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User Manual for Two-Dimensional Multi-Class Phytoplankton Model with Internal Nutrient Pool Kinetics

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USER MANUAL FOR TWO-DIMENSIONAL MULTI-CLASS PHYTOPLANKTON MODEL WITH INTERNAL NUTRIENT POOL KINETICS

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NOTICE

FOREWORD

The mission of the Environmental Research Laboratory - Duluth is to investigate the fate and effects of pollutants on freshwater ecosystems. The development and validation of quantitative methods for assessing the transport and fate of contaminants in the Laurentian Great Lakes are conducted at the EPA Large Lakes Research Station at Grosse Ile, Michigan. These methods are developed to address site-specific water quality problems in the Great Lakes; however, they are sufficiently generic that they can be applied to other water bodies as well.

The model documented in this report has been developed as part of a long-term case study of eutrophication in Saginaw Bay, Lake Huron. Results from this model were used to determine the target phosphorus loading to Saginaw Bay as part of the 1978 Water Quality Agreement between the U.S. and Canada. The purpose of this user manual is to document the model for scientists and engineers so that it can be used for other physical systems.

The application of this model should be approached with caution. It is a reasonably sophisticated water quality model that requires an experienced FORTRAN programmer for successful operation. Model calibration and interpretation of results require a good working knowledge of water quality modeling, and prior experience with more simple dynamic water quality models. Applications of this model should be conducted within an overall research program that includes the acquisition of laboratory and field data for determination of kinetic and stoichiometric coefficients, and for validation of model results.

No claims are made that the model is applicable to every problem, nor that it is error-free.

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ABSTRACT

As part of a long-term case study of eutrophication in Saginaw Bay, Lake Huron, a multi-class phytoplankton model with internal nutrient pool kinetics was developed. The model is a deterministic mass balance model which is temporally dynamic, and spatially segmented in the horizontal. The nutrients included in the model are phosphorus, nitrogen, and silicon.

The purpose of this user manual is to document the model for scientists and engineers so that it can be applied to other physical systems. An overview of the model is presented, along with the governing equations for conservation of mass, and the equations for all process kinetic formulations. The structure of the computer code is presented, with emphasis on model input and output.

Two spatially simplified examples are presented in detail. The first example involves a hypothetical lake with a single input tributary, and a single output tributary. The second example involves a hypothetical embayment with a single input tributary, and a large open boundary. To illustrate how the model is applied to a system with multiple spatial segments, a third example is presented in which the input data groups are set up for Saginaw Bay.

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SECTION 1

EXECUTIVE SUMMARY

As part of a long-term case study of eutrophication in Saginaw Bay, Lake Huron, a multi-class phytoplankton model with internal nutrient pool kinetics was developed. The model is a deterministic mass balance model which is temporally dynamic, and spatially segmented in the horizontal. Each of the spatial segments contains a water column layer and a surficial sediment layer. Water exchange among the segments is represented by advective and bulk diffusive flows. The nutrients included in the model are phosphorus, nitrogen, and silicon.

The purpose of this user manual is to document the model for scientists and engineers so that it can be applied to other physical systems. An overview of the model is presented, along with the governing equations for conservation of mass, and the equations for all process kinetic formulations. The structure of the computer code is presented, with emphasis on model input and output.

The model is intended for shallow lakes and embayments that are well-mixed in the vertical. It is designed to address water quality problems that stem from nutrient enrichment, and which are manifested primarily by overproduction of phytoplankton biomass. It is especially well suited to problems that involve multiple groups of phytoplankton, for example, spring diatom blooms and summer-fall blooms of nuisance blue-green phytoplankton, including nitrogen-fixing blue-greens. The model is not applicable to water quality problems that involve dissolved oxygen depletion.

For effective use of the model, the user must have FORTRAN experience, and a good working knowledge of dynamic water quality models. It is strongly recommended that the user have prior experience with applications of relatively simple dynamic models that involve chlorophyll, nutrients, and zooplankton.

The model is coded in FORTRAN 77. The primary system for which the model has been documented is the IBM PC/AT, with an IBM Personal Computer Disk Operating System (DOS), and IBM Personal Computer Professional FORTRAN. The model can also run without modification on a VAX 11/780 minicomputer with a VMS operating system.

Two simplified examples are presented in detail. The first example involves a hypothetical lake which consists of a single, well-mixed spatial segment. The hydraulic configuration for this lake is limited to a single input tributary, and a single output tributary. The second example involves a hypothetical embayment. This example is identical to that for the simplified lake, with the exception that the hydraulic configuration includes a single input tributary, and a large open boundary. To illustrate how the model is applied to a system with multiple spatial segments, a third example is presented in which the input data groups are set up for Saginaw Bay.

SECTION 2

INTRODUCTION

Control of nutrient inputs to water bodies is one of the principal means for attempting to reverse the symptoms of cultural eutrophication. Cultural eutrophication, here defined as overproduction of phytoplankton biomass caused by increased anthropogenic nutrient inputs, may lead to increased turbidity, aesthetic nuisances, and dissolved oxygen depletion. It may also lead to filter-clogging, taste, and odor problems in water supplies.

As part of a long-term case study of eutrophication in Saginaw Bay, Lake Huron, a multi-class phytoplankton model with internal nutrient pool kinetics was developed (Bierman et al. 1980; Bierman and Dolan 1981). This model was calibrated to an extensive set of baseline field data collected in 1974 and 1975 (Bierman and Dolan 1986a). The calibrated model was then used in a predictive mode to estimate the responses of the bay to a range of phosphorus control strategies. Subsequently, a post-audit was conducted in which the model predictions were compared with an extensive set of resurvey data acquired in 1980, after the bay had experienced a substantial reduction in external phosphorus loadings (Bierman and Dolan 1986b).

The purpose of this user manual is to document the model in such a way that it can be applied to other physical systems. Section 3 contains an overview of the model, and discusses the particular types of water quality problems for which it is best suited. Section 4 describes the fundamental equations used for conservation of mass, and the kinetic processes incorporated for nutrients, phytoplankton, zooplankton, and sediments. Section 5 contains an overview and flowchart for the computer code. Section 6 discusses the structure of the various input data groups.

Two simplified examples are presented in detail in Section 7. The first example involves a hypothetical lake which consists of a single, well-mixed spatial segment. The hydraulic configuration for this lake is limited to a single input tributary, and a single output tributary. The second example involves a hypothetical embayment. This example is identical to that for the simplified lake, with the exception that the hydraulic configuration includes a single input tributary, and a large open boundary. To illustrate how the model is applied to a system with multiple spatial segments, a third example is presented in which the input data groups are set up for Saginaw Bay.

Section 8 discusses various operational considerations such as acquisition procedures, hardware and software requirements, and testing procedures. The appendices contain a glossary of all variable names, a tabulation of all process kinetic equations in the model, and model output files for the three examples.

SECTION 3

MODEL OVERVIEW

3.1 STATE VARIABLES

The model is a deterministic mass balance model which is temporally dynamic, and spatially segmented in the horizontal. Each of the spatial segments contains a water column layer and a surficial sediment layer. Water exchange among the segments is represented by advective and bulk diffusive flows. Each of the constituents in the water column is assumed to be transported in the horizontal by these flows. Exchanges between the water column and sediment can occur by settling, resuspension, and, under certain conditions, by mineralization of sediment nutrients to the water column.

The model includes phytoplankton biomass in terms of multiple functional groups. The nutrients included are phosphorus, nitrogen, and silicon. Internal nutrient pool kinetics is used to describe the processes of phytoplankton nutrient uptake and growth. The model includes two different functional groups of zooplankton, herbivorous and carnivorous, and implicitly includes higher-order predation on the carnivorous zooplankton.

Nutrients are represented in both available and unavailable forms in the water column. Various transformation and recycle processes occur between these forms for each nutrient. No explicit distinction is made between available and unavailable nutrient forms in the sediment. The purpose of the sediment nutrient compartments is to complete the total mass balance cycle for the system.

3.2 APPLICABILITY

The model is intended for shallow lakes and embayments that are well-mixed in the vertical. It is designed to address water quality problems that stem from nutrient enrichment, and which are manifested primarily by overproduction of phytoplankton biomass. It is especially well suited to problems that involve multiple groups of phytoplankton, for example, spring diatom blooms and summer-fall blooms of nuisance blue-green phytoplankton, including nitrogen-fixing blue-greens.

The model is not applicable to water quality problems that involve dissolved oxygen depletion. Dissolved oxygen is not included as a state variable in the model. In general, shallow lakes and embayments that are vertically well-mixed do not experience problems with dissolved oxygen.

The transport structure of the water body must be determined separately and specified as input to the model. Transport in the model is represented as advective and bulk diffusive exchange flows among the various water column spatial segments. For applications that involve simple spatial segmentation schemes, these parameters can usually be determined using basic hydraulic information. For more complicated systems, these parameters usually need to be determined using a mass balance model for a conservative constituent, or a hydrodynamic model. One of the state variables in the model represents a conservative constituent that can be used to check the transport parameters specified.

3.3 USER REQUIREMENTS

For effective use of the model, the user must have FORTRAN experience, and a good working knowledge of dynamic water quality models at the level of Chapra and Reckhow (1983). It is strongly recommended that the user also have experience with applications of relatively simple dynamic water quality models that involve chlorophyll, nutrients, and zooplankton.

The model is coded in FORTRAN 77. The primary system for which the model has been documented is the IBM PC/AT, with an IBM Personal Computer Disk Operating System (DOS), and IBM Personal Computer Professional FORTRAN. The model can also run without modification on a VAX 11/780 minicomputer with a VMS operating system.

Applications that involve simple spatial segmentation schemes and only a few phytoplankton groups can be run effectively on the IBM PC/AT. For each of the simplified examples in this manual, a 30-day simulation requires approximately 2 minutes of computer time. Applications that involve more complex spatial segmentation schemes and more phytoplankton groups will generally require a minicomputer.

Section 8 contains additional details on hardware and software requirements.

SECTION 4

MODEL DEVELOPMENT

4.1 BACKGROUND

The model was originally developed for Saginaw Bay, Lake Huron. Saginaw Bay is a broad, shallow extension of the western shore of Lake Huron (Figure 1). The bay, oriented in a southwesterly direction, is approximately 85 km long and 42 km wide, and it has a watershed with a total drainage area of approximately 21,000 km^2. The bay has an average depth of 10 m, a hydraulic detention time of approximately four months, and is vertically well-mixed. The Saginaw River is the major tributary, accounting for over 90% of the total tributary inflow to the bay. The principal land use categories in the watershed are agriculture and forest. The total population of the watershed is slightly over 1,200,000, most of it concentrated into four major urban-industrial centers: Bay City, Midland, Saginaw, and Flint.

Water quality in Saginaw Bay has been severely impacted by waste discharges and runoff inputs. The principal results of eutrophication in the bay were adverse taste and odor, and filter-clogging problems experienced by municipal water treatment plants.

A schematic diagram of the Saginaw Bay version of the model is shown in Figure 2. Phytoplankton biomass was represented in terms of five functional groups: diatoms, greens, non-nitrogen-fixing blue-greens, nitrogen-fixing blue-greens, and "others". The last category consisted primarily of dinoflagellates and cryptomonads.

The model was applied to five spatial segments on Saginaw Bay (Figure 3) that were determined on the basis of observed gradients in water quality. The inner portion of the bay (segments one, two, and three) has an average depth of 6m, and the outer portion (segments four and five) has an average depth of 15 m. Water exchange among the segments, and between Saginaw Bay and Lake Huron proper, was determined using an advective-dispersive model for transport of chloride (Richardson 1976).

During 1974-1980, an extensive data base was acquired on Saginaw Bay for a large number of physical, chemical, and biological parameters. A total of 62 sampling stations was established in the bay proper and in the lower Saginaw River (Figure 3). Ninety-three sampling cruises were conducted during the study period at intervals of two-three weeks between April and December of each year.

The objective of the calibration effort was to determine a single set of model coefficients that resulted in the best overall fit between model output and field data for both 1974 and 1975. A

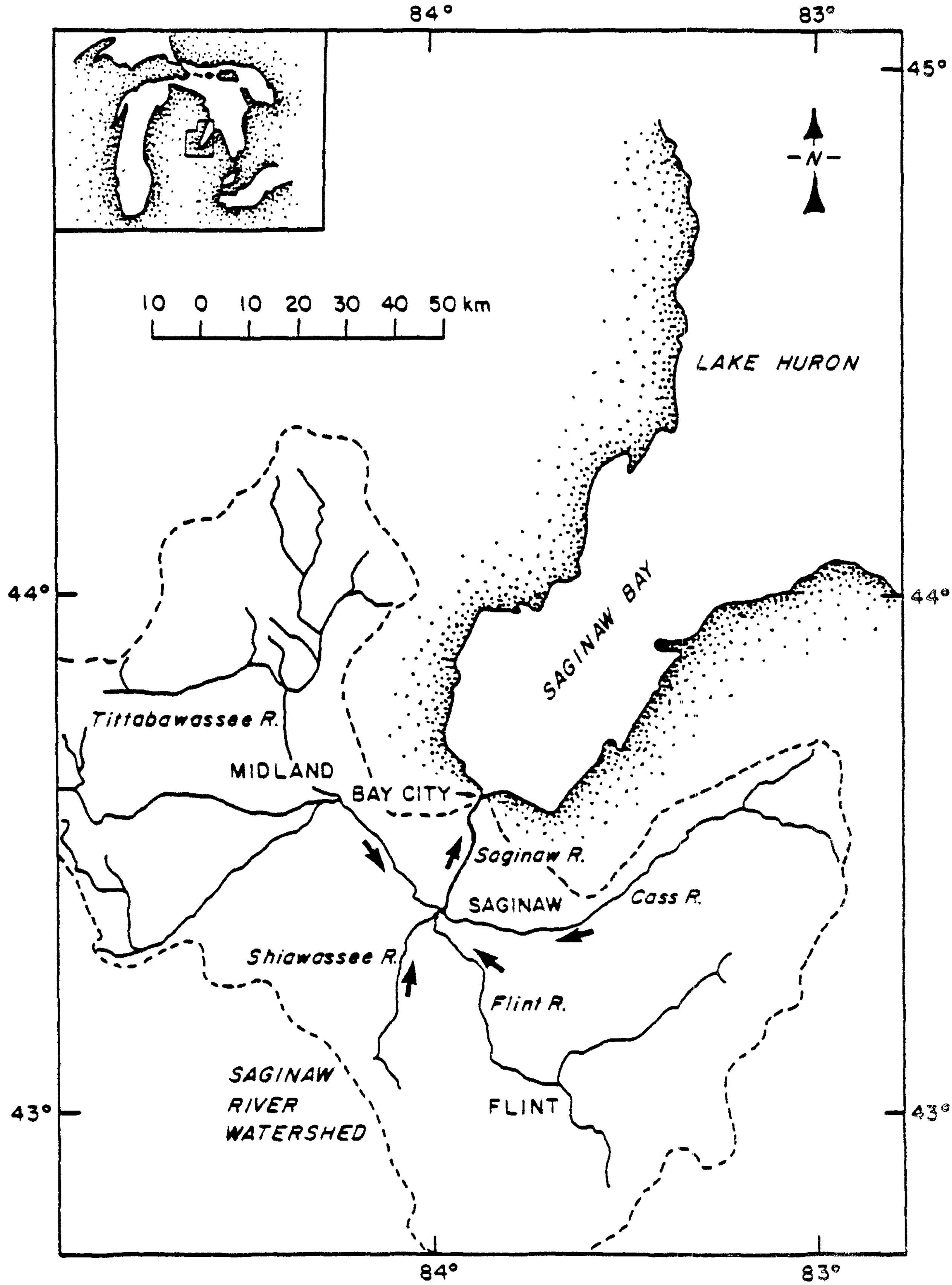


Figure 1. Saginaw Bay and Saginaw River Watershed

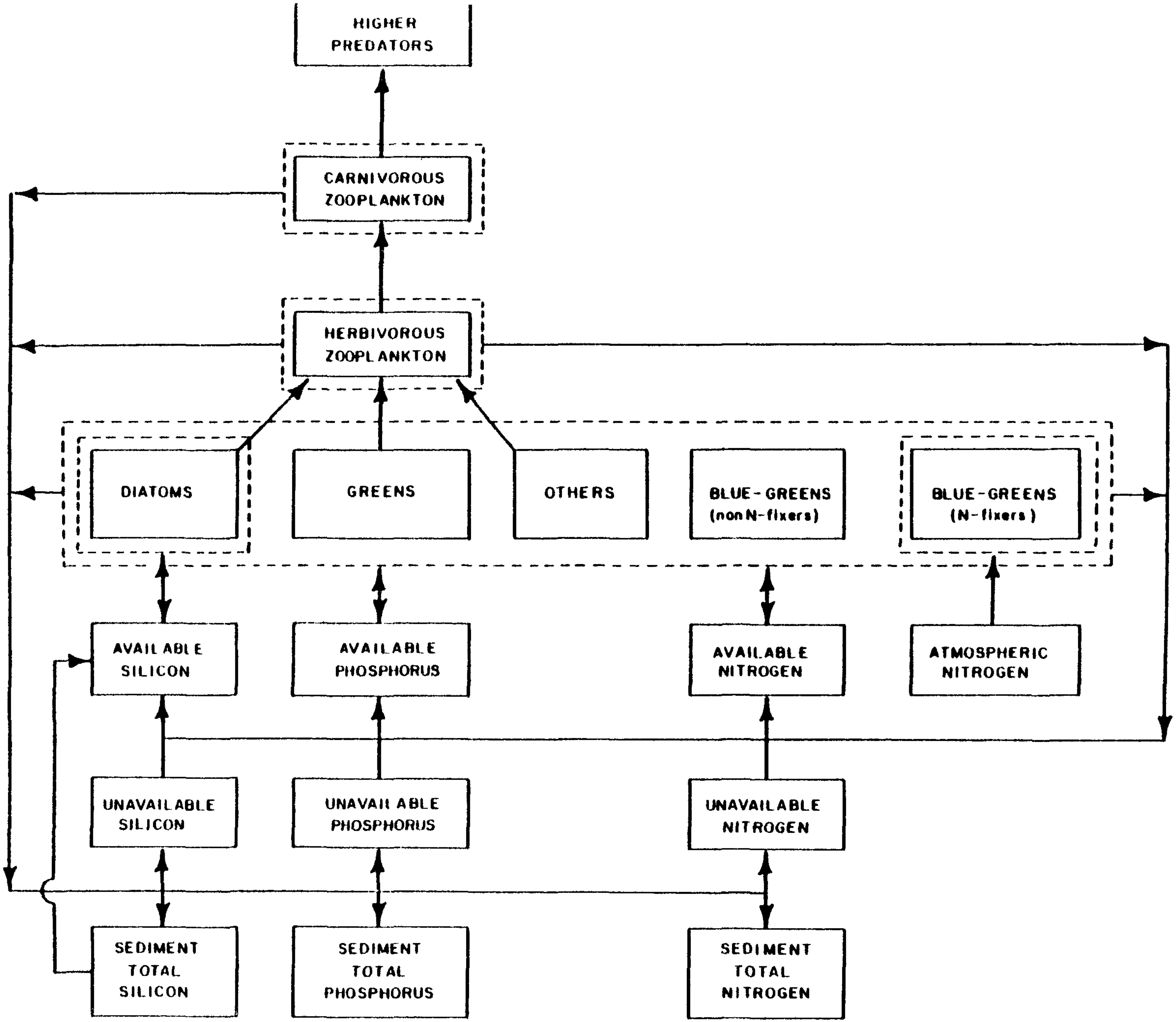


Figure 2. Schematic Diagram of Principal Model Compartments and Interaction Pathways for Saginaw Bay

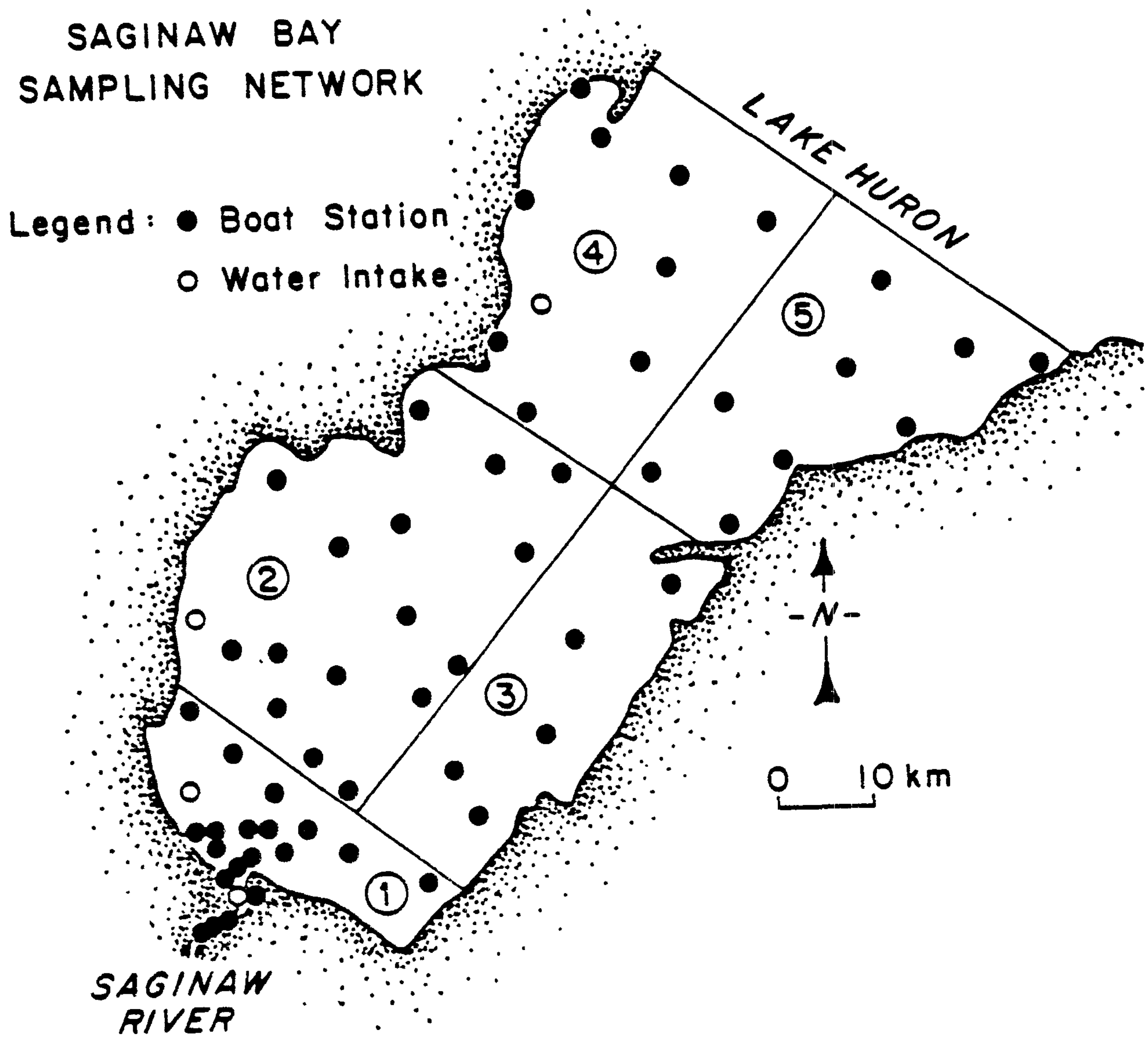


Figure 3. Sampling Station Network and Spatial Segmentation Grid for Saginaw Bay

simple Student's t test was used to check for significant differences between observed mean values from the field data, and mean values computed by the model (Thomann 1982). Seasonal mean values of model output and field data were also compared because the hydrological and productivity cycles in the bay are characterized by distinct seasonal patterns.

Graphical results for selected variables from model calibration to the 1974 data are presented in Figures 4-6. The solid lines represent model output, and the data are sampling cruise means with three standard errors. In general, the number of samples for each cruise was such that three standard errors corresponded to approximately one full standard deviation of the data about the observed mean. Results for phytoplankton concentrations are plotted on a logarithmic scale because the data from individual sampling stations were found to be lognormally distributed for each of the sampling cruises. Mean values were calculated using a maximum likelihood method (Aitchison and Brown 1963).

It was concluded that the model was successfully calibrated to the field data. An important finding was that water column total phosphorus concentrations appeared to be strongly influenced by wind-induced sediment resuspension. The degree of this influence seemed to be seasonally dependent. In the calibrated model, the resuspension mechanism accounted for 36 and 68%, respectively, of the computed spring and fall average total phosphorus concentrations. Sediment-water interactions should be an important consideration in the application of the model to shallow, highly dynamic systems.

To develop estimates of the responses of Saginaw Bay to anticipated reductions in phosphorus loadings, a series of predictive simulations was conducted with the calibrated model. The response of the bay in terms of threshold odor in the municipal water supply was estimated by applying a regression equation (Bierman et al. 1984) to the model predictions for blue-green phytoplankton biomass. For each reduced load, an estimate was made of the number of days on which threshold odor violations could be expected to occur.

In the post-audit phase of the study, the long-term response trend for threshold odor agreed well with the model prediction range (Figure 7). In particular, observations agreed with the prediction that threshold odor violations in the principal municipal water supply would be eliminated if the tributary phosphorus loadings could be reduced to 400-500 metric ton/yr.

4.2 CONSERVATION OF MASS

The fundamental governing principle for the model is conservation of mass in time and space. The behavior of each constituent, or state variable, is described by the two-dimensional advection-diffusion equation:

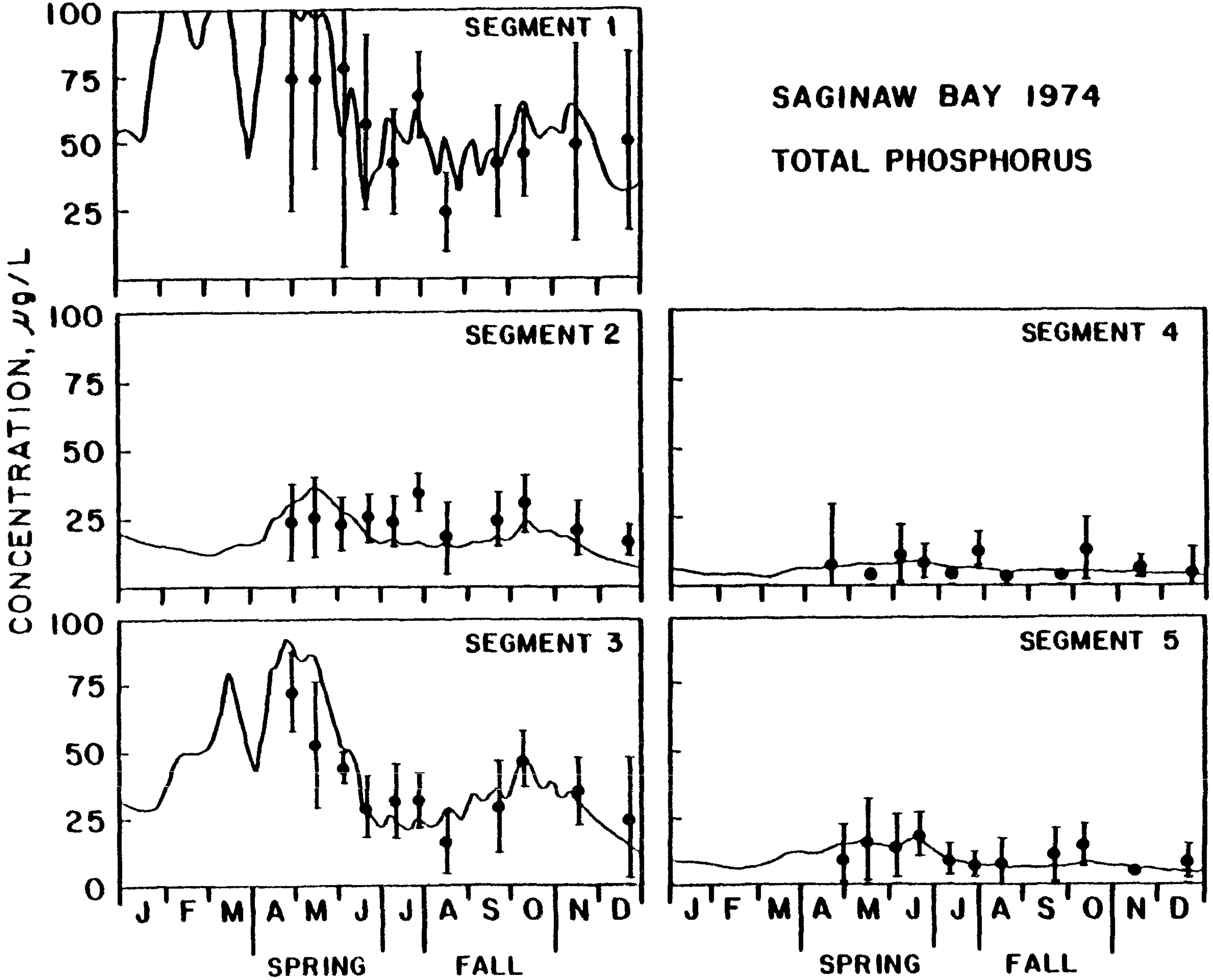


Figure 4. Relationship between Model Output and Field Data for Total Phosphorus for Saginaw Bay in 1974

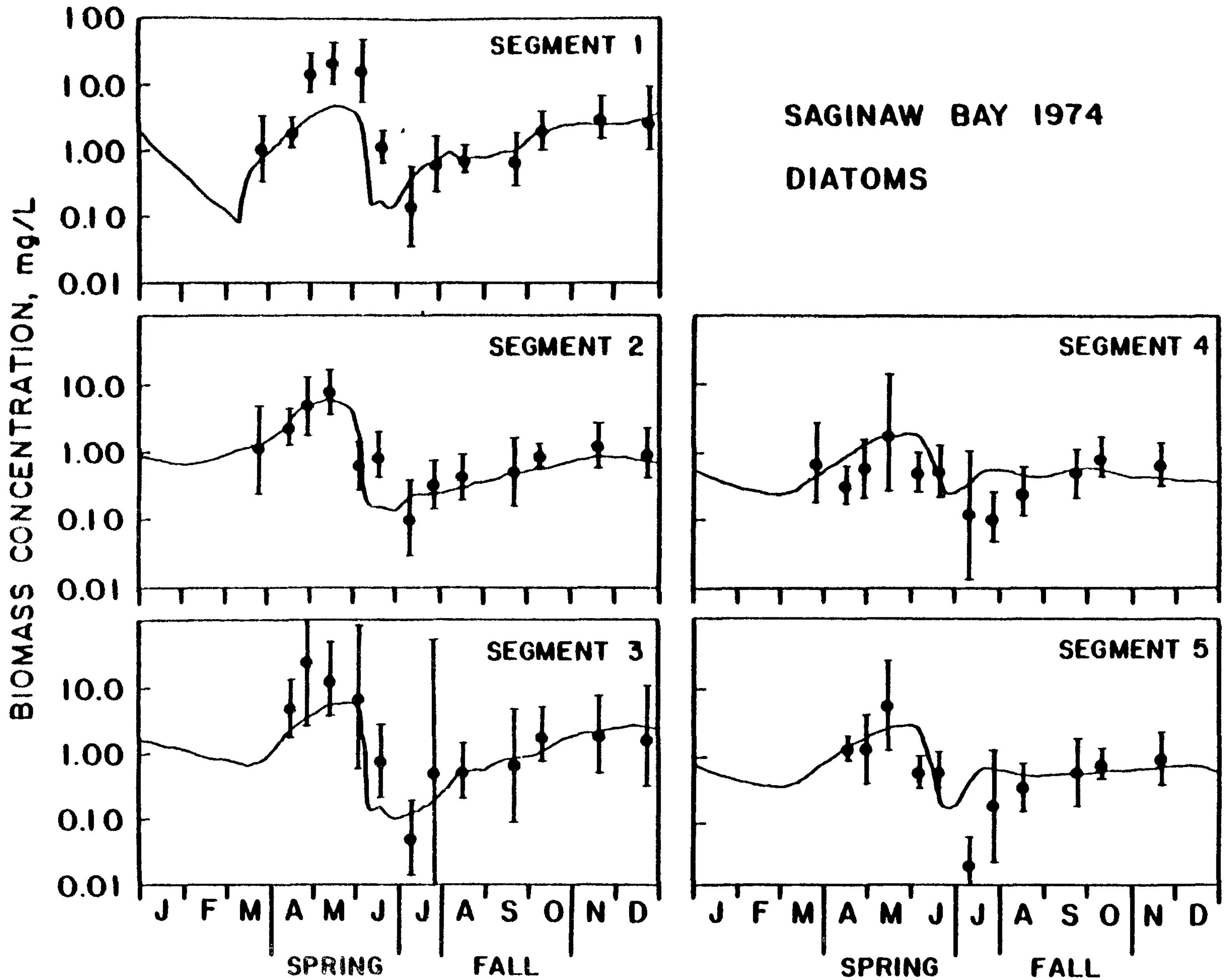


Figure 5. Relationship between Model Output and Field Data for Diatom Phytoplankton Biomass for Saginaw Bay in 1974

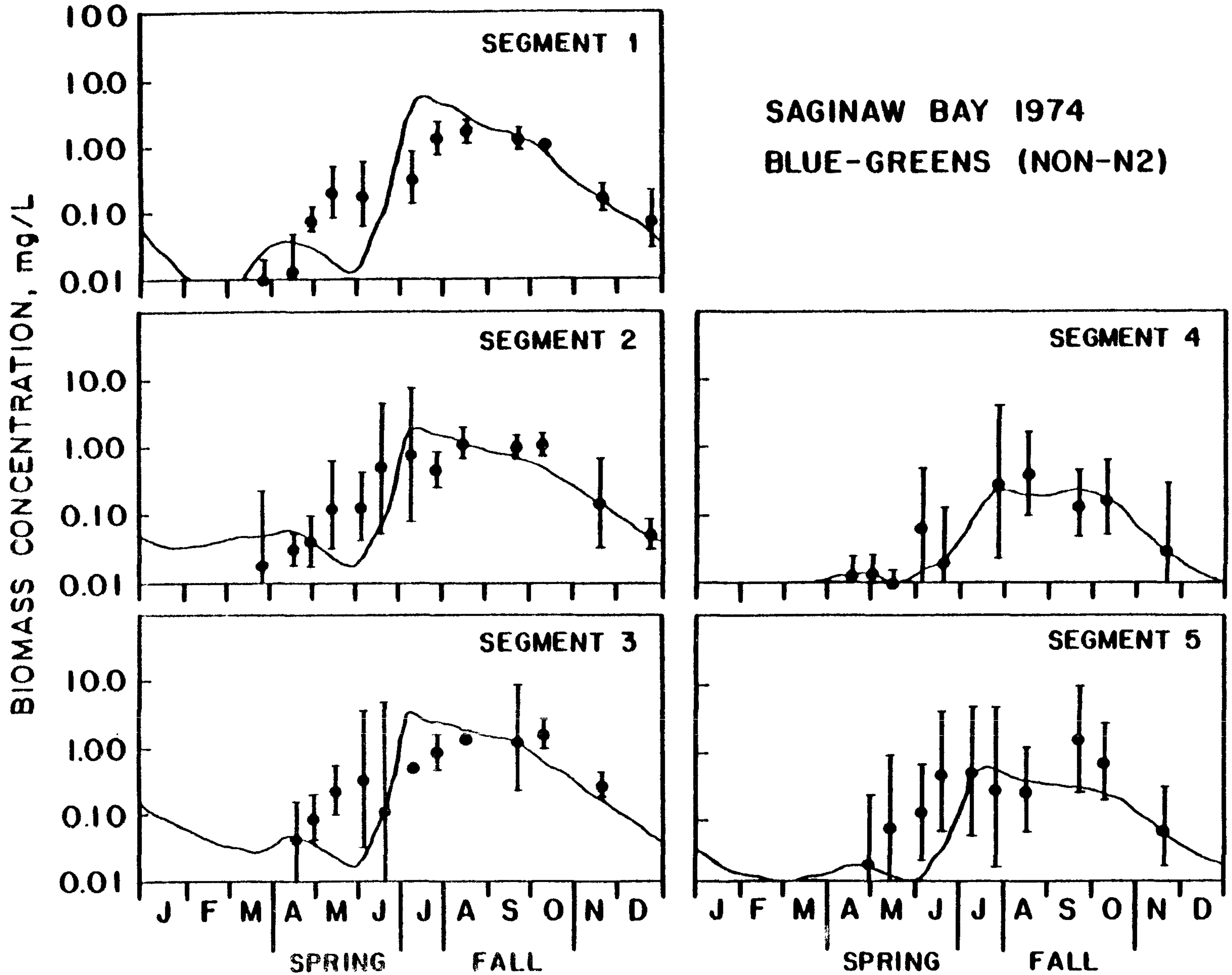


Figure 6. Relationship between Model Output and Field Data for Blue-Green Phytoplankton (Non-Nitrogen-Fixing) Biomass for Saginaw Bay in 1974

