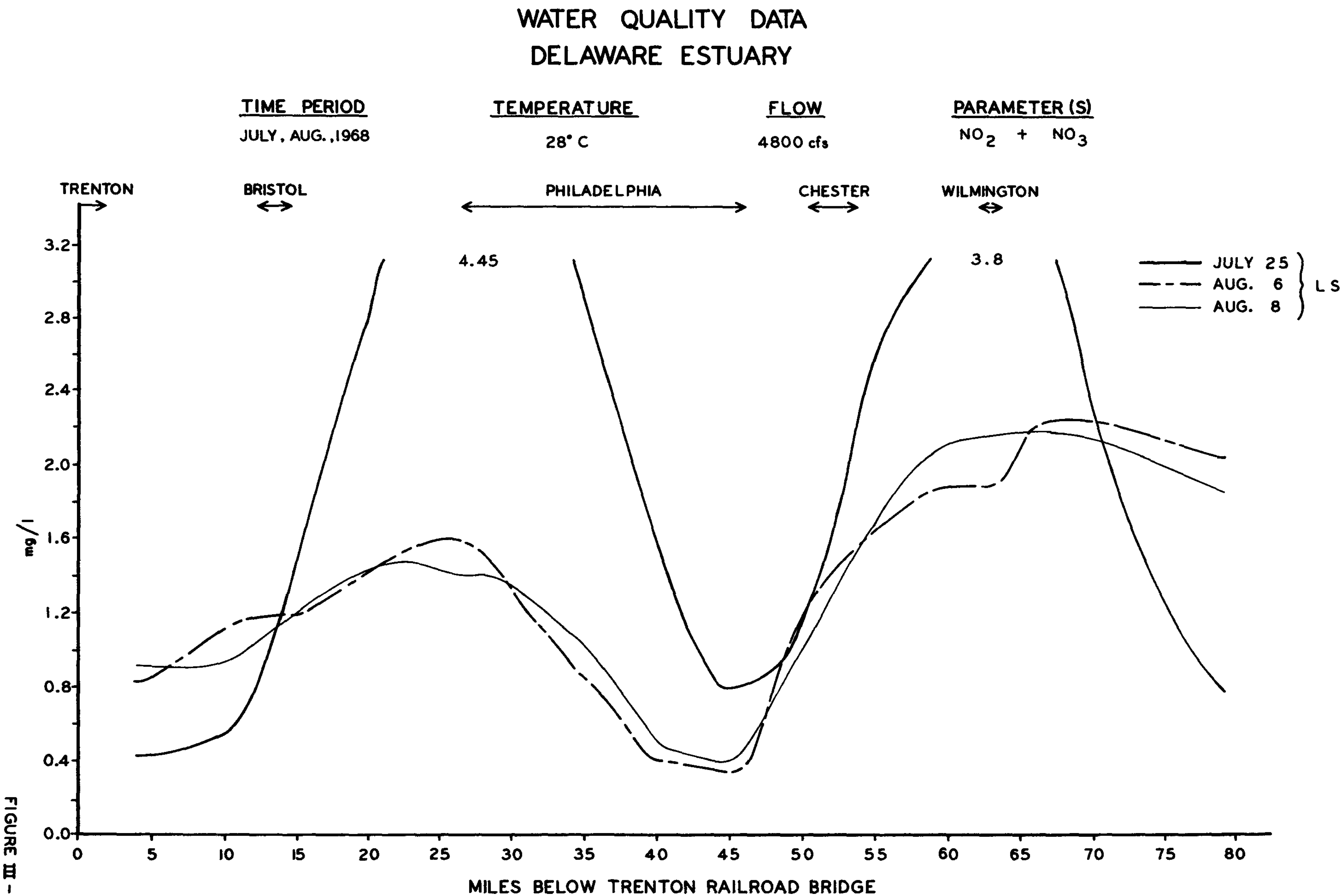


FIGURE III-45

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, AUG., 1968	28° C	4800 cfs	NORG

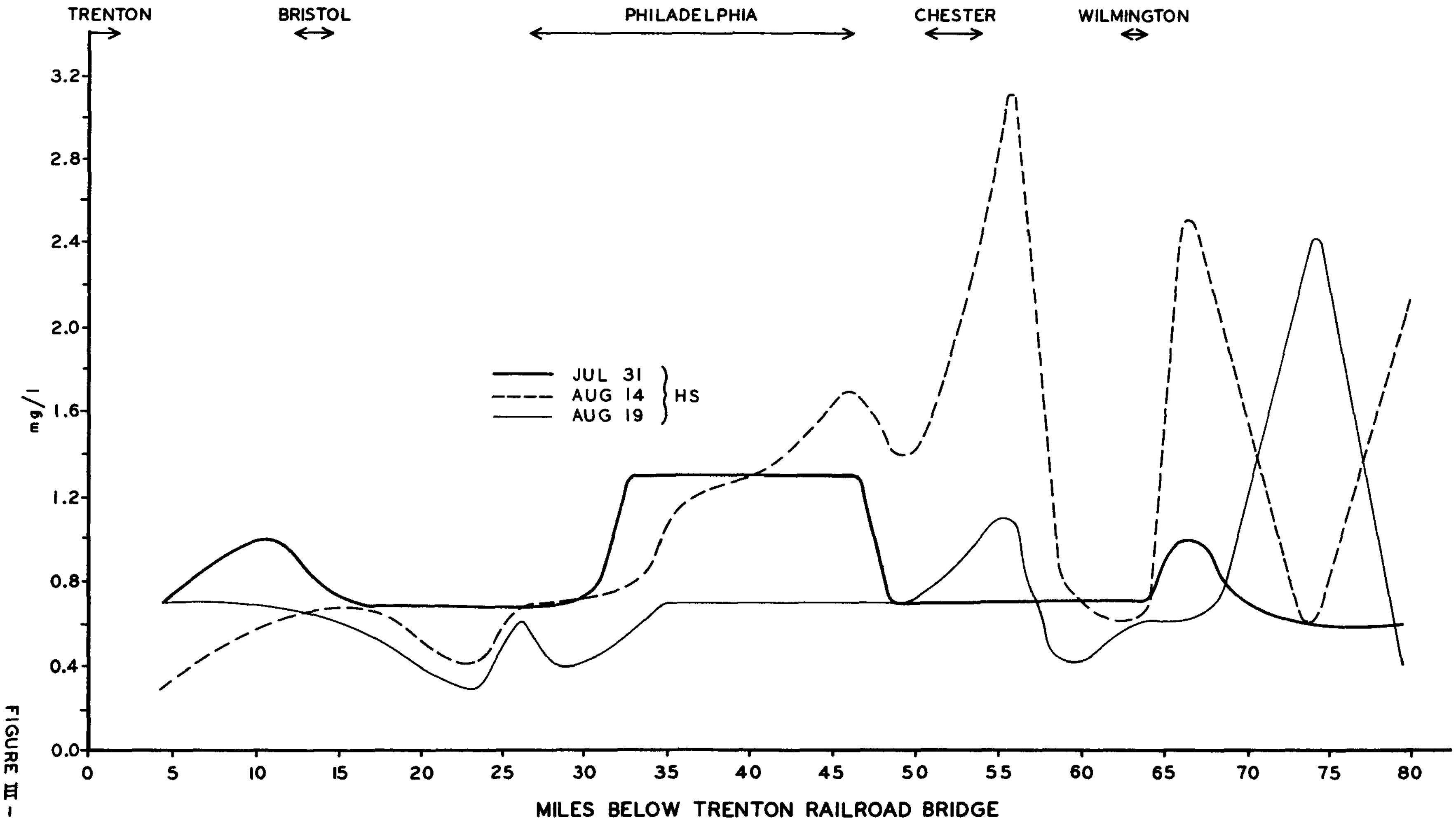


FIGURE III - 46

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, AUG., 1968	28° C	4800 cfs	NH_3

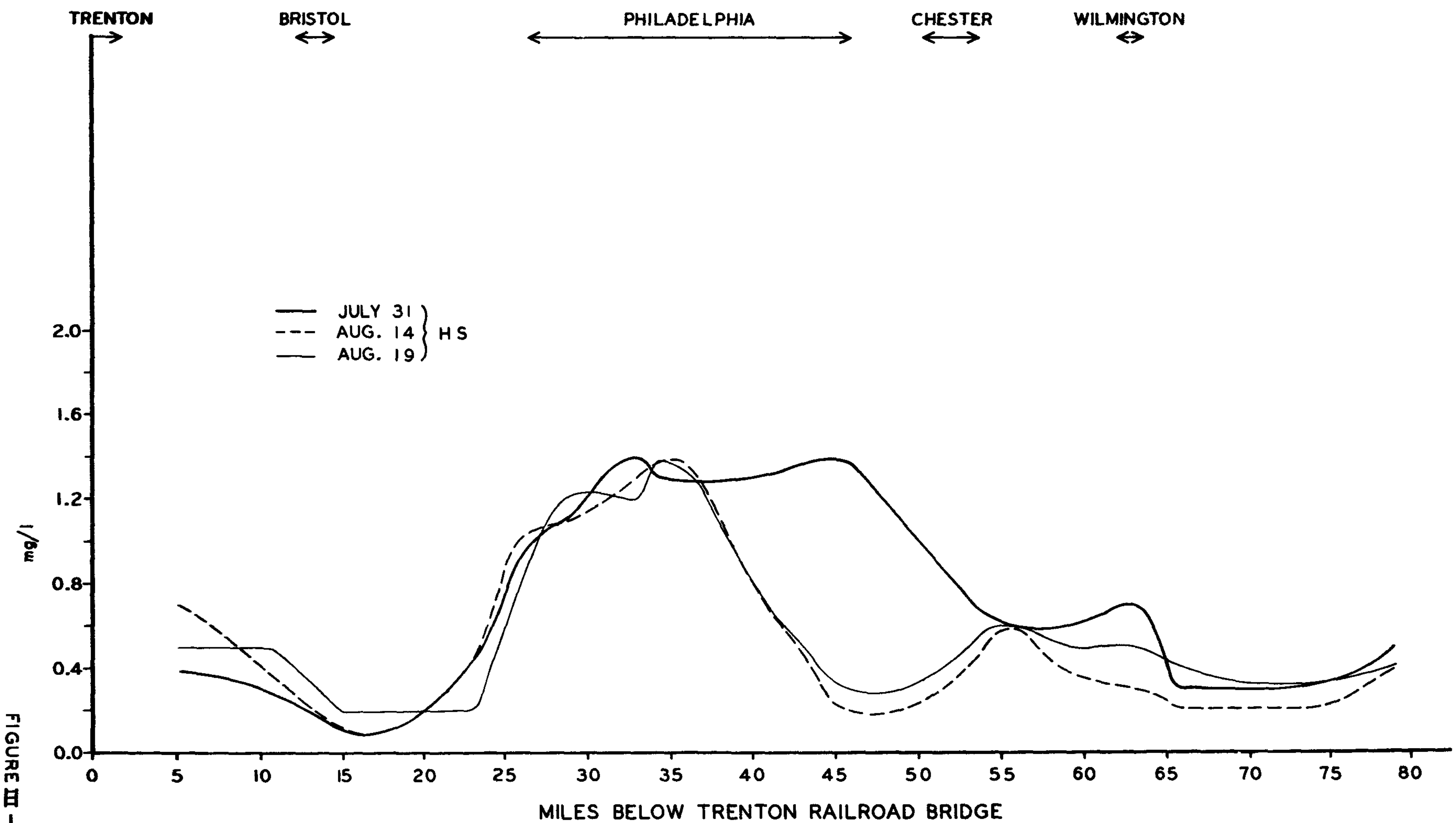


FIGURE III-47

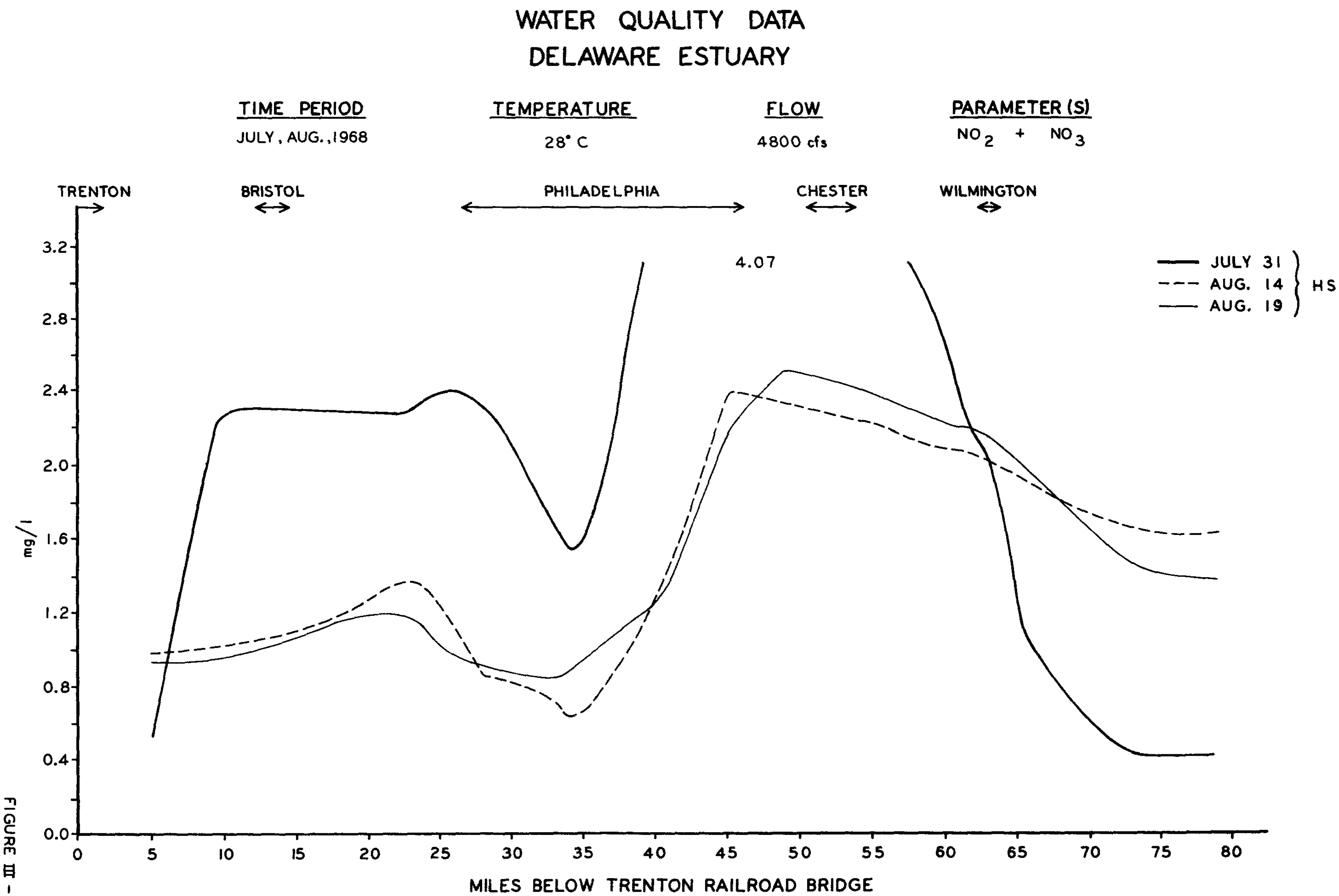


FIGURE III - 48

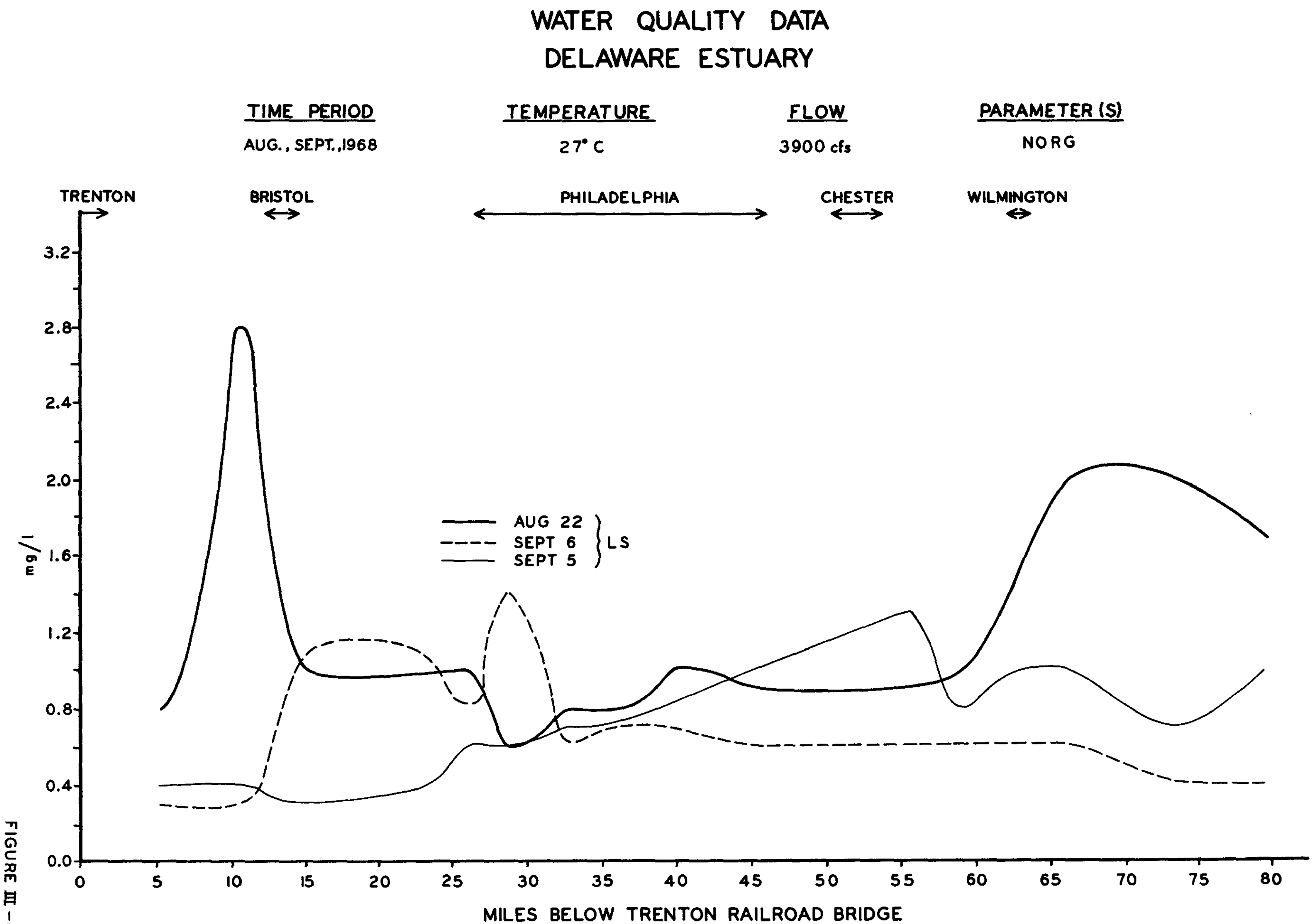


FIGURE III-49

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., SEPT., 1968	27°C	3900 cfs	NH_3

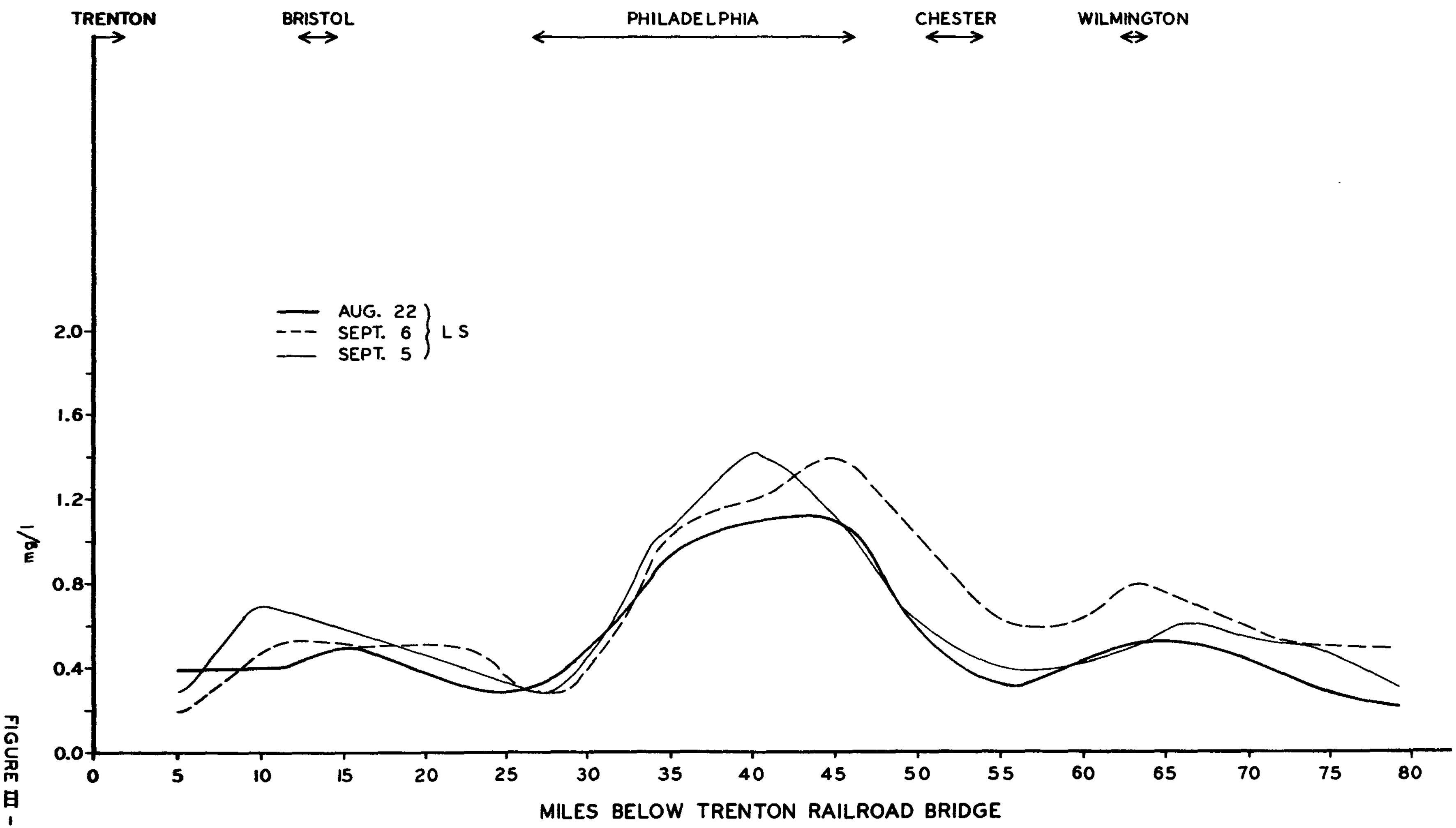


FIGURE III - 50

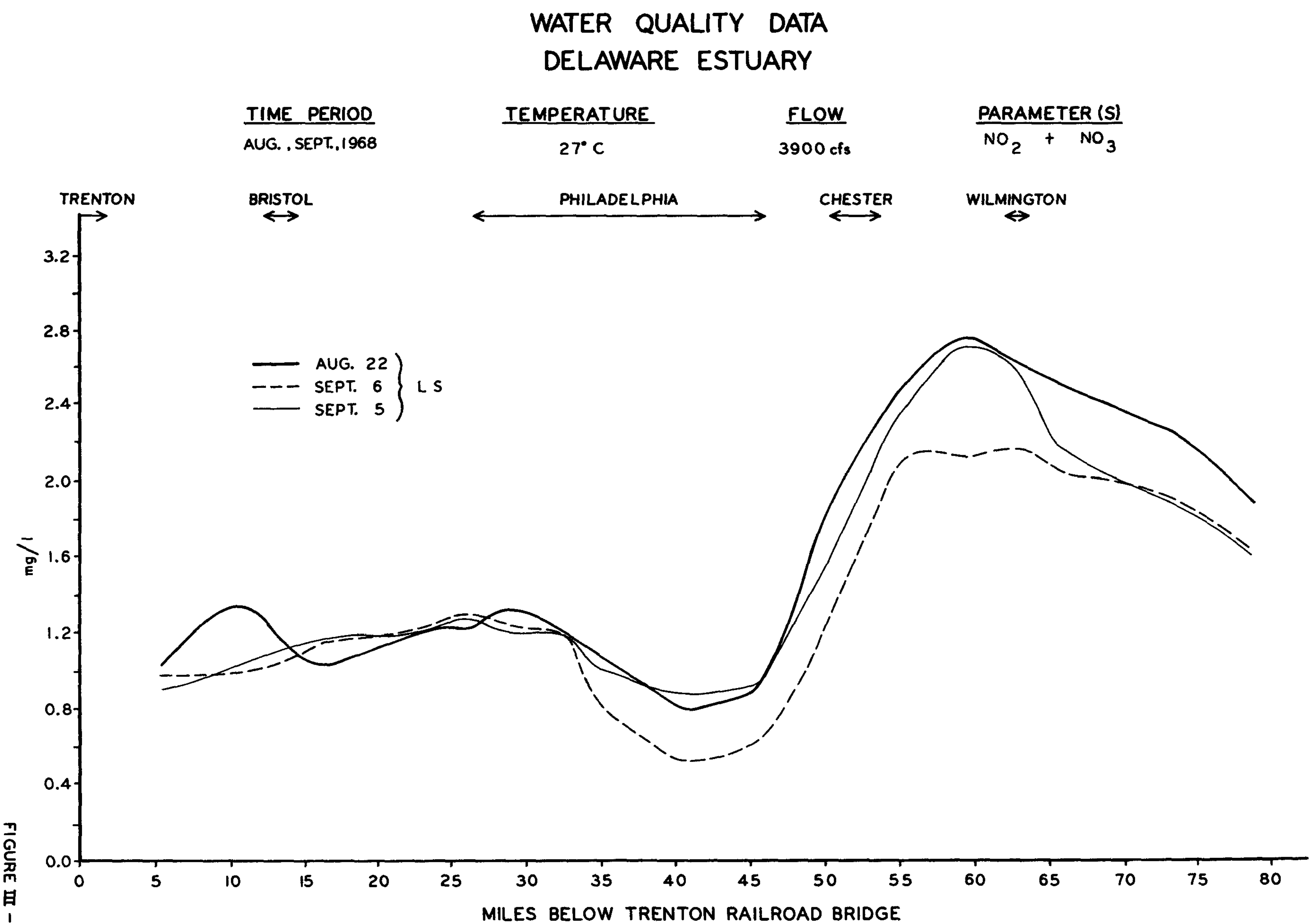


FIGURE III-51

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY , 1968	25 - 28° C	5000 - 15,000 cfs	CHLORO. a

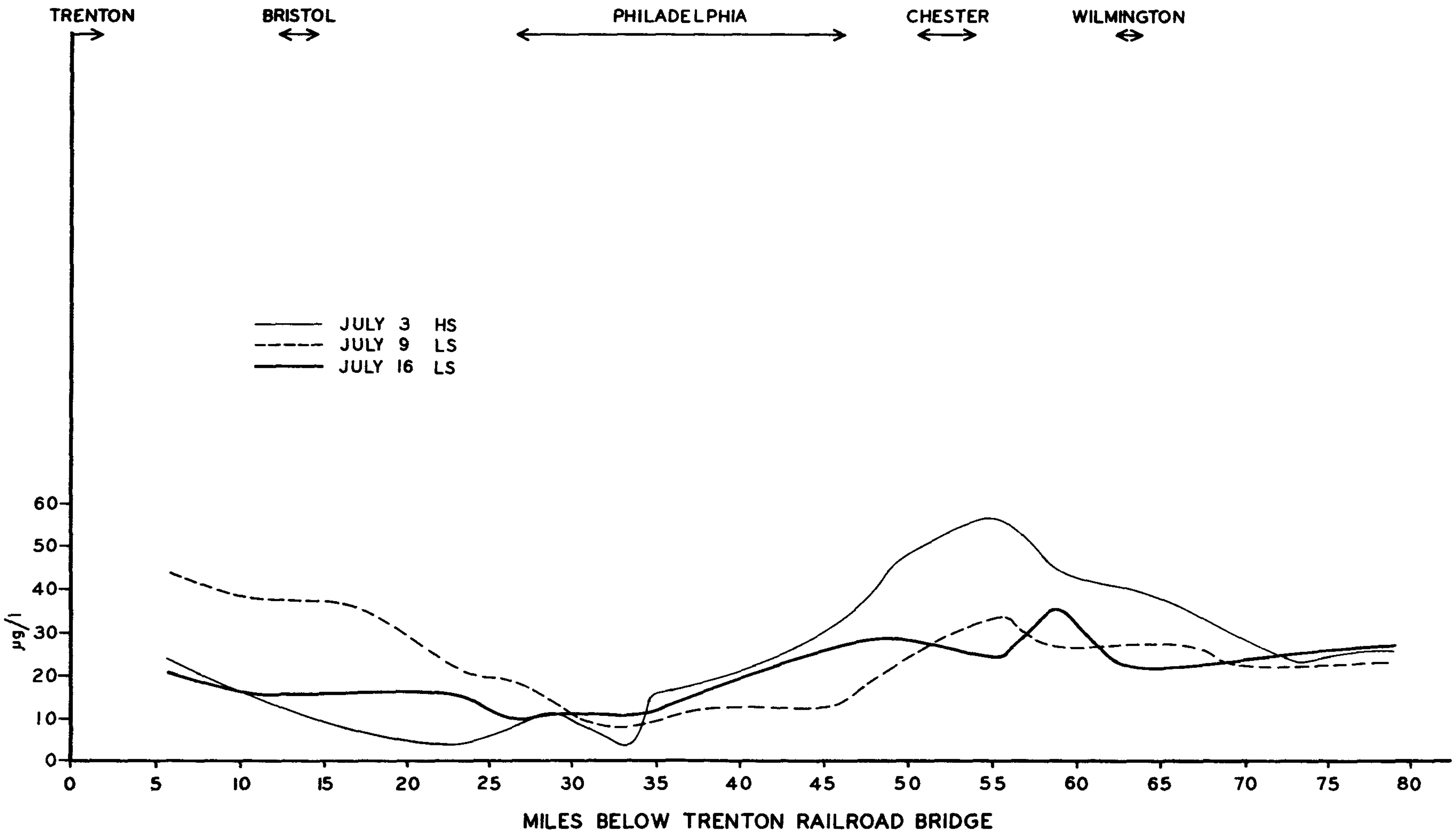


FIGURE III - 52

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, AUG., 1968	28° C	4800 cfs	CHLORO. a

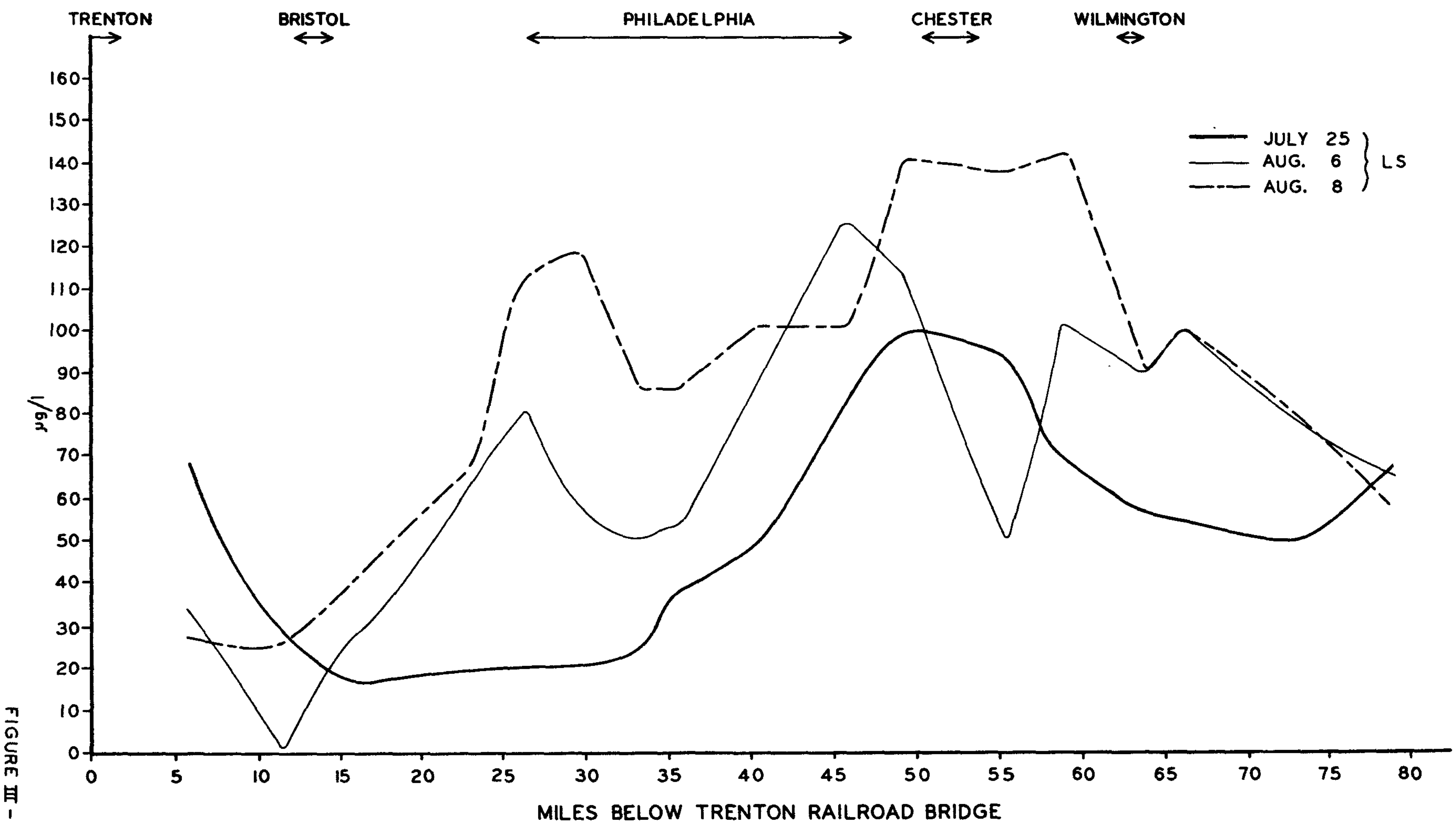


FIGURE III - 53

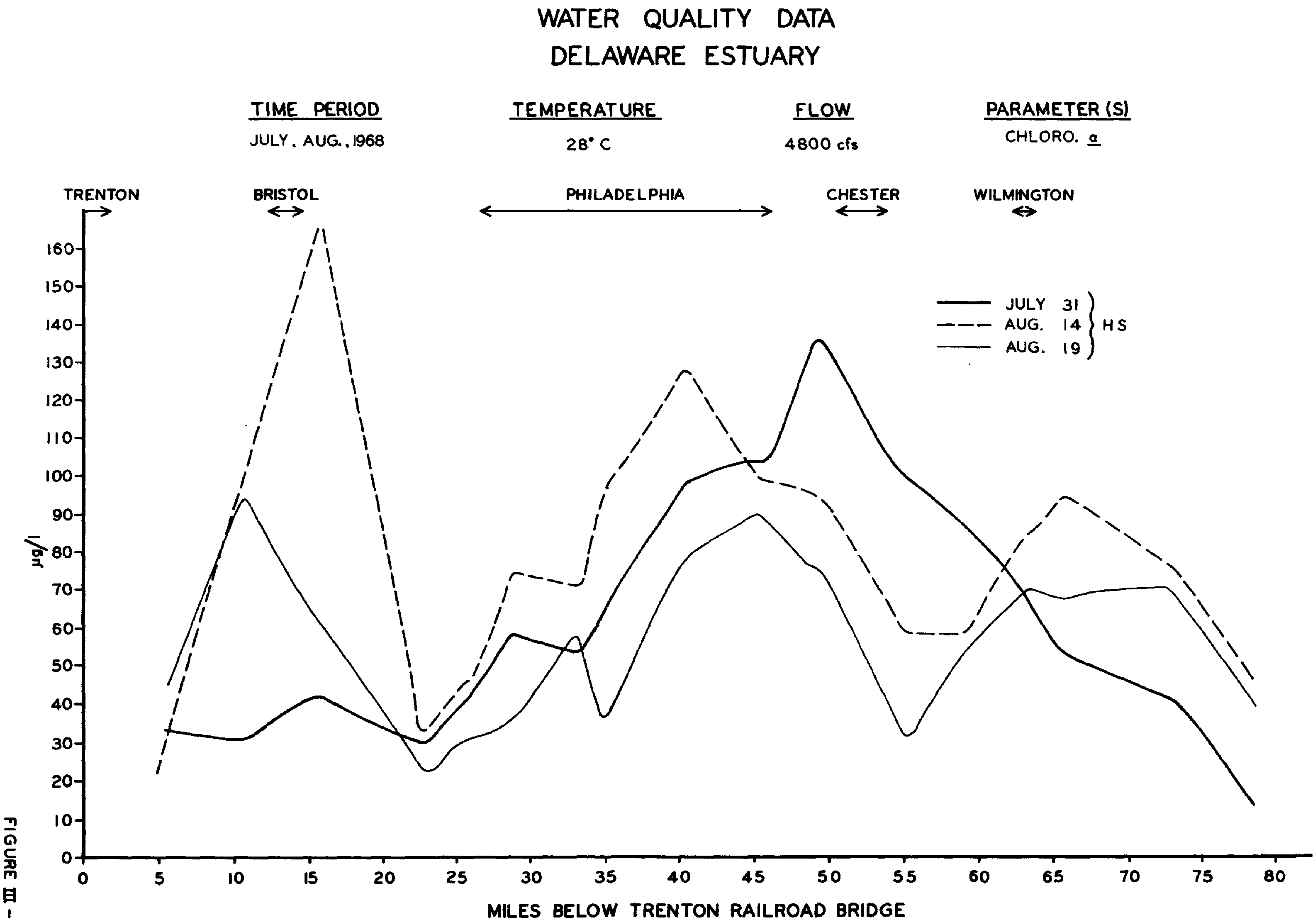


FIGURE III - 54

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., SEPT., 1968	27° C	3900 cfs	CHLORO. a

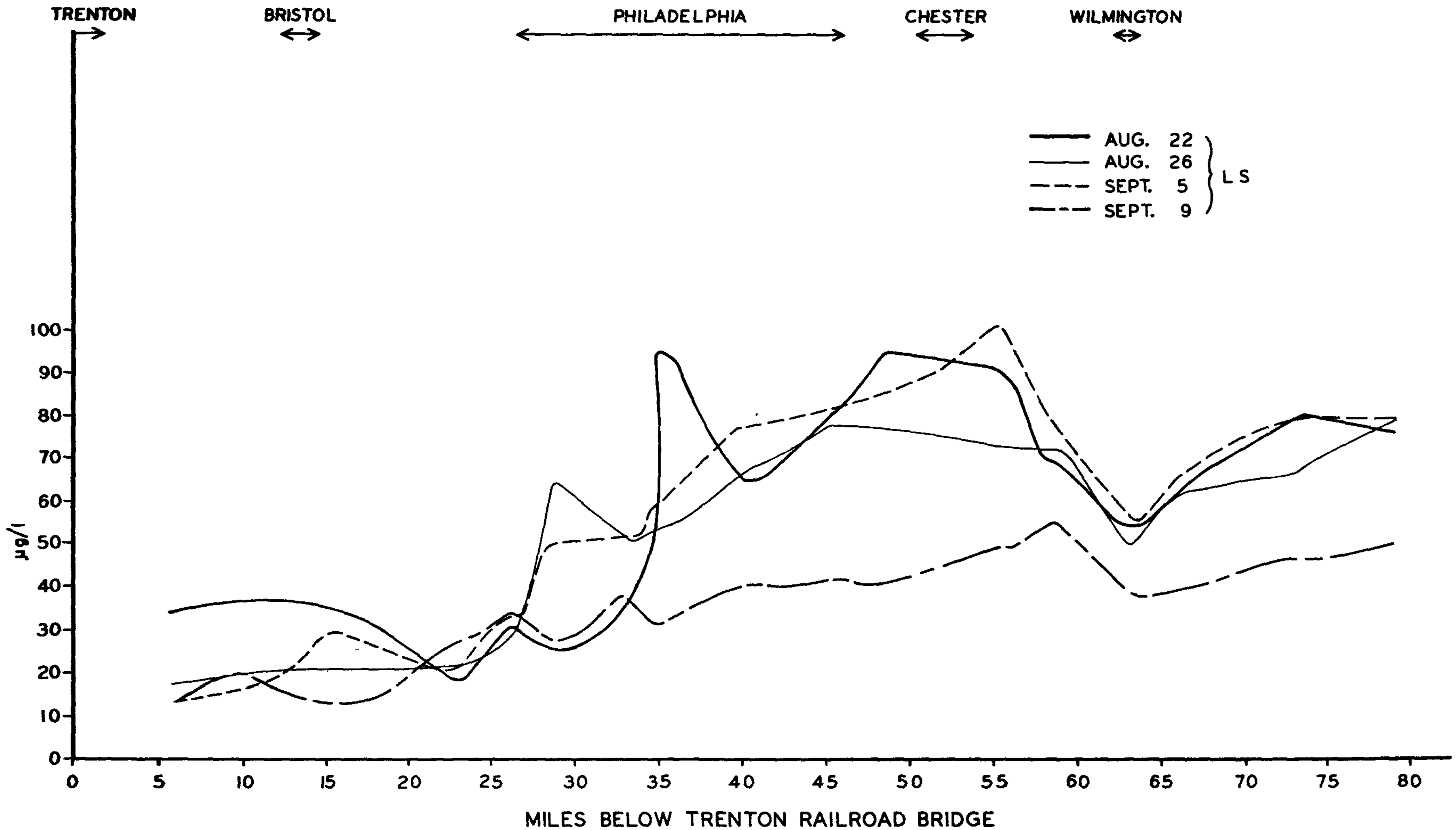


FIGURE III-55

July, 1976

This survey was conducted during a two week period in July, 1976 and was designed for the purpose of verifying a future two-dimensional model. The product of the Technical Advisory Committee, Delaware Estuary 208 Planning Program, it was conceptually similar to the 1975 survey and involved the same participants. The major difference was the exclusion of transect sampling. The same 32 water quality stations were sampled between Liston Point and Trenton during six slack water runs. In the reach below Torresdale three boats ran abreast, sampling along both shorelines as well as the mid-channel. The mid-channel data collected by AFO personnel will be presented in this report for model verification purposes. In addition to the estuary monitoring, sampling was conducted at the major municipal and industrial waste discharges and the larger tributary inputs.

The Delaware River flow at Trenton was moderate and steady, averaging about 7,500 cfs. Water temperatures during the period were also steady and averaged about 25^{o}C. The longitudinal DO profiles observed during each of the slack water runs are shown in Figures III-56 and III-57. The first figure contains the three low water slack sampling results, while the second shows similar data for high water slack conditions. The effects of tidal excursion are quite evident. The actual shapes of the profiles closely resemble those presented previously for different time periods. Major DO depressions to 2.0 mg/l or less occurred in the vicinity of Philadelphia, followed by a gradual but steady recovery downstream of Chester. The three low slack runs were quite consistent, with maximum DO concentration differences of about 1.0 mg/l. The variability in the high slack data, however, was much greater, particularly towards the end of the period.

As with the case of DO, the major nitrogen fractions monitored during the July, 1976 time period generally showed consistent patterns with previously described data sets. These data are presented in Figures III-58 through III-63. Organic nitrogen was least variable, with a buildup from about 0.4 mg/l to 0.6 mg/l beginning at Philadelphia. Ammonia nitrogen again experienced a substantial reduction above and below Philadelphia as a result of nitrification. Maximum concentrations were about 0.6 mg/l during both slack conditions, which is less than some other data sets have indicated. In one instance (high slack data) this level was unexpectedly attained below Trenton. The observed ammonia concentrations were very consistent within each week of the sampling period. The spatial variation of nitrate nitrogen, the most abundant form throughout the estuary, mimicked other data sets in showing an almost uninterrupted but continual rise between Trenton and Wilmington. Concentrations increased from about 0.8 mg/l to over 2.0 mg/l. The greatest rate of increase occurred below Philadelphia where nitrification appeared most prominent, as corroborated by the rapidly declining ammonia levels. Even allowing for nitrification, however, there existed a surplus of nitrates near Wilmington, indicating the possibility of major external sources along this reach of the estuary.

Figures III-64 and III-65 present the longitudinal chlorophyll _a_ profiles for the six individual sampling runs. During both weeks of the study a sizeable algae bloom was observed in the vicinity of Torresdale, Pennsylvania and Beverly, New Jersey, as demonstrated by the high chlorophyll a peaks depicted in these figures. As can be seen, chlorophyll a levels of 100 μg/l or more were fairly common in the bloom area. Examination of the actual algae cells under a microscope indicated that the bloom was comprised of diverse, green, pollution tolerant species. Other areas of the Delaware exhibited background algae conditions.

Figures III-66 and III-67 present the longitudinal profiles for Secchi Disk readings, a convenient measure of light penetration. A significant decline in light penetration occurred below river miles 55 and 45 for LS and HS data sets, respectively; this decline is always present below Philadelphia, and results from the flocculation of silt in the freshwater as the salinity wedge is first encountered. A significant increase in light penetration occurred during the second (HS) week of this survey at and above Philadelphia. No explanation for this can be offered at this time.

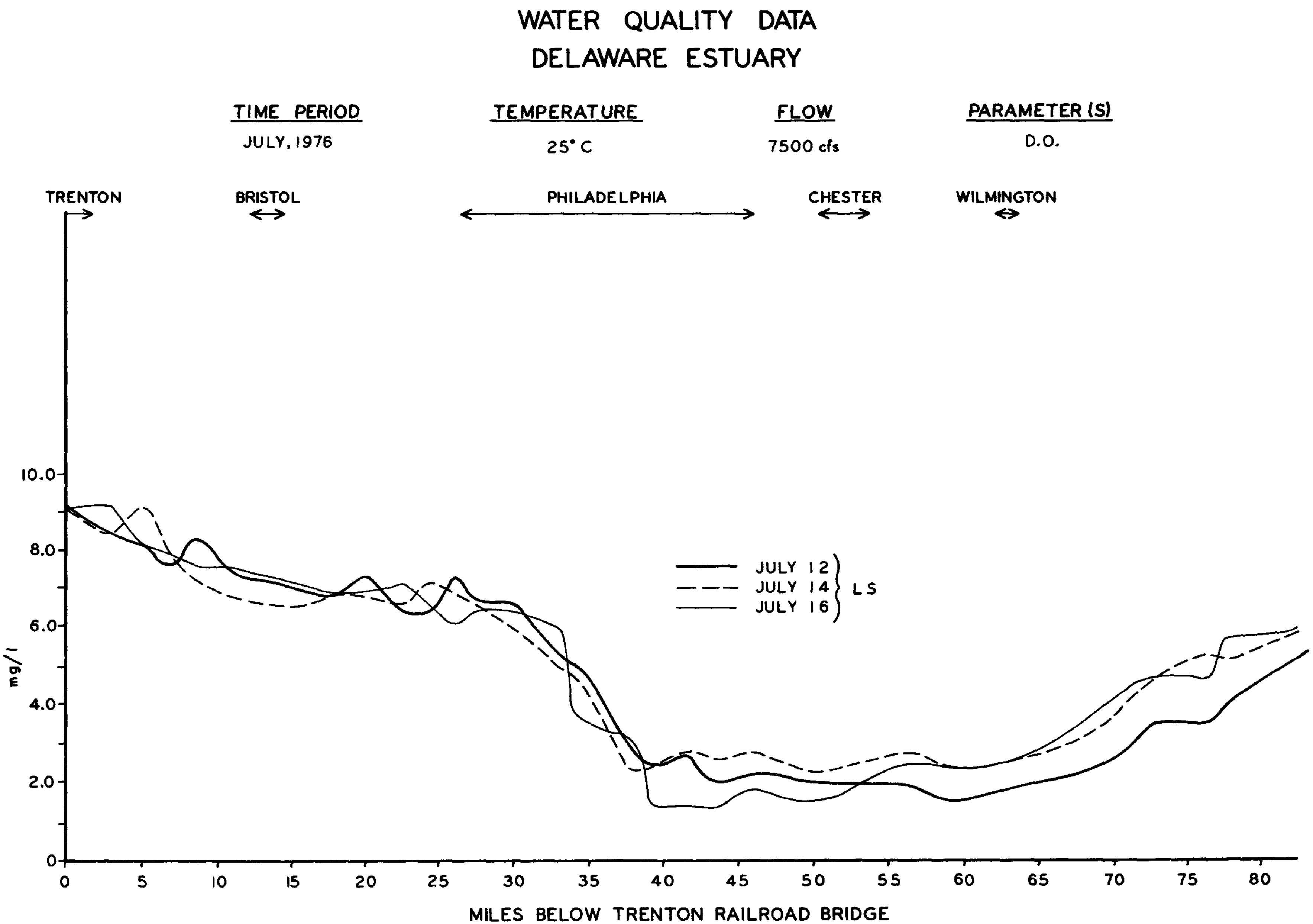


FIGURE III - 56

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, 1976	25° C	7500 cfs	D.O.

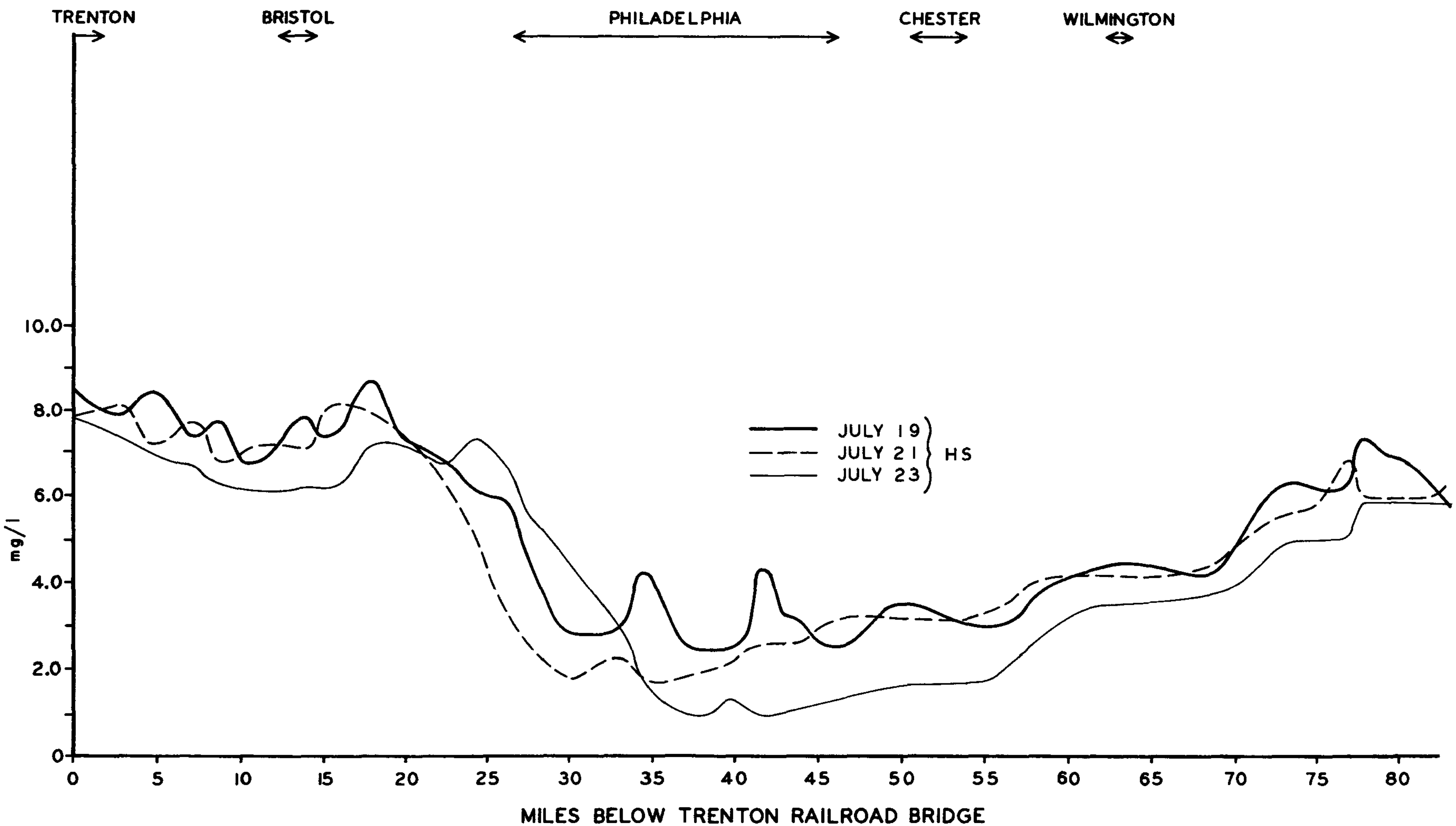


FIGURE III - 57

WATER QUALITY DATA
DELAWARE ESTUARY

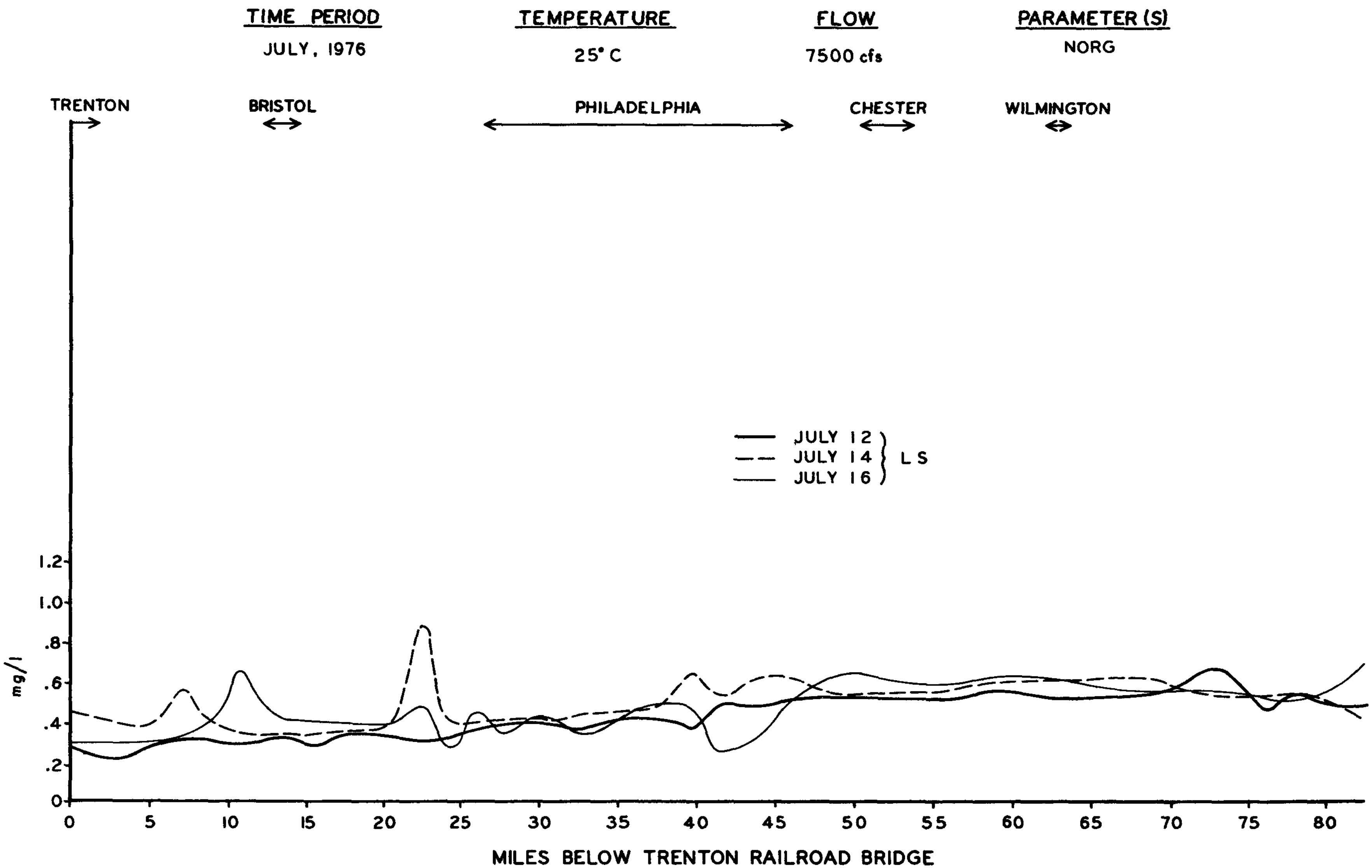


FIGURE III - 58

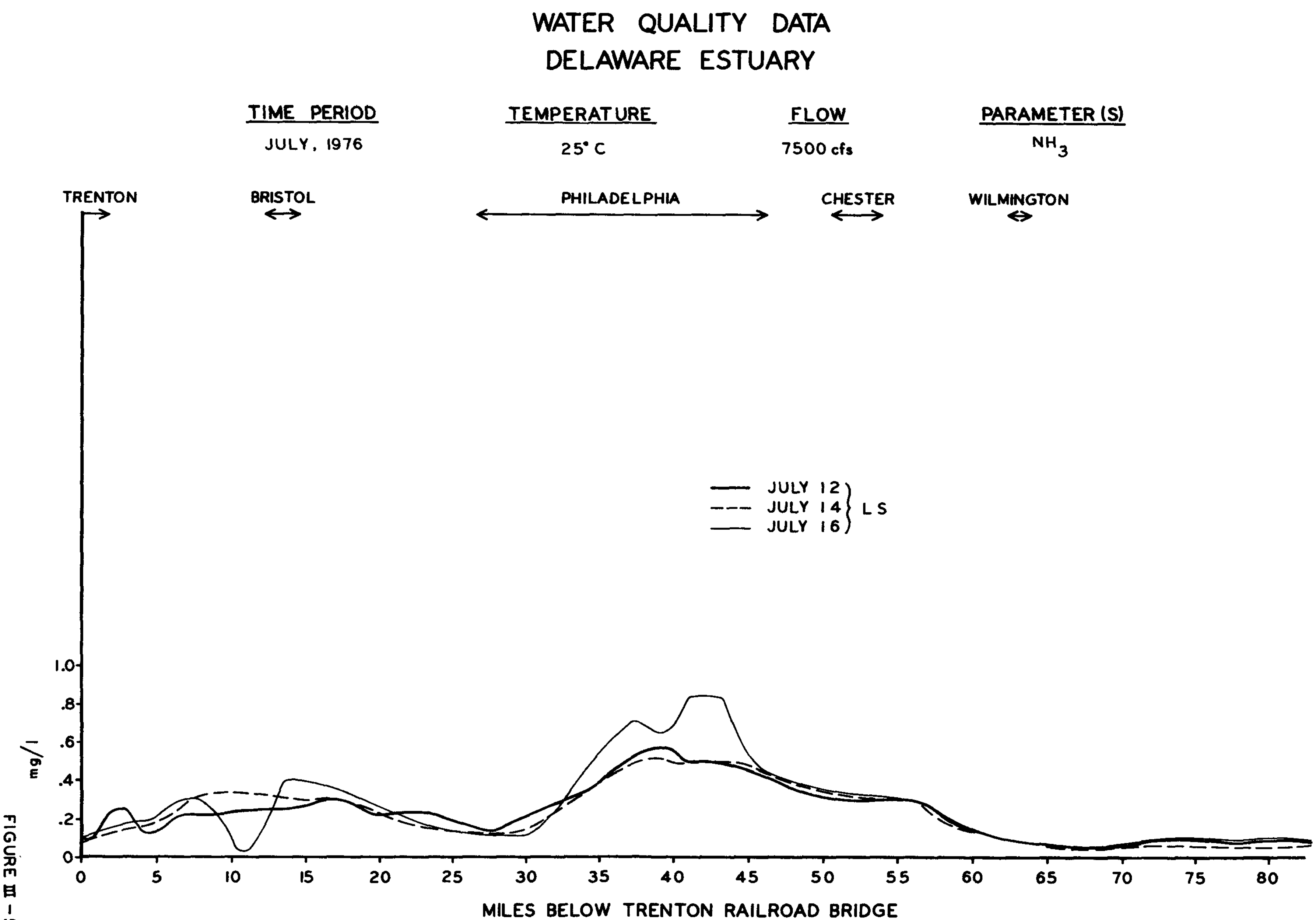


FIGURE III - 59

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, 1976	25° C	7500 cfs	NO_2 + NO_3

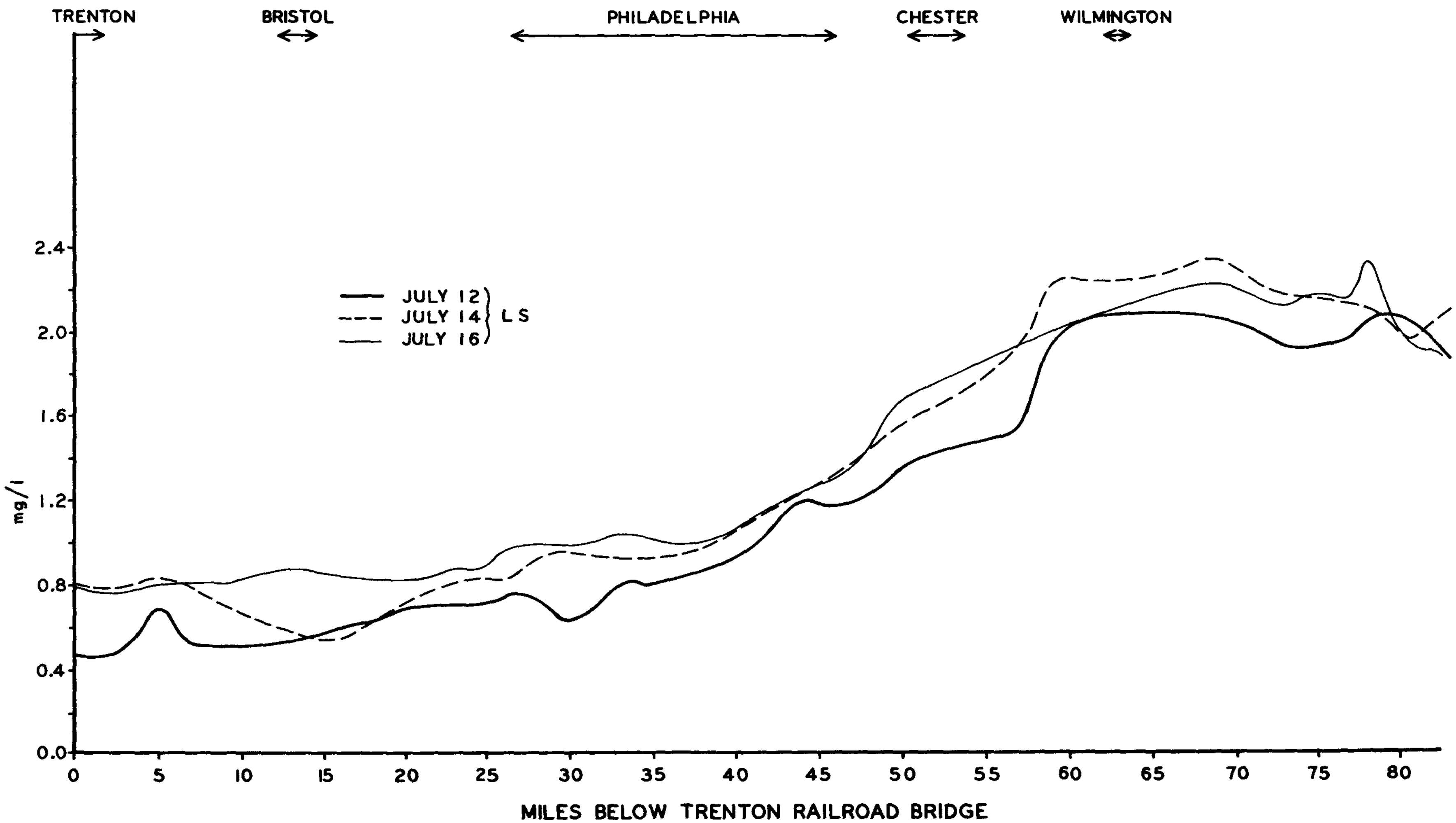


FIGURE III - 60

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, 1976	25° C	7500 cfs	NORG

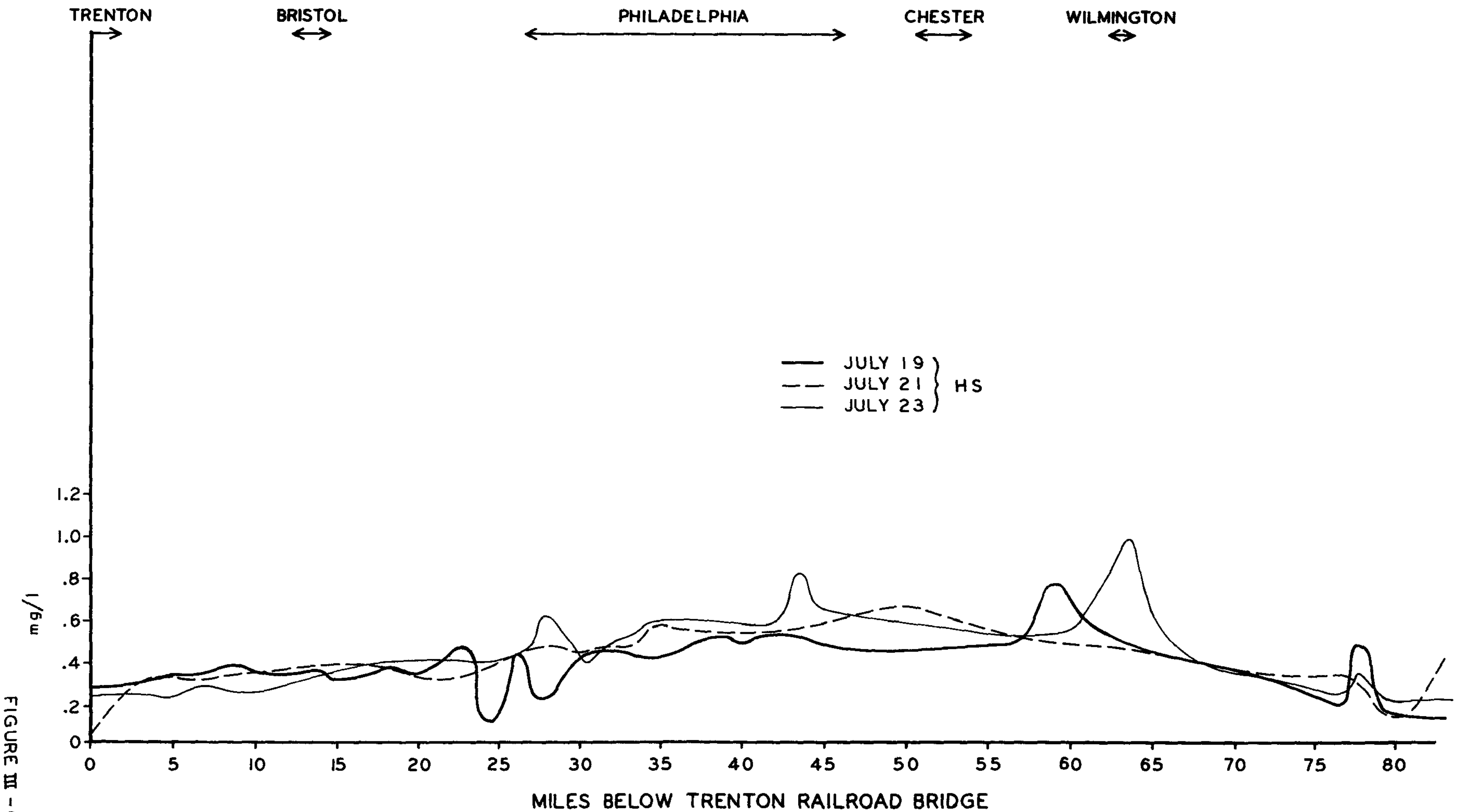


FIGURE III - 61

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, 1976	25° C	7500 cfs	NH_3

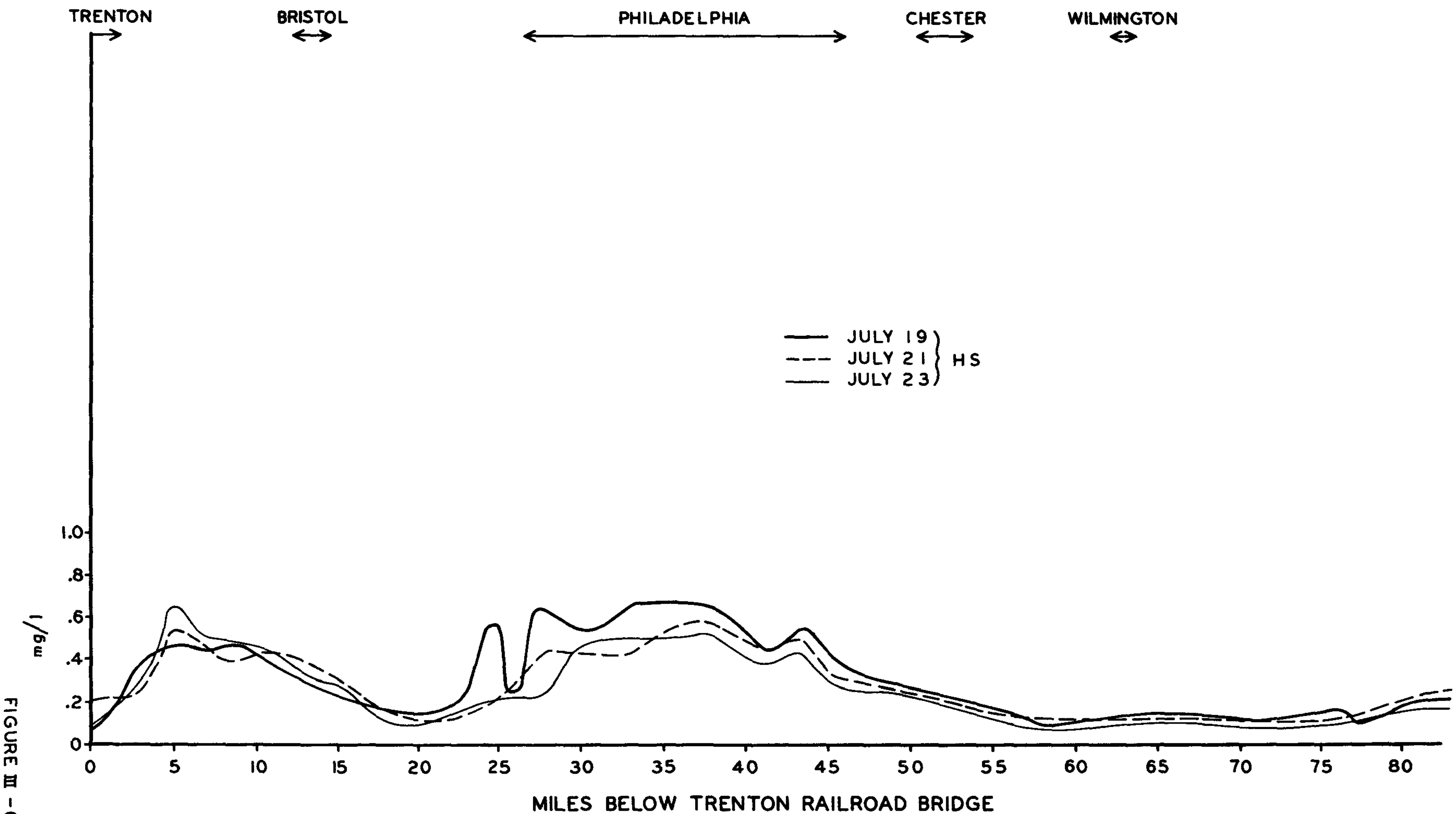


FIGURE III - 62

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, 1976	25° C	7500 cfs	NO_2 + NO_3