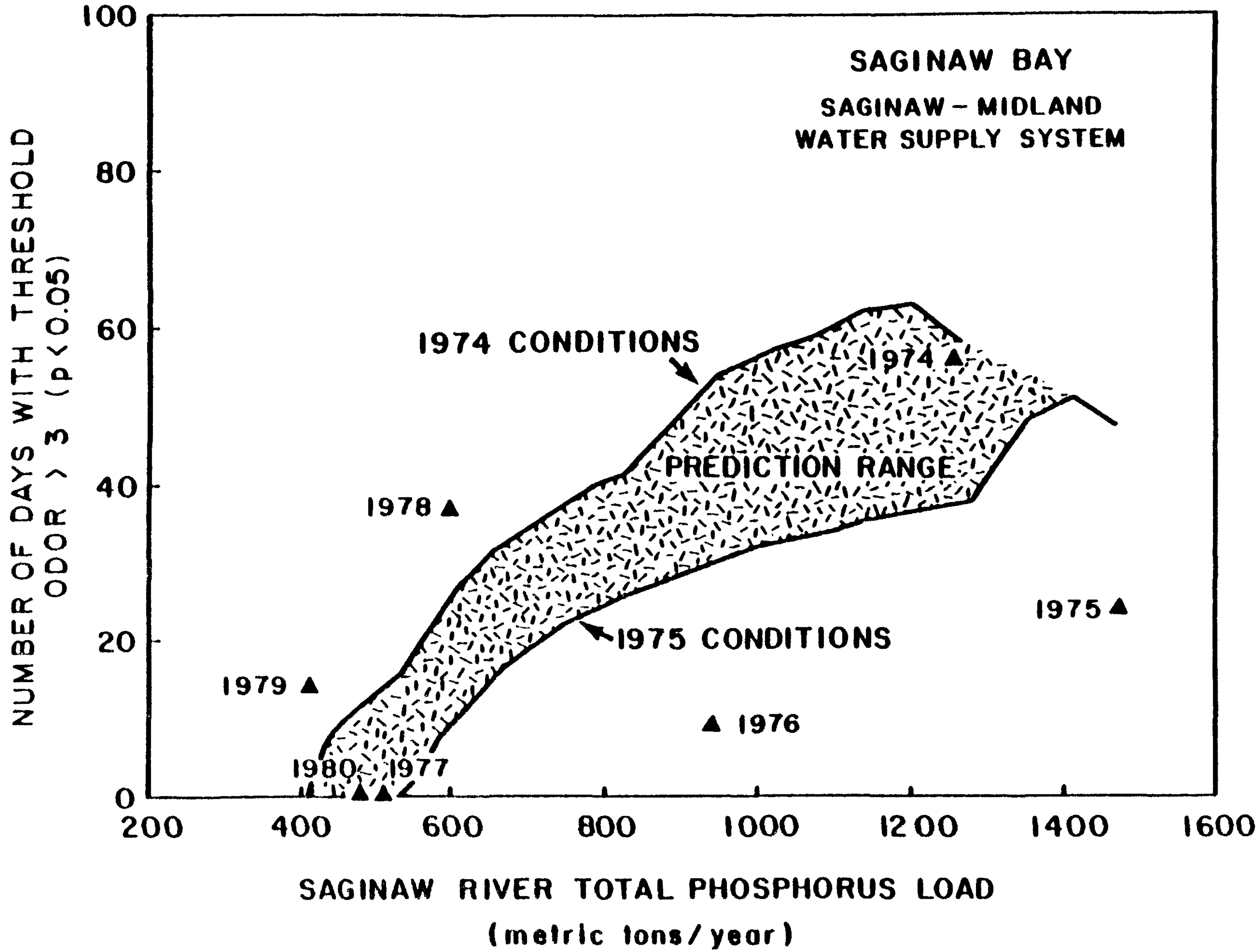


Figure 7. Relationship between Predicted and Observed Threshold Odor Violations as a Function of Saginaw River Total Phosphorus Loadings

$$\frac{\partial C}{\partial t} = D_x \frac{\partial^2 C}{\partial x^2} + D_y \frac{\partial^2 C}{\partial y^2} - \frac{\partial}{\partial x}(U_x C) - \frac{\partial}{\partial y}(U_y C)$$

$$\pm S(x, y, t) \tag{4.1}$$

where:

C	=	constituent concentration (M/L^3)
t	=	time (T)
x, y	=	spatial coordinates in the horizontal (L)
D_x, D_y	=	turbulent diffusion coefficients in the x and y directions, respectively (L^2/T)
U_x, U_y	=	flow velocities in the x and y directions, respectively (L/T)
$S(x,y,t)$	=	sources and sinks of constituent C (M/L^3-T).

The turbulent diffusion coefficients represent mixing caused by large-scale eddys, and dispersion caused by velocity gradients, or shears, within the mean advective flow. In general, dispersion usually predominates in estuaries, and turbulent diffusion predominates in lakes. For long-term simulations, however, mixing can be adequately represented as turbulent diffusion.

The solution method used in the model consists of a finite difference approximation to the derivatives of Equation 4.1. This method is a control volume approach developed by Thomann (1972), and used in the Water Quality Analysis Simulation Program (WASP) (Di Toro et al. 1983). It consists of treating the water body as a series of completely mixed volumes, or spatial segments. It results in transformation of Equation 4.1 from a partial differential equation in time and space to a system of N ordinary differential equations in time, where N is the number of control volumes or segments.

Using the control volume approach, the change in mass of a constituent with respect to time for a given spatial segment is:

$$V_k \frac{dC_k}{dt} = \sum_j \left[-Q_{kj}(\alpha_{kj}C_k + \beta_{kj}C_j) + E_{kj}(C_j - C_k)\right] \pm S_k \tag{4.2}$$

where:

C_k	=	constituent concentration in segment k (M/L^3)
C_j	=	constituent concentration in adjacent segment j (M/L^3)
V_k	=	volume of segment k (L^3)
Q_{kj}	=	advective flow between segments k and j (L^3/T)

E'_{kj} = bulk diffusion coefficient (L^3/T)
= $E_{kj}A_{kj}/\bar{L}$ (L^3/T)
E_{kj} = turbulent diffusion coefficient (L^2/T)
A_{kj} = cross sectional area between segments k and j (L^2)
α_{kj} = dimensionless weighting factor
= $L_j/(L_j + L_k)$
L_k = length of segment k in direction of flow (L)
L_j = length of segment j in direction of flow (L)
β_{kj} = $1 - \alpha_{kj}$
S_k = sources and sinks of constituent in segment k (M/T).

The parameters α_{kj} and β_{kj} are weighting coefficients that correct for cases where adjacent segments have unequal lengths. Positive solutions are maintained by the stability criteria:

$$\alpha_{kj} > 1 - (E'_{kj}/Q_{kj}) \tag{4.3}$$

The general time step constraint for Equation 4.2 is:

$$1 + U \frac{\Delta t}{L} (\beta - \alpha) - \frac{2E\Delta t}{L^2} - k\Delta t > 0 \tag{4.4}$$

where $U = Q/A$. Refer to Thomann (1972) and Chapra and Reckhow (1983) for a more detailed discussion.

To integrate Equations 4.2, the model uses Ralston's second-order Runge-Kutta method (Chapra and Canale 1985). Previous versions of the model used a fourth-order Runge-Kutta method, and an Adams-Moulton predictor-corrector method. The fourth-order method required four derivative evaluations for every time step. The predictor-corrector method required two derivative evaluations, plus any additional evaluations that were required to meet specified convergence criteria. Experience has shown that the second-order Runge-Kutta method gives solutions of comparable accuracy to these other two methods. It requires only half the number of derivative evaluations as the fourth-order method, and it is much easier to program than the predictor-corrector method.

In some applications, particular combinations of spatial segment, derivative, and time step can cause negative values for some state variables. This is most likely to occur during periods of extreme nutrient limitation, or during periods when phytoplankton blooms "crash" due to heavy zooplankton grazing pressure. In these situations, the variables that are most likely to become negative are internal nutrient levels, and dissolved available nutrient concentrations in the water column. On occasion, phytoplankton biomass can also become negative. If this occurs, the computer program issues a warning to the user, but takes no corrective action. The user should respond by repeating the computation with a smaller time step.

4.3 KINETIC PROCESSES

All state variables in the model are described by Equation 4.2. This equation has two major components: inter-segmental transport, and intra-segmental sources and sinks. Included in these sources and sinks are constituent loadings from tributaries, the atmosphere, and the sediments, as well as transfers among state variables (constituents). The equations for sources, sinks, and loadings are tabulated in Appendix B for all of the model state variables. The process mechanisms represented by these equations are briefly discussed below. Refer to Bierman et al. (1980) for a more detailed discussion.

4.3.1 Phytoplankton

Phytoplankton functional groups are distinguished primarily on the basis of nutrient requirements, growth rates, settling characteristics, and susceptibility to grazing by herbivorous zooplankton. All phytoplankton groups have absolute requirements for phosphorus and nitrogen, with the exception of nitrogen-fixing blue-greens which can continue to grow in the absence of dissolved available nitrogen. Diatoms are the only group with a major absolute requirement for silicon.

The relative maximum growth rates and temperature optima among the various phytoplankton groups are such that a typical successional pattern during the growing season begins in spring with diatoms, progresses to greens, and finally leads to blue-greens in late summer-fall. Various types of flagellates and cryptomonads can occur as well.

Diatoms and greens are generally considered to be acceptable food sources for herbivorous zooplankton. Many species of blue-greens, including those frequently responsible for nuisance blooms, are not significantly grazed. Other functional groups are grazed to varying degrees.

The number and type of phytoplankton functional groups selected for a given application will generally depend on the water quality issues to be addressed, and on the availability of field data.

The phytoplankton nutrient uptake and growth processes in the model are based on internal nutrient pool kinetics. The principal advantages of this approach are more realistic descriptions of non-steady-state conditions, and of nutrient recycle. The principal disadvantages are increased computational complexity and the need to specify additional model coefficients.

The principal features of the internal nutrient pool kinetics model are the following:

1. Growth rates depend directly on internal nutrient levels, not on environmental nutrient concentrations.

2. Nutrient uptake rate is a function of both internal nutrient level and the environmental concentration.

3. The active internal nutrient pool which participates in the nutrient uptake mechanism is a function of the total internal nutrient level. This feedback mechanism prevents the cells from absorbing arbitrarily large amounts of a nutrient and depleting the external environment.

Fixation of atmospheric nitrogen is modeled by constraining the internal nitrogen level to a maximum value whenever the dissolved available nitrogen concentration in the water column is below a user-specified threshold value. This insures that the specific growth rate for the nitrogen-fixing blue-green group will not be limited by nitrogen during such periods.

Other phytoplankton processes included in the model are respiration, decomposition, and settling.

4.3.2 Nutrients

The nutrients included in the model are phosphorus, nitrogen, and silicon. These are generally considered to be the most important nutrients that limit phytoplankton growth in natural waters. In the water column, each of the nutrients exists in a dissolved available form, and in a total unavailable form. No explicit distinction is made between dissolved and particulate fractions for the unavailable forms.

In the sediments, only total nutrient concentrations are represented. The principal reason for including sediment nutrients in the model is that in shallow systems, resuspension can significantly influence water column nutrient concentrations. To obtain a realistic mass balance it is necessary to model the coupled water column-sediment system.

Nutrient recycle consists of two distinct components: a component associated with the minimum cell quota, or stoichiometry, required by the phytoplankton, and a component associated with the internal nutrient level in excess of the minimum cell quota. When loss of phytoplankton biomass occurs due to respiration, decomposition, or grazing, the nutrient component associated with the minimum cell quota is recycled to the total unavailable compartment in the water column. The nutrient component associated with the excess internal level is recycled directly to the dissolved available compartment in the water column.

Other nutrient processes included in the model are mineralization, and settling of the total unavailable forms.

4.3.3 Zooplankton

Two functional groups of zooplankton are included in the model: herbivorous and carnivorous. Herbivorous zooplankton graze directly on one or more phytoplankton groups, and carnivorous zooplankton graze directly on the herbivorous zooplankton. Higher order predation on the carnivorous zooplankton is not explicitly included in the model. Instead, it is implicitly represented by a second-order predation function. Refuge concentrations are provided for the phytoplankton and both zooplankton groups. These are threshold concentrations below which no grazing or predation can occur.

4.3.4 Sediments

The sediment nutrients are modeled using simple input-output mechanisms. There are no process kinetic reactions within the sediment compartment, with the exception of nutrient mineralization which may occur. Evidence indicates that such mineralization is especially important in the overall silicon mass balance cycle.

The principal nutrient fluxes into the sediment are due to phytoplankton settling, and settling of total unavailable nutrients. The principal output flux is due to resuspension. Resuspension in the model is represented by a threshold function of wind speed (Dolan and Bierman 1982). A resuspension event is modeled with a constant apparent resuspension velocity for sediment nutrients on user-specified days for which wind speed exceeds a given value. Resuspension is zero on all other days. Resuspended nutrients are assigned to the total unavailable nutrient compartments in the water column because they are primarily in particulate forms.

The sediment compartments in the model represent only surficial sediments with user-specified mixing depths. Operationally, these depths are usually considered to be 10 cm for depositional areas, and smaller (or zero) for non-depositional areas. There is a long-term apparent net loss velocity from the surficial sediment layer to the deeper sediment layer. This velocity represents long-term burial.

4.3.5 Light Extinction

Light extinction in the model is parameterized as a function of inverse Secchi depth (Beeton 1958). This is the most general formulation commonly used in contemporary water quality models. Effler (1985) investigated the applicability of this approach for different lakes, and attempted to define ranges of uncertainty to be expected when using this formulation.

Alternatively, the user can easily modify the computer code to incorporate any site specific function for light extinction. For the final calibration and post-audit phases of the Saginaw Bay study, daily light extinction coefficients were computed using a multiple linear regression between measured extinction coefficients, and measured values for phytoplankton biomass (grouped as diatoms and non-diatoms) and unavailable phosphorus (mostly particulate) concentrations. This approach accounted for effects on the extinction coefficient due to phytoplankton self-shading, and to background suspended solids concentrations, using particulate phosphorus as an indicator. Di Toro (1978) has developed a useful relationship between extinction coefficient and concentrations of various types of suspended particles.

Photoperiod in the model is computed daily using a sine function of Julian day. This function approximates photoperiod at 44 degrees north latitude. User modification is required for systems at different latitudes.

SECTION 5

STRUCTURE OF COMPUTER CODE

5.1 OVERVIEW

The computer code is in modular form, consisting of a main program and 14 subroutines. There is also an associated file that contains a master set of COMMON statements and REAL declarations. This file is accessed by each of the 15 program units through use of an INCLUDE statement.

There are four principal data input files, and two output files. Three of the data input files are directly user-supplied, and the fourth consists of output from a separate pre-processing package. This package itself requires a data input file that is user-supplied. Figure 8 contains a schematic diagram of the model input and output data files, and their relationship to both the model and the pre-processing package. Table 1 contains brief descriptions of each data file.

The model is extremely flexible in terms of accomodating constant or time-variable values for advective flows, bulk diffusive flows, loadings, boundary conditions, and other environmental forcing functions. This is because organization, interpolation, and formatting of the forcing functions is conducted off-line by the user and the pre-processing package. This approach allows the model itself to be more simple, and to require less computer memory. However, additional effort and responsibility are placed on the user in terms of data organization and preliminary data reduction.

The model does not have any intrinsic graphics capability. This is because the model contains a large number of different state variables, and it can be configured for a large number of different combinations and permutations of spatial segments, phytoplankton groups, and zooplankton groups. The judgment was made that it would not be cost-effective to develop a generalized graphics package for the model. Instead, with the increasing popularity and availability of spreadsheets and graphics programs for personal computers, including the IBM PC/AT, users can generate plots to suit their own particular applications.

5.2 PROGRAM UNITS

A flowchart for all program units in the model, with the exception of subroutine PLOT, is shown in Figure 9. Subroutine PLOT has the same logic flow as subroutine OUTPUT. Table 2 contains brief descriptions of all model subroutines.

The computer code is in modular form. There are separate program units for computing transport, and for computing phytoplankton, herbivorous zooplankton, carnivorus zooplankton,

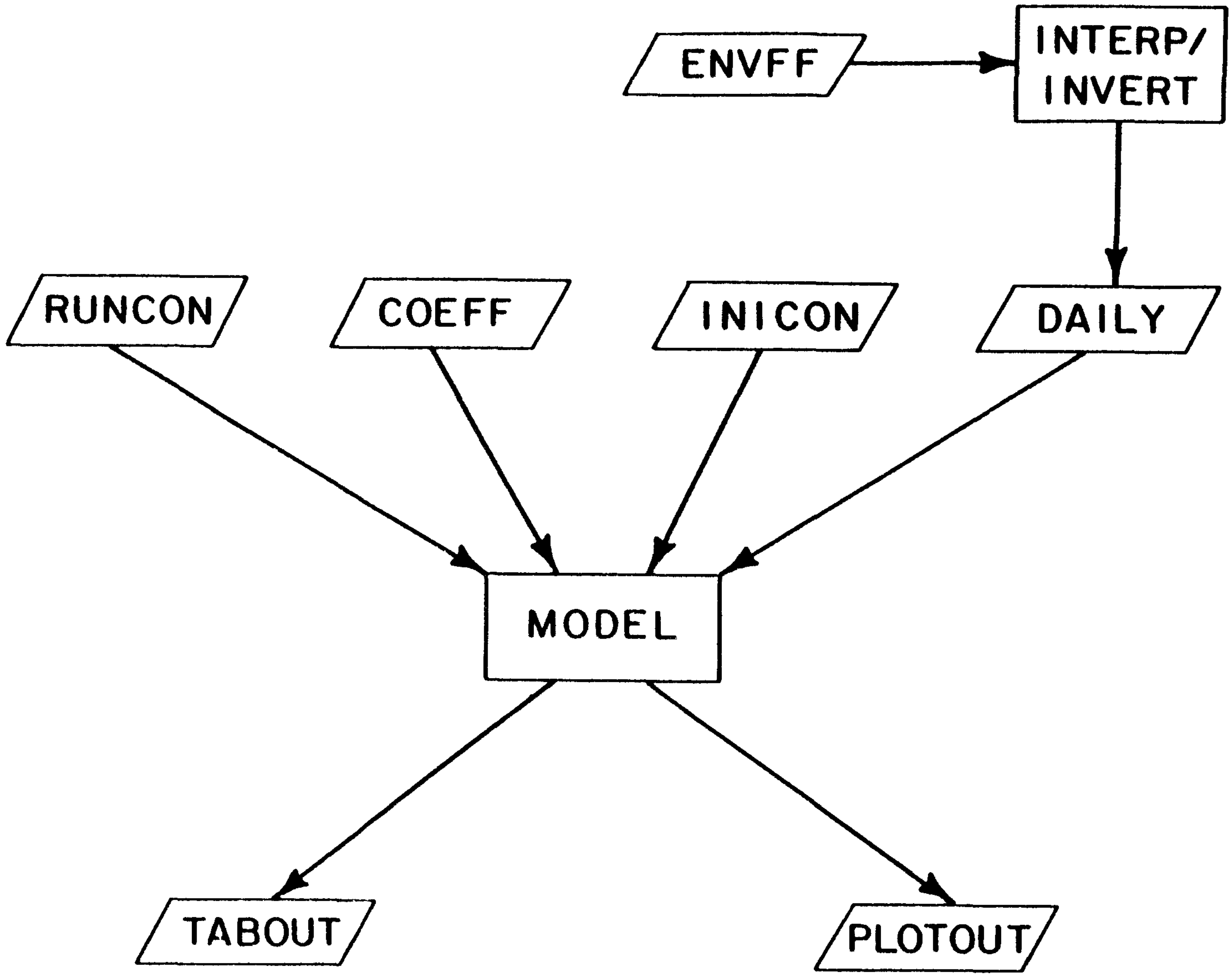


Figure 8. Schematic Diagram of Model Input and Output Data Files

Table 1. Description of Model Input and Output Data Files

Data File	Description	Source
ENVFF	Time series for environmental forcing functions	User supplied
DAILY	Daily values for environmental forcing functions computed by piecewise linear interpolation	INTERP/INVERT Output
RUNCON	Run control parameters and system configuration	User supplied
COEFF	Internal model coefficients	User supplied
INICON	Initial conditions	User supplied
TABOUT	Output in tabular format for line printer	MODEL output
PLOTOUT	Output for selected variables in format suitable for graphics	MODEL output

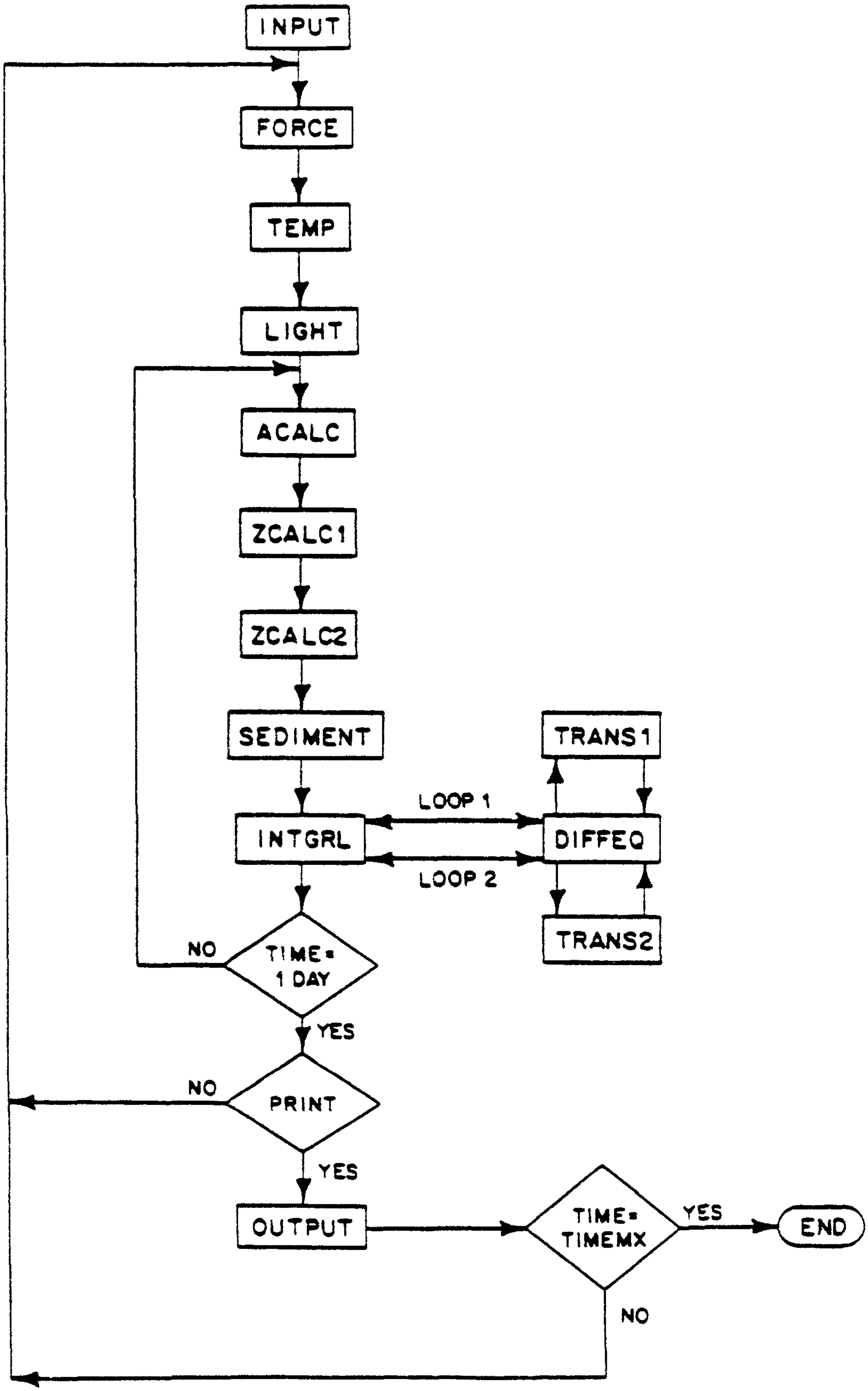


Figure 9. Flowchart for Model Structure

Table 2. Description of Model Subroutines

Subroutine	Description
INPUT	Reads RUNCON, COEFF, AND INICON files and initializes all variables
FORCE	Reads daily values for environmental forcing functions
TEMP	Computes daily values for temperature reduction factors
LIGHT	Computes daily values for light reduction factors
ACALC	Computes values for phytoplankton specific growth rates and loss processes
ZCALC1	Computes values for herbivorous zooplankton specific growth rates, loss processes, and nutrient recycle rates
ZCALC2	Computes values for carnivorous zooplankton specific growth rates, loss processes, and nutrient recycle rates
SEDIMENT	Computes values for sediment loading rates
DIFFEQ	Computes values for state variable derivatives
INTGRL	Integrates state variable differential equations
TRANS1	Computes transport for internal nutrient storage variables
TRANS2	Computes transport for all other variables
OUTPUT	Writes model output to a tabular file
PLOT	Writes model output for selected variables to a file in format suitable for graphics

and sediment kinetics. Values for all environmental forcing functions are updated daily by a separate module. Inputs and outputs are also handled by separate program units.

There is a nested hierarchy of subroutines that is related to different time scales within the model. Loop 1 (Figure 9) contains the differential equations for phytoplankton internal nutrient levels and dissolved available nutrients in the water column. The characteristic time scales for these processes in natural systems are on the order of minutes. Loop 2 (Figure 9) contains the differential equations for all other state variables. The characteristic time scales for these processes are on the order of hours. Different integration time steps are used for each of these loops in the model.

Environmental forcing functions can vary over a wide range of time scales. Advective and bulk diffusive flows can be considered to vary over weekly, monthly, or seasonal time scales. Tributary loadings can vary over daily to seasonal time scales. In practice, the availability of field data is usually the determining factor for the actual scales used for a particular application. The pre-processing package conducts a linear interpolation, on a daily basis, between the user-specified values for each forcing function, regardless of the time intervals between the values. Accordingly, the real accuracy of the forcing functions in the model depends solely on the accuracy and frequency of the data that the user specifies to the pre-processing package. The model updates all environmental forcing factors daily by reading the output file from the pre-processing package.

Model output consists of a data file in tabular format (TABOUT) that can be sent to a line printer, and a data file (PLOTOUT) that can be used as input to a user-supplied graphics program. Examples of tabular output files are contained in the appendices. The subroutine PLOT is configured for the special case of only one spatial segment, and for only selected output variables. Users must configure this subroutine to suit their own particular applications in terms of numbers of spatial segments and variables to be plotted.

Separate time intervals can be selected for tabular and plot outputs. Generally, tabulated output is requested at intervals of between 5 and 15 days, depending on the particular application. An appropriate time scale for plot output is usually 1 to 5 days.

SECTION 6

MODEL INPUT STRUCTURE

6.1 OVERVIEW

This section contains descriptions of the four principal input data files. Variable names and input sequences are illustrated for each file. The pre-processing package is described, and the organization and reduction of environmental forcing factors are discussed. Appendix A contains a glossary of all variable names, including array dimensions and physical units.

6.2 SUMMARY OF DATA GROUPS

6.2.1 Run Control

The run control file, RUNCON, contains information needed to configure the model for the particular site-specific application. After initial setup and testing, the data values in this file will usually not be changed during the model calibration process. Table 3 contains the record input format for the RUNCON file.

The computer code is dimensioned for a maximum of 10 spatial segments. Each spatial segment can have up to a maximum of five interactions with other spatial segments and/or boundaries. A boundary is considered to be either a large open boundary, or a tributary. There are important constraints on how these boundaries can be set up, and on how the forcing factors for transport must be specified. These constraints are discussed below in detail.

The code is dimensioned for a maximum of five phytoplankton groups. Although it is possible to run the model for only one group, it is assumed that applications will involve between two and five groups. One of the phytoplankton groups must be a diatom for proper representation of the silicon mass balance cycle. The inclusion of a nitrogen-fixing blue-green group is optional.

The code is dimensioned for a maximum of two herbivorous zooplankton and two carnivorous zooplankton groups. Most applications will involve only one carnivorous zooplankton, and one or two hervbivorous zooplankton. The herbivorous zooplankton can be configured to graze on one or more phytoplankton groups. Not all of the phytoplankton groups need to be grazed. The carnivorous zooplankton can only graze on herbivorous zooplankton.

The model can be run to simulate any desired period in real time. It can be run to simulate a seasonal cycle, or it can be run over an entire year. If constant environmental forcing

Table 3. Record Input Format for RUNCON File

Variable Sequence Number	Variable(s)	Format
1	NSGMTS, INTMAX	2I5
2	VX(N), DEPTH(N)	2E10.3
3	INT(N,J)	I5
4	VOLSDX(N), DEPTHS(N)	2E10.3
5	NBDNTS, NFXLDS, NMISC	3I5
6	NASPEC, NDITMS, NN2BGS	3I5
7	ISILCA(L)	5I5
8	NFIX(L)	5I5
9	NZSPEC, NZ1SPC, NZ2SPC	3I5
10	IZ1PAR(K1,L)	5I5
11	IZ2PAR(K2,K1)	2I5
12	TIMEMX, TPLOT, TPRINT, ISKIP	3E10.4,I5
13	H1, H2	2E10.4

functions are specified, it can also be run to steady-state. The print interval (TPRINT) can have any value, as long as it is less than the maximum run time. The variable ISKIP is a switch that controls the optional printing of derivatives and component terms to the tabular model output file. If ISKIP = 0, the derivatives are printed; if ISKIP = 1, the printing of derivatives is suppressed.

The integration time step for loop 2 (H2) must be an integer multiple of the time step for loop 1 (H1). An integer multiple of H2 must equal one day. Experience has shown that H1 should correspond to approximately 15-30 minutes, and H2 should correspond to approximately 3-6 hours, depending on the particular application. As part of the preliminary testing phase for any new application, sensitivity analyses should be run for different integration time steps.

The present version of the computer code requires fixed values for NBDNTS, NFXLDS, and NMISC. These values are used by the model to determine the total number of environmental forcing functions for a particular application.

6.2.2 Model Coefficients

The file of model coefficients, COEFF, contains values for all kinetic and stoichiometric constants. After initial setup and testing, these are the values that are varied to calibrate the model to a given set of field data. Table 4 contains the record input format for the COEFF file.

The selection of appropriate values for the variables in COEFF requires a considerable knowledge of the scientific literature, and good judgment on the part of the user. Otherwise, use of the model will simply be an exercise in curve-fitting. Refer to Bierman et al. (1980) for a detailed discussion of the rationale and approach for selection of model coefficients for the Saginaw Bay case study. An excellent resource for selection of stoichiometric and kinetic coefficients for a wide variety of physical, chemical, and biological processes is Bowie et al. (1985).

The user should be aware of a constraint between the minimum cell quotas of the phytoplankton, and the phosphorus and nitrogen stoichiometries of the two zooplankton types. To prevent a mass balance violation, the minimum cell quota of a grazed phytoplankton type must not be less than the stoichiometry of the herbivorous zooplankton for the same nutrient. In addition, the stoichiometries for the herbivorous and carnivorous zooplankton must be identical for the same nutrient.

To help insure these constraints, the computer code assigns the same phosphorus and nitrogen stoichiometries to the herbivorous and carnivorous zooplankton that the user specifies

Table 4. Record Input Format for COEFF File

Variable Sequence Number	Variable(s)	Format
1	TBASE1, TBASE2, TBASE3, TBASE4	4E10.3
2	AVNFIX	1E10.3
3	GMAX(L), TBASEA(L), TBASAR(L)	3E10.3
4	R1PM(L), PK1(L), K1P(L), K2P(L), PSAMIN(L), KPCELL(L)	6E10.3
5	R1NM(L), NK1(L), K1N(L), K2N(L), NSAMIN(L), KNCELL(L)	6E10.3
6	R1SM(L), SK1(L), K1S(L), K2S(L), SSAMIN(L), KSCELL(L)	6E10.3
7	ASINK(L), RDCMP(L), KDCMP(L), RADSAT(L), RRESP(L)	5E10.3
8	Z1ASSM(K1), KZ1SAT(K1), AZMIN(K1), B1DETH(K1)	4E10.3
9	RZ1MAX(K1), TBASZ1(K1)	2E10.3
10	Z1EFF(K1,L)	5F5.0
11	Z2ASSM(K2), KZ2SAT(K2), Z12MIN(K2), B2DETH(K2), P2DETH(K2), Z23MIN(K2)	6E10.3
12	RZ2MAX(K2), TBASZ2(K2)	2E10.3
13	Z2EFF(K2,K1)	2F5.0
14	RTUP, RTUN, RTUS	3E10.3
15	KRTUP, KRTUN, KRTUS	3E10.3
16	TUPSNK, TUNSNK, TUSSNK	3E10.3
17	VUPP(N), VUPN(N), VUPS(N)	3E10.3
18	KRSEDP(N), KRSEDN(N), KRSEDS(N)	3E10.3
19	VPLONG(N), VNLONG(N), VSLONG(N)	3E10.3

(continued)

Table 4. (continued)

20	NEVNTS	I5
21	TSTART(M), TSTOP(M)	2F5.0

for the respective minimum cell quotas for the phytoplankton group corresponding to L = 1. The user needs to insure that the minimum cell quotas for phosphorus and nitrogen for any other grazed phytoplankton groups are equal to or greater than those for this first group.