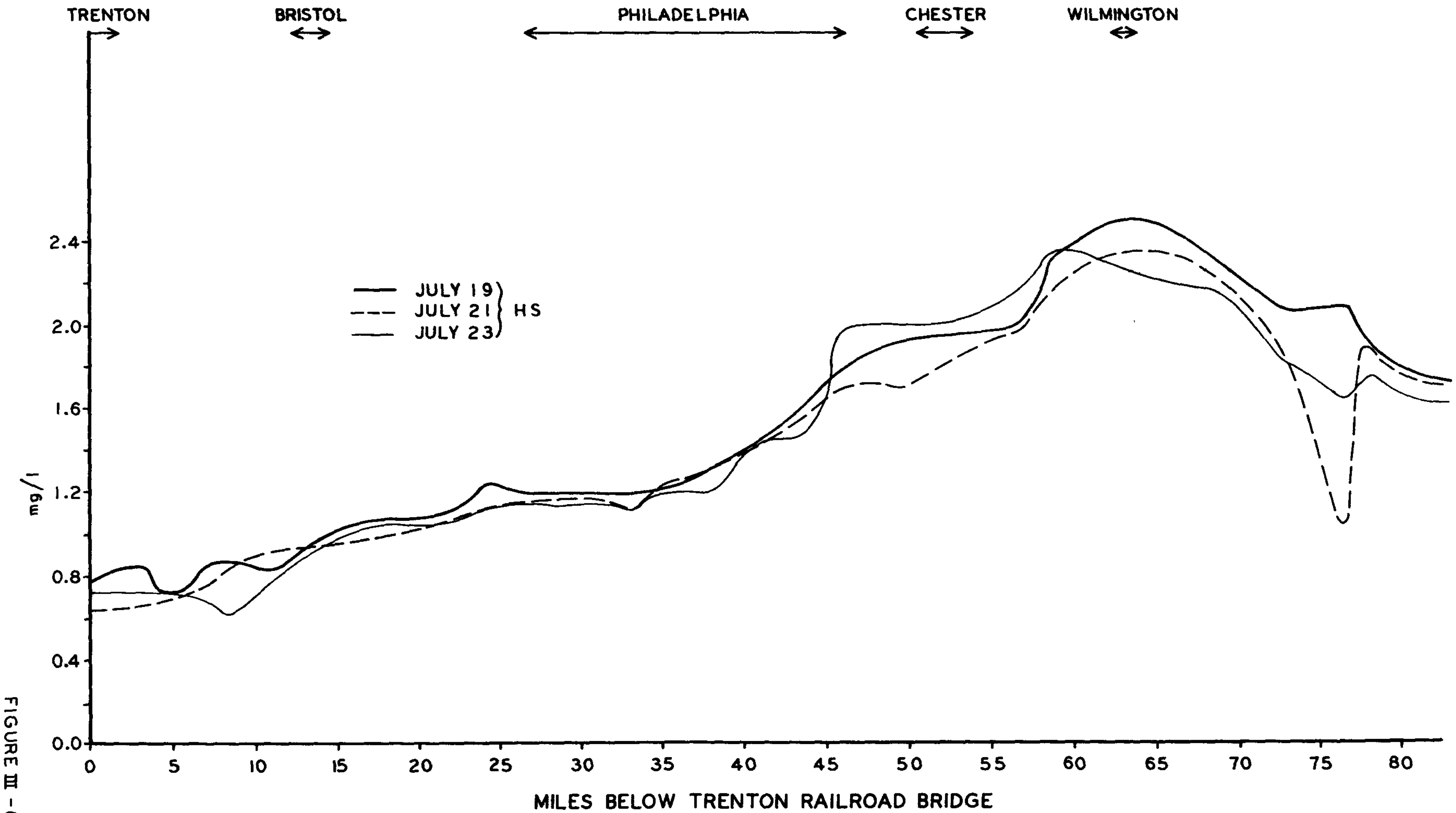


FIGURE III - 63

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY , 1976	25° C	7500 cfs	CHLORO. a

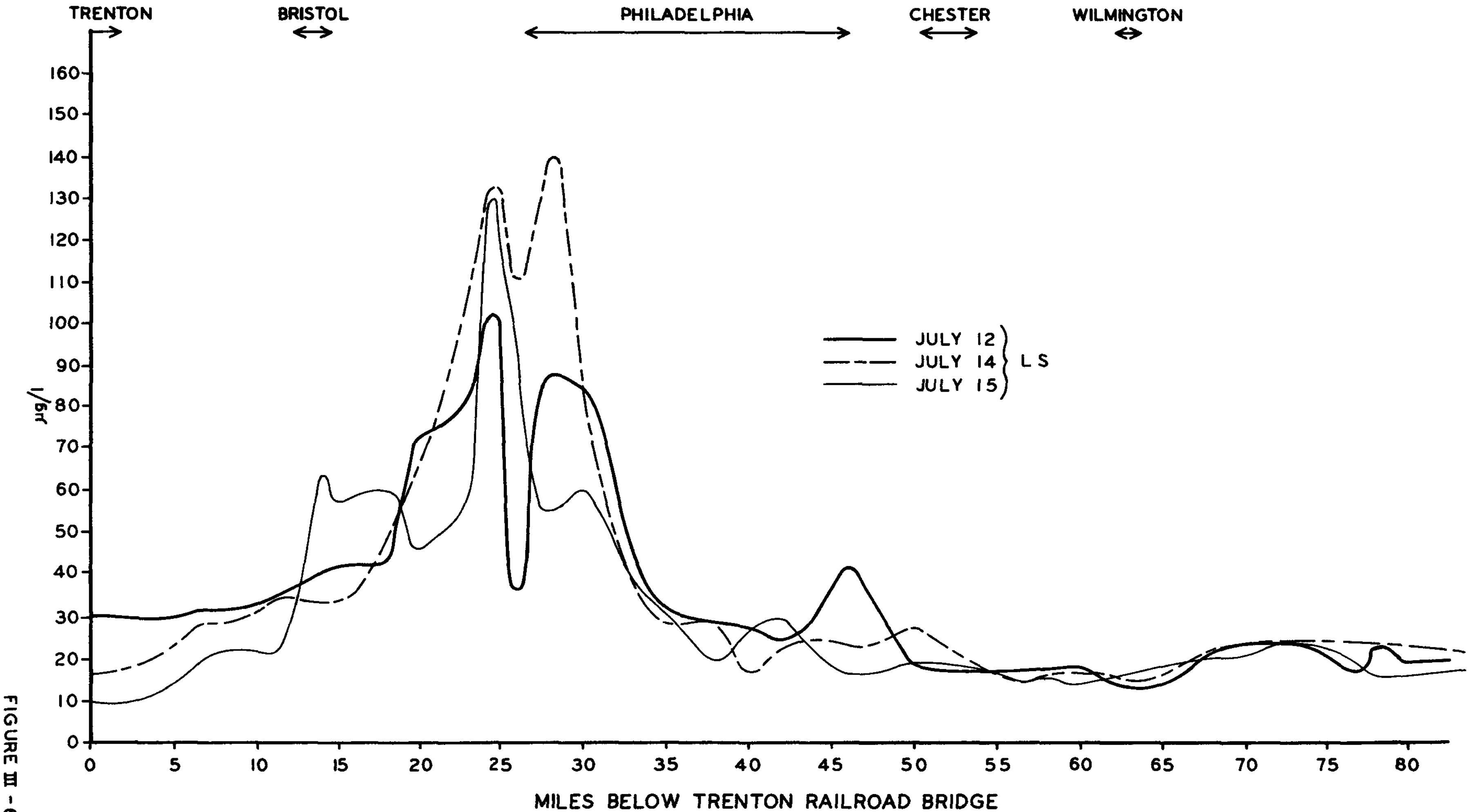


FIGURE III - 64

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY , 1976	25° C	7500 cfs	CHLORO. a

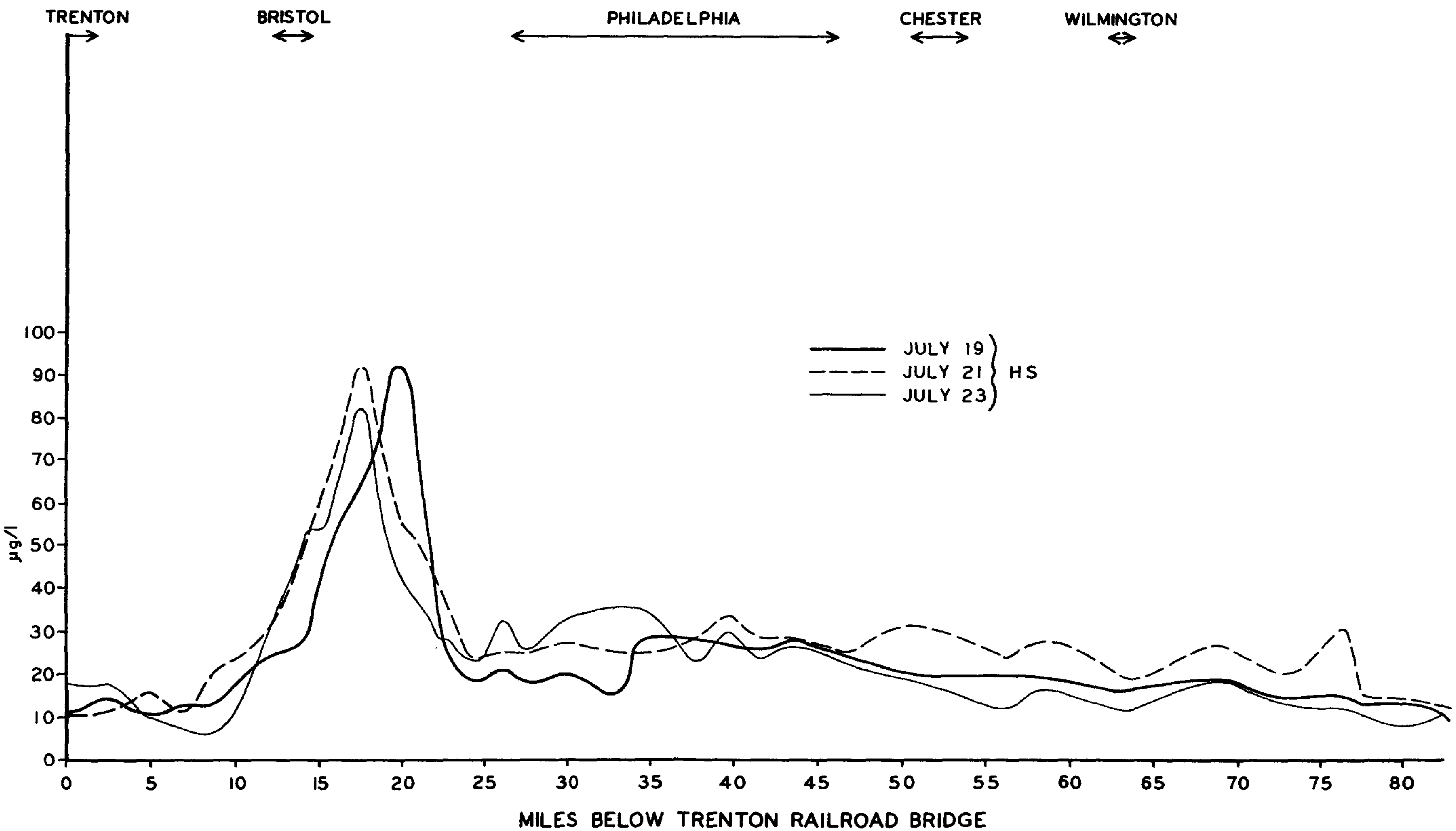


FIGURE III - 65

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, 1976	25° C	7500 cfs	SECCHI DISC

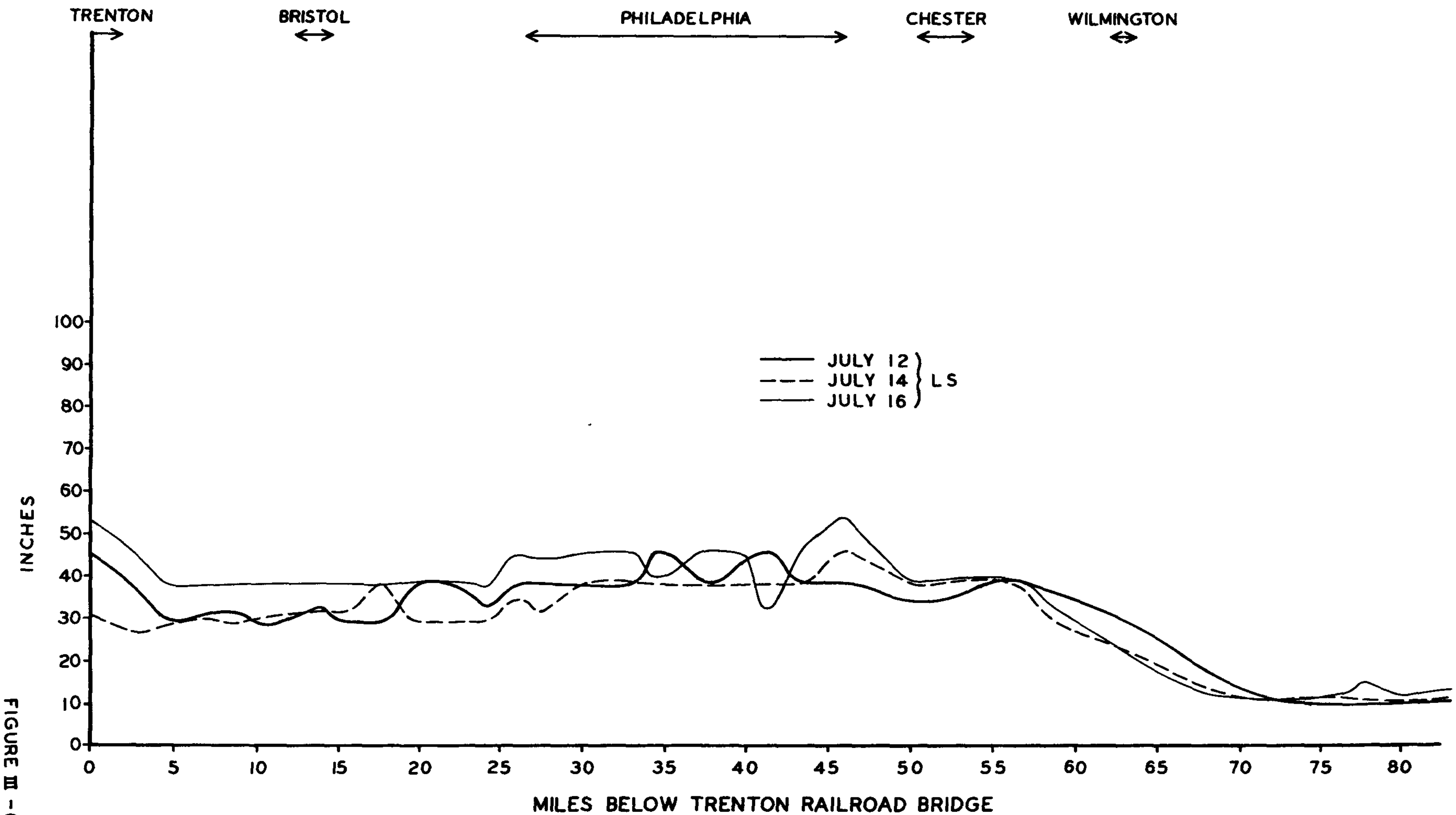


FIGURE III - 66

WATER QUALITY DATA
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, 1976	25° C	7500 cfs	SECCHI DISC

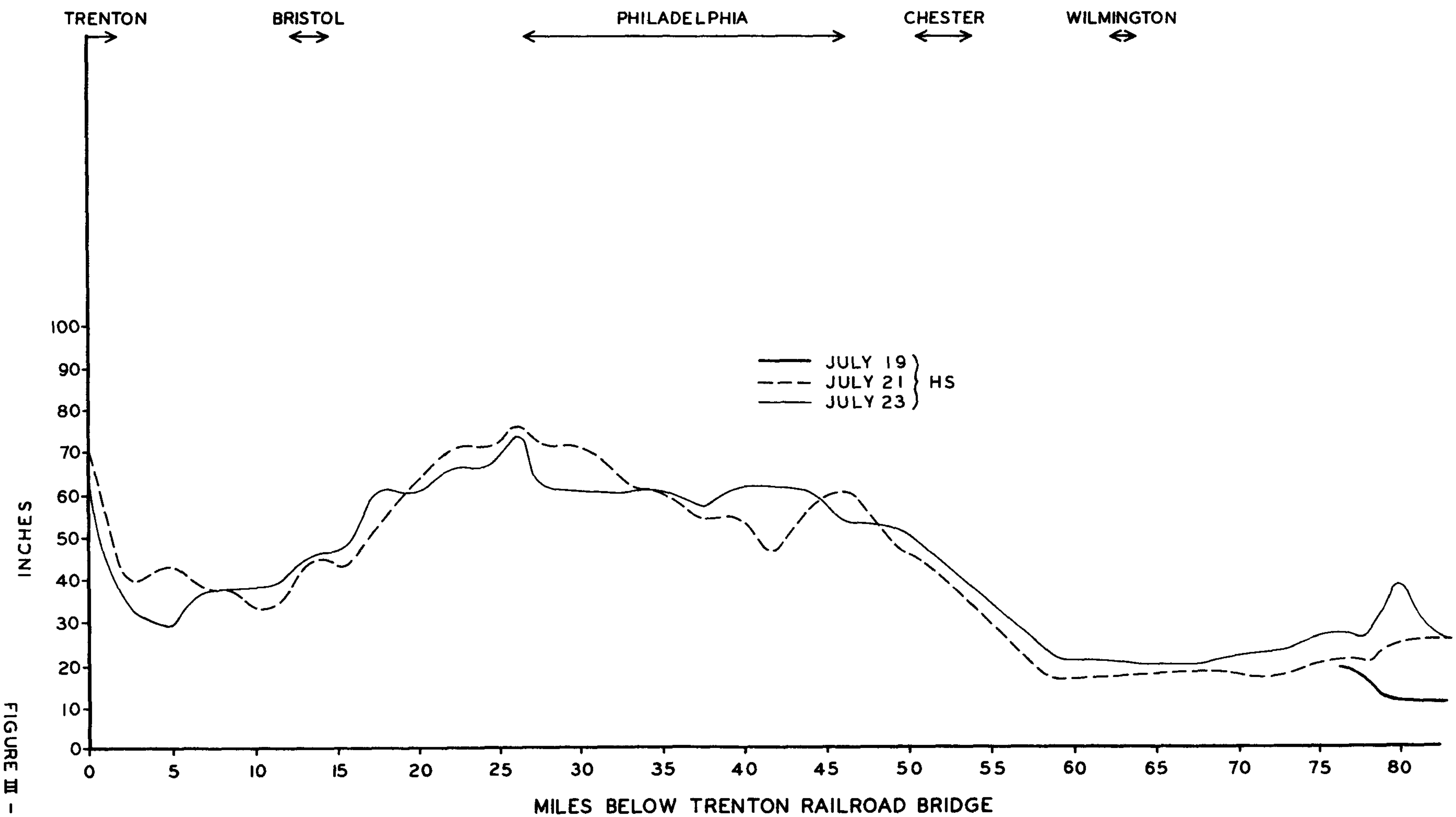


FIGURE III - 67

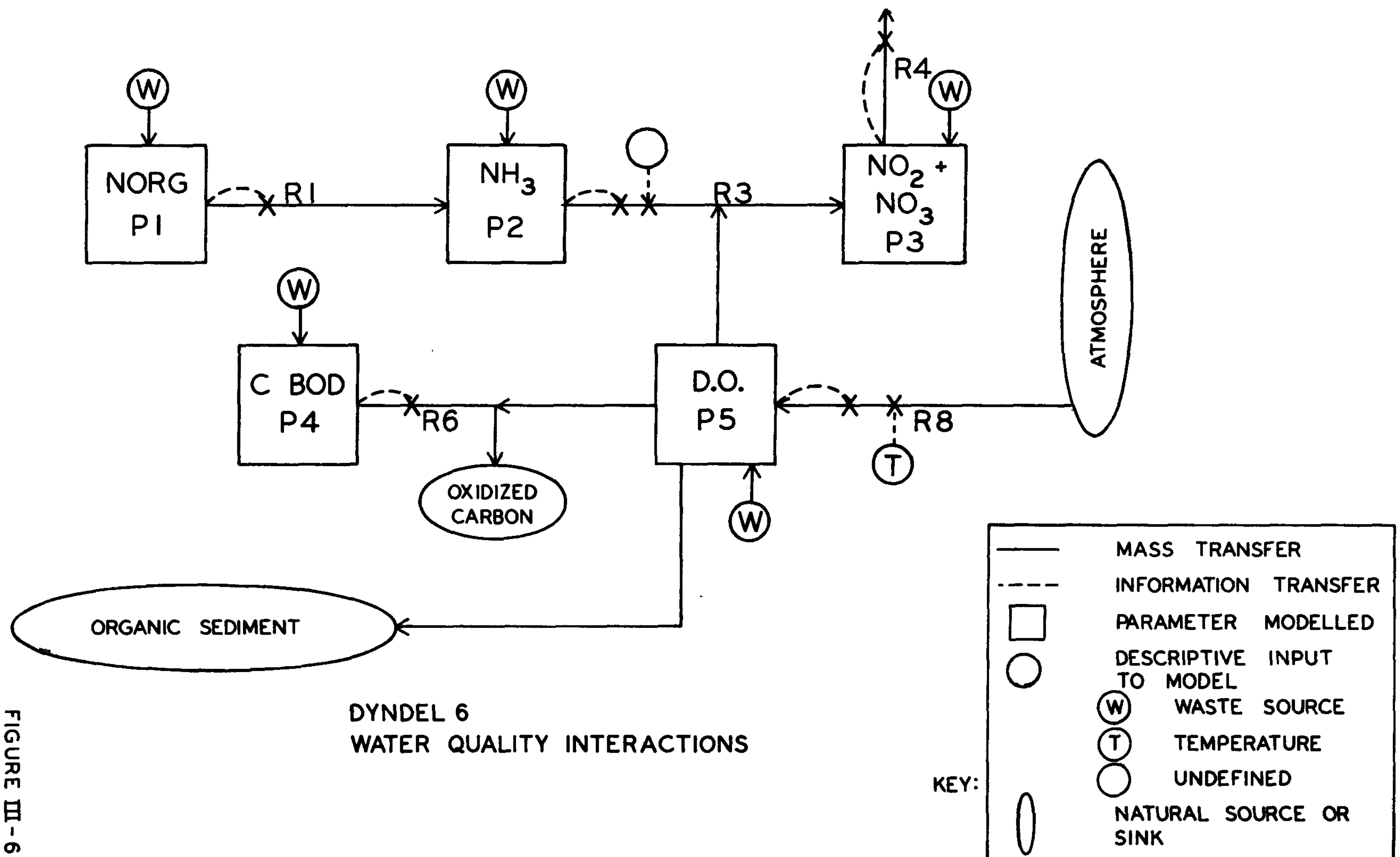
c) Quality Model Construction

A detailed discussion of the quality model's structure was presented in Chapter II. Many of the reactions and constituent linkages contained in the model were formulated prior to the Delaware calibration study with the remainder being necessitated through this calibration process. To implement our philosophy of beginning simple, a decision had to be made concerning which of the model's functional options should be included in the preliminary analysis. Previous studies of the Delaware Estuary had shown the necessity of considering, in some fashion, the oxidation of both carbonaceous and nitrogenous material in the water column and in the bottom sediments. A description of the sequential model formulations that were pursued during the course of this study follows:

Initial Formulation

Figure III-68 is a schematic diagram outlining the constituent linkages and reactions employed in the initial model. Total carbonaceous material oxidized in the water column was represented by a single parameter, CBOD, coupled to DO in a linear reaction. The problems inherent in this traditional formulation, such as the imprecision of the BOD test, the uncertainty in defining the relationship between 5-day and ultimate first stage demands, and the uncertainty in projecting decay rates were recognized, but were considered less troublesome than trying to model either COD or TOC as an oxygen demand source.

FIRST FORMULATION, INITIAL STRUCTURE
DELAWARE ESTUARY MODEL



DYNDEL 6
WATER QUALITY INTERACTIONS

FIGURE III-68

The treatment of the nitrogen cycle can be represented either by the decay of a single parameter, NBOD, or by a set of multi-stage consecutive reactions. The latter option was chosen because previous studies had demonstrated the crucial importance of nitrification on the DO resources of the estuary. The two oxidized forms of nitrogen, NO_2 and NO_3, were combined in the model because the nitrite fraction is extremely transitory, and separate laboratory analyses are not normally performed. Both theory and previous studies show the $NH_3 \rightarrow NO_2$ step to be rate limiting to the overall nitrification process. All forms of organic nitrogen were represented by a single parameter. No attempt was made to distinguish between the dissolved and particulate fractions, since data of this type were not available. The decomposition of organic nitrogen (including hydrolysis) to ammonia was treated as a first order reaction in the model. Although no attempt was made to model algal growth dynamics in this study, a nitrate loss rate indicative of algal uptake was included in this initial model formulation.

The oxidation of carbonaceous and nitrogenous material in the sediments is a well documented problem in the Delaware Estuary. Unfortunately, adequate data to permit the explicit modelling of sediment dynamics do not exist. In fact, good "in situ" measurements of a gross oxygen demand rate at various locations in the Delaware were just recently obtained. Sediment oxygen demand (SOD) is represented in the model as a zeroth order decay of DO and is input as an areal term.

Finally, the process of reaeration was represented by the O'Connor-Dobbins formula; although two other formulas are available in the model, this was considered more appropriate for large bodies of water.

Second Formulation

The consecutive reactions comprising the nitrogen cycle in the original formulation were expanded to include a feedback loop between nitrate nitrogen and organic nitrogen. This last reaction, which completes the primary nitrogen cycle circuit, was intended to represent the biological uptake and conversion of nitrate to algal cellular material (organic N). The new nitrogen series feedback model was recalibrated and its importance was reflected in the altered nitrogen profiles, and decay parameters.

Third Formulation

The second formulation of the nitrogen model implied that total nitrogen behaved conservatively. To test this assumption, a mass balance was performed using the model predictions of total nitrogen for two data sets as compared to actual field data. A significant loss of nitrogen was found to occur in the vicinity of major waste sources, especially when DO concentrations were less than 1 mg/l. Consequently, two sinks for nitrogen were added to the model structure: (1) settling of organic nitrogen near major waste inputs, and (2) denitrification ($NO_3 \rightarrow N_2$ gas) in low DO waters. These additions substantially improved the predictions of the total nitrogen distribution as well as the $NO_2 + NO_3$ distribution.

Fourth Formulation

The third formulation of the nitrogen model was coupled to the original DO - CBOD model with the addition of a comparable settling rate for CBOD near major waste outfalls and the predicted DO profile provided by this formulation was compared to observed July 1974 data. It was believed that the basic shape and magnitude of the DO sag, particularly its flatness, could best be explained by certain non-linear feedback effects which have been observed by others under low DO conditions [13], [14], [15], [16].

The first change was a modification of the sediment oxygen demand when predicted DO levels were less than 2.0 mg/l, such that the effective demand varies as the DO raised to the 0.45 power [15]. The second change was linking denitrification to DO and CBOD so that the oxygen in nitrite and nitrate was made available to the active decomposing bacteria [17]. Again, this newly structured model was capable of simulating more closely the original data set (July 1974) used for calibration.

Fifth Formulation

It is known that temperature significantly effects most biological and chemical reaction rates. The next revision to the model involved the application of temperature correction factors to permit obtaining the various reaction rates at temperatures other than the 27°C that existed during the July, 1974 period. This revision required the considerable utilization of literature material since no actual field data were available. The result was a second model calibration using a data set collected during October 1973 when the temperature was 20°C.

Sixth Formulation

Previous modelling studies of the Delaware Estuary have assumed no net addition or depletion of DO due to algal photosynthesis and respiration. The July 1974 and October 1973 data sets containing relatively low, non-bloom chlorophyll a values were described reasonable well by the model without consideration of photosynthesis and respiration. When the model was tested against the August 1975 data, however, significant discrepancies between predicted and observed DO were noted in an area affected by a large algae bloom (chlorophyll a > 100 μg/l). Further evidence of algal effects on the DO budget in the Delaware Estuary has been compiled from the USGS monitor near the Ben Franklin Bridge. A 24 hour cycle in 1964 exhibited summer DO values having an amplitude of 0.4 mg/l, with the minimum occurring near dawn, and the maximum in the mid-afternoon. Unfortunately, corresponding chlorophyll data were not available.

To investigate the implications of phytoplankton concentrations on the DO levels in the estuary, reasonable values for photosynthesis and respiration rates were bracketed in a literature search, including data AFO generated for the Potomac Estuary. These rates were then incorporated in the model and linked to the observed chlorophyll a, temperature, euphotic depth (estimated from Secchi Disk and turbidity observations), and photoperiod. Calibration of the P and R rates was performed on the August 1975 data set. These rates were subsequently used to recalibrate the 1973 and 1974 data sets after being adjusted by (1) a temperature correction factor found in the literature, and (2) by observed chlorophyll levels during those surveys. Both adjustments are computed internally.

It should again be emphasized that this was not meant to be a predictive model of algal growth dynamics. Chlorophyll was handled strictly as an external forcing function. The final model structure is illustrated in Figure III-69.

FINAL STRUCTURE
DELAWARE ESTUARY MODEL

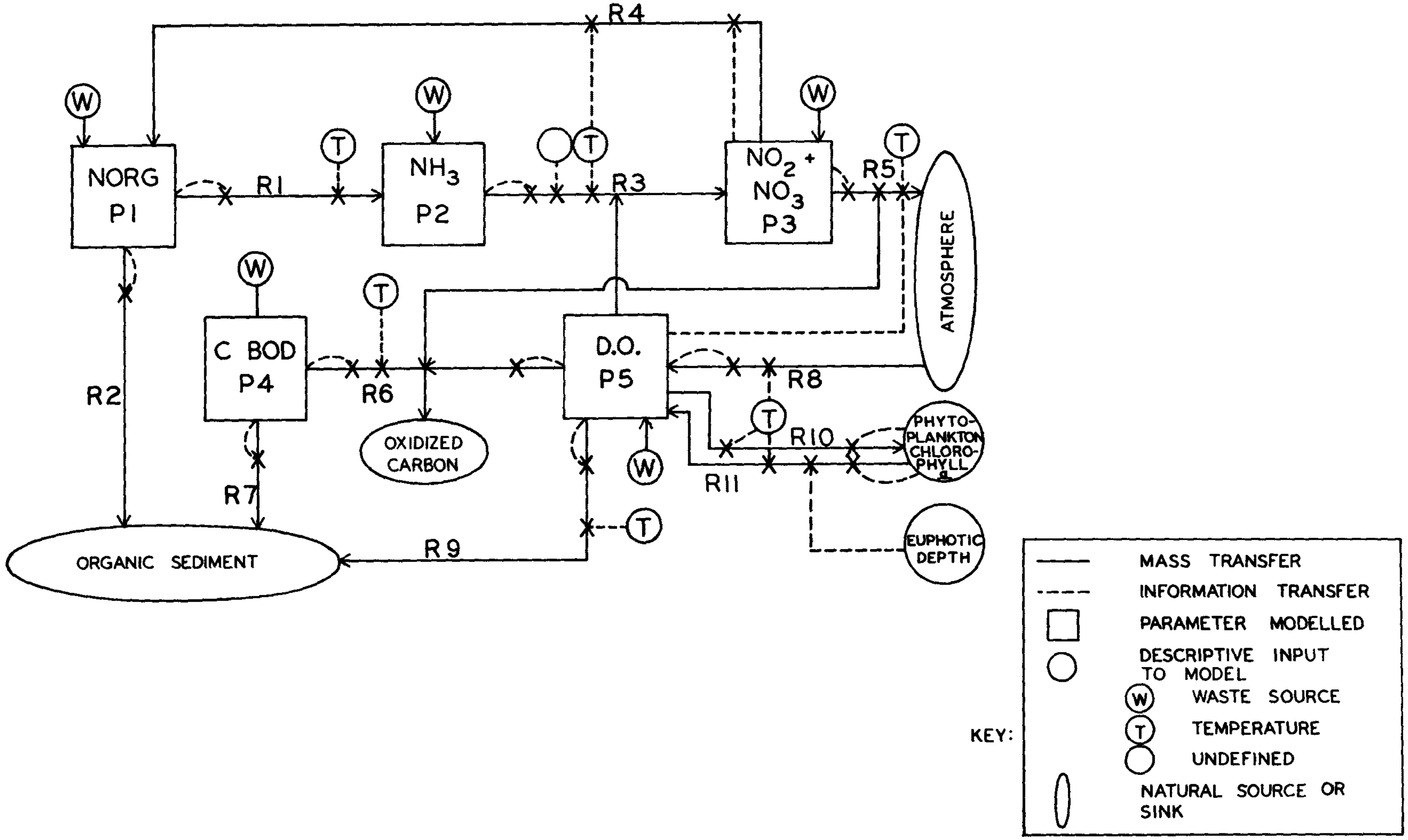


FIGURE III-69

d) Comparison of Model Predictions with Observed Data

The ultimate test of a model's predictive ability lies in its relative success in reproducing the basic processes and mechanisms influencing the prototype. A widely accepted method of gauging and assessing the confidence one can place in a model's predictions involves simulating several historical conditions and comparing model predictions with observed data. If a favorable comparison results, the model can be considered either calibrated or verified depending upon the amount and independence of the observed data and the degree to which model inputs are "fixed". Normally, a visual inspection combined with engineering judgement will suffice, although some modellers have attempted to add more objectivity through the use of statistical tests.

As discussed previously, three independent sets of data were used to calibrate the model for the nitrogen cycle and DO. Complications arising from algal effects necessitated a greater effort being directed towards the calibration phase, particularly in terms of DO, than originally planned. A fourth data set comprised of two separate periods, and a fifth data set collected in July 1976 were used strictly for the purpose of model verification. Under this situation, all model inputs were determined _a priori_. Figures III-70 through III-77 present observed data and corresponding model predictions for calibration, whereas Figures III-78 through III-88 present similar data for verification. Because this model is a real time system, care had to be taken in selecting output times which nearly coincided with the particular slack water tide of the observed data.

All of the calibration and verification runs utilized a simulation period of greater than 16 days in order to achieve the steady state theoretically represented by the observed data. It was determined from model runs having longer durations, made to investigate transient sensitivity response, that a two-to-three week simulation period was indeed sufficient to approximate steady state conditions for both the nitrogen and DO distributions, assuming reasonable initial conditions were specified.

Each of the figures cited above contain a similar format for presenting the observed and predicted data. The observed data are depicted by a bar indicating the range in data. Predicted data, on the other hand, are shown as a continuous profile drawn from model output at each junction. Two different predicted DO profiles are presented for each data set, representing the occurrence of slack water near the beginning and near the end of the photoperiod. Since the actual sampling runs normally started at the lower end of the estuary in early or mid-morning, the lower profile should be of greater value when interpreting the data. Inspection of the observed and predicted Org N, NH_3, NO_2 + NO_3 and DO profiles reveals a favorable comparison in every case with respect to the spatial gradients and trends, the magnitude and position of critical peaks and valleys, and, perhaps most importantly, the configuration of the DO sag.

Because of the apparent anomaly in the 1968 dissolved oxygen data in Figures III-78, III-79 and III-82, a comparison of the overall range in model predictions with an extensive body of DO data collected by the Philadelphia Water Department and USGS during this same period is shown in Figure III-84. This highlights the model's ability to accommodate different classes of data sets (non-slack water and continuous monitor, respectively) and to predict the dramatic DO variability encountered in the field due to both the tidal cycle and, when large algal levels persist, the diurnal cycle.

The final verification exercise, illustrated in Figures III-85 through III-88, was based on the most recent intensive data set available - July 1976. While the DO profiles show acceptable agreement, some significant discrepancies in the observed and predicted NH_3 and NO_3 values are evident. It appears that an increase in the nitrification rates from earlier data sets would achieve a better comparison below Philadelphia. This may indicate either a random or a systematic change from the basic nitrification inhibition hypothesis developed from older data sets and described in the next section. The acquisition and analysis of additional summer data is necessary to more fully assess nitrification inhibition patterns and trends in the Delaware Estuary.

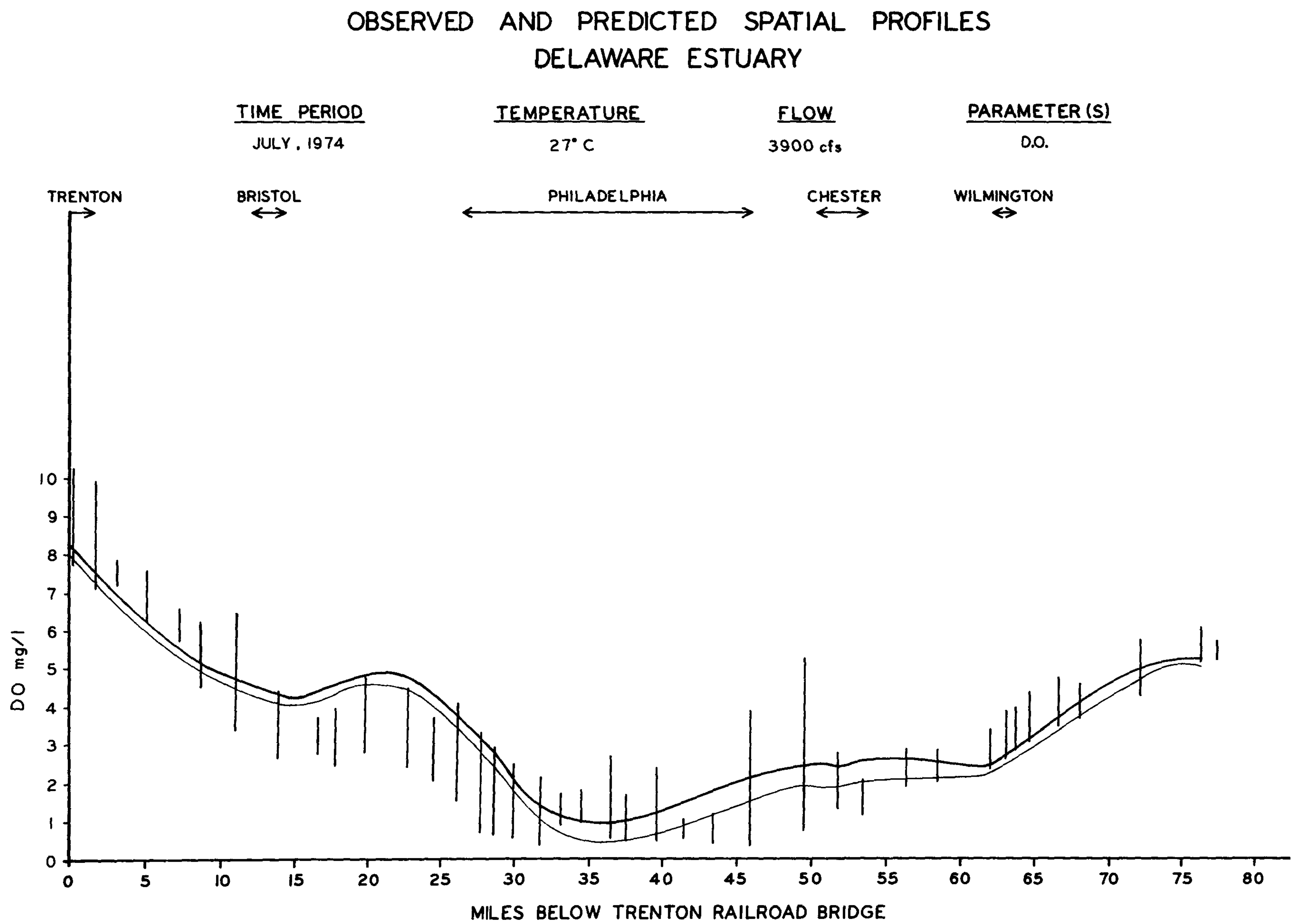


FIGURE III - 70

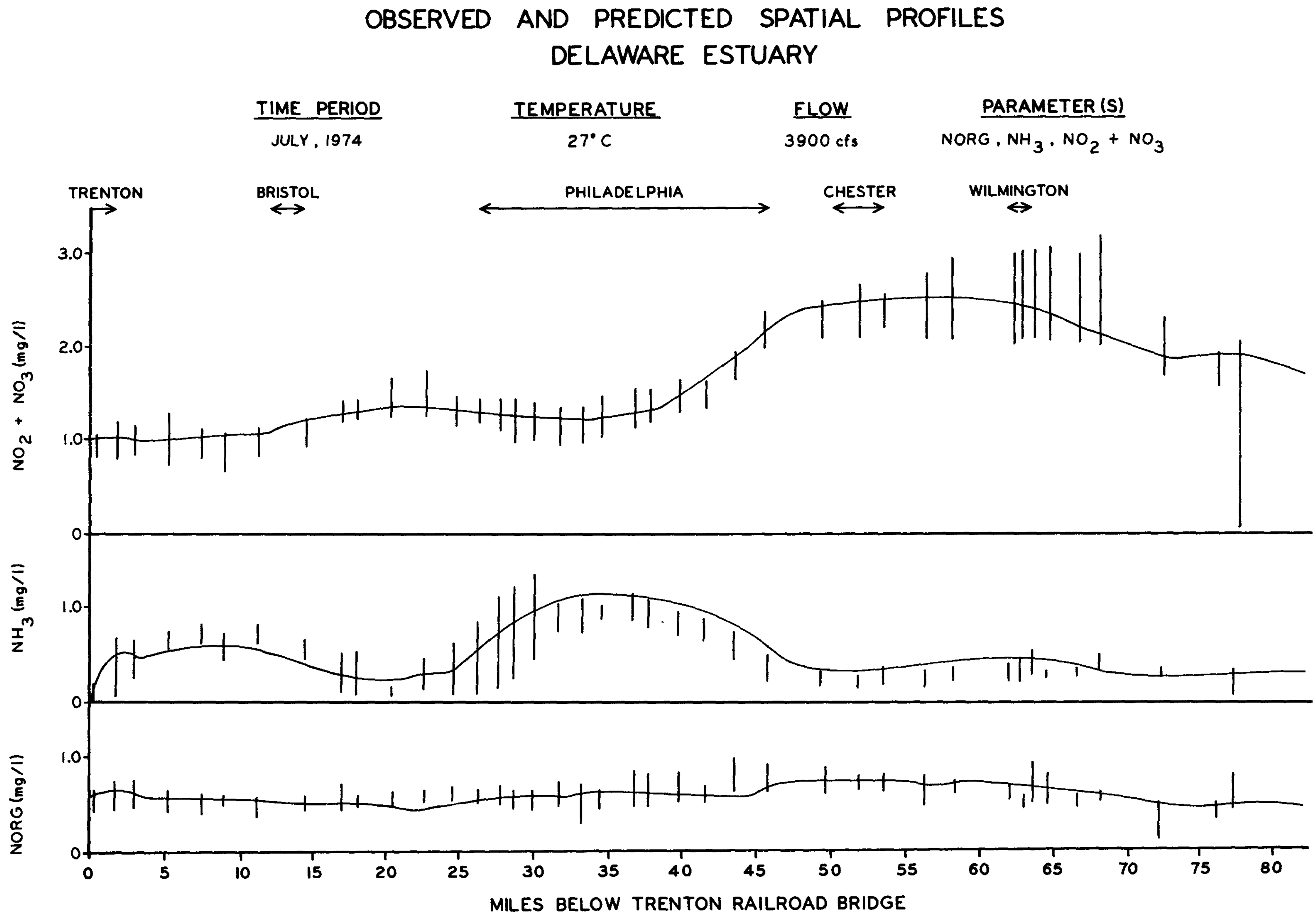


FIGURE III - 71

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
OCT. 1973	19 – 20° C	3900 cfs	D.O.

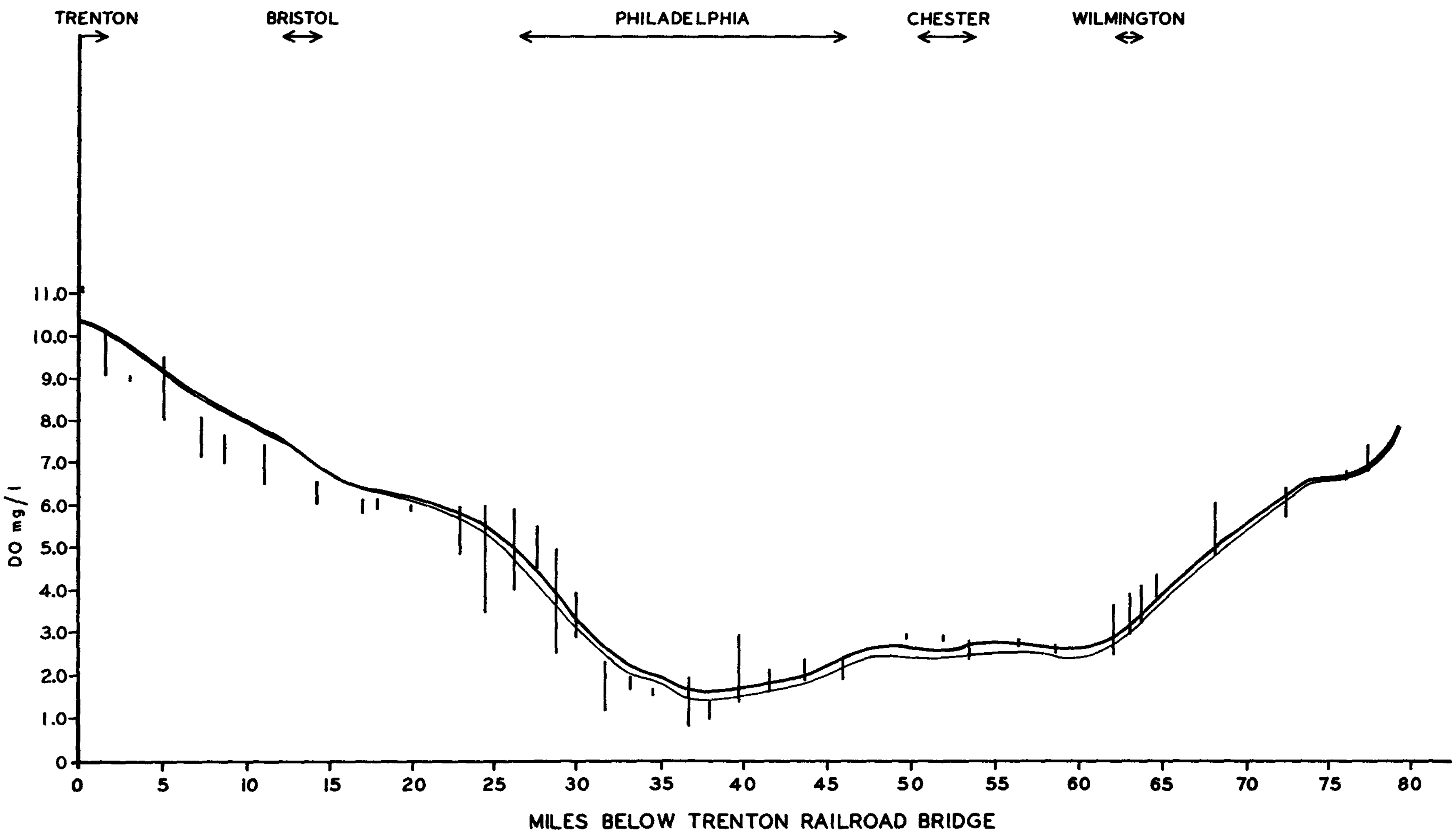


FIGURE III - 72

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
OCT. 1973	19 – 20° C	3900 cfs	NORG, NH_3, $NO_2 + NO_3$

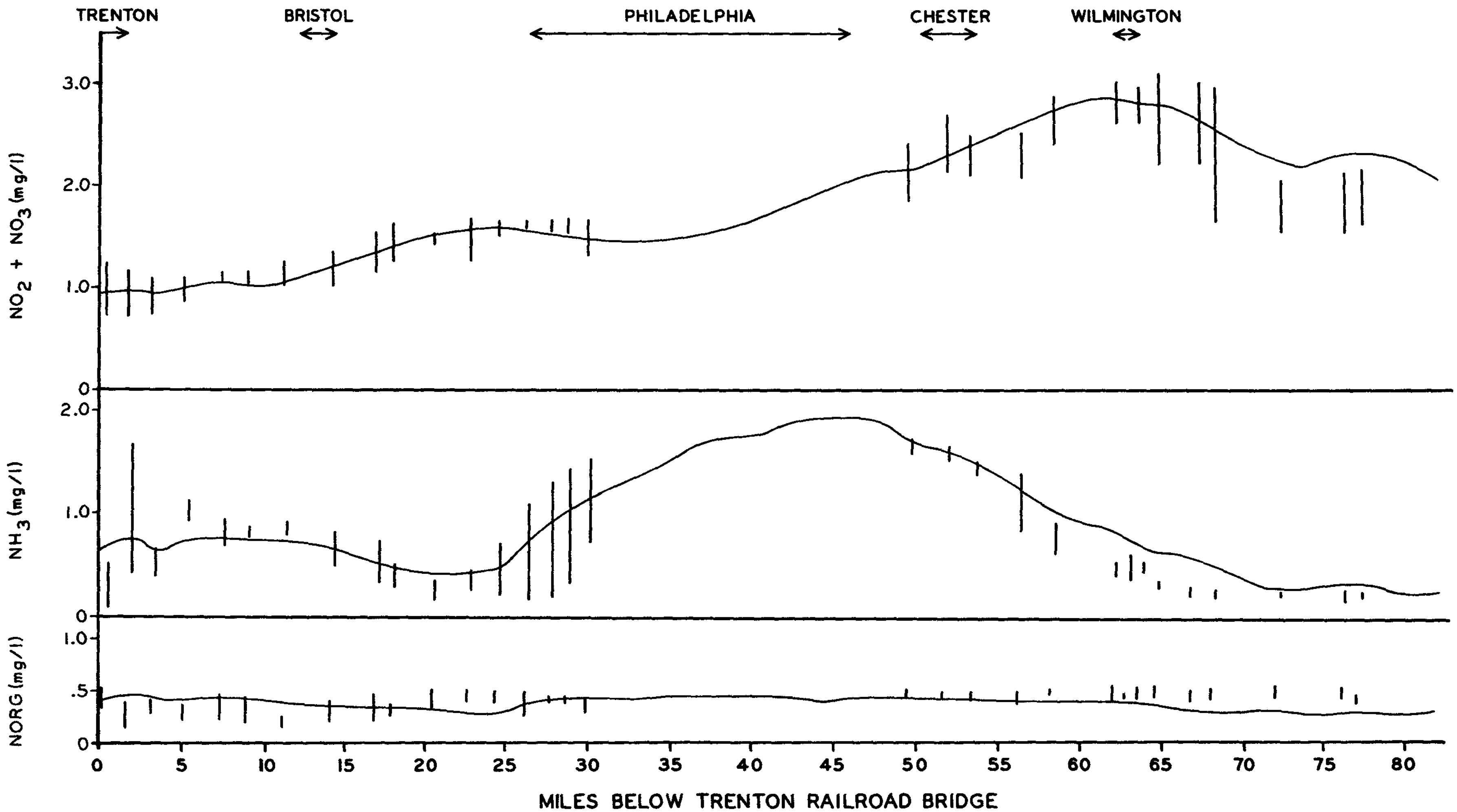


FIGURE III - 73

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG. 1975	27° C	7880 cfs HWS	D.O.

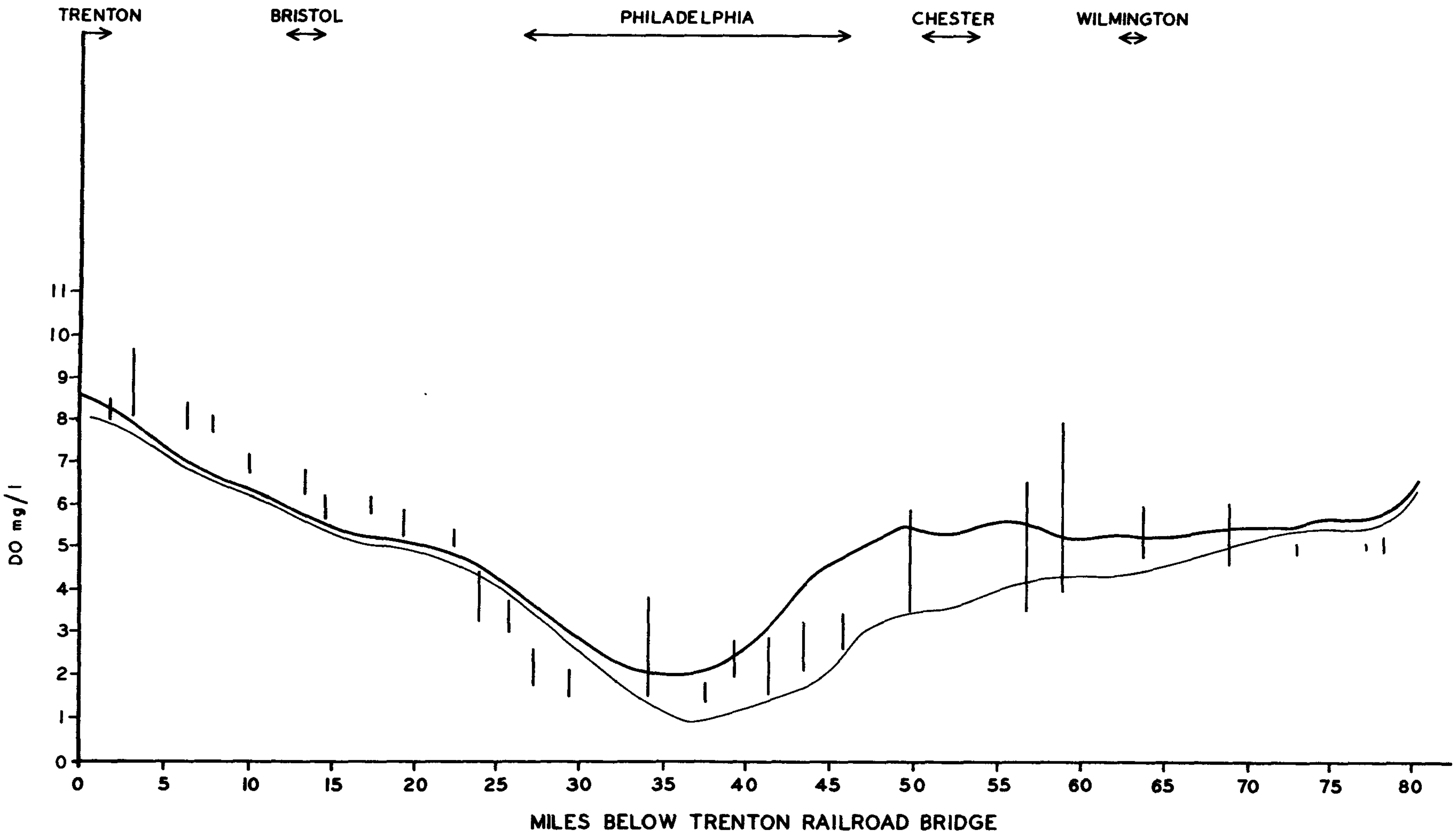


FIGURE III-74

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., 1975	27° C	7880 cfs LWS	D.O.

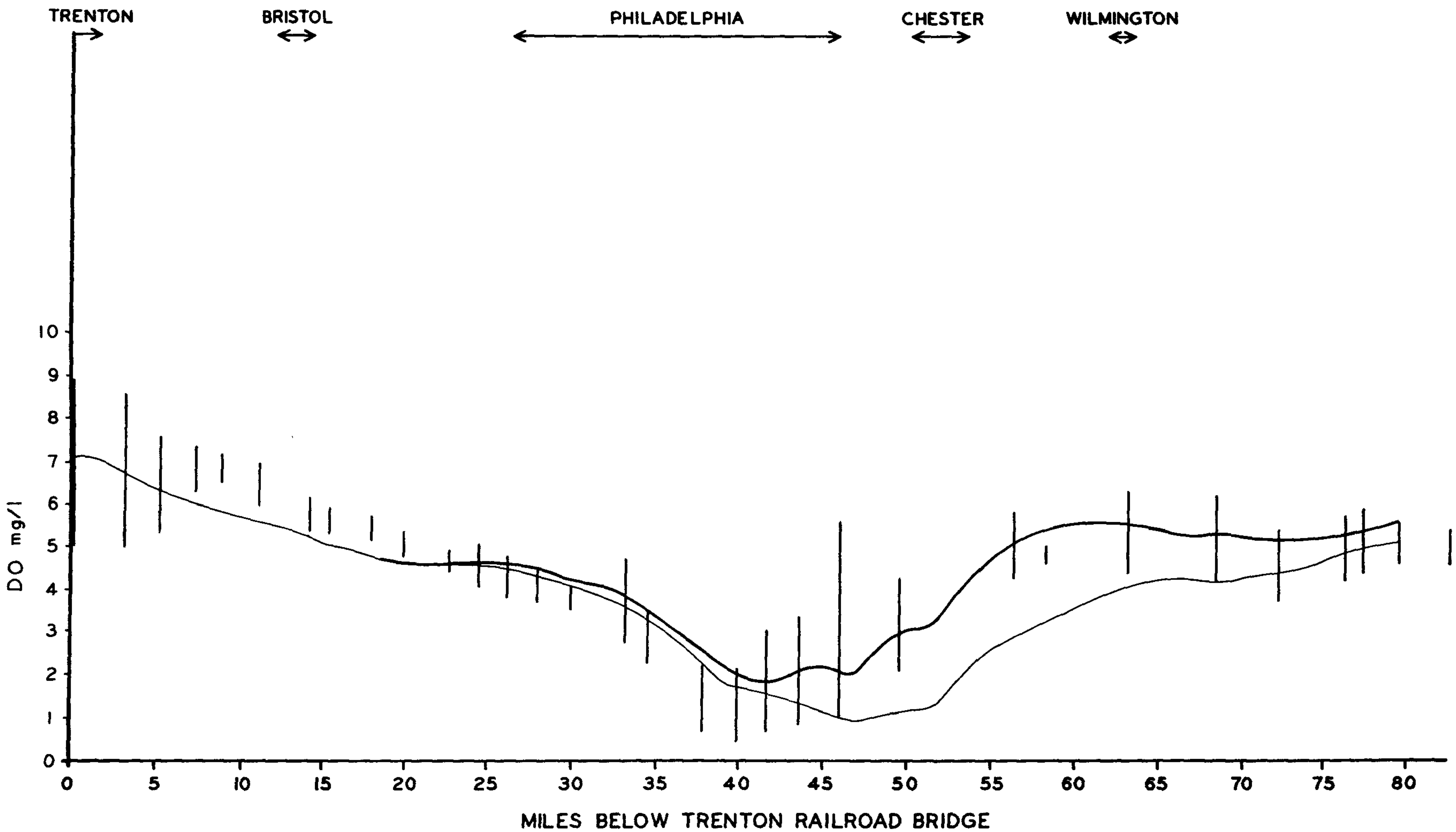


FIGURE III - 75

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., 1975	27° C	7880 cfs HWS	NORG, NH_3, $NO_2 + NO_3$

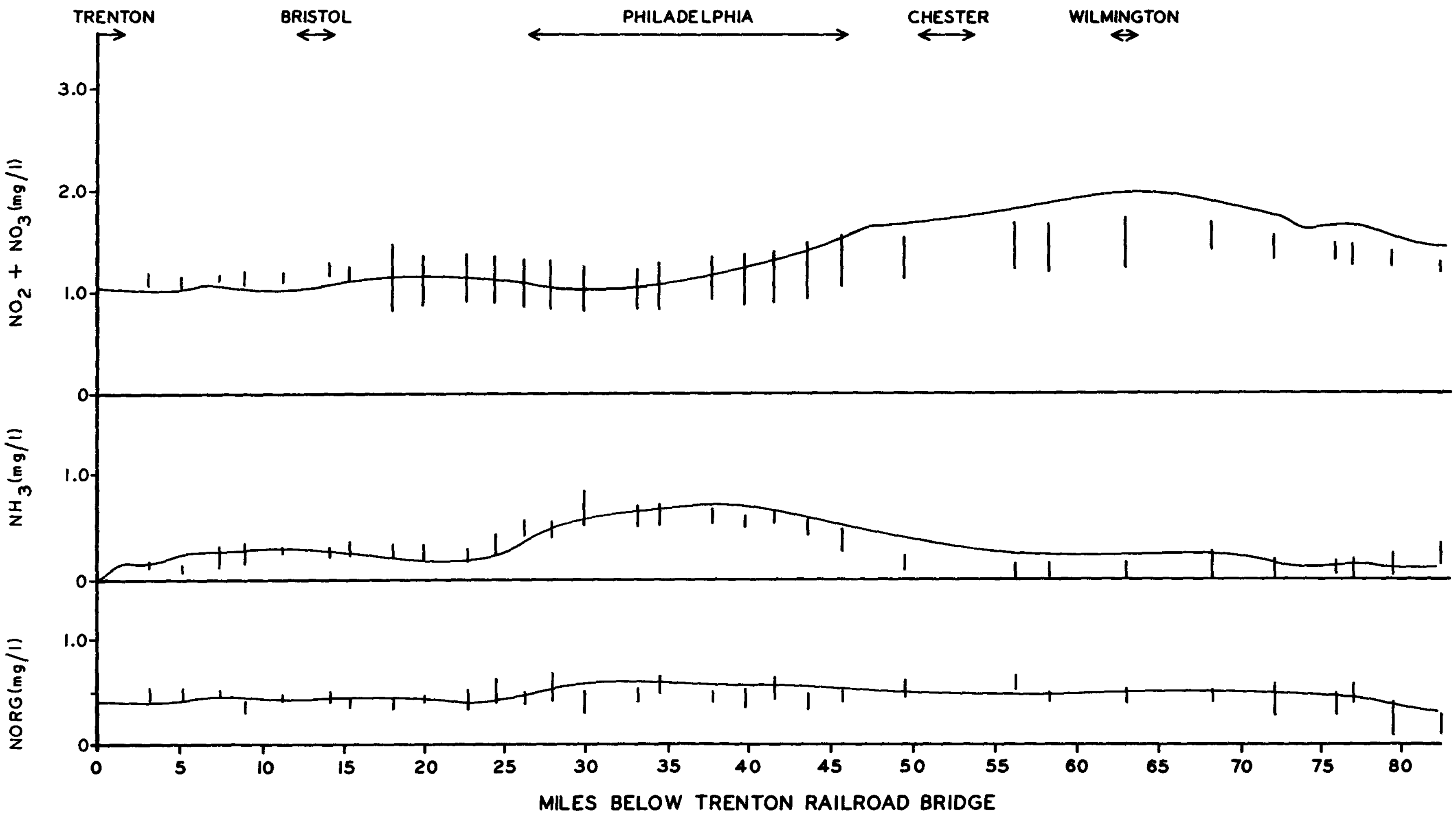


FIGURE III - 76

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., 1975	27° C	7880 cfs LWS	NORG, NH_3, $NO_2 + NO_3$

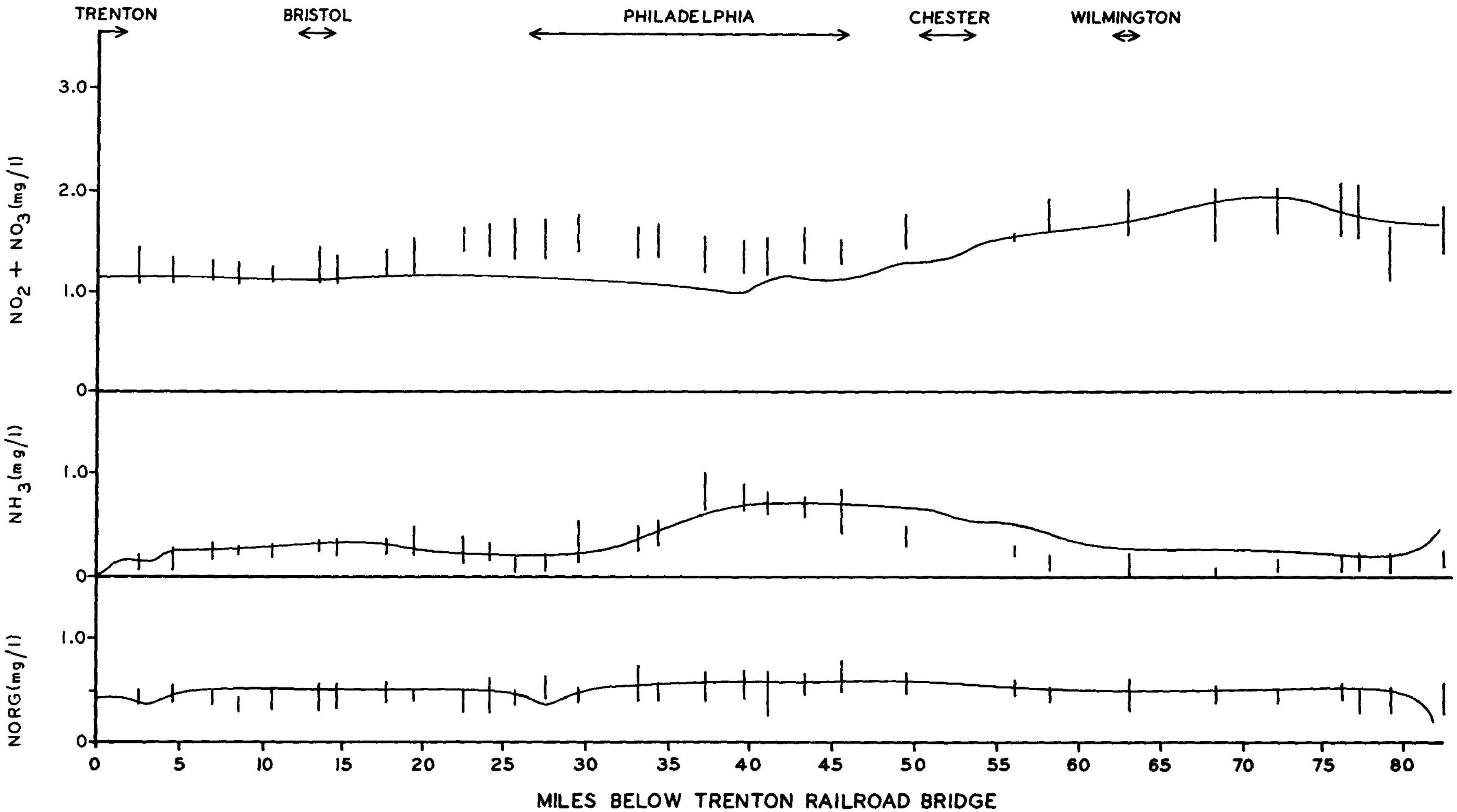


FIGURE III - 77

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, AUG., 1968	28° C	4800 cfs HWS	D.O.

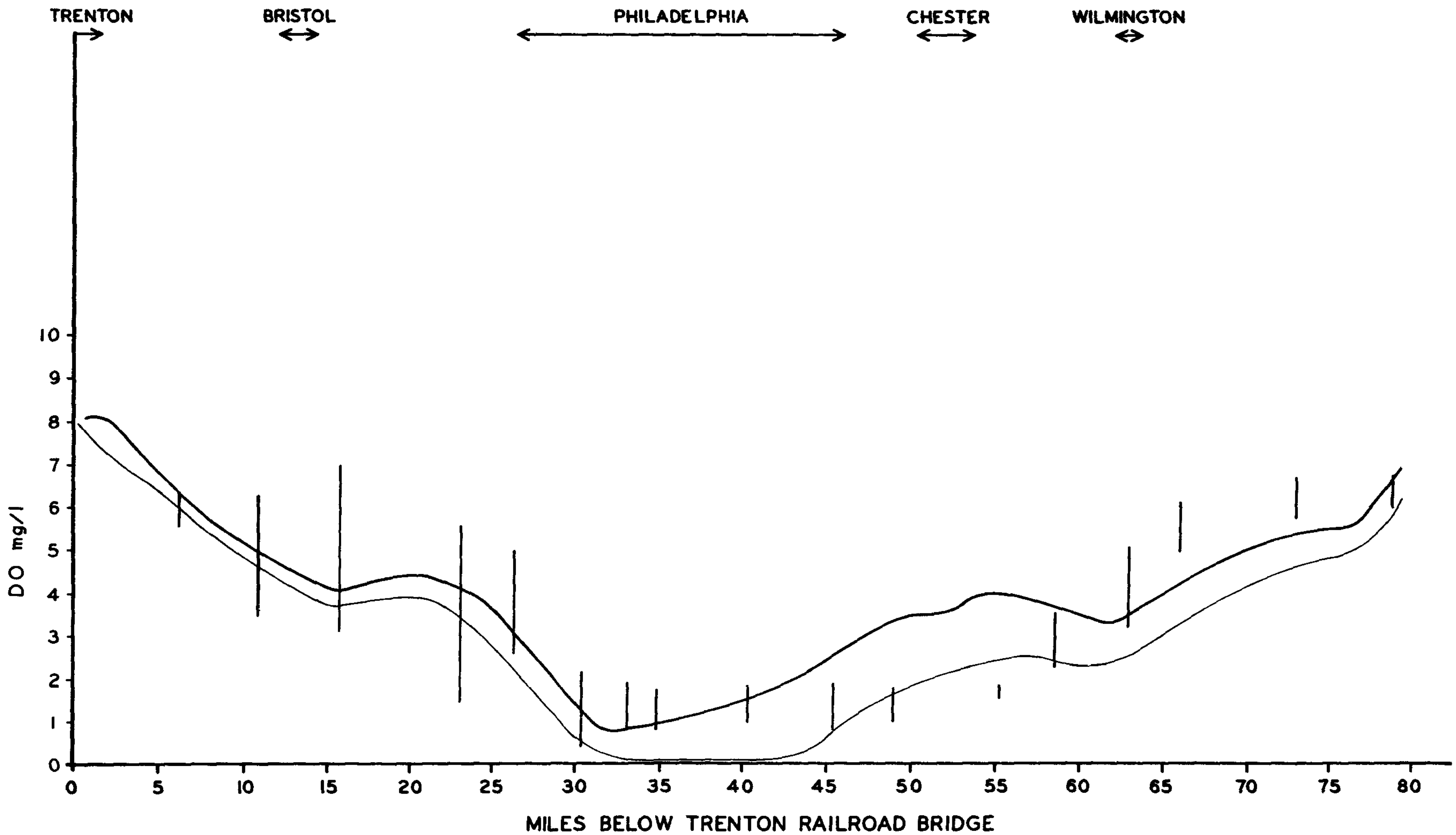


FIGURE III - 78

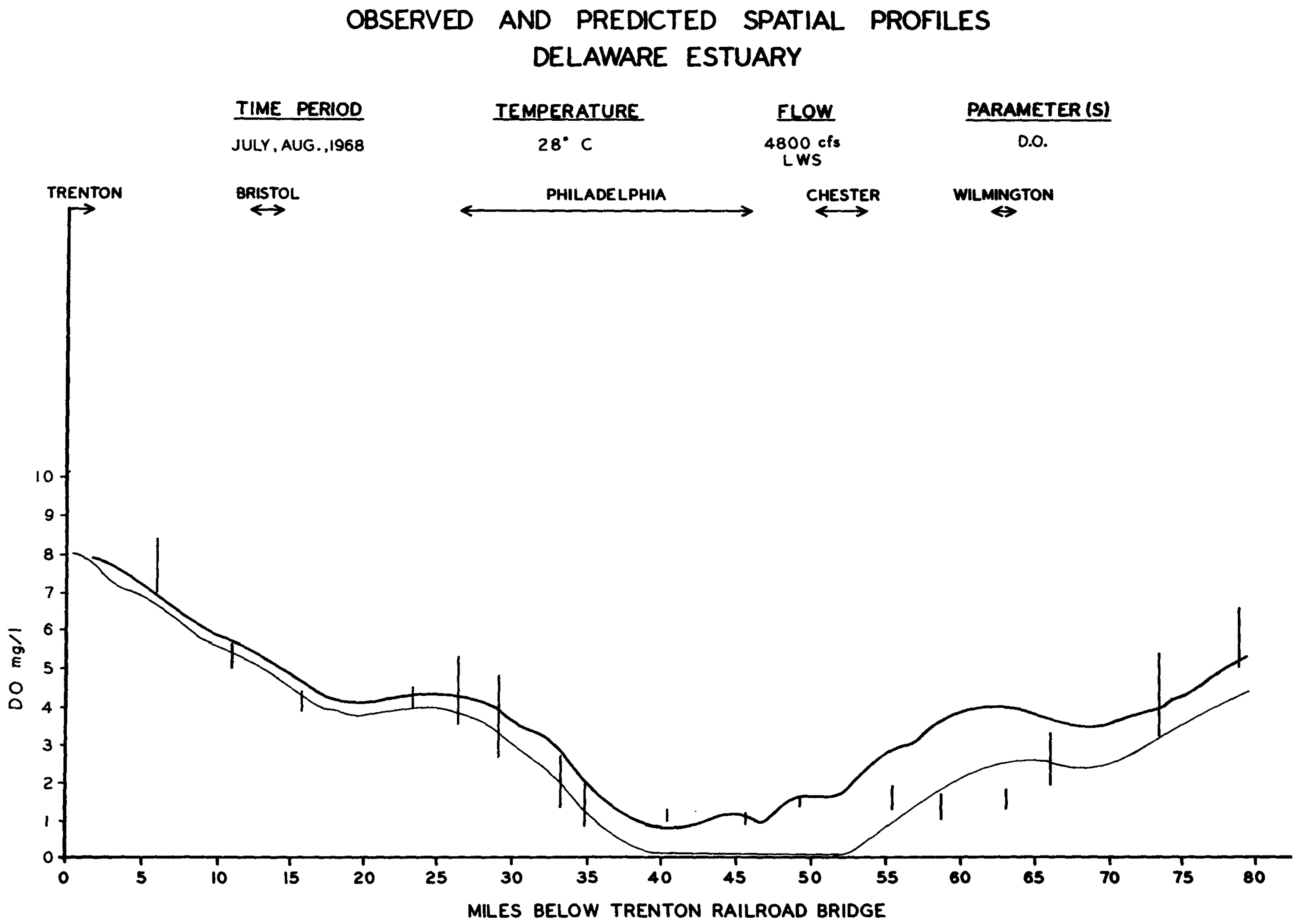


FIGURE III - 79

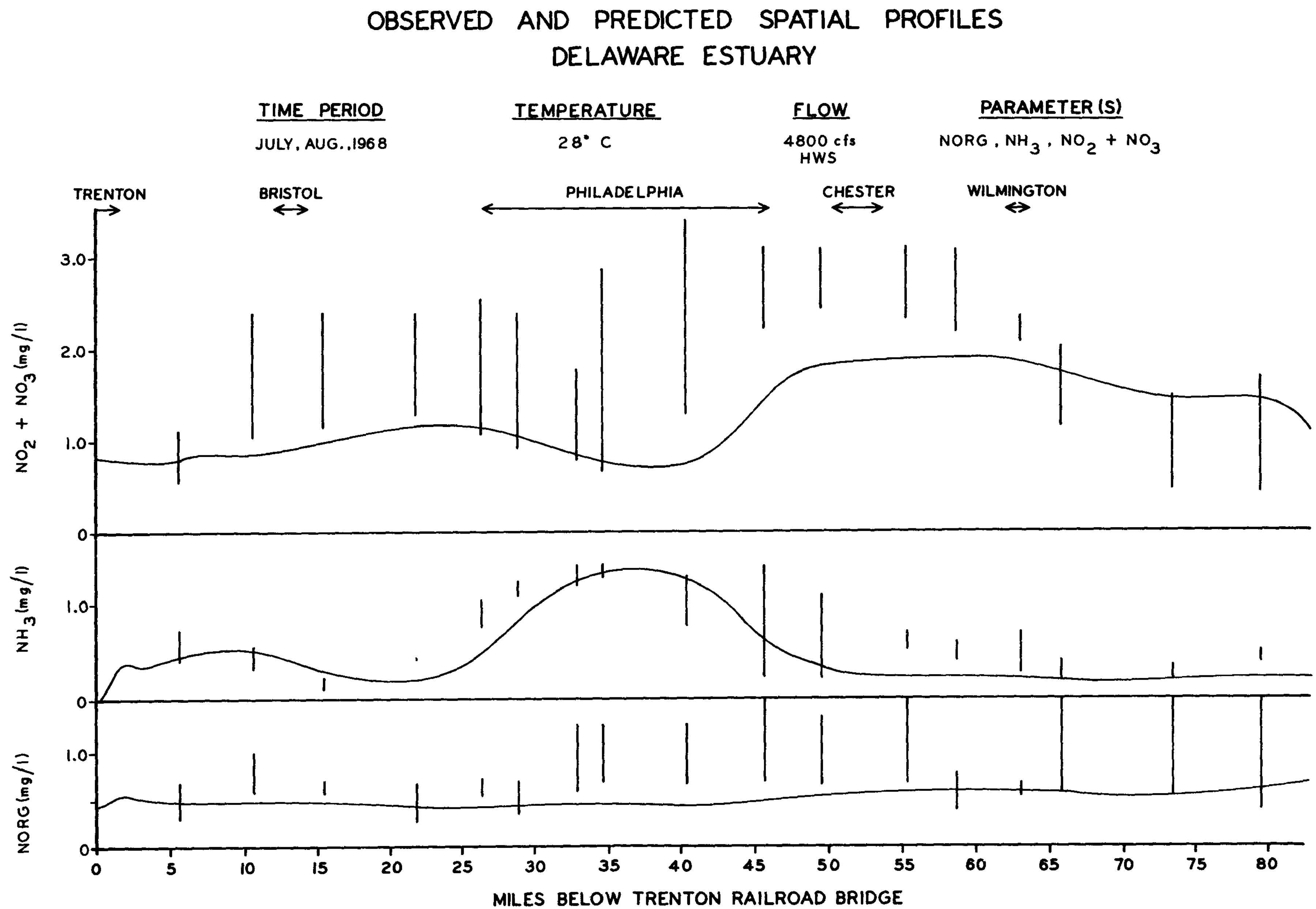


FIGURE III - 80

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY, AUG., 1968	28° C	4800 cfs LWS	NORG, NH_3, $NO_2 + NO_3$

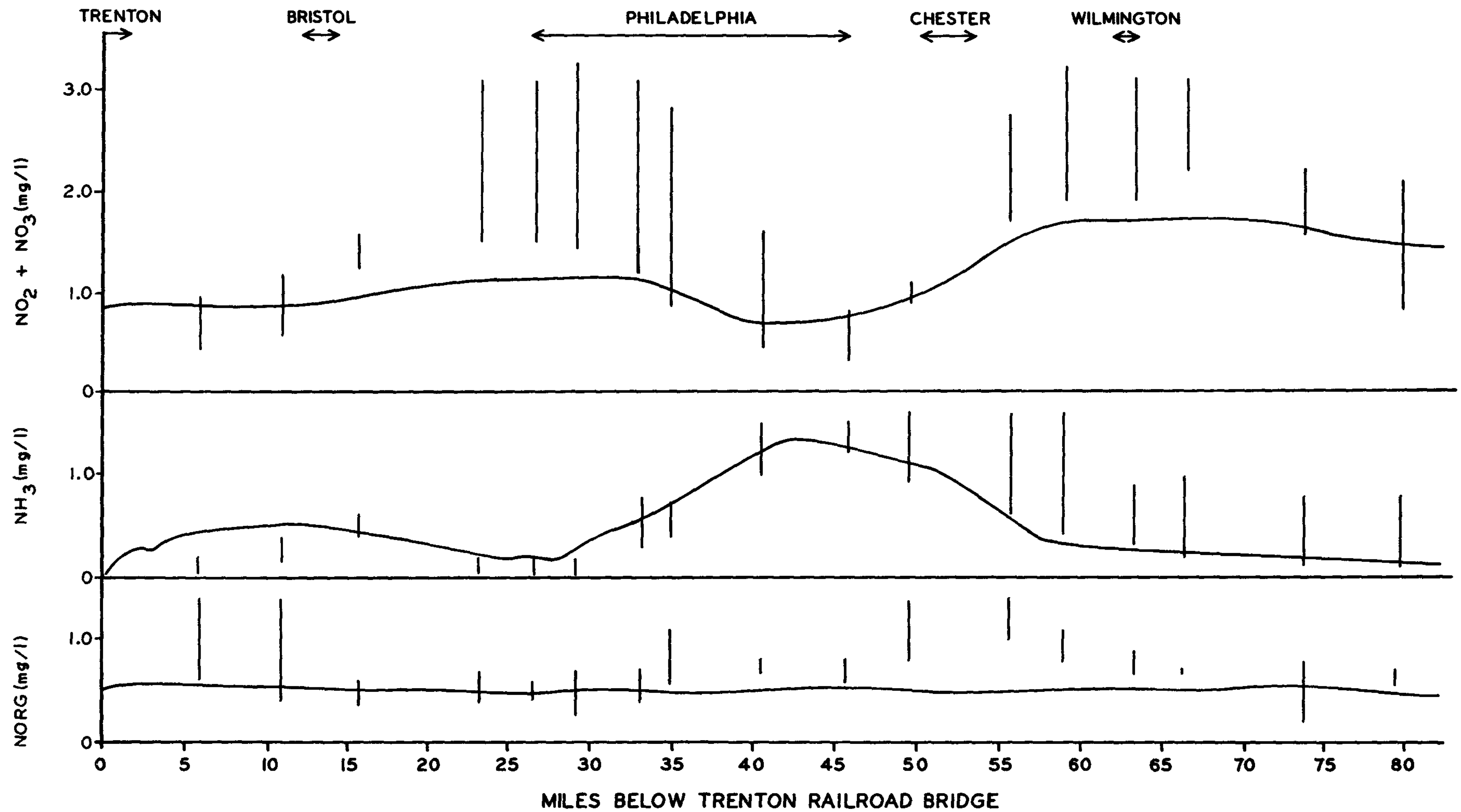


FIGURE III-81

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., SEPT., 1968	27° C	3900 cfs LWS	D.O.

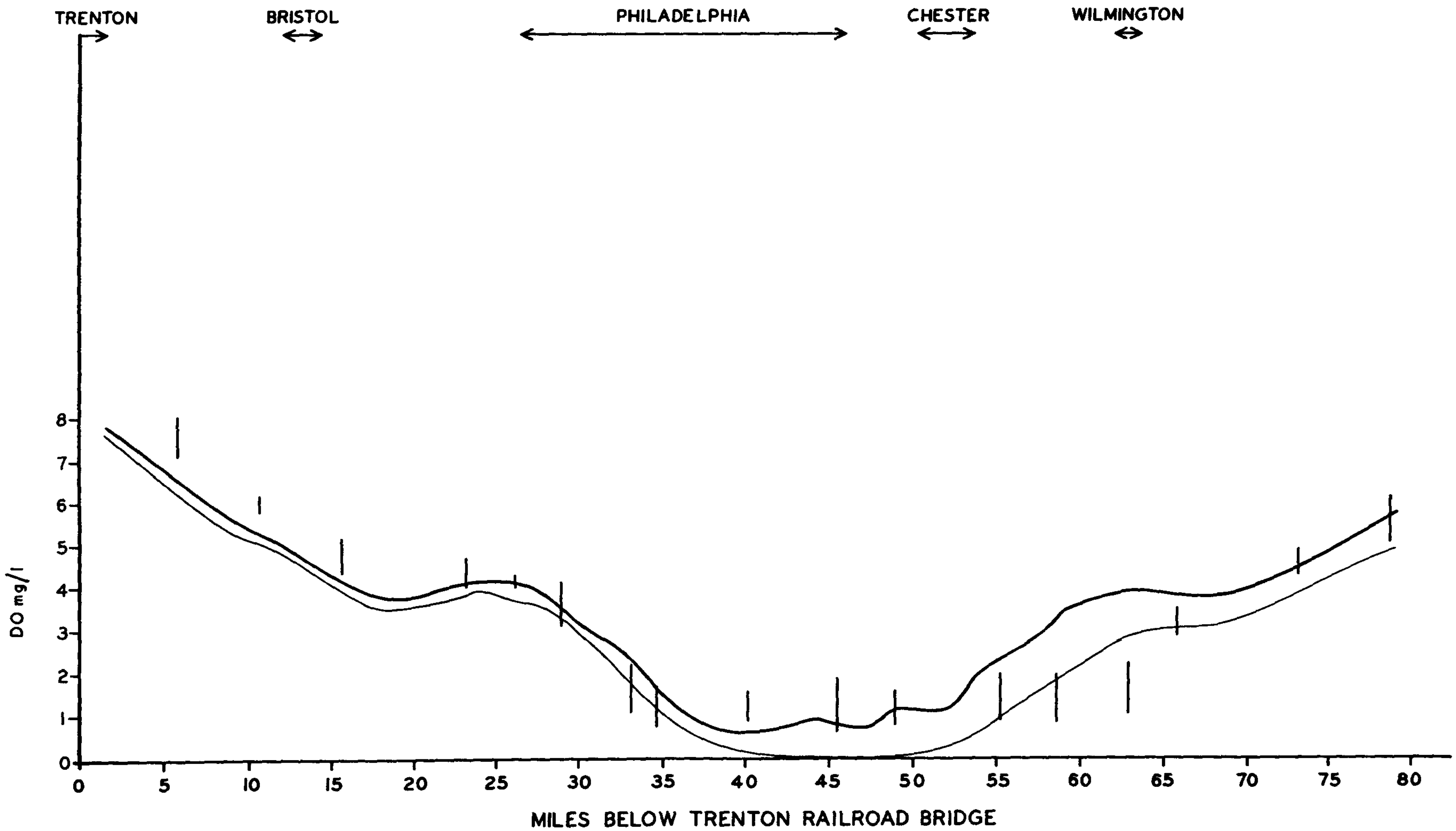


FIGURE III - 82

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
AUG., SEPT., 1968	27° C	3900 cfs LWS	NORG, NH_3, NO_2 + NO_3

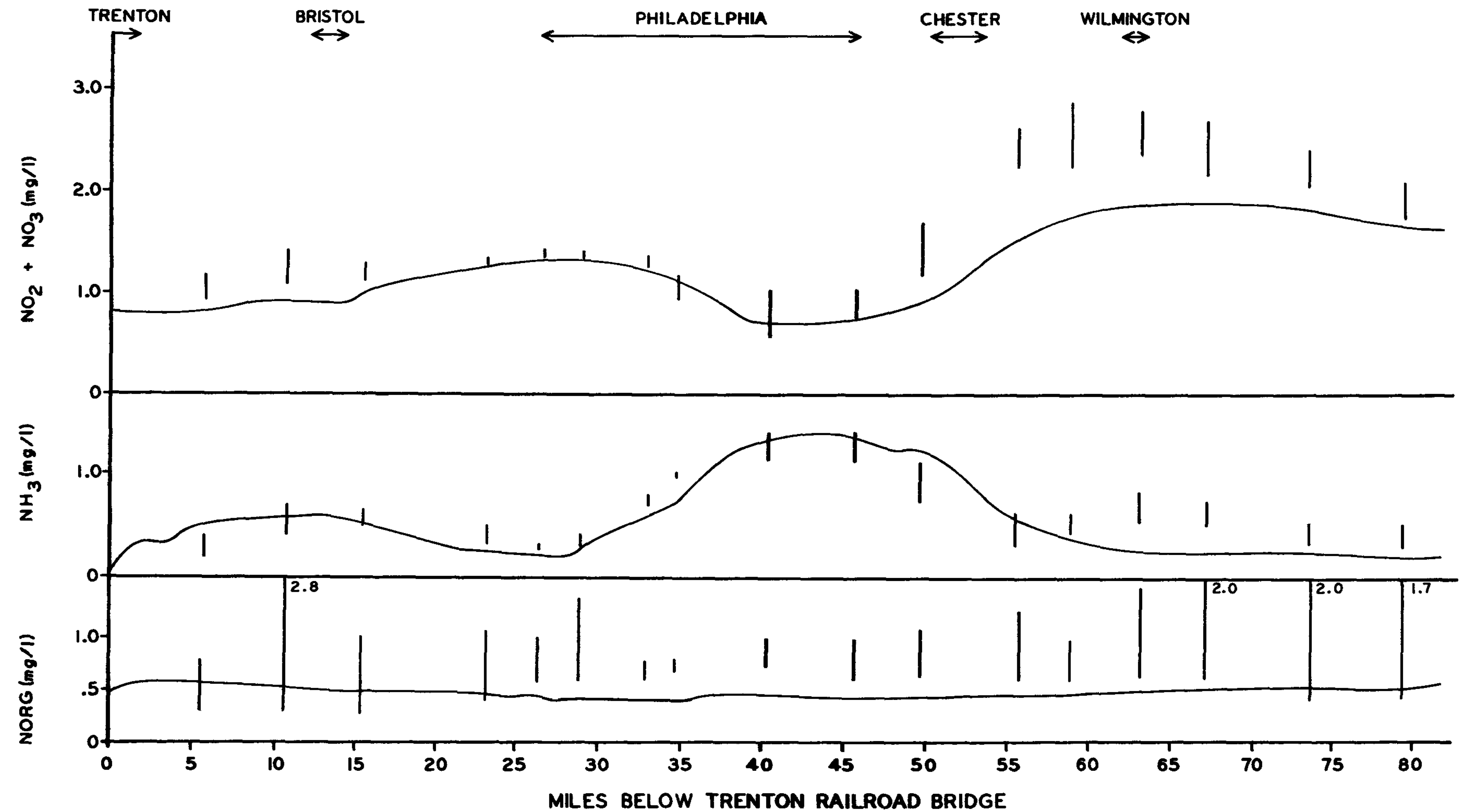


FIGURE III - 83

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 17 - SEPT 4, 1968	27 - 28° C	3900 cfs 4800 cfs	D.O.

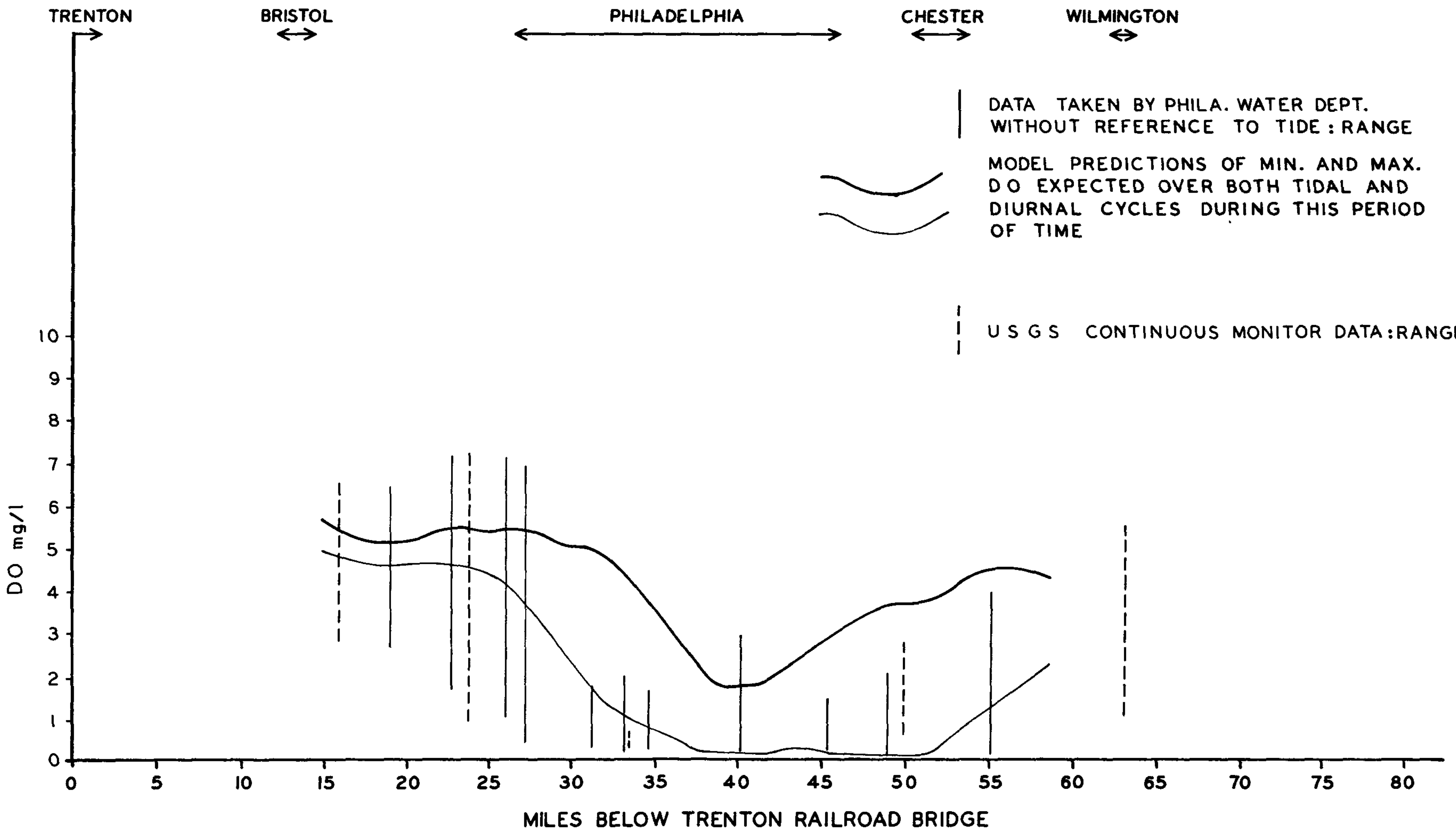


FIGURE III - 84

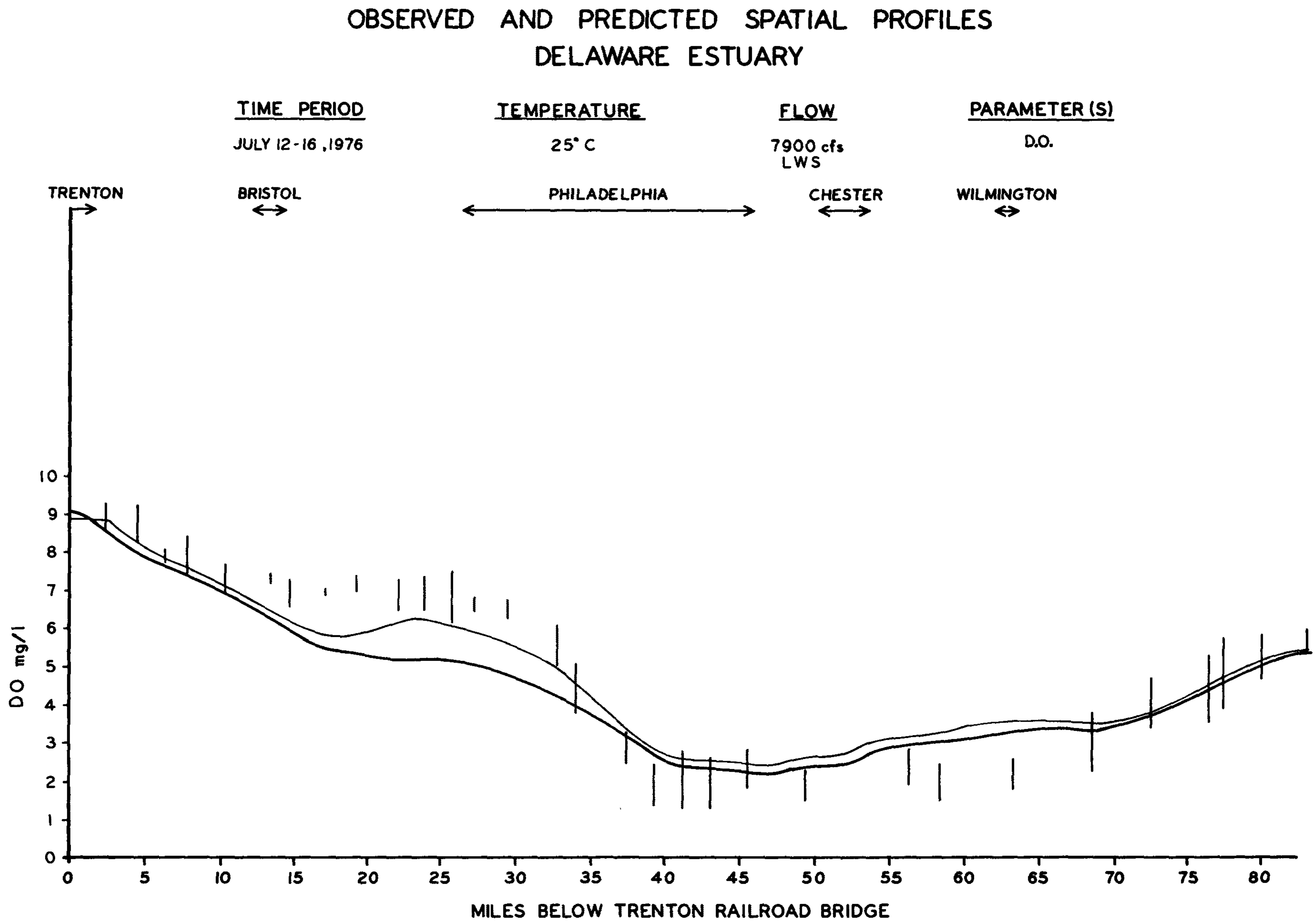


FIGURE III - 85

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 19-23,1976	25° C	7900 cfs HWS	D.O.

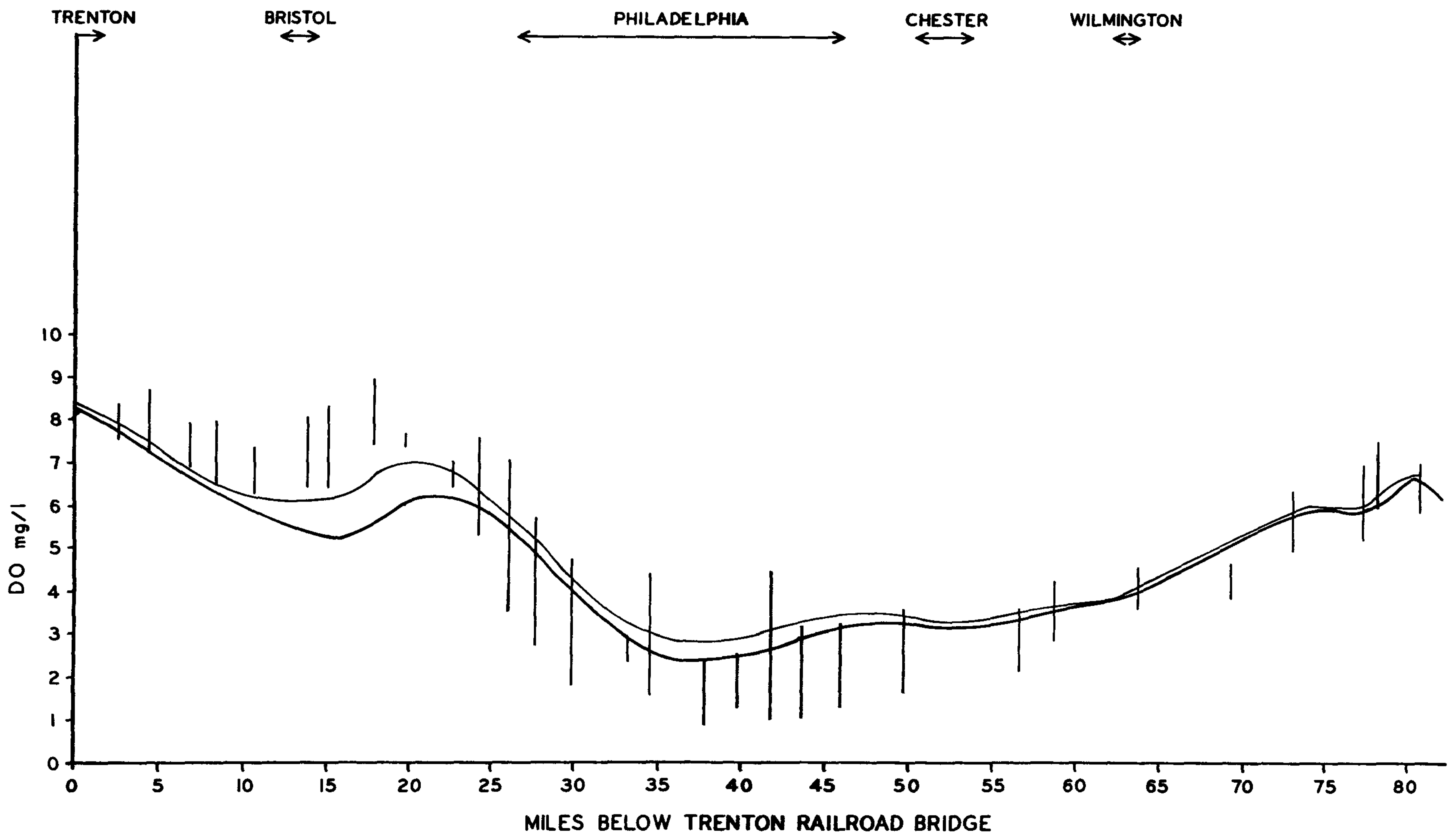


FIGURE III - 86

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 19-23, 1976	25° C	7900 cfs HWS	NORG, NH_3, $NO_2 + NO_3$

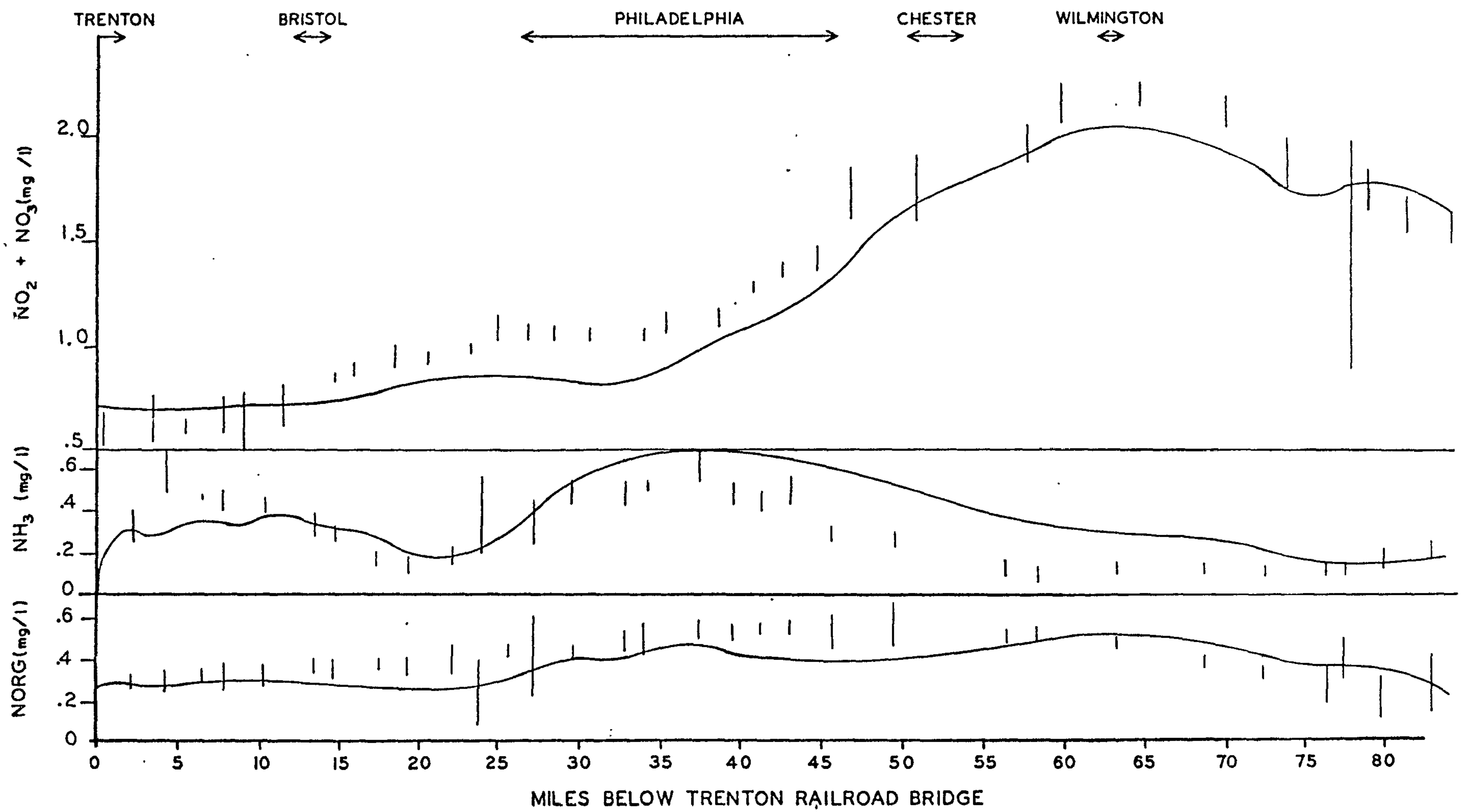


FIGURE III-88

OBSERVED AND PREDICTED SPATIAL PROFILES
DELAWARE ESTUARY

TIME PERIOD	TEMPERATURE	FLOW	PARAMETER (S)
JULY 19-23, 1976	25° C	7900 cfs HWS	NORG, NH_3, $NO_2 + NO_3$

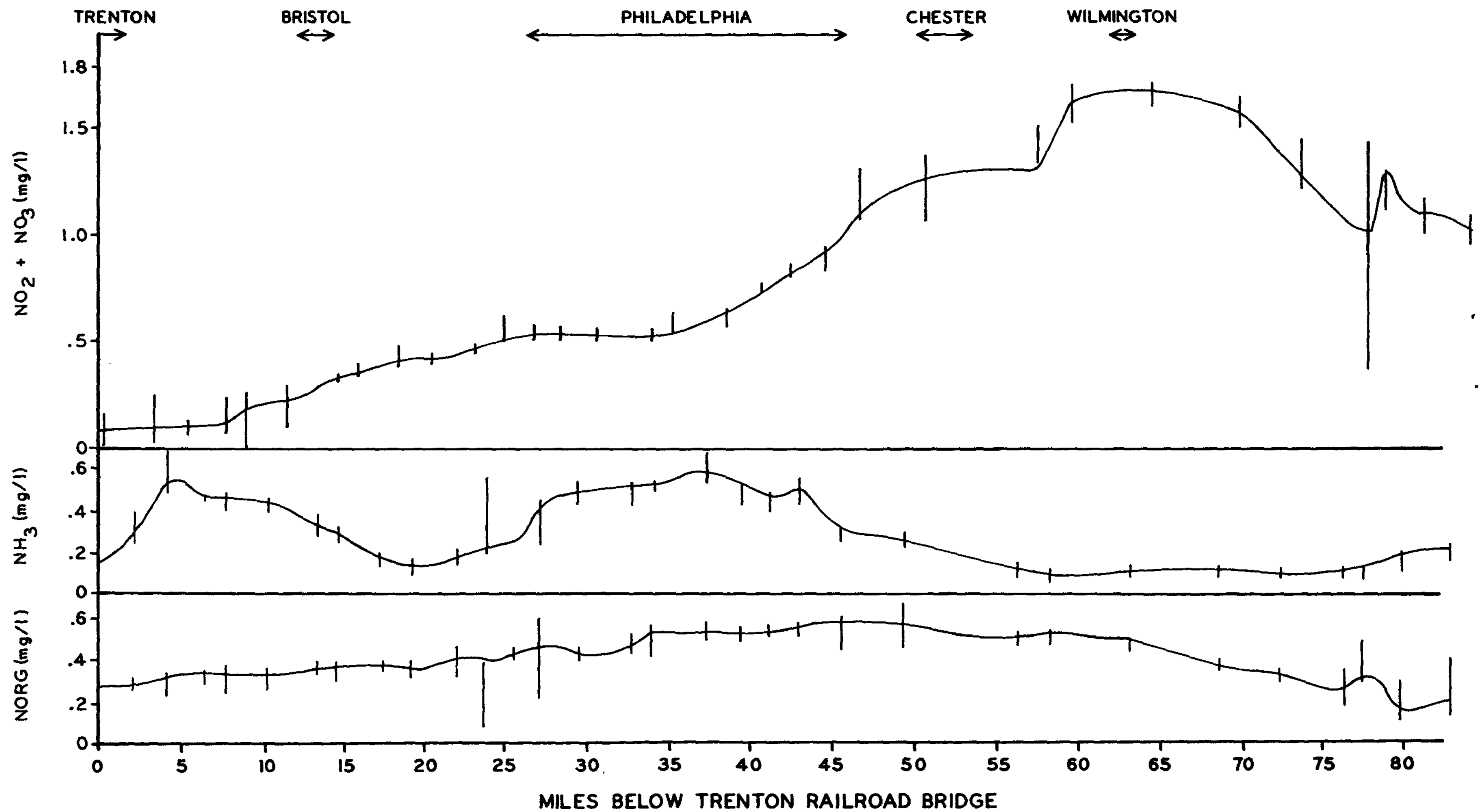


FIGURE III - 88

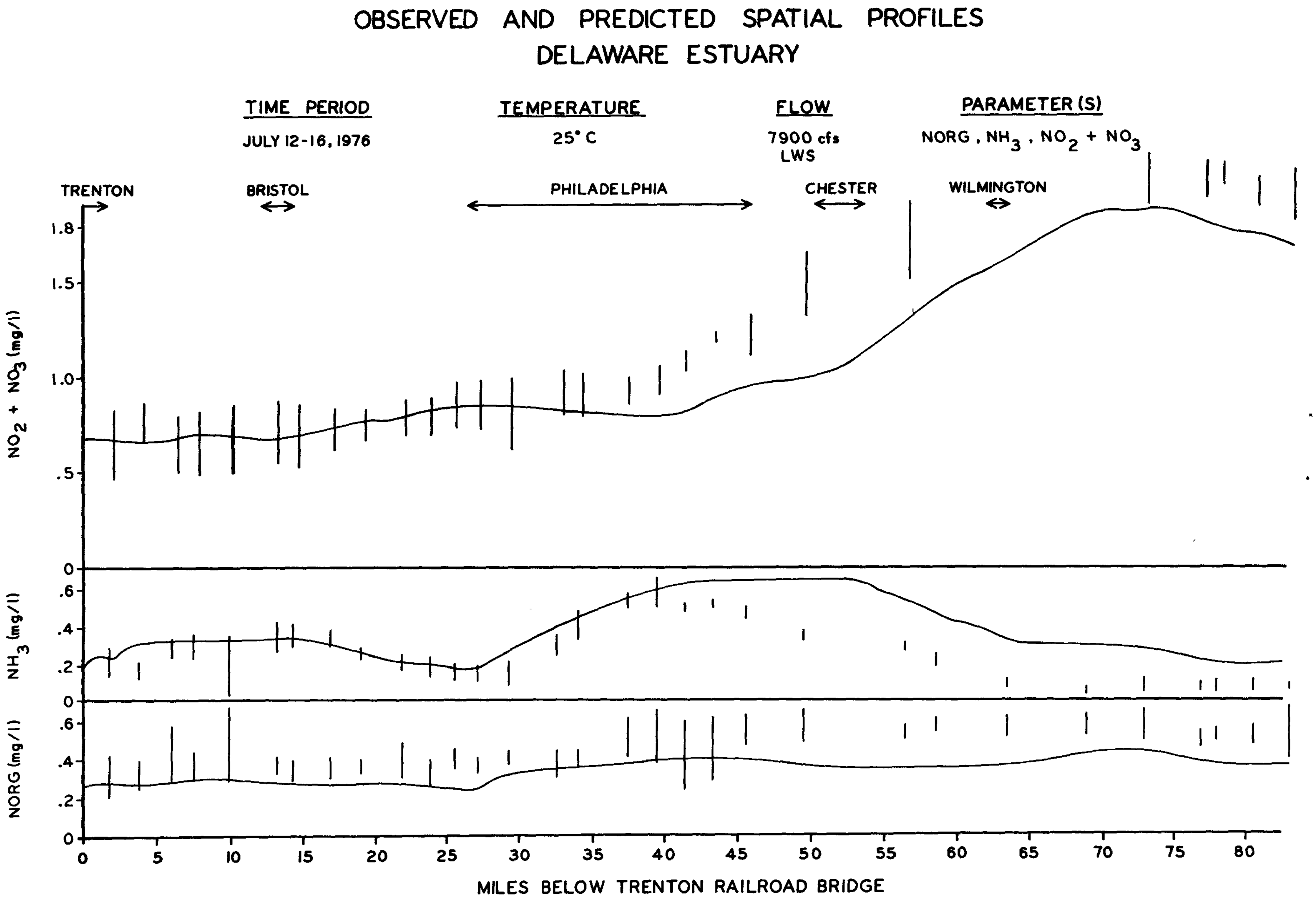


FIGURE III-87

e) Discussion of Reaction Rates

Without a doubt, the most crucial and difficult aspect of applying and verifying a water quality model is the proper selection of reaction rates and other coefficients, particularly those which produce considerable sensitivity to the model's predictions. In most instances they cannot be defined in-situ, and attempts to quantitate them through laboratory experiments leave a lot to be desired since a highly controlled lab environment can seldom duplicate the complex and dynamic processes in a real world situation. Moreover, the problem of reaction rates is obviously compounded when the study area is influenced by tidal action. Normally, the only recourses available are to utilize the model itself to "force fit" a given condition through an iterative process, or to rely on literature data.

Figure III-69 illustrates the various interactions employed by the final version of the Delaware Estuary model and provides a symbol which designates the rate associated with each interaction. Table III-5 describes these rates in further detail along with the actual values assigned in the model. The reactions contained in the model represent physical (R2, R7, R8), chemical (R1), and biochemical (R1, R3, R4, R5, R6, R9, R10, R11) processes whose importance have already been recognized and identified. Most of the temperature correction factors shown in the table were obtained from the literature. Others were estimated during

TABLE III-5

Description of Reaction Rates
for
Delaware Estuary Water Quality Model

Reaction	Products	Rate Value(s) (20°C)	Temp. Corr. Factor (θ)	Comments
R1 - hydrolysis (first order)	$N_{org} \rightarrow NH_3$	0.07/day	1.047	Assumed to be spatially constant.
R2 - settling (first order)	$N_{org} \rightarrow$ Sediment	0.07 - 0.15/day	1.00	Higher value assumed in vicinity of major outfalls where solids content is great. Also reflects settling of algae.
R3 - nitrification (first order)	$NH_3 + DO \rightarrow NO_2$ $NO_2 + DO \rightarrow NO_3$	$0.02 \rightarrow 0.20$/day	1.08	Rate spatially varied. Shock effects of heavy organic and other industrial pollutants from Phila. Metro Area inhibits reaction. Recovery to pre-inhibition rate dependent on temperature (hypothesis).
R4 - biological uptake (first order)	$NO_3 \rightarrow N_{org}$	0.02/day	1.16	Spatially constant. Mediated by all autotrophic organisms including algae.
R5 - denitrification (non-linear feedback)	$NO_3 + CBOD \rightarrow NO_2 + CO_2$ $NO_2 + CBOD \rightarrow N_2 + CO_2$	$0 \rightarrow 0.28$/day	1.12	Reaction provides source of oxygen. Rate dependent upon ambient DO concentrations as follows: DO > 1.0, R5 = 0, 1.0 > DO > 0.2, R5 = 0 - 0.12 0.2 > DO $\geq$ 0.0, R5 = 0.12 - 0.28
R6 - Carbonaceous BOD decay (first order)	$CBOD + DO \rightarrow CO_2$	0.18 & 0.23/day	1.047	Spatially varied to reflect major organic inputs. Lower value applied above Phila.; higher value below.

TABLE III-5 - continued

Reaction	Products	Rate Value(s) (20°C)	Temp. Corr. Factor (0)	Comments
R7 - settling (first order)	CBOD → Sediment	0.02 & 0.07/day	1.00	Higher value applies near major outfalls to account for increased solids deposition (contributes to SOD).
R8 - reaeration	O_2 → DO	0.10 - 0.29/day (Average)	1.026	O'Connor-Dobbins Formulation, recalculated every time step.
R9 - sediment oxygen demand (non-linear feedback)	DO → Sediment	0.5 → 2.7 gr/m^2/day	1.05	Rate spatially varied and attenuated when DO < 2.0 mg/l according to the expression $(DO/2.0)^{0.45}$; highest rates found around Philadelphia.
R10 - respiration (zeroth order)	DO → CO_2	0.017 mgO_2 /µg chloro/day	1.085	Effective rate dependent upon chloro concentration; can be varied spatially to reflect different species of algae, if required data exists.
R11 - photosynthesis (Zeroth order)	$CO_2 \xrightarrow{light}$ DO	0.079 mgO_2 /µg chloro/day	1.085	Effective rate dependent upon chloro concentration; can be varied spatially to reflect different species of algae if required data exists.
R12 - Euphotic depth*	-----------	(average range) 3 - 12 ft.	-----	Varies spatially and with time; low in areas affected by salinity wedge (usually Wilmington and below); this depth represents 99% light penetration, and is estimated from Secchi Disk & turbidity measurements in accordance with literature relationships. Visual correlations also performed.

* Not a reaction rate itself, but included because of its important effects on one - R11

calibration studies. Some clarification and elaboration of the data presented in Table III-5 follows.

There are several mechanisms by which organic N can be converted to ammonia N, including both chemical and biological, but the principal one assumed in this study was hydroloysis. Thomann and others have considered it as a first order reaction [18]. Settling of the organic N fraction in a particulate form (i.e., sewage solids and algal cells) is known to occur but actual rates are not well documented. Areas of the estuary where particulate organic N was thought to be exceptionally high were assumed to be more greatly affected by this deposition process, hence the rationale for spatially varying the rate R2. Had better data been available, it would also have been possible to vary this rate over the tidal cycle to permit the major deposition to occur at or near slack water tide when settling velocities are greatest. A similar logic was applied to the settling of CBOD material, although smaller rates were assumed for this process. It was believed that the settling of algae would have a much more dominant role as a sink for organic N then it would as a sink for CBOD. The rates used for R7, therefore, pertain primarily to the settling of sewage solids in the vicinity of the major wastewater discharges.

Nitrification is an extremely difficult reaction to assess because of the uncertainty surrounding the behavior of the nitrifying bacteria <u>Nitrosomonous</u> and <u>Nitrobacter</u> as well as the lack of quantitative information relative to their existing populations. It was evident early in this modelling study that the nitrification reaction did not proceed at the same rate throughout the estuary. In fact, a zone of inhibition was strongly suggested by the observed ammonia distributions and by attempts to reproduce the data with existing waste loads. An hypothesis was established that attributed the inhibition of nitrification to the shock effects of heavy organic and industrial pollutant loading experienced in the Philadelphia area. It was hypothesized that the areal extent of this inhibition zone was directly related to temperature and its effects on the repopulation of bacterial organisms. Figure III-89 presents the relationship between temperature and inhibition zone programmed into the model. While this hypothesis has not been adequately confirmed with actual field data, which it should, it did seem plausible to Dr. Thomas Tuffey, a nitrification expert, who performed independent studies in the Delaware Estuary, and it is somewhat supported by other literature studies. Subsequent to this work, Bob Tiedemann at Rutgers University, completed a masters thesis concerning nitrification in the Delaware Estuary [19]. Nitrifier data taken during 1975 and 1976 basically supported the patterns predicted by this hypothesis. Unfortunately, this hypothesis, as it presently stands, adds an element of descriptiveness rather than predictiveness to the model. It should further be noted that a spatially variable first order reaction was assumed for nitrification as others have done,

NITRIFICATION INHIBITION PATTERN BASED UPON MODELLING STUDIES
DELAWARE ESTUARY

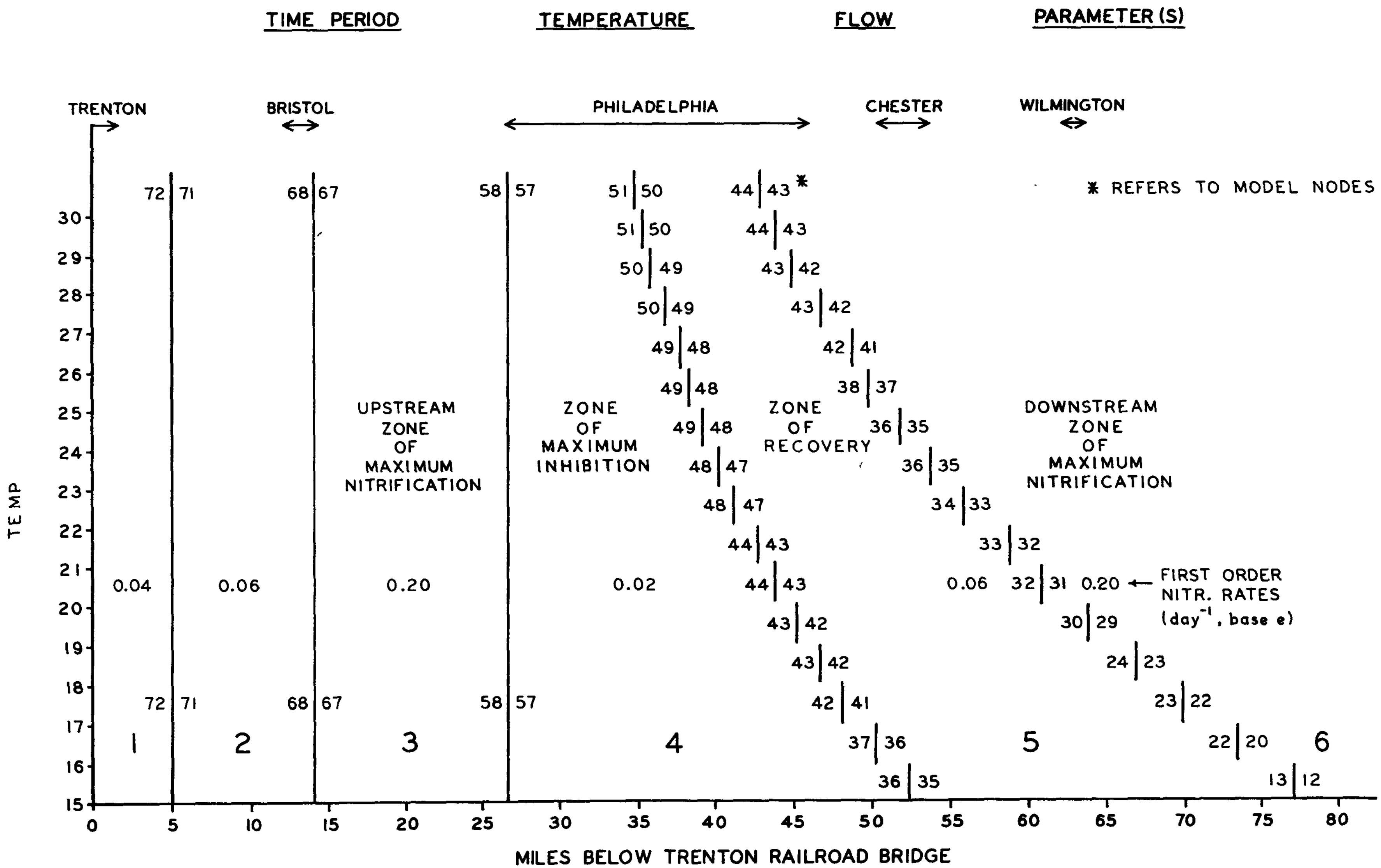


FIGURE III - 89

although this is probably an over-simplification to some extent.

Biological uptake of nitrate nitrogen was considered as a first order reaction with a constant rate and was assumed to be mediated by all autotrophic organisms. A similar method was employed in the Potomac Estuary model with reasonable success. Recent studies reported in the literature, however, have underscored the appropriateness of Michaelis-Menton kinetics to represent both nutrient uptake and algal growth dynamics. This non-linear reaction, with its rate related to substrate conditions, should prove valuable for future modelling endeavors in the Delaware Estuary.

A substantial reach of the estuary experiences very low DO levels on a fairly consistent basis during the summer. Although this condition did not appear to inhibit the nitrification process, it was reasonable to expect areas of denitrification. Indeed the observed data seemed to support the occurrence of denitrification since total nitrogen was not behaving conservatively. Therefore, a non-linear feedback was incorporated in the model so that denitrification was "turned on" when DO dropped below 1.0 mg/l and the rate increased in a two-step linear fashion to a maximum value (0.28 mg/l) corresponding to a DO of 0.0 mg/l. The following formulations were employed for this purpose:

<u>1.0 > DO > 0.2</u> :

$$\text{Denit. Rate } (20°C) = 0.12 + \left(\frac{0.12}{0.2-1.0}\right) \cdot (DO - 0.2)$$

<u>0.2 > DO > 0.0</u> :

$$\text{Denit. Rate } (20°C) = 0.28 - \left(\frac{0.28-0.12}{0.2}\right) \cdot (DO)$$

It was further assumed that the oxygen molecule disassociated during the denitrification process would contribute to the bacterial stabilization of the carbonaceous organic material present in the system.

The deoxygenation rate for carbonaceous BOD was initially estimated from trial model runs and then compared to literature values including those derived from earlier Delaware studies. Two rates were ultimately arrive at - the lower (0.18/day) applied to the relatively clean portion of the estuary upstream from Philadelphia and the higher (0.23/day) applied to the more polluted segments. This approach agreed with the concept of the reaction and the tendency of organisms to adjust to a given "food" supply. The actual rates compared favorably to the literature, although they were substantially lower than those used by DECS (0.45/day). It should be pointed out, however, that DECS used a comparatively low SOD rate which might have compensated somewhat for the high oxygen requirements of the CBOD reaction. The classical correction factor (1.047) was used to convert R6 to temperatures other than 20°C.

The basic uninhibited sediment oxygen demand (SOD) rates were initially estimated from a combination of data collected by the DECS Staff and the EPA National Field Investigations Center (NFIC) Cincinnati, Ohio. This latter effort, performed during the summer of 1974, was intended to provide in situ oxygen uptake measurements using a benthic respirometer at about 10 stations between Trenton and the C&D Canal. Because of equipment problems and serious limitations in the respirometer (the unit was designed for lake use and not estuaries having strong tidal currents), however, no such data was obtained. Instead, samples of the bottom sediment had to be collected and transported to the NFIC laboratory for uptake analyses. The results of this study, after adjusting for earlier organic bottom cover information, were used for the original model calibration and verification attempts and are depicted in Figure III-90.

During the summer of 1976, staff at AFO designed and constructed two benthic respirometers for use in relatively shallow areas of the Delaware Estuary (i.e., depth <20 feet). These units were constructed out of sheet metal and have the shape of a pyramid with a base composed of horizontal and vertical stabilizing flanges. An internal stirring mechanism and DO probe were provided to obtain concentration measurements. The respirometer is positioned (sealed) in the bottom mud manually by means of a long pole that attaches to a fitting on the apex of the pyramid. The base area of the respirometer is 4 square feet and its volume is 27.6 litres.

Twelve stations were selected between Trenton and Marcus Hook for in situ benthic oxygen uptake measurements. With the exception of the upper three, two measurements were obtained at each station, one along the Pennsylvania shore and the other along the New Jersey shore at depths ranging from 5-20 feet. The results of each measurement are shown in Figure III-90 along with the actual SOD rates used in the model. All of the data have been corrected to 20°C. The SOD rates were computed by subtracting the (small) respiration rate in the water column from the measured initial slope of the DO concentration vs time relationship inside the respirometer, where a constant negative slope normally occurred for the first 30 to 60 minutes of the test. No attempt was made to either define or include the anaerobic process contributing to a stabilization of the bottom muds, but rather to isolate the impact of the top few centimeters, where aerobic conditions would normally exist, on the oxygen resources of the overlying water. A non-linear feedback was incorporated in the model to consider the effects of low DO concentrations (i.e., <2.0 mg/l) on the reduction of the SOD rate [16]. The expression used for this purpose was essentially from the literature and is shown in Table III-5.