To specify NEVNTS, the user must determine the number of significant resuspension events that occur in the water body during the period of simulation. One way to do this is to conduct a regression analysis of suspended solids concentration, or a suitable indicator, versus wind speed. A threshold wind speed can be identified that produces a significant increase in suspended solids concentration. The frequency and duration of resuspension events can then be estimated for any desired period of time by using daily wind speed records. The start and stop days for each of these events can then be specified as model input.

It is also possible to run the model without any resuspension events. To do this, the user can specify NEVNTS = 0. With this option, no values need to be specified for TSTART or TSTOP.

6.2.3 Initial Conditions

The initial condition file, INICON, contains initial values for all of the model state variables. After initial setup and testing, these values will not be changed for a given simulation period. Table 5 contains the record input format for the INICON file.

The INICON file also contains values for atmospheric loadings for each of the nutrient state variables. This was done for operational reasons. Atmospheric sources contribute to the total loading of a water body, and they must be considered. In most cases, however, insufficient data exist to construct time series for these loadings. Instead, constant values are usually specified for the entire period of simulation.

6.3 ENVIRONMENTAL FORCING FUNCTIONS

Values for all environmental forcing functions are specified by the user in the file ENVFF. The pre-processing package, consisting of the programs INTERP and INVERT, operates on ENVFF and produces the output file DAILY. The model reads DAILY once each day to update all of the forcing functions. Table 6 contains the record input format for ENVFF.

There are 28 environmental forcing functions for each spatial segment. Values must be specified for all 28 functions. Zeroes or dummy values must be used, as appropriate, so that ENVFF is fully defined. Values appear in ENVFF in segment-major order.

Table 5. Record Input Format for INICON File

Variable Sequence Number	Variable(s)	Format
1	AVP(1,N), AVN(1,N), AVS(1,N), TUP(1,N), TUN(1,N), TUS(1,N), CL(1,N)	7E10.3
2	A(L,N), PSA(L,N), NSA(L,N), SSA(L,N)	4E10.3
3	Z1(K1,N)	1E10.3
4	Z2(K2,N)	1E10.3
5	SEDP(N), SEDN(N), SEDS(N)	3E10.3
6	WAVPAX(N), WAVNAX(N), WAVSAX(N), WTUPAX(N), WTUNAX(N), WTUSAX(N), WCLAX(N)	7E10.3

Table 6. Record Input Format for ENVFF File

Variable Sequence Number	Forcing Function		Format
1	PSABD(L,N),	JULIAN DAY	2E10.3
2	NSABD(L,N),	JULIAN DAY	2E10.3
3	SSABD(L,N),	JULIAN DAY	2E10.3
4	ABD(L,N),	JULIAN DAY	2E10.3
5	Z1BD(K1,N),	JULIAN DAY	2E10.3
6	Z2BD(K2,N),	JULIAN DAY	2E10.3
7	TPBD(N),	JULIAN DAY	2E10.3
8	AVPBD(N),	JULIAN DAY	2E10.3
9	TKNBD(N),	JULIAN DAY	2E10.3
10	NO3BD(N),	JULIAN DAY	2E10.3
11	NH3BD(N),	JULIAN DAY	2E10.3
12	TSBD(N),	JULIAN DAY	2E10.3
13	AVSBD(N),	JULIAN DAY	2E10.3
14	CLBD(N),	JULIAN DAY	2E10.3
15	WTP(N),	JULIAN DAY	2E10.3
16	WAVP(N),	JULIAN DAY	2E10.3
17	WTKN(N),	JULIAN DAY	2E10.3
18	WNO3(N),	JULIAN DAY	2E10.3
19	WNH3(N),	JULIAN DAY	2E10.3
20	WTS(N),	JULIAN DAY	2E10.3
21	WAVS(N),	JULIAN DAY	2E10.3
22	WCL(N),	JULIAN DAY	2E10.3

(continued)

Table 6. (continued)

23	Q(N,J),	JULIAN DAY	2E10.3
24	EPRIME(N,J),	JULIAN DAY	2E10.3
25	ALPHA(N,J),	JULIAN DAY	2E10.3
26	T(N),	JULIAN DAY	2E10.3
27	RADINC(N),	JULIAN DAY	2E10.3
28	SECCHI(N),	JULIAN DAY	2E10.3

Variable numbers 1-14 (Table 6) consist of boundary concentrations for state variables or their components. If a given spatial segment does not have a boundary, then all of these values must be set to zero.

Variable numbers 15-22 (Table 6) consist of external tributary loadings. In practice, the spatial segmentation scheme is usually configured so that a separate segment is created for each major tributary. In the limiting case of one spatial segment, there may be an inflow tributary and an outflow tributary. In this case, however, loading will still only occur from one tributary.

There are important constraints on the transport forcing functions, Q(N,J), EPRIME(N,J), and ALPHA(N,J), and on the possible types of segment interactions. These constraints are summarized in Table 7.

The index, N, refers to a given reference segment. The index, J, refers to the sequence number of the possible interactions for this reference segment. The value of J ranges from 1 to INTMAX. Variables indexed with J must be fully defined. That is, if there is no interaction for a particular value of J, then zeroes must be used for those variables in ENVFF.

The two principal types of segment interfaces are adjacent segments and boundaries. Boundaries can be either large open boundaries, such as for an embayment, or tributaries. Transport in the form of constituent mass flux always occurs across adjacent segment and open boundary interfaces.

Transport may or may not occur across tributary boundaries, depending on specification of boundary conditions. A tributary boundary is considered to be transporting if there exists a flow and a boundary concentration. A tributary boundary is considered to be non-transporting if there exists a flow, but no (or zero) boundary concentration. Input tributaries are usually considered to be non-transporting. Constituent mass loading rates from such tributaries are considered to be point sources. Output tributaries must be considered transporting boundaries in order to maintain continuity and to conserve mass in the reference segment.

By convention, the order of segment interactions is: adjacent segments, non-transporting tributaries, and transporting boundaries (tributaries or open boundaries). Transport of a constituent across a segment boundary is permitted only for the interaction corresponding to J = INTMAX. This boundary can be either a tributary or an open boundary, however, transport must occur across every open boundary. If a segment has a tributary boundary and an open boundary, then transport must occur across the open boundary. If a segment has two tributary boundaries, then the upstream tributary must be considered a point source,

Table 7. Constraints on Physical Configuration and Transport Variables

Interface Type	Q(N,J)	EPRIME(N,J)	ALPHA(N,J)	J	CBOUND(N)
Adjacent Segment	Arbitrary	$E' \neq 0$	Stability Criterion	$J <$ INTMAX	0
Open Boundary	Arbitrary	$E' \neq 0$	Stability Criterion	$J =$ INTMAX	CBOUND > 0
Tributary					
Trans-porting	$Q \neq 0$	$E' = 0$	1	$J =$ INTMAX	CBOUND > 0
Non-Trans-porting	$Q \neq 0$	$E' = 0$	1	$J <$ INTMAX	0

and the downstream tributary must operationally be considered a transporting boundary.

By convention, Q(N,J) is considered negative for flow into a segment, and positive for flow out. The value for Q(N,J) must be non-zero for a tributary. The algebraic sum of all flows for a given spatial segment must be zero. The computer code contains an algorithm that checks flow balance daily for each spatial segment. A warning is issued if a flow balance violation is detected, but no corrective action is taken.

By convention, EPRIME(N,J) must be non-zero for adjacent segments and open boundaries. It must be zero for all tributaries. The computer code uses the value of EPRIME(N,J) to identify tributary boundaries for the transport algorithms. The user should note that EPRIME(N,J) refers to bulk diffusion (L^3/T), not the turbulent diffusion coefficient (L^2/T).

The values for ALPHA(N,J) must satisfy the stability criteria in Equation 4.3 for all interactions involving adjacent segments and open boundaries. The computer code contains an algorithm that checks these stability criteria each day, and takes corrective action if a violation is detected. In the tabulated model output, values are printed for both the user-specified and corrected values of ALPHA(N,J).

The values for ALPHA(N,J) must be equal to 1 for all tributary interactions. This is a consequence of the convention that EPRIME(N,J) is zero for all tributaries.

Values for boundary concentrations, represented generically by the variable CBOUND(N) (Table 7), must be zero in the case of a non-transporting boundary, and greater than zero in the case of a transporting boundary. Dummy values greater than zero must be specified in cases where a tributary is the only outflow for a given spatial segment. This is required to activate the transport algorithm in the computer code so that mass can be conserved.

The pre-processing package consists of two separate program units, INTERP and INVERT. The program INTERP computes daily time series values for each variable in the ENVFF file. Output is stored in an intermediate file. Each record in this file consists of the time series for one environmental forcing function.

The program INVERT re-formats this intermediate file so that each record contains the values for all environmental forcing factors on the same day. If the intermediate file is considered to be a matrix, then INVERT conducts an inversion of rows and columns. Output from INVERT is stored in the DAILY file. The DAILY file is then read directly by the model.

In principle, this two-step pre-processing operation could be conducted in a single step. However, especially for applications involving multiple spatial segments, large arrays need to be defined. On a personal computer, these arrays would usually exceed the addressable memory space.

SECTION 7

EXAMPLE APPLICATIONS

7.1 APPROACH

Two simplified examples are presented in detail. Both of the examples involve a single spatial segment, however, they have different hydraulic configurations. These examples represent a large class of potential applications for the model. Two phytoplankton groups are included for illustrative purposes. The extension to additional groups is straightforward.

For the simplified examples, the files RUNCON, COEFF, and INICON are presented in three different ways. First, the actual data file is presented in model input format. Second, a map of associated variable names is presented for the values in the file. Finally, in an appendix, the actual model output file is presented. This file contains a run header that echoes all of the input data values for RUNCON, COEFF, and INICON, including labels for all variable names. It also contains values for all environmental forcing functions.

To illustrate how the model is configured for multiple spatial segments, the input data files RUNCON, COEFF, and INICON are presented for Saginaw Bay. Values for the ENVFF file are presented for spatial segment 1. Space limitations preclude presentation of the ENVFF file for all five spatial segments, however, the complete model output file for this example is presented in an appendix.

Although subsets of actual data from Saginaw Bay are used for these examples, no water quality inferences are to be drawn from the results presented. The examples are intended solely to illustrate the use of the computer code.

7.2 EXAMPLE 1: SIMPLIFIED LAKE

7.2.1 Introduction

A schematic diagram of the simplified version of the model is shown in Figure 10. This version is applied to both the lake and embayment examples. It includes two phytoplankton groups, diatoms and others. There are no nitrogen-fixing phytoplankton. Both of the phytoplankton are grazed by a single herbivorous zooplankton. The herbivorous zooplankton, in turn, is grazed by a single carnivorous zooplankton.

The spatial segmentation scheme for the simplified lake is shown in Figure 11. It consists of one completely mixed segment, an input tributary, and an output tributary. Since bulk diffusion (EPRIME(N,J)) is zero for all tributary boundaries, the transport for this example is simply flow (Q(N,J)) in, and flow

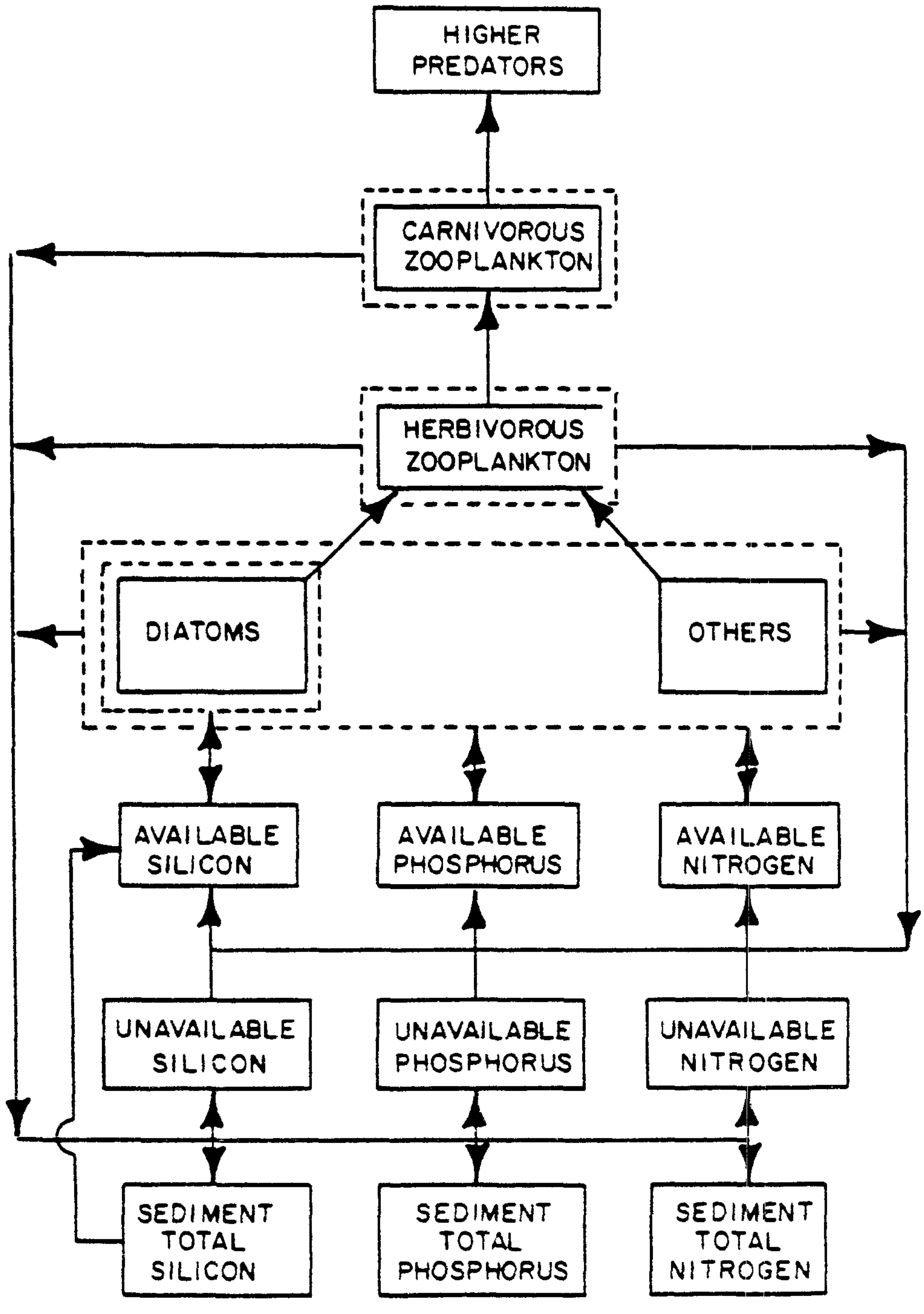


Figure 10. Schematic Diagram of Principal Model Compartments and Interaction Pathways for Simplified Lake and Embayment Examples

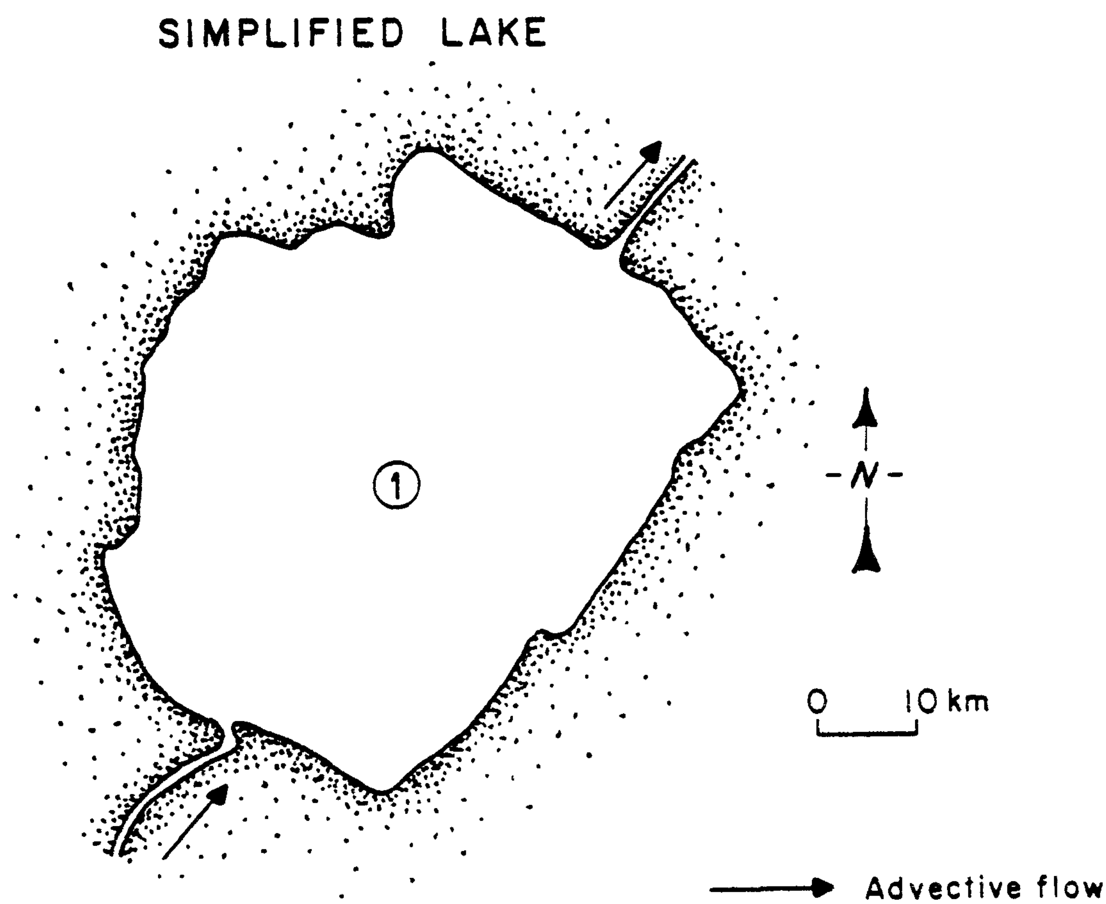


Figure 11. Spatial Segmentation and Physical Transport for Simplified Lake Example

out.

7.2.2 Data Input

7.2.2.1 Run Control

The RUNCON file in model input format for the simplified lake example is shown in Table 8. The map of variable names for this file is shown in Table 9. Note that some variables that are two-dimensional (e.g., INT(N,J)) have multiple records.

The index N refers to the number of the reference segment, in this case, segment 1. The index J is the sequence number of the interactions with the reference segment. The value of J ranges from 1 to INTMAX. The value of INT(N,J) is the number of the interacting segment that corresponds to the values of N and J.

In this example, there are two segment interactions. Both of these interactions are with tributaries. Since the tributaries are external to the model segmentation, the values of INT(1,1) and INT(1,2) are, by convention, set equal to 1, the same number as the reference segment. These can be called "self-interactions".

The variables VX(1) and VOLSDX(1) are the values of V(1) and VOLSED(1), respectively, in I/O units (m^3). See the note at the end of Appendix A regarding I/O units.

7.2.2.2 Model Coefficients

The COEFF file in model input format is shown in Table 10. The map of variable names for this file is shown in Table 11. Note that the dimensioned variables for the phytoplankton have separate records for each phytoplankton group.

The value for AVNFIX has been input as zero because there are no nitrogen-fixing phytoplankton.

There are 24 resuspension events (NEVNTS). For the first event, TSTART(1) = 98 and TSTOP(1) = 99. This corresponds to a resuspension event that begins at TIME = 98, lasts for one day, and terminates at TIME = 99. The second event begins at TIME = 103, lasts for two days, and terminates at TIME = 105.

7.2.2.3 Initial Conditions

The INICON file in model input format is shown in Table 12. The map of variable names for this file is shown in Table 13. The two dimensions for the nutrient state variables are necessitated by the structure of the transport algorithms in the computer code.

The variables WAVPAX(1), ..., WCLAX(1) are the values of

Table 8. Values for RUNCON File for Simplified Lake Example

1	2		
0.806E10	0.583E01		
1			
1			
.138E09	.100E00		
8	8	3	
2	1	0	
1	0		
0	0		
2	1	1	
1	1		
1			
.365E03	.500E01	.500E01	1
.250E-01	.125E00		

Table 9. Map of Variable Names for RUNCON File for Simplified Lake Example

NSGMTS	INTMAX		
VX(1)	DEPTH(1)		
INT(1,1)			
INT(1,2)			
VOLSDX(1)	DEPTHS(1)		
NBDNTS	NFXLDS	NMISC	
NASPEC	NDITMS	NN2BGS	
ISILCA(1)	ISILCA(2)		
NFIX(1)	NFIX(2)		
NZSPEC	NZ1SPC	NZ2SPC	
IZ1PAR(1,1)	IZ1PAR(1,2)		
IZ2PAR(1,1)			
TIMEMX	TPLOT	TPRINT	ISKIP
H1	H2		

Table 10. Values for COEFF File for Simplified Lake Example

.1070E01	.1070E01	.1070E01	.1070E01		
.000E00					
.210E01	.1060E01	.1060E01			
.180E01	.1090E01	.1090E01			
.100E-01	.226E02	.154E00	.150E01	.500E-03	.500E-03
.200E-01	.226E02	.154E00	.300E00	.100E-02	.100E-02
.200E00	.107E02	.239E00	.445E00	.100E-01	.100E-01
.200E00	.107E02	.239E00	.445E00	.200E-01	.200E-01
.500E00	.534E01	.239E00	.445E00	.350E-01	.350E-01
.100E00	.250E00	.200E03	.100E03	.300E-01	
.500E-01	.500E00	.200E03	.500E02	.300E-01	
.600E00	.100E01	.200E00	.300E-01		
.550E00	.1070E01				
1.0 .50					
.600E00	.125E00	.250E-01	.300E-01	.100E01	.250E-01
.550E00	.1070E01				
1.0					
.200E-01	.200E-01	.200E-01			
.100E01	.100E01	.100E01			
.150E00	.150E00	.150E00			
.175E-03	.114E-03	.175E-03			
.000E00	.000E00	.625E-03			
.822E-05	.822E-05	.822E-05			
24					
98. 99.					
103. 105.					
111. 113.					
118. 119.					
121. 122.					
126. 127.					
129. 130.					
132. 133.					
134. 135.					
158. 160.					
161. 162.					
184. 185.					
201. 202.					
223. 224.					
238. 239.					
243. 244.					
254. 255.					
258. 259.					
267. 268.					
272. 273.					
274. 275.					
277. 279.					
294. 296.					
309. 310.					

Table 11. Map of Variable Names for COEFF File for Simplified Lake Example

TBASE1	TBASE2	TBASE3	TBASE4		
AVNFIX					
GMAX(1)	TBASEA(1)	TBASAR(1)			
GMAX(2)	TBASEA(2)	TBASAR(2)			
R1PM(1)	PK1(1)	K1P(1)	K2P(1)	PSAMIN(1)	KPCELL(1)
R1PM(2)	PK1(2)	K1P(2)	K2P(2)	PSAMIN(2)	KPCELL(2)
R1NM(1)	NK1(1)	K1N(1)	K2N(1)	NSAMIN(1)	KNCELL(1)
R1NM(2)	NK1(2)	K1N(2)	K2N(2)	NSAMIN(2)	KNCELL(2)
R1SM(1)	SK1(1)	K1S(1)	K2S(1)	SSAMIN(1)	KSCELL(1)
ASINK(1)	RDCMP(1)	KDCMP(1)	RADSAT(1)	RRESP(1)	
ASINK(2)	RDCMP(2)	KDCMP(2)	RADSAT(2)	RRESP(2)	
Z1ASSM(1)	KZ1SAT(1)	AZMIN(1)	B1DETH(1)		
RZ1MAX(1)	TBASZ1(1)				
Z1EFF(1,1)	Z1EFF(1,2)				
Z2ASSM(1)	KZ2SAT(1)	Z12MIN(1)	B2DETH(1)	P2DETH(1)	Z23MIN(1)
RZ2MAX(1)	TBASZ2(1)				
Z2EFF(1,1)					
RTUP	RTUN	RTUS			
KRTUP	KRTUN	KRTUS			
TUPSNK	TUNSNK	TUSSNK			
VUPP(1)	VUPN(1)	VUPS(1)			
KRSEDP(1)	KRSEDN(1)	KRSEDS(1)			
VPLONG(1)	VNLONG(1)	VSLONG(1)			
NEVNTS					
TSTART(1)	TSTOP(1)				
.	.				
.	.				
.	.				
TSTART(24)	TSTOP(24)				

Table 12. Values for INICON File for Simplified Lake Example

.539E-02	.128E01	.700E00	.131E-01	.381E-01	.700E00	.220E02
.894E00	.125E-02	.350E-01	.105E00			
.473E-01	.500E-02	.700E-01	.000E00			
.130E-02						
.312E-01						
.120E03	.136E04	.479E03				
.499E01	.737E03	.684E02	.122E02	.332E03	.684E02	.000E00

Table 13. Map of Variable Names for INICON File for Simplified Lake Example

AVP(1,1)	AVN(1,1)	AVS(1,1)	TUP(1,1)	TUN(1,1)	TUS(1,1)	CL(1,1)
A(1,1)	PSA(1,1)	NSA(1,1)	SSA(1,1)			
A(2,1)	PSA(2,1)	NSA(2,1)	SSA(2,1)			
Z1(1,1)						
Z2(1,1)						
SEDP(1)	SEDN(1)	SEDS(1)				
WAVPAX(1)	WAVNAX(1)	WAVSAX(1)	WTUPAX(1)	WTUNAX(1)	WTUSAX(1)	WCLAX(1)

WAVPA(1), ..., WCLA(1) in I/O units (kg/day).

7.2.3 Environmental Forcing Functions

The full environmental forcing function file, ENVFF, is shown in Table 14. Note that there are multiple records for variables that have two dimensions. The first record for each variable is understood to be Julian day 1. The last record must be for Julian day = TIMEMX. This example file has been set up for a 365-day run.

Note the flexibility in specification of time intervals between measured values for each of the forcing functions. The time intervals do not need to be constant for a given function. There can be different sets of intervals for different functions. A function can be made constant by simply specifying equal beginning and ending values.

Non-zero dummy values are specified for all boundary conditions. This is because a tributary is the only outflow for this particular system, and such a tributary must be considered operationally as a transporting boundary (Section 6.3 and Table 7). The input tributary is non-transporting, and it is treated as a point source.

The values for Q(1,1) represent tributary inflow, and the values for Q(1,2) represent tributary outflow. The outflow tributary is the second segment interaction (J = 2) because, operationally, it is considered a transporting boundary. A transporting boundary must always be the interaction for which J = INTMAX.

The values for EPRIME(1,1) and EPRIME(1,2) are zero because they both correspond to tributary boundaries.

Values of 0.5 have been specified for ALPHA(1,1) and ALPHA(1,2). Although this is inconsistent with the constraints in Table 7, it was done intentionally to illustrate the corrective action that will be taken by the computer code. The code will correct both of these values to 1.0 because they are tributary interactions.

7.2.4 Model Output

Tabulated model output is shown in Appendix C. The output begins with a run header that echoes all of the input data from the files RUNCON, COEFF, and INICON. Next, model output is shown at TIME = 0 (beginning of Julian day 1) after all environmental forcing functions have been specified for the first day, and after initial values have been computed for all process rates and derivatives. Next, model output is shown after 5 days of simulation. All output variables are labeled. Refer to the glossary in Appendix A for definitions and units.

Table 14. ENVFF File For Simplified Lake Example

0.999E00		PSABD(1,1)	(mg P/mg A)
0.999E00	0.365E03		
0.999E00		PSABD(2,1)	(mg P/mg A)
0.999E00	0.365E03		
0.999E00		NSABD(1,1)	(mg N/mg A)
0.999E00	0.365E03		
0.999E00		NSABD(2,1)	(mg N/mg A)
0.999E00	0.365E03		
0.999E00		SSABD(1,1)	(mg S/mg A)
0.999E00	0.365E03		
0.999E00		SSABD(2,1)	(mg S/mg A)
0.999E00	0.365E03		
0.999E00		ABD(1,1)	(mg/l)
0.999E00	0.365E03		
0.999E00		ABD(2,1)	(mg/l)
0.999E00	0.365E03		
0.999E00		Z1BD(1,1)	(mg/l)
0.999E00	0.365E03		
0.999E00		Z2BD(1,1)	(mg/l)
0.999E00	0.365E03		
0.999E01		TPBD(1)	(mg P/l)
0.999E01	0.365E03		
0.999E00		AVPBD(1)	(mg P/l)
0.999E00	0.365E03		
0.999E01		TKNBD(1)	(mg N/l)
0.999E01	0.365E03		
0.999E00		NO3BD(1)	(mg N/l)
0.999E00	0.365E03		
0.999E00		NH3BD(1)	(mg N/l)
0.999E00	0.365E03		
0.999E01		TSBD(1)	(mg S/l)
0.999E01	0.365E03		
0.999E00		AVSBD(1)	(mg S/l)
0.999E00	0.365E03		
0.999E00		CLBD(1)	(mg CL/l)
0.999E00	0.365E03		
0.233E04		WTP(1)	(kg P/day)
0.939E04	0.300E02		
0.137E05	0.600E02		
0.595E04	0.900E02		
0.769E04	0.120E03		
0.462E04	0.150E03		
0.341E04	0.180E03		
0.170E04	0.210E03		
0.986E03	0.240E03		
0.986E03	0.270E03		
0.992E03	0.300E03		
0.992E03	0.330E03		
0.902E03	0.365E03		

(continued)

Table 14. (continued)

0.110E04		WAVP(1)	(kg P/day)
0.193E04	0.300E02		
0.187E04	0.600E02		
0.135E04	0.900E02		
0.840E03	0.120E03		
0.564E03	0.150E03		
0.629E03	0.180E03		
0.357E03	0.210E03		
0.552E03	0.240E03		
0.648E03	0.270E03		
0.626E03	0.300E03		
0.719E03	0.330E03		
0.512E03	0.365E03		
0.217E05		WTKN(1)	(kg N/day)
0.211E05	0.300E02		
0.594E05	0.600E02		
0.273E05	0.900E02		
0.227E05	0.120E03		
0.216E05	0.150E03		
0.612E04	0.180E03		
0.462E04	0.210E03		
0.538E04	0.240E03		
0.486E04	0.270E03		
0.461E04	0.300E03		
0.448E04	0.330E03		
0.435E04	0.365E03		
0.419E05		WNO3(1)	(kg N/day)
0.104E06	0.300E02		
0.795E05	0.600E02		
0.707E05	0.900E02		
0.399E05	0.120E03		
0.333E05	0.150E03		
0.438E04	0.180E03		
0.125E04	0.210E03		
0.657E03	0.240E03		
0.122E04	0.270E03		
0.210E04	0.300E03		
0.206E04	0.330E03		
0.192E04	0.365E03		
0.176E04		WNH3(1)	(kg N/day)
0.379E04	0.300E02		
0.651E04	0.600E02		
0.456E04	0.900E02		
0.281E04	0.120E03		
0.203E04	0.150E03		
0.882E03	0.180E03		
0.114E04	0.210E03		
0.176E04	0.240E03		
0.211E04	0.270E03		
0.230E04	0.300E03		

(continued)

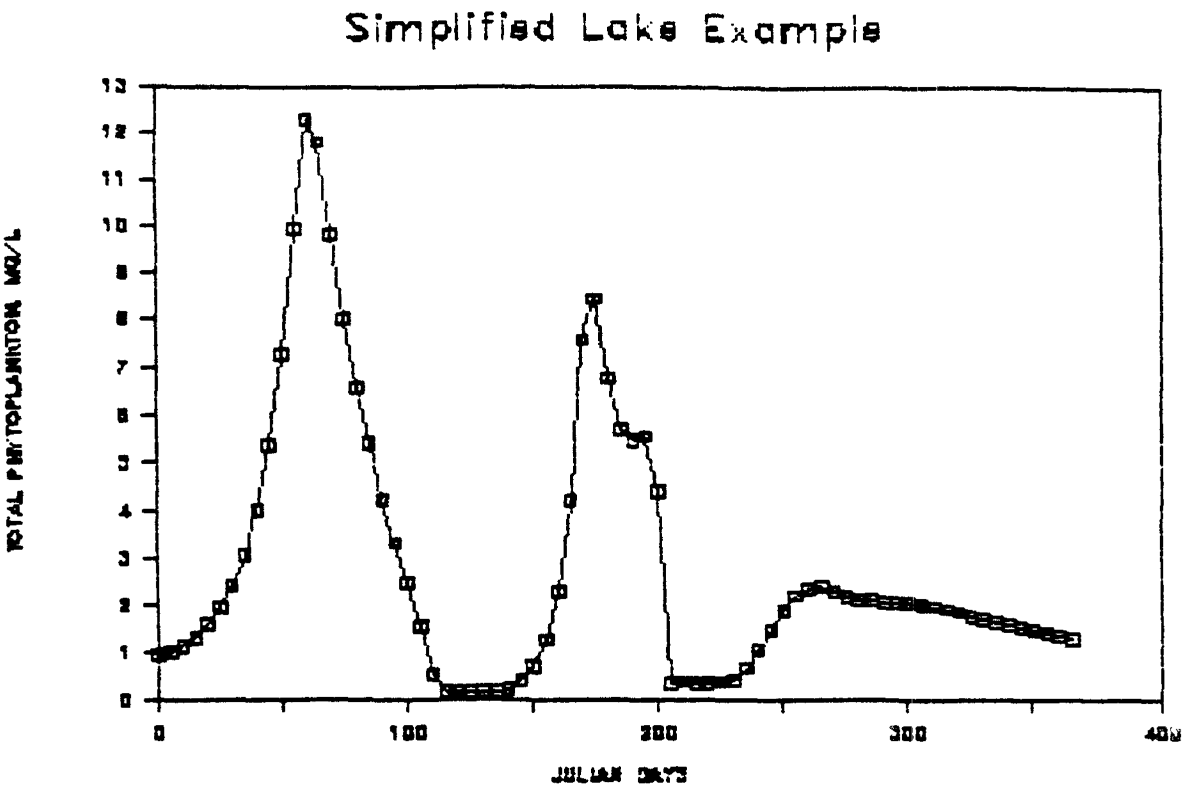
Table 14. (continued)