Specific studies to define algal photosynthesis and respiration rates in the Delaware Estuary have not been performed and considerable reliance had to be placed on the

SEDIMENT OXYGEN DEMAND RATES
DELAWARE ESTUARY

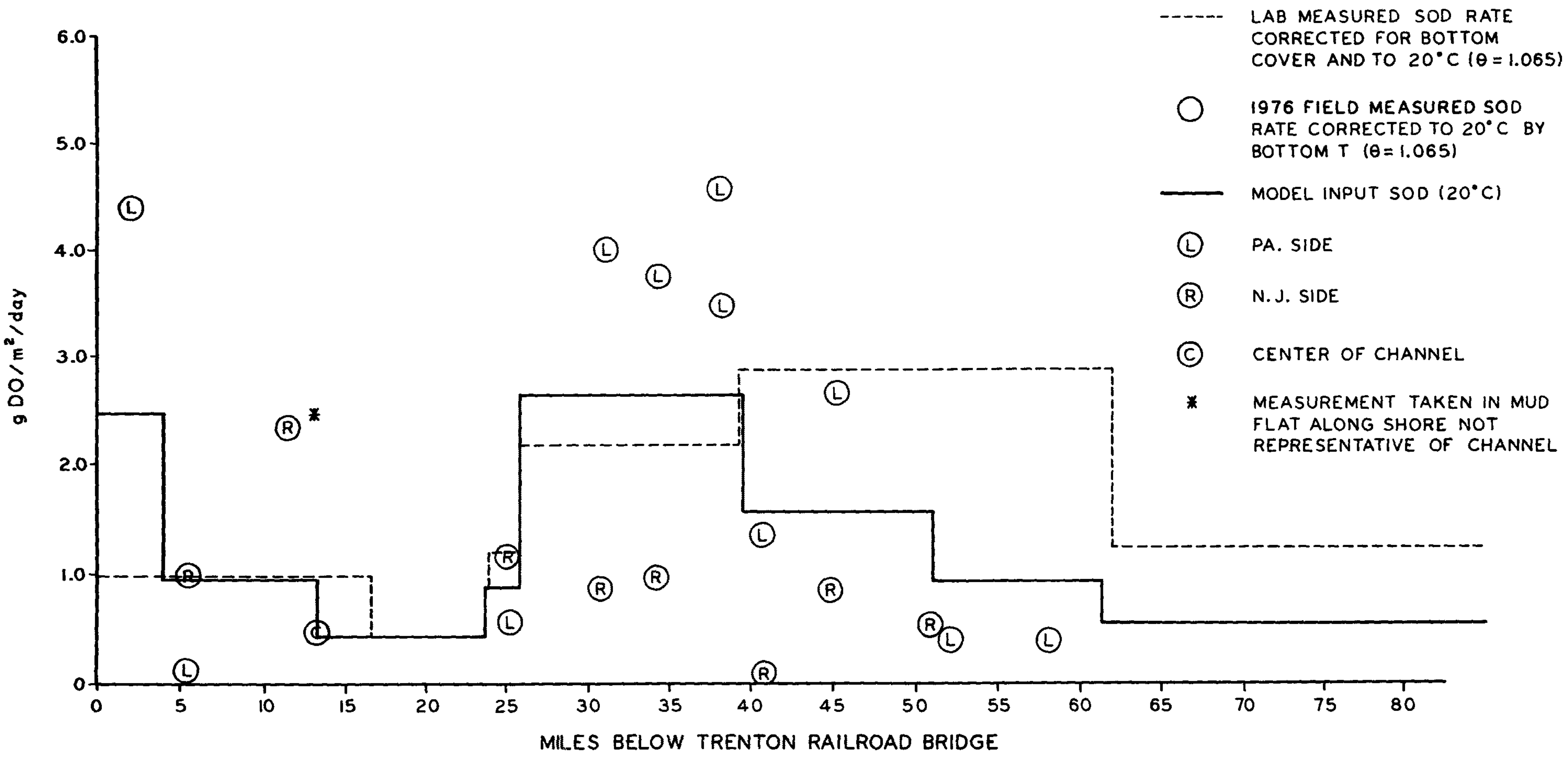


FIGURE III - 90

literature again [20], [21], [22]. Fortunately, AFO had conducted studies of this nature in the Potomac Estuary and the rates derived there served as a convenient starting point for estimating P and R rates for the Delaware. As can be seen in the table, both rates were a function of the chlorophyll a concentrations, which had to be known a priori. The respiration rate was practically identical to that used in the Potomac, but the photosynthesis rate underwent some change to reflect the findings reported in the literature. It should be noted that these rates were intended to apply to an entire algal community rather than to specific species.

Respiration was assumed to occur throughout the day and over the entire water column whereas photosynthesis was limited to the daylight period (12 hours) and the euphotic depth. The euphotic depth (1% of ambient radiant energy) was taken to be 3 times the Secchi Disk measurement [23]. A relationship was established between Secchi Disk and turbidity based upon observed data collected during some of the water quality surveys. This relationship, which is presented in Figure III-91, was used for certain data sets where turbidity but no light extinction measurements were available.

RELATIONSHIP BETWEEN TURBIDITY AND SECCHI DISK
DELAWARE ESTUARY
JULY 1974

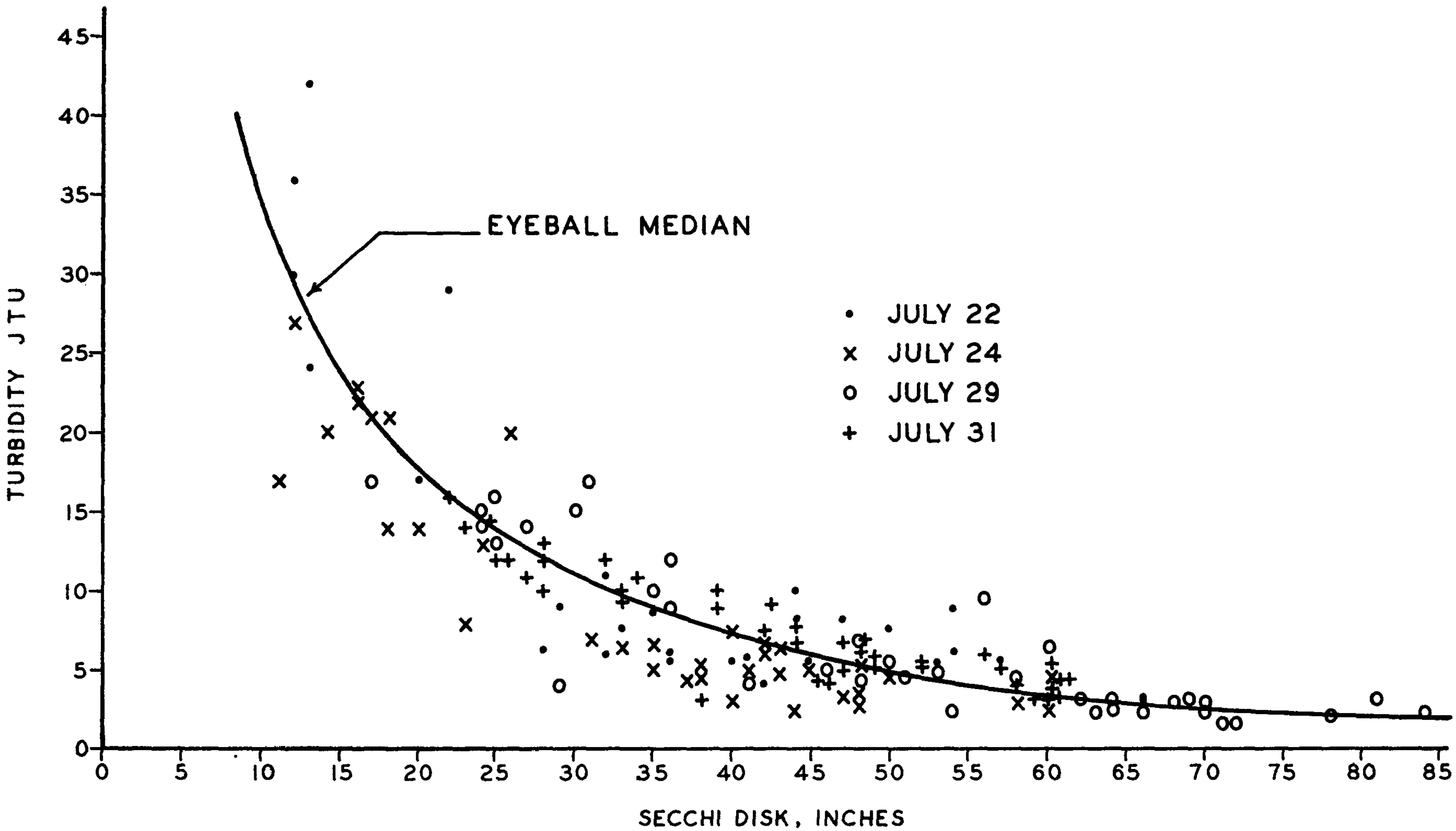


FIGURE III - 91

F. SENSITIVITY ANALYSIS

The importance of an adequate and meaningful sensitivity analysis to indicate where field and laboratory resources could best be allocated for improving the reliability and confidence one might have in a model's predictions should be underscored. This is particularly true when either large sums of money or major water quality management decisions are riding on the outcome of modelling studies, which is happening with increased frequency. Model sensitivity has, unfortunately, often been neglected or just glossed over in studies where the consequences of such action could have had profound implications.

Since the model described in this report contained non-linear components, sensitivity results could take on connotations different from the usual linear analysis. Therefore, care had to be exercised in the design of a streamlined but useful sensitivity study. Model runs were performed to determine the sensitivity of the following rates and other inputs.

1. Physical
   a) Temperature (1 change)
   b) Inflow (1 change)
   c) Reaeration - R8 (3 different formulations)
2. Biological
   a) BOD Decay - R6 (1 change)
   b) Nitrification - R3 (2 changes)
   c) SOD - R9 (2 changes)

d) Denitrification - R5 (2 changes)

e) Photosynthesis - R11 (1 change)

f) Respiration - R10 (1 change)

g) Euphotic Depth - R12 (1 change)

h) Algal Densities (chlorophyll *a* concentration) (2 changes)

A few comments regarding the sensitivity analysis are in order. The basic approach taken was to alter the various inputs used for the original model calibration and verification efforts to new but reasonable values one at a time. Unfortunately, the sensitivity runs did not reflect the latest estimates of SOD rates since they were all made prior to the existence of the new benthic respirometer discussed in the previous section. This should not, however, significantly effect the degree of sensitivity indicated for any of the parameters, including SOD itself. In many instances only one change of value was assumed which would provide a meaningful comparison of model results for identifying sensitivity. In others, two or even three changes were made where available options, uncertainty, or the suspected implications so dictated. Each of the above rates was checked for sensitivity under both linear and non-linear conditions. The July 1974 data set calibration served to test sensitivity in the non-linear regime; a hypothetical October incorporating waste loads that would ensure DO levels greater than 2.0 mg/l, the breakpoint for non-linear feedbacks, served to test sensitivity in the linear region. Algal sensitivity was subjected to additional studies. In addition to determining sensitivity of algal related rates for a typical level of algae when linearity and non-linearity existed, special runs were made to indicate the net effects of the algal levels themselves, including the large algae bloom that was experienced during August 1975. The total impact of that bloom on predicted DO concentrations is dramatic, as can be seen in Figure III-119. Additional sensitivity runs related to that high bloom condition, when P and R rates had a more pronounced effect, were also performed. Finally, some of the rates associated with the nitrogen cycle were not included in this sensitivity analysis, due to the lack of sensitivity on the resultant DO profiles that they exhibited when tested in conjunction with model calibration studies.

The following figures portray the results of the sensitivity analysis. The different inputs utilized in the model for each sensitivity run are shown on the graphs. No attempt was made to either quantify or compare the degree of sensitivity associated with every parameter tested but rather to allow the readers to draw their own conclusions.

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	TEMPERATURE	0 - 80	TEMPERATURE = 18	TEMPERATURE = 20

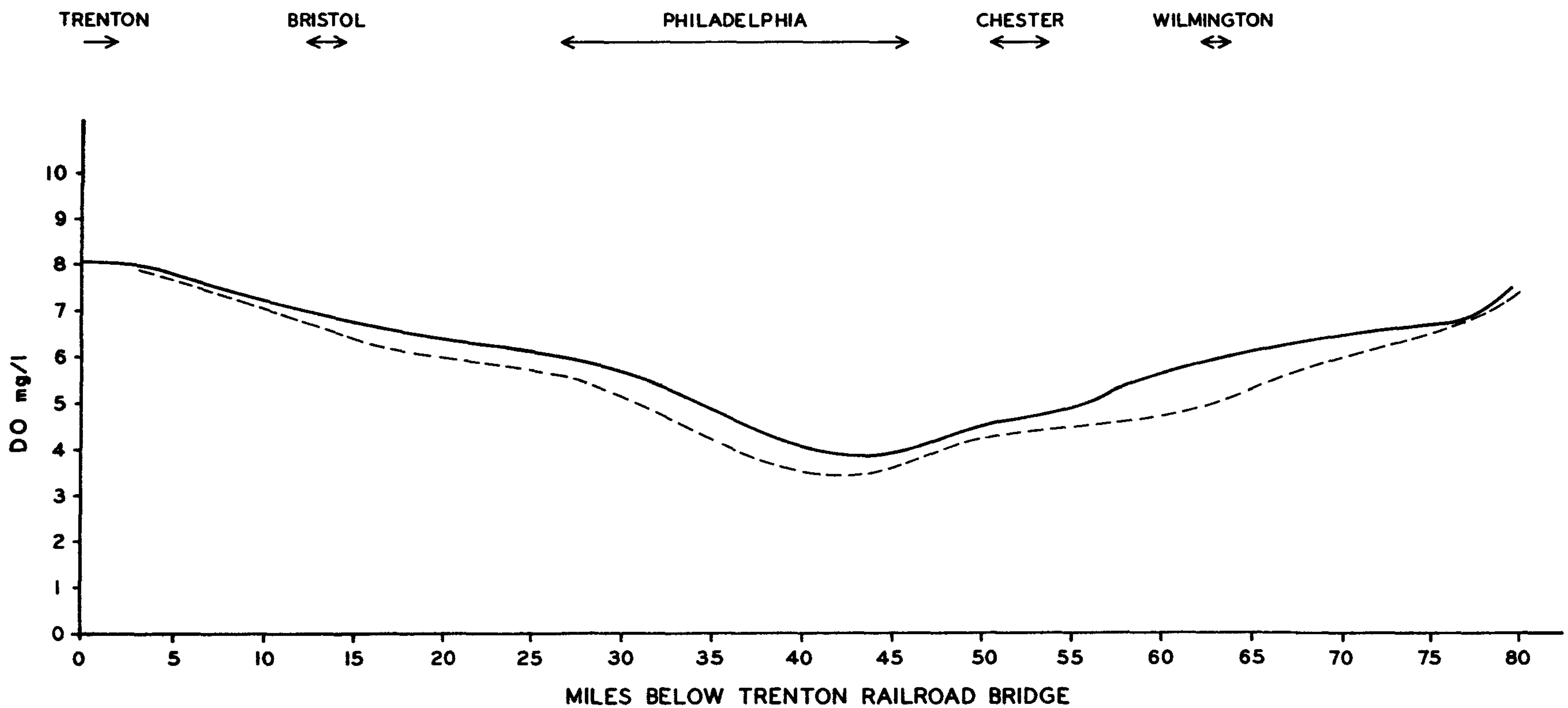


FIGURE III - 92

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	TEMPERATURE	0-80	TEMPERATURE = 27	TEMPERATURE = 29
JULY, 1974				

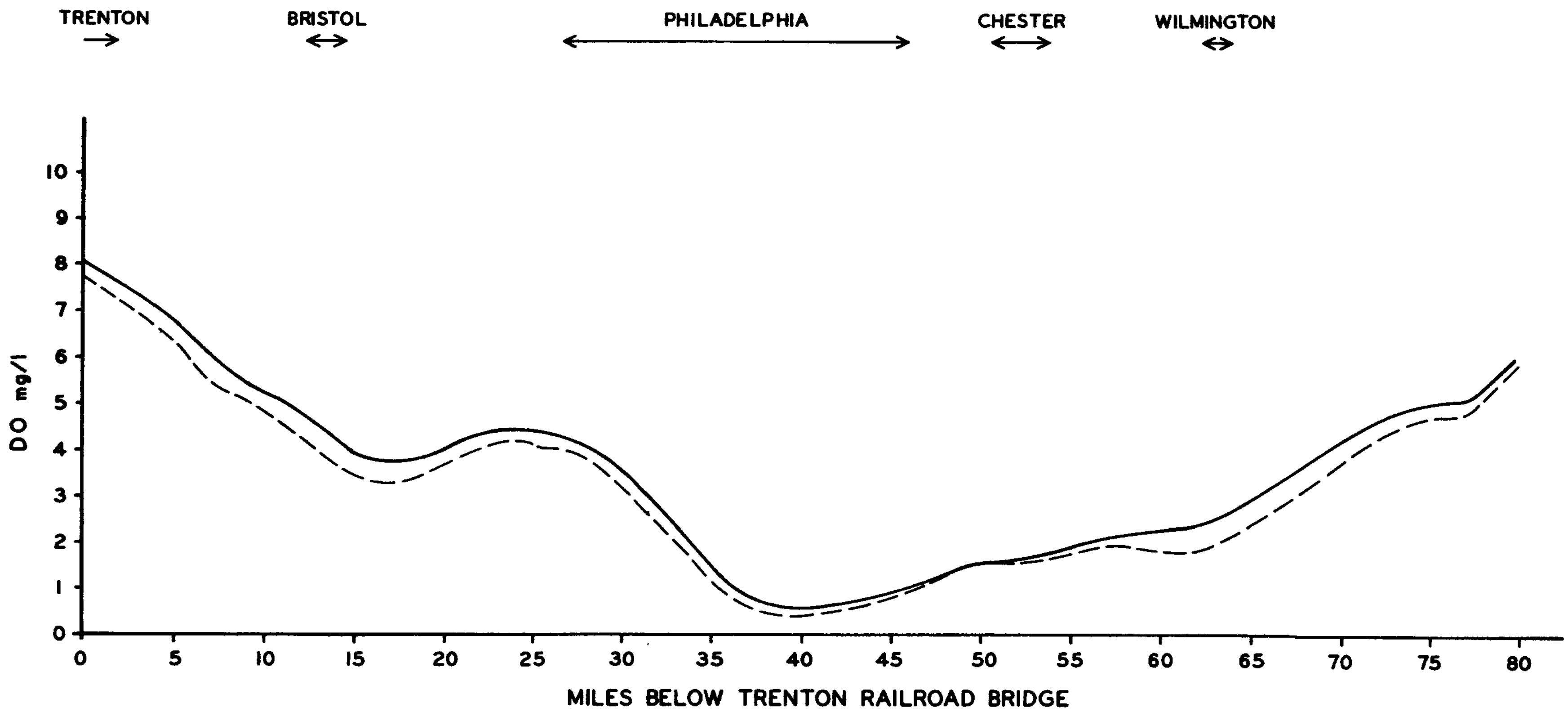


FIGURE III-93

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	FLOW	0 - 80	FLOW = 6600 cfs	FLOW = 4800 cfs

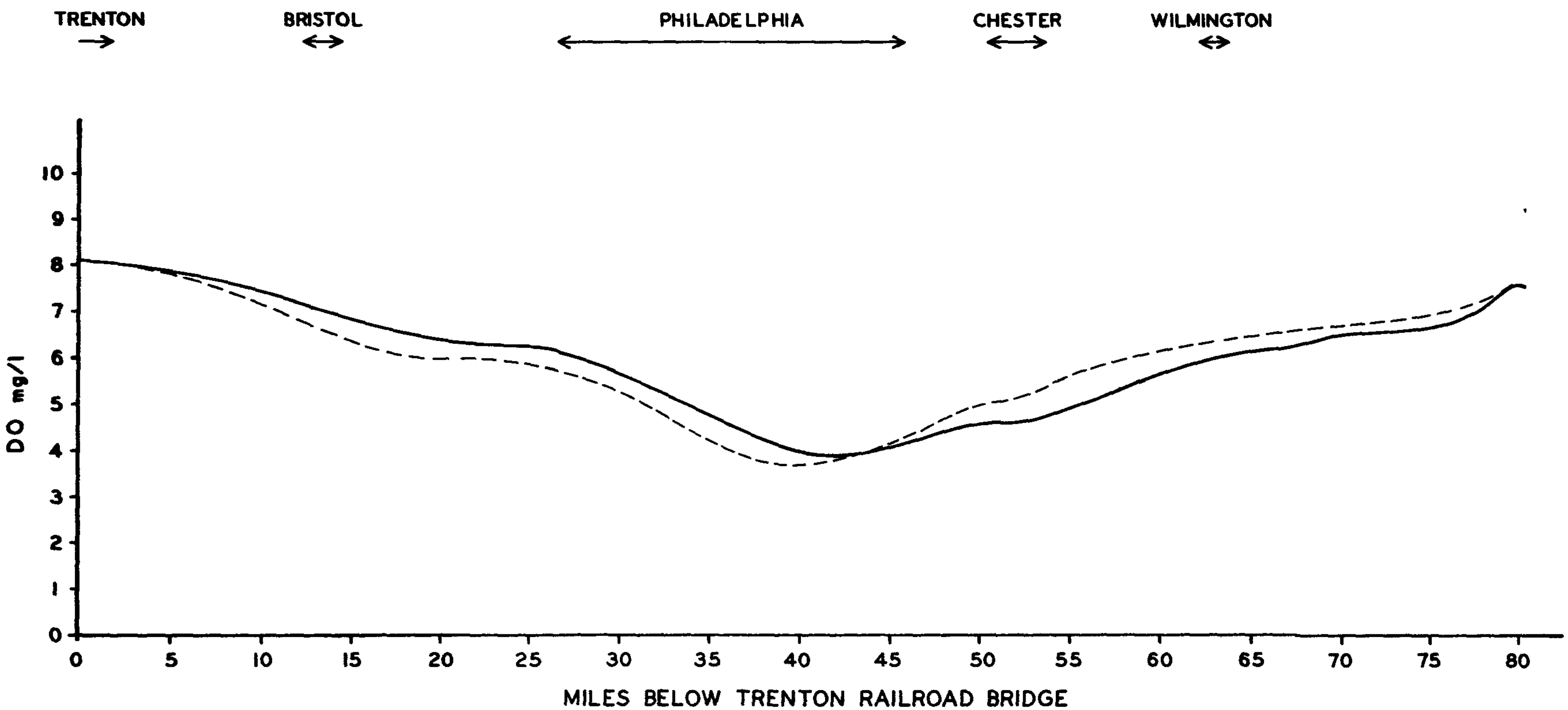


FIGURE III-94

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	FLOW	0 - 80	FLOW = 3900 cfs	FLOW = 2450 cfs
JULY, 1974				

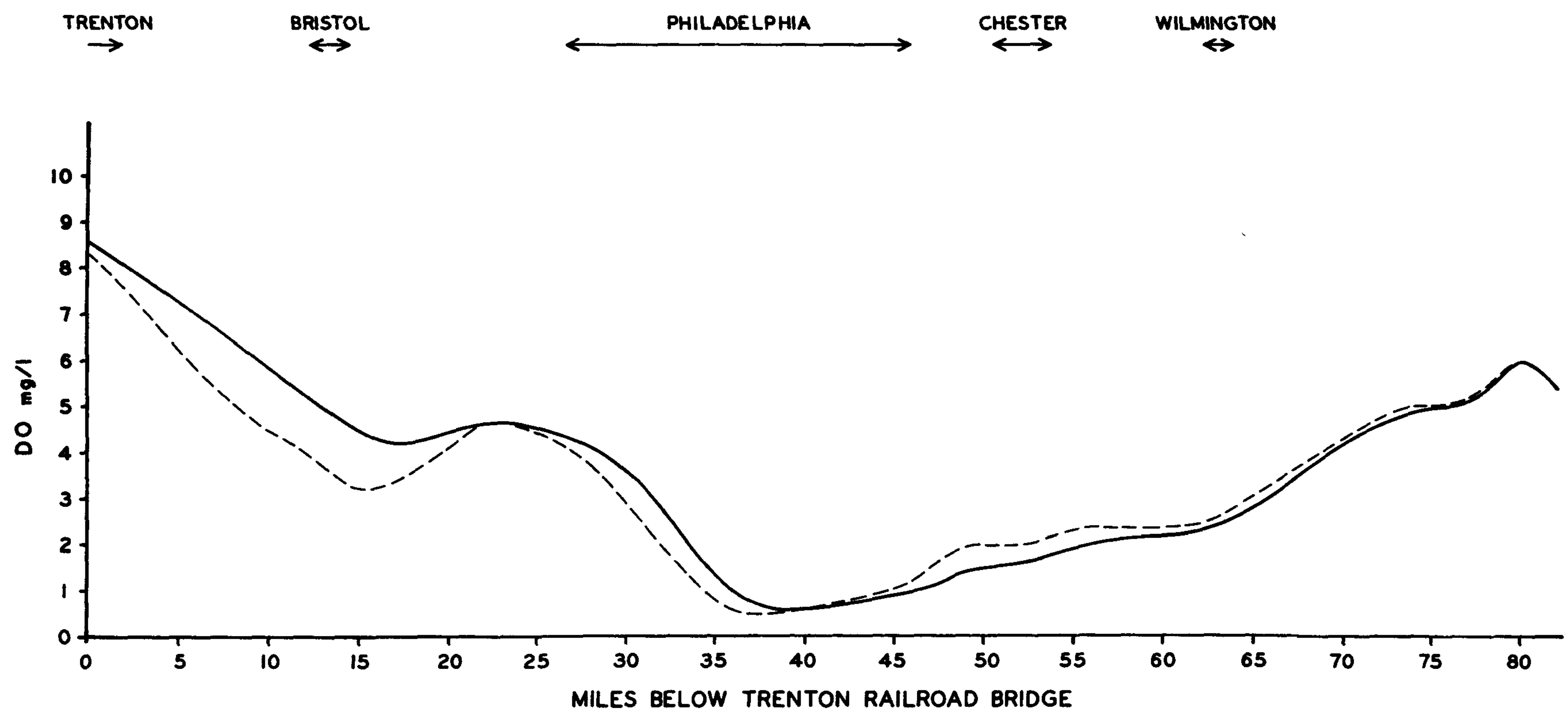


FIGURE III - 95

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	REAERATION	0 — 80	O'CONNOR - DOBBINS EQUATION	CHURCHILL EQUATION

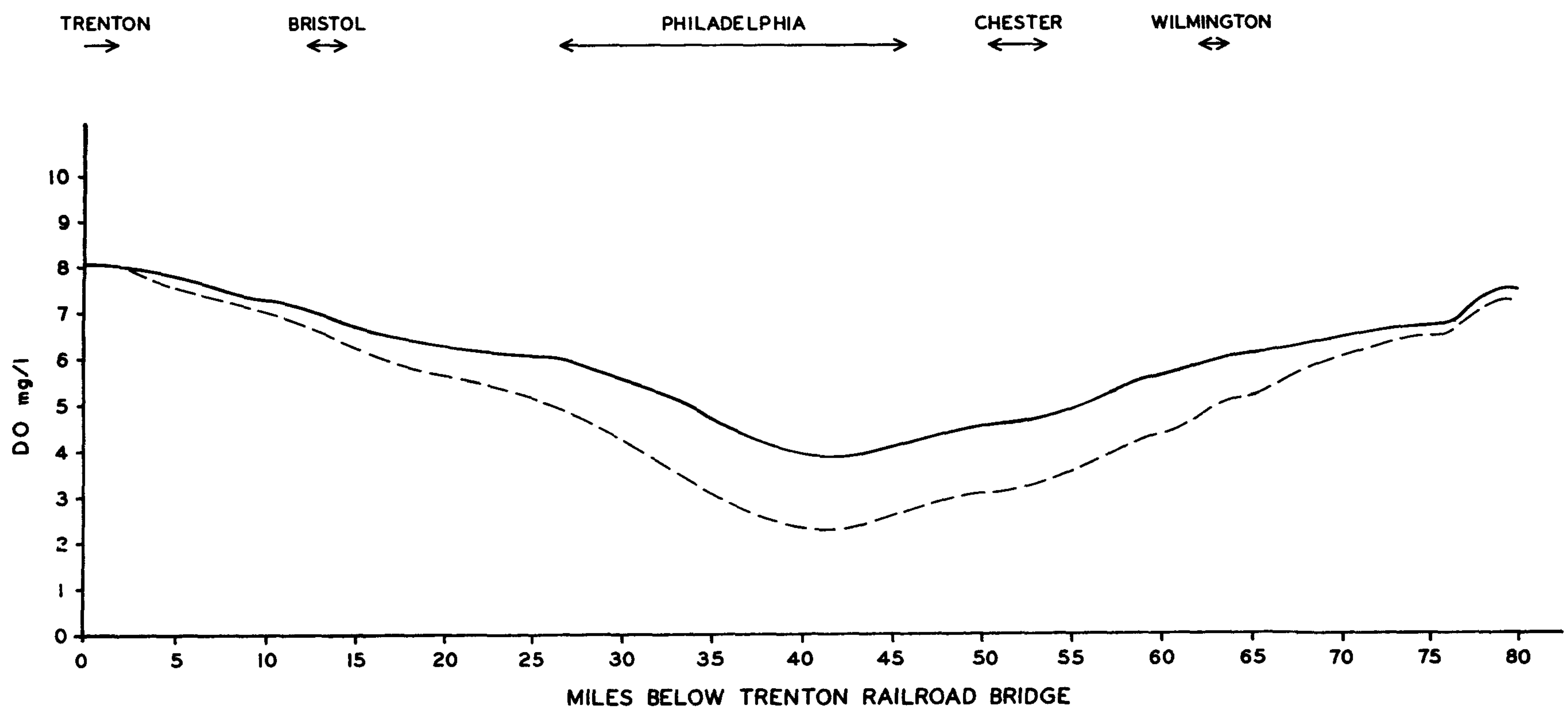


FIGURE III - 96

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	REAERATION	0 - 80	O'CONNOR - DOBBINS EQUATION	U S G S EQUATION

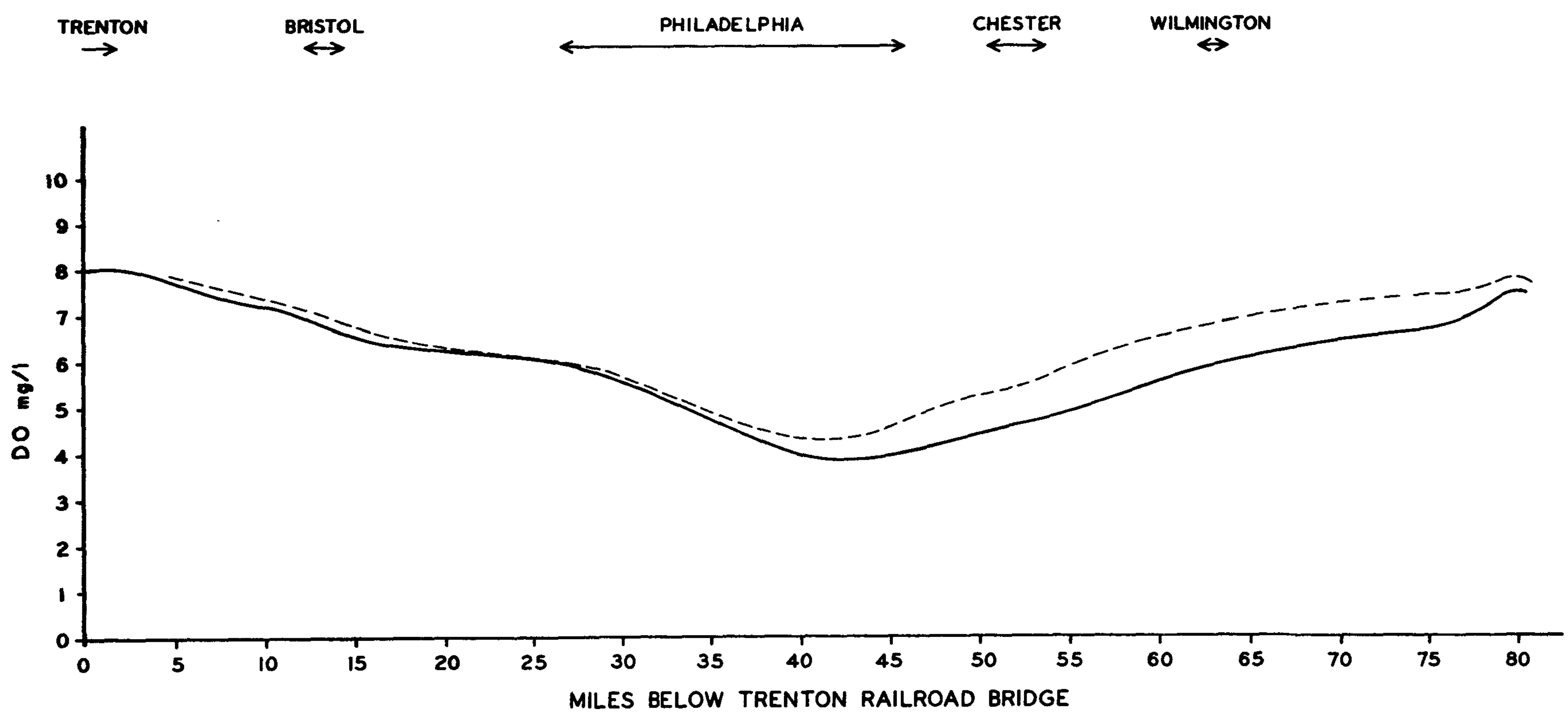


FIGURE III - 97

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	REAERATION	0 – 80	O'CONNOR - DOBBINS EQUATION	CHURCHILL EQUATION
JULY, 1974				

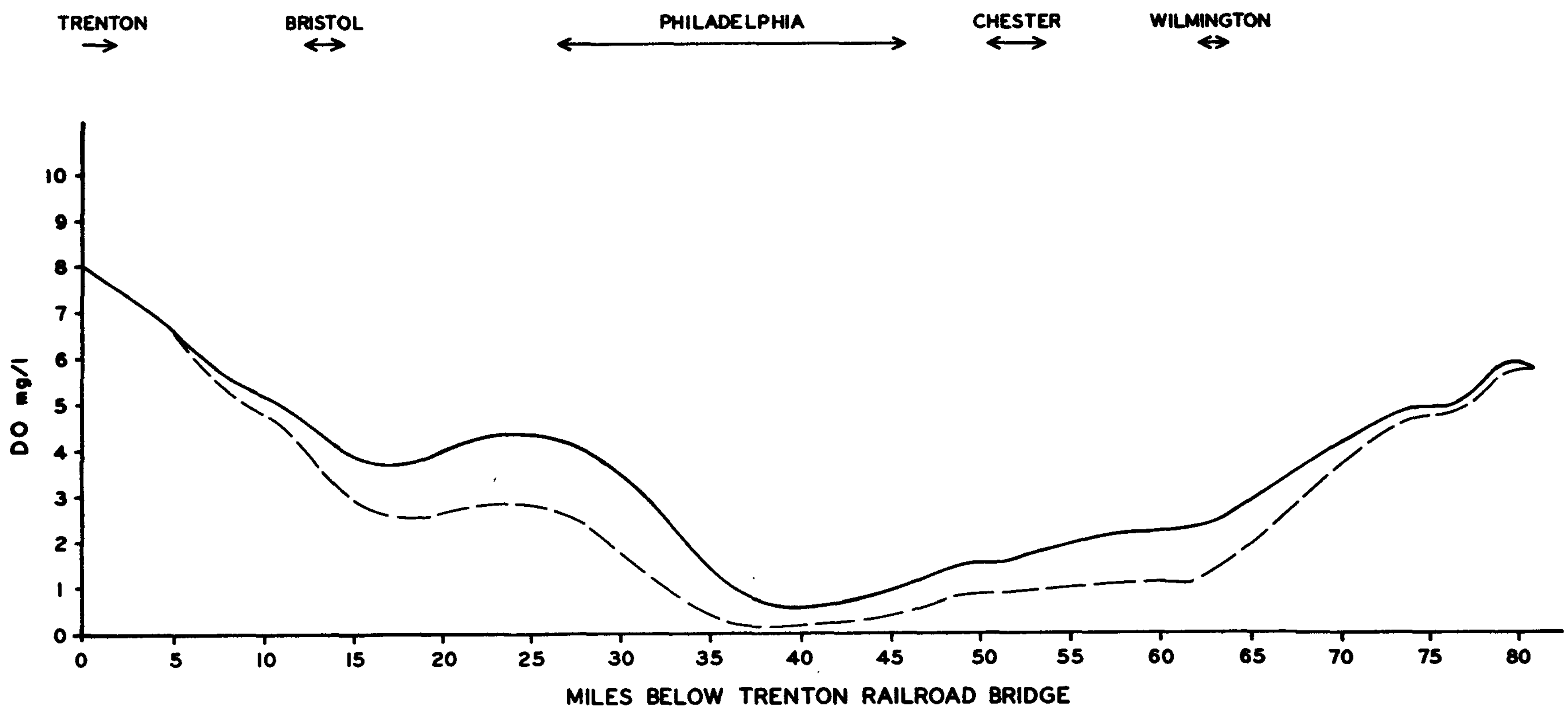


FIGURE III - 98

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	REAERATION	0 – 80	O'CONNOR - DOBBINS EQUATION	USGS EQUATION
JULY, 1974				

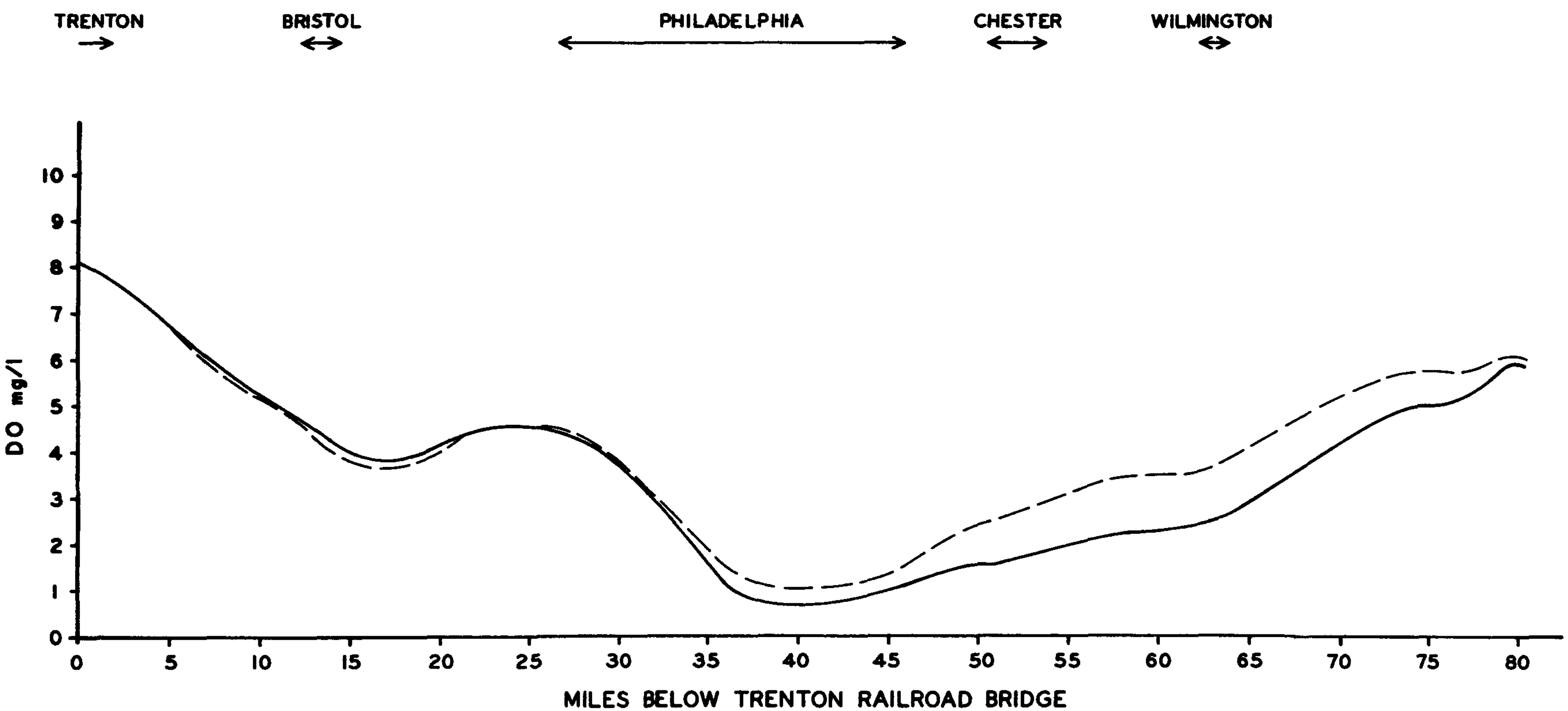


FIGURE III - 99

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	CBOD, OXIDATION RATE	0 – 80	MILE 0-27.5, 0.18 MILE 27.5 - 80, 0.23	MILE 0-80, 0.33

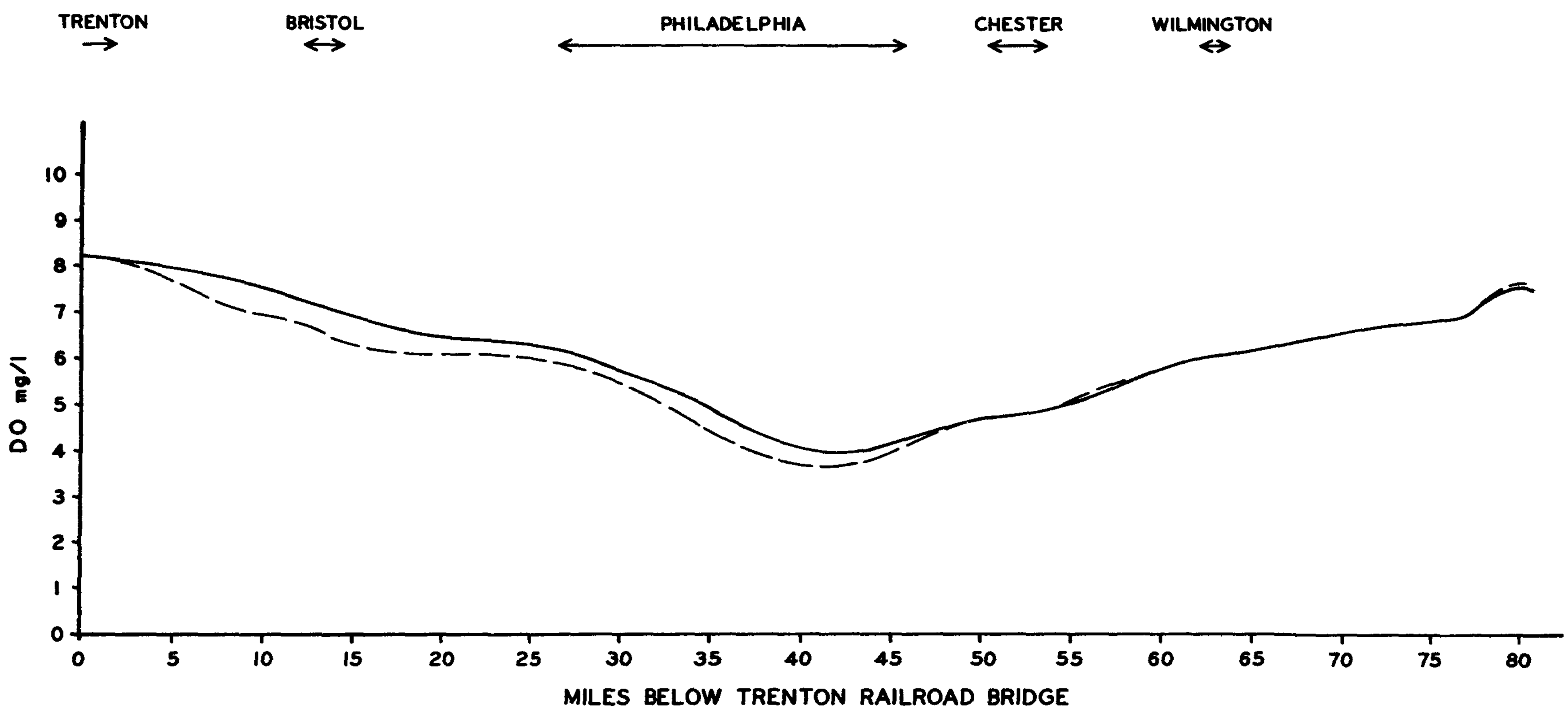


FIGURE III - 100

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	CBOD, OXIDATION RATE	0 – 80	MILE 0-27.5, 0.18 MILE 27.5-80, 0.23	MILE 0-80, 0.33
JULY, 1974				

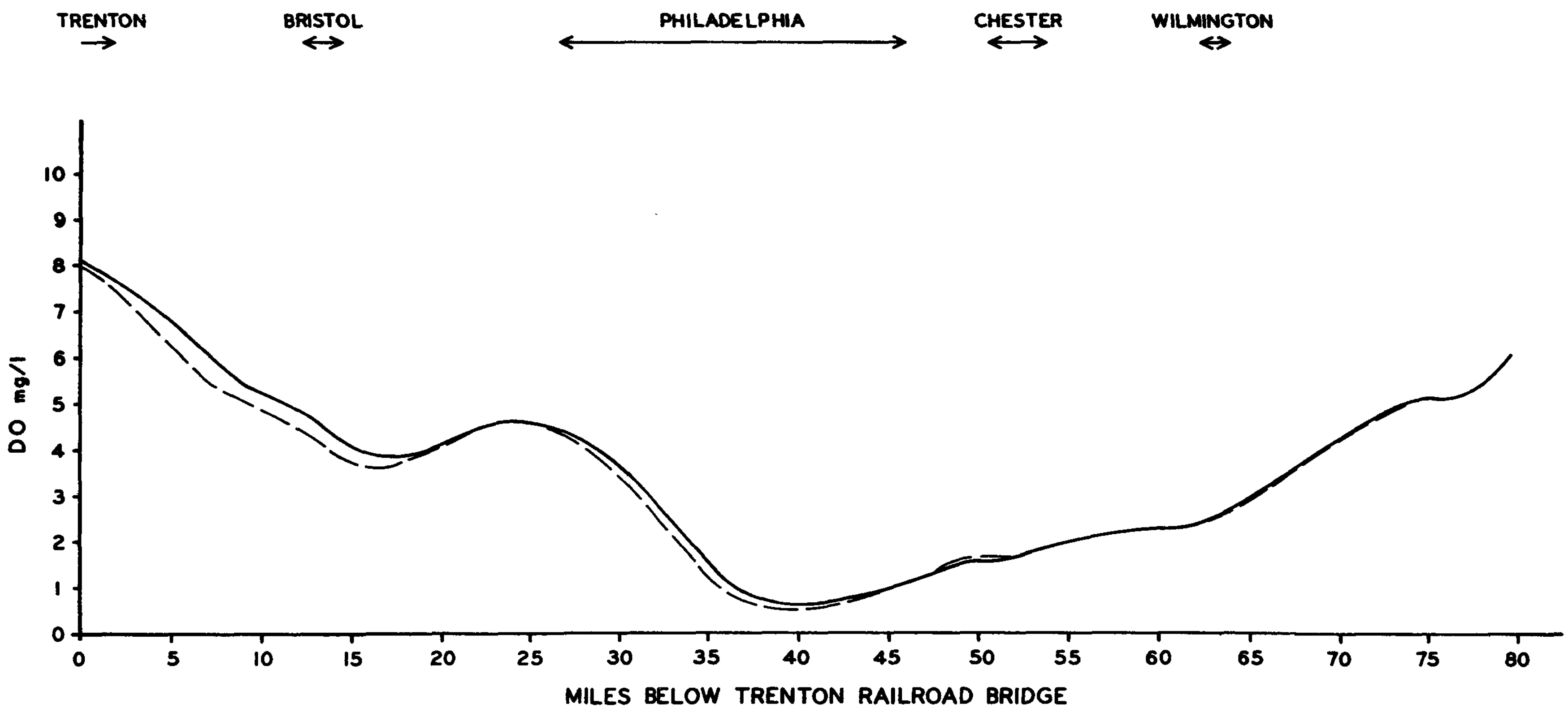


FIGURE III - 101

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER	NITRIFICATION RATES	0 – 80	MILE 0 - 5 , .04	MILE 0 - 5 , .08
			MILE 5 - 14 , .06	MILE 5 - 14 , .12
LINEAR REGION			MILE 14 - 27 , .20	MILE 14 - 27 , .40
			MILE 27 - 47 , .02	MILE 27 - 47 , .04
			MILE 47 - 67 , .06	MILE 47 - 67 , .12
			MILE 67 - 80 , .20	MILE 67 - 80 , .40

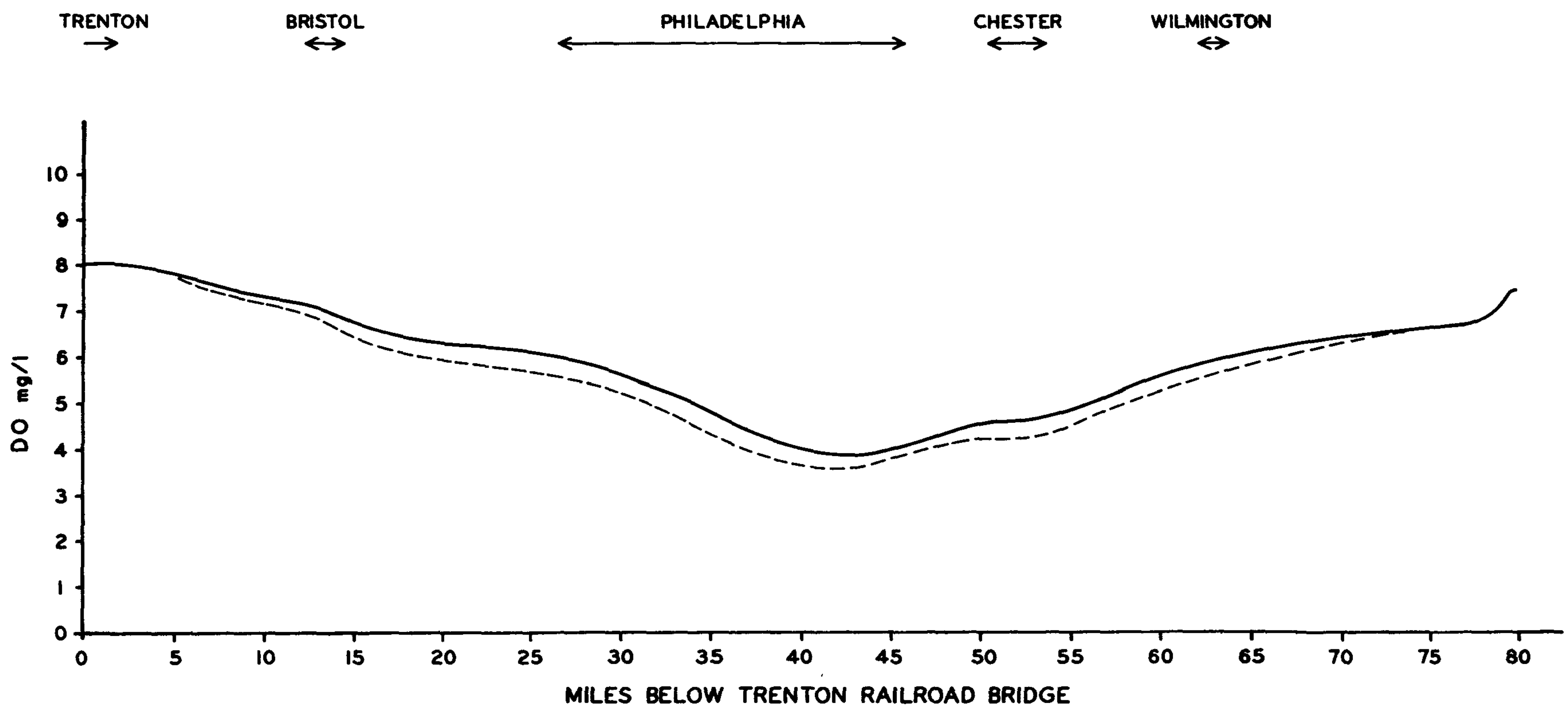


FIGURE III - 102

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	NITRIFICATION RATES	0 – 80	MILE 0 - 5 , .04 MILE 5 - 14 , .06 MILE 14 - 27 , .20 MILE 27 - 47 , .02 MILE 47 - 67 , .06 MILE 67 - 80 , .20	MILE 27 - 67 , .20

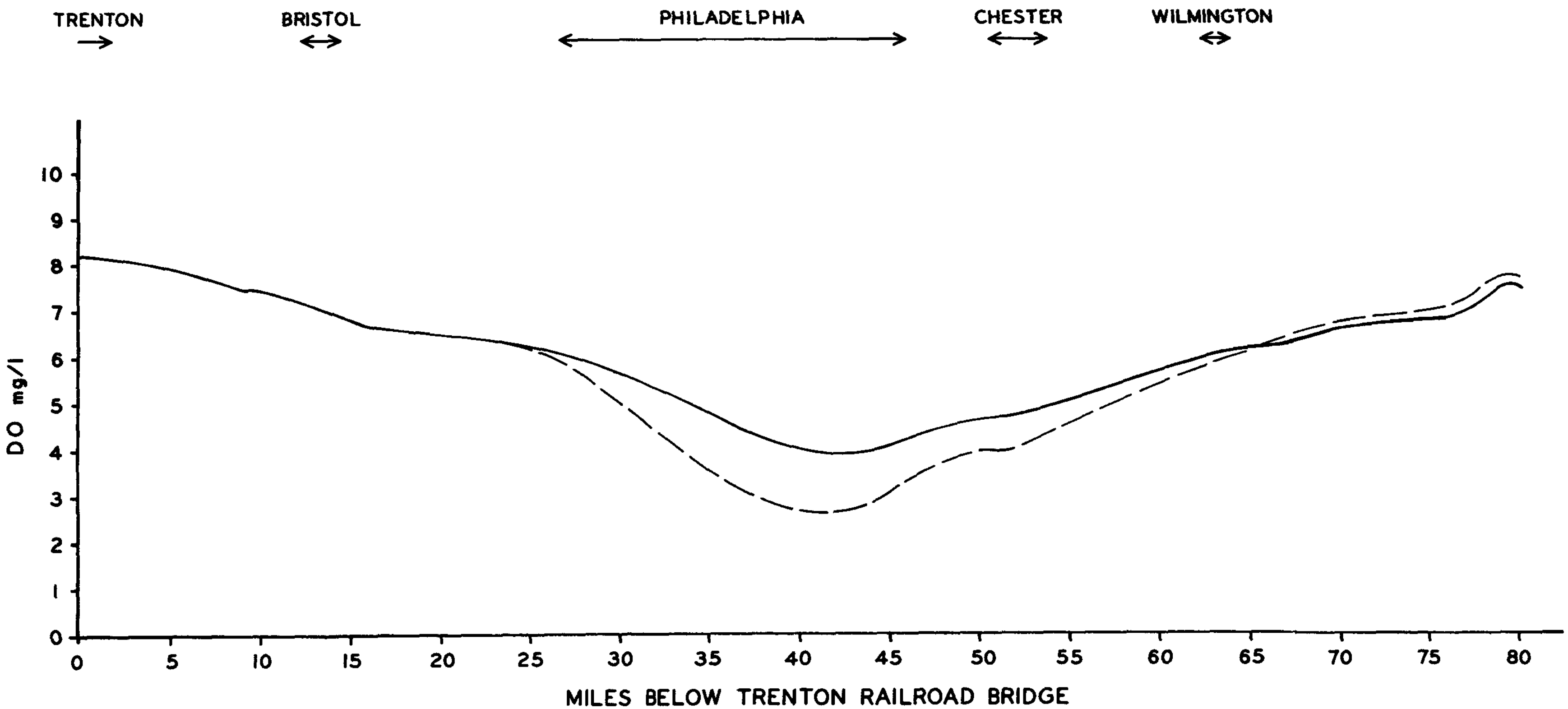


FIGURE III - 103

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	NITRIFICATION RATES	0 - 80	MILE 0 - 5 , .04	MILE 0 - 5 , .08
			MILE 5 - 14 , .06	MILE 5 - 14 , .12
JULY , 1974			MILE 14 - 27 , .20	MILE 14 - 27 , .40
			MILE 27 - 37 , .02	MILE 27 - 37 , .04
			MILE 37 - 47 , .06	MILE 37 - 47 , .12
			MILE 47 - 80 , .20	MILE 47 - 80 , .40

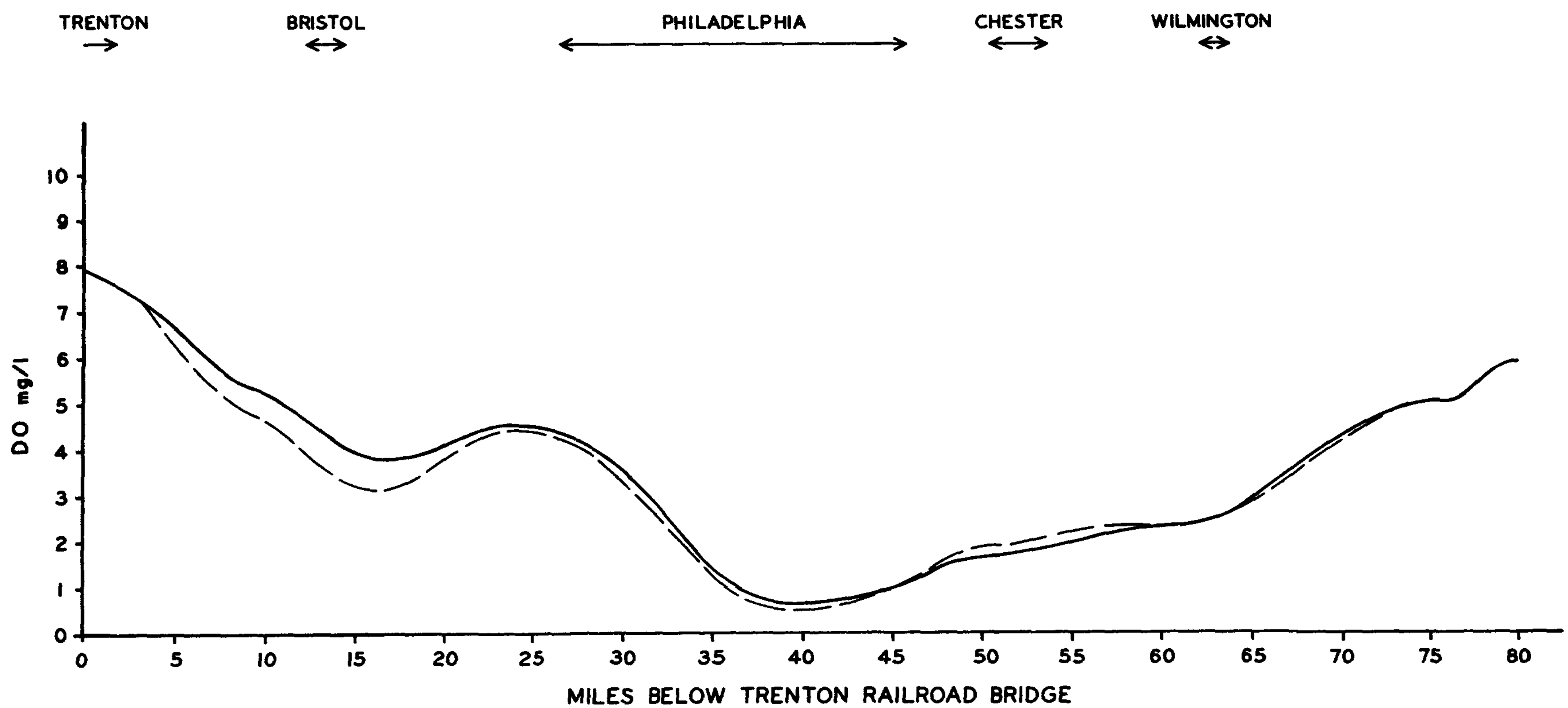


FIGURE III - 104

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	NITRIFICATION RATES	0-80	MILE 0 - 5, .04	MILE 27-47, .20
			MILE 5 - 14, .06	
JULY, 1974			MILE 14 - 27, .20	
			MILE 27-37, .02	
			MILE 37-47, .06	
			MILE 47-80, .20	

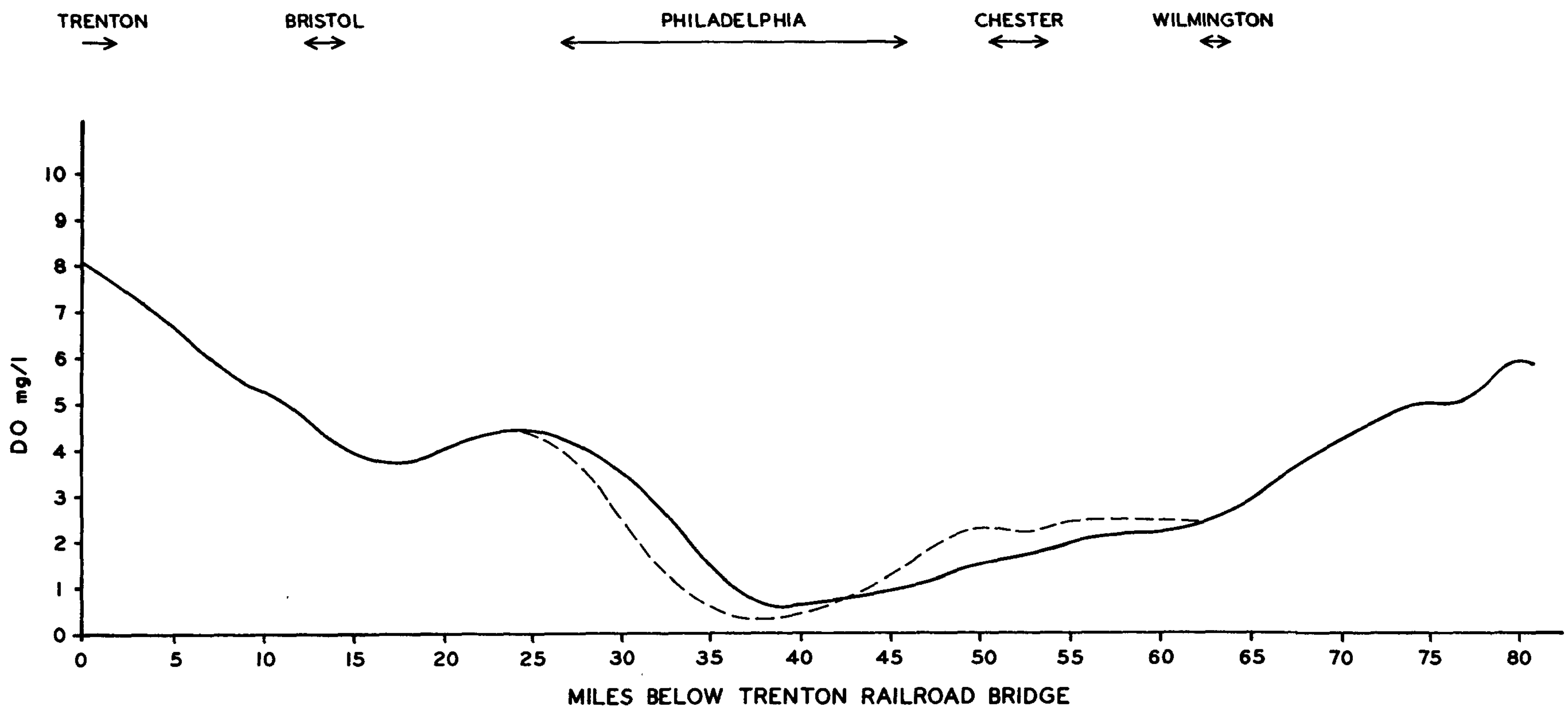


FIGURE III - 105

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER	SOD RATE	0 – 80	MILE 0 - 16 , 1.0	MILE 0 - 16 , 1.00
			MILE 16 - 23 , 0.5	MILE 16 - 23 , 0.75
LINEAR REGION			MILE 23 - 25 , 1.2	MILE 23 - 25 , 1.10
			MILE 25 - 38 , 2.2	MILE 25 - 38 , 1.60
			MILE 38 - 60 , 2.9	MILE 38 - 60 , 1.95
			MILE 60 - 80 , 1.3	MILE 60 - 80 , 1.15