0.246E04	0.330E03		
0.259E04	0.365E03		
.628E05		WTS(1)	(kg S/day)
.111E06	.300E02		
.124E06	.600E02		
.118E06	.900E02		
.434E05	.120E03		
.540E05	.150E03		
.238E05	.180E03		
.139E05	.210E03		
.154E05	.240E03		
.204E05	.270E03		
.216E05	.300E03		
.150E05	.330E03		
.147E05	.365E03		
0.314E05		WAVS(1)	(kg S/day)
0.557E05	0.300E02		
0.619E05	0.600E02		
0.591E05	0.900E02		
0.217E05	0.120E03		
0.270E05	0.150E03		
0.119E05	0.180E03		
0.694E04	0.210E03		
0.770E04	0.240E03		
0.102E05	0.270E03		
0.108E05	0.300E03		
0.748E04	0.330E03		
0.736E04	0.365E03		
0.721E06		WCL(1)	(kg CL/day)
0.197E07	0.300E02		
0.171E07	0.600E02		
0.208E07	0.900E02		
0.161E07	0.120E03		
0.103E07	0.150E03		
0.686E06	0.180E03		
0.494E06	0.210E03		
0.578E06	0.240E03		
0.651E06	0.270E03		
0.914E06	0.300E03		
0.308E06	0.330E03		
0.344E05	0.365E03		
-0.176E03		Q(1,1)	(m**3/sec)
-0.176E03	0.260E03		
-0.167E00	0.261E03		
-0.167E00	0.300E03		
-0.230E03	0.301E03		
-0.230E03	0.365E03		
0.176E03		Q(1,2)	(m**3/sec)
0.176E03	0.260E03		
0.167E00	0.261E03		

(continued)

Table 14. (continued)

0.167E00	0.300E03		
0.230E03	0.301E03		
0.230E03	0.365E03		
0.000E00		EPRIME(1,1)	(m**3/sec)
0.000E00	0.365E03		
0.000E00		EPRIME(1,2)	(m**3/sec)
0.000E00	0.365E03		
0.500E00		ALPHA(1,1)	
0.500E00	0.365E03		
0.500E00		ALPHA(1,2)	
0.500E00	0.365E03		
0.290E00		T(1)	(degrees C)
0.125E01	0.300E02		
0.644E01	0.600E02		
0.871E01	0.900E02		
0.987E01	0.120E03		
0.166E02	0.150E03		
0.219E02	0.180E03		
0.218E02	0.210E03		
0.170E02	0.240E03		
0.118E02	0.270E03		
0.871E01	0.300E03		
0.290E00	0.365E03		
0.100E03		RADINC(1)	(ly/day)
0.700E02	0.300E02		
0.100E03	0.600E02		
0.300E03	0.900E02		
0.440E03	0.120E03		
0.600E03	0.150E03		
0.660E03	0.180E03		
0.625E03	0.210E03		
0.540E03	0.240E03		
0.390E03	0.270E03		
0.210E03	0.300E03		
0.100E03	0.365E03		
0.167E01		SECCHI(1)	(meters)
0.313E01	0.300E02		
0.313E01	0.600E02		
0.760E00	0.900E02		
0.126E01	0.120E03		
0.114E01	0.150E03		
0.118E01	0.180E03		
0.113E01	0.210E03		
0.101E01	0.240E03		
0.770E00	0.270E03		
0.112E01	0.300E03		
0.167E01	0.365E03		



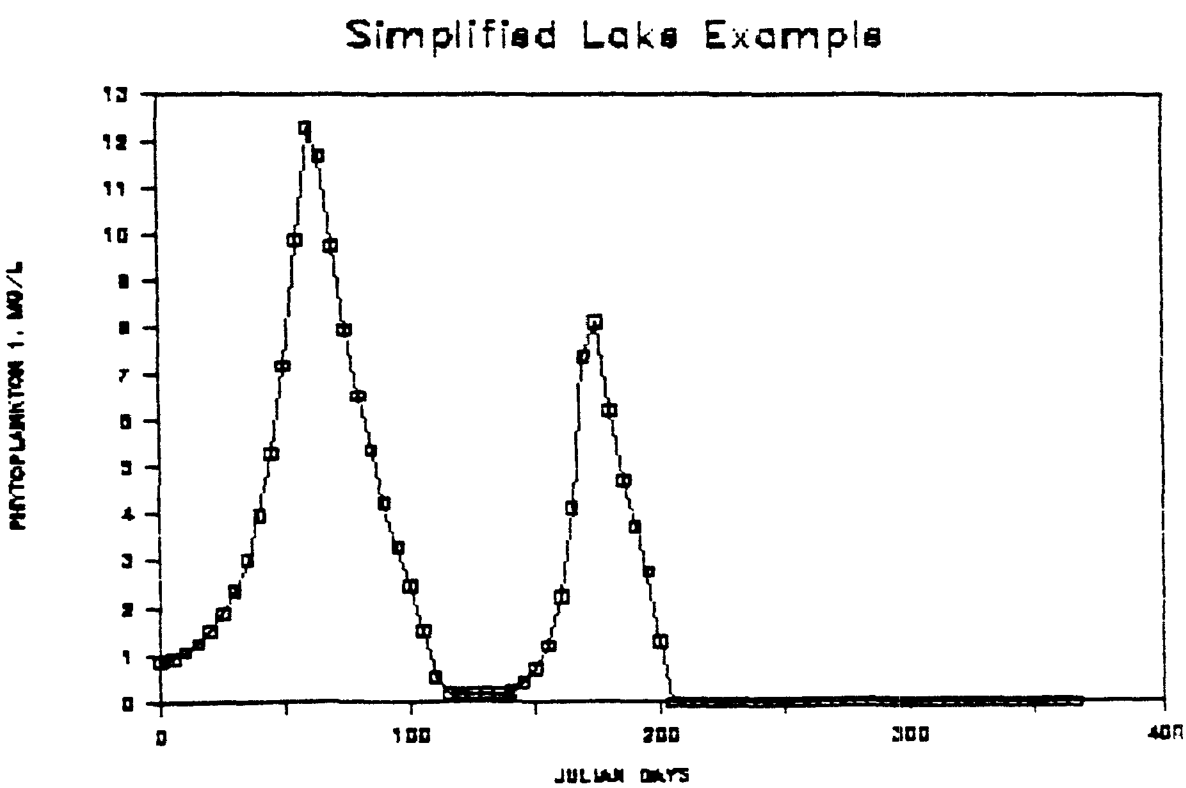
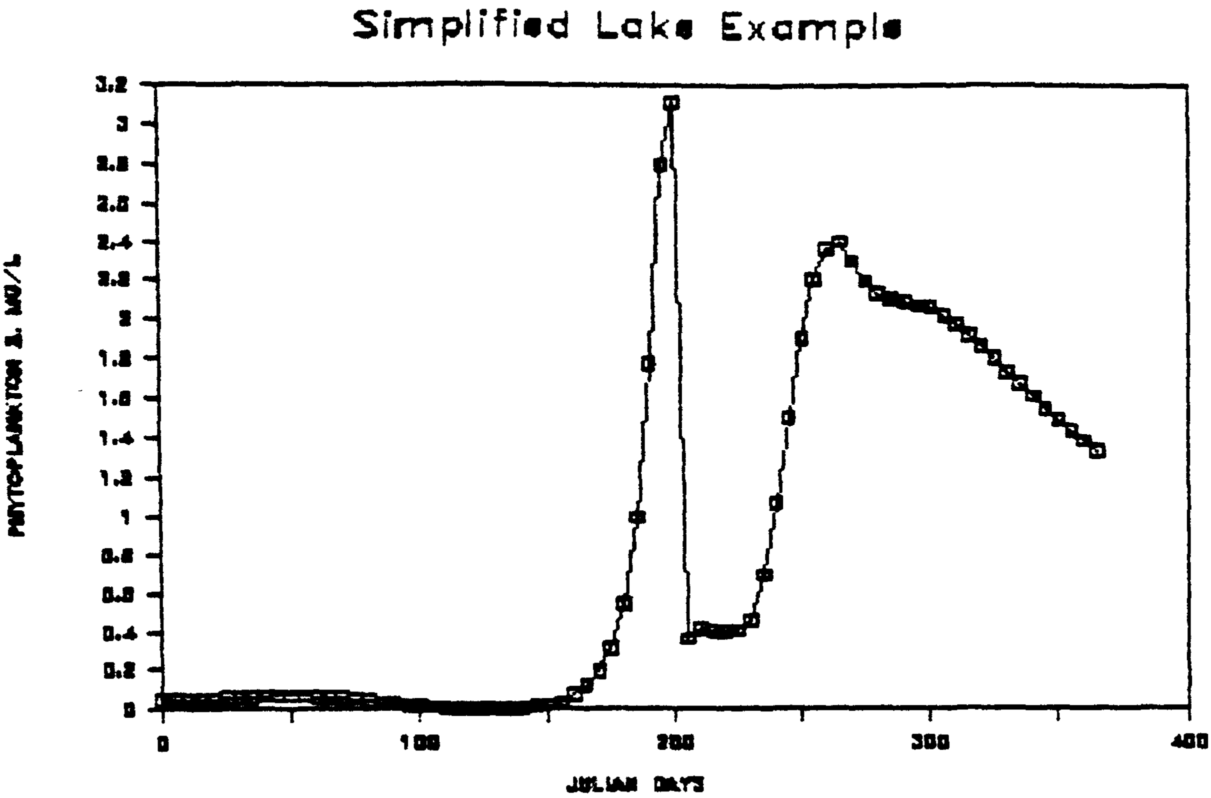


Figure 12. Graphical Output for Phytoplankton, Total Phosphorus, and Chloride Concentrations for Simplified Lake Example

(continued)



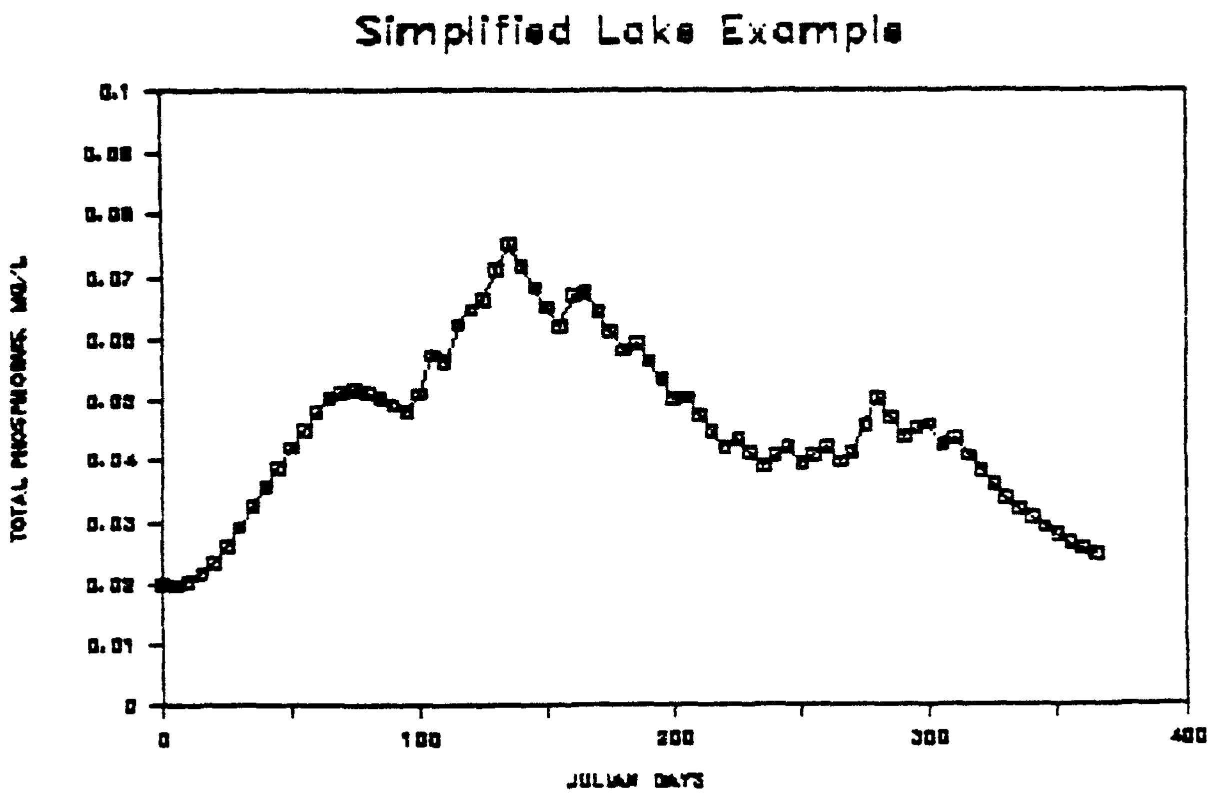


Figure 12. (continued)

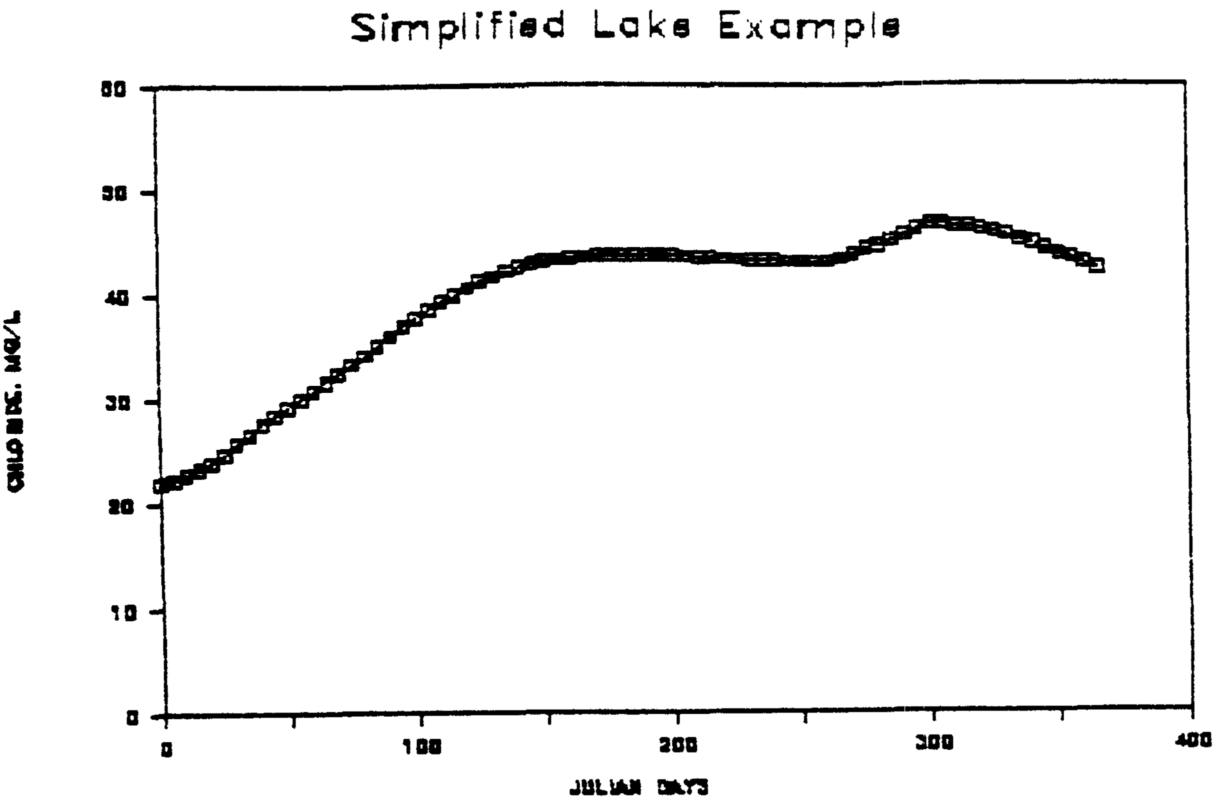


Figure 12. (continued)

Plots for selected state variables are shown in Figure 12 for a 365-day simulation period. These plots were generated from the PLOTOUT file using Lotus 1-2-3. Users can generate plots to suit their own applications, depending on their particular hardware and software capabilities.

7.3 EXAMPLE 2: SIMPLIFIED EMBAYMENT

7.3.1 Introduction

The same version of the model that was applied to the simplified lake (Figure 10) is extended to the case of a simplified embayment. The spatial segmentation scheme for this example is shown in Figure 13. It consists of one completely mixed segment, an input tributary, and a large open boundary.

7.3.2 Data Input

7.3.2.1 Run Control

The RUNCON file for this example is the same as the RUNCON file for the simplified lake example (Tables 8 and 9). For the embayment, there are two segment interactions. One is with a tributary, and one is with an open boundary. Since these are also external to the model segmentation, they too are "self-interactions"

7.3.2.2 Model Coefficients

The COEFF file is also the same as the COEFF file for the simplified lake example (Tables 10 and 11). The variables in this file are independent of the change in the types of "self-interactions". They only depend on the number of spatial segments, and on the configuration of the principal model compartments (Figure 10).

7.3.2.3 Initial Conditions

The INICON file is the same as the INICON file for the simplified lake example (Tables 12 and 13).

7.3.3 Environmental Forcing Functions

The full environmental forcing function file, ENVFF, is shown in Table 15. The difference in segmentation schemes between the lake and embayment examples is reflected exclusively in the boundary concentrations, and in the transport parameters.

The boundary concentrations here are real, and they are associated with the open boundary. This is because transport must occur across every open boundary (Section 6.3 and Table 7). As in the previous example, the input tributary is non-transporting, and it is treated as a point source.

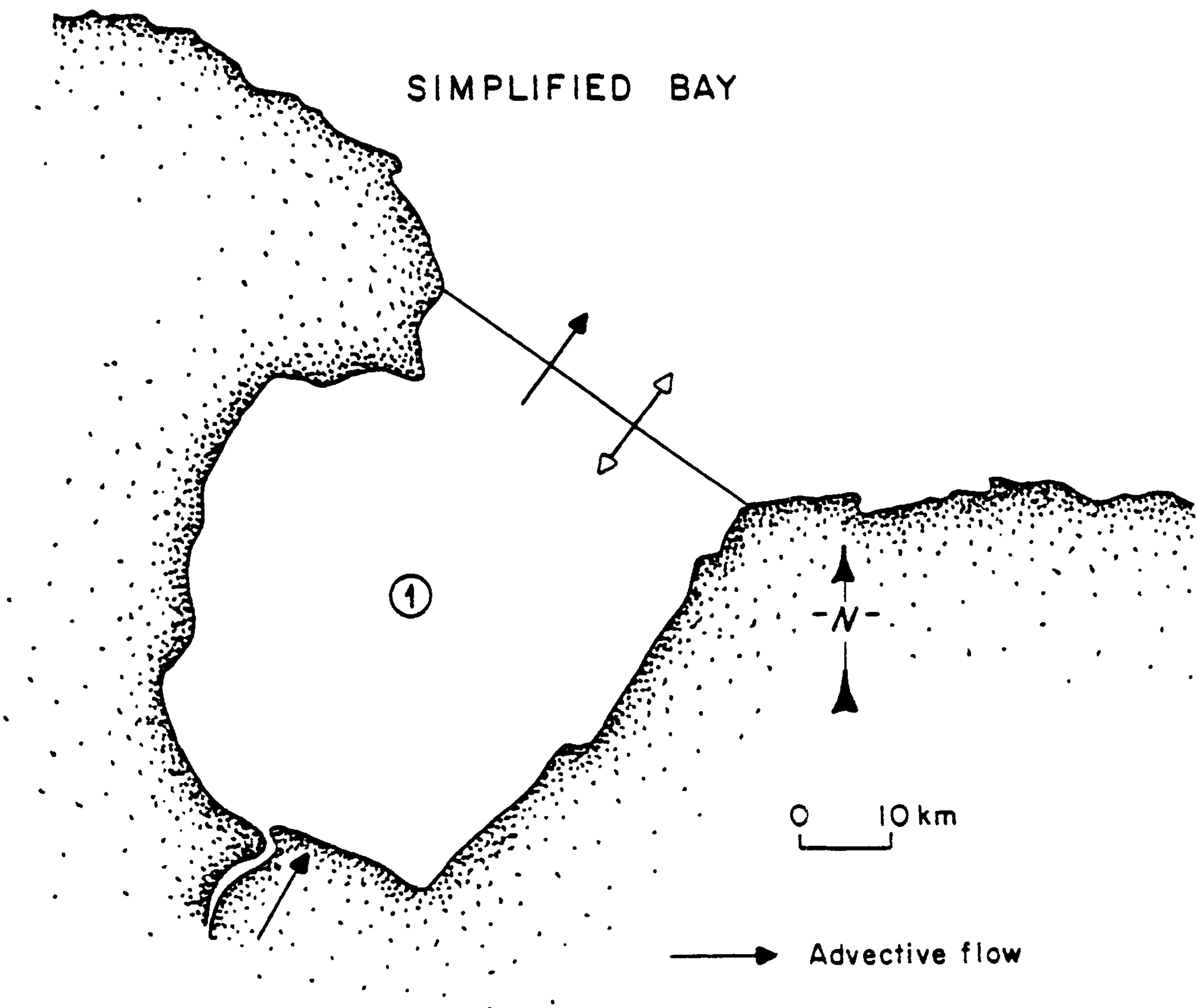


Figure 13. Spatial Segmentation and Physical Transport for Simplified Embayment Example

Table 15. ENVFF File For Simplified Embayment Example

.750E-03		PSABD(1,1)	(mg P/mg A)
.750E-03	0.365E03		
.200E-02		PSABD(2,1)	(mg P/mg A)
.200E-02	0.365E03		
.400E-01		NSABD(1,1)	(mg N/mg A)
.400E-01	0.365E03		
.800E-01		NSABD(2,1)	(mg N/mg A)
.800E-01	0.365E03		
.140E00		SSABD(1,1)	(mg S/mg A)
.140E00	0.365E03		
.000E00		SSABD(2,1)	(mg S/mg A)
.000E00	0.365E03		
.203E00		ABD(1,1)	(mg/l)
.130E00	.105E03		
.270E00	.118E03		
.314E00	.134E03		
.346E00	.154E03		
.197E00	.168E03		
.614E-01	.189E03		
.892E-01	.205E03		
.148E00	.225E03		
.426E00	.261E03		
.259E00	.279E03		
.235E00	.319E03		
.203E00	.365E03		
.488E-02		ABD(2,1)	(mg/l)
.300E-02	.105E03		
.660E-03	.118E03		
.660E-03	.134E03		
.162E-01	.154E03		
.360E-02	.168E03		
.460E-03	.189E03		
.820E-02	.205E03		
.880E-02	.225E03		
.115E00	.261E03		
.930E-02	.279E03		
.570E-02	.319E03		
.488E-02	.365E03		
.581E-02		Z1BD(1,1)	(mg/l)
.462E-03	.118E03		
.186E-02	.133E03		
.357E-01	.169E03		
.351E-01	.189E03		
.210E-01	.206E03		
.397E-01	.225E03		
.269E-01	.261E03		
.174E-01	.279E03		
.808E-02	.315E03		
.581E-02	.365E03		

(continued)

Table 15. (continued)

.265E-01		Z2BD(1,1)	(mg/1)
.116E-01	.118E03		
.126E-01	.133E03		
.219E-01	.169E03		
.191E-01	.189E03		
.106E-01	.206E03		
.261E-01	.225E03		
.112E-01	.261E03		
.316E-01	.279E03		
.328E-01	.315E03		
.265E-01	.365E03		
.415E-02		TPBD(1)	(mg P/1)
.409E-02	.136E03		
.500E-02	.166E03		
.555E-02	.197E03		
.530E-02	.228E03		
.487E-02	.289E03		
.418E-02	.319E03		
.415E-02	.365E03		
.102E-02		AVPBD(1)	(mg P/1)
.165E-02	.116E03		
.713E-03	.138E03		
.701E-03	.177E03		
.750E-03	.206E03		
.732E-03	.246E03		
.815E-03	.276E03		
.893E-03	.341E03		
.914E-03	.365E03		
.124E00		TKNBD(1)	(mg N/1)
.155E00	.117E03		
.155E00	.132E03		
.130E00	.153E03		
.181E00	.168E03		
.131E00	.188E03		
.207E00	.205E03		
.252E00	.224E03		
.144E00	.260E03		
.395E00	.278E03		
.124E00	.314E03		
.120E00	.350E03		
.124E00	.365E03		
.272E00		NO3BD(1)	(mg N/1)
.260E00	.105E03		
.309E00	.136E03		
.288E00	.166E03		
.286E00	.197E03		
.265E00	.228E03		
.256E00	.289E03		
.277E00	.319E03		
.272E00	.365E03		

(continued)

Table 15. (continued)

.123E-01		NH3BD(1)	(mg N/1)
.147E-01	.105E03		
.963E-02	.136E03		
.124E-01	.166E03		
.998E-02	.197E03		
.739E-02	.228E03		
.414E-02	.289E03		
.113E-01	.319E03		
.123E-01	.365E03		
.132E01		TSBD(1)	(mg S/1)
.175E01	.105E03		
.160E01	.136E03		
.138E01	.166E03		
.105E01	.197E03		
.988E00	.228E03		
.752E00	.289E03		
.113E01	.319E03		
.132E01	.365E03		
.660E00		AVSBD(1)	(mg S/1)
.874E00	.105E03		
.801E00	.136E03		
.691E00	.166E03		
.525E00	.197E03		
.494E00	.228E03		
.376E00	.289E03		
.565E00	.319E03		
.660E00	.365E03		
.527E01		CLBD(1)	(mg CL/1)
.527E01	.105E03		
.538E01	.106E03		
.538E01	.155E03		
.620E01	.156E03		
.620E01	.175E03		
.609E01	.176E03		
.609E01	.215E03		
.580E01	.216E03		
.580E01	.260E03		
.570E01	.261E03		
.570E01	.290E03		
.580E01	.291E03		
.580E01	.341E03		
.549E01	.342E03		
.549E01	.365E03		
0.233E04		WTP(1)	(kg P/day)
0.939E04	0.300E02		
0.137E05	0.600E02		
0.595E04	0.900E02		
0.769E04	0.120E03		
0.462E04	0.150E03		
0.341E04	0.180E03		

(continued)

Table 15. (continued)

0.170E04	0.210E03		
0.986E03	0.240E03		
0.986E03	0.270E03		
0.992E03	0.300E03		
0.992E03	0.330E03		
0.902E03	0.365E03		
0.110E04		WAVP(1)	(kg P/day)
0.193E04	0.300E02		
0.187E04	0.600E02		
0.135E04	0.900E02		
0.840E03	0.120E03		
0.564E03	0.150E03		
0.629E03	0.180E03		
0.357E03	0.210E03		
0.552E03	0.240E03		
0.648E03	0.270E03		
0.626E03	0.300E03		
0.719E03	0.330E03		
0.512E03	0.365E03		
0.217E05		WTKN(1)	(kg N/day)
0.211E05	0.300E02		
0.594E05	0.600E02		
0.273E05	0.900E02		
0.227E05	0.120E03		
0.216E05	0.150E03		
0.612E04	0.180E03		
0.462E04	0.210E03		
0.538E04	0.240E03		
0.486E04	0.270E03		
0.461E04	0.300E03		
0.448E04	0.330E03		
0.435E04	0.365E03		
0.419E05		WNO3(1)	(kg N/day)
0.104E06	0.300E02		
0.795E05	0.600E02		
0.707E05	0.900E02		
0.399E05	0.120E03		
0.333E05	0.150E03		
0.438E04	0.180E03		
0.125E04	0.210E03		
0.657E03	0.240E03		
0.122E04	0.270E03		
0.210E04	0.300E03		
0.206E04	0.330E03		
0.192E04	0.365E03		
0.176E04		WNH3(1)	(kg N/day)
0.379E04	0.300E02		
0.651E04	0.600E02		
0.456E04	0.900E02		
0.281E04	0.120E03		

(continued)

Table 15. (continued)

0.203E04	0.150E03		
0.882E03	0.180E03		
0.114E04	0.210E03		
0.176E04	0.240E03		
0.211E04	0.270E03		
0.230E04	0.300E03		
0.246E04	0.330E03		
0.259E04	0.365E03		
.628E05		WTS(1)	(kg S/day)
.111E06	.300E02		
.124E06	.600E02		
.118E06	.900E02		
.434E05	.120E03		
.540E05	.150E03		
.238E05	.180E03		
.139E05	.210E03		
.154E05	.240E03		
.204E05	.270E03		
.216E05	.300E03		
.150E05	.330E03		
.147E05	.365E03		
0.314E05		WAVS(1)	(kg S/day)
0.557E05	0.300E02		
0.619E05	0.600E02		
0.591E05	0.900E02		
0.217E05	0.120E03		
0.270E05	0.150E03		
0.119E05	0.180E03		
0.694E04	0.210E03		
0.770E04	0.240E03		
0.102E05	0.270E03		
0.108E05	0.300E03		
0.748E04	0.330E03		
0.736E04	0.365E03		
0.721E06		WCL(1)	(kg CL/day)
0.197E07	0.300E02		
0.171E07	0.600E02		
0.208E07	0.900E02		
0.161E07	0.120E03		
0.103E07	0.150E03		
0.686E06	0.180E03		
0.494E06	0.210E03		
0.578E06	0.240E03		
0.651E06	0.270E03		
0.914E06	0.300E03		
0.308E06	0.330E03		
0.344E05	0.365E03		
-0.176E03		Q(1,1)	(m**3/sec)
-0.176E03	0.260E03		
-0.167E00	0.261E03		

(continued)

Table 15. (continued)

-0.167E00	0.300E03		
-0.230E03	0.301E03		
-0.230E03	0.365E03		
0.176E03		Q(1,2)	(m**3/sec)
0.176E03	0.260E03		
0.167E00	0.261E03		
0.167E00	0.300E03		
0.230E03	0.301E03		
0.230E03	0.365E03		
0.000E00		EPRIME(1,1)	(m**3/sec)
0.000E00	0.365E03		
0.652E03		EPRIME(1,2)	(m**3/sec)
0.652E03	0.260E03		
0.531E00	0.261E03		
0.531E00	0.300E03		
0.146E04	0.301E03		
0.146E04	0.365E03		
0.500E00		ALPHA(1,1)	
0.500E00	0.365E03		
0.309E00		ALPHA(1,2)	
0.309E00	0.260E03		
0.045E00	0.261E03		
0.045E00	0.300E03		
0.325E00	0.301E03		
0.325E00	0.365E03		
0.290E00		T(1)	(degrees C)
0.125E01	0.300E02		
0.644E01	0.600E02		
0.871E01	0.900E02		
0.987E01	0.120E03		
0.166E02	0.150E03		
0.219E02	0.180E03		
0.218E02	0.210E03		
0.170E02	0.240E03		
0.118E02	0.270E03		
0.871E01	0.300E03		
0.290E00	0.365E03		
0.100E03		RADINC(1)	(ly/day)
0.700E02	0.300E02		
0.100E03	0.600E02		
0.300E03	0.900E02		
0.440E03	0.120E03		
0.600E03	0.150E03		
0.660E03	0.180E03		
0.625E03	0.210E03		
0.540E03	0.240E03		
0.390E03	0.270E03		
0.210E03	0.300E03		
0.100E03	0.365E03		
0.167E01		SECCHI(1)	(meters)

(continued)

Table 15. (continued)

0.313E01	0.300E02
0.313E01	0.600E02
0.760E00	0.900E02
0.126E01	0.120E03
0.114E01	0.150E03
0.118E01	0.180E03
0.113E01	0.210E03
0.101E01	0.240E03
0.770E00	0.270E03
0.112E01	0.300E03
0.167E01	0.365E03

The values for EPRIME(1,1) are zero because they correspond to the tributary boundary. The values for EPRIME(1,2) are non-zero because they correspond to the open boundary. The open boundary is the second segment interaction (J = 2) because it is a transporting boundary, and such a boundary must always be J = INTMAX.

The value for ALPHA(1,1) has been specified as 0.5. The computer code will correct this to a value of 1.0 because this is a tributary interaction. The values for ALPHA(1,2) have been specified consistent with the stability criterion. No corrective action will be taken for these values.

7.3.4 Model Ouput

Tabulated model output is shown in Appendix D. For illustrative purposes, ISKIP has been set equal to zero for this example. Consequently, model output includes values for derivatives and component terms. These values can be cross-referenced with comments in the FORTRAN source file for subroutine OUTPUT. Plots for selected state variables are shown in Figure 14 for a 365-day simulation period.

7.4 EXAMPLE 3: SAGINAW BAY

7.4.1 Introduction

The schematic diagram for the Saginaw Bay version of the model is shown in Figure 2. The spatial segmentation scheme, including advective and bulk diffusive flows, is shown in Figure 15. The principal objective for this example is to illustrate how the model is configured for multiple spatial segments.

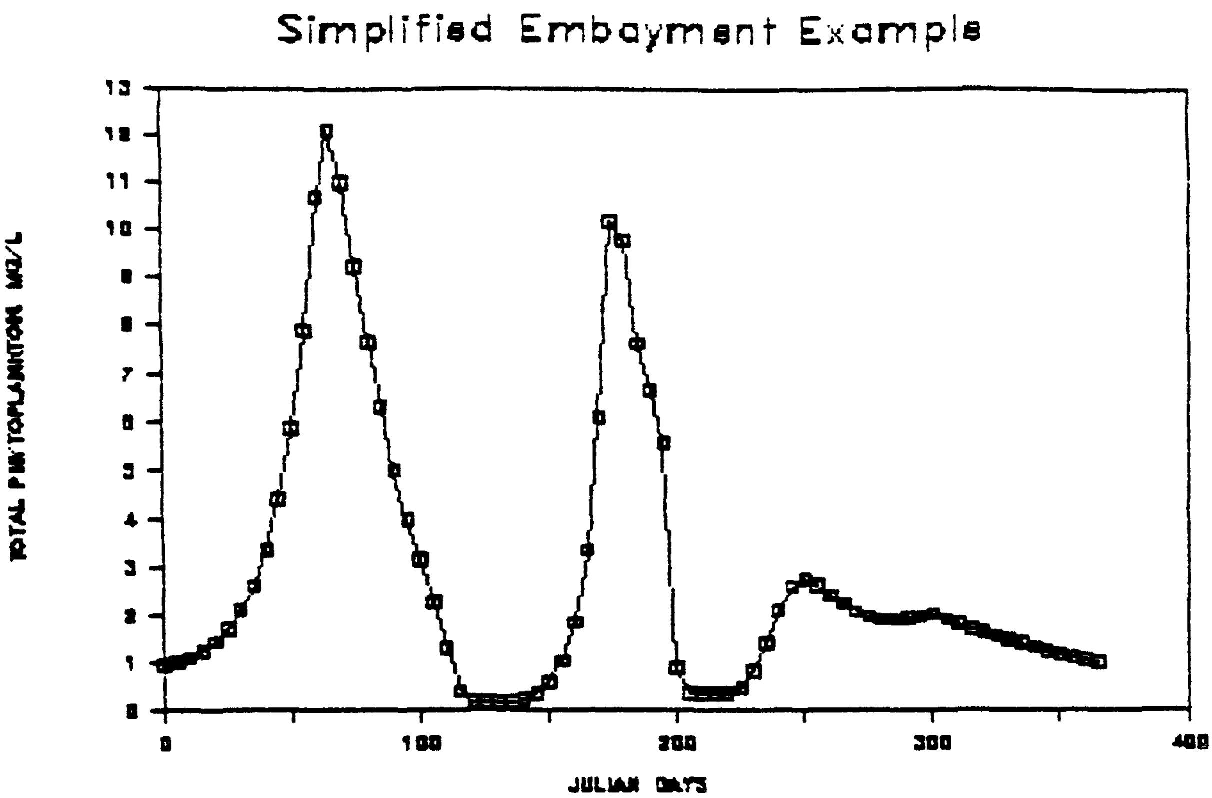
Listings of the RUNCON, COEFF, and INICON files are presented without maps for variable names. Values for the ENVFF file are presented in Appendix E only for spatial segment 1. Refer to tabular model output in Appendix F to cross-reference input data values with their associated variable names. This model output also includes values for environmental forcing functions for all five spatial segments.