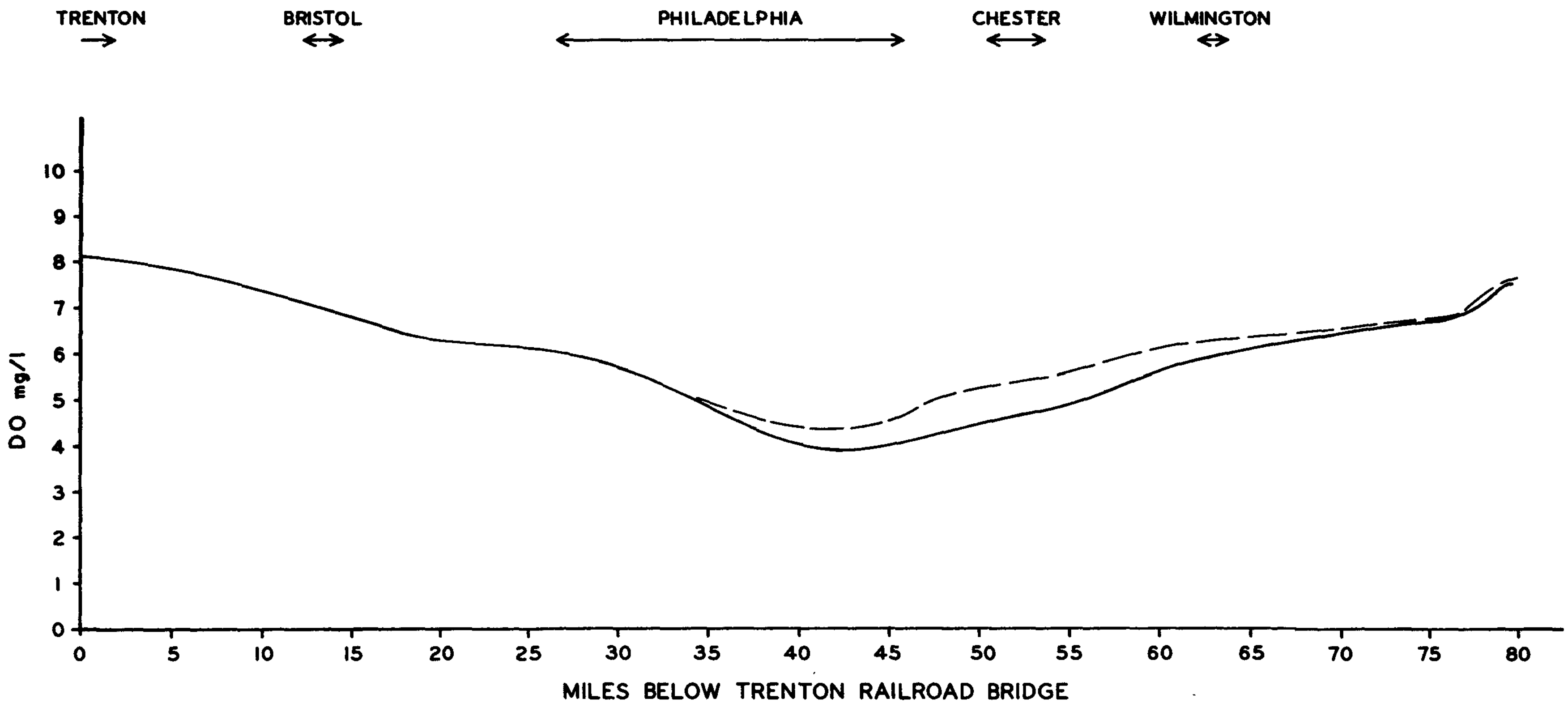


FIGURE III - 106

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	SOD RATE	16 - 80	MILE 0 - 16, 1.0 MILE 16 - 23, 0.5 MILE 23 - 25, 1.2 MILE 25 - 38, 2.2 MILE 38 - 60, 2.9 MILE 60 - 80, 1.3	MILE 16 - 80, 1.0

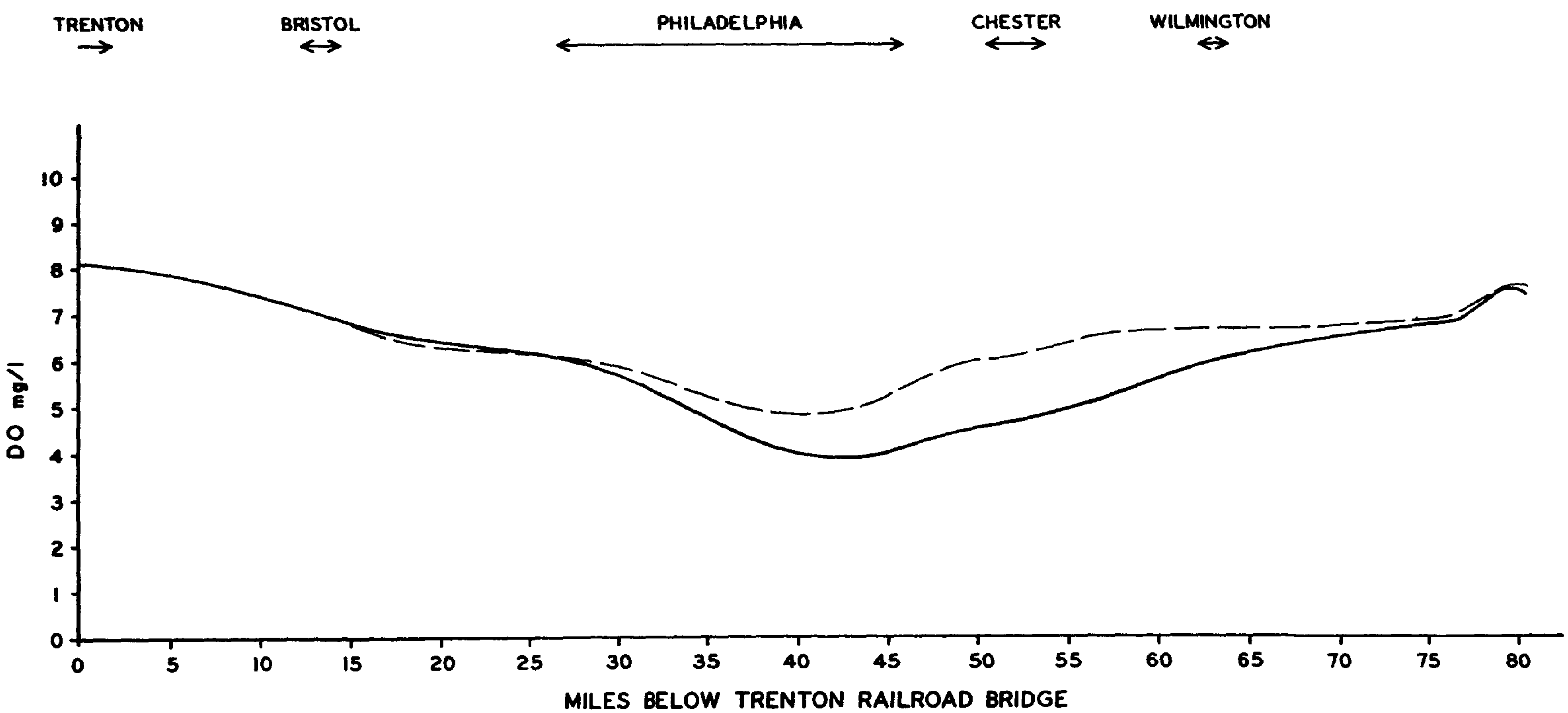


FIGURE III - 107

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	SOD RATE	0 – 80	MILE 0 – 16 , 1.0 MILE 16 – 23 , 0.5 MILE 23 – 25 , 1.2 MILE 25 – 38 , 2.2 MILE 38 – 60 , 2.9 MILE 60 – 80 , 1.3	MILE 0 – 80 , 0.0

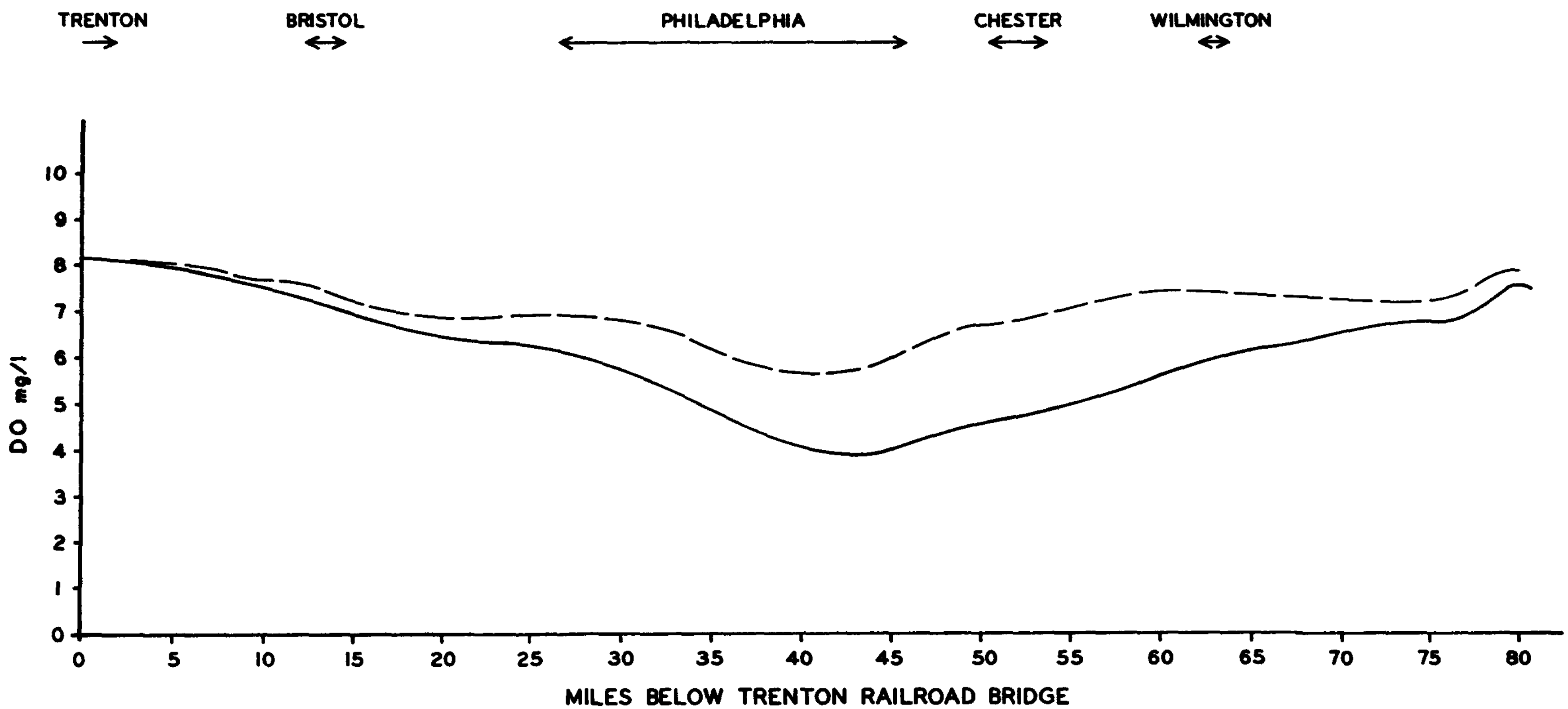


FIGURE III – 108

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR JULY, 1974	SOD RATE	16 - 80	MILE 0 - 16, 1.0 MILE 16 - 23, 0.5 MILE 23 - 25, 1.2 MILE 25 - 38, 2.2 MILE 38 - 60, 2.9 MILE 60 - 80, 1.3	MILE 0 - 80, 1.0

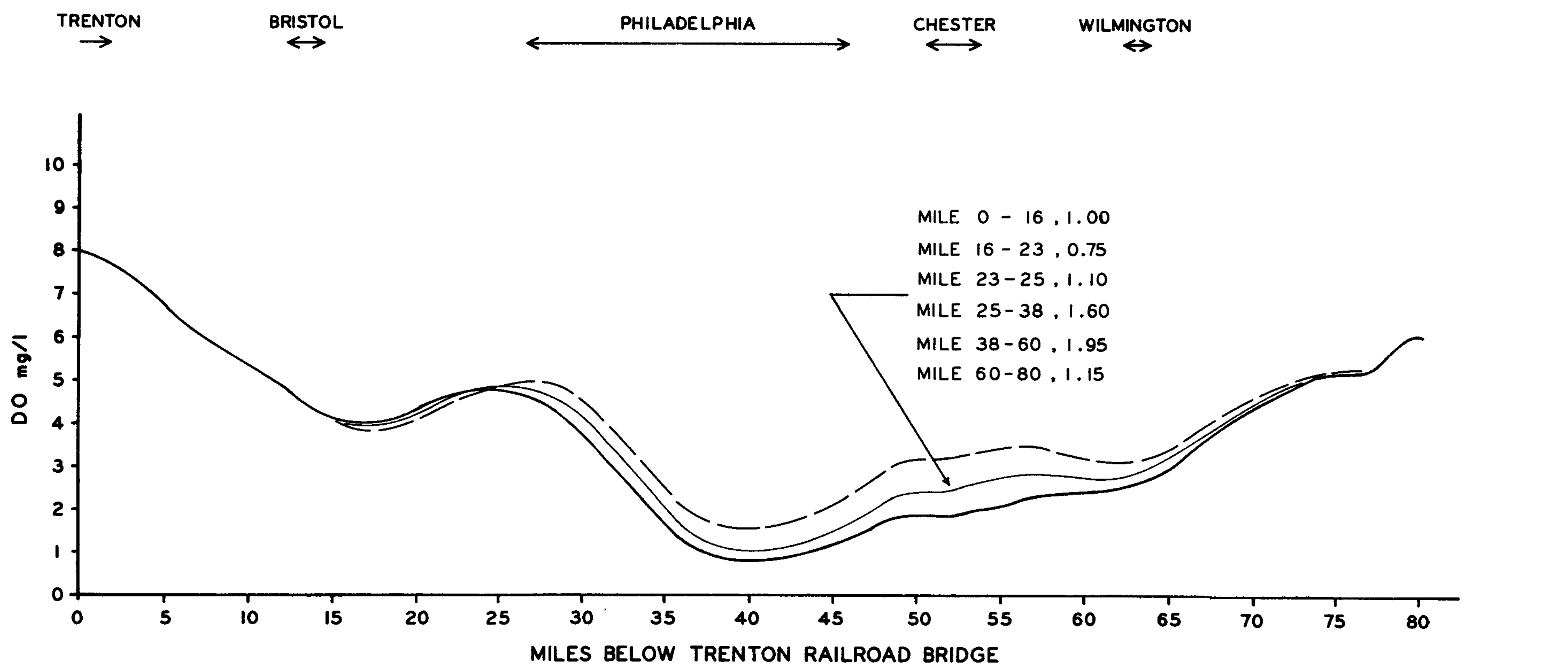


FIGURE III - 109

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	DENITRIFICATION RATES	36-46	MAXIMUM RATE = 0.28	MAXIMUM RATE = 0.0

JULY, 1974

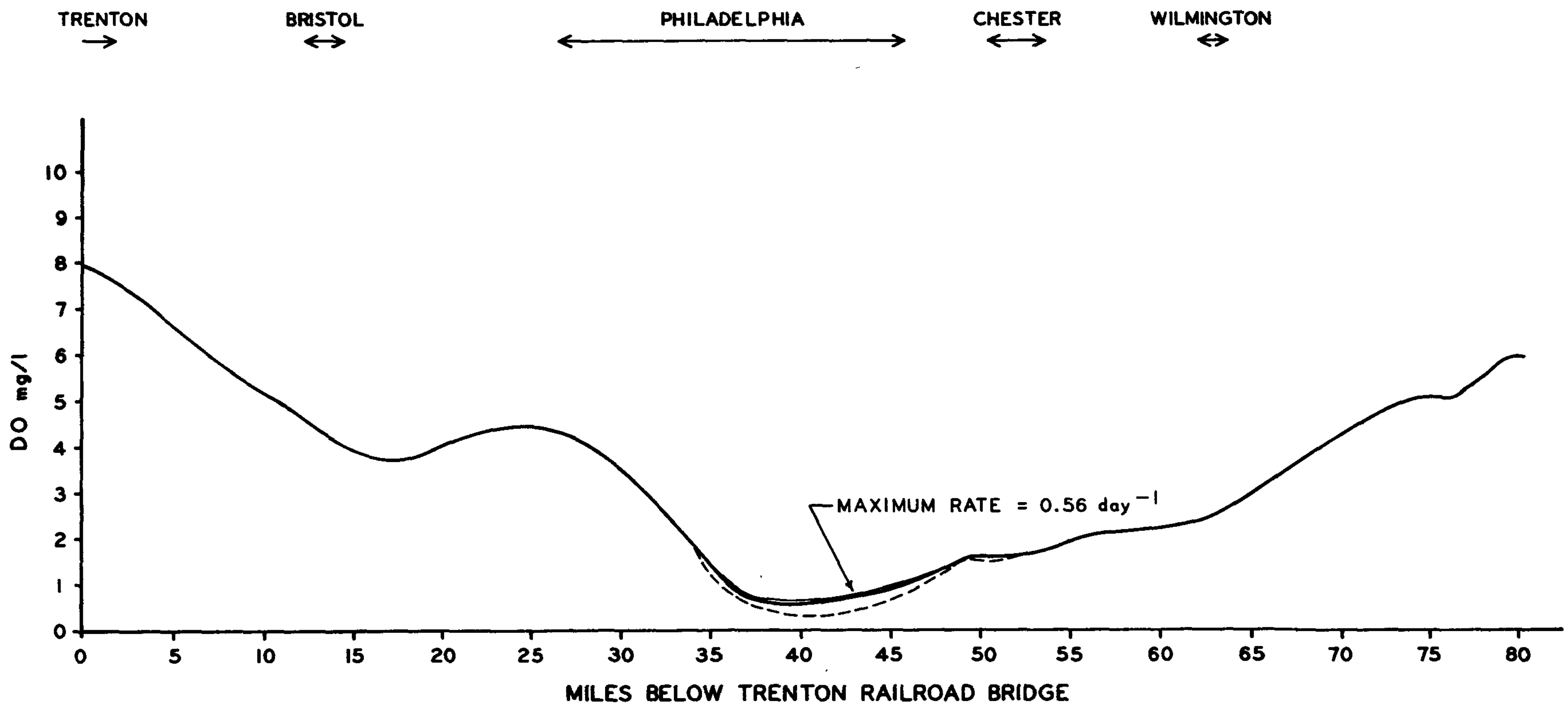


FIGURE III - 110

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	PHOTOSYNTHESIS RATE	0 - 80	MILE 0 - 80 , 0.14	MILE 0 - 80 , 0.16

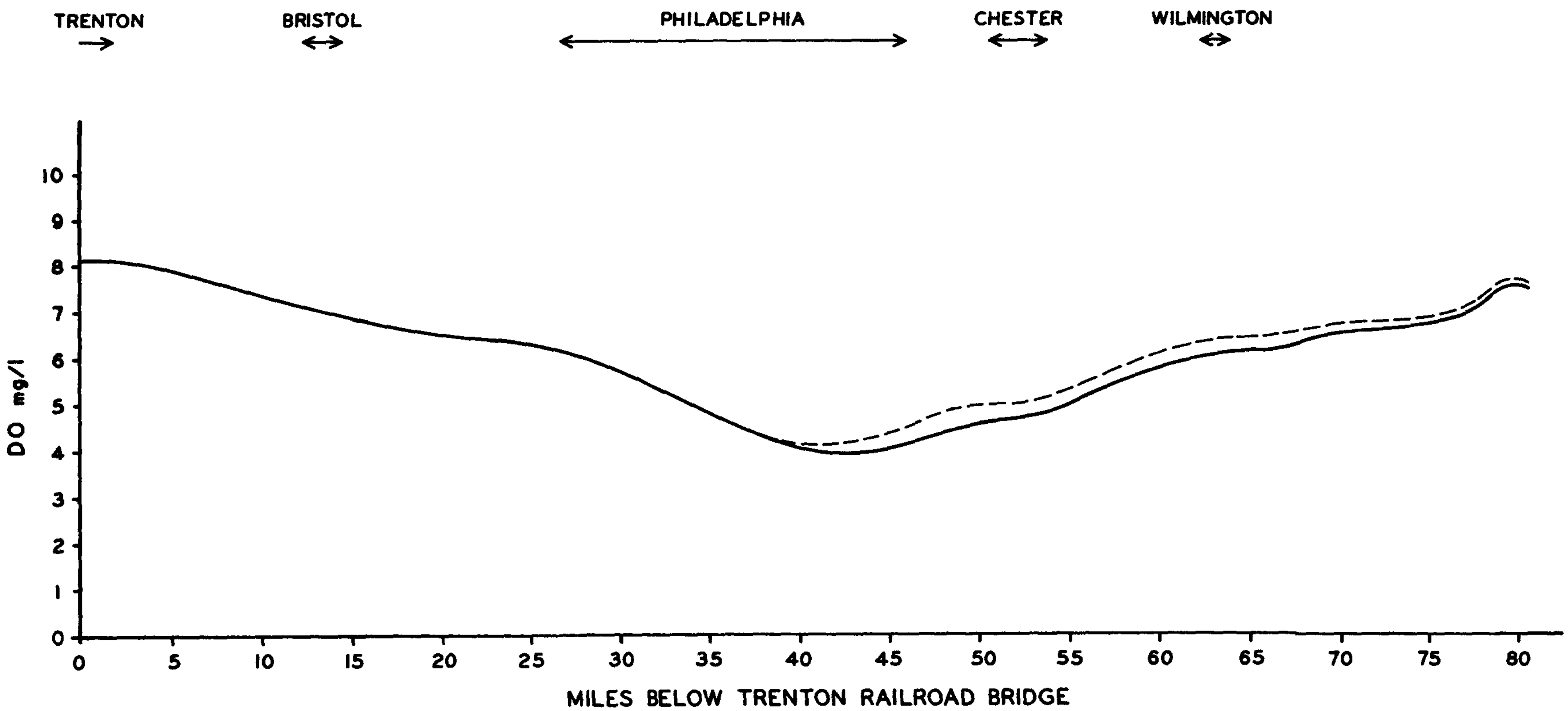


FIGURE III - 111

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	PHOTOSYNTHESIS RATE	0 – 80	MILE 0 – 80 ,0.14	MILE 0 – 80 ,0.16 MILE 0 – 80 ,0.12

JULY, 1974

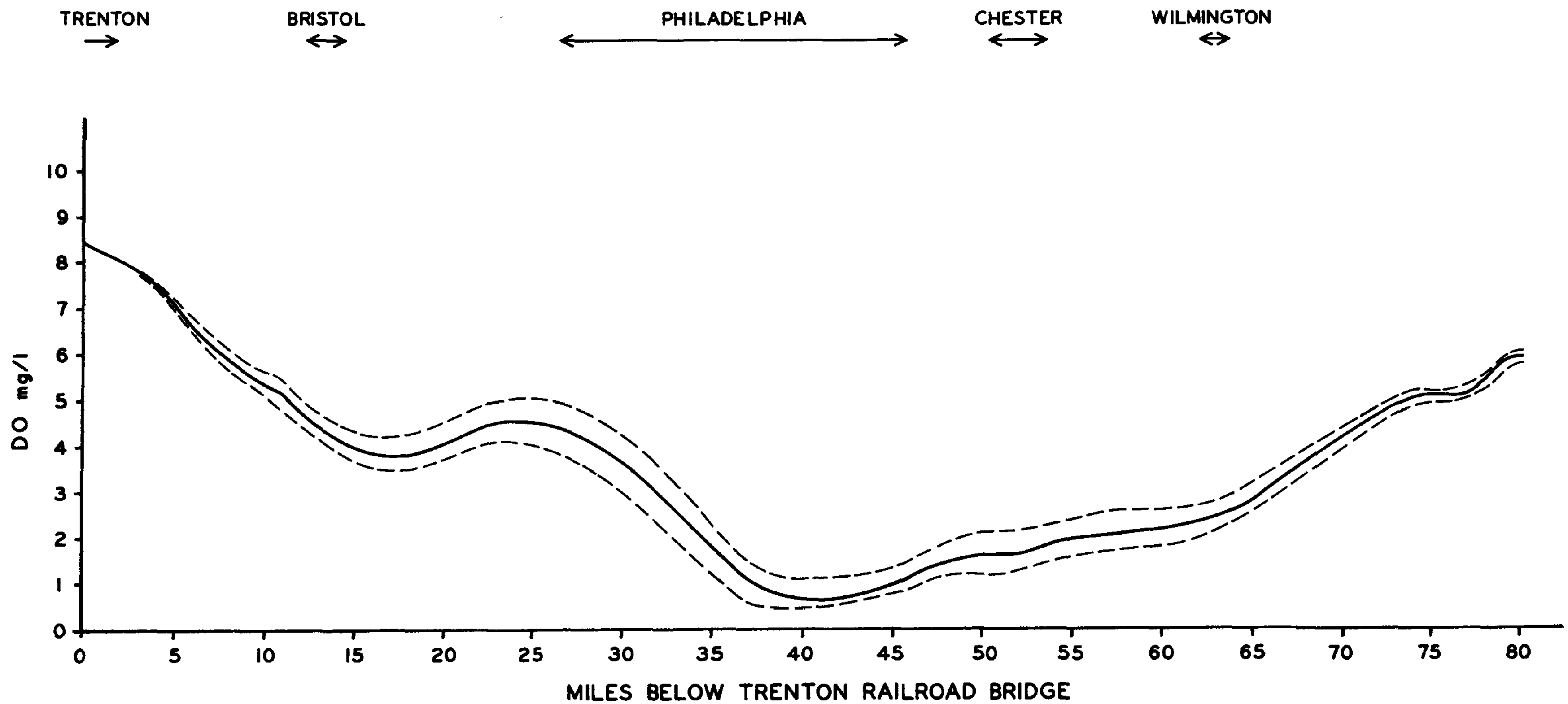


FIGURE III - 112

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER LINEAR REGION	RESPIRATION RATES	0 – 80	MILE 0 – 80, .026	MILE 0 – 80, .03

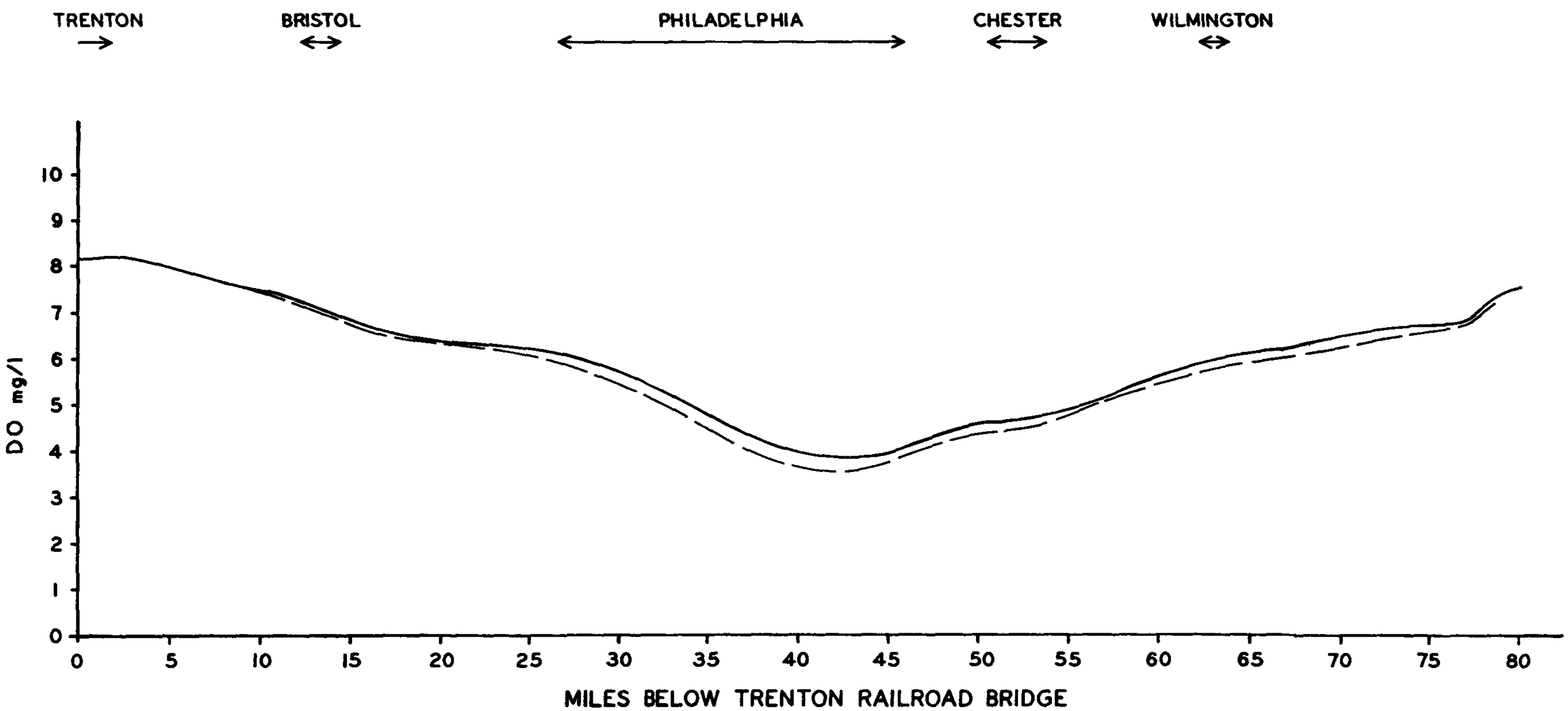


FIGURE III - 113

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	RESPIRATION RATES	0 - 80	MILE 0 - 80 , .026	MILE 0 - 80 , .03

JULY , 1974

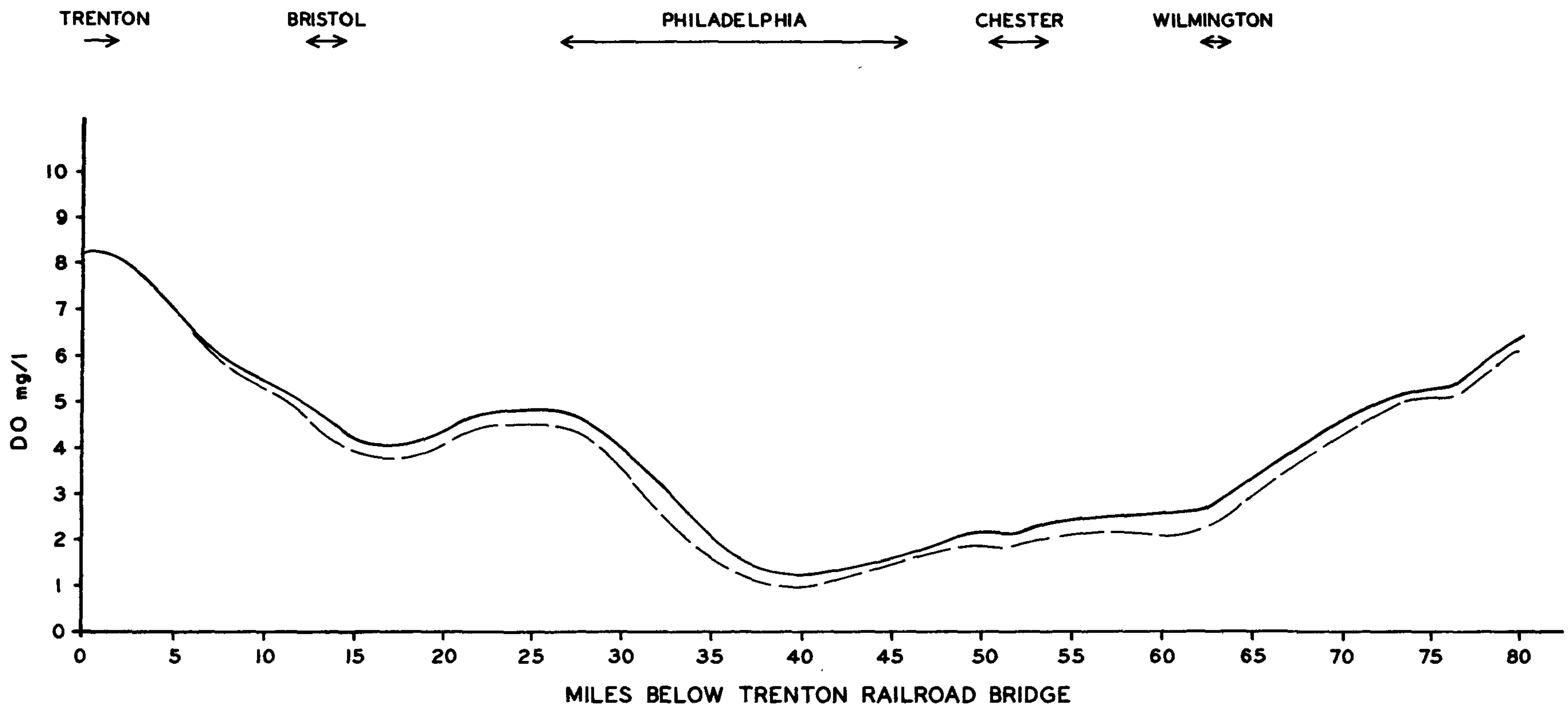


FIGURE III - 114

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER	EUPHOTIC DEPTH	0 - 80	MILE 0 - 23 , 9.0	MILE 0 - 23 , 13.5
			MILE 23-50 , 10.0	MILE 23-50 , 15.0
LINEAR REGION			MILE 50-70 , 7.7	MILE 50-70 , 11.5
			MILE 70-80 , 5.0	MILE 70-80 , 7.5

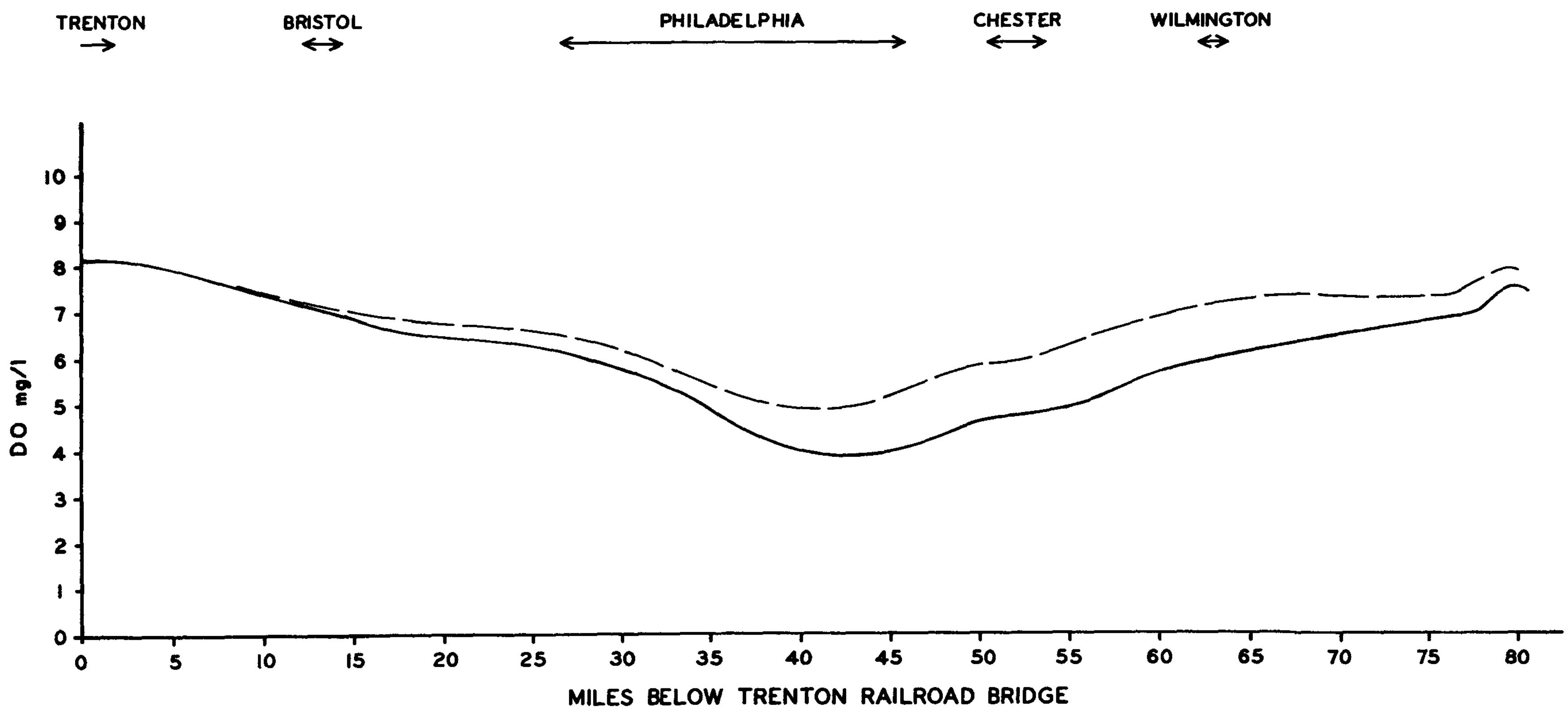


FIGURE III - 115

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	EUPHOTIC DEPTH	0 – 80	MILE 0 – 16 , 10.0	MILE 0 – 16 , 15.0
			MILE 16 – 50 , 12.0	MILE 16 – 50 , 18.0
JULY , 1974			MILE 50 – 60 , 9.0	MILE 50 – 60 , 13.5
			MILE 60 – 80 , 5.5	MILE 60 – 80 , 8.3

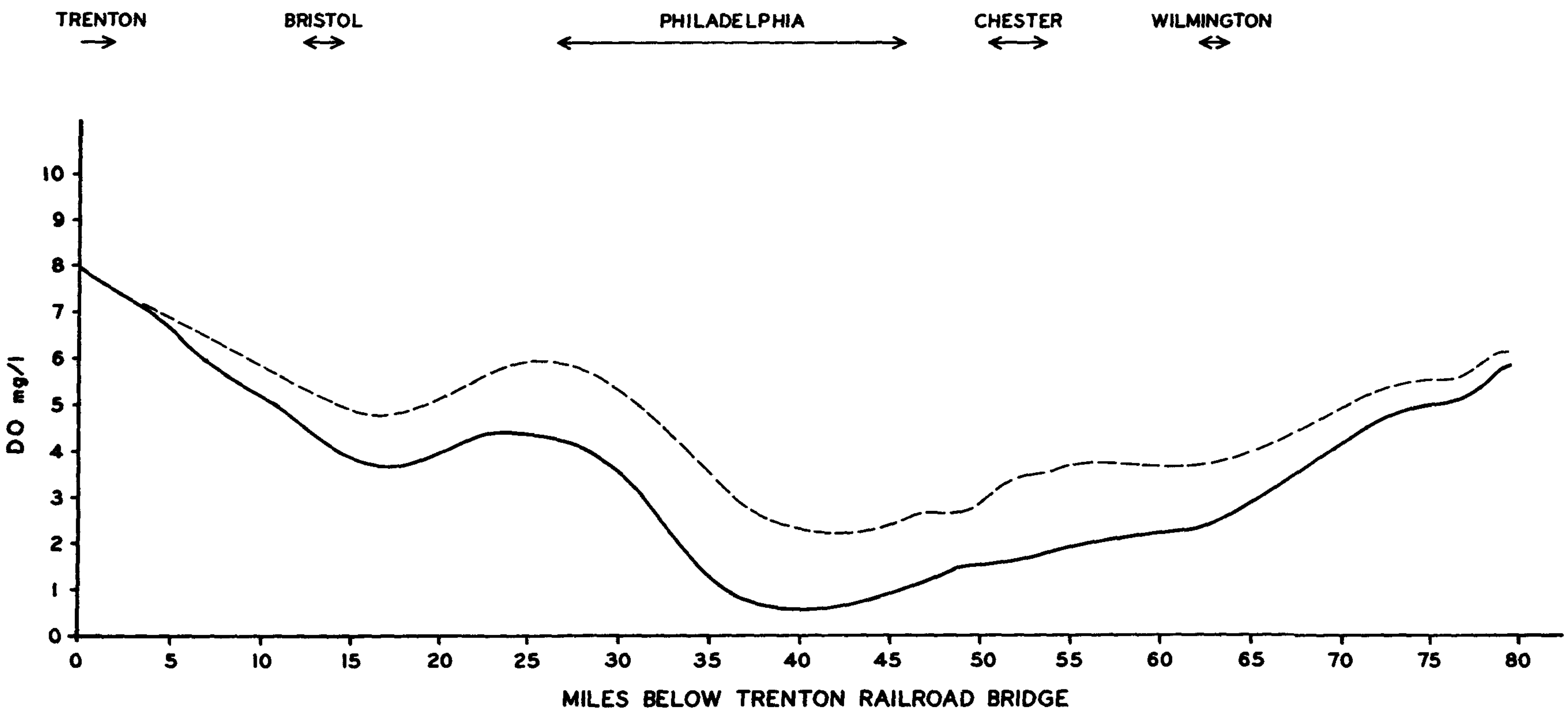


FIGURE III - 116

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
HYPOTHETICAL OCTOBER	ALGAL DENSITIES	0 - 80	MILE 0 – 25 , 10	MILE 0 – 80 , 0
LINEAR REGION			MILE 25-38 , 20	
			MILE 38-65 , 35	
			MILE 65-80 , 45	

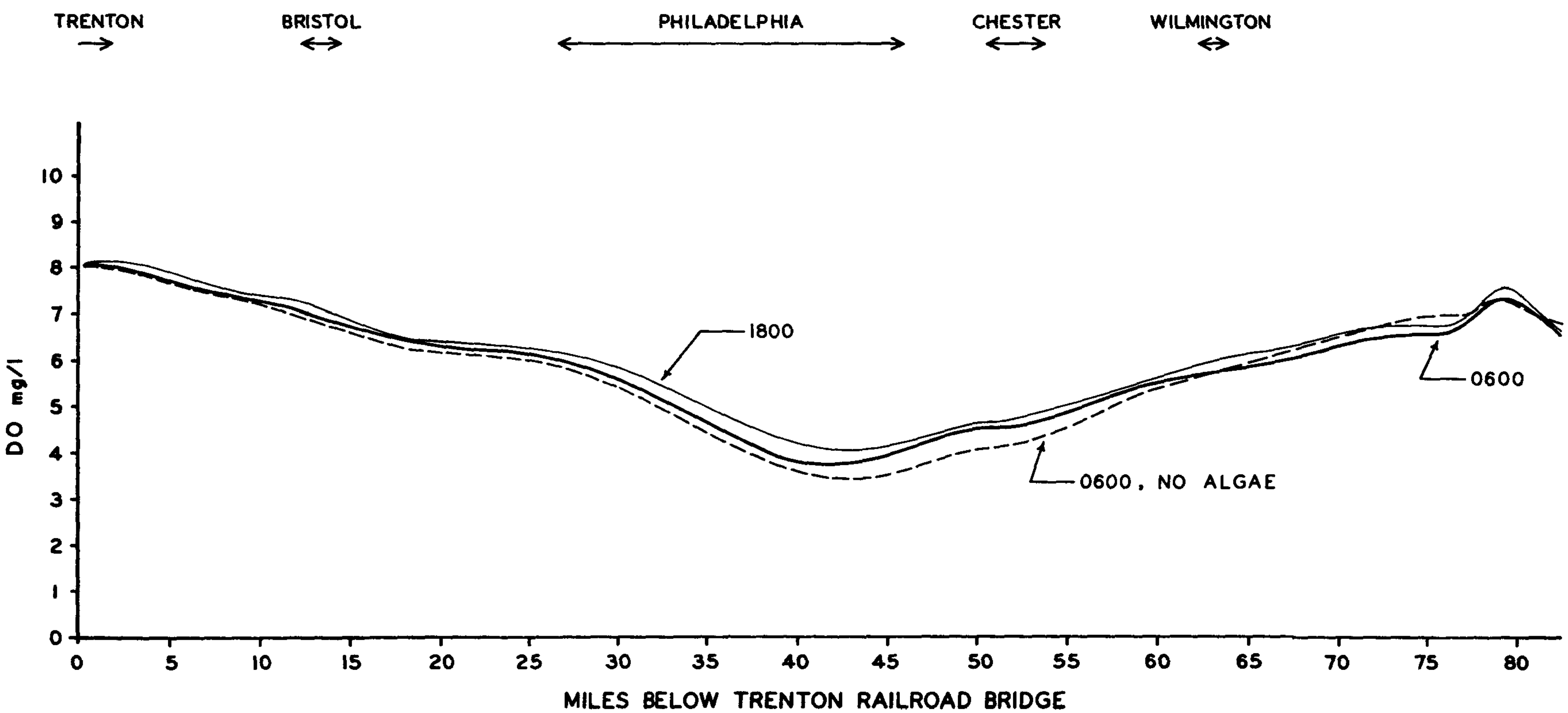


FIGURE III - 117

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
NON-LINEAR	ALGAL DENSITIES	0 - 80	MILE 0 - 25, 15	MILE 0 - 80, 0
			MILE 25-38, 25	
JULY, 1974			MILE 38-60, 35	
			MILE 60-80, 30	

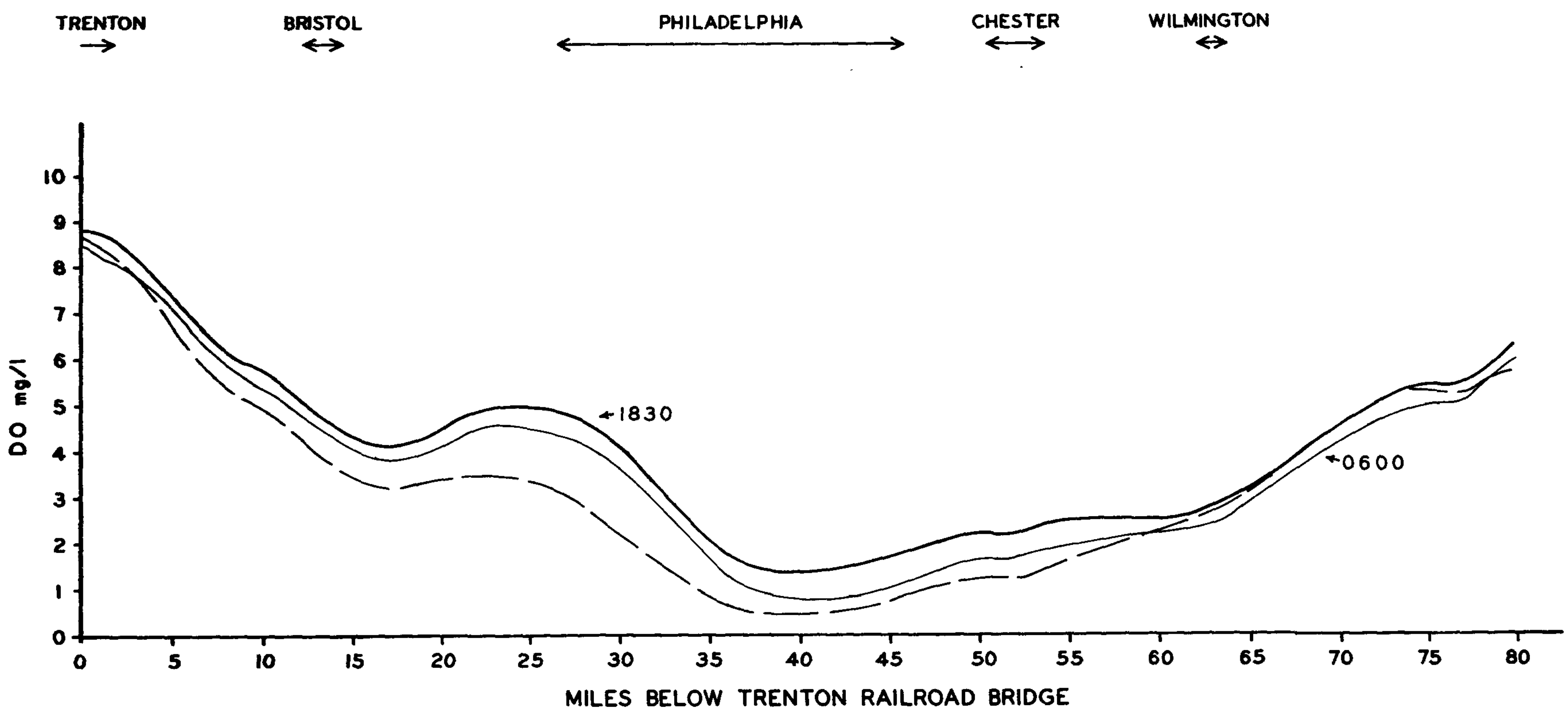


FIGURE III - 118

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
AUGUST, 1975 BLOOM CONDITION	ALGAL DENSITIES	0 – 80	MILE 0 – 16 ,15.0 MILE 16 – 35 ,12.5 MILE 35-43 , 50 MILE 43-48 ,125 MILE 48-55 ,140 MILE 55-58 ,125 MILE 58-68 , 75 MILE 68-80 , 25	MILE 0 – 80 , 0

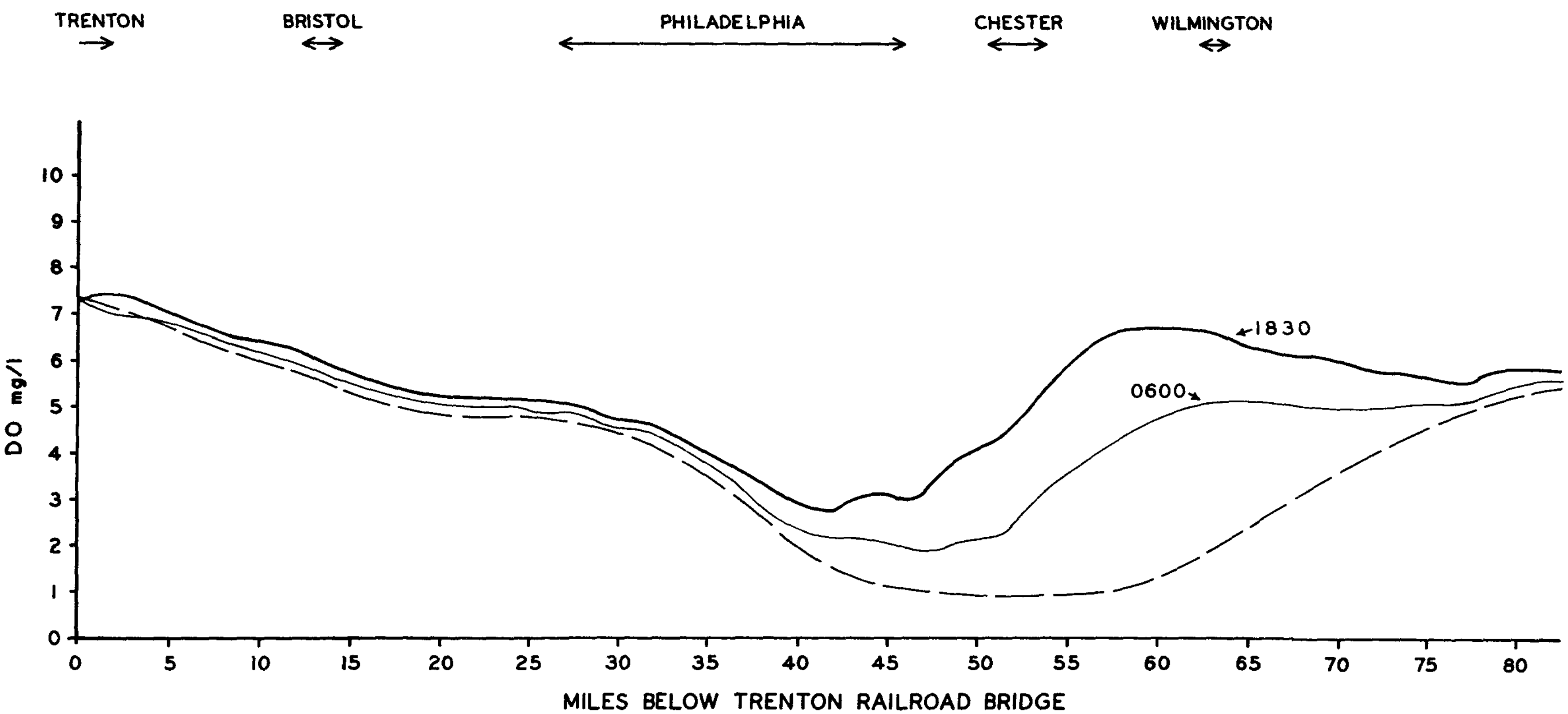


FIGURE III - 119

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
AUGUST, 1975 BLOOM CONDITION	PHOTOSYNTHESIS RATE	0 – 80	MILE 0 – 80 , .079	MILE 0 – 80 , .090 MILE 0 – 80 , .068

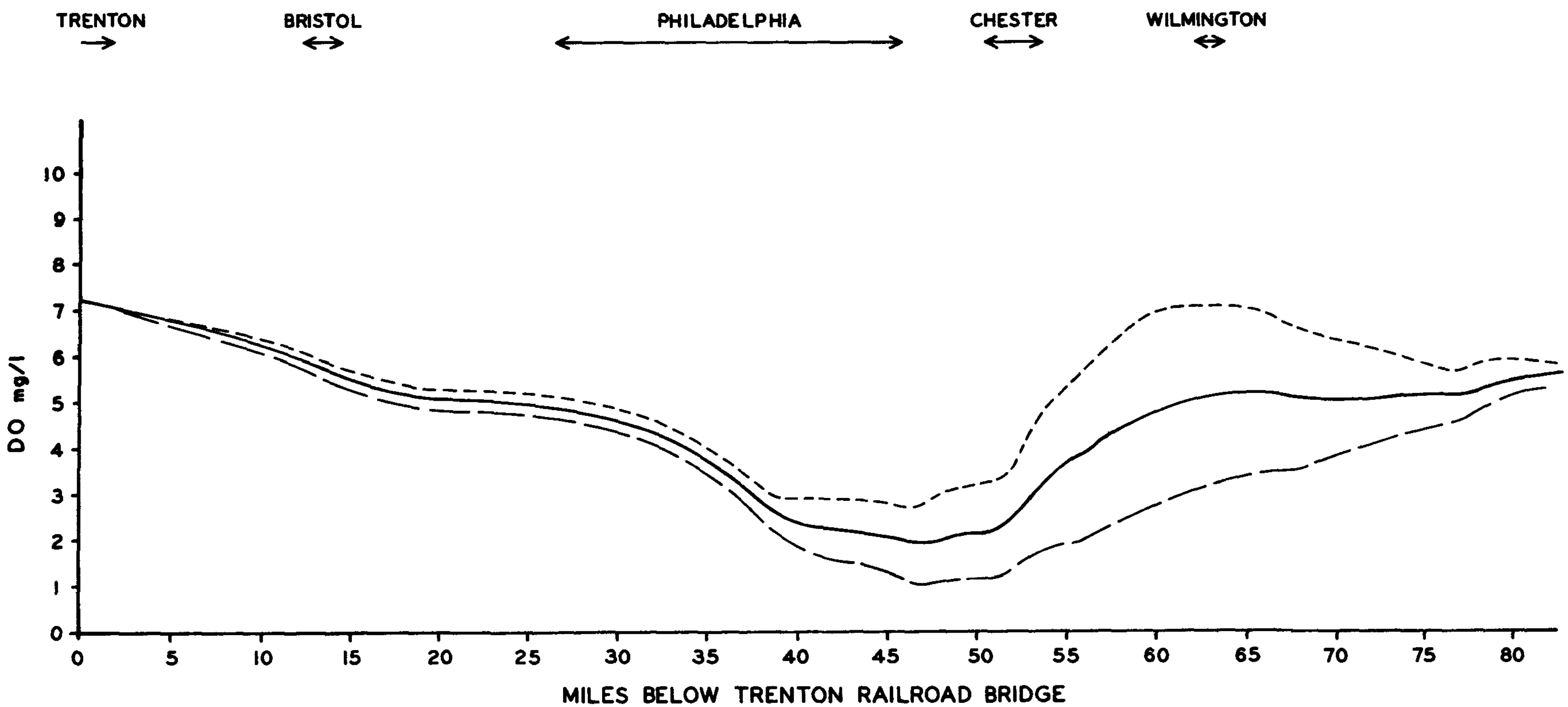


FIGURE III - 120

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
AUGUST, 1975 BLOOM CONDITION	RESPIRATION RATES	0 – 80	MILE 0 – 80 , .015	MILE 0 – 80 , .017

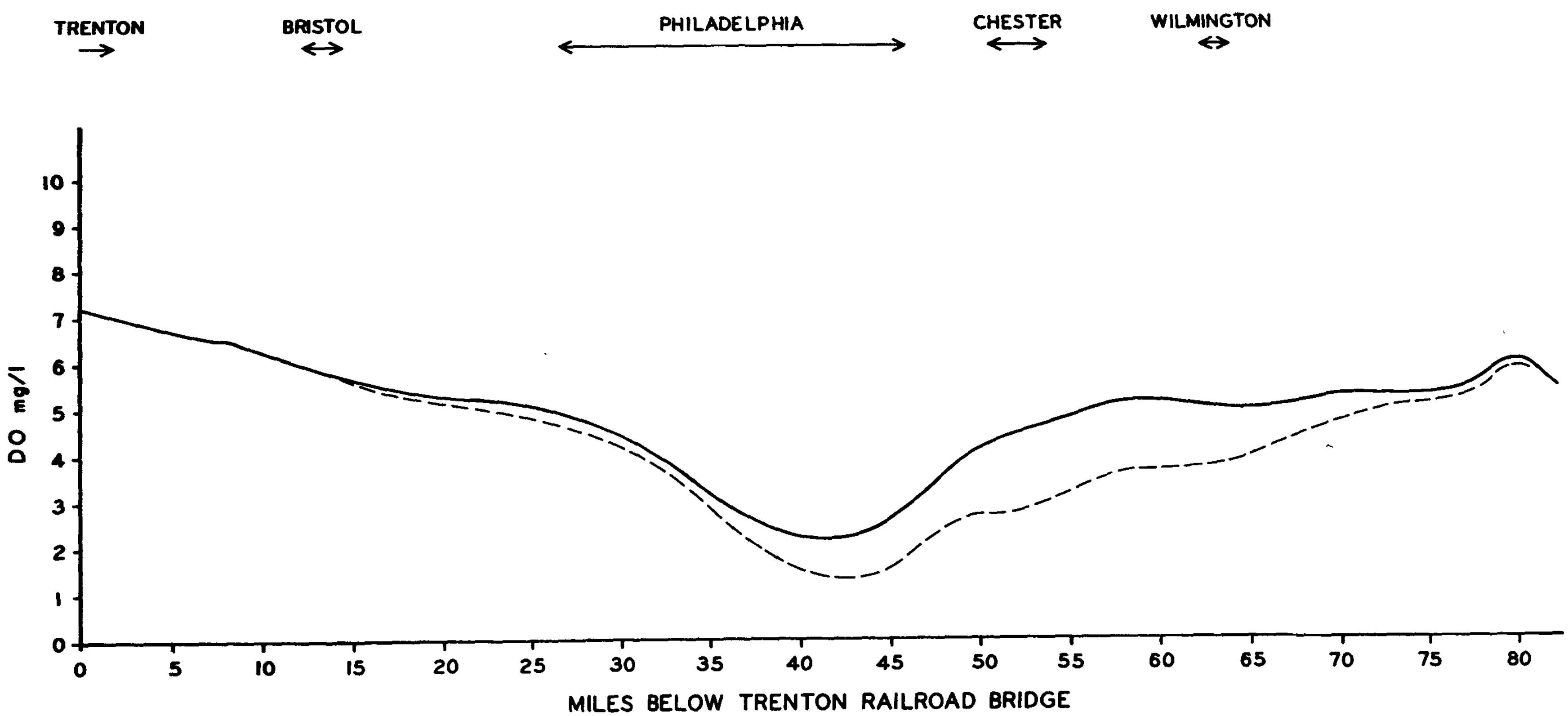


FIGURE III - 121

SENSITIVITY ANALYSIS
DELAWARE ESTUARY D.O. MODEL

BASE CONDITION	MODEL INPUT VARIED	RIVER MILEAGE AFFECTED	ORIGINAL VALUE (SOLID LINE)	NEW VALUE (DASHED LINE)
AUGUST, 1975	EUPHOTIC DEPTH	0 - 80	MILE 0 - 16 , 9.0	MILE 0 - 16 , 13.5
BLOOM CONDITION			MILE 16 - 25 , 8.0	MILE 16 - 25 , 12.0
			MILE 25 - 57 , 10.0	MILE 25 - 57 , 15.0
			MILE 57 - 70 , 8.0	MILE 57 - 70 , 12.0
			MILE 70 - 80 , 5.5	MILE 70 - 80 , 8.3

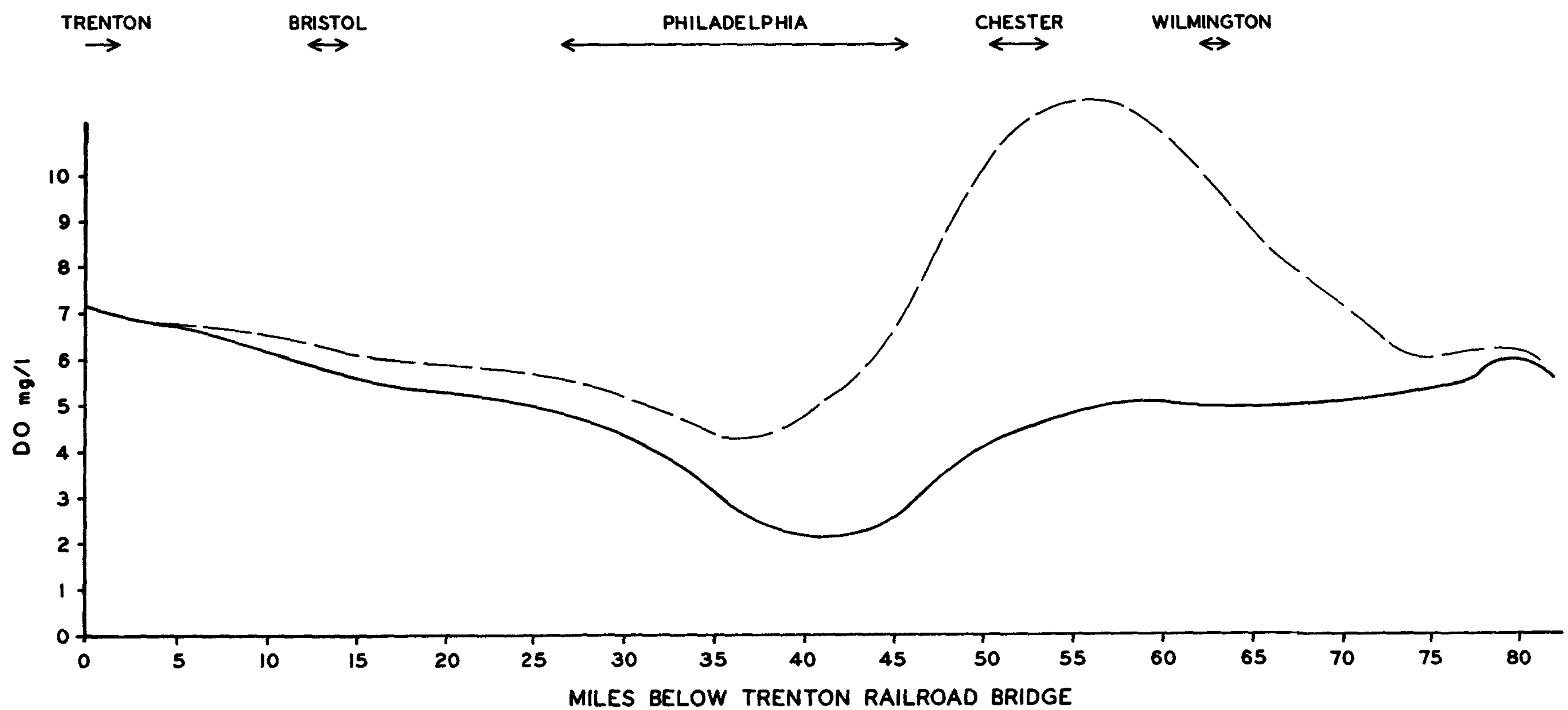


FIGURE III - 122

IV. FUTURE STUDIES AND AREAS OF MODEL REFINEMENT

Four distinct areas where future studies should be directed in the Delaware Estuary are enumerated below. If these studies are implemented and prove to be successful, it is believed that the predictive capability via mathematical modelling should be greatly enhanced in many respects.

1) The refinement of certain biological rates is perhaps the most important area to study. Of particular importance is the nitrification rate and the hypothesis currently adopted that governs the inhibition characteristics of this reaction. The revelation experienced with the 1976 data set in terms of an apparent reduction in nitrification inhibition exemplifies the need for this study. Other rates in the model which should undergo further refinement because of their particular importance are those for photosynthesis, respiration, and SOD.

2) The development and application of a model capable of addressing phytoplankton production and its relationship to nutrient cycles and the DO budget is strongly suggested by data simulation and sensitivity studies in the present study.

3) The refinement of the model's advection and dispersion components to more accurately represent these processes as they occur in a real system and to minimize numerical problems associated with the solution techniques would be desirable.

4) The development and utilization of a two dimensional network with this model would be useful to better assess the water quality impact of storm water and other shock loads as well as to improve the predictive resolution in the lateral plane where such gradients are known or suspected.

ACKNOWLEDGEMENTS

A study such as this requires the cooperation of many individuals and institutions. Data needs in particular are too intensive to be handled by one field office, or even one agency. The Delaware River Basin Commission (DRBC), with the assistance of the State of Delaware's Department of Natural Resources and Environmental Control, has compiled a very detailed water quality data base which dates to 1967. The City of Philadelphia maintains a less comprehensive but quite useful estuary monitoring program dating from 1949. The United States Geological Survey (USGS) is not only responsible for the vital discharge data from tributaries, but also several continuous water quality monitors in the estuary. The necessary physical data describing the estuary came from the U.S. Coast and Geodetic Survey.

A special body of data was generated by the "208" program under the supervision of the Delaware Valley Regional Planning Commission. Two comprehensive and intensive water quality and wastewater data sets required the cooperation of all members of the Technical Advisory Committee to the 208 program--the Delaware Department of Natural Resources and Environmental Control, the Pennsylvania Department of Environmental Resources, the New Jersey Department of Environmental Resources, the City of Philadelphia Water Department, USGS, and DRBC, along with the Annapolis Field Office.

In addition to these government agencies, we would like to specially acknowledge the numerous industries and municipalities along the estuary who provided valuable data characterizing their wastewater discharges both through the NPDES self-monitoring program and their own separate monitoring programs.

Finally, many individuals gave us valuable advice, technical assistance and independent perspectives. Deserving special mention are those persons representing the various agencies comprising the Technical Advisory Committee, including Dr. Robert Shubinski and Dick Schmaltz with Water Resources Engineers. Dr. Ken Young of GKY Associates also provided helpful advice. Dr. Thomas Tuffey, formerly at Rutgers University, and Bob Tiedemann, a former graduate student at Rutgers, gave us valuable outside perspective on the process of nitrification in the Delaware Estuary.