7.4.2 Data Input

7.4.2.1 Run Control

The RUNCON file for Saginaw Bay is shown in Table 16. In this example, there are five spatial segments. There is an input tributary to segment 1, and open boundaries associated with segments 4 and 5. There is a maximum of five possible segment interactions (INTMAX = 5). Each segment has at least two interactions with adjacent segments.

By convention, the order of segment interactions is: adjacent segments, non-transporting tributaries, transporting



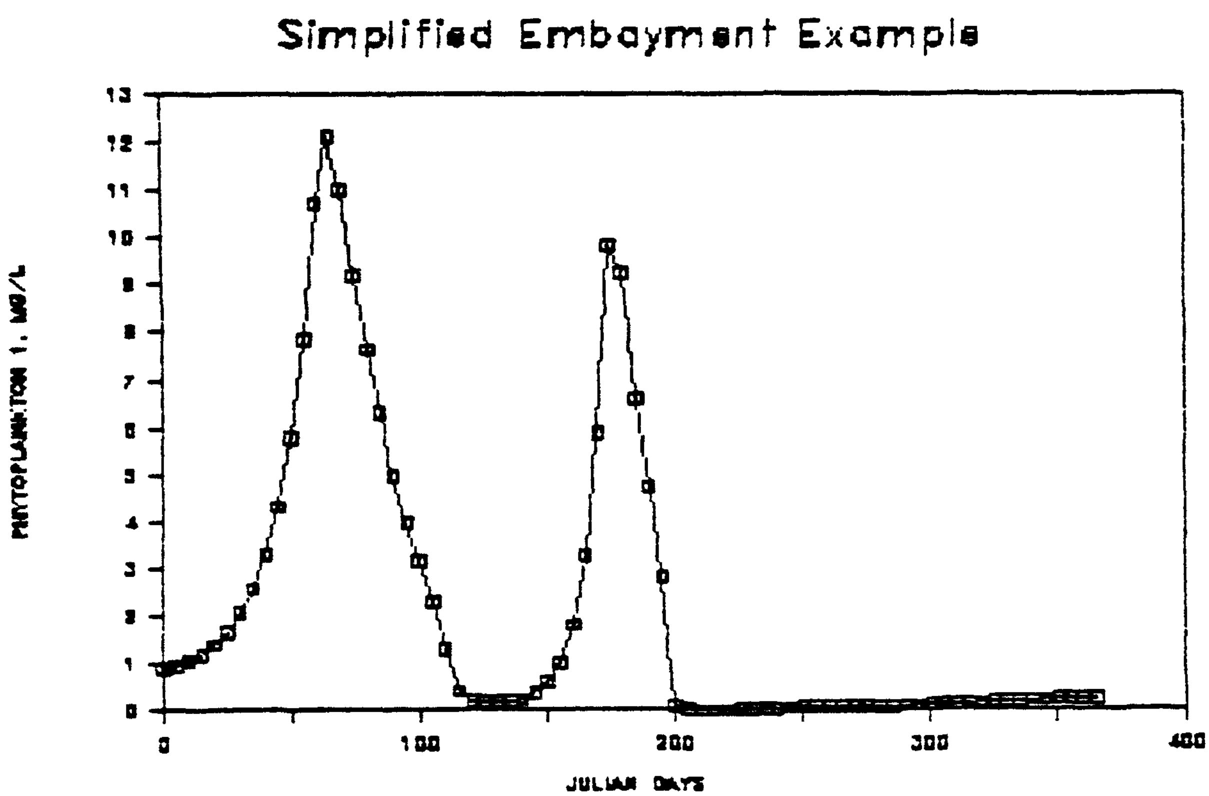
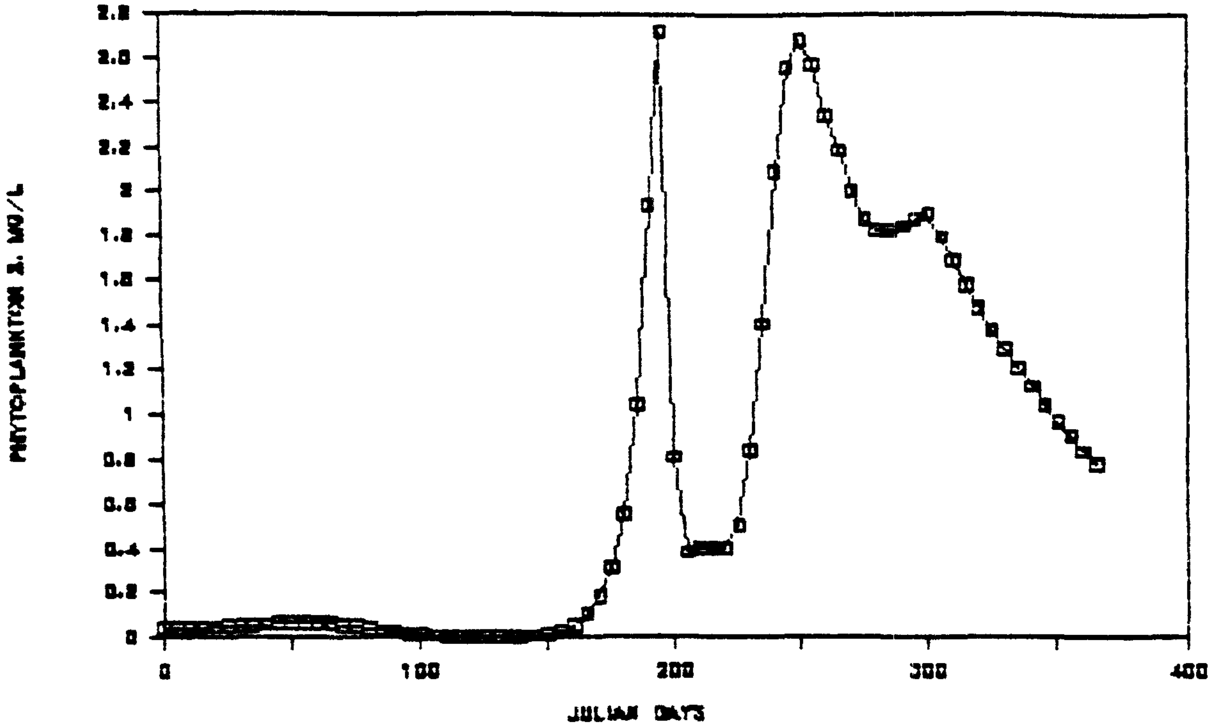


Figure 14. Graphical Output for Phytoplankton, Total Phosphorus, and Chloride Concentrations for Simplified Embayment Example

Simplified Embayment Example



Simplified Embayment Example

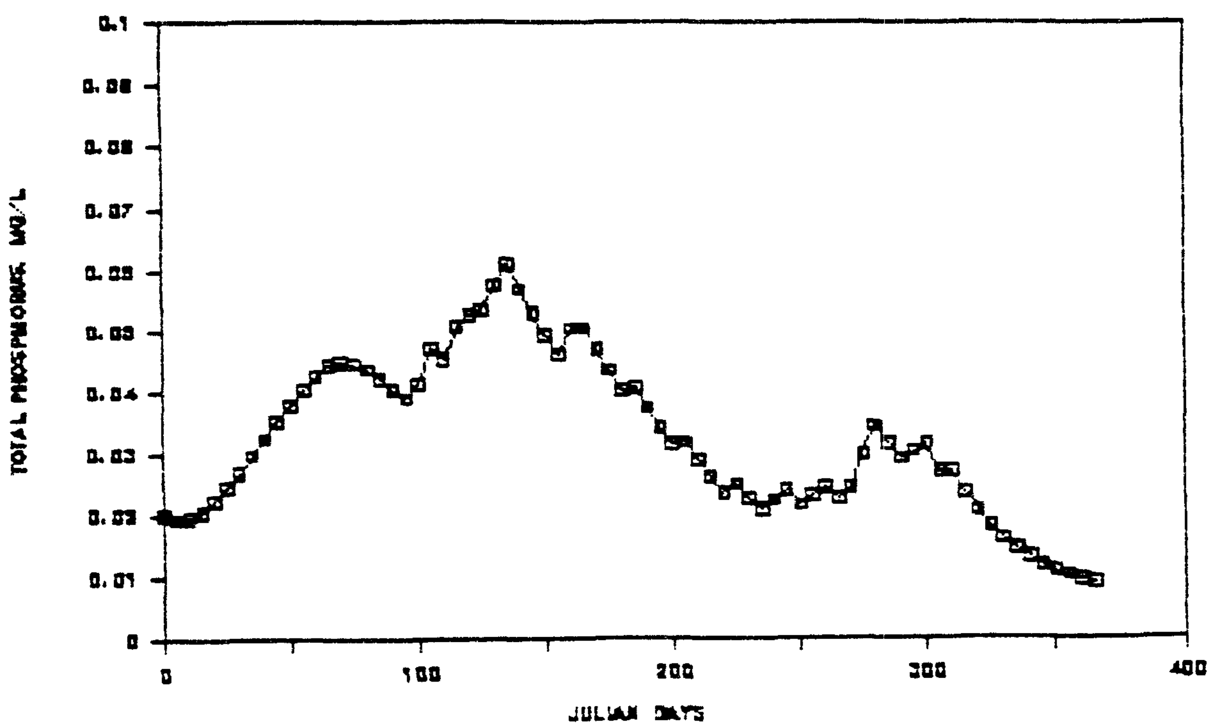


Figure 14. (continued)

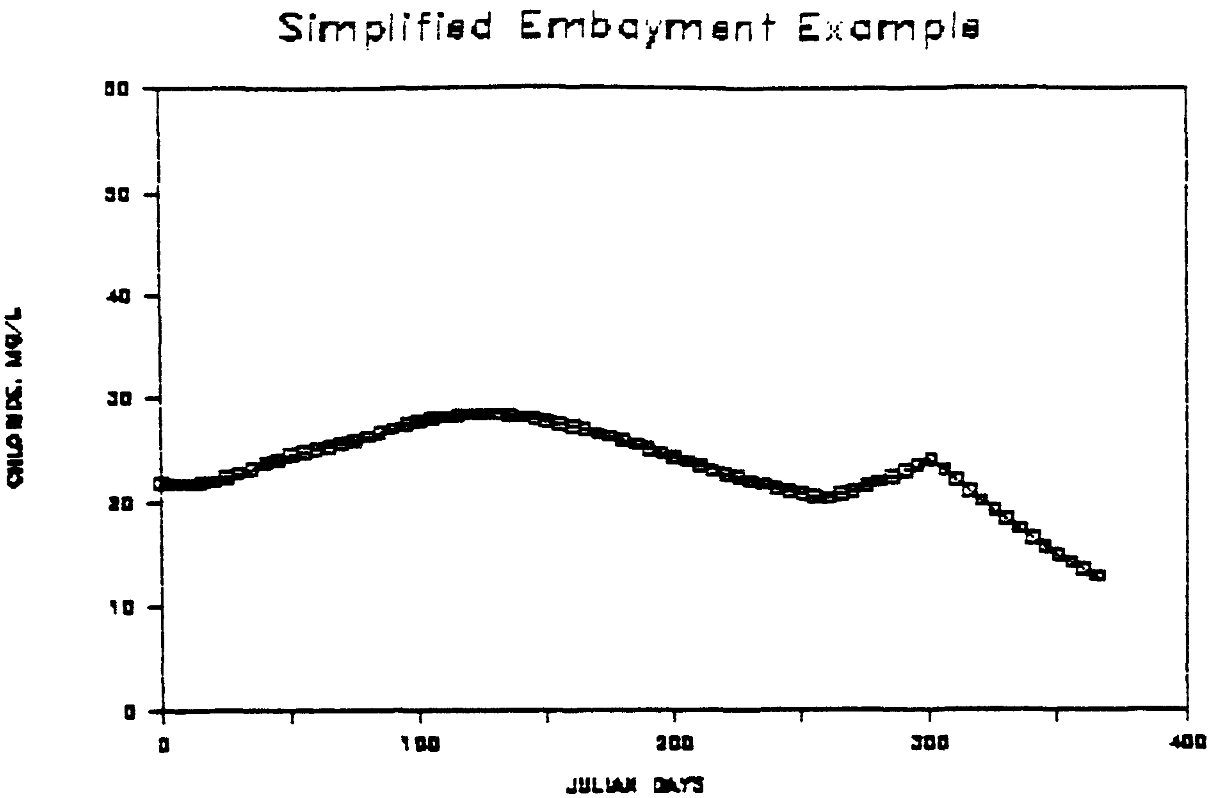


Figure 14. (continued)

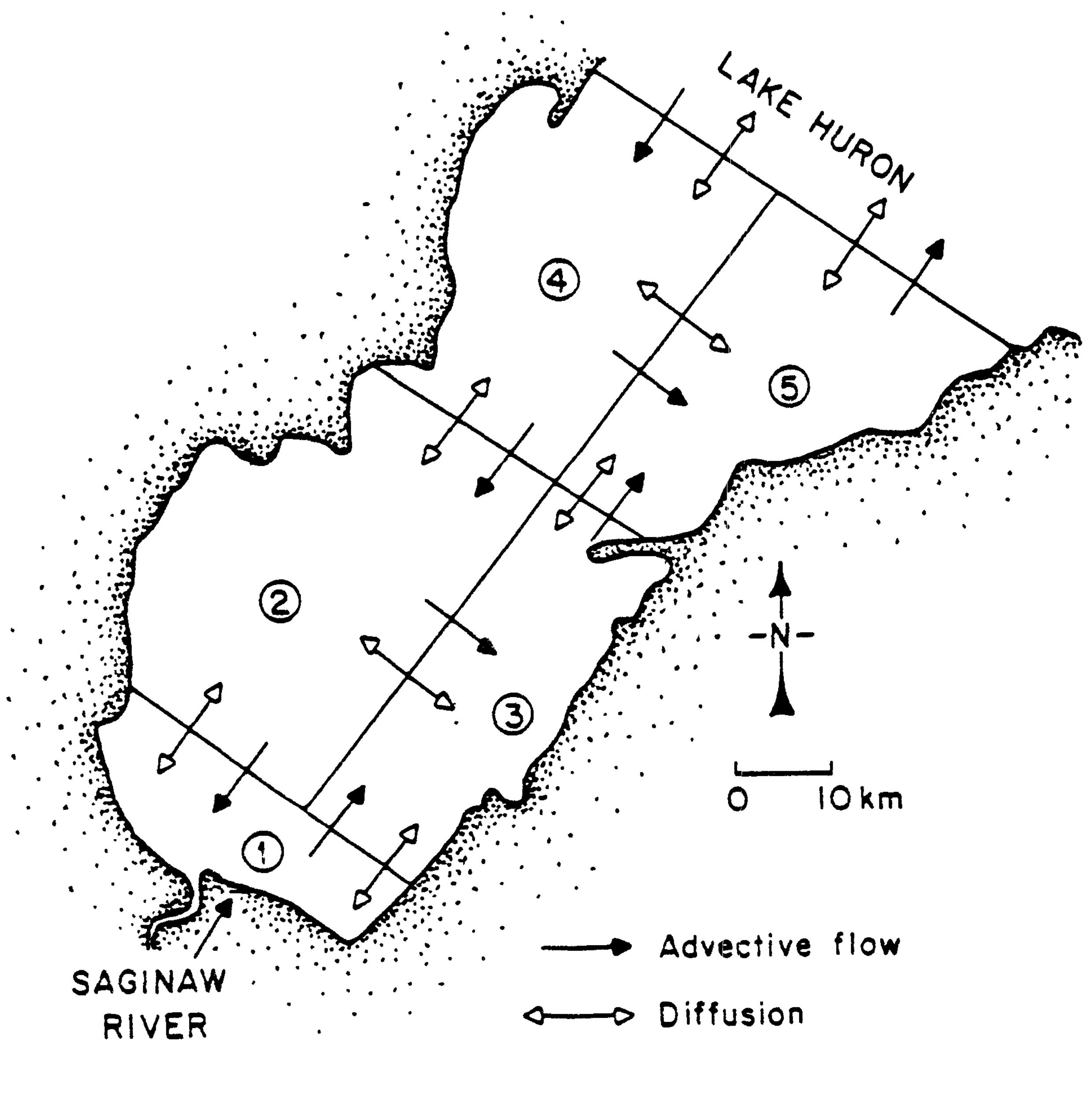


Figure 15. Spatial Segmentation and Physical Transport for Saginaw Bay Example

Table 16. RUNCON File for Saginaw Bay Example

```
  5    5
0.894E09  0.385E01
  2
  3
  0
  1
  0
0.589E10  0.733E01
  1
  3
  4
  0
  0
0.127E10  0.374E01
  1
  2
  5
  0
  0
0.788E10  0.132E02
  2
  5
  0
  0
  4
0.939E10  0.152E02
  3
  4
  0
  0
  5
 .232E07  .100E-01
 .804E08   .100E00
 .340E08   .100E00
 .597E08   .100E00
 .618E08   .100E00
  8    8    3
  5    1    1
  1    0    0    0    0
  0    0    0    0    1
  2    1    1
  1    1    1
  1
 .365E03   .500E01   .500E01    1
.250E-01   .125E00
```

boundaries (tributaries or open boundaries). Since there is a maximum of three interactions with adjacent segments in this example, the values J = 1, 2, and 3, have been reserved for adjacent segment interactions. The value J = 4 is used for the non-transporting tributary in segment 1. The value J = 5 (INTMAX) is used for the transporting (open) boundaries in segments 4 and 5.

The values of INT(N,J) for adjacent segment interactions are the segment numbers of the interacting segments. For example, INT(1,1) = 2 means that for segment 1 (N = 1), the first interaction (J = 1) is with segment 2. The values for tributary and open boundary interactions correspond to "self-interactions", as in the two previous examples.

7.4.2.2 Model Coefficients

The values for the COEFF file are shown in Table 17. The extension from two to five phytoplankton types is straightforward. Note that a non-zero value has been specified for AVNFIX because this example includes a nitrogen-fixing blue-green phytoplankton.

7.4.2.3 Initial Conditions

The values for the INICON file are shown in Table 18. The extension from one to five segments is straightforward.

7.4.3 Environmental Forcing Functions

The environmental forcing file, ENVFF, is shown for segment 1 in Appendix E. Space limitations preclude presentation of this file for all five segments.

Zero values need to be specified for the boundary conditions for segments 1, 2, and 3 because there are no transporting boundaries for these segments. Real boundary conditions need to be specified for segments 4 and 5.

Values for Q(N,J), EPRIME(N,J), and ALPHA(N,J) all follow the conventions discussed in Section 6.3, and the constraints presented in Table 7. For spatial segment 1, the values in Appendix E can be cross-referenced with the transport pattern shown in Figure 15, and with the model output in Appendix F. For spatial segments 2 through 5, the transport pattern in Figure 15 can be cross-referenced with the model output in Appendix F.

7.4.4 Model Output

Tabulated model output is shown in Appendix F. Output is included for all five spatial segments after 5 days of simulation.

Table 17. COEFF File for Saginaw Bay Example

.1070E01	.1070E01	.1070E01	.1070E01		
.150E00					
.240E01	.1060E01	.1060E01			
.240E01	.1070E01	.1070E01			
.210E01	.1060E01	.1060E01			
.160E01	.1090E01	.1090E01			
.160E01	.1090E01	.1090E01			
.100E-01	.226E02	.154E00	.150E01	.500E-03	.500E-03
.200E-01	.226E02	.154E00	.125E01	.100E-02	.100E-02
.200E-01	.226E02	.154E00	.125E01	.100E-02	.100E-02
.200E-01	.226E02	.154E00	.300E00	.100E-02	.100E-02
.200E-01	.226E02	.154E00	.450E00	.100E-02	.100E-02
.200E00	.107E02	.239E00	.445E00	.100E-01	.100E-01
.200E00	.107E02	.239E00	.445E00	.200E-01	.200E-01
.200E00	.107E02	.239E00	.445E00	.200E-01	.200E-01
.200E00	.107E02	.239E00	.445E00	.200E-01	.200E-01
.200E00	.107E02	.239E00	.445E00	.200E-01	.200E-01
.500E00	.534E01	.239E00	.445E00	.350E-01	.350E-01
.100E00	.250E00	.200E03	.100E03	.300E-01	
.100E00	.250E00	.200E03	.100E03	.300E-01	
.100E00	.250E00	.200E03	.100E03	.300E-01	
.200E-01	.500E00	.200E03	.500E02	.300E-01	
.200E-01	.500E00	.200E03	.500E02	.300E-01	
.600E00	.100E01	.200E00	.300E-01		
.550E00	.1070E01				
1.0 .50	.50				
.600E00	.125E00	.250E-01	.300E-01	.100E01	.250E-01
.550E00	.1070E01				
1.0					
.200E-01	.200E-01	.200E-01			
.100E01	.100E01	.100E01			
.150E00	.150E00	.150E00			
.350E-02	.228E-02	.350E-02			
.175E-03	.114E-03	.175E-03			
.250E-03	.162E-03	.250E-03			
.417E-04	.271E-04	.417E-04			
.362E-04	.235E-04	.362E-04			
.000E00	.000E00	.625E-03			
.000E00	.000E00	.625E-03			
.000E00	.000E00	.625E-03			
.000E00	.000E00	.625E-03			
.000E00	.000E00	.625E-03			
.000E00	.000E00	.000E00			
.822E-05	.822E-05	.822E-05			
.000E00	.000E00	.000E00			
.822E-05	.822E-05	.822E-05			
.822E-05	.822E-05	.822E-05			
24					
98. 99.					

(continued)

Table 17. (continued)

103.	105.
111.	113.
118.	119.
121.	122.
126.	127.
129.	130.
132.	133.
134.	135.
158.	160.
161.	162.
184.	185.
201.	202.
223.	224.
238.	239.
243.	244.
254.	255.
258.	259.
267.	268.
272.	273.
274.	275.
277.	279.
294.	296.
309.	310.

Table 18. INICON File for Saginaw Bay Example

.112E-01	.631E00	.395E00	.412E-01	.381E-01	.395E00	.250E02
.539E-02	.128E01	.700E00	.131E-01	.381E-01	.700E00	.220E02
.694E-02	.148E01	.540E00	.227E-01	.150E00	.540E00	.290E02
.291E-02	.298E00	.493E00	.184E-02	.146E00	.493E00	.500E01
.490E-02	.300E00	.381E00	.366E-02	.218E00	.381E00	.800E01
.194E01	.125E-02	.350E-01	.105E00			
.219E-01	.250E-02	.700E-01	.000E00			
.310E-01	.250E-02	.700E-01	.000E00			
.668E-01	.500E-02	.700E-01	.000E00			
.319E-01	.500E-02	.700E-01	.000E00			
.894E00	.125E-02	.350E-01	.105E00			
.421E-02	.250E-02	.700E-01	.000E00			
.448E-01	.250E-02	.700E-01	.000E00			
.473E-01	.500E-02	.700E-01	.000E00			
.343E-02	.500E-02	.700E-01	.000E00			
.169E01	.125E-02	.350E-01	.105E00			
.425E-01	.250E-02	.700E-01	.000E00			
.293E-01	.250E-02	.700E-01	.000E00			
.144E00	.500E-02	.700E-01	.000E00			
.230E-01	.500E-02	.700E-01	.000E00			
.590E00	.125E-02	.350E-01	.105E00			
.137E-01	.250E-02	.700E-01	.000E00			
.120E00	.250E-02	.700E-01	.000E00			
.646E-02	.500E-02	.700E-01	.000E00			
.402E-03	.500E-02	.700E-01	.000E00			
.834E00	.125E-02	.350E-01	.105E00			
.138E-01	.250E-02	.700E-01	.000E00			
.736E-01	.250E-02	.700E-01	.000E00			
.416E-01	.500E-02	.700E-01	.000E00			
.203E-02	.500E-02	.700E-01	.000E00			
.150E-02						
.130E-02						
.246E-02						
.377E-03						
.780E-02						
.282E-01						
.312E-01						
.316E-01						
.807E-03						
.247E-01						
.335E01	.378E02	.134E02				
.120E03	.136E04	.479E03				
.120E03	.136E04	.479E03				
.316E02	.357E03	.126E03				
.406E02	.459E03	.162E03				
.499E01	.737E03	.684E02	.122E02	.332E03	.684E02	.000E00
.173E02	.255E04	.237E03	.423E02	.115E04	.237E03	.000E00
.731E01	.108E04	.100E03	.179E02	.486E03	.100E03	.000E00
.128E02	.189E04	.176E03	.314E02	.853E03	.176E03	.000E00
.133E02	.196E04	.182E03	.325E02	.883E03	.182E03	.000E00

SECTION 8

OPERATIONAL CONSIDERATIONS

8.1 ACQUISITION PROCEDURES

To obtain a copy of the computer code, write to:

Center for Water Quality Modeling
Environmental Research Laboratory
U.S. Environmental Protection Agency
College Station Road
Athens, GA 30613.

The code will be distributed on a personal computer diskette. The diskette will contain FORTRAN source files for the model and the pre-processing package. It will also contain RUNCON, COEFF, INICON, and ENVFF files for the two simplified examples presented in this manual.

8.2 HARDWARE AND SOFTWARE REQUIREMENTS

Hardware and software requirements are dictated by the needs of FORTRAN 77, as well as by the needs of the model. The basic hardware requirements are the following:

- IBM PC/AT
- Fixed disk drive
- 1 Diskette drive
- Math Co-processor
- Monitor
- Large carriage (132 column) printer.

The basic software requirements are the following:

- IBM Personal Computer Disk Operating System (DOS) (Version 2.1 or higher)
- IBM Personal Computer Professional FORTRAN (Version 1.0)
- Graphics program (e.g., Lotus 1-2-3).

The requirements for computer memory depend to some extent on the particular operating environment, and on the types of other software packages that may be installed on the computer. The IBM Professional FORTRAN requires 192K bytes of memory for compilation and link editing. The executable load module for the model requires 142K bytes of memory.

These requirements have been presented in terms of the IBM PC/AT because this is the principal system for which the model has been documented. The model has been run without modification on a VAX 11/780 minicomputer with a VMS operating system. The model can be run on any computer that has FORTRAN 77 capability.

Minimal I/O modifications may be required for systems other than the IBM PC/AT and the VAX.

8.3 TESTING PROCEDURES

The FORTRAN source files for the model and the pre-processing package must be compiled into object modules, and linked to create executable load modules. The programs INTERP and INVERT must be run, in sequence, to create the DAILY file for model input.

The sequence of the testing procedure is the following:

1. Compile and link INTERP.FOR, INVERT.FOR, and MODEL.FOR.

   Note that MASTER.FOR is not compiled or linked. It is automatically accessed by MODEL.FOR.

2. Run INTERP

3. Run INVERT

4. Run MODEL.

The default file names in INTERP.FOR, INVERT.FOR, and MODEL.FOR all refer to the Simplified Lake Example. This is the example that will be reproduced when MODEL is run. To reproduce the Simplified Embayment Example, edit the appropriate file names in these three source files, and repeat the above procedure.

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APPENDIX A

GLOSSARY OF PRINCIPAL VARIABLES

A(L,N)	Phytoplankton concentration (mg/l)
ADUM(K1,L,N)	Minimum concentration of a phytoplankton for grazing by herbivorous zooplankton (mg/l)
ALOSS1(L,N)	Phytoplankton specific respiration rate (1/day)
ALOSS2(L,N)	Phytoplankton specific decomposition rate (1/day)
ALOSS3(L,N)	Phytoplankton specific settling rate (1/day)
ALPHA(N,J)	Weighting factor for water column segment concentrations. Used in transport computations. (dimensionless)
ASINK(L)	Phytoplankton apparent net settling rate (meters/day)
AVNFIX	Dissolved available nitrogen concentration threshold for nitrogen fixation (mg/l)
AVP(1,N) (AVN(1,N), AVS(1,N))	Dissolved available phosphorus (nitrogen, silicon) concentration in the water column (mg/l)
AZMIN(K1)	Minimum concentration of total phytoplankton for herbivorous zooplankton grazing (mg/l)
BPI(L,N)	Phytoplankton biomass production integral (mg/l)
B1DETH(K1)	Rate coefficient for herbivorous zooplankton respiration (1/day)
B2DETH(K2)	Rate coefficient for carnivorous zooplankton respiration (1/day)
CL(1,N)	Chloride (conservative constituent) concentration (mg/l)
DEPTH(N)	Depth of water column spatial segment (meters)
DEPTHS(N)	Depth of sediment spatial segment (meters)
DUMMY1(18,10), DUMMY2(13,10)	Dummy arrays for storing transport components of total derivatives
EPRIME(N,J)	Bulk diffusion (liters/day)
FCROP(L)	Fraction of total phytoplankton crop

	(dimensionless)
FX(NMAX2)	Array containing current values of all total derivatives
FXDUM(NMAX2)	Dummy array containing temporary values of all total derivatives
GMAX(L)	Phytoplankton maximum growth rate (1/day)
H1	Integration time step for state variables in loop 1 (days)
H2	Integration time step for state variables in loop 2 (days)
ICHECK	Flag to compute all derivatives at TIME = 0
INT(N,J)	Array for segment interactions
INTMAX	Maximum number of interacting spatial segments
ISILCA(L)	Array for indicating diatom phytoplankton types
ISKIP	Run control switch for writing derivatives and component terms to model output file
IZ1PAR(K1,L)	Array for interactions between herbivorous zooplankton and phytoplankton
IZ2PAR(K2,K1)	Array for interactions between carnivorous zooplankton and herbivorous zooplankton
J	Summation index for sequence number of interacting spatial segments
KDCMP(L)	Half-saturation coefficient for phytoplankton decomposition (mg-day/l)
KPCELL(L) (KNCELL(L), KSCELL(L))	Internal half-saturation coefficient for phosphorus (nitrogen, silicon) limited phytoplankton growth (mg/mg A)
KRSEDP(N) (KRSEDN(N), KRSEDS(N))	Rate coefficient for mineralization of sediment phosphorus (nitrogen, silicon) to the dissolved available compartment in the water column (1/day)
KRTUP (KRTUN, KRTUS)	Half-saturation coefficient for mineralization of phosphorus (nitrogen, silicon) from unavailable to available compartments in the water column (mg A/l)
KZ1SAT(K1)	Half-saturation concentration of total phytoplankton for herbivorous zooplankton grazing

	(mg/1)
KZ2SAT(K2)	Half-saturation concentration of herbivorous zooplankton for carnivorous zooplankton grazing (mg/1)
K1	Summation index for number of herbivorous zooplankton
K2	Summation index for number of carnivorous zooplankton
K1P(L) (K1N(L), K1S(L))	Coefficient in phytoplankton phosphorus (nitrogen, silicon) uptake mechanism (dimensionless)
K2P(L) (K2N(L), K2S(L))	Coefficient in phytoplankton phosphorus (nitrogen, silicon) uptake mechanism (dimensionless)
L	Summation index for number of phytoplankton
M	Index for sequence number of sediment resuspension event
N	Summation index for number of water column spatial segments
NASPEC	Total number of phytoplankton types
NBDNTS	Number of boundary nutrient concentrations
NDITMS	Total number of diatom phytoplankton
NEQS1	Number of state variables per spatial segment in loop 1
NEQS2	Number of state variables per spatial segment in loop 2
NEVNTS	Total number of sediment resuspension events
NFIX(L)	Array for indicating nitrogen-fixing phytoplankton types
NFXLDS	Number of external point loadings
NMIN1	Lower limit of array element range for state variables in loop 1 (NMIN1 = 1)
NMIN2	Lower limit of array element range for state variables in loop 2 (NMIN2 = NMAX1 + 1)
NMAX1	Upper limit of array element range for state

	variables in loop 1 (NMAX1 = NSGMTS*NEQS1)
NMAX2	Upper limit of array element range for state variables in loop 2 (NMAX2 = NMAX1 + NSGMTS*NEQS2)
NN2BGS	Total number of nitrogen-fixing blue green phytoplankton
NSGMTS	Total number of water column spatial segments
NSPARS	Number of environmental forcing parameters per spatial segment
NTPARS	Total number of environmental forcing parameters
NZSPEC	Total number of zooplankton
NZ1SPC	Total number of herbivorous zooplankton
NZ2SPC	Total number of carnivorous zooplankton
ONOFF	Switch for sediment resuspension (dimensionless)
PCA(L,N) (NCA(L,N), SCA(L,N))	Intracellular concentration of available phosphorus (nitrogen, silicon) (mg/l)
PHOTO	Photoperiod (dimensionless)
PK1(L) (NK1(L), SK1(L))	Affinity coefficient in phosphorus (nitrogen, silicon) uptake mechanism (liters/mg)
PPI(N)	Integral of primary production rate (mg C/meter**3)
PPR(N)	Primary production rate (mg C/meter**3/hr)
PSA(L,N) (NSA(L,N), SSA(L,N))	Internal phosphorus (nitrogen, silicon) storage (mg/mg A)
PSAMIN(L) (NSAMIN(L), SSAMIN(L))	Minimum cell quota for phosphorus (nitrogen, silicon) storage (mg/mg A)
PSZ1 (NSZ1)	Phosphorus (nitrogen) stoichiometry for herbivorous zooplankton (mg/mg Z)
PSZ2 (NSZ2)	Phosphorus (nitrogen) stoichiometry for carnivorous zooplankton (mg/mg Z)
P2DETH(K2)	Rate coefficient for second-order predation on carnivorous zooplankton (1/mg-day)

Q(N,J)	Advective flow (liters/day)
RADINC(N)	Incident solar radiation (langleys/day)
RADSAT(L)	Saturation light intensity for phytoplankton growth (langleys/day)
RAGZD(L,N)	Rate at which a phytoplankton is grazed by herbivorous zooplankton (mg/l-day)
RATE1(18,7), RATE2(16,9)	Dummy arrays containing values for components of total derivatives
RDCMP(L)	Rate coefficient for phytoplankton decomposition (1/day)
RECIN(NTPARS)	Array containing values for all environmental forcing parameters for current Julian day
RLIGHT(L,N)	Light reduction factor for phytoplankton growth rate (dimensionless)
RPSINK(N) (RNSINK(N), RSSINK(N))	Flux rate of total phosphorus (nitrogen, silicon from water column to sediment (kg/day)
RRESP(L)	Rate coefficient for phytoplankton respiration (1/day)
RTUP (RTUN, RTUS)	Rate coefficient for mineralization of phosphoru (nitrogen, silicon) from unavailable to availabl compartments in the water column (1/day)
RZ1(K1,N)	Herbivorous zooplankton specific growth rate (1/day)
RZ1GZD(K1,N)	Rate at which herbivorous zooplankton are grazed by carnivorous zooplankton (mg/l-day)
RZ1MAX(K1)	Herbivorous zooplankton maximum growth rate (1/day)
RZ1PEX(K1,N) (RZ1NEX(K1,N), RZ1SEX(K1,N))	Rate at which phosphorus (nitrogen, silicon) is excreted to the unavailable compartment by herbivorous zooplankton (mg/mg Z-day)
RZ2(K2,N)	Carnivorous zooplankton specific growth rate (1/day)
RZ2GZD(K2,N)	Carnivorous zooplankton predatory death rate (1/day)
RZ2MAX(K2)	Carnivorous zooplankton maximum growth rate

	(1/day)
RZ2PEX(K2,N) (RZ2NEX(K2,N), RZ2SEX(K2,N))	Rate at which phosphorus (nitrogen, silicon) is excreted to the unavailable compartment by carnivorous zooplankton (mg/mg Z-day)
R1P(L,N) (R1N(L,N), R1S(L,N))	Specific phosphorus (nitrogen, silicon) uptake rate (mg/mg A-day)
R1PM(L) (R1NM(L), R1SM(L))	Maximum phosphorus (nitrogen, silicon) uptake rate (1/day)
R2PS(L,N) (R2NS(L,N), R2SS(L,N))	Specific phytoplankton growth rate as a function of phosphorus (nitrogen, silicon) limitation (1/day)
SECCHI(N)	Secchi depth (meters)
SEDP(N) (SEDN(N), SEDS(N))	Total phosphorus (nitrogen, silicon) concentration in the sediment (mg/l)
SPGR(L,N)	Phytoplankton specific growth rate (1/day)
T(N)	Water temperature (degrees Celsius)
TBASAR(L)	Temperature coefficient for phytoplankton respiration (dimensionless)
TBASEA(L)	Temperature coefficient for phytoplankton growth and nutrient uptake (dimensionless)
TBASE1	Temperature coefficient for nutrient mineralization in the water column (dimensionless)
TBASE2	Temperature coefficient for phytoplankton decomposition (dimensionless)
TBASE3	Temperature coefficient for zooplankton respiration (dimensionless)
TBASE4	Temperature coefficient for nutrient mineralization in the sediment (dimensionless)
TBASZ1(K1)	Temperature coefficient for herbivorous zooplankton growth (dimensionless)
TBASZ2(K2)	Temperature coefficient for carnivorous zooplankton growth (dimensionless)
TCROP(N)	Total phytoplankton concentration (mg/l)

TIME	Current time for model simulation (Julian days)
TIMEMX	Maximum time for model simulation (Julian days)
TPNET(N) (TNNET(N), TSNET(N))	Integral of net phosphorus (nitrogen, silicon) flux from water column to sediment (kg)
TPLOT	Time interval for writing to graphics output file, PLOTOUT (Julian days)
TPRINT	Time interval for writing to tabular output file, TABOUT (Julian days)
TPSUNK(N) (TNSUNK(N), TSSUNK(N))	Integral of total phosphorus (nitrogen, silicon) flux rate from water column to sediment (kg)
TSTART(M)	Julian day for start of sediment resuspension event
TSTOP(M)	Julian day for end of sediment resuspension event
TUP(1,N) (TUN(1,N), TUS(1,N))	Total unavailable phosphorus (nitrogen, silicon) concentration in the water column (mg/l)
TUPSNK (TUNSNK, TUSSNK)	Apparent net settling velocity for total unavailable phosphorus (nitrogen, silicon) in the water column (meters/day)
TWGTA(L,N)	Temperature reduction factor for phytoplankton growth and nutrient uptake (dimensionless)
TWGTAD(N)	Temperature reduction factor for phytoplankton decomposition (dimensionless)
TWGTAR(L,N)	Temperature reduction factor for phytoplankton respiration (dimensionless)
TWGTM(N)	Temperature reduction factor for nutrient mineralization in the water column (dimensionless)
TWGTSD(N)	Temperature reduction factor for nutrient mineralization in the sediment (dimensionless)
TWGTZR(N)	Temperature reduction factor for zooplankton respiration (dimensionless)
TWGTZ1(K1,N)	Temperature reduction factor for herbivorous zooplankton growth (dimensionless)
TWGTZ2(K2,N)	Temperature reduction factor for carnivorous

	zooplankton growth (dimensionless)
V(N)	Volume of water column spatial segment (liters)
VOLSED(N)	Volume of sediment spatial segment (liters)
VPLONG(N) (VNLONG(N), VSLONG(N))	Long term apparent net loss velocity for total phosphorus (nitrogen, silicon) from surficial sediment to deep sediment layer (meters/day)
VUPP(N) (VUPN(N), VUPS(N))	Apparent net resuspension velocity for total phosphorus (nitrogen, silicon) from the sediment to the water column (meters/day)
WAVP(N) (WAVN(N), WAVS(N))	Total external loading rate for dissolved available phosphorus (nitrogen, silicon) (kg/day)
WAVPA(N) (WAVNA(N), WAVSA(N))	Atmospheric loading rate for dissolved available phosphorus (nitrogen, silicon) (kg/day)
WAVPS(N) (WAVNS(N), WAVSS(N))	Sediment loading rate for dissolved available phosphorus (nitrogen, silicon) (kg/day)
WAVPT(N) (WAVNT(N), WAVST(N))	Tributary loading rate for dissolved available phosphorus (nitrogen, silicon) (kg/day)
WCL(N)	Total external loading rate for chloride (kg/day)
WCLA(N)	Atmospheric loading rate for chloride (kg/day)
WCLS(N)	Sediment loading rate for chloride (kg/day)
WCLT(N)	Tributary loading rate for chloride (kg/day)
WNH3(N)	Tributary loading rate for ammonia nitrogen (kg/day)
WNO3(N)	Tributary loading rate for nitrate nitrogen (kg/day)
WTKN(N)	Tributary loading rate for total kjeldahl nitrogen (kg/day)
WTP(N)	Tributary loading rate for total phosphorus (kg/day)
WTS(N)	Tributary loading rate for total silicon (kg/day)
WTUP(N)	Total external loading rate for total unavailable

(WTUN(N), WTUS(N))	phosphorus (nitrogen, silicon) (kg/day)
WTUPA(N) (WTUNA(N), WTUSA(N))	Atmospheric loading rate for total unavailable phosphorus (nitrogen, silicon) (kg/day)
WTUPS(N) (WTUNS(N), WTUSS(N))	Sediment loading rate for total unavailable phosphorus (nitrogen, silicon) (kg/day)
WTUPT(N) (WTUNT(N), WTUST(N))	Tributary loading rate for total unavailable phosphorus (nitrogen, silicon) (kg/day)
XTINCO(N)	Water column light extinction coefficient (1/meters)
Y(NMAX2)	Array containing current values of all state variables
YDUM(NMAX2)	Dummy array containing temporary values of all state variables
Z1(K1,N)	Herbivorous zooplankton concentration (mg/l)
Z1ASSM(K1)	Herbivorous zooplankton assimilation efficiency (dimensionless)
Z1DUM(K2,K1,N)	Minimum concentration of a herbivorous zooplankton for carnivorous zooplankton grazing (mg/l)
Z1EFF(K1,L)	Ingestion efficiency of herbivorous zooplankton for a phytoplankton (dimensionless)
Z1KDUM(K1,N)	Effective half-saturation concentration of total phytoplankton for herbivorous zooplankton grazing (mg/l)
Z1LSS1(K1,N)	Herbivorous zooplankton specific respiration rate (1/day)
Z12MIN(K2)	Minimum concentration of total herbivorous zooplankton for carnivorous zooplankton grazing (mg/l)
Z2(K2,N)	Carnivorous zooplankton concentration (mg/l)
Z2ASSM(K2)	Carnivorous zooplankton assimilation efficiency (dimensionless)
Z2EFF(K2,K1)	Ingestion efficiency of carnivorous zooplankton for herbivorous zooplankton (dimensionless)

Z2KDUM(K2,N)	Effective half-saturation concentration of total herbivorous zooplankton for carnivorous zooplankton grazing (mg/l)
Z2LSS1(K2,N)	Carnivorous zooplankton specific respiration rate (1/day)
Z23MIN(K2)	Minimum concentration of carnivorous zooplankton for higher-order predation (mg/l)

Note: The suffix "BD" denotes the boundary value of a variable.

The suffix "X" denotes the value of a variable in I/O units, for those variables which involve conversions between I/O units and working units.

The suffix "I" on a loading variable refers to the time integral of the variable, as opposed to the daily loading rate.

All loading rates and loading integrals have I/O units of kg/day and kg, respectively. Internal working units for these variables are mg/day and mg, respectively.

APPENDIX B

PROCESS KINETIC EQUATIONS

PHYTOPLANKTON

Nutrient Uptake:

```
R1P(L,N) = R1PM(L)*TWGTA(L,N)*(1./(1. + PK1(L)*PCA(L,N))
           -1./(1. + PK1(L)*AVP(1,N)))

     PCA(L,N) = K1P(L)*AVP(1,N)*EXP(K2P(L)*((PSA(L,N)/PSAMIN(L))
                - 1.))
```

Growth:

```
R2PS(L,N) = GMAX(L)*TWGTA(L,N)*RLIGHT(L,N)*(PSA(L,N) - PSAMIN(L))/
            (KPCELL(L) + PSA(L,N) - PSAMIN(L))

     SPGR(L,N) = AMIN1(R2PS(L,N),R2NS(L,N),R2SS(L,N))

     RLIGHT(L,N) = 2.718*PHOTO*(EXP(-ALPHA1) - EXP(-ALPHA0))/
                   (XTINCO(N)*DEPTH(N))

     ALPHA0 = RADINC(N)/(RADSAT(L)*PHOTO)

     ALPHA1 = ALPHA0*EXP(-XTINCO*DEPTH(N))

     XTINCO(N) = 1.9/SECCHI(N)
```

Respiration:

```
ALOSS1(L,N) = RRESP(L)*TWGTAR(L,N)
```

Decomposition:

```
ALOSS2(L,N) = RDCMP(L)*TWGTAD(N)*TCROP(N)/
              (TCROP(N) + (KDCMP(L)*SPGR(L,N)))
```

Settling:

```
ALOSS3(L,N) = ASINK(L)/DEPTH(N)
```

HERBIVOROUS ZOOPLANKTON

Growth:

```
RZ1(K1,N) = RZ1MAX(K1)*TWGTZ1(K1,N)*Z1ASSM(K1)*SUM2Z1(K1,N)/
            (Z1KDUM(K1,N) + SUM2Z1(K1,N))
```

$$SUM2Z1(K1,N) = \sum_{L} Z1EFF(K1,L)*A(L,N) - AZMIN(K1)$$

$$\mathrm{Z1KDUM(K1,N)} = \mathrm{SUM2Z1(K1,N)*KZ1SAT(K1)} / \sum_{L} \mathrm{Z1EFF(K1,L)*A(L,N)}$$

Rate at which phytoplankton type L is grazed:

$$\mathrm{RAGZD(L,N)} = \sum_{K1} \mathrm{RZ1MAX(K1)*TWGTZ1(K1,N)*Z1(K1,N)*(Z1EFF(K1,L)*A(L,N) - ADUM(K1,L,N))/(Z1KDUM(K1,N) + SUM2Z1(K1,N))}$$

$$\mathrm{ADUM(K1,L,N)} = \mathrm{Z1EFF(K1,L)*A(L,N)*AZMIN(K1)} / \sum_{L} \mathrm{Z1EFF(K1,L)*A(L,N)}$$

Rate at which phosphorus is excreted to the unavailable compartment in the water column:

$$\mathrm{RZ1PEX(K1,N)} = \mathrm{RZ1MAX(K1)*TWGTZ1(K1,N)*(1. - Z1ASSM(K1))*SUMZ1P(K1,N)/(Z1KDUM(K1,N) + SUM2Z1(K1,N))}$$

$$\mathrm{SUMZ1P(K1,N)} = \sum_{L} \mathrm{(Z1EFF(K1,L)*A(L,N) - ADUM(K1,L,N))*PSAMIN(L)}$$

Rate at which silicon is excreted to the unavailable compartment in the water column:

$$\mathrm{RZ1SEX(K1,N)} = \mathrm{RZ1MAX(K1)*TWGTZ1(K1,N)*SUMZ1S(K1,N)/(Z1KDUM(K1,N) + SUM2Z1(K1,N))}$$

$$\mathrm{SUMZ1S(K1,N)} = \sum_{L} \mathrm{(Z1EFF(K1,L)*A(L,N) - ADUM(K1,L,N))*SSAMIN(L)}$$

Death (respiration) rate:

$$\mathrm{Z1LSS1(K1,N)} = \mathrm{B1DETH(K1)*TWGTZR(N)}$$

CARNIVOROUS ZOOPLANKTON

Growth:

$$\mathrm{RZ2(K2,N)} = \mathrm{RZ2MAX(K2)*TWGTZ2(K2,N)*Z2ASSM(K2)*SUM2Z2(K2,N)/(Z2KDUM(K2,N) + SUM2Z2(K2,N))}$$

$$\mathrm{SUM2Z2(K2,N)} = \sum_{K1} \mathrm{Z2EFF(K2,K1)*Z1(K1,N) - Z12MIN(K2)}$$

$$\mathrm{Z2KDUM(K2,N)} = \mathrm{SUM2Z2(K2,N)*KZ2SAT(K2)} / \sum_{K1} \mathrm{Z2EFF(K2,K1)*Z1(K1,N)}$$

Rate at which herbivorous zooplankton type K1 is grazed:

$$\mathrm{RZ1GZD(K1,N)} = \sum_{K2} \mathrm{RZ2MAX(K2)*TWGTZ2(K2,N)*Z2(K2,N)*(Z2EFF(K2,K1)*Z1(K1,N) - Z1DUM(K2,K1,N))/(Z2KDUM(K2,N) + SUM2Z2(K2,N))}$$

$$\mathrm{Z1DUM(K2,K1,N)} = \mathrm{Z2EFF(K2,K1)*Z1(K1,N)*Z12MIN(K2)} / \sum_{K1} \mathrm{Z2EFF(K2,K1)*Z1(K1,N)}$$

Rate at which phosphorus is excreted to the unavailable compartment in the water column:

$$RZ2PEX(K2,N) = RZ2MAX(K2)*TWGTZ2(K2,N)*(1. - Z2ASSM(K2))*SUMZ2P(K2,N)/(Z2KDUM(K2,N) + SUM2Z2(K2,N))$$

$$SUMZ2P(K2,N) = \sum_{K1} (Z2EFF(K2,K1)*Z1(K1,N) - Z1DUM(K2,K1,N))*PSZ1$$

No silicon is excreted to the unavailable compartment by carnivorous zooplankton because no silicon is ingested by grazing on herbivorous zooplankton.

Death (respiration) rate:

$$Z2LSS1(K2,N) = B2DETH(K2)*TWGTZR(N)$$

Second-order predatory death rate:

$$RZ2GZD(K2,N) = P2DETH(K2)*Z2(N)*TWGTZ2(K2,N)$$

$$\text{IF: } Z2(K2,N) > Z23MIN(K2)$$

NUTRIENTS (Water Column)

Available nutrient forms:

Phytoplankton uptake $= \sum_{L} R1P(L,N)*A(L,N)$

Recycle from phytoplankton respiration losses $= \sum_{L} A(L,N)*(PSA(L,N) - PSAMIN(L))*ALOSS1(L,N)$

Recycle from phytoplankton decomposition losses $= \sum_{L} A(L,N)*(PSA(L,N) - PSAMIN(L))*ALOSS2(L,N)$

Recycle from herbivorous zooplankton excretion $= \sum_{L} (PSA(L,N) - PSAMIN(L))*RAGZD(L,N)$

Mineralization from unavailable compartment $= RTUP*TWGTM(N)*TCROP(N)*TUP(1,N)/(TCROP(N) - KRTUP)$

External loading $= WAVP(N)/V(N)$

Mineralization from sediment compartment $= KRSEDP(N)*TWGTSD(N)*VOLSED(N)*SEDP(N)$

Unavailable nutrient forms:

Recycle from phytoplankton respiration losses $= \sum_{L} A(L,N)*PSAMIN(L)*ALOSS1(L,N)$

Recycle from phytoplankton decomposition losses = $\sum_{L}$ A(L,N)*PSAMIN(L)*ALOSS2(L,N)

Recycle from herbivorous zooplankton excretion = $\sum_{K1}$ RZ1PEX(K1,N)*Z1(K1,N)

Recycle from herbivorous zooplankton respiration = $\sum_{K1}$ Z1LSS1(K1,N)*Z1(K1,N)*PSZ1

Recycle from carnivorous zooplankton excretion = $\sum_{K2}$ RZ2PEX(K2,N)*Z2(K2,N)

Recycle from carnivorous zooplankton respiration = $\sum_{K2}$ Z2LSS1(K2,N)*Z2(K2,N)*PSZ2

Mineralization to available compartment = RTUP*TWGTM(N)*TCROP(N)*TUP(1,N)/(TCROP(N) - KRTUP)

Settling: = TUPSNK*TUP(1,N)/DEPTH(N)

External loading = WTUP(N)/V(N)

External loading from sediment resuspension = ONOFF*VUPP(N)*VOLSED(N)*SEDP(N)/DEPTHS(N)

ONOFF = 1 wind speed > threshold for resuspension
ONOFF = 0 wind speed < threshold for resuspension

NUTRIENTS (Sediment)

Flux from phytoplankton settling = V(N)* $\sum_{L}$ ALOSS3(L,N)*A(L,N)*PSA(L,N)

Flux from settling of unavailable nutrient forms = V(N)*TUPSNK*TUP(1,N)/DEPTH(N)

Loss to resuspension = ONOFF*VUPP(N)*VOLSED(N)*SEDP(N)/DEPTHS(N)

Long term loss to deep sediment = VPLONG(N)*SEDP(N)/DEPTHS(N)

Loss to mineralization to water column = KRSEDP(N)*TWGTSD(N)*VOLSED(N)*SEDP(N)

TEMPERATURE COEFFICIENTS

TWGTA(L,N) = TBASEA(L)**(T(N) - 20.)

TWGTAR(L,N) = TBASAR(L)**(T(N) - 20.)

```
TWGTAD(N)     = TBASE2**(T(N) - 20.)

TWGTZ1(K1,N) = TBASZ1(K1)**(T(N) - 20.)

TWGTZR(N)     = TBASE3**(T(N) - 20.)

TWGTZ2(K2,N) = TBASZ2(K2)**(T(N) - 20.)

TWGTM(N)      = TBASE1**(T(N) - 20.)

TWGTSD(N)     = TBASE4**(T(N) -20.)
```

APPENDIX C

MODEL OUTPUT FOR SIMPLIFIED LAKE EXAMPLE

********** RUNCON INPUT **********

NSGMTS = 1
INTMAX = 2

SEGMENT	VOLUME (M**3)	DEPTH (M)
1	0.806E+10	0.583E+01

SEGMENT	INTERACTION	INTERACTING SEGMENT
1	1	1
1	2	1

SEDIMENT SEGMENT	VOLUME (M**3)	DEPTH (M)
1	0.138E+09	0.100E+00

NBDNTS = 8
NFXLDS = 8
NMISC = 3

NASPEC = 2
NDITMS = 1
NM2BGS = 0

PHYTO	ISILCA	NFIX
1	1	0
2	0	0

NZSPEC = 2
NZ1SPC = 1
NZ2SPC = 1

HERB ZOO	PHYTO	IZ1PAR
1	1	1
1	2	1

CARN ZOO	HERB ZOO	IZ2PAR
1	1	1

TIMEMX = 0.500E+01
TPLOT = 0.500E+01
TPRINT = 0.500E+01
ISKIP = 1

H1 = 0.2500E-01
H2 = 0.1250E+00

########## COEFF INPUT ##########

TBASE1 = 0.1070E+01
TBASE2 = 0.1070E+01
TBASE3 = 0.1070E+01
TBASE4 = 0.1070E+01

AVNFIX = 0.000E+00

PHYTO	GMAX	TBASEA	TBASAR
1	0.210E+01	0.106E+01	0.106E+01
2	0.180E+01	0.109E+01	0.109E+01

PHYTO	R1PM	PK1	K1P	K2P	PSAMIN	KPCELL
1	0.100E-01	0.226E+02	0.154E+00	0.150E+01	0.500E-03	0.500E-03
2	0.200E-01	0.226E+02	0.154E+00	0.300E+00	0.100E-02	0.100E-02

PHYTO	R1NM	NK1	K1N	K2N	NSAMIN	KNCELL
1	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.100E-01	0.100E-01
2	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.200E-01	0.200E-01

PHYTO	R1SM	SK1	K1S	K2S	SSAMIN	KSCELL
1	0.500E+00	0.534E+01	0.239E+00	0.445E+00	0.350E-01	0.350E-01

PHYTO	ASINK	RDCMP	KDCMP	RADSAT	RRESP
1	0.100E+00	0.250E+00	0.200E+03	0.100E+03	0.300E-01
2	0.500E-01	0.500E+00	0.200E+03	0.500E+02	0.300E-01

HERB ZOO	Z1ASSM	KZ1SAT	AZMIN	B1DETH
1	0.600E+00	0.100E+01	0.200E+00	0.300E-01

HERB ZOO	RZ1MAX	TBASZ1
1	0.550E+00	0.107E+01

HERB ZOO	PHYTO	Z1EFF
1	1	0.100E+01
1	2	0.500E+00

CARN ZOO	Z2ASSM	KZ2SAT	Z12MIN	B2DETH	P2DETH	Z23MIN
1	0.600E+00	0.125E+00	0.250E-01	0.300E-01	0.100E+01	0.250E-01

CARN ZOO	RZ2MAX	TBASZ2
1	0.550E+00	0.107E+01

CARN ZOO HERB ZOO Z2EFF

1	1	0.100E+01

RTUP	RTUN	RTUS
0.200E-01	0.200E-01	0.200E-01

KRTUP	KRTUN	KRTUS
0.100E+01	0.100E+01	0.100E+01

TUPSNK	TUNSNK	TUSSNK
0.150E+00	0.150E+00	0.150E+00

SEDIMENT SEGMENT	VUPP	VUPN	VUPS
1	0.175E-03	0.114E-03	0.175E-03

SEDIMENT SEGMENT	KRSEDP	KRSEDN	KRSEDS
1	0.000E+00	0.000E+00	0.625E-03

SEDIMENT SEGMENT	VPLONG	VNLONG	VSLONG
1	0.822E-05	0.822E-05	0.822E-05

NEVNTS = 24

TSTART	TSTOP
98.	99.
103.	105.
111.	113.
118.	119.
121.	122.
126.	127.
129.	130.
132.	133.
134.	135.
158.	160.
161.	162.
184.	185.
201.	202.
223.	224.
238.	239.
243.	244.
254.	255.
258.	259.
267.	268.
272.	273.
274.	275.
277.	279.
294.	296.
309.	310.

********** INICON INPUT **********

SEGMENT	AVP	AVN	AVS	TUP	TUN	TUS	CL
1	0.539E-02	0.128E+01	0.700E+00	0.131E-01	0.381E-01	0.700E+00	0.220E+02

SEGMENT	PHYTO	A	PSA	NSA	SSA
1	1	0.894E+00	0.125E-02	0.350E-01	0.105E+00
1	2	0.473E-01	0.500E-02	0.700E-01	0.000E+00

SEGMENT	HERB ZOO	Z1
1	1	0.130E-02

SEGMENT	CARN ZOO	Z2
1	1	0.312E-01

SEGMENT	SEDP	SEDN	SEDS
1	0.120E+03	0.136E+04	0.479E+03

SEGMENT	WAVPA	WAVNA	WAVSA	WTUPA	WTUNA	WTUSA	WCLA
1	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00

```
*******************************************
**************    DAY =    0.   **************
*******************************************
```

```
*********   DAY =    0.     SEGMENT =    1   *********
```

TEMPERATURE   = 0.290E+00
LIGHT INTENSITY = 0.100E+03
XTINC COEFF   = 0.114E+01

TOTAL PHYTO = 0.941E+00
TOTAL ZOO   = 0.325E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.199E-01	0.135E+01	0.149E+01
SEDIMENT	0.120E+03	0.136E+04	0.479E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.539E-02	0.128E+01	0.700E+00	0.131E-01	0.381E-01	0.700E+00	0.220E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.860E-03	0.247E-01	0.626E-01
MG/MG TOT PHYTO	0.913E-03	0.263E-01	0.665E-01

PRIM PROD RATE (MG C/M**3/HR)   = 0.152E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.180E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAMI
1	0.894E+00	0.950E+00	0.125E-02	0.250E+01	0.350E-01	0.350E+01	0.105E+00	0.300E+01
2	0.473E-01	0.502E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.549E-01	0.491E-01	0.549E-01	0.653E-01	0.610E-01	0.317E+00	0.137E+00
2	0.342E-01	0.162E-02	0.383E-01	0.342E-01	0.990E+02	0.183E+00	0.145E+00

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.130E-02	0.416E-01	0.791E-02	0.264E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.312E-01	0.000E+00	0.791E-02	0.264E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.110E+04	0.437E+05	0.314E+05	0.123E+04	0.199E+05	0.314E+05	0.721E+06
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.109E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

TOTAL	0.110E+04	0.444E+05	0.424E+05	0.124E+04	0.203E+05	0.315E+05	0.721E+06

LOADING INTEGRALS (KG)

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.110E+04	0.437E+05	0.314E+05	0.123E+04	0.199E+05	0.314E+05	0.721E+06
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.109E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.110E+04	0.444E+05	0.424E+05	0.124E+04	0.203E+05	0.315E+05	0.721E+06

RPSINK	RNSINK	RSSINK
0.289E+04	0.125E+05	0.158E+06
TPSUNK	TNSUNK	TSSUNK
0.289E+04	0.125E+05	0.158E+06
TPNET	TNNET	TSNET
0.289E+04	0.125E+05	0.147E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
1	1	1	-0.176E+03	0.000E+00	0.100E+01	0.500E+00
1	2	1	0.176E+03	0.000E+00	0.100E+01	0.500E+00

########## BOUNDARY VALUES ##########

TPBD	AVPBD	TKNBD	NO3BD	NH3BD	TSBD	AVSBD	CLBD
0.999E+01	0.999E+00	0.999E+01	0.999E+00	0.999E+00	0.999E+01	0.999E+00	0.999E+00

AVPBD	AVNBD	AVSBD	TUPBD	TUNBD	TUSBD	CLBD
0.999E+00	0.200E+01	0.999E+00	0.699E+01	0.698E+01	0.699E+01	0.999E+00

PHYTO	A	PSABD	NSABD	SSABD
1	0.999E+00	0.999E+00	0.999E+00	0.999E+00
2	0.999E+00	0.999E+00	0.999E+00	0.999E+00

HERB ZOO	Z1BD
1	0.999E+00

CARN ZOO	Z2BD
1	0.999E+00

```
*********************************************
**************    DAY =    5.   **************
*********************************************
```

```
**********   DAY =    5.    SEGMENT =    1   **********
```

TEMPERATURE   = 0.422E+00
LIGHT INTENSITY = 0.959E+02
XTINC COEFF   = 0.102E+01

TOTAL PHYTO = 0.103E+01
TOTAL ZOO   = 0.301E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.197E-01	0.137E+01	0.143E+01
SEDIMENT	0.120E+03	0.136E+04	0.484E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.614E-02	0.129E+01	0.687E+00	0.123E-01	0.451E-01	0.623E+00	0.223E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.749E-03	0.256E-01	0.895E-01
MG/MG TOT PHYTO	0.729E-03	0.249E-01	0.870E-01

PRIM PROD RATE (MG C/M**3/HR)   = 0.146E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.891E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAMI
1	0.980E+00	0.953E+00	0.106E-02	0.213E+01	0.340E-01	0.340E+01	0.126E+00	0.361E+01
2	0.481E-01	0.468E-01	0.507E-02	0.507E+01	0.636E-01	0.318E+01	0.000E+00	0.000E+00

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.541E-01	0.243E+00	0.541E-01	0.721E-01	0.738E-01	0.320E+00	0.152E+00
2	0.369E-01	0.829E-02	0.432E-01	0.369E-01	0.990E+02	0.185E+00	0.162E+00

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.153E-02	0.439E-01	0.798E-02	0.266E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.286E-01	0.000E+00	0.798E-02	0.266E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.121E+04	0.525E+05	0.348E+05	0.209E+04	0.196E+05	0.347E+05	0.893E+06
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.111E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

TOTAL	0.122E+04	0.532E+05	0.459E+05	0.210E+04	0.199E+05	0.348E+05	0.893E+06

LOADING INTEGRALS (KG)

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.579E+04	0.240E+06	0.165E+06	0.830E+04	0.988E+05	0.165E+06	0.404E+07
ATMOSPHERIC	0.249E+02	0.368E+04	0.342E+03	0.610E+02	0.166E+04	0.342E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.548E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.581E+04	0.244E+06	0.221E+06	0.836E+04	0.100E+06	0.166E+06	0.404E+07

RPSINK	RNSINK	RSSINK
0.271E+04	0.141E+05	0.147E+06
TPSUNK	TNSUNK	TSSUNK
0.140E+05	0.656E+05	0.769E+06
TPNET	TNNET	TSNET
0.140E+05	0.656E+05	0.714E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
1	1	1	-0.176E+03	0.000E+00	0.100E+01	0.500E+00
1	2	1	0.176E+03	0.000E+00	0.100E+01	0.500E+00

########## BOUNDARY VALUES ##########

TPBO	AVPBO	TKNBO	NO3BO	NH3BO	TSBO	AVSBO	CLBO
0.999E+01	0.999E+00	0.999E+01	0.999E+00	0.999E+00	0.999E+01	0.999E+00	0.999E+00

AVPBO	AVNBO	AVSBO	TUPBO	TUNBO	TUSBO	CLBO
0.999E+00	0.200E+01	0.999E+00	0.699E+01	0.698E+01	0.699E+01	0.999E+00

PHYTO	A	PSABO	NSABO	SSABO
1	0.999E+00	0.999E+00	0.999E+00	0.999E+00
2	0.999E+00	0.999E+00	0.999E+00	0.999E+00

HERB ZOO	Z1BO
1	0.999E+00

CARN ZOO	Z2BO
1	0.999E+00

APPENDIX D

MODEL OUTPUT FOR SIMPLIFIED EMBAYMENT EXAMPLE

********** RUNCON INPUT **********

NSGMTS = 1
INTMAX = 2

SEGMENT	VOLUME (M**3)	DEPTH (M)
1	0.806E+10	0.583E+01

SEGMENT	INTERACTION	INTERACTING SEGMENT
1	1	1
1	2	1

SEDIMENT SEGMENT	VOLUME (M**3)	DEPTH (M)
1	0.138E+09	0.100E+00

NBDNTS = 8
NFXLDS = 8
NMISC = 3

NASPEC = 2
NDITMS = 1
NN2BGS = 0

PHYTO	ISILCA	NFIX
1	1	0
2	0	0

NZSPEC = 2
NZ1SPC = 1
NZ2SPC = 1

HERB ZOO	PHYTO	IZ1PAR
1	1	1
1	2	1

CARN ZOO	HERB ZOO	IZ2PAR
1	1	1

TIMEMX = 0.500E+01
TPLOT = 0.500E+01
TPRINT = 0.500E+01
ISKIP = 0

H1 = 0.2500E-01
H2 = 0.1250E+00

********** COEFF INPUT **********

TBASE1 = 0.1070E+01
TBASE2 = 0.1070E+01
TBASE3 = 0.1070E+01
TBASE4 = 0.1070E+01

AVNFIX = 0.000E+00

PHYTO	GMAX	TBASEA	TBASAR
1	0.210E+01	0.106E+01	0.106E+01
2	0.180E+01	0.109E+01	0.109E+01

PHYTO	R1PM	PK1	K1P	K2P	PSAMIN	KPCELL
1	0.100E-01	0.226E+02	0.154E+00	0.150E+01	0.500E-03	0.500E-03
2	0.200E-01	0.226E+02	0.154E+00	0.300E+00	0.100E-02	0.100E-02

PHYTO	R1NM	NK1	K1N	K2N	NSAMIN	KNCELL
1	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.100E-01	0.100E-01
2	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.200E-01	0.200E-01

PHYTO	R1SM	SK1	K1S	K2S	SSAMIN	KSCELL
1	0.500E+00	0.534E+01	0.239E+00	0.445E+00	0.350E-01	0.350E-01

PHYTO	ASINK	RDCMP	KDCMP	RADSAT	RRESP
1	0.100E+00	0.250E+00	0.200E+03	0.100E+03	0.300E-01
2	0.500E-01	0.500E+00	0.200E+03	0.500E+02	0.300E-01

HERB ZOO	Z1ASSM	KZ1SAT	AZMIN	B1DETH
1	0.600E+00	0.100E+01	0.200E+00	0.300E-01

HERB ZOO	RZ1MAX	TBASZ1
1	0.550E+00	0.107E+01

HERB ZOO	PHYTO	Z1EFF
1	1	0.100E+01
1	2	0.500E+00

CARN ZOO	Z2ASSM	KZ2SAT	Z12MIN	B2DETH	P2DETH	Z23MIN
1	0.600E+00	0.125E+00	0.250E-01	0.300E-01	0.100E+01	0.250E-01

CARN ZOO	RZ2MAX	TBASZ2
1	0.550E+00	0.107E+01

CARN ZOO	HERB ZOO	Z2EFF

1	1	0.100E+01

RTUP	RTUN	RTUS
0.200E-01	0.200E-01	0.200E-01

KRTUP	KRTUN	KRTUS
0.100E+01	0.100E+01	0.100E+01

TUPSNK	TUNSNK	TUSSNK
0.150E+00	0.150E+00	0.150E+00

SEDIMENT SEGMENT	VUPP	VUPN	VUPS
1	0.175E-03	0.114E-03	0.175E-03

SEDIMENT SEGMENT	KRSEDP	KRSEDN	KRSEDS
1	0.000E+00	0.000E+00	0.625E-03

SEDIMENT SEGMENT	VPLONG	VNLONG	VSLONG
1	0.822E-05	0.822E-05	0.822E-05

NEVNTS = 24

TSTART	TSTOP
98.	99.
103.	105.
111.	113.
118.	119.
121.	122.
126.	127.
129.	130.
132.	133.
134.	135.
158.	160.
161.	162.
184.	185.
201.	202.
223.	224.
238.	239.
243.	244.
254.	255.
258.	259.
267.	268.
272.	273.
274.	275.
277.	279.
294.	296.
309.	310.