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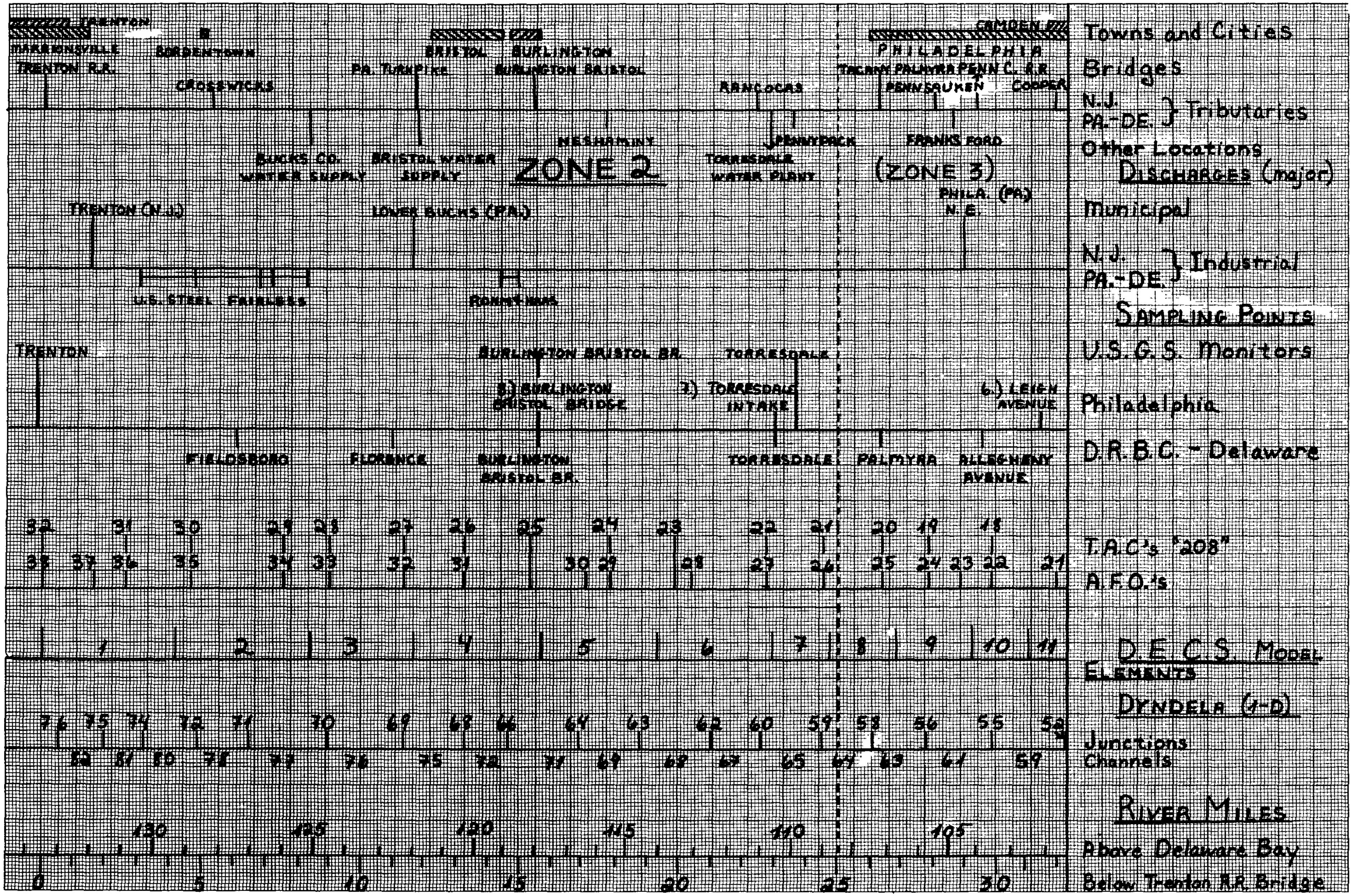
APPENDIX



TRENTON
MORRISVILLE
BORDENTOWN
BRISTOL
BURLINGTON
PHILADELPHIA
CAMDEN
TRENTON R.R.
PA. TURNPIKE
BURLINGTON BRISTOL
TACONY PALMYRA
PENN C. R.R.
CROSSWICKS
RANCOCAS
PENNSAUKEN
COOPER
BUCKS CO. WATER SUPPLY
BRISTOL WATER SUPPLY
NESHAMINY
ZONE 2
TORRESDALE WATER PLANT
PENNYPACK
FRANKS FORD
(ZONE 3)
TRENTON (N.J.)
LOWER BUCKS (PA.)
PHILA. (PA) N.E.
U.S. STEEL
FAIRLESS
ROHM & HAAS
TRENTON
BURLINGTON BRISTOL BR.
TORRESDALE
3) BURLINGTON BRISTOL BRIDGE
3) TORRESDALE INTAKE
6.) LEIGH AVENUE
FIELDSBORO
FLORENCE
BURLINGTON BRISTOL BR.
TORRESDALE
PALMYRA
ALLEGHENY AVENUE
32 31 30 29 28 27 26 25 24 23 22 21 20 19 18
38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21
1 2 3 4 5 6 7 8 9 10 11
76 75 74 72 71 70 69 68 66 64 63 62 60 59 58 56 55 53
82 81 80 78 77 76 75 72 71 69 68 67 65 64 63 61 59
130 125 120 115 110 105
0 5 10 15 20 25 30
Towns and Cities
Bridges
N.J.
PA.-DE. } Tributaries
Other Locations
Discharges (major)
Municipal
N.J.
PA.-DE. } Industrial
Sampling Points
U.S.G.S. Monitors
Philadelphia
D.R.B.C. - Delaware
T.A.C.'s "208"
A.F.O.'s
D.E.C.S. Model Elements
DYNDELA (1-D)
Junctions
Channels
River Miles
Above Delaware Bay
Below Trenton R.R. Bridge

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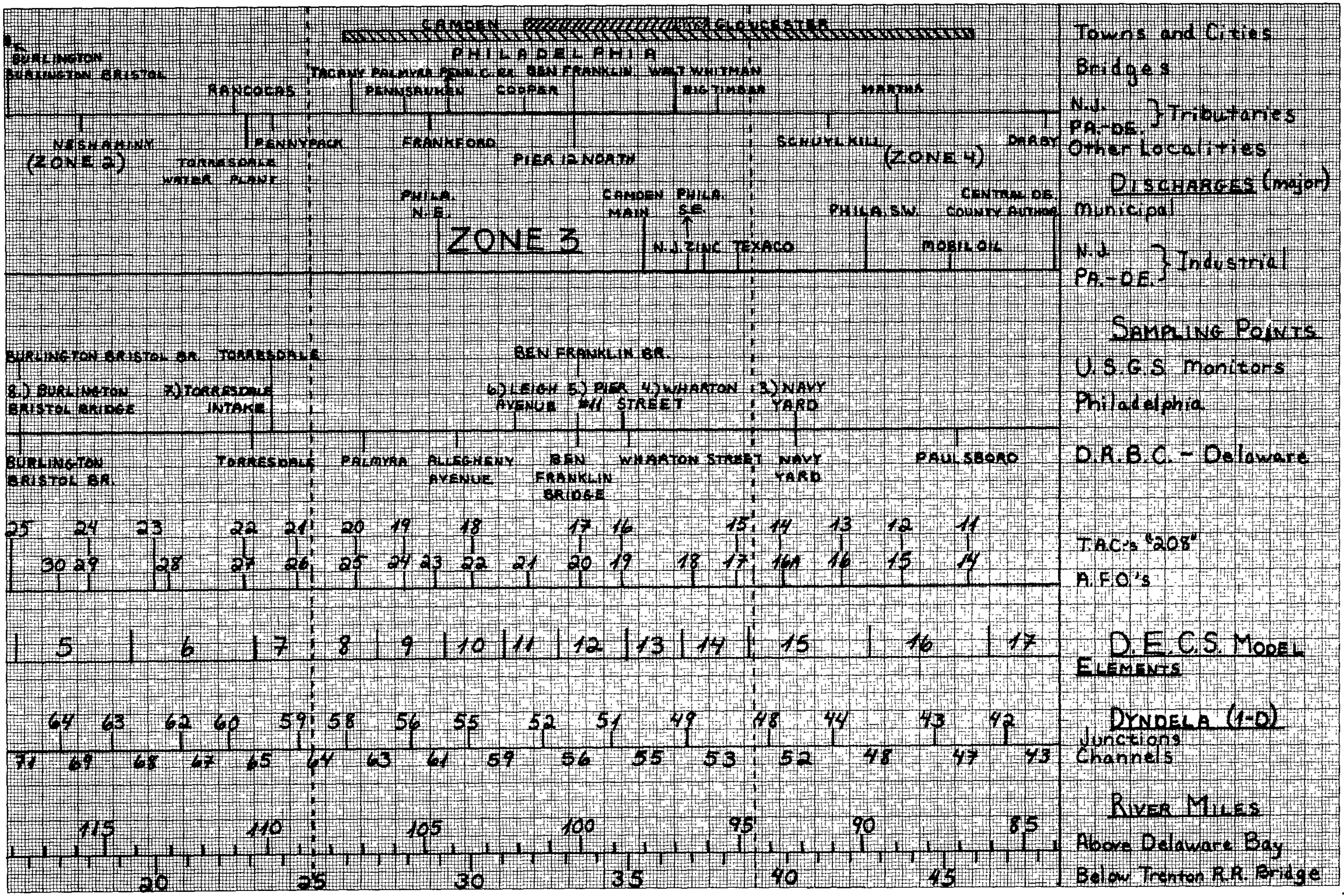
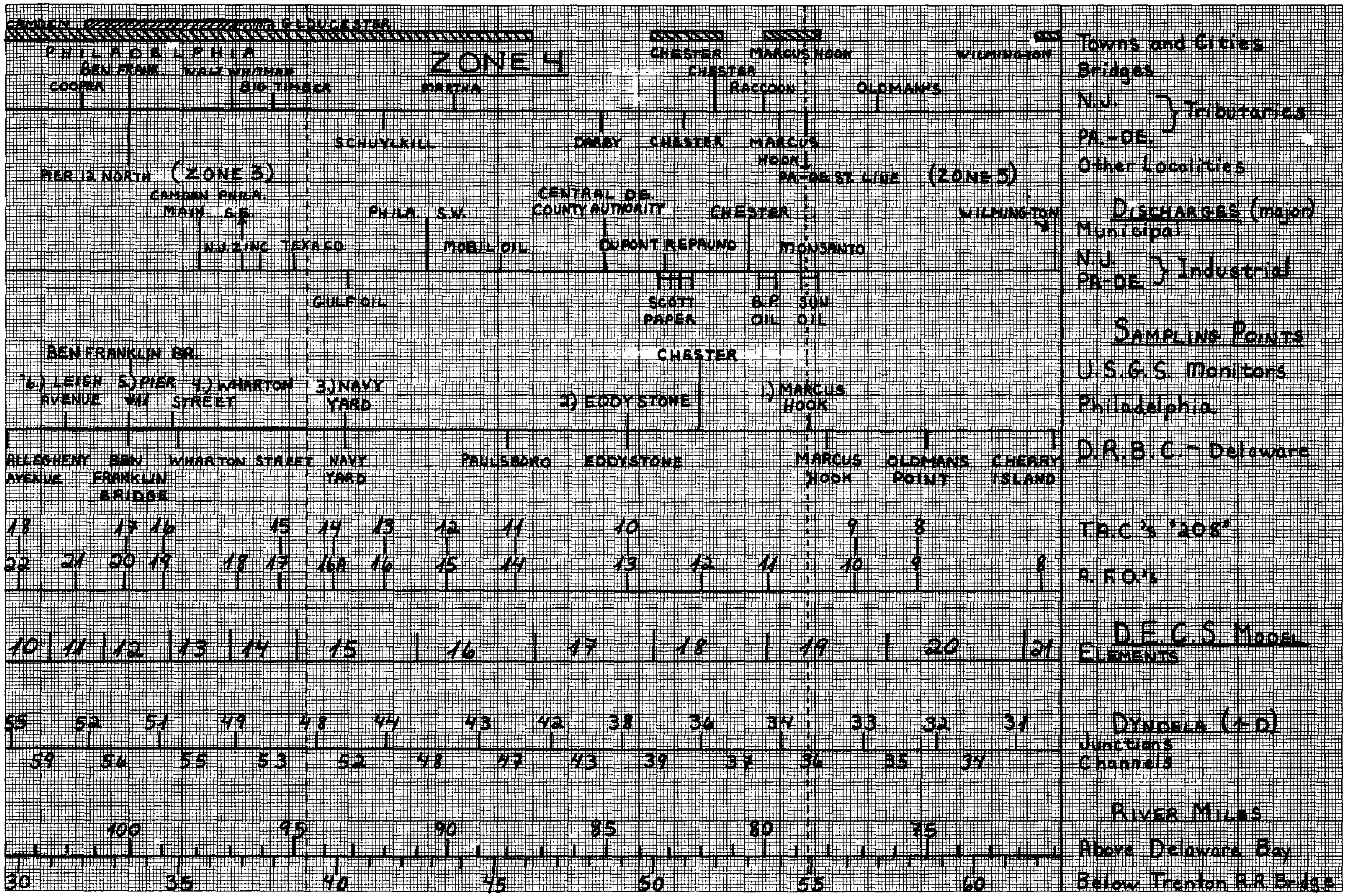


CAMDEN
GLOUCESTER
PHILADELPHIA
BURLINGTON
BURLINGTON BRISTOL
RANCOCAS
TACONY PALMYRA
PENN.C.RR
BEN FRANKLIN
WALT WHITMAN
PENNSAUKEN
COOPER
BIG TIMBER
MANTUA
NESHAMINY
PENNYPACK
FRANKFORD
SCHUYLKILL
DARBY
(ZONE 2)
TORRESDALE WATER PLANT
PIER 12 NORTH
(ZONE 4)
PHILA. N.E.
CAMDEN MAIN
PHILA. S.E.
PHILA. S.W.
CENTRAL DE. COUNTY AUTHOR.
ZONE 3
N.J. ZINC
TEXACO
MOBIL OIL
BURLINGTON BRISTOL BR.
TORRESDALE
BEN FRANKLIN BR.
8.) BURLINGTON BRISTOL BRIDGE
7.) TORRESDALE INTAKE
6.) LEIGH AVENUE
5.) PIER #11
4.) WHARTON STREET
3.) NAVY YARD
BURLINGTON BRISTOL BR.
TORRESDALE
PALMYRA
ALLEGHENY AVENUE
BEN FRANKLIN BRIDGE
WHARTON STREET
NAVY YARD
PAULSBORO
25 24 23 22 21 20 19 18 17 16 15 14 13 12 11
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16A 16 15 14
5 6 7 8 9 10 11 12 13 14 15 16 17
64 63 62 60 59 58 56 55 52 51 49 48 44 43 42
71 69 68 67 65 64 63 61 59 56 55 53 52 48 47 43
115 110 105 100 95 90 85
20 25 30 35 40 45
Towns and Cities
Bridges
N.J.
PA.-DE.
Tributaries
Other Localities
DISCHARGES (major)
Municipal
N.J.
PA.-DE.
Industrial
SAMPLING POINTS
U.S.G.S. Monitors
Philadelphia
D.R.B.C. – Delaware
T.A.C.'s "208"
A.F.O.'s
D.E.C.S. MODEL ELEMENTS
DYNDELA (1-D)
Junctions
Channels
RIVER MILES
Above Delaware Bay
Below Trenton R.R. Bridge


CAMDEN
GLOUCESTER
PHILADELPHIA
BEN FRANK.
WALT WHITMAN
COOPER
BIG TIMBER
ZONE 4
MARTHA
CHESTER
MARCUS HOOK
WILMINGTON
CHESTER
RACCOON
OLDMAN'S
SCHUYLKILL
DARBY
CHESTER
MARCUS HOOK
PIER 12 NORTH (ZONE 3)
PA-DE ST. LINE (ZONE 5)
CAMDEN PHILA. MAIN S.E.
CENTRAL DE. COUNTY AUTHORITY
PHILA. S.W.
CHESTER
WILMINGTON
N.J. ZINC
TEXACO
MOBIL OIL
DUPONT REPAUNO
MONSANTO
GULF OIL
SCOTT PAPER
B.P. OIL
SUN OIL
BEN FRANKLIN BR.
CHESTER
6.) LEIGH AVENUE
5.) PIER 11
4.) WHARTON STREET
3.) NAVY YARD
2.) EDDYSTONE
1.) MARCUS HOOK
ALLEGHENY AVENUE
BEN FRANKLIN BRIDGE
WHARTON STREET
NAVY YARD
PAULSBORO
EDDYSTONE
MARCUS HOOK
OLDMANS POINT
CHERRY ISLAND
18 17 16 15 14 13 12 11 10 9 8
22 21 20 19 18 17 16A 16 15 14 13 12 11 10 9 8
10 11 12 13 14 15 16 17 18 19 20 21
55 52 51 49 48 44 43 42 38 36 34 33 32 31
59 56 55 53 52 48 47 43 39 37 36 35 34
100 95 90 85 80 75
30 35 40 45 50 55 60
Towns and Cities
Bridges
N.J.
PA.-DE.
Tributaries
Other Localities
DISCHARGES (major)
Municipal
N.J.
PA-DE
Industrial
SAMPLING POINTS
U.S.G.S. Monitors
Philadelphia
D.R.B.C. - Delaware
T.R.C.'s "208"
R.F.O.'s
D.E.C.S. MODEL
ELEMENTS
DYNOELA (1-D)
Junctions
Channels
RIVER MILES
Above Delaware Bay
Below Trenton R.R. Bridge

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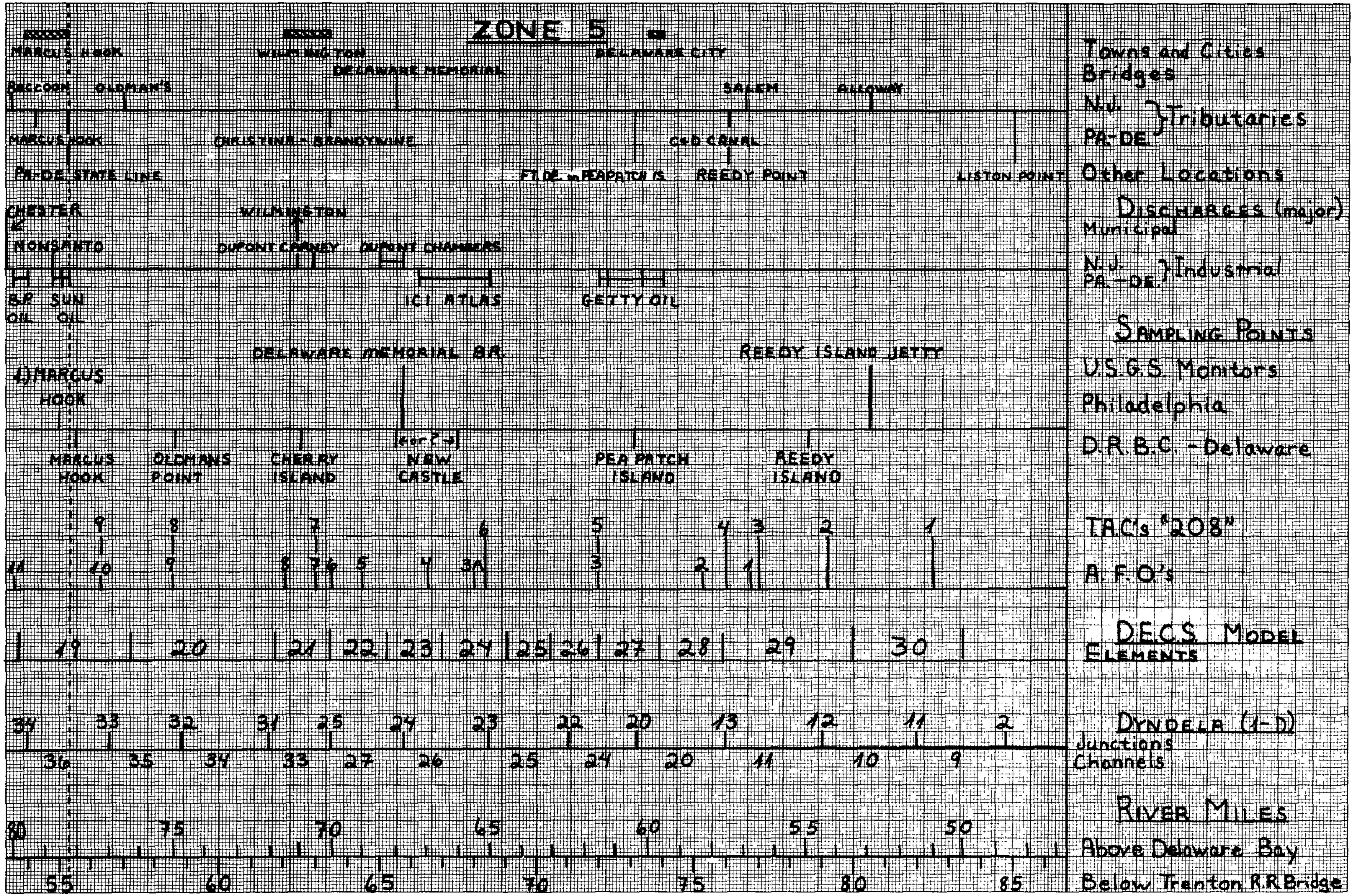
ZONE 5
MARCUS HOOK
WILMINGTON
DELAWARE CITY
DELAWARE MEMORIAL
RACCOON
OLDMAN'S
SALEM
ALLOWAY
MARCUS HOOK
CHRISTINA - BRANDYWINE
C&D CANAL
PA-DE STATE LINE
FT. DE. on PEAPATCH IS.
REEDY POINT
LISTON POINT
CHESTER
WILMINGTON
MONSANTO
DUPONT CARNEY
DUPONT CHAMBERS
B.P. OIL
SUN OIL
ICI ATLAS
GETTY OIL
DELAWARE MEMORIAL BR.
REEDY ISLAND JETTY
1) MARCUS HOOK
MARCUS HOOK
OLDMANS POINT
CHERRY ISLAND
NEW CASTLE
PEA PATCH ISLAND
REEDY ISLAND
9 8 7 6 5 4 3 2 1
11 10 9 8 7 6 5 4 3A 3 2 1
19 20 21 22 23 24 25 26 27 28 29 30
34 33 32 31 25 24 23 22 20 13 12 11 2
36 35 34 33 27 26 25 24 20 11 10 9
80 75 70 65 60 55 50
55 60 65 70 75 80 85
Towns and Cities
Bridges
N.J.
PA-DE
Tributaries
Other Locations
DISCHARGES (major)
Municipal
N.J.
PA-DE
Industrial
SAMPLING POINTS
U.S.G.S. Monitors
Philadelphia
D.R.B.C. - Delaware
T.A.C.'s "208"
A.F.O.'s
DECS MODEL ELEMENTS
DYNDELA (1-D)
Junctions
Channels
RIVER MILES
Above Delaware Bay
Below Trenton R.R. Bridge

****

SECTION 3 WATER QUALITY INPUTS

****

SUMMARY OF POINT SOURCE INPUTS

SIMULATION PERIOD : JULY 12 - 23 , 1976

CONSTITUENT 1 IS NORG (MG/L)
CONSTITUENT 2 IS NH3 (MG/L)
CONSTITUENT 3 IS NO3 (MG/L)
CONSTITUENT 4 IS CBOD (MG/L)
CONSTITUENT 5 IS DO (MG/L)

MUNICIPAL AND INDUSTRIAL WASTEWATER AND TRIBUTARY INFLOW BY NODE

INPUT NODE	NAME OF DISCHARGE	TYPE OF DISCHARGE	******* FLOW ******* MGD	CFS	UNADJUSTED CONC (MG/L) + ADJ. FACTORS CONST1	CONST2	CONST3	CONST4	CONST5	ADJUSTED INPUT LOADS - 1000 LB/DAY. CONST1	CONST2	CONST3	CONST4	CONST5
14	SALEMCTY	MUN	-2.80		2.10	8.50	0.0	48.00	5.30					
				-4.34	1.00	1.00	1.00	1.45	1.00	0.05	0.20	0.0	1.63	0.12
	NODE TOTAL			-4.34						0.05	0.20	0.0	1.63	0.12
17	SALEM	TRIB	-2.39		0.0	0.0	0.0	5.50	0.0					
				-3.70	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.16	0.0
	NODE TOTAL			-3.70						0.0	0.0	0.0	0.16	0.0
21	GETTYOIL	IND	-8.00		20.00	37.30	0.90	31.00	3.00					
				-12.40	1.00	1.00	1.00	1.90	1.00	1.34	2.49	0.06	3.93	0.20
	NODE TOTAL			-12.40						1.34	2.49	0.06	3.93	0.20
22	AMOCO	IND	-0.63		1.00	17.00	0.0	134.20	0.0					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.01	0.09	0.0	1.28	0.0
	NODE TOTAL			-0.93						0.01	0.09	0.0	1.28	0.0
23	PENNSVLE	MUN	-0.90		12.00	29.00	0.0	129.70	0.0					
				-1.39	1.00	1.00	1.00	1.45	1.00	0.09	0.22	0.0	1.41	0.0

	NODE TOTAL			-1.39						0.09	0.22	0.0	1.41	0.0
24	OPCHAMBR	IND	-100.00		5.00	12.00	13.00	102.20	4.00					
				-155.00	1.00	1.00	1.00	1.45	1.00	4.17	10.02	10.85	123.69	3.34
24	ICI 1	IND	-2.60		1.80	0.20	1.80	31.00	4.00					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.04	0.00	0.04	0.98	0.09
24	ICI 7	IND	-1.10		1.50	0.20	2040.00	24.00	5.00					
				-1.70	1.00	1.00	1.00	1.45	1.00	0.01	0.00	18.73	0.32	0.05
24	ICI 8	IND	-0.10		0.70	0.20	1.80	50.00	6.00					
				-0.16	1.00	1.00	1.00	1.45	1.00	0.00	0.00	0.00	0.06	0.01
24	ICI 13	IND	-0.90		21.00	72.00	0.90	500.00	1.00					
				-1.39	1.00	1.00	1.00	1.45	1.00	0.16	0.54	0.01	5.45	0.01
	NODE TOTAL			-162.28						4.38	10.56	29.63	130.49	3.48
25	UPENSNCK	MUN	-0.50		0.0	0.0	0.0	128.10	0.0					
				-0.78	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.78	0.0
25	WLMINGTN	MUN	-70.50		7.00	13.00	2.30	16.00	4.00					
				-109.28	1.00	1.00	1.00	1.45	1.00	4.12	7.65	1.35	13.65	2.35
	NODE TOTAL			-110.05						4.12	7.65	1.35	14.43	2.35
29	CHRISTNA	TRIB	-148.39		1.00	0.23	1.52	4.50	4.00					
				-230.00	1.00	1.00	1.00	1.45	1.00	1.24	0.28	1.88	8.08	4.95
	NODE TOTAL			-230.00						1.24	0.28	1.88	8.08	4.95
30	BRANDYWN	TRIB	-304.97		0.84	0.06	2.09	9.60	8.20					
				-472.70	1.00	1.00	1.00	1.45	1.00	2.14	0.15	5.32	35.43	20.87
	NODE TOTAL			-472.70						2.14	0.15	5.32	35.43	20.87
31	PENSGROV	MUN	-0.30		0.0	0.0	0.0	25.60	0.0					
				-0.47	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.09	0.0
31	OPEDGMOR	IND	-8.00		1.00	0.30	1.90	4.00	5.00					
				-12.40	1.00	1.00	1.00	1.90	1.00	0.07	0.02	0.13	0.51	0.33
	NODE TOTAL			-12.87						0.07	0.02	0.13	0.60	0.33
33	OLDMANS	TRIB	-31.16		1.00	0.14	1.24	3.40	5.00					
				-48.30	1.00	1.00	1.00	1.45	1.00	0.26	0.04	0.32	1.28	1.30
33	ALLDCHEM	IND	-24.40		1.20	1.50	2.00	9.00	2.00					
				-37.82	1.00	1.00	1.00	1.90	1.00	0.24	0.31	0.41	3.48	0.41
33	PHOENIX	IND	-11.00		1.09	2.51	1.97	3.80	0.0					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.10	0.23	0.18	0.66	0.0

	NODE TOTAL			-103.17						0.60	0.57	0.91	5.43	1.71
34	CHESTER	MUN	-8.80		4.80	15.60	1.10	143.00	1.00					
				-13.64	1.00	1.00	1.00	1.45	1.00	0.35	1.15	0.08	15.23	0.07
34	MARCUSHK	MUN	-0.60		22.97	15.98	2.00	137.70	0.0					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.12	0.08	0.01	1.00	0.0
34	BP 201	IND	-2.20		3.00	3.00	0.50	30.00	4.00					
				-3.41	1.00	1.00	1.00	1.90	1.00	0.06	0.06	0.01	1.05	0.07
34	BP 101	IND	-74.00		1.00	0.30	2.50	7.00	3.00					
				-114.70	1.00	1.00	1.00	1.90	1.00	0.62	0.19	1.54	8.21	1.85
34	BP 002	IND	-38.00		1.00	0.40	2.50	5.00	4.00					
				-58.90	1.00	1.00	1.00	1.90	1.00	0.32	0.13	0.79	3.01	1.27
34	FMC	IND	-2.50		1.30	0.20	2.80	114.00	6.00					
				-3.88	1.00	1.00	1.00	1.45	1.00	0.03	0.00	0.06	3.45	0.13
34	MONSANTO	IND	-1.80		25.00	44.00	0.0	187.00	1.00					
				-2.79	1.00	1.00	1.00	1.90	1.00	0.38	0.66	0.0	5.34	0.02
34	SUNOIL 1	IND	-74.00		2.50	2.90	2.80	32.00	3.00					
				-114.70	1.00	1.00	1.00	1.90	1.00	1.54	1.79	1.73	37.55	1.85
	NODE TOTAL			-312.94						3.40	4.05	4.22	74.85	5.26
36	CHESTER	TRIB	-25.81		1.00	0.30	6.30	2.70	8.00					
				-40.00	1.00	1.00	1.00	1.45	1.00	0.22	0.06	1.36	0.84	1.72
36	SCOTT 2	IND	-6.70		7.00	0.20	2.40	137.00	7.00					
				-10.39	1.00	1.00	1.00	1.90	1.00	0.39	0.01	0.13	14.56	0.39
36	SCOTT 3	IND	-7.50		9.00	0.10	2.00	100.00	7.00					
				-11.63	1.00	1.00	1.00	1.90	1.00	0.56	0.01	0.13	11.89	0.44
36	SCOTT 4	IND	-3.90		8.00	0.17	2.20	121.00	7.00					
				-6.05	1.00	1.00	1.00	1.90	1.00	0.26	0.01	0.07	7.48	0.23
	NODE TOTAL			-68.05						1.43	0.09	1.69	34.78	2.78
38	RIDLEY	TRIB	-6.58		1.07	0.50	2.59	2.30	7.40					
				-10.20	1.00	1.00	1.00	1.45	1.00	0.06	0.03	0.14	0.18	0.41
	NODE TOTAL			-10.20						0.06	0.03	0.14	0.18	0.41
39	UCARBIDE	IND	-2.60		1.90	13.91	3.90	22.40	2.50					
				-4.03	1.00	1.00	1.00	1.90	1.00	0.04	0.30	0.08	0.92	0.05
	NODE TOTAL			-4.03						0.04	0.30	0.08	0.92	0.05
40	DARBY	TRIB	-13.06		1.00	1.20	2.20	3.70	3.00					
				-28.00	1.00	1.00	1.00	1.45	1.00	0.15	0.18	0.33	0.81	0.45
40	CDCA	MUN	-8.00		2.00	20.00	0.80	50.00	3.00					
				-12.40	1.00	1.00	1.00	1.45	1.00	0.13	1.34	0.05	4.84	0.20

40	ORBYCRSA	MUN	-11.10		3.00	21.70	1.90	32.00	3.00					
				-17.21	1.00	1.00	1.00	1.45	1.00	0.28	2.01	0.18	4.30	0.28
40	MUKNPATS	MUN	-5.00		2.00	12.00	5.80	20.00	2.60					
				-7.75	1.00	1.00	1.00	1.45	1.00	0.08	0.50	0.24	1.21	0.11
40	TINICUM	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
	NODE TOTAL			-65.35						0.65	4.03	0.80	11.16	1.04
42	DPRPAUNO	IND	-15.00		2.00	5.00	22.00	31.00	6.00					
				-23.25	1.00	1.00	1.00	1.90	1.00	0.25	0.63	2.75	7.37	0.75
42	HURCULES	IND	-0.60		0.0	0.0	0.0	5.10	0.0					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.05	0.0
	NODE TOTAL			-24.18						0.25	0.63	2.75	7.42	0.75
43	GLOSTRCO	MUN	-11.40		2.40	5.70	5.80	9.00	5.00					
				-17.67	1.00	1.00	1.00	1.45	1.00	0.23	0.54	0.55	1.24	0.48
43	PAULSBRO	MUN	-1.30		0.0	26.93	0.0	64.00	0.0					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.29	0.0	1.01	0.0
43	MOBILCP1	IND	-13.30		2.00	0.0	6.00	8.00	5.00					
				-20.61	1.00	1.00	1.00	1.90	1.00	0.22	0.0	0.67	1.69	0.56
43	MOBILNY2	IND	-4.70		1.25	2.50	10.15	14.70	3.80					
				-7.28	1.00	1.00	1.00	1.90	1.00	0.05	0.10	0.40	1.10	0.15
43	MOBILIW3	IND	-4.30		0.0	29.00	0.0	76.00	0.0					
				-6.67	1.00	1.00	1.00	1.90	1.00	0.0	1.04	0.0	5.18	0.0
43	SHELL	IND	-1.90		19.19	3.71	0.0	29.30	0.0					
				-2.94	1.00	1.00	1.00	1.90	1.00	0.30	0.06	0.0	0.88	0.0
43	OLINCHEM	IND	-17.40		0.0	2.06	0.0	3.30	0.0					
				-26.97	1.00	1.00	1.00	1.90	1.00	0.0	0.30	0.0	0.91	0.0
43	MANTUA	TRIB	-7.10		0.0	5.06	0.68	4.70	0.0					
				-11.00	1.00	1.00	1.00	1.45	1.00	0.0	0.30	0.04	0.40	0.0
	NODE TOTAL			-95.16						0.80	2.63	1.66	12.41	1.18
44	PHILA SW	MUN	-140.00		5.00	6.20	0.61	44.00	4.00					
				-217.00	1.00	1.00	1.00	1.45	1.00	5.84	7.24	0.71	74.55	4.67
44	WOODBURY	MUN	-1.90		0.0	1.24	0.0	85.40	0.0					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.0	0.02	0.0	1.96	0.0
44	NAT PARK	MUN	-0.60		0.0	3.71	0.0	64.00	0.0					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.02	0.0	0.46	0.0
	NODE TOTAL			-220.87						5.84	7.28	0.71	76.98	4.67

45	GULF OIL	IND	-9.30		2.80	1.90	12.00	18.00	4.60					
				-14.42	1.00	1.00	1.00	1.90	1.00	0.22	0.15	0.93	2.65	0.36
45	ARCO SPL	IND	-3.50		2.40	0.40	3.90	5.00	-6.00					
				-5.43	1.00	1.00	1.00	1.90	-1.00	0.07	0.01	0.11	0.28	0.18
45	ARCO NYD	IND	-2.20		2.00	0.40	0.70	64.00	1.60					
				-3.41	1.00	1.00	1.00	1.90	1.00	0.04	0.01	0.01	2.23	0.03
45	ARCO WPL	IND	-0.10		2.00	3.00	0.50	8.00	3.00					
				-0.16	1.00	1.00	1.00	1.90	1.00	0.00	0.00	0.00	0.01	0.00
	NODE TOTAL			-23.40						0.33	0.17	1.06	5.18	0.56
47	SCHUYLKL	TRIB	-870.97		0.15	0.04	2.25	2.60	8.00					
				-1350.00	1.00	1.00	1.00	1.45	1.00	1.09	0.29	16.36	27.41	58.16
	NODE TOTAL			-1350.00						1.09	0.29	16.36	27.41	58.16
48	GLOSTRCY	MUN	-3.00		5.00	14.00	0.0	54.00	0.0					
				-4.65	1.00	1.00	1.00	1.45	1.00	0.13	0.35	0.0	1.96	0.0
48	BELLMAWR	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
48	BROKLAWN	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
48	MTEPHRAM	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
48	NJ ZINC	IND	-4.00		1.50	0.50	0.0	7.00	2.00					
				-6.20	1.00	1.00	1.00	1.90	1.00	0.05	0.02	0.0	0.44	0.07
48	TEXACO	IND	-4.40		1.60	0.0	4.70	10.00	5.00					
				-6.82	1.00	1.00	1.00	1.90	1.00	0.06	0.0	0.17	0.70	0.18
48	BIGTIMBR	TRIB	-45.16		1.80	0.84	1.70	5.00	5.60					
				-70.00	1.00	1.00	1.00	1.45	1.00	0.68	0.32	0.64	2.73	2.11
	NODE TOTAL			-87.67						0.91	0.68	0.81	5.84	2.36
49	PHILA SE	MUN	-131.00		6.00	2.10	1.40	89.00	4.00					
				-203.05	1.00	1.00	1.00	1.45	1.00	6.56	2.30	1.53	141.11	4.37
49	CAMDEN M	MUN	-26.00		16.00	10.00	0.0	150.00	1.00					
				-40.30	1.00	1.00	1.00	1.45	1.00	3.47	2.17	0.0	47.20	0.22
49	MCAND&FB	IND	-1.30		0.0	0.0	0.0	256.10	0.0					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	4.03	0.0
49	HARSHOW	IND	-0.60		0.0	0.0	0.0	128.10	0.0					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.93	0.0
49	GAF	IND	-11.00		1.86	0.0	0.0	23.00	0.0					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.17	0.0	0.0	4.01	0.0

	NODE TOTAL			-263.34						10.20	4.47	1.53	197.28	4.59
50	NEWTON	TRIB	-3.87		4.20	1.05	1.30	1.70	2.70					
				-6.00	1.00	1.00	1.00	1.45	1.00	0.14	0.03	0.04	0.08	0.09
	NODE TOTAL			-6.00						0.14	0.03	0.04	0.08	0.09
51	AMSTAR 1	IND	-1.90		1.60	0.50	1.60	3.00	3.60					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.03	0.01	0.03	0.07	0.06
51	AMSTAR 3	IND	-23.60		1.20	0.40	1.60	3.30	3.50					
				-36.58	1.00	1.00	1.00	1.45	1.00	0.24	0.08	0.32	0.94	0.69
	NODE TOTAL			-39.52						0.26	0.09	0.34	1.01	0.75
52	NATSUGAR	IND	-15.80		2.00	0.30	0.70	5.00	2.00					
				-24.49	1.00	1.00	1.00	1.45	1.00	0.26	0.04	0.09	0.96	0.26
	NODE TOTAL			-24.49						0.26	0.04	0.09	0.96	0.26
54	CAMDEN N	MUN	-3.20		12.00	25.00	0.0	108.00	0.0					
				-4.96	1.00	1.00	1.00	1.45	1.00	0.32	0.67	0.0	4.18	0.0
54	COOPER	TRIB	-28.39		1.80	3.00	1.30	6.00	4.40					
				-44.00	1.00	1.00	1.00	1.45	1.00	0.43	0.71	0.31	2.06	1.04
	NODE TOTAL			-48.96						0.75	1.38	0.31	6.24	1.04
55	PHILA NE	MUN	-172.00		8.00	9.90	0.50	65.00	2.60					
				-266.60	1.00	1.00	1.00	1.45	1.00	11.49	14.21	0.72	135.31	3.73
55	PENSAUKN	MUN	-4.20		7.00	17.00	0.0	162.00	0.0					
				-6.51	1.00	1.00	1.00	1.45	1.00	0.25	0.60	0.0	8.23	0.0
55	GEORGPAC	IND	-0.80		6.00	0.10	0.10	503.00	1.00					
				-1.24	1.00	1.00	1.00	1.45	1.00	0.04	0.00	0.00	4.87	0.01
	NODE TOTAL			-274.35						11.77	14.81	0.72	148.41	3.74
56	FRANKFRT	TRIB	-6.45		1.00	1.32	2.00	6.90	3.40					
				-10.00	1.00	1.00	1.00	1.45	1.00	0.05	0.07	0.11	0.54	0.18
	NODE TOTAL			-10.00						0.05	0.07	0.11	0.54	0.18
57	MTLAUREL	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
57	PENSAUKN	TRIB	-11.61		1.50	2.00	1.70	6.40	3.00					
				-18.00	1.00	1.00	1.00	1.45	1.00	0.15	0.19	0.16	0.90	0.29
	NODE TOTAL			-18.00						0.15	0.19	0.16	0.90	0.29
58	PALMYRA	MUN	-0.40		4.90	32.40	3.50	47.60	3.50					
				-0.62	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.01	0.23	0.01

	NODE TOTAL			-0.62						0.02	0.11	0.01	0.23	0.01
59	CINAMNSN	MUN	-2.00		8.00	16.00	0.0	30.00	3.00					
				-3.10	1.00	1.00	1.00	1.45	1.00	0.13	0.27	0.0	0.73	0.05
59	PENYPACK	TRIB	-3.23		1.00	0.10	3.20	1.00	10.40					
				-5.00	1.00	1.00	1.00	1.45	1.00	0.03	0.00	0.09	0.04	0.28
	NODE TOTAL			-8.10						0.16	0.27	0.09	0.77	0.33
60	POQUESNG	TRIB	-3.23		1.00	0.10	3.20	1.00	10.40					
				-5.00	1.00	1.00	1.00	1.45	1.00	0.03	0.00	0.09	0.04	0.28
	NODE TOTAL			-5.00						0.03	0.00	0.09	0.04	0.28
61	WLINGBRO	MUN	-1.90		1.24	0.0	0.0	38.40	0.0					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.02	0.0	0.0	0.88	0.0
61	RANCOCAS	TRIB	-154.84		1.20	0.20	1.40	3.50	7.00					
				-240.00	1.00	1.00	1.00	1.45	1.00	1.55	0.26	1.81	6.56	9.05
	NODE TOTAL			-242.94						1.57	0.26	1.81	7.44	9.05
64	BRLINGTN	MUN	-1.20		9.00	4.00	0.0	150.00	0.0					
				-1.86	1.00	1.00	1.00	1.45	1.00	0.09	0.04	0.0	2.18	0.0
64	TENNECO	IND	-1.30		6.00	18.00	3.10	34.50	3.30					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.07	0.20	0.03	0.54	0.04
	NODE TOTAL			-3.88						0.16	0.24	0.03	2.72	0.04
65	FALLSTWP	MUN	-2.60		14.39	2.32	11.14	9.60	0.0					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.31	0.05	0.24	0.30	0.0
65	NESHAMNY	TRIB	-100.26		1.04	0.12	3.00	1.70	8.30					
				-155.40	1.00	1.00	1.00	1.45	1.00	0.87	0.10	2.51	2.06	6.95
	NODE TOTAL			-159.43						1.18	0.15	2.75	2.36	6.95
66	BRSTLBRO	MUN	-1.70		4.00	8.00	2.80	42.00	7.00					
				-2.63	1.00	1.00	1.00	1.45	1.00	0.06	0.11	0.04	0.86	0.10
66	BRSTLTWP	MUN	-1.70		12.00	15.00	0.80	20.00	2.00					
				-2.63	1.00	1.00	1.00	1.45	1.00	0.17	0.21	0.01	0.41	0.03
66	ROHM&HAS	IND	-1.00		8.00	0.10	0.40	22.00	5.00					
				-1.55	1.00	1.00	1.00	1.45	1.00	0.07	0.00	0.00	0.27	0.04
66	OTR&ASNK	TRIB	-6.45		0.0	0.0	0.0	12.30	0.0					
				-10.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.96	0.0
	NODE TOTAL			-16.82						0.29	0.33	0.05	2.50	0.17

69	FLORENCE	MUN	-0.60		3.71	11.14	0.0	64.00	5.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.06	0.0	0.46	0.03
69	LWRBUCKS	MUN	-7.90		5.00	20.00	0.50	18.00	3.60					
				-12.25	1.00	1.00	1.00	1.45	1.00	0.33	1.32	0.03	1.72	0.24
69	BRIPARCH	IND	-3.20		22.29	0.37	0.0	12.80	0.0					
				-4.96	1.00	1.00	1.00	1.45	1.00	0.60	0.01	0.0	0.50	0.0
69	MARTINS	TRIB	-5.48		0.0	0.0	0.0	3.60	0.0					
				-8.50	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.24	0.0
	NODE TOTAL			-26.63						0.94	1.38	0.03	2.92	0.26
71	USSRODML	IND	-7.00		1.00	2.80	1.20	2.00	6.00					
				-10.85	1.00	1.00	1.00	0.0	1.00	0.06	0.16	0.07	0.0	0.35
71	USSTRMTP	IND	-61.30		1.00	2.30	1.50	2.00	5.00					
				-95.02	1.00	1.00	1.00	1.45	1.00	0.51	1.18	0.77	1.48	2.56
	NODE TOTAL			-105.87						0.57	1.34	0.84	1.48	2.91
72	BORDENTN	MUN	-1.00		3.60	14.60	0.0	48.30	5.00					
				-1.55	1.00	1.00	1.00	1.45	1.00	0.03	0.12	0.0	0.58	0.04
	NODE TOTAL			-1.55						0.03	0.12	0.0	0.58	0.04
73	HAMILTON	MUN	-8.60		5.00	25.00	3.00	18.00	4.00					
				-13.33	1.00	1.00	1.00	1.45	1.00	0.36	1.79	0.22	1.87	0.29
73	CROSWICK	TRIB	-40.65		0.80	0.14	1.24	3.00	7.00					
				-63.00	1.00	1.00	1.00	1.45	1.00	0.27	0.05	0.42	1.48	2.37
	NODE TOTAL			-76.33						0.63	1.84	0.64	3.35	2.66
75	TRENTON	MUN	-19.00		6.00	45.00	0.0	90.00	1.00					
				-29.45	1.00	1.00	1.00	1.45	1.00	0.95	7.14	0.0	20.70	0.16
	NODE TOTAL			-29.45						0.95	7.14	0.0	20.70	0.16
76	MORRISVL	MUN	-3.70		1.00	31.50	1.81	18.00	7.40					
				-5.73	1.00	1.00	1.00	1.45	1.00	0.03	0.97	0.06	0.81	0.23
76	ASSNPINK	TRIB	-65.81		0.80	0.67	2.40	3.00	7.20					
				-102.00	1.00	1.00	1.00	1.45	1.00	0.44	0.37	1.32	2.39	3.95
	NODE TOTAL			-107.73						0.47	1.34	1.37	3.20	4.18

SUMMARY OF DISCHARGE LOADS BY ZONE AND TYPE

INPUT ZONE	TYPE OF DISCHARGE	NUMBER OF DISCHARGES	ADJUSTED INPUT LOADS - 1000 LB/DAY CONST1	CONST2	CONST3	CONST4	CONST5	INPUT LOADS - PERCENT OF ZONE BY TYPE CONST1	CONST2	CONST3	CONST4	CONST5
1	MUN	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	IND	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	TRIB	1.	11.61	2.90	29.03	156.32	385.62	100.00	100.00	100.00	100.00	100.00
	ZONE TOTAL	1.	11.61	2.90	29.03	156.32	385.62	16.34	3.59	26.48	15.33	72.10
2	MUN	12.	2.50	12.08	0.60	31.51	1.16	35.82	83.86	7.75	65.56	4.28
2	IND	5.	1.30	1.55	0.87	2.79	2.99	18.57	10.73	11.35	5.80	11.05
2	TRIB	8.	3.19	0.78	6.23	13.76	22.88	45.61	5.41	80.89	28.64	84.67
	ZONE TOTAL	25.	6.99	14.41	7.70	48.06	27.02	9.83	17.81	7.03	4.71	5.05
3	MUN	7.	22.10	20.05	2.26	336.26	8.34	93.65	94.64	68.16	94.55	76.08
3	IND	7.	0.74	0.13	0.43	15.81	1.02	3.12	0.60	13.07	4.45	9.28
3	TRIB	4.	0.76	1.01	0.62	3.58	1.60	3.23	4.77	18.77	1.01	14.64
	ZONE TOTAL	18.	23.60	21.19	3.32	355.65	10.96	33.22	26.19	3.03	34.87	2.05
4	MUN	15.	7.16	13.54	1.83	107.77	5.81	48.35	67.11	6.03	41.91	7.52
4	IND	23.	5.45	5.46	9.60	116.98	8.57	36.83	27.04	31.69	45.49	11.10
4	TRIB	6.	2.19	1.18	18.87	32.38	62.85	14.82	5.85	62.28	12.59	81.38
	ZONE TOTAL	44.	14.81	20.18	30.30	257.13	77.23	20.85	24.94	27.64	25.21	14.44
5	MUN	5.	4.26	8.07	1.35	17.56	2.48	30.35	36.28	3.45	8.66	7.28
5	IND	10.	6.14	13.70	30.40	140.36	4.43	43.73	61.59	77.40	69.18	13.00
5	TRIB	4.	3.64	0.47	7.53	44.96	27.13	25.92	2.13	19.16	22.16	79.72
	ZONE TOTAL	19.	14.03	22.24	39.28	202.87	34.03	19.75	27.48	35.83	19.89	6.36
	GRAND TOTAL	107.	71.03	80.91	109.62	1020.03	534.86					

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SECTION 4 WATER QUALITY BOUNDARY CONDITIONS

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SEAWARD BOUNDARY CONDITIONS

NODE 1 : COURTHOUSE PT , MARYLAND

' CIN1 ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.30	0.30	1.00	2.00	7.00

NODE 2 : LISTON PT , DELAWARE

' CINMAX ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.20	0.10	1.60	1.50	6.00

UPSTREAM BOUNDARY CONDITIONS

NODE 76 RECIEVES VARYING LOADS FROM DELAWARE (RIVR)

FLOW PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	FLOW (CFS)
1	2400	-7880.00

QUAL PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	1100	0.28	0.07	0.70	3.77	9.30
1101	1300	0.28	0.07	0.70	3.77	8.30

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SECTION 5 ***** SUMMARY OF HYDRAULIC INPUTS *****

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JUNCTION HEAD AND HYD. RADIUS AND X-SECTIONAL AREA OF CHANNELS ARE AT MEAN TIDE **

CHANNEL DATA									JUNCTION DATA								
CHAN.	LENGTH	WIDTH	AREA	MANNING	NET FLOW	HYD. RADIUS	JUNC. AT ENDS		JUNC.	INFLOW	HEAD	CHANNELS ENTERING JUNCTION					
1	7000.	2400.	31042.	0.010	1539.43	12.9	1	3	1	0.0	0.10	1	0	0	0	0	
2	11000.	850.	24479.	0.010	1539.41	28.8	3	4	2	0.0	-0.07	9	0	0	0	0	
3	11000.	650.	18647.	0.010	1539.43	28.7	4	5	3	0.0	0.10	1	2	0	0	0	
4	11000.	600.	17093.	0.010	1539.40	28.5	5	6	4	0.0	0.10	2	3	0	0	0	
5	11000.	600.	16918.	0.010	1539.41	28.2	6	7	5	0.0	0.10	3	4	0	0	0	
6	11000.	600.	13768.	0.010	1539.38	22.9	7	8	6	0.0	0.10	4	5	0	0	0	
7	11000.	600.	12384.	0.010	1539.39	20.6	8	9	7	0.0	0.11	5	6	0	0	0	
8	15679.	600.	11039.	0.010	1539.39	18.4	9	10	8	0.0	0.11	6	7	0	0	0	
9	14994.	12995.	212742.	0.010	-13197.96	16.4	2	11	9	0.0	0.10	7	8	0	0	0	
10	14994.	11829.	183011.	0.010	-13198.80	15.5	11	12	10	0.0	0.09	8	12	0	0	0	
11	14994.	7700.	119235.	0.010	-16448.20	15.5	12	13	11	0.0	-0.03	9	10	0	0	0	
12	11995.	4500.	78133.	0.010	1539.33	17.4	10	13	12	0.0	0.01	10	11	13	0	0	
13	19326.	1700.	11956.	0.010	3249.09	7.0	12	14	13	0.0	0.09	11	12	14	18	20	
14	7330.	7600.	68899.	0.010	5736.47	9.1	13	14	14	0.0	0.10	13	14	15	19	0	
15	8996.	1000.	8622.	0.015	-16.39	8.6	14	15	15	0.0	0.19	15	16	0	0	0	
16	8996.	4332.	32726.	0.015	-16.17	7.6	15	16	16	0.0	0.19	16	17	0	0	0	
17	8996.	5331.	40389.	0.015	-15.61	7.6	16	17	17	-15.0	0.19	17	0	0	0	0	
18	13661.	3800.	53787.	0.010	6690.48	14.2	13	18	18	0.0	0.11	18	21	0	0	0	
19	8996.	5600.	23845.	0.010	9001.87	4.3	14	19	19	0.0	0.14	19	22	0	0	0	
20	13661.	3400.	70398.	0.010	-27337.84	20.7	13	20	20	0.0	0.14	20	22	24	0	0	
21	10662.	6000.	45839.	0.010	6690.38	7.6	18	21	21	0.0	0.21	21	23	0	0	0	
22	9663.	4900.	48016.	0.010	9001.70	9.8	19	20	22	0.0	0.21	23	24	25	0	0	
23	10996.	7600.	98327.	0.010	6690.25	12.9	21	22	23	0.0	0.24	25	26	0	0	0	
24	13994.	3900.	66887.	0.010	-18336.19	17.2	20	22	24	0.0	0.25	26	27	0	0	0	
25	13661.	8996.	149854.	0.010	-11646.09	16.7	22	23	25	0.0	0.26	27	28	33	0	0	
26	11995.	8274.	146746.	0.010	-11646.25	17.7	23	24	26	0.0	0.27	28	29	32	0	0	
27	11995.	6942.	145752.	0.010	-11646.41	21.0	24	25	27	0.0	0.27	29	30	0	0	0	
28	9330.	1000.	14333.	0.015	-780.04	14.3	25	26	28	0.0	0.26	30	31	0	0	0	
29	9330.	722.	7506.	0.015	-262.06	10.4	26	27	29	-262.0	0.26	31	0	0	0	0	
30	9330.	389.	3595.	0.015	-262.07	9.2	27	28	30	-518.0	0.29	32	0	0	0	0	
31	9330.	278.	2289.	0.015	-262.05	8.2	28	29	31	0.0	0.29	33	34	0	0	0	
32	9330.	389.	2239.	0.015	-517.98	5.8	26	30	32	0.0	0.32	34	35	0	0	0	
33	11995.	8163.	148160.	0.016	-10866.51	18.2	25	31	33	0.0	0.35	35	36	0	0	0	
34	11995.	7441.	128240.	0.016	-10866.80	17.2	31	32	34	-49.0	0.37	36	37	38	0	0	
35	11995.	6997.	114339.	0.016	-10866.88	16.3	32	33	35	0.0	0.38	38	40	0	0	0	
36	13328.	5720.	114952.	0.016	-10867.02	20.1	33	34	36	-83.0	0.40	37	39	0	0	0	
37	11995.	4054.	90971.	0.020	-11728.44	22.4	34	36	37	0.0	0.43	40	41	0	0	0	
38	10662.	3887.	63885.	0.020	910.37	16.4	34	35	38	0.0	0.43	39	41	42	43	0	
39	11995.	4332.	85987.	0.020	-11645.45	19.8	36	38	39	0.0	0.44	42	44	45	0	0	
40	7330.	2443.	15694.	0.020	910.35	6.4	35	37	40	-60.0	0.41	44	0	0	0	0	
41	7330.	2100.	18473.	0.020	910.36	8.8	37	38	41	0.0	0.48	45	46	0	0	0	
42	6331.	2600.	29988.	0.020	-24.01	11.5	38	39	42	0.0	0.46	43	47	0	0	0	
43	11995.	4942.	92486.	0.020	-10711.02	18.7	38	42	43	-24.0	0.48	46	47	48	0	0	
44	8996.	300.	1799.	0.020	-60.01	6.0	39	40	44	0.0	0.50	48	49	52	0	0	
45	6331.	1944.	13392.	0.020	36.03	6.9	39	41	45	0.0	0.51	49	50	0	0	0	
46	11995.	2388.	28789.	0.020	36.07	12.1	41	43	46	0.0	0.52	50	51	0	0	0	
47	11995.	3499.	77940.	0.020	-10710.95	22.3	42	43	47	-2067.0	0.52	51	0	0	0	0	

48	14994.	3998.	89676.	0.020	-10650.69	22.4	43	44
49	10662.	750.	9224.	0.020	-2067.88	12.3	44	45
50	10662.	611.	10216.	0.020	-2067.64	16.7	45	46
51	10662.	555.	7346.	0.020	-2067.23	13.2	46	47
52	11995.	3887.	86115.	0.020	-8582.41	22.2	44	48
53	11995.	2832.	66038.	0.020	-8582.29	23.3	48	49
54	8996.	167.	2119.	0.020	0.01	12.7	49	50
55	11995.	2332.	65651.	0.020	-8582.16	28.2	49	51
56	10329.	2888.	76207.	0.020	-8582.17	26.4	51	52
57	6331.	1400.	19081.	0.020	-948.65	13.6	52	53
58	8996.	300.	2091.	0.020	-31.97	7.0	53	54
59	11995.	3165.	74005.	0.020	-7633.55	23.4	52	55
60	7997.	2499.	30571.	0.020	-916.71	12.2	53	55
61	9674.	3195.	65797.	0.020	-8295.45	20.6	55	56
62	9007.	300.	3453.	0.020	-13.98	11.5	56	57
63	9674.	2474.	52892.	0.035	-8281.66	21.4	56	58
64	9674.	2752.	58386.	0.035	-8281.88	21.2	58	59
65	9674.	2419.	47327.	0.035	-8232.13	19.6	59	60
66	9007.	600.	8262.	0.035	-174.87	13.8	60	61
67	9007.	2863.	49229.	0.035	-8107.45	17.2	60	62
68	9007.	2391.	44320.	0.035	-8107.51	18.5	62	63
69	9508.	1890.	38949.	0.035	-8107.66	20.6	63	64
70	8331.	334.	4628.	0.035	-159.87	13.9	64	65
71	9508.	1640.	37847.	0.035	-7948.16	23.1	64	66
72	11009.	1307.	31421.	0.035	-6300.30	24.0	66	68
73	7839.	862.	14330.	0.040	-1648.29	16.6	66	67
74	7839.	834.	14004.	0.040	-1648.41	16.8	67	68
75	9674.	1362.	31621.	0.040	-7948.96	23.2	68	69
76	10842.	1334.	32490.	0.040	-7948.75	24.4	69	70
77	12009.	1418.	29466.	0.040	-7948.03	20.8	70	71
78	9007.	1362.	22853.	0.040	-7946.87	16.8	71	72
79	6005.	334.	3833.	0.040	-64.13	11.5	72	73
80	7506.	1473.	21551.	0.040	-7381.72	14.6	72	74
81	78000.	1168.	16973.	0.040	-7880.84	14.5	74	75
82	8000.	862.	9652.	0.040	-7860.27	11.2	75	76

48	0.0	0.51	52	53	0	0	0	0
49	0.0	0.52	53	54	55	0	0	0
50	0.0	0.52	54	0	0	0	0	0
51	0.0	0.53	55	56	0	0	0	0
52	0.0	0.54	56	57	59	0	0	0
53	0.0	0.54	57	58	60	0	0	0
54	-32.0	0.53	58	0	0	0	0	0
55	-255.0	0.55	59	60	61	0	0	0
56	0.0	0.56	61	62	63	0	0	0
57	-14.0	0.56	62	0	0	0	0	0
58	0.0	0.59	63	64	0	0	0	0
59	0.0	0.61	64	65	0	0	0	0
60	0.0	0.64	65	66	67	0	0	0
61	-175.0	0.64	66	0	0	0	0	0
62	0.0	0.67	67	68	0	0	0	0
63	0.0	0.69	68	69	0	0	0	0
64	0.0	0.71	69	70	71	0	0	0
65	-160.0	0.71	70	0	0	0	0	0
66	0.0	0.73	71	72	73	0	0	0
67	0.0	0.73	73	74	0	0	0	0
68	0.0	0.74	72	74	75	0	0	0
69	0.0	0.77	75	76	0	0	0	0
70	0.0	0.79	76	77	0	0	0	0
71	0.0	0.83	77	78	0	0	0	0
72	0.0	0.88	78	79	80	0	0	0
73	-64.0	0.88	79	0	0	0	0	0
74	0.0	0.92	80	81	0	0	0	0
75	0.0	0.98	81	82	0	0	0	0
76	-7880.0	1.18	82	0	0	0	0	0

****

SECTION 3 WATER QUALITY INPUTS

****

SUMMARY OF POINT SOURCE INPUTS

SIMULATION PERIOD : AUGUST 1 - 15 , 1975

CONSTITUENT 1 IS NORG (MG/L)
CONSTITUENT 2 IS NH3 (MG/L)
CONSTITUENT 3 IS NO3 (MG/L)
CONSTITUENT 4 IS CBOD (MG/L)
CONSTITUENT 5 IS DO (MG/L)

MUNICIPAL AND INDUSTRIAL WASTEWATER AND TRIBUTARY INFLOW BY NODE

INPUT NODE	NAME OF DISCHARGE	TYPE OF DISCHARGE	******* FLOW ******* MGD	CFS	UNADJUSTED CONC (MG/L) + ADJ. FACTORS CONST1	CONST2	CONST3	CONST4	CONST5	ADJUSTED INPUT LOADS - 1000 LB/DAY CONST1	CONST2	CONST3	CONST4	CONST5
14	SALEMCTY	MUN	-2.80		2.10	8.50	0.0	48.00	5.30					
				-4.34	1.00	1.00	1.00	1.45	1.00	0.05	0.20	0.0	1.63	0.12
	NODE TOTAL			-4.34						0.05	0.20	0.0	1.63	0.12
17	SALEM	TRIB	-2.39		0.0	0.0	0.0	5.50	0.0					
				-3.70	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.16	0.0
	NODE TOTAL			-3.70						0.0	0.0	0.0	0.16	0.0
21	GETTYOIL	IND	-9.00		42.52	86.12	8.10	16.30	1.20					
				-13.95	1.00	1.00	1.00	1.93	1.00	3.19	6.47	0.61	2.33	0.09
	NODE TOTAL			-13.95						3.19	6.47	0.61	2.33	0.09
22	AMOCO	IND	-0.60		1.00	17.00	0.0	134.20	0.0					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.01	0.09	0.0	1.28	0.0
	NODE TOTAL			-0.93						0.01	0.09	0.0	1.28	0.0
23	PENNSVLE	MUN	-0.93		12.00	29.00	0.0	129.70	0.0					
				-1.39	1.00	1.00	1.00	1.45	1.00	0.09	0.22	0.0	1.41	0.0

	NODE TOTAL			-1.39						0.09	0.22	0.0	1.41	0.0
24	DPCHAMBR	IND	-93.40		3.50	12.70	23.25	77.60	6.00					
				-144.77	1.00	1.00	1.00	1.45	1.00	2.73	9.90	18.13	87.72	4.68
24	ICI 1	IND	-2.20		1.83	1.44	4.52	104.80	4.50					
				-3.41	1.00	1.00	1.00	1.45	1.00	0.03	0.03	0.08	2.79	0.08
24	ICI 3	IND	-1.30		1.17	0.16	2.15	88.00	5.10					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.01	0.00	0.02	1.38	0.06
24	ICI 4	IND	-0.40		0.56	0.27	1.39	58.20	5.90					
				-0.62	1.00	1.00	1.00	1.45	1.00	0.00	0.00	0.00	0.28	0.02
24	ICI 7	IND	-1.00		16.82	83.18	100.00	789.00	0.0					
				-1.55	1.00	1.00	1.00	1.45	1.00	0.14	0.69	0.83	9.55	0.0
	NODE TOTAL			-152.36						2.92	10.62	19.07	101.72	4.84
25	UPENSNCK	MUN	-0.50		0.0	0.0	0.0	128.10	0.0					
				-0.78	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.78	0.0
25	WLMINGTN	MUN	-60.50		6.60	8.90	0.90	44.30	5.20					
				-93.78	1.00	1.00	1.00	1.45	1.00	3.33	4.49	0.45	32.44	2.63
	NODE TOTAL			-94.55						3.33	4.49	0.45	33.21	2.63
29	CHRISTNA	TRIB	-148.39		1.00	0.23	1.52	4.50	4.00					
				-230.00	1.00	1.00	1.00	1.45	1.00	1.24	0.28	1.88	8.08	4.95
	NODE TOTAL			-230.00						1.24	0.28	1.88	8.08	4.95
30	BRANDYWN	TRIB	-304.97		0.84	0.06	2.09	9.60	8.20					
				-472.70	1.00	1.00	1.00	1.45	1.00	2.14	0.15	5.32	35.43	20.87
	NODE TOTAL			-472.70						2.14	0.15	5.32	35.43	20.87
31	PENSGROV	MUN	-0.30		0.0	0.0	0.0	25.60	0.0					
				-0.47	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.09	0.0
31	DPEDGMOR	IND	-11.60		2.06	0.41	1.65	4.30	0.0					
				-17.98	1.00	1.00	1.00	1.90	1.00	0.20	0.04	0.16	0.79	0.0
	NODE TOTAL			-18.44						0.20	0.04	0.16	0.88	0.0
33	OLDMANS	TRIB	-31.16		1.00	0.14	1.24	3.40	5.00					
				-48.30	1.00	1.00	1.00	1.45	1.00	0.26	0.04	0.32	1.28	1.30
33	ALLDCHEM	IND	-25.80		1.89	4.64	4.18	15.00	0.60					
				-39.99	1.00	1.00	1.00	1.90	1.00	0.41	1.00	0.90	6.14	0.13
33	PHOENIX	IND	-11.00		1.09	2.51	1.97	3.80	0.0					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.10	0.23	0.18	0.66	0.0

	NODE TOTAL			-105.34						0.77	1.27	1.40	8.08	1.43
34	CHESTER	MUN	-9.20		0.0	7.96	1.72	84.20	5.40					
				-14.26	1.00	1.00	1.00	1.45	1.00	0.0	0.61	0.13	9.38	0.41
34	MARCUSHK	MUN	-0.60		22.97	15.98	2.00	137.70	0.0					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.12	0.08	0.01	1.00	0.0
34	BP 201	IND	-2.40		0.0	1.12	0.90	36.50	2.40					
				-3.72	1.00	1.00	1.00	1.90	1.00	0.0	0.02	0.02	1.39	0.05
34	BP 101	IND	-77.00		0.0	0.20	2.02	11.20	6.90					
				-119.35	1.00	1.00	1.00	1.90	1.00	0.0	0.13	1.30	13.68	4.43
34	BP 002	IND	-39.00		0.0	0.16	1.96	11.70	5.00					
				-60.45	1.00	1.00	1.00	1.90	1.00	0.0	0.05	0.64	7.24	1.63
34	FMC	IND	-3.20		0.74	0.74	3.71	140.00	0.0					
				-4.96	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.10	5.42	0.0
34	MONSANTO	IND	-1.40		18.57	1.86	0.0	3586.00	0.0					
				-2.17	1.00	1.00	1.00	1.90	1.00	0.22	0.02	0.0	79.62	0.0
34	SUNOIL 1	IND	-88.30		11.00	2.34	2.24	30.00	5.00					
				-136.87	1.00	1.00	1.00	1.90	1.00	8.11	1.72	1.65	42.01	3.69
	NODE TOTAL			-342.70						8.46	2.66	3.85	159.73	10.21
36	CHESTER	TRIB	-53.03		1.07	0.50	2.59	2.30	7.40					
				-82.20	1.00	1.00	1.00	1.45	1.00	0.47	0.22	1.15	1.48	3.28
36	SCOTT 2	IND	-4.60		0.0	0.0	1.81	91.00	7.10					
				-7.13	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.07	6.64	0.27
36	SCOTT 3	IND	-8.30		0.0	0.0	1.88	88.00	8.70					
				-12.87	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.13	11.58	0.60
36	SCOTT 4	IND	-3.50		0.0	0.0	1.81	83.00	6.80					
				-5.43	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.05	4.61	0.20
	NODE TOTAL			-107.62						0.47	0.22	1.40	24.30	4.35
38	RIDLEY	TRIB	-6.58		1.07	0.50	2.59	2.30	7.40					
				-10.20	1.00	1.00	1.00	1.45	1.00	0.06	0.03	0.14	0.18	0.41
	NODE TOTAL			-10.20						0.06	0.03	0.14	0.18	0.41
39	UCARBIDE	IND	-2.60		1.90	13.91	3.90	22.40	2.50					
				-4.03	1.00	1.00	1.00	1.90	1.00	0.04	0.30	0.08	0.92	0.05
	NODE TOTAL			-4.03						0.04	0.30	0.08	0.92	0.05
40	DARBY	TRIB	-38.32		1.52	0.80	2.00	2.40	5.20					
				-59.40	1.00	1.00	1.00	1.45	1.00	0.49	0.26	0.64	1.11	1.66
40	COCA	MUN	-9.70		7.30	13.93	1.01	37.50	6.90					
				-15.04	1.00	1.00	1.00	1.45	1.00	0.59	1.13	0.08	4.40	0.56

40	DRBYCRSA	MUN	-17.30		0.98	10.12	1.76	6.50	7.00					
				-26.82	1.00	1.00	1.00	1.45	1.00	0.14	1.46	0.25	1.36	1.01
40	MUKNPATS	MUN	-5.70		0.0	0.0	0.0	0.0	0.0					
				-8.84	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
40	TINICUM	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
	NODE TOTAL			-110.08						1.22	2.85	0.98	6.88	3.23
42	DPRPAUNO	IND	-14.20		1.10	37.10	15.20	10.80	0.0					
				-22.01	1.00	1.00	1.00	1.90	1.00	0.13	4.40	1.80	2.43	0.0
42	HERCULES	IND	-0.60		0.0	0.0	0.0	5.10	0.0					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.05	0.0
	NODE TOTAL			-22.94						0.13	4.40	1.80	2.48	0.0
43	GLOSTRCO	MUN	-6.50		0.0	3.71	3.71	3.80	0.0					
				-10.08	1.00	1.00	1.00	1.45	1.00	0.0	0.20	0.20	0.30	0.0
43	PAULSBRO	MUN	-1.30		0.0	26.93	0.0	64.00	0.0					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.29	0.0	1.01	0.0
43	MOBILCP1	IND	-7.20		2.90	4.30	0.90	37.40	1.40					
				-11.16	1.00	1.00	1.00	1.90	1.00	0.17	0.26	0.05	4.27	0.08
43	MOBILNY2	IND	-4.70		1.25	2.50	10.15	14.70	3.80					
				-7.28	1.00	1.00	1.00	1.90	1.00	0.05	0.10	0.40	1.10	0.15
43	MOBILIW3	IND	-4.30		0.0	29.00	0.0	76.00	0.0					
				-6.67	1.00	1.00	1.00	1.90	1.00	0.0	1.04	0.0	5.18	0.0
43	SHELL	IND	-1.90		19.19	3.71	0.0	29.30	0.0					
				-2.94	1.00	1.00	1.00	1.90	1.00	0.30	0.06	0.0	0.88	0.0
43	OLINCHEM	IND	-17.40		0.0	2.06	0.0	3.30	0.0					
				-26.97	1.00	1.00	1.00	1.90	1.00	0.0	0.30	0.0	0.91	0.0
43	MANTUA	TRIB	-7.10		0.0	5.06	0.68	4.70	0.0					
				-11.00	1.00	1.00	1.00	1.45	1.00	0.0	0.30	0.04	0.40	0.0
	NODE TOTAL			-78.11						0.53	2.55	0.69	14.05	0.23
44	PHILA SW	MUN	-173.00		3.30	1.80	0.25	50.00	0.0					
				-268.15	1.00	1.00	1.00	1.45	1.00	11.99	2.60	0.36	104.69	0.0
44	WOODBURY	MUN	-1.90		0.0	1.24	0.0	85.40	0.0					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.0	0.02	0.0	1.96	0.0
44	NAT PARK	MUN	-0.60		0.0	3.71	0.0	64.00	0.0					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.02	0.0	0.46	0.0
	NODE TOTAL			-272.02						11.99	2.64	0.36	107.12	0.0

45	GULF OIL	IND	-10.40		0.0	2.49	1.51	4.10	6.20					
				-16.12	1.00	1.00	1.00	1.90	1.00	0.0	0.22	0.13	0.68	0.54
45	ARCO SPL	IND	-2.70		0.0	34.44	0.0	34.60	7.70					
				-4.18	1.00	1.00	1.00	1.90	1.00	0.0	0.78	0.0	1.48	0.17
45	ARCO NYD	IND	-1.40		0.0	0.32	1.15	40.00	2.30					
				-2.17	1.00	1.00	1.00	1.90	1.00	0.0	0.00	0.01	0.89	0.03
45	ARCO WPL	IND	-0.10		0.0	3.97	0.49	5.50	4.70					
				-0.16	1.00	1.00	1.00	1.90	1.00	0.0	0.00	0.00	0.01	0.00
				---------						------	------	------	------	------
	NODE TOTAL			-22.63						0.0	1.00	0.14	3.05	0.74
47	SCHUYLKL	TRIB	-1329.03		0.60	0.08	1.98	3.40	6.20					
				-2060.00	1.00	1.00	1.00	1.45	1.00	6.66	0.89	21.96	54.69	68.78
				---------						------	------	------	------	------
	NODE TOTAL			-2060.00						6.66	0.89	21.96	54.69	68.78
48	GLOSTRCY	MUN	-2.50		2.90	15.90	2.07	18.60	0.0					
				-3.88	1.00	1.00	1.00	1.45	1.00	0.06	0.33	0.04	0.56	0.0
48	BELLMAWR	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
48	BROKLAWN	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
48	MTEPHRAM	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
48	NJ ZINC	IND	-11.60		2.27	11.76	1.44	32.60	0.0					
				-17.98	1.00	1.00	1.00	1.90	1.00	0.22	1.14	0.14	6.00	0.0
48	TEXACO	IND	-4.50		1.59	10.08	0.80	76.80	0.0					
				-6.98	1.00	1.00	1.00	1.90	1.00	0.06	0.38	0.03	5.48	0.0
48	BIGTIMBR	TRIB	-3.87		4.20	1.05	1.30	1.70	2.70					
				-6.00	1.00	1.00	1.00	1.45	1.00	0.14	0.03	0.04	0.08	0.09
				---------						------	------	------	------	------
	NODE TOTAL			-34.83						0.48	1.88	0.25	12.12	0.09
49	PHILA SE	MUN	-125.00		7.27	1.58	0.55	120.00	0.0					
				-193.75	1.00	1.00	1.00	1.45	1.00	7.59	1.65	0.57	181.54	0.0
49	CAMDEN M	MUN	-21.90		15.64	7.05	0.0	226.00	0.0					
				-33.94	1.00	1.00	1.00	1.45	1.00	2.90	1.29	0.0	59.90	0.0
49	MCAND&FR	IND	-1.30		0.0	0.0	0.0	256.10	0.0					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	4.03	0.0
49	HARSHOW	IND	-0.60		0.0	0.0	0.0	128.10	0.0					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.93	0.0
49	GAF	IND	-11.00		1.36	0.0	0.0	23.00	0.0					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.17	0.0	0.0	4.01	0.0
				---------						------	------	------	------	------

	NODE TOTAL			-247.69						10.65	2.94	0.57	250.42	0.0
50	NEWTON	TRIB	-3.87		4.20	1.05	1.30	1.70	2.70					
				-6.00	1.00	1.00	1.00	1.45	1.00	0.14	0.03	0.04	0.08	0.09
	NODE TOTAL			-6.00						0.14	0.03	0.04	0.08	0.09
51	AMSTAR 1	IND	-23.60		0.0	0.33	1.67	5.00	6.30					
				-36.58	1.00	1.00	1.00	1.45	1.00	0.0	0.07	0.33	1.43	1.24
51	AMSTAR 3	IND	-2.00		0.0	0.37	1.74	6.20	5.40					
				-3.10	1.00	1.00	1.00	1.45	1.00	0.0	0.01	0.03	0.15	0.09
	NODE TOTAL			-39.68						0.0	0.07	0.36	1.58	1.33
52	NATSUGAR	IND	-15.70		0.0	0.18	1.27	8.60	7.50					
				-24.33	1.00	1.00	1.00	1.45	1.00	0.0	0.02	0.17	1.63	0.98
	NODE TOTAL			-24.33						0.0	0.02	0.17	1.63	0.98
54	CAMDEN N	MUN	-3.90		6.19	23.52	15.17	92.00	0.0					
				-6.05	1.00	1.00	1.00	1.45	1.00	0.20	0.77	0.49	4.34	0.0
54	COOPER	TRIB	-43.87		0.60	1.76	1.00	5.50	6.70					
				-68.00	1.00	1.00	1.00	1.45	1.00	0.22	0.64	0.37	2.92	2.45
	NODE TOTAL			-74.04						0.42	1.41	0.86	7.26	2.45
55	PHILA NE	MUN	-199.00		11.60	5.20	0.17	51.00	2.00					
				-308.45	1.00	1.00	1.00	1.45	1.00	19.27	8.64	0.28	122.83	3.32
55	PENSAUKN	MUN	-3.60		6.17	18.50	4.50	69.30	0.0					
				-5.58	1.00	1.00	1.00	1.45	1.00	0.19	0.56	0.14	3.02	0.0
55	GEORGPAC	IND	-1.90		1.30	2.30	0.90	222.00	0.0					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.02	0.04	0.01	5.10	0.0
	NODE TOTAL			-316.97						19.47	9.23	0.43	130.96	3.32
56	FRANKFRT	TRIB	-6.45		1.00	1.32	2.00	6.90	3.40					
				-10.00	1.00	1.00	1.00	1.45	1.00	0.05	0.07	0.11	0.54	0.18
	NODE TOTAL			-10.00						0.05	0.07	0.11	0.54	0.18
57	MTLAUREL	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
57	PENSAUKN	TRIB	-8.77		1.00	1.32	2.00	6.90	3.40					
				-13.60	1.00	1.00	1.00	1.45	1.00	0.07	0.10	0.15	0.73	0.25
	NODE TOTAL			-13.60						0.07	0.10	0.15	0.73	0.25
58	PALMYRA	MUN	-0.40		4.90	32.40	3.50	47.60	3.50					
				-0.62	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.01	0.23	0.01

	NODE TOTAL			-0.62						0.02	0.11	0.01	0.23	0.01
59	CINAMNSN	MUN	-1.60		4.60	22.00	0.0	30.00	5.00					
				-2.48	1.00	1.00	1.00	1.45	1.00	0.06	0.29	0.0	0.58	0.07
59	PENYPACK	TRIB	-3.23		1.00	0.10	3.20	1.00	10.40					
				-5.00	1.00	1.00	1.00	1.45	1.00	0.03	0.00	0.09	0.04	0.28
	NODE TOTAL			-7.48						0.09	0.30	0.09	0.62	0.35
60	POQUESNG	TRIB	-3.23		1.00	0.10	3.20	1.00	10.40					
				-5.00	1.00	1.00	1.00	1.45	1.00	0.03	0.00	0.09	0.04	0.28
	NODE TOTAL			-5.00						0.03	0.00	0.09	0.04	0.28
61	WLINGBRO	MUN	-1.90		1.24	0.0	0.0	38.40	0.0					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.02	0.0	0.0	0.88	0.0
61	RANCOCAS	TRIB	-112.90		1.33	0.14	1.24	3.80	4.90					
				-175.00	1.00	1.00	1.00	1.45	1.00	1.25	0.13	1.17	5.19	4.62
	NODE TOTAL			-177.94						1.27	0.13	1.17	6.08	4.62
64	BRLINGTN	MUN	0.0		0.0	0.0	0.0	0.0	0.0					
				0.0	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.0
64	TENNECO	IND	-1.30		6.00	18.00	3.10	34.50	3.30					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.07	0.20	0.03	0.54	0.04
	NODE TOTAL			-2.02						0.07	0.20	0.03	0.54	0.04
65	FALLSTWP	MUN	-2.60		14.39	2.32	11.14	9.60	0.0					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.31	0.05	0.24	0.30	0.0
65	NESHAMNY	TRIB	-100.26		1.04	0.12	3.00	1.70	8.30					
				-155.40	1.00	1.00	1.00	1.45	1.00	0.87	0.10	2.51	2.06	6.95
	NODE TOTAL			-159.43						1.18	0.15	2.75	2.36	6.95
66	BRSTLBRO	MUN	-2.10		21.37	6.49	4.60	13.00	6.30					
				-3.26	1.00	1.00	1.00	1.45	1.00	0.37	0.11	0.08	0.33	0.11
66	BRSTLTWP	MUN	-2.30		3.71	0.0	1.39	3.20	0.0					
				-3.57	1.00	1.00	1.00	1.45	1.00	0.07	0.0	0.03	0.09	0.0
66	ROHM&HAS	IND	-1.20		0.98	0.49	0.10	30.00	1.70					
				-1.86	1.00	1.00	1.00	1.45	1.00	0.01	0.00	0.00	0.44	0.02
66	OTR&ASNK	TRIB	-6.45		0.0	0.0	0.0	12.30	0.0					
				-10.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.96	0.0
	NODE TOTAL			-18.66						0.46	0.12	0.11	1.82	0.13

69	LWRBUCKS	MUN	-8.50	-13.18	9.29 1.00	49.52 1.00	0.62 1.00	42.70 1.45	5.00 1.00	0.66	3.51	0.04	4.39	0.35
69	FLORENCE	MUN	-0.60	-0.93	3.71 1.00	11.14 1.00	0.0 1.00	64.00 1.45	5.00 1.00	0.02	0.06	0.0	0.46	0.03
69	PATPARCH	IND	-3.20	-4.96	32.29 1.00	0.37 1.00	0.0 1.00	12.80 1.45	0.0 1.00	0.60	0.01	0.0	0.50	0.0
69	MARTINS	TRIB	-5.43	-6.50	0.0 1.00	0.0 1.00	0.0 1.00	3.60 1.45	0.0 1.00	0.0	0.0	0.0	0.24	0.0
	NODE TOTAL			-27.56						1.27	3.58	0.04	5.59	0.38
71	USSTRMTP	IND	-32.30	-50.07	1.74 1.00	2.44 1.00	1.90 1.00	3.40 1.45	5.00 1.00	0.47	0.66	0.51	1.33	1.35
71	USSRODML	IND	0.0	0.0	0.0 1.00	0.0 1.00	0.0 1.00	0.0 0.0	0.0 1.00	0.0	0.0	0.0	0.0	0.0
	NODE TOTAL			-50.07						0.47	0.66	0.51	1.33	1.35
72	BORDENTN	MUN	-1.00	-1.55	3.60 1.00	14.60 1.00	0.0 1.00	46.30 1.45	5.00 1.00	0.03	0.12	0.0	0.58	0.04
	NODE TOTAL			-1.55						0.03	0.12	0.0	0.58	0.04
73	HAMILTON	MUN	-9.00	-13.95	8.00 1.00	26.60 1.00	12.00 1.00	11.90 1.45	5.00 1.00	0.60	2.00	0.90	1.30	0.38
73	CROSWICK	TRIB	-40.65	-63.00	0.80 1.00	0.14 1.00	1.24 1.00	3.00 1.45	7.00 1.00	0.27	0.05	0.42	1.48	2.37
	NODE TOTAL			-76.95						0.87	2.05	1.32	2.77	2.75
75	TRENTON	MUN	-19.30	-29.91	0.90 1.00	14.90 1.00	0.76 1.00	40.00 1.45	1.60 1.00	0.14	2.40	0.12	9.34	0.26
	NODE TOTAL			-29.91						0.14	2.40	0.12	9.34	0.26
76	MORRISVL	MUN	-3.90	-6.05	1.00 1.00	31.50 1.00	1.81 1.00	18.00 1.45	7.40 1.00	0.03	1.03	0.06	0.85	0.24
76	ASSNPINK	TRIB	-65.81	-102.00	0.80 1.00	0.67 1.00	2.40 1.00	3.00 1.45	7.20 1.00	0.44	0.37	1.32	2.39	3.95
	NODE TOTAL			-108.04						0.47	1.39	1.38	3.24	4.20

SUMMARY OF DISCHARGE LOADS BY ZONE AND TYPE

INPUT ZONE	TYPE OF DISCHARGE	NUMBER OF DISCHARGES	ADJUSTED INPUT LOADS - 1000 LB/DAY					INPUT LOADS - PERCENT OF ZONE BY TYPE				
			CONST1	CONST2	CONST3	CONST4	CONST5	CONST1	CONST2	CONST3	CONST4	CONSIS
1	MUN	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	IND	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	TRIB	1.	17.40	3.39	43.71	92.29	360.69	100.00	100.00	100.00	100.00	100.00
	ZONE TOTAL	1.	17.40	3.39	43.71	92.29	360.69	17.66	4.73	38.14	8.39	70.22
2	MUN	12.	2.33	9.57	1.48	19.12	1.47	36.60	86.29	19.39	55.70	6.91
2	IND	5.	1.14	0.87	0.55	2.80	1.40	17.93	7.82	7.18	8.17	6.57
2	TRIB	8.	2.59	0.65	5.59	12.40	18.45	45.46	5.89	73.43	36.13	86.52
	ZONE TOTAL	25.	6.35	11.09	7.61	34.32	21.33	6.45	15.47	6.64	3.12	4.15
3	MUN	7.	30.15	13.00	1.50	371.87	3.33	97.81	93.01	55.48	94.52	38.67
3	IND	7.	0.19	0.13	0.54	17.29	2.31	0.62	0.94	19.97	4.39	26.84
3	TRIB	4.	0.48	0.65	0.60	4.27	2.97	1.57	6.05	24.55	1.09	34.48
	ZONE TOTAL	18.	30.83	13.98	2.70	393.43	8.62	31.28	19.50	2.35	35.77	1.68
4	MUN	15.	12.89	6.74	1.03	125.12	1.93	42.94	34.74	3.42	32.46	2.25
4	IND	23.	9.32	10.94	6.61	202.46	11.90	31.05	56.37	20.87	52.51	13.51
4	TRIB	6.	7.81	1.73	23.98	57.94	74.21	26.01	8.89	75.71	15.03	84.24
	ZONE TOTAL	44.	30.03	19.41	31.67	385.53	88.09	30.47	27.07	27.64	35.05	17.15
5	MUN	5.	3.47	4.91	0.45	36.34	2.75	24.92	20.61	1.57	18.71	7.87
5	IND	10.	6.82	18.45	20.92	112.92	5.05	48.97	77.41	72.39	58.14	14.47
5	TRIB	4.	3.64	0.47	7.53	44.96	27.13	26.10	1.99	26.04	23.15	77.66
	ZONE TOTAL	19.	13.93	20.83	28.90	194.22	34.93	14.14	33.23	25.22	17.66	6.80
	GRAND TOTAL	107.	93.53	71.71	114.59	1099.78	513.66					

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SECTION 4 WATER QUALITY BOUNDARY CONDITIONS

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SEAWARD BOUNDARY CONDITIONS

NODE 1 : COURTHOUSE PT , MARYLAND

' CIN1 ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.30	0.30	1.00	1.00	7.00

NODE 2 : LISTON PT , DELAWARE

' CINMAX ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.32	0.12	1.40	1.50	5.50

UPSTREAM BOUNDARY CONDITIONS

NODE 76 RECIEVES VARYING LOADS FROM DELAWARE (RIVR)

FLOW PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	FLOW (CFS)
1	2400	-7880.00

QUAL PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	850	0.41	0.08	1.03	2.17	8.50
851	1550	0.41	0.08	1.14	2.17	7.20

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SECTION 5 ***** SUMMARY OF HYDRAULIC INPUTS *****

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JUNCTION HEAD AND HYD. RADIUS AND X-SECTIONAL AREA OF CHANNELS ARE AT MEAN TIDE **

CHAN.	LENGTH	WIDTH	AREA	MANNING	NET FLOW	HYD. RADIUS	JUNC. AT ENDS		JUNC.	INFLOW	HEAD	CHANNELS ENTERING JUNCTION				
1	7000.	2400.	31042.	0.010	1539.43	12.9	1	3	1	0.0	0.10	1	0	0	0	0
2	11000.	850.	24479.	0.010	1539.41	28.8	3	4	2	0.0	-0.07	9	0	0	0	0
3	11000.	650.	18647.	0.010	1539.43	28.7	4	5	3	0.0	0.10	1	2	0	0	0
4	11000.	600.	17093.	0.010	1539.40	28.5	5	6	4	0.0	0.10	2	3	0	0	0
5	11000.	600.	16918.	0.010	1539.41	28.2	6	7	5	0.0	0.10	3	4	0	0	0
6	11000.	600.	13768.	0.010	1539.38	22.9	7	8	6	0.0	0.10	4	5	0	0	0
7	11000.	600.	12384.	0.010	1539.39	20.6	8	9	7	0.0	0.11	5	6	0	0	0
8	15679.	600.	11039.	0.010	1539.39	18.4	9	10	8	0.0	0.11	6	7	0	0	0
9	14994.	12995.	212742.	0.010	-13197.96	16.4	2	11	9	0.0	0.10	7	8	0	0	0
10	14994.	11829.	193011.	0.010	-13198.80	15.5	11	12	10	0.0	0.09	8	12	0	0	0
11	14994.	7700.	119235.	0.010	-16448.20	15.5	12	13	11	0.0	-0.03	9	10	0	0	0
12	11995.	4500.	78133.	0.010	1539.33	17.4	10	13	12	0.0	0.01	10	11	13	0	0
13	19326.	1700.	11956.	0.010	3249.09	7.0	12	14	13	0.0	0.09	11	12	14	18	20
14	7330.	7600.	68899.	0.010	5736.47	9.1	13	14	14	0.0	0.10	13	14	15	19	0
15	8996.	1000.	8622.	0.015	-16.39	3.6	14	15	15	0.0	0.19	15	16	0	0	0
16	8996.	4332.	32726.	0.015	-16.17	7.6	15	16	16	0.0	0.19	16	17	0	0	0
17	8996.	5331.	40389.	0.015	-15.61	7.6	16	17	17	-15.0	0.19	17	0	0	0	0
18	13661.	3800.	53787.	0.010	6690.48	14.2	13	18	18	0.0	0.11	18	21	0	0	0
19	8996.	5600.	23845.	0.010	9001.87	4.3	14	19	19	0.0	0.14	19	22	0	0	0
20	13661.	3400.	70398.	0.010	-27337.84	20.7	13	20	20	0.0	0.14	20	22	24	0	0
21	10662.	6000.	45839.	0.010	6690.36	7.6	18	21	21	0.0	0.21	21	23	0	0	0
22	9663.	4900.	48016.	0.010	9001.70	9.8	19	20	22	0.0	0.21	23	24	25	0	0
23	10996.	7600.	98327.	0.010	6690.25	12.9	21	22	23	0.0	0.24	25	26	0	0	0
24	13994.	3900.	66887.	0.010	-18336.19	17.2	20	22	24	0.0	0.25	26	27	0	0	0
25	13661.	8996.	149854.	0.010	-11646.09	16.7	22	23	25	0.0	0.26	27	28	33	0	0
26	11995.	8274.	146746.	0.010	-11646.25	17.7	23	24	26	0.0	0.27	28	29	32	0	0
27	11995.	6942.	145752.	0.010	-11646.41	21.0	24	25	27	0.0	0.27	29	30	0	0	0
28	9330.	1000.	14333.	0.015	-780.04	14.3	25	26	28	0.0	0.26	30	31	0	0	0
29	9330.	722.	7506.	0.015	-262.06	10.4	26	27	29	-262.0	0.26	31	0	0	0	0
30	9330.	389.	3595.	0.015	-262.07	9.2	27	28	30	-518.0	0.29	32	0	0	0	0
31	9330.	278.	2289.	0.015	-262.05	3.2	28	29	31	0.0	0.29	33	34	0	0	0
32	9330.	389.	2279.	0.015	-517.98	5.8	26	30	32	0.0	0.32	34	35	0	0	0
33	11995.	8163.	148160.	0.016	-10866.51	13.2	25	31	33	0.0	0.35	35	36	0	0	0
34	11995.	7441.	128240.	0.016	-10866.80	17.2	31	32	34	-49.0	0.37	36	37	38	0	0
35	11995.	6997.	114339.	0.016	-10866.88	16.3	32	33	35	0.0	0.38	38	40	0	0	0
36	13328.	5720.	114952.	0.016	-10867.02	20.1	33	34	36	-83.0	0.40	37	39	0	0	0
37	11995.	4054.	90971.	0.020	-11728.44	22.4	34	36	37	0.0	0.43	40	41	0	0	0
38	10662.	3887.	63835.	0.020	910.37	16.4	34	35	38	0.0	0.43	39	41	42	43	0
39	11995.	4332.	85987.	0.020	-11645.45	19.8	36	38	39	0.0	0.44	42	44	45	0	0
40	7330.	2443.	15694.	0.020	910.35	6.4	35	37	40	-60.0	0.41	44	0	0	0	0
41	7330.	2100.	18473.	0.020	910.36	8.8	37	38	41	0.0	0.48	45	46	0	0	0
42	6331.	2600.	29988.	0.020	-24.01	11.5	38	39	42	0.0	0.46	43	47	0	0	0
43	11995.	4942.	92486.	0.020	-10711.02	18.7	38	42	43	-24.0	0.48	46	47	48	0	0
44	8996.	300.	1799.	0.020	-60.01	6.0	39	40	44	0.0	0.50	48	49	52	0	0
45	6331.	1944.	13792.	0.020	36.03	6.9	39	41	45	0.0	0.51	49	50	0	0	0
46	11995.	2338.	28789.	0.020	36.07	12.1	41	43	46	0.0	0.52	50	51	0	0	0
47	11995.	3499.	77940.	0.020	-10710.95	22.3	42	43	47	-2067.0	0.52	51	0	0	0	0

79 12

48	14994.	3998.	89676.	0.020	-10650.69	22.4	43	44
49	10662.	750.	9224.	0.020	-2067.88	13.3	44	45
50	10662.	611.	10216.	0.020	-2067.64	16.7	45	46
51	10662.	555.	7346.	0.020	-2067.23	13.2	46	47
52	11995.	3887.	86115.	0.020	-8582.41	22.2	44	48
53	11995.	2832.	66008.	0.020	-8582.29	23.3	48	49
54	8996.	167.	2119.	0.020	0.01	12.7	49	50
55	11995.	2332.	65651.	0.020	-8582.16	28.2	49	51
56	10329.	2988.	76207.	0.020	-8582.17	26.4	51	52
57	6331.	1400.	19081.	0.020	-948.65	13.6	52	53
58	8996.	300.	2091.	0.020	-31.97	7.0	53	54
59	11995.	3165.	74005.	0.020	-7633.55	23.4	52	55
60	7997.	2499.	30571.	0.020	-916.71	12.2	53	55
61	9674.	3195.	65797.	0.020	-3295.45	20.6	55	56
62	9007.	300.	3453.	0.020	-13.98	11.5	56	57
63	9674.	2474.	52892.	0.035	-8281.66	21.4	56	58
64	9674.	2752.	58386.	0.035	-8281.88	21.2	58	59
65	9674.	2419.	47327.	0.035	-8282.13	19.6	59	60
66	9007.	600.	8262.	0.035	-174.87	13.8	60	61
67	9007.	2863.	49229.	0.035	-8107.45	17.2	60	62
68	9007.	2391.	44320.	0.035	-8107.51	18.5	62	63
69	9508.	1890.	39949.	0.035	-8107.66	20.6	63	64
70	6331.	334.	4628.	0.035	-159.87	13.9	64	65
71	9508.	1640.	37847.	0.035	-7948.16	23.1	64	66
72	11009.	1307.	31421.	0.035	-6300.30	24.0	66	68
73	7839.	862.	14330.	0.040	-1648.29	16.6	66	67
74	7839.	834.	14004.	0.040	-1648.41	16.8	67	68
75	9674.	1362.	31621.	0.040	-7948.96	23.2	68	69
76	10842.	1334.	32490.	0.040	-7948.75	24.4	69	70
77	12009.	1418.	29466.	0.040	-7948.03	20.8	70	71
78	9007.	1362.	22853.	0.040	-7946.87	16.8	71	72
79	6005.	334.	3833.	0.040	-64.13	11.5	72	73
80	7506.	1473.	21551.	0.040	-7881.72	14.6	72	74
81	8000.	1168.	16973.	0.040	-7380.84	14.5	74	75
82	8000.	862.	9652.	0.040	-7380.27	11.2	75	76

48	0.0	0.51	52	53	0	0	0
49	0.0	0.52	53	54	55	0	0
50	0.0	0.52	54	0	0	0	0
51	0.0	0.53	55	56	0	0	0
52	0.0	0.54	56	57	59	0	0
53	0.0	0.54	57	58	60	0	0
54	-32.0	0.53	58	0	0	0	0
55	-255.0	0.55	59	60	61	0	0
56	0.0	0.56	61	62	63	0	0
57	-14.0	0.56	62	0	0	0	0
58	0.0	0.59	63	64	0	0	0
59	0.0	0.61	64	65	0	0	0
60	0.0	0.64	65	66	67	0	0
61	-175.0	0.64	66	0	0	0	0
62	0.0	0.67	67	68	0	0	0
63	0.0	0.69	68	69	0	0	0
64	0.0	0.71	69	70	71	0	0
65	-160.0	0.71	70	0	0	0	0
66	0.0	0.73	71	72	73	0	0
67	0.0	0.73	73	74	0	0	0
68	0.0	0.74	72	74	75	0	0
69	0.0	0.77	75	76	0	0	0
70	0.0	0.79	76	77	0	0	0
71	0.0	0.83	77	78	0	0	0
72	0.0	0.88	78	79	80	0	0
73	-64.0	0.88	79	0	0	0	0
74	0.0	0.92	80	81	0	0	0
75	0.0	0.98	81	82	0	0	0
76	-7880.0	1.18	82	0	0	0	0

SECTION 3 WATER QUALITY INPUTS

SUMMARY OF POINT SOURCE INPUTS

SIMULATION PERIOD : JULY 22 -31 , 1974

CONSTITUENT 1 IS NORG (MG/L)
CONSTITUENT 2 IS NH3 (MG/L)
CONSTITUENT 3 IS NO3 (MG/L)
CONSTITUENT 4 IS CBOD (MG/L)
CONSTITUENT 5 IS DO (MG/L)

MUNICIPAL AND INDUSTRIAL WASTEWATER AND TRIBUTARY INFLOW BY NODE

INPUT NODE	NAME OF DISCHARGE	TYPE OF DISCHARGE	******* FLOW ******* MGD	CFS	UNADJUSTED CONC (MG/L) + ADJ. FACTORS CONST1	CONST2	CONST3	CONST4	CONST5	ADJUSTED INPUT LOADS - 1000 LB/DAY CONST1	CONST2	CONST3	CONST4	CONST5
14	SALEMCTY	MUN	-2.80		2.10	8.50	0.0	48.00	5.30					
				-4.34	1.00	1.00	1.00	1.45	1.00	0.05	0.20	0.0	1.63	0.12
	NODE TOTAL			-4.34						0.05	0.20	0.0	1.63	0.12
17	SALEM	TRIB	-2.58		0.0	0.0	0.0	5.50	6.00					
				-4.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.17	0.13
	NODE TOTAL			-4.00						0.0	0.0	0.0	0.17	0.13
21	GETTYOIL	IND	-403.00		1.60	3.90	1.70	5.00	5.00					
				-624.65	1.00	1.00	1.00	1.90	1.00	5.38	13.12	5.72	31.96	16.82
	NODE TOTAL			-624.65						5.38	13.12	5.72	31.96	16.82
22	AMOCO	IND	-0.60		1.00	17.00	0.0	134.20	3.00					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.01	0.09	0.0	1.28	0.02
	NODE TOTAL			-0.93						0.01	0.09	0.0	1.28	0.02
23	PENNSVLE	MUN	-0.60		16.70	40.90	0.0	179.00	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.08	0.20	0.0	1.30	0.02

74-1

	NODE TOTAL			-0.93						0.08	0.20	0.0	1.30	0.02
24	ICI 1	IND	-9.00		3.20	1.70	18.60	100.60	5.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.24	0.13	1.40	10.96	0.38
24	DPCHAMBR	IND	-126.00		3.90	22.80	8.40	142.60	6.00					
				-195.30	1.00	1.00	1.00	1.45	1.00	4.10	23.98	8.83	217.46	6.31
	NODE TOTAL			-209.25						4.34	24.11	10.23	228.42	6.69
25	DPCARNEY	IND	-1.90		2.50	63.10	1.60	368.90	2.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.04	1.00	0.03	8.48	0.03
25	UPENSNCK	MUN	-0.50		5.30	26.50	0.0	128.10	2.00					
				-0.78	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.0	0.78	0.01
25	WLMINGTN	MUN	-80.00		6.60	34.40	0.30	97.40	3.00					
				-124.00	1.00	1.00	1.00	1.45	1.00	4.41	22.97	0.20	94.30	2.00
	NODE TOTAL			-127.72						4.47	24.08	0.23	103.56	2.04
29	CHRISTNA	TRIB	-67.10		0.50	0.10	1.80	2.10	7.00					
				-104.00	1.00	1.00	1.00	1.45	1.00	0.28	0.06	1.01	1.71	3.92
	NODE TOTAL			-104.00						0.28	0.06	1.01	1.71	3.92
30	BRANDYWN	TRIB	-123.68		0.70	0.20	2.00	3.40	7.00					
				-191.70	1.00	1.00	1.00	1.45	1.00	0.72	0.21	2.06	5.09	7.23
	NODE TOTAL			-191.70						0.72	0.21	2.06	5.09	7.23
31	PENSGROV	MUN	-0.30		7.40	7.40	0.0	51.20	2.00					
				-0.47	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.0	0.19	0.01
31	DPEDGMOR	IND	-1.30		1.90	1.90	13.00	6.40	5.00					
				-2.02	1.00	1.00	1.00	1.90	1.00	0.02	0.02	0.14	0.13	0.05
	NODE TOTAL			-2.48						0.04	0.04	0.14	0.32	0.06
33	OLDMANS	TRIB	-19.35		1.00	0.10	1.20	3.40	5.00					
				-30.00	1.00	1.00	1.00	1.45	1.00	0.16	0.02	0.19	0.80	0.81
33	ALLDCHEM	IND	-32.00		1.50	4.50	2.40	19.70	1.00					
				-49.60	1.00	1.00	1.00	1.90	1.00	0.40	1.20	0.64	10.00	0.27
33	PHOENIX	IND	-11.00		0.90	0.0	0.50	3.80	3.00					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.08	0.0	0.05	0.66	0.28
	NODE TOTAL			-96.65						0.64	1.22	0.88	11.46	1.35
34	CHESTER	MUN	-9.00		0.90	8.00	3.20	86.50	5.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.07	0.60	0.24	9.42	0.38
34	MARCUSHK	MUN	-0.60		44.60	14.90	1.90	122.90	3.00					

				-0.93	1.00	1.00	1.00	1.45	1.00	0.22	0.07	0.01	0.89	0.02
34	BP 201	IND	-117.00		0.40	0.70	2.20	14.30	5.00					
				-181.35	1.00	1.00	1.00	1.90	1.00	0.39	0.68	2.15	26.53	4.88
34	FMC	IND	-2.00		1.20	1.20	3.70	281.60	3.00					
				-3.10	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.06	6.82	0.05
34	MONSANTO	IND	-1.60		12.00	6.70	1.90	2172.00	2.00					
				-2.48	1.00	1.00	1.00	1.90	1.00	0.16	0.09	0.03	55.11	0.03
34	SUNOIL 1	IND	-81.50		10.40	7.10	1.90	49.00	5.00					
				-126.33	1.00	1.00	1.00	1.90	1.00	7.07	4.83	1.29	63.33	3.40
	NODE TOTAL			-328.14						7.94	6.30	3.78	162.11	8.75
36	CHESTER	TRIB	-31.61		1.10	0.90	2.00	9.70	7.40					
				-49.00	1.00	1.00	1.00	1.45	1.00	0.29	0.24	0.53	3.71	1.95
36	SCOTT 2	IND	-4.60		0.90	0.90	2.30	61.20	7.10					
				-7.13	1.00	1.00	1.00	1.90	1.00	0.03	0.03	0.09	4.46	0.27
36	SCOTT 3	IND	-8.30		0.90	0.90	2.30	89.80	8.70					
				-12.87	1.00	1.00	1.00	1.90	1.00	0.06	0.06	0.16	11.82	0.60
36	SCOTT 4	IND	-3.70		0.90	0.90	2.30	103.60	6.80					
				-5.73	1.00	1.00	1.00	1.90	1.00	0.03	0.03	0.07	6.08	0.21
	NODE TOTAL			-74.73						0.41	0.36	0.85	26.08	3.04
39	UCARBIDE	IND	-2.60		4.60	13.80	18.40	22.20	2.50					
				-4.03	1.00	1.00	1.00	1.90	1.00	0.10	0.30	0.40	0.92	0.05
	NODE TOTAL			-4.03						0.10	0.30	0.40	0.92	0.05
40	CDCA	MUN	-10.00		6.50	10.20	3.10	41.90	7.00					
				-15.50	1.00	1.00	1.00	1.45	1.00	0.54	0.85	0.26	5.07	0.58
40	DARBY	TRIB	-15.48		3.30	7.70	2.30	2.40	5.00					
				-24.00	1.00	1.00	1.00	1.45	1.00	0.43	1.00	0.30	0.45	0.65
40	DRBYCRSA	MUN	-17.30		0.90	4.00	2.00	2.40	7.00					
				-26.82	1.00	1.00	1.00	1.45	1.00	0.13	0.58	0.29	0.50	1.01
40	MUKNPATS	MUN	-5.80		2.70	36.50	6.20	15.70	5.00					
				-8.99	1.00	1.00	1.00	1.45	1.00	0.13	1.77	0.30	1.10	0.24
40	TINICUM	MUN	-0.60		5.60	11.10	3.70	12.80	5.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.03	0.06	0.02	0.09	0.03
	NODE TOTAL			-76.23						1.26	4.25	1.16	7.22	2.51
42	DPRPAUNO	IND	-16.30		0.70	72.00	10.00	36.00	3.00					
				-25.26	1.00	1.00	1.00	1.90	1.00	0.10	9.80	1.36	9.31	0.41
42	HURCULES	IND	-0.60		0.0	0.0	0.0	5.10	3.00					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.05	0.02

	NODE TOTAL			-26.19						0.10	9.80	1.36	9.35	0.42
43	GLOSTRCO	MUN	-9.00		2.80	12.90	3.70	26.60	5.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.21	0.97	0.28	2.90	0.38
43	PAULSBRO	MUN	-1.30		0.0	26.90	0.0	64.00	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.29	0.0	1.01	0.03
43	MANTUA	TRIB	-7.10		11.80	4.20	0.70	3.00	5.00					
				-11.00	1.00	1.00	1.00	1.45	1.00	0.70	0.25	0.04	0.26	0.30
43	OLINCHEM	IND	-17.40		2.80	1.40	0.0	2.20	3.00					
				-26.97	1.00	1.00	1.00	1.90	1.00	0.41	0.20	0.0	0.61	0.44
43	MOBILCP1	IND	-25.00		2.00	9.10	0.60	55.10	3.00					
				-38.75	1.00	1.00	1.00	1.90	1.00	0.42	1.90	0.13	21.85	0.63
43	SHELL	IND	-1.90		11.70	3.70	0.60	20.50	3.00					
				-2.94	1.00	1.00	1.00	1.90	1.00	0.19	0.06	0.01	0.62	0.05
	NODE TOTAL			-95.63						1.92	3.67	0.45	27.23	1.81
44	PHILA SW	MUN	-147.00		7.70	5.30	2.50	64.40	2.00					
				-227.85	1.00	1.00	1.00	1.45	1.00	9.45	6.50	3.07	114.57	2.45
44	WOODBURY	MUN	-1.90		1.20	0.0	0.0	85.40	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.02	0.0	0.0	1.96	0.05
44	NAT PARK	MUN	-0.60		0.0	3.70	0.0	64.00	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.02	0.0	0.46	0.02
44	GULFOIL3	IND	-14.00		0.0	0.0	0.0	7.70	6.00					
				-21.70	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	1.71	0.70
44	GULFOIL2	IND	-0.30		0.0	0.0	0.0	24.00	6.00					
				-0.47	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.11	0.02
44	GULFOIL1	IND	-5.90		0.0	0.0	0.0	2.00	6.00					
				-9.15	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.19	0.30
44	TEXACO	IND	-4.00		3.00	10.50	0.80	70.40	3.00					
				-6.20	1.00	1.00	1.00	1.90	1.00	0.10	0.35	0.03	4.47	0.10
	NODE TOTAL			-269.23						9.57	6.87	3.09	123.48	3.63
45	ARCO SPL	IND	-3.10		0.0	25.10	0.0	108.20	3.00					
				-4.81	1.00	1.00	1.00	1.90	1.00	0.0	0.65	0.0	5.32	0.08
45	ARCO NYD	IND	-1.50		0.0	0.0	0.0	39.90	3.00					
				-2.32	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.95	0.04
45	ARCO WPL	IND	-0.10		0.0	0.0	0.0	6.00	3.00					
				-0.16	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.01	0.00
	NODE TOTAL			-7.28						0.0	0.65	0.0	6.28	0.12

47	SCHUYLKL	TRIB	-481.94		1.70	0.80	2.00	5.50	7.00					
				-747.00	1.00	1.00	1.00	1.45	1.00	6.84	3.22	8.05	32.08	28.16
	NODE TOTAL			-747.00						6.84	3.22	8.05	32.08	28.16
48	BIGTIMBR	TRIB	-3.87		1.00	1.00	1.30	1.70	2.70					
				-6.00	1.00	1.00	1.00	1.45	1.00	0.03	0.03	0.04	0.08	0.09
48	BELLMAWR	MUN	-1.90		4.30	16.70	0.60	25.60	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.07	0.26	0.01	0.59	0.05
48	BROKLAWN	MUN	-1.30		2.80	13.00	0.90	0.0	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.03	0.14	0.01	0.0	0.03
48	MTEPHRAM	MUN	-1.30		3.70	13.00	0.90	12.80	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.04	0.14	0.01	0.20	0.03
	NODE TOTAL			-12.98						0.17	0.58	0.07	0.87	0.20
49	CAMDEN M	MUN	-36.00		6.30	14.00	0.10	227.70	3.00					
				-55.80	1.00	1.00	1.00	1.45	1.00	1.89	4.21	0.03	99.21	0.90
49	PHILA SE	MUN	-123.00		8.70	4.90	1.40	112.10	3.00					
				-190.65	1.00	1.00	1.00	1.45	1.00	8.93	5.03	1.44	166.88	3.08
49	MCAND&FB	IND	-1.30		0.0	0.0	0.0	256.10	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	4.03	0.03
49	HARSHOW	IND	-0.60		0.0	0.0	0.0	128.10	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.93	0.02
49	GAF	IND	-11.00		2.00	0.0	0.0	92.00	3.00					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.18	0.0	0.0	16.05	0.28
49	NJ ZINC	IND	-11.50		2.30	31.20	1.40	26.00	3.00					
				-17.82	1.00	1.00	1.00	1.90	1.00	0.22	2.99	0.13	4.74	0.29
	NODE TOTAL			-284.27						11.23	12.23	1.60	291.84	4.59
50	GLOSTRCY	MUN	-2.50		6.20	14.90	0.0	100.60	3.00					
				-3.88	1.00	1.00	1.00	1.45	1.00	0.13	0.31	0.0	3.04	0.06
	NODE TOTAL			-3.88						0.13	0.31	0.0	3.04	0.06
51	AMSTAR 1	IND	-12.00		0.0	1.10	0.0	13.00	5.00					
				-18.60	1.00	1.00	1.00	1.45	1.00	0.0	0.11	0.0	1.89	0.50
	NODE TOTAL			-18.60						0.0	0.11	0.0	1.89	0.50
52	NATSUGAR	IND	-18.10		0.0	0.0	0.0	4.10	7.50					
				-28.06	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.90	1.13
	NODE TOTAL			-28.06						0.0	0.0	0.0	0.90	1.13
54	COOPER	TRIB	-28.39		0.60	0.40	1.30	7.00	6.70					

				-44.00	1.00	1.00	1.00	1.45	1.00	0.14	0.09	0.31	2.40	1.59
54	CAMDEN N	MUN	-3.60		3.00	20.00	7.20	90.00	2.00					
				-5.58	1.00	1.00	1.00	1.45	1.00	0.09	0.60	0.22	3.92	0.06
	NODE TOTAL			-49.58						0.23	0.70	0.52	6.33	1.65
55	PHILA NE	MUN	-129.00		8.40	8.90	0.70	46.90	2.00					
				-292.95	1.00	1.00	1.00	1.45	1.00	13.25	14.04	1.10	107.28	3.16
55	GEORGPAC	IND	-1.90		0.0	0.0	0.0	768.00	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	17.66	0.05
55	PENSAUKN	MUN	-3.60		1.50	0.0	0.0	192.00	3.00					
				-5.58	1.00	1.00	1.00	1.45	1.00	0.05	0.0	0.0	8.37	0.09
	NODE TOTAL			-301.47						13.30	14.04	1.10	133.31	3.29
58	PALMYRA	MUN	-0.60		3.70	20.40	1.90	25.60	3.50					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.10	0.01	0.19	0.02
	NODE TOTAL			-0.93						0.02	0.10	0.01	0.19	0.02
61	RANCOCAS	TRIB	-58.06		2.10	1.20	2.10	10.00	5.00					
				-90.00	1.00	1.00	1.00	1.45	1.00	1.02	0.58	1.02	7.03	2.42
61	WLINGBRO	MUN	-1.90		3.10	11.80	0.0	42.70	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.05	0.19	0.0	0.98	0.05
	NODE TOTAL			-92.94						1.07	0.77	1.02	8.01	2.47
64	TENNECO	IND	-1.30		6.50	17.60	2.80	34.60	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.07	0.19	0.03	0.54	0.03
	NODE TOTAL			-2.02						0.07	0.19	0.03	0.54	0.03
65	NESHAMNY	TRIB	-28.39		3.40	1.30	6.50	2.60	8.30					
				-44.00	1.00	1.00	1.00	1.45	1.00	0.81	0.31	1.54	0.89	1.97
65	FALLSTWP	MUN	-2.60		1.40	3.70	11.10	6.70	3.00					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.03	0.08	0.24	0.21	0.07
	NODE TOTAL			-48.03						0.84	0.39	1.78	1.10	2.03
66	OTR&ASNK	TRIB	-6.45		0.0	0.0	0.0	3.00	5.00					
				-10.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.23	0.27
66	BRSTLBRO	MUN	-1.30		9.30	13.90	4.60	6.40	6.30					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.10	0.15	0.05	0.10	0.07
66	BRSTLTWP	MUN	-2.60		3.70	10.70	1.40	6.70	3.00					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.08	0.23	0.03	0.21	0.07
66	ROHM&HAS	IND	-3.80		0.30	9.50	0.10	39.40	2.00					
				-5.89	1.00	1.00	1.00	1.45	1.00	0.01	0.30	0.00	1.81	0.06

	NODE TOTAL			-21.93						0.19	0.68	0.08	2.36	0.47
69	MARTINS	TRIB	-5.16		0.0	0.0	0.0	3.80	5.00					
				-8.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.24	0.22
69	LWRBUCKS	MUN	-7.50		8.80	14.40	0.0	32.00	3.00					
				-11.63	1.00	1.00	1.00	1.45	1.00	0.55	0.90	0.0	2.90	0.19
69	FLORENCE	MUN	-0.60		4.00	22.00	0.0	55.00	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.0	0.40	0.02
69	PATPARCH	IND	-3.20		26.00	8.90	0.0	43.50	3.00					
				-4.96	1.00	1.00	1.00	1.45	1.00	0.69	0.24	0.0	1.68	0.08
	NODE TOTAL			-25.51						1.27	1.25	0.0	5.23	0.50
71	US STEEL	IND	-72.90		1.70	2.40	1.90	3.40	5.00					
				-112.99	1.00	1.00	1.00	1.45	1.00	1.03	1.46	1.16	3.00	3.04
	NODE TOTAL			-112.99						1.03	1.46	1.16	3.00	3.04
72	BORDENTN	MUN	-1.30		2.80	11.10	0.90	38.10	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.03	0.12	0.01	0.60	0.03
	NODE TOTAL			-2.02						0.03	0.12	0.01	0.60	0.03
73	CROSWICK	TRIB	-21.94		1.20	2.90	2.00	3.80	7.00					
				-34.00	1.00	1.00	1.00	1.45	1.00	0.22	0.53	0.37	1.01	1.28
73	HAMILTON	MUN	-9.00		2.80	11.30	1.10	11.90	3.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.21	0.85	0.08	1.30	0.23
	NODE TOTAL			-47.95						0.43	1.38	0.45	2.31	1.51
75	TRENTON	MUN	-18.50		4.20	40.20	1.20	77.70	2.00					
				-28.68	1.00	1.00	1.00	1.45	1.00	0.65	6.21	0.19	17.40	0.31
	NODE TOTAL			-28.68						0.65	6.21	0.19	17.40	0.31
76	ASSNPINK	TRIB	-45.16		0.80	0.70	2.40	3.00	7.20					
				-70.00	1.00	1.00	1.00	1.45	1.00	0.30	0.26	0.90	1.64	2.71
76	MORRISVL	MUN	-3.90		0.0	31.50	1.80	18.00	7.40					
				-6.05	1.00	1.00	1.00	1.45	1.00	0.0	1.03	0.06	0.85	0.24
	NODE TOTAL			-76.04						0.30	1.29	0.96	2.49	2.95

SUMMARY OF DISCHARGE LOADS BY ZONE AND TYPE

INPUT ZONE	TYPE OF DISCHARGE	NUMBER OF DISCHARGES	ADJUSTED INPUT LOADS - 1000 LB/DAY CONST1	CONST2	CONST3	CONST4	CONST5	INPUT LOADS - PERCENT OF ZONE BY TYPE CONST1	CONST2	CONST3	CONST4	CONST5
1	MUN	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	IND	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	TRIB	1.	12.60	2.10	21.00	91.36	176.41	100.00	100.00	100.00	100.00	100.00
	ZONE TOTAL	1.	12.60	2.10	21.00	91.36	176.41	14.37	1.47	30.26	6.75	61.24
2	MUN	10.	1.72	9.86	0.66	24.95	1.26	29.30	71.80	11.58	57.98	9.42
2	IND	4.	1.81	2.19	1.19	7.04	3.22	30.79	15.94	20.96	16.36	24.12
2	TRIB	6.	2.34	1.68	3.83	11.04	8.87	39.91	12.26	67.46	25.66	66.47
	ZONE TOTAL	20.	5.87	13.74	5.68	43.03	13.35	6.70	9.63	8.18	3.18	4.63
3	MUN	7.	24.36	24.29	2.80	388.88	7.37	97.81	88.36	86.35	88.89	65.50
3	IND	7.	0.40	3.10	0.13	46.20	2.29	1.62	11.29	4.15	10.56	20.38
3	TRIB	1.	0.14	0.09	0.31	2.40	1.59	0.57	0.34	9.51	0.55	14.12
	ZONE TOTAL	15.	24.91	27.49	3.24	437.48	11.25	28.40	19.27	4.67	32.30	3.90
4	MUN	14.	10.94	12.26	4.49	138.78	5.29	38.65	34.05	23.37	35.08	10.86
4	IND	20.	9.08	19.00	5.77	220.25	12.26	32.07	52.80	30.02	55.67	25.18
4	TRIB	5.	8.29	4.73	8.95	36.58	31.14	29.28	13.15	46.60	9.25	63.95
	ZONE TOTAL	39.	28.30	35.99	19.21	395.61	48.69	32.27	25.23	27.68	29.21	16.90
5	MUN	5.	4.58	23.50	0.20	98.19	2.16	28.60	37.12	0.99	25.38	5.62
5	IND	3.	10.27	39.53	16.80	280.92	24.15	64.13	62.44	82.90	72.61	62.91
5	TRIB	4.	1.16	0.26	3.27	7.76	12.08	7.27	0.44	16.12	2.01	31.48
	ZONE TOTAL	17.	16.02	63.31	20.27	386.88	38.39	18.26	44.39	29.21	28.57	13.32
	GRAND TOTAL	92.	87.70	142.64	69.40	1354.36	288.08					

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SECTION 4 WATER QUALITY BOUNDARY CONDITIONS

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SEAWARD BOUNDARY CONDITIONS

NODE 1 : COURTHOUSE PT , MARYLAND

' CIN1 ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.30	0.30	1.00	1.00	7.00

NODE 2 : LISTON PT , DELAWARE

' CINMAX ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.32	0.12	1.40	1.50	5.50

UPSTREAM BOUNDARY CONDITIONS

NODE 76 RECIEVES VARYING LOADS FROM DELAWARE (RIVR)

FLOW PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	FLOW (CFS)
1	2400	-3900.00

QUAL PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.60	0.10	1.00	4.35	8.40

SECTION 5 ***** SUMMARY OF HYDRAULIC INPUTS *****

JUNCTION HEAD AND HYD. RADIUS AND X-SECTIONAL AREA OF CHANNELS ARE AT MEAN TIDE **

CHANNEL DATA									JUNCTION DATA							
CHAN.	LENGTH	WIDTH	AREA	MANNING	NET FLOW	HYD. RADIUS	JUNC. AT ENDS		JUNC.	INFLOW	HEAD	CHANNELS ENTERING JUNCTION				
1	7000.	2400.	31041.	0.010	1912.28	12.9	1	3	1	0.0	0.10	1	0	0	0	0
2	11000.	850.	24478.	0.010	1912.25	28.8	3	4	2	0.0	-0.07	9	0	0	0	0
3	11000.	650.	18646.	0.010	1912.22	28.7	4	5	3	0.0	0.10	1	2	0	0	0
4	11000.	600.	17093.	0.010	1912.22	28.5	5	6	4	0.0	0.10	2	3	0	0	0
5	11000.	600.	16916.	0.010	1912.22	28.2	6	7	5	0.0	0.10	3	4	0	0	0
6	11000.	600.	13766.	0.010	1912.21	22.9	7	8	6	0.0	0.10	4	5	0	0	0
7	11000.	600.	12381.	0.010	1912.16	20.6	8	9	7	0.0	0.10	5	6	0	0	0
8	15679.	600.	11035.	0.010	1912.13	18.4	9	10	8	0.0	0.10	6	7	0	0	0
9	14994.	12995.	212732.	0.010	-8267.95	16.4	2	11	9	0.0	0.10	7	8	0	0	0
10	14994.	11829.	182978.	0.010	-8268.04	15.5	11	12	10	0.0	0.08	8	12	0	0	0
11	14994.	7700.	119189.	0.010	-11744.06	15.5	12	13	11	0.0	-0.04	9	10	0	0	0
12	11995.	4500.	78096.	0.010	1912.04	17.4	10	13	12	0.0	0.01	10	11	13	0	0
13	19326.	1700.	11946.	0.010	3474.65	7.0	12	14	13	0.0	0.08	11	12	14	18	20
14	7330.	7600.	68837.	0.010	5870.88	9.1	13	14	14	0.0	0.09	13	14	15	19	0
15	8996.	1000.	8615.	0.015	-16.88	8.6	14	15	15	0.0	0.18	15	16	0	0	0
16	8996.	4332.	32701.	0.015	-16.56	7.5	15	16	16	0.0	0.18	16	17	0	0	0
17	8996.	5331.	40358.	0.015	-15.80	7.6	16	17	17	-15.0	0.18	17	0	0	0	0
18	13661.	3800.	53752.	0.010	8258.80	14.1	13	18	18	0.0	0.10	18	21	0	0	0
19	8996.	5600.	23791.	0.010	9362.25	4.2	14	19	19	0.0	0.13	19	22	0	0	0
20	13661.	3400.	70365.	0.010	-23963.29	20.7	13	20	20	0.0	0.13	20	22	24	0	0
21	10662.	6000.	45761.	0.010	8258.62	7.6	18	21	21	0.0	0.19	21	23	0	0	0
22	9663.	4900.	47962.	0.010	9361.95	9.8	19	20	22	0.0	0.20	23	24	25	0	0
23	10996.	7600.	98206.	0.010	8258.32	12.9	21	22	23	0.0	0.22	25	26	0	0	0
24	13994.	3900.	66834.	0.010	-14601.62	17.1	20	22	24	0.0	0.23	26	27	0	0	0
25	13661.	8996.	149701.	0.010	-6343.82	16.6	22	23	25	0.0	0.24	27	28	33	0	0
26	11995.	8274.	146591.	0.010	-6344.27	17.7	23	24	26	0.0	0.25	28	29	32	0	0
27	11995.	6942.	145814.	0.010	-6344.72	21.0	24	25	27	0.0	0.25	29	30	0	0	0
28	9330.	1000.	14312.	0.015	-780.15	14.3	25	26	28	0.0	0.24	30	31	0	0	0
29	9330.	722.	7491.	0.015	-262.20	10.4	26	27	29	-262.0	0.24	31	0	0	0	0
30	9330.	389.	3587.	0.015	-262.20	9.2	27	28	30	-518.0	0.27	32	0	0	0	0
31	9330.	278.	2283.	0.015	-262.14	8.2	28	29	31	0.0	0.26	33	34	0	0	0
32	9330.	389.	2231.	0.015	-517.97	5.7	26	30	32	0.0	0.29	34	35	0	0	0
33	11995.	8163.	147978.	0.016	-5565.14	18.1	25	31	33	0.0	0.32	35	36	0	0	0
34	11995.	7441.	128049.	0.016	-5565.73	17.2	31	32	34	-49.0	0.34	36	37	38	0	0
35	11995.	6997.	114127.	0.016	-5566.24	16.3	32	33	35	0.0	0.34	38	40	0	0	0
36	13328.	5720.	114753.	0.016	-5566.64	20.1	33	34	36	-83.0	0.36	37	39	0	0	0
37	11995.	4054.	90810.	0.020	-7000.09	22.4	34	36	37	0.0	0.38	40	41	0	0	0
38	10662.	3887.	63741.	0.020	1482.16	16.4	34	35	38	0.0	0.38	39	41	42	43	0
39	11995.	4332.	85787.	0.020	-6917.19	19.8	36	38	39	0.0	0.39	42	44	45	0	0
40	7330.	2443.	15593.	0.020	1482.06	6.4	35	37	40	-60.0	0.36	44	0	0	0	0
41	7330.	2100.	18372.	0.020	1482.03	8.7	37	38	41	0.0	0.41	45	46	0	0	0
42	6331.	2600.	29857.	0.020	590.30	11.5	38	39	42	0.0	0.40	43	47	0	0	0
43	11995.	4942.	92225.	0.020	-6025.57	18.7	38	42	43	-24.0	0.42	46	47	48	0	0
44	8996.	300.	1783.	0.020	-59.98	5.9	39	40	44	0.0	0.43	48	49	52	0	0
45	6331.	1944.	13284.	0.020	650.27	6.6	39	41	45	0.0	0.43	49	50	0	0	0
46	11995.	2388.	28643.	0.020	650.27	12.0	41	43	46	0.0	0.43	50	51	0	0	0
47	11995.	3499.	77735.	0.020	-6025.62	22.2	42	43	47	-750.0	0.43	51	0	0	0	0

48	14994.	3998.	89416.	0.020	-5351.27	22.4	43	44
49	10662.	750.	9167.	0.020	-751.47	12.2	44	45
50	10662.	611.	10164.	0.020	-751.10	16.6	45	46
51	10662.	555.	7296.	0.020	-750.42	13.1	46	47
52	11995.	3887.	85840.	0.020	-4599.58	22.1	44	48
53	11995.	2832.	65795.	0.020	-4599.59	23.2	48	49
54	8996.	167.	2106.	0.020	0.05	12.6	49	50
55	11995.	2332.	65454.	0.020	-4599.84	28.1	49	51
56	10329.	2888.	75966.	0.020	-4600.16	26.3	51	52
57	6331.	1400.	18961.	0.020	-311.13	13.5	52	53
58	8996.	300.	2065.	0.020	-31.88	6.9	53	54
59	11995.	3165.	73732.	0.020	-4289.50	23.3	52	55
60	7997.	2499.	30353.	0.020	-279.42	12.1	53	55
61	9674.	3195.	63511.	0.020	-4314.67	20.5	55	56
62	9007.	300.	3425.	0.020	-13.93	11.4	56	57
63	9674.	2474.	52545.	0.035	-4301.65	21.3	56	58
64	9674.	2752.	58074.	0.035	-4302.45	21.1	58	59
65	9674.	2419.	47015.	0.035	-4303.24	19.4	59	60
66	9007.	600.	9180.	0.035	-174.75	13.6	60	61
67	9007.	2863.	48809.	0.035	-4129.09	17.0	60	62
68	9007.	2391.	43929.	0.035	-4129.36	18.4	62	63
69	9508.	1890.	38607.	0.035	-4129.66	20.4	63	64
70	6331.	334.	4564.	0.035	-159.78	13.7	64	65
71	9508.	1640.	37523.	0.035	-3970.52	22.9	64	66
72	11009.	1307.	31145.	0.035	-3144.93	23.8	66	68
73	7839.	862.	14151.	0.040	-826.42	16.4	66	67
74	7839.	834.	13825.	0.040	-826.70	16.6	67	68
75	9674.	1362.	31311.	0.040	-3972.45	23.0	68	69
76	10842.	1334.	32159.	0.040	-3972.60	24.1	69	70
77	12009.	1418.	29084.	0.040	-3971.66	20.5	70	71
78	9007.	1362.	22449.	0.040	-3969.69	16.5	71	72
79	6005.	334.	3729.	0.040	-64.25	11.2	72	73
80	7506.	1473.	21073.	0.040	-3903.59	14.3	72	74
81	8000.	1168.	18562.	0.040	-3901.94	14.2	74	75
82	8000.	862.	9275.	0.040	-3900.78	10.8	75	76

48	0.0	0.44	52	53	0	0	0
49	0.0	0.45	53	54	55	0	0
50	0.0	0.44	54	0	0	0	0
51	0.0	0.45	55	56	0	0	0
52	0.0	0.45	56	57	59	0	0
53	0.0	0.46	57	58	60	0	0
54	-32.0	0.46	58	0	0	0	0
55	-255.0	0.46	59	60	61	0	0
56	0.0	0.47	61	62	63	0	0
57	-14.0	0.47	62	0	0	0	0
58	0.0	0.48	63	64	0	0	0
59	0.0	0.49	64	65	0	0	0
60	0.0	0.50	65	66	67	0	0
61	-175.0	0.50	66	0	0	0	0
62	0.0	0.51	67	68	0	0	0
63	0.0	0.52	68	69	0	0	0
64	0.0	0.52	69	70	71	0	0
65	-160.0	0.52	70	0	0	0	0
66	0.0	0.52	71	72	73	0	0
67	0.0	0.52	73	74	0	0	0
68	0.0	0.53	72	74	75	0	0
69	0.0	0.53	75	76	0	0	0
70	0.0	0.54	76	77	0	0	0
71	0.0	0.55	77	78	0	0	0
72	0.0	0.57	78	79	80	0	0
73	-64.0	0.57	79	0	0	0	0
74	0.0	0.59	80	81	0	0	0
75	0.0	0.61	81	82	0	0	0
76	-3900.0	0.68	82	0	0	0	0

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SECTION 3 WATER QUALITY INPUTS

****

SUMMARY OF POINT SOURCE INPUTS

SIMULATION PERIOD : OCTOBER 1 21 , 1973

CONSTITUENT 1 IS NORG (MG/L)
CONSTITUENT 2 IS NH3 (MG/L)
CONSTITUENT 3 IS NO3 (MG/L)
CONSTITUENT 4 IS CBOD (MG/L)
CONSTITUENT 5 IS DO (MG/L)

MUNICIPAL AND INDUSTRIAL WASTEWATER AND TRIBUTARY INFLOW BY NODE

INPUT NODE	NAME OF DISCHARGE	TYPE OF DISCHARGE	******* FLOW ******* MGD	CFS	UNADJUSTED CONC (MG/L) + ADJ. FACTORS CONST1	CONST2	CONST3	CONST4	CONST5	ADJUSTED INPUT LOADS - 1000 LB/DAY CONST1	CONST2	CONST3	CONST4	CONST5
14	SALEMCTY	MUN	-2.80		2.10	8.50	0.0	48.00	5.00					
				-4.34	1.00	1.00	1.00	1.45	1.00	0.05	0.20	0.0	1.63	0.12
	NODE TOTAL			-4.34						0.05	0.20	0.0	1.63	0.12
17	SALEM	TRIB	-2.58		0.0	0.0	0.0	5.50	9.00					
				-4.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.17	0.19
	NODE TOTAL			-4.00						0.0	0.0	0.0	0.17	0.19
21	GETTYOIL	IND	-370.00		6.00	5.30	2.00	2.50	5.00					
				-573.50	1.00	1.00	1.00	1.90	1.00	18.53	16.37	6.18	14.67	15.44
	NODE TOTAL			-573.50						18.53	16.37	6.18	14.67	15.44
22	AMOCO	IND	-0.60		1.00	17.00	0.0	134.20	3.00					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.01	0.09	0.0	1.28	0.02
	NODE TOTAL			-0.93						0.01	0.09	0.0	1.28	0.02
23	PENNSVLE	MUN	-0.60		16.70	40.90	0.0	179.00	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.08	0.20	0.0	1.30	0.02