********** INICON INPUT **********

SEGMENT	AVP	AVN	AVS	TUP	TUN	TUS	CL
1	0.539E-02	0.128E+01	0.700E+00	0.131E-01	0.381E-01	0.700E+00	0.220E+02

SEGMENT	PHYTO	A	PSA	NSA	SSA
1	1	0.894E+00	0.125E-02	0.350E-01	0.105E+00
1	2	0.473E-01	0.500E-02	0.700E-01	0.000E+00

SEGMENT	HERB ZOO	Z1
1	1	0.130E-02

SEGMENT	CARN ZOO	Z2
1	1	0.312E-01

SEGMENT	SEDP	SEDN	SEDS
1	0.120E+03	0.136E+04	0.479E+03

SEGMENT	WAVPA	WAVNA	WAVSA	WTUPA	WTUNA	WTUSA	WCLA
1	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00

```
********************************************
*************   DAY =    0.   **************
********************************************

**********   DAY =    0.     SEGMENT =    1   **********
```

TEMPERATURE   = 0.290E+00
LIGHT INTENSITY = 0.100E+03
XTINC COEFF   = 0.114E+01

TOTAL PHYTO = 0.941E+00
TOTAL ZOO   = 0.325E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.199E-01	0.135E+01	0.149E+01
SEDIMENT	0.120E+03	0.136E+04	0.479E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.539E-02	0.128E+01	0.700E+00	0.131E-01	0.381E-01	0.700E+00	0.220E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.860E-03	0.247E-01	0.626E-01
MG/MG TOT PHYTO	0.913E-03	0.263E-01	0.665E-01

PRIM PROD RATE (MG C/M**3/HR)   = 0.152E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.180E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAM
1	0.894E+00	0.950E+00	0.125E-02	0.250E+01	0.350E-01	0.350E+01	0.105E+00	0.300E+0
2	0.473E-01	0.502E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+0

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.549E-01	0.491E-01	0.549E-01	0.653E-01	0.610E-01	0.317E+00	0.137E+00
2	0.342E-01	0.162E-02	0.383E-01	0.342E-01	0.990E+02	0.183E+00	0.145E+00

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.130E-02	0.416E-01	0.791E-02	0.264E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.312E-01	0.000E+00	0.791E-02	0.264E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.110E+04	0.437E+05	0.314E+05	0.123E+04	0.199E+05	0.314E+05	0.721E+06
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.109E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

TOTAL	0.110E+04	0.444E+05	0.424E+05	0.124E+04	0.203E+05	0.315E+05	0.721E+06

LOADING INTEGRALS (KG)

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.110E+04	0.437E+05	0.314E+05	0.123E+04	0.199E+05	0.314E+05	0.721E+06
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.109E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.110E+04	0.444E+05	0.424E+05	0.124E+04	0.203E+05	0.315E+05	0.721E+06

RPSINK	RNSINK	RSSINK
0.289E+04	0.125E+05	0.158E+06
TPSUNK	TNSUNK	TSSUNK
0.289E+04	0.125E+05	0.158E+06
TPNET	TNNET	TSNET
0.289E+04	0.125E+05	0.147E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
1	1	1	-0.176E+03	0.000E+00	0.100E+01	0.500E+00
1	2	1	0.176E+03	0.652E+03	0.309E+00	0.309E+00

########## BOUNDARY VALUES ##########

TPBO	AVPBO	TKNBO	NO3BO	NH3BO	TSBO	AVSBO	CLBO
0.415E-02	0.102E-02	0.124E+00	0.272E+00	0.123E-01	0.132E+01	0.660E+00	0.527E+01

AVPBO	AVNBO	AVSBO	TUPBO	TUNBO	TUSBO	CLBO
0.102E-02	0.284E+00	0.660E+00	0.295E-02	0.103E+00	0.632E+00	0.527E+01

PHYTO	A	PSABO	NSABO	SSABO
1	0.203E+00	0.750E-03	0.400E-01	0.140E+00
2	0.488E-02	0.200E-02	0.800E-01	0.000E+00

HERB ZOO	Z1BO
1	0.581E-02

CARN ZOO	Z2BO
1	0.265E-01

DERIVATIVES AND COMPONENT TERMS

DERIVATIVE	X1	X2	X3	X4	X5	X6	X7	X8	X9
-0.204E-03	-0.646E-06	-0.135E-03	-0.686E-04						
0.102E-04	-0.176E-05	0.183E-03	-0.171E-03						
-0.441E-03	0.646E-05	0.147E-02	-0.192E-02						
-0.154E-02	0.587E-05	0.849E-03	-0.239E-02						

0.108E-01	0.452E-04	0.165E-01	-0.576E-02

0.261E-03	-0.350E-04	0.112E-03	0.742E-05	0.651E-05	0.752E-07	0.335E-04	0.137E-03
-0.344E-02	-0.808E-02	-0.136E-02	0.226E-03	0.154E-03	0.231E-05	0.974E-04	0.551E-02
-0.830E-02	-0.155E-02	-0.147E-01	0.595E-03	0.326E-03	0.615E-05	0.179E-02	0.526E-02

0.149E-01	-0.562E-02	0.491E-01	-0.851E-02	-0.465E-02	-0.153E-01	-0.878E-04
-0.137E-03	-0.330E-03	0.162E-02	-0.260E-03	-0.755E-03	-0.406E-03	-0.232E-05

0.670E-04	0.232E-04	0.541E-04	-0.103E-04	0.000E+00
-0.589E-03	-0.856E-04	0.000E+00	-0.247E-03	-0.257E-03

-0.291E-03	-0.824E-04	0.759E-05	0.192E-07	0.514E-08	0.000E+00	0.123E-06	-0.335E-04	-0.337E-03	0.154E-03
0.189E-02	0.296E-03	0.152E-03	0.384E-06	0.103E-06	0.000E+00	0.247E-05	-0.974E-04	-0.980E-03	0.252E-02
-0.171E-01	-0.171E-02	0.461E-03	0.307E-05	-0.179E-02	-0.180E-01	0.390E-02			
-0.472E-01	-0.137E+00	0.895E-01							

0.111E-01	0.209E-01	0.000E+00	0.000E+00	-0.986E-02
-0.215E-01	0.903E-01	0.000E+00	0.000E+00	-0.112E+00
0.103E+01	0.115E+01	0.000E+00	-0.789E-01	-0.394E-01

****
************** DAY = 5. **************
****

********* DAY = 5. SEGMENT = 1 *********

TEMPERATURE = 0.422E+00
LIGHT INTENSITY = 0.959E+02
XTINC COEFF = 0.102E+01

TOTAL PHYTO = 0.101E+01
TOTAL ZOO = 0.301E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.193E-01	0.135E+01	0.143E+01
SEDIMENT	0.120E+03	0.136E+04	0.484E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.600E-02	0.126E+01	0.686E+00	0.120E-01	0.467E-01	0.623E+00	0.218E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.731E-03	0.251E-01	0.876E-01
MG/MG TOT PHYTO	0.727E-03	0.250E-01	0.871E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.143E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.883E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/S
1	0.959E+00	0.953E+00	0.106E-02	0.213E+01	0.341E-01	0.341E+01	0.126E+00	0.361
2	0.469E-01	0.467E-01	0.506E-02	0.506E+01	0.637E-01	0.318E+01	0.000E+00	0.000

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.541E-01	0.241E+00	0.541E-01	0.721E-01	0.738E-01	0.320E+00	0.152E+00
2	0.369E-01	0.821E-02	0.432E-01	0.369E-01	0.990E+02	0.185E+00	0.162E+00

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.166E-02	0.434E-01	0.798E-02	0.266E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.285E-01	0.000E+00	0.798E-02	0.266E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.121E+04	0.525E+05	0.348E+05	0.209E+04	0.196E+05	0.347E+05	0.893E+06
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.111E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

TOTAL	0.122E+04	0.532E+05	0.459E+05	0.210E+04	0.199E+05	0.348E+05	0.893E+06

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.579E+04	0.240E+06	0.165E+06	0.830E+04	0.988E+05	0.165E+06	0.404E+07
ATMOSPHERIC	0.249E+02	0.368E+04	0.342E+03	0.610E+02	0.166E+04	0.342E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.548E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.581E+04	0.244E+06	0.221E+06	0.836E+04	0.100E+06	0.166E+06	0.404E+07

RPSINK	RNSINK	RSSINK
0.265E+04	0.144E+05	0.146E+06
TPSUNK	TNSUNK	TSSUNK
0.139E+05	0.660E+05	0.768E+06
TPNET	TNNET	TSNET
0.139E+05	0.660E+05	0.713E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
1	1	1	-0.176E+03	0.000E+00	0.100E+01	0.500E+00
1	2	1	0.176E+03	0.652E+03	0.309E+00	0.309E+00

********** BOUNDARY VALUES **********

TPBD	AVPBD	TKNBD	NO3BD	NH3BD	TSBD	AVSBD	CLBD
0.415E-02	0.104E-02	0.125E+00	0.272E+00	0.124E-01	0.134E+01	0.668E+00	0.527E+01

AVPBD	AVNBD	AVSBD	TUPBD	TUNBD	TUSBD	CLBD
0.104E-02	0.284E+00	0.668E+00	0.293E-02	0.104E+00	0.640E+00	0.527E+01

PHYTO	A	PSABD	NSABD	SSABD
1	0.200E+00	0.750E-03	0.400E-01	0.140E+00
2	0.481E-02	0.200E-02	0.800E-01	0.000E+00

HERB ZOO	Z1BD
1	0.563E-02

CARN ZOO	Z2BD
1	0.260E-01

***** DERIVATIVES AND COMPONENT TERMS *****

DERIVATIVE	X1	X2	X3	X4	X5	X6	X7	X8	X9
-0.144E-05	-0.372E-06	0.565E-04	-0.575E-04						
0.973E-05	-0.178E-05	0.198E-03	-0.187E-03						
-0.110E-03	0.705E-05	0.173E-02	-0.184E-02						
-0.101E-02	0.950E-05	0.133E-02	-0.235E-02						

0.102E-02	0.162E-04	0.783E-02	-0.683E-02

0.929E-04	-0.395E-04	-0.634E-04	0.623E-05	0.607E-05	0.774E-07	0.320E-04	0.151E-03
-0.255E-02	-0.796E-02	-0.171E-02	0.232E-03	0.163E-03	0.294E-05	0.124E-03	0.661E-02
-0.191E-03	-0.140E-02	-0.750E-02	0.838E-03	0.493E-03	0.107E-04	0.166E-02	0.570E-02

0.146E-01	-0.612E-02	0.519E-01	-0.919E-02	-0.541E-02	-0.164E-01	-0.117E-03
-0.704E-05	-0.328E-03	0.173E-02	-0.261E-03	-0.747E-03	-0.403E-03	-0.286E-05

0.784E-04	0.194E-04	0.722E-04	-0.133E-04	0.000E+00
-0.511E-03	-0.677E-04	0.000E+00	-0.227E-03	-0.216E-03

-0.146E-03	-0.743E-04	0.831E-05	0.255E-07	0.663E-08	0.000E+00	0.114E-06	-0.320E-04	-0.309E-03	0.261E-03
0.155E-02	0.238E-03	0.166E-03	0.510E-06	0.133E-06	0.000E+00	0.227E-05	-0.124E-03	-0.120E-02	0.247E-02
-0.139E-01	-0.107E-02	0.511E-03	0.411E-05	-0.166E-02	-0.160E-01	0.431E-02			
-0.244E-01	-0.135E+00	0.111E+00							

0.935E-02	0.192E-01	0.000E+00	0.000E+00	-0.987E-02
-0.775E-02	0.104E+00	0.000E+00	0.000E+00	-0.112E+00
0.939E+00	0.106E+01	0.000E+00	-0.804E-01	-0.398E-01

APPENDIX E

ENVFF FILE FOR SEGMENT 1 FOR SAGINAW BAY EXAMPLE

```
0.000E00                     PSABD(1,1)  (mg P/mg A)
0.000E00  0.365E03
0.000E00                     PSABD(2,1)  (mg P/mg A)
0.000E00  0.365E03
0.000E00                     PSABD(3,1)  (mg P/mg A)
0.000E00  0.365E03
0.000E00                     PSABD(4,1)  (mg P/mg A)
0.000E00  0.365E03
0.000E00                     PSABD(5,1)  (mg P/mg A)
0.000E00  0.365E03
0.000E00                     NSABD(1,1)  (mg N/mg A)
0.000E00  0.365E03
0.000E00                     NSABD(2,1)  (mg N/mg A)
0.000E00  0.365E03
0.000E00                     NSABD(3,1)  (mg N/mg A)
0.000E00  0.365E03
0.000E00                     NSABD(4,1)  (mg N/mg A)
0.000E00  0.365E03
0.000E00                     NSABD(5,1)  (mg N/mg A)
0.000E00  0.365E03
0.000E00                     SSABD(1,1)  (mg S/mg A)
0.000E00  0.365E03
0.000E00                     SSABD(2,1)  (mg S/mg A)
0.000E00  0.365E03
0.000E00                     SSABD(3,1)  (mg S/mg A)
0.000E00  0.365E03
0.000E00                     SSABD(4,1)  (mg S/mg A)
0.000E00  0.365E03
0.000E00                     SSABD(5,1)  (mg S/mg A)
0.000E00  0.365E03
0.000E00                     ABD(1,1)    (mg/l)
0.000E00  0.365E03
0.000E00                     ABD(2,1)    (mg/l)
0.000E00  0.365E03
0.000E00                     ABD(3,1)    (mg/l)
0.000E00  0.365E03
0.000E00                     ABD(4,1)    (mg/l)
0.000E00  0.365E03
0.000E00                     ABD(5,1)    (mg/l)
0.000E00  0.365E03
0.000E00                     Z1BD(1,1)   (mg/l)
0.000E00  0.365E03
0.000E00                     Z2BD(1,1)   (mg/l)
0.000E00  0.365E03
0.000E00                     TPBD(1)     (mg P/l)
0.000E00  0.365E03
0.000E00                     AVPBD(1)    (mg P/l)
0.000E00  0.365E03
0.000E00                     TKNBD(1)    (mg N/l)
```

0.000E00	0.365E03		
0.000E00		NO3BD(1)	(mg N/1)
0.000E00	0.365E03		
0.000E00		NH3BD(1)	(mg N/1)
0.000E00	0.365E03		
0.000E00		TSBD(1)	(mg S/1)
0.000E00	0.365E03		
0.000E00		AVSBD(1)	(mg S/1)
0.000E00	0.365E03		
0.000E00		CLBD(1)	(mg CL/1)
0.000E00	0.365E03		
.307E04		WTP(1)	(kg P/day)
.158E04	.160E02		
.864E04	.240E02		
.271E05	.290E02		
.704E04	.320E02		
.291E04	.340E02		
.126E04	.490E02		
.521E04	.560E02		
.582E04	.590E02		
.324E05	.660E02		
.116E05	.670E02		
.403E04	.740E02		
.258E04	.900E02		
.117E05	.950E02		
.544E04	.990E02		
.475E04	.114E03		
.330E04	.134E03		
.173E05	.141E03		
.725E04	.142E03		
.300E04	.147E03		
.197E04	.154E03		
.629E04	.162E03		
.271E04	.165E03		
.126E04	.206E03		
.117E04	.295E03		
.343E04	.311E03		
.529E03	.337E03		
.128E04	.365E03		
.123E04		WAVP(1)	(kg P/day)
.123E04	.300E01		
.289E03	.180E02		
.114E04	.210E02		
.161E04	.220E02		
.195E04	.240E02		
.223E04	.250E02		
.407E04	.280E02		
.977E03	.300E02		
.152E04	.320E02		
.833E03	.360E02		
.434E03	.490E02		
.150E04	.560E02		
.133E04	.590E02		
.423E04	.640E02		
.189E04	.670E02		

.636E03	.780E02		
.371E03	.990E02		
.432E04	.100E03		
.109E04	.101E03		
.318E03	.106E03		
.115E04	.109E03		
.442E03	.126E03		
.149E04	.134E03		
.290E03	.135E03		
.240E03	.141E03		
.774E03	.142E03		
.165E03	.153E03		
.701E03	.155E03		
.276E03	.158E03		
.122E04	.162E03		
.499E03	.165E03		
.154E04	.171E03		
.293E03	.176E03		
.499E03	.193E03		
.320E03	.226E03		
.395E03	.262E03		
.946E03	.274E03		
.602E03	.280E03		
.817E03	.295E03		
.847E03	.305E03		
.216E03	.311E03		
.824E03	.317E03		
.916E03	.325E03		
.416E03	.337E03		
.492E03	.353E03		
.527E03	.365E03		
.116E05		WTKN(1)	(kg N/day)
.383E04	.140E02		
.495E05	.210E02		
.194E05	.250E02		
.376E05	.300E02		
.876E04	.380E02		
.189E05	.520E02		
.116E05	.590E02		
.184E06	.660E02		
.220E05	.720E02		
.220E05	.890E02		
.417E05	.950E02		
.181E05	.101E03		
.252E05	.105E03		
.802E04	.116E03		
.105E05	.123E03		
.219E05	.135E03		
.480E05	.141E03		
.139E05	.147E03		
.829E04	.158E03		
.161E05	.162E03		
.886E04	.165E03		
.365E04	.179E03		

.585E04	.279E03	
.435E04	.353E03	
.435E04	.365E03	
.205E05		WNO3(1) (kg N/day)
.111E05	.180E02	
.439E05	.240E02	
.234E06	.280E02	
.117E06	.300E02	
.302E05	.390E02	
.334E05	.530E02	
.419E05	.590E02	
.184E06	.650E02	
.580E05	.740E02	
.300E05	.900E02	
.137E06	.950E02	
.576E05	.101E03	
.547E05	.106E03	
.202E05	.112E03	
.313E05	.137E03	
.536E05	.141E03	
.251E05	.142E03	
.211E05	.169E03	
.454E04	.179E03	
.421E04	.189E03	
.135E04	.207E03	
.114E04	.225E03	
.167E04	.261E03	
.226E04	.280E03	
.192E04	.353E03	
.192E04	.365E03	
.176E04		WNH3(1) (kg N/day)
.176E04	.200E01	
.861E03	.180E02	
.347E04	.210E02	
.999E04	.280E02	
.545E04	.320E02	
.192E04	.380E02	
.103E04	.490E02	
.179E04	.520E02	
.470E04	.560E02	
.394E04	.590E02	
.173E05	.650E02	
.499E04	.730E02	
.421E04	.800E02	
.211E04	.870E02	
.532E04	.920E02	
.890E03	.950E02	
.188E04	.101E03	
.365E04	.105E03	
.902E03	.109E03	
.168E04	.119E03	
.324E04	.123E03	
.242E04	.134E03	
.501E04	.135E03	

.480E03	.141E03		
.489E04	.142E03		
.516E03	.143E03		
.140E04	.155E03		
.313E04	.162E03		
.180E04	.165E03		
.144E04	.172E03		
.744E03	.176E03		
.461E03	.226E03		
.222E04	.261E03		
.259E04	.352E03		
.259E04	.365E03		
.110E06		WTS(1)	(kg S/day)
.916E05	.300E01		
.546E05	.100E02		
.230E06	.120E02		
.376E05	.140E02		
.124E06	.250E02		
.708E05	.260E02		
.125E06	.290E02		
.780E05	.410E02		
.114E06	.440E02		
.612E05	.490E02		
.244E06	.550E02		
.362E06	.590E02		
.798E05	.620E02		
.106E06	.660E02		
.110E05	.790E02		
.356E06	.840E02		
.236E06	.860E02		
.129E06	.910E02		
.199E06	.100E03		
.126E06	.108E03		
.342E06	.109E03		
.292E06	.114E03		
.149E06	.119E03		
.450E05	.125E03		
.640E05	.128E03		
.624E05	.138E03		
.149E06	.141E03		
.464E05	.143E03		
.752E05	.148E03		
.280E05	.158E03		
.108E06	.162E03		
.574E05	.168E03		
.776E05	.171F03		
.376E05	.176E03		
.102E05	.193E03		
.730E04	.213E03		
.838E04	.227E03		
.832E04	.248E03		
.900E04	.255E03		
.176E05	.274E03		
.131E05	.295E03		

.278E05	.311E03		
.152E05	.325E03		
.900E04	.337E03		
.148E05	.353E03		
.100E05	.365E03		
0.548E05		WAVS(1)	(kg S/day)
0.458E05	0.300E01		
0.273E05	0.100E02		
0.115E06	0.120E02		
0.188E05	0.140E02		
0.621E05	0.250E02		
0.354E05	0.260E02		
0.627E05	0.290E02		
0.390E05	0.410E02		
0.570E05	0.440E02		
0.306E05	0.490E02		
0.122E06	0.550E02		
0.181E06	0.590E02		
0.399E05	0.620E02		
0.528E05	0.660E02		
0.551E04	0.790E02		
0.178E06	0.840E02		
0.118E06	0.860E02		
0.643E05	0.910E02		
0.995E05	0.100E03		
0.629E05	0.108E03		
0.171E06	0.109E03		
0.146E06	0.114E03		
0.747E05	0.119E03		
0.225E05	0.125E03		
0.320E05	0.128E03		
0.312E05	0.138E03		
0.747E05	0.141E03		
0.232E05	0.143E03		
0.376E05	0.148E03		
0.140E05	0.158E03		
0.542E05	0.162E03		
0.287E05	0.168E03		
0.388E05	0.171E03		
0.188E05	0.176E03		
0.509E04	0.193E03		
0.365E04	0.213E03		
0.419E04	0.227E03		
0.416E04	0.248E03		
0.450E04	0.255E03		
0.882E04	0.274E03		
0.655E04	0.295E03		
0.139E05	0.311E03		
0.762E04	0.325E03		
0.450E04	0.337E03		
0.739E04	0.353E03		
0.500E04	0.365E03		
.105E07		WCL(1)	(kg CL/day)
.315E06	.150E02		

.796E06	.180E02
.520E07	.230E02
.176E07	.250E02
.292E07	.280E02
.165E07	.290E02
.651E06	.370E02
.127E07	.510E02
.291E06	.530E02
.177E07	.560E02
.145E07	.600E02
.229E07	.650E02
.108E07	.730E02
.197E07	.740E02
.566E06	.880E02
.190E07	.910E02
.330E07	.920E02
.240E07	.940E02
.291E07	.950E02
.138E07	.990E02
.116E07	.101E03
.188E07	.105E03
.991E06	.109E03
.761E06	.116E03
.102E07	.128E03
.920E06	.134E03
.450E07	.137E03
.117E07	.141E03
.626E06	.147E03
.134E07	.151E03
.754E06	.155E03
.626E06	.158E03
.168E07	.162E03
.942E06	.165E03
.821E06	.172E03
.379E06	.179E03
.595E06	.190E03
.421E06	.213E03
.464E06	.272E03
.846E06	.274E03
.637E06	.280E03
.853E06	.295E03
.970E06	.311E03
.407E06	.325E03
.208E06	.337E03
.309E06	.353E03
.379E06	.365E03

Q(1,1) (m**3/sec)

0.000E00	
0.000E00	0.700E02
-0.615E03	0.710E02
-0.615E03	0.155E03
-0.262E04	0.156E03
-0.262E04	0.170E03
0.000E00	0.171E03
0.000E00	0.175E03

-0.437E02	0.176E03		
-0.437E02	0.215E03		
-0.631E03	0.216E03		
-0.631E03	0.260E03		
-0.222E03	0.261E03		
-0.222E03	0.290E03		
-0.404E03	0.291E03		
-0.404E03	0.341E03		
0.000E00	0.342E03		
0.000E00	0.365E03		
0.307E03		Q(1,2)	(m**3/sec)
0.307E03	0.700E02		
0.993E03	0.710E02		
0.993E03	0.105E03		
0.895E03	0.106E03		
0.895E03	0.155E03		
0.277E04	0.156E03		
0.277E04	0.170E03		
0.112E03	0.171E03		
0.112E03	0.175E03		
0.101E03	0.176E03		
0.101E03	0.215E03		
0.669E03	0.216E03		
0.669E03	0.260E03		
0.264E03	0.261E03		
0.264E03	0.290E03		
0.455E03	0.291E03		
0.455E03	0.341E03		
0.310E02	0.342E03		
0.310E02	0.365E03		
0.000E00		Q(1,3)	(m**3/sec)
0.000E00	0.365E03		
-0.307E03		Q(1,4)	(m**3/sec)
-0.307E03	0.700E02		
-0.378E03	0.710E02		
-0.378E03	0.105E03		
-0.280E03	0.106E03		
-0.280E03	0.155E03		
-0.141E03	0.156E03		
-0.141E03	0.170E03		
-0.112E03	0.171E03		
-0.112E03	0.175E03		
-0.570E02	0.176E03		
-0.570E02	0.215E03		
-0.380E02	0.216E03		
-0.380E02	0.260E03		
-0.420E02	0.261E03		
-0.420E02	0.290E03		
-0.510E02	0.291E03		
-0.510E02	0.341E03		
-0.310E02	0.342E03		
-0.310E02	0.365E03		
.000E00		Q(1,5)	(m**3/sec)
.000E00	.365E03		

0.191E01		EPRIME(1,1) (m**3/sec)
0.191E01	0.700E02	
0.382E03	0.710E02	
0.382E03	0.155E03	
0.764E03	0.156E03	
0.764E03	0.170E03	
0.191E01	0.171E03	
0.191E01	0.175E03	
0.191E03	0.176E03	
0.191E03	0.215E03	
0.382E03	0.216E03	
0.382E03	0.260E03	
0.955E02	0.261E03	
0.955E02	0.290E03	
0.382E03	0.291E03	
0.382E03	0.341E03	
0.191E01	0.342E03	
0.191E01	0.365E03	
0.589E00		EPRIME(1,2) (m**3/sec)
0.589E00	0.700E02	
0.118E03	0.710E02	
0.118E03	0.155E03	
0.236E03	0.156E03	
0.236E03	0.170E03	
0.589E00	0.171E03	
0.589E00	0.175E03	
0.589E02	0.176E03	
0.589E02	0.215E03	
0.118E03	0.216E03	
0.118E03	0.260E03	
0.295E02	0.261E03	
0.295E02	0.290E03	
0.118E03	0.291E03	
0.118E03	0.341E03	
0.589E00	0.342E03	
0.589E00	0.365E03	
0.000E00		EPRIME(1,3) (m**3/sec)
0.000E00	0.365E03	
0.000E00		EPRIME(1,4) (m**3/sec)
0.000E00	0.365E03	
0.000E00		EPRIME(1,5) (m**3/sec)
0.000E00	0.365E03	
0.800E00		ALPHA(1,1)
0.800E00	0.700E02	
0.310E00	0.710E02	
0.310E00	0.155E03	
0.146E00	0.156E03	
0.146E00	0.170E03	
0.800E00	0.171E03	
0.800E00	0.215E03	
0.303E00	0.216E03	
0.303E00	0.260E03	
0.215E00	0.261E03	
0.215E00	0.290E03	

0.800E00	0.291E03	
0.800E00	0.365E03	
0.999E00		ALPHA(1,2)
0.999E00	0.700E02	
0.941E00	0.710E02	
0.941E00	0.105E03	
0.934E00	0.106E03	
0.934E00	0.155E03	
0.957E00	0.156E03	
0.957E00	0.170E03	
0.997E00	0.171E03	
0.997E00	0.175E03	
0.786E00	0.176E03	
0.786E00	0.215E03	
0.912E00	0.216E03	
0.912E00	0.260E03	
0.944E00	0.261E03	
0.944E00	0.290E03	
0.786E00	0.291E03	
0.786E00	0.341E03	
0.990E00	0.342E03	
0.990E00	0.365E03	
0.000E00		ALPHA(1,3)
0.000E00	0.365E03	
0.100E01		ALPHA(1,4)
0.100E01	0.365E03	
.000E00		ALPHA(1,5)
.000E00	.365E03	
0.577E00		T(1) (degrees C)
0.200E01	0.500E02	
0.716E01	0.108E03	
0.989E01	0.119E03	
0.100E02	0.135E03	
0.172E02	0.155E03	
0.161E02	0.170E03	
0.222E02	0.190E03	
0.218E02	0.207E03	
0.224E02	0.226E03	
0.167E02	0.262E03	
0.120E02	0.280E03	
0.861E01	0.315E03	
0.433E00	0.351E03	
0.577E00	0.365E03	
.100E02		RADINC(1) (ly/day)
.140E02	.300E02	
.200E02	.600E02	
.300E02	.900E02	
.330E02	.970E02	
.337E03	.980E02	
.440E03	.120E03	
.600E03	.150E03	
.660E03	.180E03	
.625E03	.210E03	
.540E03	.240E03	

.390E03	.270E03	
.210E03	.300E03	
.115E03	.330E03	
.110E03	.342E03	
.550E02	.343E03	
.500E02	.365E03	
0.132E01		SECCHI(1) (meters)
0.300E01	0.520E02	
0.500E00	0.108E03	
0.100E01	0.119E03	
0.700E00	0.135E03	
0.750E00	0.154E03	
0.950E00	0.171E03	
0.110E01	0.190E03	
0.700E00	0.207E03	
0.800E00	0.226E03	
0.600E00	0.262E03	
0.800E00	0.280E03	
0.110E01	0.316E03	
0.130E01	0.351E03	
0.132E01	0.365E03	

APPENDIX F

MODEL OUTPUT FOR SAGINAW BAY EXAMPLE

********** RUNCON INPUT **********

NSGMTS = 5
INTMAX = 5

SEGMENT	VOLUME (M**3)	DEPTH (M)
1	0.894E+09	0.385E+01
2	0.589E+10	0.733E+01
3	0.127E+10	0.374E+01
4	0.788E+10	0.132E+02
5	0.939E+10	0.152E+02

SEGMENT	INTERACTION	INTERACTING SEGMENT
1	1	2
1	2	3
1	3	0
1	4	1
1	5	0

SEGMENT	INTERACTION	INTERACTING SEGMENT
2	1	1
2	2	3
2	3	4
2	4	0
2	5	0

SEGMENT	INTERACTION	INTERACTING SEGMENT
3	1	1
3	2	2
3	3	5
3	4	0
3	5	0

SEGMENT	INTERACTION	INTERACTING SEGMENT
4	1	2
4	2	5
4	3	0
4	4	0
4	5	4

SEGMENT	INTERACTION	INTERACTING SEGMENT
5	1	3
5	2	4
5	3	0
5	4	0
5	5	5

SEDIMENT SEGMENT	VOLUME (M**3)	DEPTH (M)
1	0.232E+07	0.100E-01
2	0.804E+08	0.100E+00
3	0.340E+08	0.100E+00
4	0.597E+08	0.100E+00
5	0.618E+08	0.100E+00

NBDNTS = 8
NFXLDS = 8
NMISC = 3

NASPEC = 5
NDITMS = 1
NN2BGS = 1

PHYTO	ISILCA	NFIX
1	1	0
2	0	0
3	0	0
4	0	0
5	0	1

NZSPEC = 2
NZ1SPC = 1
NZ2SPC = 1

HERB ZOO	PHYTO	IZ1PAR
1	1	1
1	2	1
1	3	1

CARN ZOO	HERB ZOO	IZ2PAR
1	1	1

TIMEMX = 0.500E+01
TPLOT = 0.500E+01
TPRINT = 0.500E+01
ISKIP = 1

H1 = 0.2500E-01
H2 = 0.1250E+00

********** COEFF INPUT **********

TBASE1 = 0.1070E+01
TBASE2 = 0.1070E+01
TBASE3 = 0.1070E+01
TBASE4 = 0.1070E+01

AVNFIX = 0.150E+00

PHYTO	GMAX	TBASEA	TBASAR
1	0.240E+01	0.106E+01	0.106E+01
2	0.240E+01	0.107E+01	0.107E+01
3	0.210E+01	0.106E+01	0.106E+01
4	0.160E+01	0.109E+01	0.109E+01
5	0.160E+01	0.109E+01	0.109E+01

PHYTO	R1PM	PK1	K1P	K2P	PSAMIN	KPCELL
1	0.100E-01	0.226E+02	0.154E+00	0.150E+01	0.500E-03	0.500E-03
2	0.200E-01	0.226E+02	0.154E+00	0.125E+01	0.100E-02	0.100E-02
3	0.200E-01	0.226E+02	0.154E+00	0.125E+01	0.100E-02	0.100E-02
4	0.200E-01	0.226E+02	0.154E+00	0.300E+00	0.100E-02	0.100E-02
5	0.200E-01	0.226E+02	0.154E+00	0.450E+00	0.100E-02	0.100E-02

PHYTO	R1NM	NK1	K1N	K2N	NSAMIN	KNCELL
1	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.100E-01	0.100E-01
2	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.200E-01	0.200E-01
3	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.200E-01	0.200E-01
4	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.200E-01	0.200E-01
5	0.200E+00	0.107E+02	0.239E+00	0.445E+00	0.200E-01	0.200E-01

PHYTO	R1SM	SK1	K1S	K2S	SSAMIN	KSCELL
1	0.500E+00	0.534E+01	0.239E+00	0.445E+00	0.350E-01	0.350E-01

PHYTO	ASINK	RDCMP	KDCMP	RADSAT	RRESP
1	0.100E+00	0.250E+00	0.200E+03	0.100E+03	0.300E-01
2	0.100E+00	0.250E+00	0.200E+03	0.100E+03	0.300E-01
3	0.100E+00	0.250E+00	0.200E+03	0.100E+03	0.300E-01
4	0.200E-01	0.500E+00	0.200E+03	0.500E+02	0.300E-01
5	0.200E-01	0.500E+00	0.200E+03	0.500E+02	0.300E-01

HERB ZOO	Z1ASSM	KZ1SAT	AZMIN	B1DETH
1	0.600E+00	0.100E+01	0.200E+00	0.300E-01

HERB ZOO	RZ1MAX	TBASZ1
1	0.550E+00	0.107E+01

HERB ZOO	PHYTO	Z1EFF
1	1	0.100E+01
1	2	0.500E+00
1	3	0.500E+00

CARN ZOO	Z2ASSM	KZ2SAT	Z12MIN	B2DETH	P2DETH	Z23MIN
1	0.600E+00	0.125E+00	0.250E-01	0.300E-01	0.100E+01	0.250E-01

CARN ZOO	RZ2MAX	TBASZ2
1	0.550E+00	0.107E+01

CARN ZOO	HERB ZOO	Z2EFF
1	1	0.100E+01

RTUP	RTUN	RTUS
0.200E-01	0.200E-01	0.200E-01

KRTUP	KRTUN	KRTUS
0.100E+01	0.100E+01	0.100E+01

TUPSNK	TUNSNK	TUSSNK
0.150E+00	0.150E+00	0.150E+00

SEDIMENT SEGMENT	VUPP	VUPN	VUPS
1	0.350E-02	0.228E-02	0.350E-02
2	0.175E-03	0.114E-03	0.175E-03
3	0.250E-03	0.162E-03	0.250E-03
4	0.417E-04	0.271E-04	0.417E-04
5	0.362E-04	0.235E-04	0.362E-04

SEDIMENT SEGMENT	KRSEDP	KRSEDN	KRSEDS
1	0.000E+00	0.000E+00	0.625E-03
2	0.000E+00	0.000E+00	0.625E-03
3	0.000E+00	0.000E+00	0.625E-03
4	0.000E+00	0.000E+00	0.625E-03
5	0.000E+00	0.000E+00	0.625E-03

SEDIMENT SEGMENT	VPLONG	VNLONG	VSLONG
1	0.000E+00	0.000E+00	0.000E+00
2	0.822E-05	0.822E-05	0.822E-05
3	0.000E+00	0.000E+00	0.000E+00
4	0.822E-05	0.822E-05	0.822E-05
5	0.822E-05	0.822E-05	0.822E-05

NEVNTS = 24

TSTART	TSTOP
98.	99.
103.	105.
111.	113.
118.	119.
121.	122.
126.	127.
129.	130.
132.	133.
134.	135.
158.	160.
161.	162.
184.	185.
201.	202.
223.	224.
238.	239.
243.	244.
254.	255.