	NODE TOTAL			-0.93						0.08	0.20	0.0	1.30	0.02
24	DPCHAMBR	IND	-118.00		4.20	25.40	0.60	152.30	6.00					
				-182.90	1.00	1.00	1.00	1.45	1.00	4.14	25.02	0.59	217.50	5.91
24	ICI 1	IND	-5.20		5.60	3.00	32.50	278.60	5.00					
				-8.06	1.00	1.00	1.00	1.45	1.00	0.24	0.13	1.41	17.53	0.22
	NODE TOTAL			-190.96						4.38	25.15	2.00	235.04	6.13
25	DPCARNEY	IND	-2.40		6.90	19.50	9.90	324.50	2.00					
				-3.72	1.00	1.00	1.00	1.45	1.00	0.14	0.39	0.20	9.43	0.04
25	UPENSNCK	MUN	-0.50		5.30	26.50	0.0	128.10	2.00					
				-0.78	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.0	0.78	0.01
25	WLMINGTN	MUN	-68.00		9.00	30.00	0.30	109.20	3.00					
				-105.40	1.00	1.00	1.00	1.45	1.00	5.11	17.03	0.17	89.87	1.70
	NODE TOTAL			-109.90						5.27	17.53	0.37	100.07	1.75
29	CHRISTNA	TRIB	-92.26		0.50	0.10	1.80	2.10	7.00					
				-143.00	1.00	1.00	1.00	1.45	1.00	0.39	0.08	1.39	2.34	5.39
	NODE TOTAL			-143.00						0.39	0.08	1.39	2.34	5.39
30	BRANDYWN	TRIB	-172.90		0.70	0.20	2.00	3.40	7.00					
				-268.00	1.00	1.00	1.00	1.45	1.00	1.01	0.29	2.89	7.11	10.10
	NODE TOTAL			-268.00						1.01	0.29	2.89	7.11	10.10
31	PENSGROV	MUN	-0.30		7.40	7.40	0.0	51.20	2.00					
				-0.47	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.0	0.19	0.01
31	DPEDGMOR	IND	-23.20		1.50	5.20	9.50	201.20	2.00					
				-35.96	1.00	1.00	1.00	1.90	1.00	0.29	1.01	1.84	74.03	0.39
	NODE TOTAL			-36.42						0.31	1.03	1.84	74.21	0.39
33	OLDMANS	TRIB	-25.81		1.00	0.10	1.20	3.40	9.00					
				-40.00	1.00	1.00	1.00	1.45	1.00	0.22	0.02	0.26	1.06	1.94
33	ALLDCHEM	IND	-32.00		1.80	2.60	2.80	15.00	1.00					
				-49.60	1.00	1.00	1.00	1.90	1.00	0.48	0.69	0.75	7.61	0.27
33	PHOENIX	IND	-11.00		0.90	0.0	0.50	3.80	3.00					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.08	0.0	0.05	0.66	0.28
	NODE TOTAL			-106.65						0.78	0.72	1.05	9.34	2.48
34	CHESTER	MUN	-9.40		0.80	7.60	3.60	85.40	5.00					
				-14.57	1.00	1.00	1.00	1.45	1.00	0.06	0.60	0.28	9.72	0.39
34	MARCUSHK	MUN	-0.60		44.60	14.90	1.90	122.90	3.00					

				-0.93	1.00	1.00	1.00	1.45	1.00	0.22	0.07	0.01	0.89	0.02
34	BP 201	IND	-113.00		2.50	6.00	3.60	50.10	5.00					
				-175.15	1.00	1.00	1.00	1.90	1.00	2.36	5.66	3.40	89.78	4.72
34	FMC	IND	-2.00		1.20	1.20	6.00	60.00	3.00					
				-3.10	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.10	1.45	0.05
34	MONSANTO	IND	-1.50		12.80	7.20	1.60	2037.00	2.00					
				-2.32	1.00	1.00	1.00	1.90	1.00	0.16	0.09	0.02	48.46	0.03
34	SUNOIL 1	IND	-68.00		12.50	6.20	2.20	47.60	5.00					
				-105.40	1.00	1.00	1.00	1.90	1.00	7.09	3.52	1.25	51.33	2.84
	NODE TOTAL			-301.47						9.92	9.96	5.06	201.63	8.04
36	SCOTT 2	IND	-4.40		0.90	0.90	2.30	49.60	7.00					
				-6.82	1.00	1.00	1.00	1.90	1.00	0.03	0.03	0.08	3.46	0.26
36	SCOTT 4	IND	-4.40		0.90	0.90	2.30	89.90	7.00					
				-6.82	1.00	1.00	1.00	1.90	1.00	0.03	0.03	0.08	6.27	0.26
36	CHESTER	TRI2	-31.61		1.10	0.90	2.00	9.70	7.00					
				-49.00	1.00	1.00	1.00	1.45	1.00	0.29	0.24	0.53	3.71	1.85
36	SCOTT 3	IND	-7.70		0.90	0.90	2.30	65.40	8.00					
				-11.94	1.00	1.00	1.00	1.90	1.00	0.06	0.06	0.15	7.99	0.51
	NODE TOTAL			-74.57						0.41	0.36	0.84	21.43	2.88
39	UCARBIDE	IND	-2.60		4.60	13.80	18.40	22.20	2.50					
				-4.03	1.00	1.00	1.00	1.90	1.00	0.10	0.30	0.40	0.92	0.05
	NODE TOTAL			-4.03						0.10	0.30	0.40	0.92	0.05
40	DARBY	TRI?	-15.48		3.30	7.70	2.30	2.40	7.00					
				-24.00	1.00	1.00	1.00	1.45	1.00	0.43	1.00	0.30	0.45	0.90
40	CDCA	MUN	-9.00		7.30	14.60	3.20	49.30	7.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.55	1.10	0.24	5.37	0.53
40	DRBYCRSA	MUN	-39.30		0.90	3.60	2.00	2.10	3.00					
				-60.92	1.00	1.00	1.00	1.45	1.00	0.30	1.18	0.66	1.00	0.98
40	MUKNPATS	MUN	-5.80		2.70	36.50	6.20	15.70	5.00					
				-6.99	1.00	1.00	1.00	1.45	1.00	0.13	1.77	0.30	1.10	0.24
40	TINICUM	MUN	-0.60		5.60	11.10	3.70	12.80	5.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.03	0.06	0.02	0.09	0.03
	NODE TOTAL			-108.78						1.43	5.10	1.51	8.01	2.68
42	DPRPAUNO	IND	-52.00		1.40	46.10	7.00	94.50	3.00					
				-80.60	1.00	1.00	1.00	1.90	1.00	0.61	20.01	3.04	77.93	1.30
42	HURCULES	IND	-0.60		0.0	0.0	0.0	5.10	3.00					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.05	0.02

	NODE TOTAL			-81.53						0.61	20.01	3.04	77.98	1.32
43	GLOSTRCO	MUN	-7.50		0.30	11.20	1.60	14.40	5.00					
				-11.63	1.00	1.00	1.00	1.45	1.00	0.02	0.70	0.10	1.31	0.31
43	PAULSBRO	MUN	-1.30		0.0	26.90	0.0	64.00	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.29	0.0	1.01	0.03
43	MANTUA	TRIB	-9.68		11.80	4.20	0.70	3.00	5.00					
				-15.00	1.00	1.00	1.00	1.45	1.00	0.95	0.34	0.06	0.35	0.40
43	OLINCHEM	IND	-17.40		2.80	1.40	0.0	2.10	3.00					
				-26.97	1.00	1.00	1.00	1.90	1.00	0.41	0.20	0.0	0.58	0.44
43	MOBILCP1	IND	-25.00		2.00	9.10	0.70	55.10	3.00					
				-38.75	1.00	1.00	1.00	1.90	1.00	0.42	1.90	0.15	21.85	0.63
43	SHELL	IND	-1.90		11.70	3.70	0.60	20.50	3.00					
				-2.94	1.00	1.00	1.00	1.90	1.00	0.19	0.06	0.01	0.62	0.05
	NODE TOTAL			-97.30						1.98	3.49	0.31	25.71	1.86
44	GULFOIL2	IND	-0.30		0.0	0.0	0.0	24.00	6.00					
				-0.47	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.11	0.02
44	GULFOIL1	IND	-5.90		0.0	0.0	0.0	2.00	6.00					
				-9.15	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.19	0.30
44	PHILA SW	MUN	-140.00		9.90	8.60	2.60	64.70	2.00					
				-217.00	1.00	1.00	1.00	1.45	1.00	11.57	10.05	3.04	109.63	2.34
44	WOODBURY	MUN	-1.90		0.0	0.0	0.0	0.0	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.0	0.05
44	NAT PARK	MUN	-0.60		3.70	3.70	0.0	64.00	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.0	0.46	0.02
44	GULFOIL3	IND	-14.00		0.0	0.0	0.0	7.70	6.00					
				-21.70	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	1.71	0.70
44	TEXACO	IND	-4.30		7.80	18.40	18.90	30.70	3.00					
				-6.67	1.00	1.00	1.00	1.90	1.00	0.28	0.66	0.68	2.09	0.11
	NODE TOTAL			-253.85						11.87	10.73	3.72	114.20	3.52
45	ARCO SPL	IND	-3.10		0.0	25.10	0.0	108.20	3.00					
				-4.81	1.00	1.00	1.00	1.90	1.00	0.0	0.65	0.0	5.32	0.08
45	ARCO NYD	IND	-1.50		0.0	0.0	0.0	39.90	3.00					
				-2.32	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.95	0.04
45	ARCO WPL	IND	-0.10		0.0	0.0	0.0	6.00	3.00					
				-0.16	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.01	0.00
	NODE TOTAL			-7.28						0.0	0.65	0.0	6.28	0.12

47	SCHUYLKL	TRIB	-903.23		0.80	0.80	2.00	5.50	7.00					
				-1400.00	1.00	1.00	1.00	1.45	1.00	6.03	6.03	15.08	60.12	52.77
	NODE TOTAL			-1400.00						6.03	6.03	15.08	60.12	52.77
48	BIGTIMBR	TRIB	-5.81		1.00	1.00	1.30	1.70	5.00					
				-9.00	1.00	1.00	1.00	1.45	1.00	0.05	0.05	0.06	0.12	0.24
48	BELLMAWR	MUN	-1.90		6.20	16.70	8.00	37.10	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.10	0.26	0.13	0.85	0.05
48	BROKLAWN	MUN	-1.30		2.80	13.00	0.90	0.0	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.03	0.14	0.01	0.0	0.03
48	MTEPHRAM	MUN	-1.30		9.30	13.00	0.90	38.40	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.10	0.14	0.01	0.60	0.03
	NODE TOTAL			-15.98						0.28	0.60	0.21	1.58	0.36
49	CAMDEN M	MUN	-30.00		8.00	20.00	0.0	227.70	3.00					
				-46.50	1.00	1.00	1.00	1.45	1.00	2.00	5.01	0.0	82.67	0.75
49	PHILA SE	MUN	-119.00		8.70	2.20	1.00	95.70	3.00					
				-184.45	1.00	1.00	1.00	1.45	1.00	8.64	2.19	0.99	137.83	2.98
49	MCAND&FR	IND	-1.30		0.0	0.0	0.0	148.60	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	2.34	0.03
49	HARSHOW	IND	-0.60		0.0	0.0	0.0	352.80	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	2.56	0.02
49	GAF	IND	-11.00		0.0	0.0	0.0	152.90	3.00					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	26.67	0.28
49	NJ ZINC	IND	-11.50		0.0	49.00	0.0	19.80	3.00					
				-17.82	1.00	1.00	1.00	1.90	1.00	0.0	4.70	0.0	3.61	0.29
	NODE TOTAL			-268.77						10.64	11.90	0.99	255.69	4.34
50	GLOSTRCY	MUN	-2.50		6.20	17.70	1.00	134.20	3.00					
				-3.88	1.00	1.00	1.00	1.45	1.00	0.13	0.37	0.02	4.06	0.06
	NODE TOTAL			-3.88						0.13	0.37	0.02	4.06	0.06
51	AMSTAR 1	IND	-12.00		0.0	1.10	0.0	13.00	5.00					
				-18.60	1.00	1.00	1.00	1.45	1.00	0.0	0.11	0.0	1.89	0.50
	NODE TOTAL			-18.60						0.0	0.11	0.0	1.89	0.50
52	NATSUGAR	IND	-18.10		0.0	0.0	0.0	25.90	7.50					
				-28.06	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	5.67	1.13
	NODE TOTAL			-28.06						0.0	0.0	0.0	5.67	1.13
54	COOPER	TRIB	-14.19		0.60	0.30	2.00	7.00	7.00					

				-22.00	1.00	1.00	1.00	1.45	1.00	0.07	0.04	0.24	1.20	0.83
54	CAMDEN N	MUN	-3.60		3.00	20.00	7.70	90.00	2.00					
				-5.58	1.00	1.00	1.00	1.45	1.00	0.09	0.60	0.23	3.92	0.06
	NODE TOTAL			-27.58						0.16	0.64	0.47	5.12	0.89
55	PHILA NE	MUN	-184.00		8.70	14.10	0.80	83.40	2.00					
				-285.20	1.00	1.00	1.00	1.45	1.00	13.36	21.65	1.23	185.72	3.07
55	GEORGPAC	IND	-1.90		0.0	0.0	0.0	117.60	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	2.70	0.05
55	PENSAUKN	MUN	-3.60		1.50	0.0	0.0	192.00	3.00					
				-5.58	1.00	1.00	1.00	1.45	1.00	0.05	0.0	0.0	8.37	0.09
	NODE TOTAL			-293.72						13.41	21.65	1.23	196.79	3.21
58	PALMYRA	MUN	-0.60		3.70	20.40	1.90	25.60	3.50					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.10	0.01	0.19	0.02
	NODE TOTAL			-0.93						0.02	0.10	0.01	0.19	0.02
61	RANCOCAS	TRIB	-75.48		2.00	1.00	1.90	10.00	9.00					
				-117.00	1.00	1.00	1.00	1.45	1.00	1.26	0.63	1.20	9.14	5.67
61	WLINGBRO	MUN	-1.90		7.40	18.00	0.0	55.70	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.12	0.29	0.0	1.28	0.05
	NODE TOTAL			-119.94						1.38	0.92	1.20	10.42	5.72
64	TENNECO	IND	-1.30		6.50	17.60	2.80	34.60	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.07	0.19	0.03	0.54	0.03
	NODE TOTAL			-2.02						0.07	0.19	0.03	0.54	0.03
65	NESHAMNY	TRIB	-56.77		1.40	0.60	2.70	4.20	9.00					
				-88.00	1.00	1.00	1.00	1.45	1.00	0.66	0.28	1.28	2.89	4.26
65	FALLSTWP	MUN	-2.60		0.90	0.90	11.10	23.20	4.00					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.24	0.73	0.09
	NODE TOTAL			-92.03						0.68	0.30	1.52	3.62	4.35
66	OTR&ASNK	TRIB	-6.45		0.0	0.0	0.0	3.00	5.00					
				-10.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.23	0.27
66	BRSTLTWP	MUN	-2.60		3.70	10.70	1.40	6.70	3.00					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.08	0.23	0.03	0.21	0.07
66	ROHM&HAS	IND	-1.70		0.70	1.40	0.70	14.10	2.00					
				-2.63	1.00	1.00	1.00	1.45	1.00	0.01	0.02	0.01	0.29	0.03
	NODE TOTAL			-16.66						0.09	0.25	0.04	0.74	0.36

69	MARTINS	TRIB	-5.16		0.0	0.0	0.0	3.80	7.00					
				-8.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.24	0.30
69	LWRBUCKS	MUN	-8.00		8.20	16.50	1.30	38.90	3.00					
				-12.40	1.00	1.00	1.00	1.45	1.00	0.55	1.10	0.09	3.77	0.20
69	FLORENCE	MUN	-0.60		4.00	22.00	0.0	55.00	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.0	0.40	0.02
69	PATPARCH	IND	-3.20		26.00	8.90	0.0	43.50	3.00					
				-4.96	1.00	1.00	1.00	1.45	1.00	0.69	0.24	0.0	1.68	0.08
	NODE TOTAL			-26.29						1.26	1.45	0.09	6.09	0.60
71	US STEEL	IND	-72.90		1.70	2.40	1.90	3.40	5.00					
				-112.99	1.00	1.00	1.00	1.45	1.00	1.03	1.46	1.16	3.00	3.04
	NODE TOTAL			-112.99						1.03	1.46	1.16	3.00	3.04
72	BORDENTN	MUN	-1.30		2.30	11.10	0.90	38.10	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.03	0.12	0.01	0.60	0.03
	NODE TOTAL			-2.02						0.03	0.12	0.01	0.60	0.03
73	CROSWICK	TRIB	-45.16		1.20	0.10	1.00	6.10	10.00					
				-70.00	1.00	1.00	1.00	1.45	1.00	0.45	0.04	0.38	3.33	3.77
73	HAMILTON	MUN	-9.00		2.80	11.30	1.10	11.90	3.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.21	0.85	0.08	1.30	0.23
	NODE TOTAL			-83.95						0.66	0.89	0.46	4.63	3.99
75	TRENTON	MUN	-18.60		4.20	59.90	1.20	74.70	2.00					
				-28.83	1.00	1.00	1.00	1.45	1.00	0.65	9.30	0.19	16.82	0.31
	NODE TOTAL			-28.83						0.65	9.30	0.19	16.82	0.31
76	MORRISVL	MUN	-3.90		0.0	31.50	1.80	18.00	7.40					
				-6.03	1.00	1.00	1.00	1.45	1.00	0.0	1.03	0.06	0.85	0.24
76	ASSNPINK	TRIB	-51.61		0.80	0.70	2.40	3.00	11.00					
				-80.00	1.00	1.00	1.00	1.45	1.00	0.34	0.30	1.03	1.87	4.74
	NODE TOTAL			-86.04						0.34	1.33	1.09	2.72	4.98

SUMMARY OF DISCHARGE LOADS BY ZONE AND TYPE

INPUT ZONE	TYPE OF DISCHARGE	NUMBER OF DISCHARGES	ADJUSTED INPUT LOADS - 1000 LB/DAY					INPUT LOADS - PERCENT OF ZONE BY TYPE				
			CONST1	CONST2	CONST3	CONST4	CONST5	CONST1	CONST2	CONST3	CONST4	CONST5
1	MUN	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	IND	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	TRIB	1.	10.50	8.40	21.00	91.36	231.02	100.00	100.00	100.00	100.00	100.00
	ZONE TOTAL	1.	10.50	8.40	21.00	91.36	231.02	10.05	4.71	27.86	5.80	60.76
2	MUN	9.	1.68	13.04	0.70	25.95	1.22	27.02	80.49	12.03	52.77	5.23
2	IND	4.	1.81	1.91	1.20	5.52	3.18	29.15	11.78	20.70	11.22	13.59
2	TRIB	6.	2.72	1.25	3.89	17.70	19.01	43.83	7.74	67.27	36.00	81.18
	ZONE TOTAL	19.	6.21	16.21	5.73	49.17	23.42	5.94	9.09	7.67	3.12	6.16
3	MUN	7.	24.29	29.92	2.48	422.76	7.03	99.71	86.05	91.29	90.06	69.26
3	IND	7.	0.0	4.81	0.0	45.45	2.29	0.0	13.84	0.0	9.68	22.58
3	TRIB	1.	0.07	0.04	0.24	1.20	0.83	0.29	0.10	8.71	0.26	8.17
	ZONE TOTAL	15.	24.36	34.77	2.72	469.41	10.15	23.31	19.51	3.61	29.80	2.67
4	MUN	14.	13.12	16.38	4.79	132.04	5.04	40.22	28.62	15.88	25.50	6.85
4	IND	20.	11.75	33.19	9.35	321.06	12.37	36.02	58.00	31.00	62.00	16.82
4	TRIB	5.	7.75	7.65	16.02	64.76	56.17	23.75	13.37	53.11	12.50	76.33
	ZONE TOTAL	39.	32.63	57.22	30.17	517.85	73.59	31.22	32.10	40.02	32.88	19.35
5	MUN	5.	5.28	17.56	0.17	93.76	1.85	17.15	28.49	1.08	20.97	4.40
5	IND	8.	23.91	43.69	11.01	342.71	22.55	77.62	70.88	70.08	76.64	53.66
5	TRIB	4.	1.61	0.39	4.53	10.69	17.63	5.23	0.63	28.84	2.39	41.94
	ZONE TOTAL	17.	30.80	61.64	15.71	447.16	42.03	29.47	34.58	20.84	28.39	11.05
	GRAND TOTAL	91.	104.49	178.24	75.38	1574.95	380.21					

****

SECTION 4 WATER QUALITY BOUNDARY CONDITIONS

****

SEAWARD BOUNDARY CONDITIONS

NODE 1 : COURTHOUSE PT , MARYLAND

' CIN1 ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.30	0.30	1.00	1.00	7.00

NODE 2 : LISTON PT , DELAWARE

' CINMAX ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	700	0.40	0.20	2.00	1.50	7.00
701	1700	0.32	0.20	2.00	1.50	7.80

UPSTREAM BOUNDARY CONDITIONS

NODE 76 RECIEVES VARYING LOADS FROM DELAWARE (RIVR)

FLOW PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	FLOW (CFS)
1	2400	-3900.00

QUAL.PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.50	0.40	1.00	2.90	11.00

****
SECTION 5 ***** SUMMARY OF HYDRAULIC INPUTS *****

****
JUNCTION HEAD AND HYD. RADIUS AND X-SECTIONAL AREA OF CHANNELS ARE AT MEAN TIDE **

CHAN.	LENGTH	WIDTH	AREA	MANNING	NET FLOW	HYD. RADIUS	JUNC. AT ENDS		JUNC.	INFLOW	HEAD	CHANNELS ENTERING JUNCTION				
1	7000.	2400.	31041.	0.010	1912.26	12.9	1	3	1	0.0	0.10	1	0	0	0	0
2	11000.	850.	24478.	0.010	1912.25	28.8	3	4	2	0.0	-0.07	9	0	0	0	0
3	11000.	650.	18646.	0.010	1912.22	28.7	4	5	3	0.0	0.10	1	2	0	0	0
4	11000.	600.	17093.	0.010	1912.22	28.5	5	6	4	0.0	0.10	2	3	0	0	0
5	11000.	600.	16916.	0.010	1912.22	28.2	6	7	5	0.0	0.10	3	4	0	0	0
6	11000.	600.	13766.	0.010	1912.21	22.9	7	8	6	0.0	0.10	4	5	0	0	0
7	11000.	600.	12381.	0.010	1912.16	20.6	8	9	7	0.0	0.10	5	6	0	0	0
8	15679.	600.	11035.	0.010	1912.13	18.4	9	10	8	0.0	0.10	6	7	0	0	0
9	14994.	12995.	212732.	0.010	-8267.95	16.4	2	11	9	0.0	0.10	7	8	0	0	0
10	14994.	11829.	182978.	0.010	-8268.04	15.5	11	12	10	0.0	0.08	8	12	0	0	0
11	14994.	7700.	119189.	0.010	-11744.06	15.5	12	13	11	0.0	-0.04	9	10	0	0	0
12	11995.	4500.	78096.	0.010	1912.04	17.4	10	13	12	0.0	0.01	10	11	13	0	0
13	19326.	1700.	11946.	0.010	3474.65	7.0	12	14	13	0.0	0.08	11	12	14	18	20
14	7330.	7600.	68837.	0.010	5870.88	9.1	13	14	14	0.0	0.09	13	14	15	19	0
15	8996.	1000.	8615.	0.015	-16.86	8.6	14	15	15	0.0	0.18	15	16	0	0	0
16	8996.	4332.	32701.	0.015	-15.56	7.5	15	16	16	0.0	0.18	16	17	0	0	0
17	8996.	5331.	40358.	0.015	-15.80	7.6	16	17	17	-15.0	0.18	17	0	0	0	0
18	13661.	3800.	53752.	0.010	8258.80	14.1	13	18	18	0.0	0.10	18	21	0	0	0
19	8996.	5600.	23791.	0.010	9362.25	4.2	14	19	19	0.0	0.13	19	22	0	0	0
20	13661.	3400.	70365.	0.010	-23963.29	20.7	13	20	20	0.0	0.13	20	22	24	0	0
21	10662.	6000.	45761.	0.010	8258.62	7.6	18	21	21	0.0	0.19	21	23	0	0	0
22	9663.	4900.	47962.	0.010	9361.95	9.8	19	20	22	0.0	0.20	23	24	25	0	0
23	10996.	7600.	98206.	0.010	8256.32	12.9	21	22	23	0.0	0.22	25	26	0	0	0
24	13994.	3900.	66834.	0.010	-14601.62	17.1	20	22	24	0.0	0.23	26	27	0	0	0
25	13661.	8996.	149701.	0.010	-6343.82	16.6	22	23	25	0.0	0.24	27	28	33	0	0
26	11995.	8274.	146591.	0.010	-6344.27	17.7	23	24	26	0.0	0.25	28	29	32	0	0
27	11995.	6942.	145614.	0.010	-6344.72	21.0	24	25	27	0.0	0.25	29	30	0	0	0
28	9330.	1000.	14312.	0.015	-780.15	14.3	25	26	28	0.0	0.24	30	31	0	0	0
29	9330.	722.	7491.	0.015	-262.20	10.4	26	27	29	-262.0	0.24	31	0	0	0	0
30	9330.	389.	3587.	0.015	-262.20	9.2	27	28	30	-518.0	0.27	32	0	0	0	0
31	9330.	278.	2283.	0.015	-262.14	8.2	28	29	31	0.0	0.26	33	34	0	0	0
32	9330.	389.	2231.	0.015	-517.97	5.7	26	30	32	0.0	0.29	34	35	0	0	0
33	11995.	8163.	147978.	0.016	-5565.14	18.1	25	31	33	0.0	0.32	35	36	0	0	0
34	11995.	7441.	128049.	0.016	-5565.73	17.2	31	32	34	-49.0	0.34	36	37	38	0	0
35	11995.	6997.	114127.	0.016	-5566.24	16.3	32	33	35	0.0	0.34	38	40	0	0	0
36	13328.	5720.	114753.	0.016	-5566.64	20.1	33	34	36	-83.0	0.36	37	39	0	0	0
37	11995.	4054.	90819.	0.020	-7000.09	22.4	34	36	37	0.0	0.38	40	41	0	0	0
38	10662.	3887.	63741.	0.020	1482.16	16.4	34	35	38	0.0	0.38	39	41	42	43	0
39	11995.	4332.	85787.	0.020	-6917.19	19.8	36	38	39	0.0	0.39	42	44	45	0	0
40	7330.	2443.	15593.	0.020	1482.06	6.4	35	37	40	-60.0	0.36	44	0	0	0	0
41	7330.	2100.	18372.	0.020	1482.03	8.7	37	38	41	0.0	0.41	45	46	0	0	0
42	6331.	2600.	29857.	0.020	590.30	11.5	38	39	42	0.0	0.40	43	47	0	0	0
43	11995.	4942.	97225.	0.020	-6025.57	18.7	38	42	43	-24.0	0.42	46	47	48	0	0
44	8996.	300.	1783.	0.020	-59.98	5.9	39	40	44	0.0	0.43	48	49	52	0	0
45	6331.	1944.	13284.	0.020	650.27	6.8	39	41	45	0.0	0.43	49	50	0	0	0
46	11995.	2388.	28643.	0.020	650.27	12.0	41	43	46	0.0	0.43	50	51	0	0	0
47	11995.	3499.	77735.	0.020	-6025.62	22.2	42	43	47	-750.0	0.43	51	0	0	0	0

48	14994.	3998.	89416.	0.020	-5351.27	22.4	43	44
49	10662.	750.	9167.	0.020	-751.47	12.2	44	45
50	10662.	611.	10164.	0.020	-751.10	16.6	45	46
51	10662.	555.	7296.	0.020	-750.42	13.1	46	47
52	11995.	3887.	85840.	0.020	-4599.58	22.1	44	48
53	11995.	2832.	65795.	0.020	-4599.59	23.2	48	49
54	8996.	167.	2106.	0.020	0.05	12.6	49	50
55	11995.	2332.	65464.	0.020	-4599.84	28.1	49	51
56	10329.	2888.	75966.	0.020	-4600.16	26.3	51	52
57	6331.	1400.	18961.	0.020	-311.13	13.5	52	53
58	8996.	300.	2065.	0.020	-31.88	6.9	53	54
59	11995.	3165.	73732.	0.020	-4289.50	23.3	52	55
60	7997.	2499.	30353.	0.020	-279.42	12.1	53	55
61	9674.	3195.	65511.	0.020	-4314.67	20.5	55	56
62	9007.	300.	3425.	0.020	-13.93	11.4	56	57
63	9674.	2474.	52646.	0.035	-4301.65	21.3	56	58
64	9674.	2752.	58074.	0.035	-4302.45	21.1	58	59
65	9674.	2419.	47015.	0.035	-4303.24	19.4	59	60
66	9007.	600.	8180.	0.035	-174.75	13.6	60	61
67	9007.	2863.	48809.	0.035	-4129.09	17.0	60	62
68	9007.	2391.	43929.	0.035	-4129.36	18.4	62	63
69	9508.	1890.	38607.	0.035	-4129.66	20.4	63	64
70	6331.	334.	4564.	0.035	-159.78	13.7	64	65
71	9508.	1640.	37523.	0.035	-3970.52	22.9	64	66
72	11009.	1307.	31145.	0.035	-3144.93	23.8	66	68
73	7839.	862.	14151.	0.040	-826.42	16.4	66	67
74	7839.	834.	13825.	0.040	-826.70	16.6	67	68
75	9674.	1362.	31311.	0.040	-3972.45	23.0	68	69
76	10842.	1334.	32159.	0.040	-3972.60	24.1	69	70
77	12009.	1418.	29084.	0.040	-3971.66	20.5	70	71
78	9007.	1362.	22449.	0.040	-3969.69	16.5	71	72
79	6005.	334.	3729.	0.040	-64.25	11.2	72	73
80	7506.	1473.	21073.	0.040	-3903.59	14.3	72	74
81	8000.	1168.	16562.	0.040	-3901.94	14.2	74	75
82	8000.	862.	9275.	0.040	-3900.78	10.8	75	76

48	0.0	0.44	52	53	0	0	0
49	0.0	0.45	53	54	55	0	0
50	0.0	0.44	54	0	0	0	0
51	0.0	0.45	55	56	0	0	0
52	0.0	0.45	56	57	59	0	0
53	0.0	0.46	57	58	60	0	0
54	-32.0	0.45	58	0	0	0	0
55	-255.0	0.46	59	60	61	0	0
56	0.0	0.47	61	62	63	0	0
57	-14.0	0.47	62	0	0	0	0
58	0.0	0.48	63	64	0	0	0
59	0.0	0.49	64	65	0	0	0
60	0.0	0.50	65	66	67	0	0
61	-175.0	0.50	66	0	0	0	0
62	0.0	0.51	67	68	0	0	0
63	0.0	0.52	68	69	0	0	0
64	0.0	0.52	69	70	71	0	0
65	-160.0	0.52	70	0	0	0	0
66	0.0	0.52	71	72	73	0	0
67	0.0	0.52	73	74	0	0	0
68	0.0	0.53	72	74	75	0	0
69	0.0	0.53	75	76	0	0	0
70	0.0	0.54	76	77	0	0	0
71	0.0	0.55	77	78	0	0	0
72	0.0	0.57	78	79	80	0	0
73	-64.0	0.57	79	0	0	0	0
74	0.0	0.59	80	81	0	0	0
75	0.0	0.61	81	82	0	0	0
76	-3900.0	0.68	82	0	0	0	0

73·11

SECTION 3 WATER QUALITY INPUTS

SUMMARY OF POINT SOURCE INPUTS

SIMULATION PERIOD : JULY 12-SEPT 5, 1968

CONSTITUENT 1 IS NORG (MG/L)
CONSTITUENT 2 IS NH3 (MG/L)
CONSTITUENT 3 IS NO3 (MG/L)
CONSTITUENT 4 IS CBOD (MG/L)
CONSTITUENT 5 IS DO (MG/L)

MUNICIPAL AND INDUSTRIAL WASTEWATER AND TRIBUTARY INFLOW BY NODE

INPUT NODE	NAME OF DISCHARGE	TYPE OF DISCHARGE	******* FLOW ******* MGD	CFS	UNADJUSTED CONC (MG/L) + ADJ. FACTORS CONST1	CONST2	CONST3	CONST4	CONST5	ADJUSTED INPUT LOADS - 1000 LB/DAY CONST1	CONST2	CONST3	CONST4	CONST5
14	SALEMCTY	MUN	-2.80		2.10	8.50	0.0	58.30	5.00					
				-4.34	1.00	1.00	1.00	1.45	1.00	0.05	0.20	0.0	1.98	0.12
	NODE TOTAL			-4.34						0.05	0.20	0.0	1.98	0.12
17	SALEM	TRIB	-2.58		0.0	0.0	0.0	5.50	9.00					
				-4.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.17	0.19
	NODE TOTAL			-4.00						0.0	0.0	0.0	0.17	0.19
21	GETTYOIL	IND	-370.00		6.00	5.30	2.00	2.80	5.00					
				-573.50	1.00	1.00	1.00	1.90	1.00	18.53	16.37	6.18	16.43	15.44
	NODE TOTAL			-573.50						18.53	16.37	6.18	16.43	15.44
22	AMOCO	IND	-0.60		1.00	17.00	0.0	134.20	3.00					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.01	0.09	0.0	1.28	0.02
	NODE TOTAL			-0.93						0.01	0.09	0.0	1.28	0.02
23	PENNSVLE	MUN	-0.60		16.70	40.90	0.0	66.90	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.08	0.20	0.0	0.49	0.02

	NODE TOTAL			-0.93						0.08	0.20	0.0	0.49	0.02
24	DPCHAMBR	IND	-113.00		4.20	25.40	0.60	50.70	6.00					
				-182.90	1.00	1.00	1.00	1.45	1.00	4.14	25.02	0.59	72.41	5.91
24	ICI 1	IND	-5.20		5.60	3.00	32.50	278.60	5.00					
				-8.06	1.00	1.00	1.00	1.45	1.00	0.24	0.13	1.41	17.53	0.22
	NODE TOTAL			-190.96						4.38	25.15	2.00	89.94	6.13
25	DPCARNEY	IND	-2.40		6.90	19.50	9.90	841.70	2.00					
				-3.72	1.00	1.00	1.00	1.45	1.00	0.14	0.39	0.20	24.45	0.04
25	UPENSNCK	MUN	-0.50		5.30	26.50	0.0	385.70	2.00					
				-0.78	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.0	2.33	0.01
25	WLMINGTN	MUN	-63.00		9.00	30.00	0.30	64.30	3.00					
				-105.40	1.00	1.00	1.00	1.45	1.00	5.11	17.03	0.17	52.92	1.70
	NODE TOTAL			-109.90						5.27	17.53	0.37	79.70	1.75
29	CHRISTNA	TRIB	-92.26		0.50	0.10	1.80	2.10	7.00					
				-143.00	1.00	1.00	1.00	1.45	1.00	0.39	0.08	1.39	2.34	5.39
	NODE TOTAL			-143.00						0.39	0.08	1.39	2.34	5.39
30	BRANDYWN	TRIB	-172.90		0.70	0.20	2.00	3.40	7.00					
				-268.00	1.00	1.00	1.00	1.45	1.00	1.01	0.29	2.89	7.11	10.10
	NODE TOTAL			-268.00						1.01	0.29	2.89	7.11	10.10
31	PENSGROV	MUN	-0.30		7.40	7.40	0.0	268.80	2.00					
				-0.47	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.0	0.98	0.01
31	DPEDGMOR	IND	-23.20		1.50	5.20	9.50	19.70	2.00					
				-35.96	1.00	1.00	1.00	1.90	1.00	0.29	1.01	1.84	7.25	0.39
	NODE TOTAL			-36.42						0.31	1.03	1.84	8.22	0.39
33	OLDMANS	TRIB	-25.81		1.00	0.10	1.20	3.40	9.00					
				-40.00	1.00	1.00	1.00	1.45	1.00	0.22	0.02	0.26	1.06	1.94
33	ALLDCHEM	IND	-32.00		1.80	2.60	2.80	20.10	1.00					
				-49.60	1.00	1.00	1.00	1.90	1.00	0.48	0.69	0.75	10.20	0.27
33	PHOENIX	IND	-11.00		0.90	0.0	0.50	0.70	3.00					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.08	0.0	0.05	0.12	0.28
	NODE TOTAL			-106.65						0.78	0.72	1.05	11.38	2.48
34	CHESTER	MUN	-9.40		0.80	7.60	3.60	11.10	5.00					
				-14.57	1.00	1.00	1.00	1.45	1.00	0.06	0.60	0.28	1.26	0.39
34	MARCUSHK	MUN	-0.60		44.60	14.90	1.90	186.30	3.00					

				-0.93	1.00	1.00	1.00	1.45	1.00	0.22	0.07	0.01	1.35	0.02
34	BP 201	IND	-113.00		2.50	6.00	3.60	50.10	5.00					
				-175.15	1.00	1.00	1.00	1.90	1.00	2.36	5.66	3.40	89.78	4.72
34	FMC	IND	-2.00		1.20	1.20	6.00	138.60	3.00					
				-3.10	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.10	3.35	0.05
34	MONSANTO	IND	-1.50		12.80	7.20	1.60	1693.00	2.00					
				-2.32	1.00	1.00	1.00	1.90	1.00	0.16	0.09	0.02	40.27	0.03
34	SUNOIL 1	IND	-68.00		12.50	6.20	2.20	0.10	5.00					
				-105.40	1.00	1.00	1.00	1.90	1.00	7.09	3.52	1.25	0.11	2.84
	NODE TOTAL			-301.47						9.92	9.96	5.06	136.13	8.04
36	CHESTER	TRIB	-31.61		1.10	0.90	2.00	9.70	7.00					
				-49.00	1.00	1.00	1.00	1.45	1.00	0.29	0.24	0.53	3.71	1.85
36	SCOTT 3	IND	-7.70		0.90	0.90	2.30	124.90	8.00					
				-11.94	1.00	1.00	1.00	1.90	1.00	0.06	0.06	0.15	15.25	0.51
	NODE TOTAL			-60.93						0.35	0.30	0.68	18.96	2.36
39	UCARBIDE	IND	-2.60		4.60	13.80	18.40	22.20	2.50					
				-4.03	1.00	1.00	1.00	1.90	1.00	0.10	0.30	0.40	0.92	0.05
	NODE TOTAL			-4.03						0.10	0.30	0.40	0.92	0.05
40	DARBY	TRIB	-15.48		3.30	7.70	2.30	2.40	7.00					
				-24.00	1.00	1.00	1.00	1.45	1.00	0.43	1.00	0.30	0.45	0.90
40	CDCA	MUN	-9.00		7.30	14.60	3.20	49.30	7.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.55	1.10	0.24	5.37	0.53
40	DRBYCRSA	MUN	-39.30		0.90	3.60	2.00	10.30	3.00					
				-60.92	1.00	1.00	1.00	1.45	1.00	0.30	1.18	0.66	4.90	0.98
40	MUKNPATS	MUN	-5.80		2.70	36.50	6.20	22.60	5.00					
				-8.99	1.00	1.00	1.00	1.45	1.00	0.13	1.77	0.30	1.59	0.24
40	TINICUM	MUN	-0.60		5.60	11.10	3.70	10.40	5.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.03	0.06	0.02	0.08	0.03
	NODE TOTAL			-108.78						1.43	5.10	1.51	12.38	2.68
42	DPRPAUNO	IND	-52.00		1.40	46.10	7.00	122.40	3.00					
				-80.60	1.00	1.00	1.00	1.90	1.00	0.61	20.01	3.04	100.94	1.30
42	HURCULES	IND	-0.60		0.0	0.0	0.0	321.90	3.00					
				-0.93	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	3.06	0.02
	NODE TOTAL			-81.53						0.61	20.01	3.04	104.00	1.32
43	GLOSTRCO	MUN	-7.50		0.30	11.20	1.60	14.40	5.00					
				-11.63	1.00	1.00	1.00	1.45	1.00	0.02	0.70	0.10	1.31	0.31

43	PAULSBRO	MUN	-1.30		0.0	26.90	0.0	105.60	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.29	0.0	1.66	0.03
43	MANTUA	TRIB	-9.68		11.80	4.20	0.70	390.00	5.00					
				-15.00	1.00	1.00	1.00	1.45	1.00	0.95	0.34	0.06	45.68	0.40
43	OLINCHEM	IND	-17.40		2.80	1.40	0.0	2.10	3.00					
				-26.97	1.00	1.00	1.00	1.90	1.00	0.41	0.20	0.0	0.58	0.44
43	MOBILCP1	IND	-25.00		2.00	9.10	0.70	110.80	3.00					
				-38.75	1.00	1.00	1.00	1.90	1.00	0.42	1.90	0.15	43.93	0.63
43	SHELL	IND	-1.90		11.70	3.70	0.60	439.80	3.00					
				-2.94	1.00	1.00	1.00	1.90	1.00	0.19	0.06	0.01	13.25	0.05
	NODE TOTAL			-97.30						1.98	3.49	0.31	106.41	1.86
44	PHILA SW	MUN	-140.00		9.90	8.60	2.60	85.10	2.00					
				-217.00	1.00	1.00	1.00	1.45	1.00	11.57	10.05	3.04	144.19	2.34
44	WOODBURY	MUN	-1.90		0.0	0.0	0.0	127.70	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	2.94	0.05
44	NAT PARK	MUN	-0.60		3.70	3.70	0.0	179.50	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.0	1.30	0.02
44	GULFOIL3	IND	-14.00		0.0	0.0	0.0	155.50	6.00					
				-21.70	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	34.52	0.70
44	TEXACO	IND	-4.30		7.80	18.40	18.90	96.80	3.00					
				-6.67	1.00	1.00	1.00	1.90	1.00	0.28	0.66	0.68	6.60	0.11
	NODE TOTAL			-249.24						11.87	10.73	3.72	189.56	3.21
45	ARCO SPL	IND	-3.10		0.0	25.10	0.0	108.20	3.00					
				-4.81	1.00	1.00	1.00	1.90	1.00	0.0	0.65	0.0	5.32	0.08
45	ARCO NYD	IND	-1.50		0.0	0.0	0.0	39.90	3.00					
				-2.32	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.95	0.04
45	ARCO WPL	IND	-0.10		0.0	0.0	0.0	6.00	3.00					
				-0.16	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	0.01	0.00
	NODE TOTAL			-7.28						0.0	0.65	0.0	6.28	0.12
47	SCHUYLKL	TRIB	-933.23		0.80	0.80	2.00	5.50	7.00					
				-1400.00	1.00	1.00	1.00	1.45	1.00	6.03	6.03	15.08	60.12	52.77
	NODE TOTAL			-1400.00						6.03	6.03	15.08	60.12	52.77
48	BIGTIMBR	TRIB	-5.81		1.00	1.00	1.30	1.70	5.00					
				-9.00	1.00	1.00	1.00	1.45	1.00	0.05	0.05	0.06	0.12	0.24
48	BELLMAWR	MUN	-1.90		6.20	16.70	8.00	47.50	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.10	0.26	0.13	1.09	0.05

48	BROKLAWN	MUN	-1.30		2.80	13.00	0.90	56.80	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.03	0.14	0.01	0.89	0.03
48	MTEPHRAM	MUN	-1.30		9.30	13.00	0.90	36.10	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.10	0.14	0.01	0.57	0.03
	NODE TOTAL			-15.98						0.28	0.60	0.21	2.67	0.36
49	CAMDEN M	MUN	-30.00		8.00	20.00	0.0	197.50	3.00					
				-46.50	1.00	1.00	1.00	1.45	1.00	2.00	5.01	0.0	71.71	0.75
49	PHILA SE	MUN	-119.00		8.70	2.20	1.00	92.10	3.00					
				-184.45	1.00	1.00	1.00	1.45	1.00	8.64	2.19	0.99	132.65	2.98
49	MCAND&FB	IND	-1.30		0.0	0.0	0.0	358.50	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	5.64	0.03
49	HARSHOW	IND	-0.60		0.0	0.0	0.0	538.60	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	3.91	0.02
49	GAF	IND	-11.00		0.0	0.0	0.0	152.90	3.00					
				-17.05	1.00	1.00	1.00	1.90	1.00	0.0	0.0	0.0	26.67	0.28
49	NJ ZINC	IND	-11.50		0.0	49.00	0.0	24.10	3.00					
				-17.82	1.00	1.00	1.00	1.90	1.00	0.0	4.70	0.0	4.40	0.29
	NODE TOTAL			-268.77						10.64	11.90	0.99	244.97	4.34
50	GLOSTRCY	MUN	-2.50		6.20	17.70	1.00	44.80	3.00					
				-3.88	1.00	1.00	1.00	1.45	1.00	0.13	0.37	0.02	1.36	0.06
	NODE TOTAL			-3.88						0.13	0.37	0.02	1.36	0.06
51	AMSTAR 1	IND	-12.00		0.0	1.10	0.0	13.00	5.00					
				-18.60	1.00	1.00	1.00	1.45	1.00	0.0	0.11	0.0	1.89	0.50
	NODE TOTAL			-18.60						0.0	0.11	0.0	1.89	0.50
52	NATSUGAR	IND	-18.10		0.0	0.0	0.0	52.90	7.50					
				-28.06	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	11.59	1.13
	NODE TOTAL			-28.06						0.0	0.0	0.0	11.59	1.13
54	COOPER	TRIB	-14.19		0.60	0.30	2.00	7.00	7.00					
				-22.00	1.00	1.00	1.00	1.45	1.00	0.07	0.04	0.24	1.20	0.83
54	CAMDEN N	MUN	-3.60		3.00	20.00	7.70	132.20	2.00					
				-5.58	1.00	1.00	1.00	1.45	1.00	0.09	0.60	0.23	5.76	0.06
	NODE TOTAL			-27.58						0.16	0.64	0.47	6.96	0.89
55	PHILA NE	MUN	-184.00		8.70	14.10	0.80	73.50	2.00					
				-285.20	1.00	1.00	1.00	1.45	1.00	13.36	21.65	1.23	163.68	3.07
55	GEORGPAC	IND	-1.90		0.0	0.0	0.0	197.10	3.00					

				-2.94	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	4.53	0.05
55	PENSAUKN	MUN	-3.60		1.50	0.0	0.0	87.30	3.00					
				-5.58	1.00	1.00	1.00	1.45	1.00	0.05	0.0	0.0	3.80	0.09
	NODE TOTAL			-293.72						13.41	21.65	1.23	172.01	3.21
58	PALMYRA	MUN	-0.60		3.70	20.40	1.90	91.20	3.50					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.10	0.01	0.66	0.02
	NODE TOTAL			-0.93						0.02	0.10	0.01	0.66	0.02
61	RANCOCAS	TRIB	-75.48		2.00	1.00	1.90	10.00	9.00					
				-117.00	1.00	1.00	1.00	1.45	1.00	1.26	0.63	1.20	9.14	5.67
61	WLINGBRO	MUN	-1.90		7.40	18.00	0.0	44.90	3.00					
				-2.94	1.00	1.00	1.00	1.45	1.00	0.12	0.29	0.0	1.03	0.05
	NODE TOTAL			-119.94						1.38	0.92	1.20	10.17	5.72
64	TENNECO	IND	-1.30		6.50	17.60	2.80	231.20	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.07	0.19	0.03	3.64	0.03
	NODE TOTAL			-2.02						0.07	0.19	0.03	3.64	0.03
65	NESHAMNY	TRIB	-56.77		1.40	0.60	2.70	4.20	9.00					
				-88.00	1.00	1.00	1.00	1.45	1.00	0.66	0.28	1.28	2.89	4.26
65	FALLSTWP	MUN	-2.60		0.90	0.90	11.10	1.90	4.00					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.02	0.02	0.24	0.06	0.09
	NODE TOTAL			-92.03						0.68	0.30	1.52	2.95	4.35
66	OTR&ASNK	TRIB	-6.45		0.0	0.0	0.0	3.00	5.00					
				-10.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.23	0.27
66	BRSTLTWP	MUN	-2.60		3.70	10.70	1.40	13.40	3.00					
				-4.03	1.00	1.00	1.00	1.45	1.00	0.08	0.23	0.03	0.42	0.07
66	ROHM&HAS	IND	-1.70		0.70	1.40	0.70	97.50	2.00					
				-2.63	1.00	1.00	1.00	1.45	1.00	0.01	0.02	0.01	2.01	0.03
	NODE TOTAL			-16.66						0.09	0.25	0.04	2.66	0.36
69	MARTINS	TRIB	-5.16		0.0	0.0	0.0	3.80	7.00					
				-8.00	1.00	1.00	1.00	1.45	1.00	0.0	0.0	0.0	0.24	0.30
69	LWRBUCKS	MUN	-8.00		8.20	16.50	1.30	30.50	3.00					
				-12.40	1.00	1.00	1.00	1.45	1.00	0.55	1.10	0.09	2.95	0.20
69	FLORENCE	MUN	-0.60		4.00	22.00	0.0	0.90	3.00					
				-0.93	1.00	1.00	1.00	1.45	1.00	0.02	0.11	0.0	0.01	0.02
69	PATPARCH	IND	-3.20		26.00	8.90	0.0	32.30	3.00					
				-4.96	1.00	1.00	1.00	1.45	1.00	0.69	0.24	0.0	1.25	0.08

	NODE TOTAL			-26.29						1.26	1.45	0.09	4.45	0.60
71	US STEEL	IND	-72.90		1.70	2.40	1.90	4.50	5.00					
				-112.99	1.00	1.00	1.00	1.45	1.00	1.03	1.46	1.16	3.97	3.04
	NODE TOTAL			-112.99						1.03	1.46	1.16	3.97	3.04
72	BORDENTN	MUN	-1.30		2.80	11.10	0.90	15.40	3.00					
				-2.02	1.00	1.00	1.00	1.45	1.00	0.03	0.12	0.01	0.24	0.03
	NODE TOTAL			-2.02						0.03	0.12	0.01	0.24	0.03
73	CROSWICK	TRIB	-45.16		1.20	0.10	1.00	6.10	10.00					
				-70.00	1.00	1.00	1.00	1.45	1.00	0.45	0.04	0.38	3.33	3.77
73	HAMILTON	MUN	-9.00		2.80	11.30	1.10	21.10	3.00					
				-13.95	1.00	1.00	1.00	1.45	1.00	0.21	0.85	0.08	2.30	0.23
	NODE TOTAL			-83.95						0.66	0.89	0.46	5.63	3.99
75	TRENTON	MUN	-18.60		4.20	59.90	1.20	49.40	2.00					
				-26.83	1.00	1.00	1.00	1.45	1.00	0.65	9.30	0.19	11.12	0.31
	NODE TOTAL			-28.83						0.65	9.30	0.19	11.12	0.31
76	MORRISVL	MUN	-3.90		0.0	31.50	1.80	12.20	7.40					
				-6.05	1.00	1.00	1.00	1.45	1.00	0.0	1.03	0.06	0.58	0.24
76	ASSNPINK	TRIB	-51.61		0.80	0.70	2.40	3.00	11.00					
				-80.00	1.00	1.00	1.00	1.45	1.00	0.34	0.30	1.03	1.87	4.74
	NODE TOTAL			-86.04						0.34	1.33	1.09	2.45	4.98

SUMMARY OF DISCHARGE LOADS BY ZONE AND TYPE

INPUT ZONE	TYPE OF DISCHARGE	NUMBER OF DISCHARGES	ADJUSTED INPUT LOADS - 1000 LB/DAY CONST1	CONST2	CONST3	CONST4	CONST5	INPUT LOADS - PERCENT OF ZONE BY TYPE CONST1	CONST2	CONST3	CONST4	CONST5
1	MUN	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	IND	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	TRIB	1.	10.50	2.10	16.80	91.36	168.01	100.00	100.00	100.00	100.00	100.00
	ZONE TOTAL	1.	10.50	2.10	16.80	91.36	168.01	10.06	1.22	23.66	6.37	53.10
2	MUN	9.	1.68	13.04	0.70	18.71	1.22	25.59	79.04	10.77	28.25	4.75
2	IND	5.	1.87	1.97	1.34	26.12	3.70	28.48	11.92	20.83	39.43	14.34
2	TRIB	7.	3.01	1.49	4.42	21.41	20.86	45.93	9.04	68.40	32.33	80.91
	ZONE TOTAL	21.	6.56	16.50	6.45	66.24	25.78	6.28	9.60	9.09	4.62	8.15
3	MUN	7.	24.29	29.92	2.48	379.61	7.03	99.71	86.05	91.29	86.38	69.26
3	IND	7.	0.0	4.81	0.0	58.63	2.29	0.0	13.84	0.0	13.34	22.58
3	TRIB	1.	0.07	0.04	0.24	1.20	0.83	0.29	0.10	8.71	0.27	8.17
	ZONE TOTAL	15.	24.36	34.77	2.72	439.44	10.15	23.33	20.23	3.83	30.63	3.21
4	MUN	14.	13.12	16.38	4.79	168.50	5.04	40.74	28.81	16.34	27.24	7.16
4	IND	15.	11.63	33.07	9.04	343.60	11.04	36.10	58.16	30.82	55.56	15.68
4	TRIB	4.	7.46	7.41	15.49	106.37	54.32	23.16	13.04	52.84	17.20	77.16
	ZONE TOTAL	33.	32.21	56.86	29.32	618.47	70.40	30.85	33.08	41.29	43.11	22.25
5	MUN	5.	5.28	17.56	0.17	58.69	1.85	17.15	28.49	1.08	26.79	4.40
5	IND	8.	23.91	43.69	11.01	149.67	22.55	77.62	70.88	70.08	68.33	53.86
5	TRIB	4.	1.61	0.39	4.53	10.69	17.63	5.23	0.63	28.84	4.88	41.94
	ZONE TOTAL	17.	30.80	61.64	15.71	219.05	42.03	29.49	35.86	22.13	15.27	13.28
	GRAND TOTAL	87.	104.43	171.87	71.01	1434.56	316.38					

****

/SECTION 4 WATER QUALITY BOUNDARY CONDITIONS

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SEAWARD BOUNDARY CONDITIONS

NODE 1 : COURTHOUSE PT , MARYLAND

' CIN1 ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.30	0.30	1.00	1.00	7.00

NODE 2 : LISTON PT , DELAWARE

' CINMAX ' PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.70	0.30	1.30	1.50	5.50

UPSTREAM BOUNDARY CONDITIONS

NODE 76 RECIEVES VARYING LOADS FROM DELAWARE (RIVR)

FLOW PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	FLOW (CFS)
1	2400	-3900.00

QUAL PERIOD = 2400 CYCLES

START CYCLE	DURATION (CYCLES)	CONST1 (MG/L)	CONST2 (MG/L)	CONST3 (MG/L)	CONST4 (MG/L)	CONST5 (MG/L)
1	2400	0.50	0.10	0.80	4.35	8.00

SECTION 5 ***** SUMMARY OF HYDRAULIC INPUTS *****

JUNCTION HEAD AND HYD. RADIUS AND X-SECTIONAL AREA OF CHANNELS ARE AT MEAN TIDE **

CHANNEL DATA

CHAN.	LENGTH	WIDTH	AREA	MANNING	NET FLOW	HYD. RADIUS	JUNC. AT ENDS	
1	7000.	2400.	31042.	0.010	1539.43	12.9	1	3
2	11000.	850.	24479.	0.010	1539.41	28.8	3	4
3	11000.	650.	18647.	0.010	1539.43	28.7	4	5
4	11000.	600.	17093.	0.010	1539.40	28.5	5	6
5	11000.	600.	16918.	0.010	1539.41	28.2	6	7
6	11000.	600.	13758.	0.010	1539.38	22.9	7	8
7	11000.	600.	12384.	0.010	1539.39	20.6	8	9
8	15679.	600.	11039.	0.010	1539.39	18.4	9	10
9	14994.	12995.	212742.	0.010	-13197.96	16.4	2	11
10	14994.	11829.	183011.	0.010	-13198.80	15.5	11	12
11	14994.	7700.	119235.	0.010	-16448.20	15.5	12	13
12	11995.	4500.	78133.	0.010	1539.33	17.4	10	13
13	19326.	1700.	11956.	0.010	3249.09	7.0	12	14
14	7330.	7600.	68899.	0.010	5736.47	9.1	13	14
15	8996.	1000.	8622.	0.015	-16.39	8.6	14	15
16	8996.	4332.	32726.	0.015	-16.17	7.6	15	16
17	8996.	5331.	40389.	0.015	-15.61	7.6	16	17
18	13661.	3800.	53787.	0.010	6690.48	14.2	13	18
19	8996.	5600.	23845.	0.010	9001.87	4.3	14	19
20	13661.	3400.	70398.	0.010	-27337.84	20.7	13	20
21	10662.	6000.	45839.	0.010	6690.38	7.6	18	21
22	9663.	4900.	48016.	0.010	9001.70	9.8	19	20
23	10996.	7600.	98327.	0.010	6690.25	12.9	21	22
24	13994.	3900.	66887.	0.010	-18336.19	17.2	20	22
25	13661.	8996.	149854.	0.010	-11646.09	16.7	22	23
26	11995.	8274.	146746.	0.010	-11646.25	17.7	23	24
27	11995.	6942.	145752.	0.010	-11646.41	21.0	24	25
28	9330.	1000.	14333.	0.015	-780.04	14.3	25	26
29	9330.	722.	7506.	0.015	-262.06	10.4	26	27
30	9330.	389.	3595.	0.015	-262.07	9.2	27	28
31	9330.	278.	2289.	0.015	-262.05	8.2	28	29
32	9330.	389.	2239.	0.015	-517.98	5.8	26	30
33	11995.	8163.	148160.	0.016	-10866.51	18.2	25	31
34	11995.	7441.	128240.	0.016	-10866.80	17.2	31	32
35	11995.	6997.	114339.	0.016	-10866.88	16.3	32	33
36	13328.	5720.	114952.	0.016	-10867.02	20.1	33	34
37	11995.	4054.	90971.	0.020	-11728.44	22.4	34	36
38	10662.	3887.	63885.	0.020	910.37	16.4	34	35
39	11995.	4332.	85987.	0.020	-11645.45	19.8	36	38
40	7330.	2443.	15694.	0.020	910.35	6.4	35	37
41	7330.	2100.	18473.	0.020	910.36	8.8	37	38
42	6331.	2600.	29988.	0.020	-24.01	11.5	38	39
43	11995.	4942.	92486.	0.020	-10711.02	18.7	38	42
44	8996.	300.	1799.	0.020	-60.01	6.0	39	40
45	6331.	1944.	13392.	0.020	36.03	6.9	39	41
46	11995.	2388.	28789.	0.020	36.07	12.1	41	43
47	11995.	3499.	77940.	0.020	-10710.95	22.3	42	43

JUNCTION DATA

JUNC.	INFLOW	HEAD	CHANNELS ENTERING JUNCTION				
1	0.0	0.10	1	0	0	0	0
2	0.0	-0.07	9	0	0	0	0
3	0.0	0.10	1	2	0	0	0
4	0.0	0.10	2	3	0	0	0
5	0.0	0.10	3	4	0	0	0
6	0.0	0.10	4	5	0	0	0
7	0.0	0.11	5	6	0	0	0
8	0.0	0.11	6	7	0	0	0
9	0.0	0.10	7	8	0	0	0
10	0.0	0.09	8	12	0	0	0
11	0.0	-0.03	9	10	0	0	0
12	0.0	0.01	10	11	13	0	0
13	0.0	0.09	11	12	14	18	20
14	0.0	0.10	13	14	15	19	0
15	0.0	0.19	15	16	0	0	0
16	0.0	0.19	16	17	0	0	0
17	-15.0	0.19	17	0	0	0	0
18	0.0	0.11	18	21	0	0	0
19	0.0	0.14	19	22	0	0	0
20	0.0	0.14	20	22	24	0	0
21	0.0	0.21	21	23	0	0	0
22	0.0	0.21	23	24	25	0	0
23	0.0	0.24	25	26	0	0	0
24	0.0	0.25	26	27	0	0	0
25	0.0	0.26	27	28	33	0	0
26	0.0	0.27	28	29	32	0	0
27	0.0	0.27	29	30	0	0	0
28	0.0	0.26	30	31	0	0	0
29	-262.0	0.26	31	0	0	0	0
30	-518.0	0.29	32	0	0	0	0
31	0.0	0.29	33	34	0	0	0
32	0.0	0.32	34	35	0	0	0
33	0.0	0.35	35	36	0	0	0
34	-49.0	0.37	36	37	38	0	0
35	0.0	0.38	38	40	0	0	0
36	-83.0	0.40	37	39	0	0	0
37	0.0	0.43	40	41	0	0	0
38	0.0	0.43	39	41	42	43	0
39	0.0	0.44	42	44	45	0	0
40	-60.0	0.41	44	0	0	0	0
41	0.0	0.48	45	46	0	0	0
42	0.0	0.46	43	47	0	0	0
43	-24.0	0.48	46	47	48	0	0
44	0.0	0.50	48	49	52	0	0
45	0.0	0.51	49	50	0	0	0
46	0.0	0.52	50	51	0	0	0
47	-2067.0	0.52	51	0	0	0	0

48	14994.	3998.	89676.	0.020	-10650.69	22.4	43	44
49	10662.	750.	9224.	0.020	-2067.88	12.3	44	45
50	10662.	611.	10216.	0.020	-2067.64	16.7	45	46
51	10662.	555.	7346.	0.020	-2067.23	13.2	46	47
52	11995.	3887.	86115.	0.020	-8582.41	22.2	44	48
53	11995.	2832.	66008.	0.020	-8582.29	23.3	48	49
54	8996.	167.	2119.	0.020	0.01	12.7	49	50
55	11995.	2332.	65651.	0.020	-8582.16	28.2	49	51
56	10329.	2888.	76207.	0.020	-8582.17	26.4	51	52
57	6331.	1400.	19081.	0.020	-948.85	13.6	52	53
58	8996.	300.	2091.	0.020	-31.97	7.0	53	54
59	11995.	3165.	74005.	0.020	-7633.55	23.4	52	55
60	7997.	2499.	30571.	0.020	-916.71	12.2	53	55
61	9674.	3195.	85797.	0.020	-8295.45	20.6	55	56
62	9007.	300.	3453.	0.020	-13.98	11.5	56	57
63	9674.	2474.	52892.	0.035	-8281.66	21.4	56	58
64	9674.	2752.	58386.	0.035	-8281.38	21.2	58	59
65	9674.	2419.	47327.	0.035	-8282.13	19.6	59	60
66	9007.	600.	8262.	0.035	-174.87	13.8	60	61
67	9007.	2863.	49229.	0.035	-8107.45	17.2	60	62
68	9007.	2391.	44320.	0.035	-8107.51	18.5	62	63
69	9508.	1890.	38949.	0.035	-8107.66	20.6	63	64
70	6331.	334.	4628.	0.035	-159.87	13.9	64	65
71	9508.	1640.	37847.	0.035	-7948.16	23.1	64	66
72	11009.	1307.	31421.	0.035	-6300.30	24.0	66	68
73	7839.	862.	14330.	0.040	-1648.29	16.6	66	67
74	7839.	834.	14004.	0.040	-1648.41	16.8	67	68
75	9674.	1362.	31621.	0.040	-7948.96	23.2	68	69
76	10842.	1334.	32490.	0.040	-7948.75	24.4	69	70
77	12009.	1418.	29466.	0.040	-7948.03	20.8	70	71
78	9007.	1362.	22853.	0.040	-7946.87	16.8	71	72
79	6005.	334.	3833.	0.040	-64.13	11.5	72	73
80	7506.	1473.	21551.	0.040	-7381.72	14.6	72	74
81	8000.	1168.	16973.	0.040	-7880.84	14.5	74	75
82	8000.	862.	9652.	0.040	-7880.27	11.2	75	76

48	0.0	0.51	52	53	0	0	0
49	0.0	0.52	53	54	55	0	0
50	0.0	0.52	54	0	0	0	0
51	0.0	0.53	55	56	0	0	0
52	0.0	0.54	56	57	59	0	0
53	0.0	0.54	57	58	60	0	0
54	-32.0	0.53	58	0	0	0	0
55	-255.0	0.55	59	60	61	0	0
56	0.0	0.56	61	62	63	0	0
57	-14.0	0.56	62	0	0	0	0
58	0.0	0.59	63	64	0	0	0
59	0.0	0.61	64	65	0	0	0
60	0.0	0.64	65	66	67	0	0
61	-175.0	0.64	66	0	0	0	0
62	0.0	0.67	67	68	0	0	0
63	0.0	0.69	68	69	0	0	0
64	0.0	0.71	69	70	71	0	0
65	-160.0	0.71	70	0	0	0	0
66	0.0	0.73	71	72	73	0	0
67	0.0	0.73	73	74	0	0	0
68	0.0	0.74	72	74	75	0	0
69	0.0	0.77	75	76	0	0	0
70	0.0	0.79	76	77	0	0	0
71	0.0	0.83	77	78	0	0	0
72	0.0	0.88	78	79	80	0	0
73	-64.0	0.88	79	0	0	0	0
74	0.0	0.92	80	81	0	0	0
75	0.0	0.98	81	82	0	0	0
76	-7880.0	1.18	82	0	0	0	0

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16. ABSTRACT

Recent data acquisition, analysis, and mathematical modelling studies were undertaken to improve the understanding of water quality interactions, particularly as they impact DO, in the Delaware Estuary. A version of the Dynamic Estuary Model, after undergoing considerable modification, was applied in an iterative process of hypothesis formation and testing. Both model parameters and model structure were updated and improved through this process until five intensive data sets gathered in the estuary between 1968 and 1976 were satisfactorily simulated. The major processes treated in this study were the advection and dispersion of salinity and dye tracers, nitrification, carbonaceous oxidation, sediment oxygen demand, reaeration, algal photosynthesis and respiration, and denitrification. The major product of this study is a calibrated and verified "real time" hydraulic and water quality model of the Delaware Estuary between Trenton and Liston Point. Among the conclusions of general importance are: (1) algae exert a variable, but generally positive influence on the DO budget; (2) non-linear reactions (such as denitrification and reduction of effective sediment oxygen demand) become significant when DO levels drop below 2 mg/l; and (3) nitrification, which experiences inhibition in a zone around Philadelphia, and sediment oxygen demand rival carbonaceous oxidation as DO sinks throughout much of the estuary. One implication of this study is that earlier forecasts of DO improvements with a simpler, linear model were somewhat optimistic.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Sedimentation oxygen demand Nitrification Photosynthesis Respiration Biochemical oxygen demand Estuaries Mathematical models Simulation Dissolved oxygen Salt water intrusion	Denitrification Delaware Estuary Estuarine dissolved oxygen budget Non-linear mathematical model Estuary water Quality model Water quality simulation	

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