258.	259.
267.	268.
272.	273.
274.	275.
277.	279.
294.	296.
309.	310.

********** INICON INPUT **********

SEGMENT	AVP	AVN	AVS	TUP	TUN	TUS	CL
1	0.112E-01	0.631E+00	0.395E+00	0.412E-01	0.381E-01	0.395E+00	0.250E+02
2	0.539E-02	0.128E+01	0.700E+00	0.131E-01	0.381E-01	0.700E+00	0.220E+02
3	0.694E-02	0.148E+01	0.540E+00	0.227E-01	0.150E+00	0.540E+00	0.290E+02
4	0.291E-02	0.298E+00	0.493E+00	0.184E-02	0.146E+00	0.493E+00	0.500E+01
5	0.490E-02	0.300E+00	0.381E+00	0.366E-02	0.218E+00	0.381E+00	0.800E+01

SEGMENT	PHYTO	A	PSA	NSA	SSA
1	1	0.194E+01	0.125E-02	0.350E-01	0.105E+00
1	2	0.219E-01	0.250E-02	0.700E-01	0.000E+00
1	3	0.310E-01	0.250E-02	0.700E-01	0.000E+00
1	4	0.668E-01	0.500E-02	0.700E-01	0.000E+00
1	5	0.319E-01	0.500E-02	0.700E-01	0.000E+00

SEGMENT	PHYTO	A	PSA	NSA	SSA
2	1	0.894E+00	0.125E-02	0.350E-01	0.105E+00
2	2	0.421E-02	0.250E-02	0.700E-01	0.000E+00
2	3	0.448E-01	0.250E-02	0.700E-01	0.000E+00
2	4	0.473E-01	0.500E-02	0.700E-01	0.000E+00
2	5	0.343E-02	0.500E-02	0.700E-01	0.000E+00

SEGMENT	PHYTO	A	PSA	NSA	SSA
3	1	0.169E+01	0.125E-02	0.350E-01	0.105E+00
3	2	0.425E-01	0.250E-02	0.700E-01	0.000E+00
3	3	0.293E-01	0.250E-02	0.700E-01	0.000E+00
3	4	0.144E+00	0.500E-02	0.700E-01	0.000E+00
3	5	0.230E-01	0.500E-02	0.700E-01	0.000E+00

SEGMENT	PHYTO	A	PSA	NSA	SSA
4	1	0.590E+00	0.125E-02	0.350E-01	0.105E+00
4	2	0.137E-01	0.250E-02	0.700E-01	0.000E+00
4	3	0.120E+00	0.250E-02	0.700E-01	0.000E+00
4	4	0.646E-02	0.500E-02	0.700E-01	0.000E+00
4	5	0.402E-03	0.500E-02	0.700E-01	0.000E+00

SEGMENT	PHYTO	A	PSA	NSA	SSA
5	1	0.834E+00	0.125E-02	0.350E-01	0.105E+00
5	2	0.138E-01	0.250E-02	0.700E-01	0.000E+00
5	3	0.736E-01	0.250E-02	0.700E-01	0.000E+00
5	4	0.416E-01	0.500E-02	0.700E-01	0.000E+00

5	5	0.203E-02	0.500E-02	0.700E-01	0.000E+00

SEGMENT	HERB ZOO	Z1
1	1	0.150E-02
2	1	0.130E-02
3	1	0.246E-02
4	1	0.377E-03
5	1	0.780E-02

SEGMENT	CARN ZOO	Z2
1	1	0.282E-01
2	1	0.312E-01
3	1	0.316E-01
4	1	0.807E-03
5	1	0.247E-01

SEGMENT	SEDP	SEDN	SEDS
1	0.335E+01	0.378E+02	0.134E+02
2	0.120E+03	0.136E+04	0.479E+03
3	0.120E+03	0.136E+04	0.479E+03
4	0.316E+02	0.357E+03	0.126E+03
5	0.406E+02	0.459E+03	0.162E+03

SEGMENT	WAVPA	WAVNA	WAVSA	WTUPA	WTUNA	WTUSA	WCLA
1	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
2	0.173E+02	0.255E+04	0.237E+03	0.423E+02	0.115E+04	0.237E+03	0.000E+00
3	0.731E+01	0.108E+04	0.100E+03	0.179E+02	0.486E+03	0.100E+03	0.000E+00
4	0.128E+02	0.189E+04	0.176E+03	0.314E+02	0.853E+03	0.176E+03	0.000E+00
5	0.133E+02	0.196E+04	0.182E+03	0.325E+02	0.883E+03	0.182E+03	0.000E+00

****

**************** DAY = 0. ****************

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********** DAY = 0. SEGMENT = 1 **********

TEMPERATURE = 0.577E+00
LIGHT INTENSITY = 0.100E+02
XTINC COEFF = 0.144E+01

TOTAL PHYTO = 0.209E+01
TOTAL ZOO = 0.297E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.555E-01	0.748E+00	0.994E+00
SEDIMENT	0.335E+01	0.378E+02	0.134E+02

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.112E-01	0.631E+00	0.395E+00	0.412E-01	0.381E-01	0.395E+00	0.250E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.193E-02	0.561E-01	0.136E+00
MG/MG TOT PHYTO	0.922E-03	0.268E-01	0.649E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.391E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.147E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SS
1	0.194E+01	0.928E+00	0.125E-02	0.250E+01	0.350E-01	0.350E+01	0.105E+00	0.300E-
2	0.219E-01	0.105E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E-
3	0.310E-01	0.148E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E-
4	0.668E-01	0.319E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E-
5	0.319E-01	0.153E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E-

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.198E-01	0.384E-01	0.198E-01	0.236E-01	0.220E-01	0.322E+00	0.426E-01
2	0.165E-01	0.361E-03	0.165E-01	0.196E-01	0.990E+02	0.269E+00	0.426E-01
3	0.173E-01	0.537E-03	0.173E-01	0.206E-01	0.990E+02	0.322E+00	0.426E-01
4	0.160E-01	0.107E-02	0.180E-01	0.160E-01	0.990E+02	0.188E+00	0.748E-01
5	0.160E-01	0.511E-03	0.180E-01	0.160E-01	0.990E+02	0.188E+00	0.748E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.150E-02	0.588E-01	0.806E-02	0.269E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.282E-01	0.000E+00	0.806E-02	0.269E+00

LOADINGS (KG/DAY)

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.123E+04	0.223E+05	0.548E+05	0.184E+04	0.984E+04	0.552E+05	0.105E+07
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.522E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.123E+04	0.230E+05	0.549E+05	0.185E+04	0.102E+05	0.553E+05	0.105E+07

LOADING INTEGRALS (KG)

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.123E+04	0.223E+05	0.548E+05	0.184E+04	0.984E+04	0.552E+05	0.105E+07
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.522E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.123E+04	0.230E+05	0.549E+05	0.185E+04	0.102E+05	0.553E+05	0.105E+07

RPSINK	RNSINK	RSSINK
0.150E+04	0.302E+04	0.185E+05
TPSUNK	TNSUNK	TSSUNK
0.150E+04	0.302E+04	0.185E+05
TPNET	TNNET	TSNET
0.150E+04	0.302E+04	0.185E+05

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
1	1	2	0.000E+00	0.191E+01	0.800E+00	0.800E+00
1	2	3	0.307E+03	0.589E+00	0.999E+00	0.999E+00
1	3	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1	4	1	-0.307E+03	0.000E+00	0.100E+01	0.100E+01
1	5	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00

########## DAY = 0. SEGMENT = 2 ##########

TEMPERATURE = 0.300E+00
LIGHT INTENSITY = 0.100E+02
XTINC COEFF = 0.102E+01

TOTAL PHYTO = 0.994E+00
TOTAL ZOO = 0.325E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.200E-01	0.136E+01	0.149E+01
SEDIMENT	0.120E+03	0.136E+04	0.479E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.539E-02	0.128E+01	0.700E+00	0.131E-01	0.381E-01	0.700E+00	0.220E+02

SURPLUS P SURPLUS N SURPLUS S

MG/L	0.947E-03	0.273E-01	0.626E-01
MG/MG TOT PHYTO	0.953E-03	0.275E-01	0.630E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.184E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.513E+01

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SS
1	0.894E+00	0.900E+00	0.125E-02	0.250E+01	0.350E-01	0.350E+01	0.105E+00	0.300E-
2	0.421E-02	0.424E-02	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E
3	0.448E-01	0.451E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E
4	0.473E-01	0.476E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E
5	0.343E-02	0.345E-02	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.145E-01	0.129E-01	0.145E-01	0.172E-01	0.161E-01	0.317E+00	0.317E-01
2	0.120E-01	0.506E-04	0.120E-01	0.143E-01	0.990E+02	0.264E+00	0.317E-01
3	0.127E-01	0.567E-03	0.127E-01	0.151E-01	0.990E+02	0.317E+00	0.317E-01
4	0.116E-01	0.550E-03	0.130E-01	0.116E-01	0.990E+02	0.183E+00	0.556E-01
5	0.116E-01	0.399E-04	0.130E-01	0.116E-01	0.990E+02	0.183E+00	0.556E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.130E-02	0.417E-01	0.791E-02	0.264E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.312E-01	0.000E+00	0.791E-02	0.264E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.604E+02	0.312E+04	0.261E+04	0.239E+03	0.111E+04	0.262E+04	0.000E+00
ATMOSPHERIC	0.173E+02	0.255E+04	0.237E+03	0.423E+02	0.115E+04	0.237E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.635E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.777E+02	0.567E+04	0.919E+04	0.281E+03	0.226E+04	0.286E+04	0.000E+00

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.604E+02	0.312E+04	0.261E+04	0.239E+03	0.111E+04	0.262E+04	0.000E+00
ATMOSPHERIC	0.173E+02	0.255E+04	0.237E+03	0.423E+02	0.115E+04	0.237E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.635E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.777E+02	0.567E+04	0.919E+04	0.281E+03	0.226E+04	0.286E+04	0.000E+00

RPSINK	RNSINK	RSSINK
0.168E+04	0.744E+04	0.919E+05
TPSUNK	TNSUNK	TSSUNK
0.168E+04	0.744E+04	0.919E+05
TPNET	TNNET	TSNET
0.168E+04	0.744E+04	0.856E+05

FLOW DIFFUSION

SEGMENT	INTERACTION	INTERACTING SEGMENT	(M**3/SEC)	(M**3/SEC)	ALPHA	ALPHAIN
2	1	1	0.000E+00	0.191E+01	0.200E+00	0.200E+00
2	2	3	0.000E+00	0.130E+01	0.297E+00	0.297E+00
2	3	4	0.000E+00	0.688E+00	0.467E+00	0.467E+00
2	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2	5	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00

********** DAY = 0. SEGMENT = 3 **********

TEMPERATURE = 0.739E+00
LIGHT INTENSITY = 0.100E+02
XTINC COEFF = 0.202E+01

TOTAL PHYTO = 0.193E+01
TOTAL ZOO = 0.341E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.328E-01	0.171E+01	0.126E+01
SEDIMENT	0.120E+03	0.136E+04	0.479E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.694E-02	0.148E+01	0.540E+00	0.227E-01	0.150E+00	0.540E+00	0.290E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.204E-02	0.542E-01	0.118E+00
MG/MG TOT PHYTO	0.106E-02	0.281E-01	0.613E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.360E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.101E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAMIN
1	0.169E+01	0.876E+00	0.125E-02	0.250E+01	0.350E-01	0.350E+01	0.105E+00	0.300E+01
2	0.425E-01	0.220E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
3	0.293E-01	0.152E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
4	0.144E+00	0.747E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
5	0.230E-01	0.119E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.147E-01	0.248E-01	0.147E-01	0.175E-01	0.163E-01	0.326E+00	0.313E-01
2	0.123E-01	0.521E-03	0.123E-01	0.146E-01	0.990E+02	0.272E+00	0.313E-01
3	0.128E-01	0.376E-03	0.128E-01	0.153E-01	0.990E+02	0.326E+00	0.313E-01
4	0.120E-01	0.172E-02	0.134E-01	0.120E-01	0.990E+02	0.190E+00	0.550E-01
5	0.120E-01	0.275E-03	0.134E-01	0.120E-01	0.990E+02	0.190E+00	0.550E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.246E-02	0.568E-01	0.815E-02	0.272E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2

1	0.316E-01	0.000E+00	0.815E-02	0.272E+00

LOADINGS (KG/DAY)

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.164E+02	0.777E+03	0.699E+03	0.665E+02	0.266E+03	0.701E+03	0.000E+00
ATMOSPHERIC	0.731E+01	0.108E+04	0.100E+03	0.179E+02	0.486E+03	0.100E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.277E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.237E+02	0.186E+04	0.356E+04	0.844E+02	0.752E+03	0.801E+03	0.000E+00

LOADING INTEGRALS (KG)

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.164E+02	0.777E+03	0.699E+03	0.665E+02	0.266E+03	0.701E+03	0.000E+00
ATMOSPHERIC	0.731E+01	0.108E+04	0.100E+03	0.179E+02	0.486E+03	0.100E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.277E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.237E+02	0.186E+04	0.356E+04	0.844E+02	0.752E+03	0.801E+03	0.000E+00

RPSINK	RNSINK	RSSINK
0.124E+04	0.990E+04	0.335E+05
TPSUNK	TNSUNK	TSSUNK
0.124E+04	0.990E+04	0.335E+05
TPNET	TNNET	TSNET
0.124E+04	0.990E+04	0.308E+05

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
3	1	1	-0.307E+03	0.589E+00	0.100E-02	0.960E-03
3	2	2	0.000E+00	0.130E+01	0.703E+00	0.703E+00
3	3	5	0.307E+03	0.406E+00	0.999E+00	0.999E+00
3	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3	5	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00

########## DAY = 0. SEGMENT = 4 ##########

TEMPERATURE = 0.674E+00
LIGHT INTENSITY = 0.100E+02
XTINC COEFF = 0.528E+00

TOTAL PHYTO = 0.731E+00
TOTAL ZOO = 0.118E-02

	TOTAL P	TOTAL N	TOTAL S
WATER	0.586E-02	0.475E+00	0.105E+01
SEDIMENT	0.316E+02	0.357E+03	0.126E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL

0.291E-02	0.298E+00	0.493E+00	0.184E-02	0.146E+00	0.493E+00	0.500E+01

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.670E-03	0.218E-01	0.413E-01
MG/MG TOT PHYTO	0.918E-03	0.298E-01	0.565E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.145E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.425E+01

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAMIN
1	0.590E+00	0.808E+00	0.125E-02	0.250E+01	0.350E-01	0.350E+01	0.105E+00	0.300E+01
2	0.137E-01	0.188E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
3	0.120E+00	0.164E+00	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
4	0.646E-02	0.884E-02	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
5	0.402E-03	0.550E-03	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.159E-01	0.937E-02	0.159E-01	0.189E-01	0.176E-01	0.324E+00	0.340E-01
2	0.132E-01	0.181E-03	0.132E-01	0.158E-01	0.990E+02	0.270E+00	0.340E-01
3	0.139E-01	0.167E-02	0.139E-01	0.165E-01	0.990E+02	0.324E+00	0.340E-01
4	0.129E-01	0.834E-04	0.145E-01	0.129E-01	0.990E+02	0.189E+00	0.597E-01
5	0.129E-01	0.519E-05	0.145E-01	0.129E-01	0.990E+02	0.189E+00	0.597E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.377E-03	0.354E-01	0.811E-02	0.270E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.807E-03	0.000E+00	0.811E-02	0.270E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.136E+02	0.742E+03	0.751E+03	0.516E+02	0.218E+03	0.749E+03	0.000E+00
ATMOSPHERIC	0.128E+02	0.189E+04	0.176E+03	0.314E+02	0.853E+03	0.176E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.127E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.264E+02	0.263E+04	0.220E+04	0.830E+02	0.107E+04	0.925E+03	0.000E+00

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.136E+02	0.742E+03	0.751E+03	0.516E+02	0.218E+03	0.749E+03	0.000E+00
ATMOSPHERIC	0.128E+02	0.189E+04	0.176E+03	0.314E+02	0.853E+03	0.176E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.127E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.264E+02	0.263E+04	0.220E+04	0.830E+02	0.107E+04	0.925E+03	0.000E+00

RPSINK	RNSINK	RSSINK
0.229E+03	0.149E+05	0.478E+05
TPSUNK	TNSUNK	TSSUNK
0.229E+03	0.149E+05	0.478E+05
TPNET	TNNET	TSNET
0.229E+03	0.149E+05	0.466E+05

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
4	1	2	0.000E+00	0.688E+00	0.533E+00	0.533E+00
4	2	5	0.300E+04	0.236E+02	0.996E+00	0.996E+00
4	3	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4	5	4	-0.300E+04	0.253E+02	0.996E+00	0.996E+00

********** BOUNDARY VALUES **********

TPBD	AVPBD	TKNBD	NO3BD	NH3BD	TSBD	AVSBD	CLBD
0.415E-02	0.102E-02	0.124E+00	0.272E+00	0.123E-01	0.132E+01	0.660E+00	0.527E+01

AVPBD	AVNBD	AVSBD	TUPBD	TUNBD	TUSBD	CLBD
0.102E-02	0.284E+00	0.660E+00	0.291E-02	0.101E+00	0.632E+00	0.527E+01

PHYTO	A	PSABD	NSABD	SSABD
1	0.203E+00	0.750E-03	0.400E-01	0.140E+00
2	0.435E-02	0.150E-02	0.800E-01	0.000E+00
3	0.198E-01	0.150E-02	0.800E-01	0.000E+00
4	0.488E-02	0.200E-02	0.800E-01	0.000E+00
5	0.824E-03	0.200E-02	0.800E-01	0.000E+00

HERB ZOO	Z1BD
1	0.581E-02

CARN ZOO	Z2BD
1	0.265E-01

********** DAY = 0. SEGMENT = 5 **********

TEMPERATURE = 0.674E+00
LIGHT INTENSITY = 0.100E+02
XTINC COEFF = 0.922E+00

TOTAL PHYTO = 0.365E+00
TOTAL ZOO = 0.325E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.101E-01	0.557E+00	0.850E+00
SEDIMENT	0.406E+02	0.459E+03	0.162E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.490E-02	0.300E+00	0.381E+00	0.366E-02	0.218E+00	0.381E+00	0.800E+01

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.931E-03	0.274E-01	0.584E-01

MG/MG TOT PHYTO 0.965E-03 0.284E-01 0.605E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.185E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.275E+01

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAMI
1	0.834E+00	0.864E+00	0.125E-02	0.250E+01	0.350E-01	0.350E+01	0.105E+00	0.300E+01
2	0.138E-01	0.143E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
3	0.736E-01	0.763E-01	0.250E-02	0.250E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
4	0.416E-01	0.431E-01	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
5	0.203E-02	0.210E-02	0.500E-02	0.500E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	ALIGHT
1	0.790E-02	0.659E-02	0.790E-02	0.941E-02	0.878E-02	0.324E+00	0.169E-01
2	0.659E-02	0.909E-04	0.659E-02	0.784E-02	0.990E+02	0.270E+00	0.169E-01
3	0.691E-02	0.509E-03	0.691E-02	0.823E-02	0.990E+02	0.324E+00	0.169E-01
4	0.642E-02	0.267E-03	0.719E-02	0.642E-02	0.990E+02	0.189E+00	0.297E-01
5	0.642E-02	0.130E-04	0.719E-02	0.642E-02	0.990E+02	0.189E+00	0.297E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.780E-02	0.417E-01	0.811E-02	0.270E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.247E-01	0.000E+00	0.811E-02	0.270E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.441E+02	0.234E+04	0.206E+04	0.177E+03	0.643E+03	0.205E+04	0.000E+00
ATMOSPHERIC	0.133E+02	0.196E+04	0.182E+03	0.325E+02	0.883E+03	0.182E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.169E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.574E+02	0.430E+04	0.393E+04	0.209E+03	0.153E+04	0.223E+04	0.000E+00

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.441E+02	0.234E+04	0.206E+04	0.177E+03	0.643E+03	0.205E+04	0.000E+00
ATMOSPHERIC	0.133E+02	0.196E+04	0.182E+03	0.325E+02	0.883E+03	0.182E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.169E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.574E+02	0.430E+04	0.393E+04	0.209E+03	0.153E+04	0.223E+04	0.000E+00

RPSINK	RNSINK	RSSINK
0.420E+03	0.224E+05	0.407E+05
TPSUNK	TNSUNK	TSSUNK
0.420E+03	0.224E+05	0.407E+05
TPNET	TNNET	TSNET
0.420E+03	0.224E+05	0.390E+05

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN

5	1	3	-0.307E+03	0.406E+00	0.100E-02	0.662E-03
5	2	4	-0.300E+04	0.236E+02	0.400E-02	0.393E-02
5	3	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5	5	5	0.331E+04	0.107E+02	0.998E+00	0.998E+00

********** BOUNDARY VALUES **********

TPBD	AVPBD	TKNBD	NO3BD	NH3BD	TSBD	AVSBD	CLBD
0.518E-02	0.102E-02	0.195E+00	0.293E+00	0.109E-01	0.138E+01	0.688E+00	0.527E+01

AVPBD	AVNBD	AVSBD	TUPBD	TUNBD	TUSBD	CLBD
0.102E-02	0.304E+00	0.688E+00	0.377E-02	0.165E+00	0.646E+00	0.527E+01

PHYTO	A	PSABD	NSABD	SSABD
1	0.331E+00	0.750E-03	0.400E-01	0.140E+00
2	0.596E-02	0.150E-02	0.800E-01	0.000E+00
3	0.285E-01	0.150E-02	0.800E-01	0.000E+00
4	0.293E-01	0.200E-02	0.800E-01	0.000E+00
5	0.522E-02	0.200E-02	0.800E-01	0.000E+00

HERB ZOO	Z1BD
1	0.115E-01

CARN ZOO	Z2BD
1	0.322E-01

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*************** DAY = 5. ***************

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********** DAY = 5. SEGMENT = 1 **********

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TEMPERATURE     = 0.693E+00
LIGHT INTENSITY = 0.106E+02
XTINC COEFF     = 0.131E+01

TOTAL PHYTO = 0.150E+01
TOTAL ZOO   = 0.245E-01
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	TOTAL P	TOTAL N	TOTAL S
WATER	0.555E-01	0.787E+00	0.124E+01
SEDIMENT	0.639E+01	0.454E+02	0.582E+02

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.167E-01	0.634E+00	0.542E+00	0.367E-01	0.713E-01	0.502E+00	0.265E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.123E-02	0.459E-01	0.142E+00
MG/MG TOT PHYTO	0.821E-03	0.307E-01	0.950E-01

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PRIM PROD RATE (MG C/M**3/HR)      = 0.276E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.633E+02
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PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAMIN
1	0.139E+01	0.928E+00	0.111E-02	0.222E+01	0.390E-01	0.390E+01	0.137E+00	0.392E+01
2	0.155E-01	0.104E-01	0.246E-02	0.246E+01	0.729E-01	0.365E+01	0.000E+00	0.000E+00
3	0.220E-01	0.147E-01	0.247E-02	0.247E+01	0.738E-01	0.369E+01	0.000E+00	0.000E+00
4	0.473E-01	0.316E-01	0.601E-02	0.601E+01	0.710E-01	0.355E+01	0.000E+00	0.000E+00
5	0.226E-01	0.151E-01	0.490E-02	0.490E+01	0.710E-01	0.355E+01	0.000E+00	0.000E+00

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.210E-01	0.165E+00	0.210E-01	0.284E-01	0.284E-01	0.325E+00	0.489E-01
2	0.189E-01	0.163E-02	0.189E-01	0.231E-01	0.990E+02	0.271E+00	0.489E-01
3	0.198E-01	0.242E-02	0.198E-01	0.243E-01	0.990E+02	0.325E+00	0.489E-01
4	0.186E-01	0.486E-02	0.215E-01	0.186E-01	0.990E+02	0.189E+00	0.853E-01
5	0.186E-01	0.232E-02	0.206E-01	0.186E-01	0.990E+02	0.189E+00	0.853E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.164E-02	0.524E-01	0.812E-02	0.271E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.229E-01	0.000E+00	0.812E-02	0.271E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.110E+04	0.199E+05	0.405E+05	0.157E+04	0.762E+04	0.405E+05	0.840E+06
ATMOSPHERIC	0.499E+01	0.737E+03	0.684E+02	0.122E+02	0.332E+03	0.684E+02	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.224E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.111E+04	0.206E+05	0.406E+05	0.158E+04	0.795E+04	0.406E+05	0.840E+06

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.596E+04	0.105E+06	0.235E+06	0.839E+04	0.436E+05	0.235E+06	0.472E+07
ATMOSPHERIC	0.249E+02	0.368E+04	0.342E+03	0.610E+02	0.166E+04	0.342E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.583E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.599E+04	0.109E+06	0.235E+06	0.846E+04	0.452E+05	0.236E+06	0.472E+07

RPSINK	RNSINK	RSSINK
0.132E+04	0.382E+04	0.219E+05
TPSUNK	TNSUNK	TSSUNK
0.714E+04	0.171E+05	0.102E+06
TPNET	TNNET	TSNET
0.714E+04	0.171E+05	0.102E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
1	1	2	0.000E+00	0.191E+01	0.800E+00	0.800E+00
1	2	3	0.307E+03	0.589E+00	0.999E+00	0.999E+00
1	3	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1	4	1	-0.307E+03	0.000E+00	0.100E+01	0.100E+01
1	5	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00

********** DAY = 5. SEGMENT = 2 **********

TEMPERATURE = 0.357E+00
LIGHT INTENSITY = 0.106E+02
XTINC COEFF = 0.101E+01

TOTAL PHYTO = 0.871E+00
TOTAL ZOO = 0.303E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.190E-01	0.136E+01	0.143E+01
SEDIMENT	0.120E+03	0.136E+04	0.484E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.575E-02	0.128E+01	0.692E+00	0.120E-01	0.371E-01	0.630E+00	0.220E+02

SURPLUS P SURPLUS N SURPLUS S

MG/L	0.733E-03	0.263E-01	0.797E-01
MG/MG TOT PHYTO	0.841E-03	0.302E-01	0.915E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.153E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.236E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSAMI
1	0.786E+00	0.902E+00	0.111E-02	0.222E+01	0.379E-01	0.379E+01	0.137E+00	0.390E+01
2	0.367E-02	0.422E-02	0.245E-02	0.245E+01	0.714E-01	0.357E+01	0.000E+00	0.000E+00
3	0.390E-01	0.448E-01	0.246E-02	0.246E+01	0.721E-01	0.360E+01	0.000E+00	0.000E+00
4	0.401E-01	0.460E-01	0.554E-02	0.554E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00
5	0.291E-02	0.334E-02	0.488E-02	0.488E+01	0.700E-01	0.350E+01	0.000E+00	0.000E+00

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.141E-01	0.591E-01	0.141E-01	0.189E-01	0.191E-01	0.318E+00	0.337E-01
2	0.127E-01	0.242E-03	0.127E-01	0.154E-01	0.990E+02	0.265E+00	0.337E-01
3	0.133E-01	0.271E-02	0.133E-01	0.163E-01	0.990E+02	0.318E+00	0.337E-01
4	0.124E-01	0.262E-02	0.142E-01	0.124E-01	0.990E+02	0.184E+00	0.587E-01
5	0.124E-01	0.190E-03	0.137E-01	0.124E-01	0.990E+02	0.184E+00	0.587E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.153E-02	0.391E-01	0.794E-02	0.265E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.288E-01	0.000E+00	0.794E-02	0.265E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.604E+02	0.312E+04	0.261E+04	0.239E+03	0.111E+04	0.262E+04	0.000E+00
ATMOSPHERIC	0.173E+02	0.255E+04	0.237E+03	0.423E+02	0.115E+04	0.237E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.644E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.777E+02	0.567E+04	0.928E+04	0.281E+03	0.226E+04	0.286E+04	0.000E+00

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.302E+03	0.156E+05	0.130E+05	0.119E+04	0.554E+04	0.131E+05	0.000E+00
ATMOSPHERIC	0.865E+02	0.128E+05	0.118E+04	0.211E+03	0.575E+04	0.118E+04	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.319E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.388E+03	0.284E+05	0.461E+05	0.140E+04	0.113E+05	0.143E+05	0.000E+00

RPSINK	RNSINK	RSSINK
0.153E+04	0.717E+04	0.847E+05
TPSUNK	TNSUNK	TSSUNK
0.809E+04	0.368E+05	0.447E+06
TPNET	TNNET	TSNET
0.809E+04	0.368E+05	0.415E+06

FLOW DIFFUSION

SEGMENT	INTERACTION	INTERACTING SEGMENT	(M**3/SEC)	(M**3/SEC)	ALPHA	ALPHAIN
2	1	1	0.000E+00	0.191E+01	0.200E+00	0.200E+00
2	2	3	0.000E+00	0.130E+01	0.297E+00	0.297E+00
2	3	4	0.000E+00	0.688E+00	0.467E+00	0.467E+00
2	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2	5	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00

********* DAY = 5. SEGMENT = 3 *********

TEMPERATURE = 0.760E+00
LIGHT INTENSITY = 0.106E+02
XTINC COEFF = 0.160E+01

TOTAL PHYTO = 0.154E+01
TOTAL ZOO = 0.316E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.311E-01	0.159E+01	0.114E+01
SEDIMENT	0.120E+03	0.136E+04	0.483E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.839E-02	0.141E+01	0.514E+00	0.204E-01	0.119E+00	0.443E+00	0.287E+02

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.148E-02	0.464E-01	0.140E+00
MG/MG TOT PHYTO	0.961E-03	0.301E-01	0.910E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.278E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.478E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SS
1	0.136E+01	0.883E+00	0.111E-02	0.222E+01	0.375E-01	0.375E+01	0.138E+00	0.394E
2	0.319E-01	0.207E-01	0.245E-02	0.245E+01	0.706E-01	0.353E+01	0.000E+00	0.000E
3	0.232E-01	0.150E-01	0.246E-02	0.246E+01	0.713E-01	0.357E+01	0.000E+00	0.000E
4	0.106E+00	0.688E-01	0.572E-02	0.572E+01	0.693E-01	0.347E+01	0.000E+00	0.000E
5	0.185E-01	0.120E-01	0.489E-02	0.489E+01	0.694E-01	0.347E+01	0.000E+00	0.000E

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	ALIGHT
1	0.178E-01	0.117E+00	0.178E-01	0.238E-01	0.242E-01	0.326E+00	0.414E-01
2	0.160E-01	0.250E-02	0.160E-01	0.194E-01	0.990E+02	0.272E+00	0.414E-01
3	0.168E-01	0.185E-02	0.168E-01	0.204E-01	0.990E+02	0.326E+00	0.414E-01
4	0.157E-01	0.822E-02	0.182E-01	0.157E-01	0.990E+02	0.191E+00	0.723E-01
5	0.157E-01	0.136E-02	0.175E-01	0.157E-01	0.990E+02	0.191E+00	0.723E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.297E-02	0.523E-01	0.816E-02	0.272E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2

1	0.286E-01	0.000E+00	0.816E-02	0.272E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.164E+02	0.777E+03	0.699E+03	0.665E+02	0.266E+03	0.701E+03	0.000E+00
ATMOSPHERIC	0.731E+01	0.108E+04	0.100E+03	0.179E+02	0.486E+03	0.100E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.279E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.237E+02	0.186E+04	0.359E+04	0.844E+02	0.752E+03	0.801E+03	0.000E+00

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.820E+02	0.388E+04	0.349E+04	0.332E+03	0.133E+04	0.350E+04	0.000E+00
ATMOSPHERIC	0.365E+02	0.540E+04	0.500E+03	0.895E+02	0.243E+04	0.500E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.139E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.119E+03	0.928E+04	0.179E+05	0.422E+03	0.376E+04	0.400E+04	0.000E+00

RPSINK	RNSINK	RSSINK
0.110E+04	0.805E+04	0.291E+05
TPSUNK	TNSUNK	TSSUNK
0.591E+04	0.457E+05	0.160E+06
TPNET	TNNET	TSNET
0.591E+04	0.457E+05	0.146E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
3	1	1	-0.307E+03	0.589E+00	0.100E-02	0.960E-03
3	2	2	0.000E+00	0.130E+01	0.703E+00	0.703E+00
3	3	5	0.307E+03	0.406E+00	0.999E+00	0.999E+00
3	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3	5	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00

********** DAY = 5. SEGMENT = 4 **********

TEMPERATURE = 0.708E+00
LIGHT INTENSITY = 0.106E+02
XTINC COEFF = 0.534E+00

TOTAL PHYTO = 0.609E+00
TOTAL ZOO = 0.588E-02

	TOTAL P	TOTAL N	TOTAL S
WATER	0.553E-02	0.457E+00	0.106E+01
SEDIMENT	0.316E+02	0.358E+03	0.130E+03

AVP AVN AVS TUP TUN TUS CL

0.272E-02	0.295E+00	0.509E+00	0.197E-02	0.132E+00	0.487E+00	0.504E+01

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.469E-03	0.218E-01	0.513E-01
MG/MG TOT PHYTO	0.771E-03	0.357E-01	0.843E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.116E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.191E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSA
1	0.495E+00	0.813E+00	0.109E-02	0.219E+01	0.407E-01	0.407E+01	0.139E+00	0.396E+
2	0.114E-01	0.187E-01	0.240E-02	0.240E+01	0.771E-01	0.385E+01	0.000E+00	0.000E+
3	0.965E-01	0.159E+00	0.242E-02	0.242E+01	0.779E-01	0.390E+01	0.000E+00	0.000E+
4	0.565E-02	0.928E-02	0.484E-02	0.484E+01	0.752E-01	0.376E+01	0.000E+00	0.000E+
5	0.427E-03	0.702E-03	0.414E-02	0.414E+01	0.759E-01	0.380E+01	0.000E+00	0.000E+

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.149E-01	0.418E-01	0.149E-01	0.207E-01	0.205E-01	0.325E+00	0.352E-01
2	0.134E-01	0.839E-03	0.134E-01	0.170E-01	0.990E+02	0.271E+00	0.352E-01
3	0.141E-01	0.764E-02	0.141E-01	0.179E-01	0.990E+02	0.325E+00	0.352E-01
4	0.137E-01	0.403E-03	0.148E-01	0.137E-01	0.990E+02	0.190E+00	0.615E-01
5	0.137E-01	0.273E-04	0.142E-01	0.137E-01	0.990E+02	0.190E+00	0.615E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.129E-02	0.318E-01	0.813E-02	0.271E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.459E-02	0.000E+00	0.813E-02	0.271E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.136E+02	0.742E+03	0.751E+03	0.516E+02	0.218E+03	0.749E+03	0.000E+00
ATMOSPHERIC	0.128E+02	0.189E+04	0.176E+03	0.314E+02	0.853E+03	0.176E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.131E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.264E+02	0.263E+04	0.224E+04	0.830E+02	0.107E+04	0.925E+03	0.000E+00

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.680E+02	0.371E+04	0.375E+04	0.258E+03	0.109E+04	0.374E+04	0.000E+00
ATMOSPHERIC	0.640E+02	0.945E+04	0.880E+03	0.157E+03	0.426E+04	0.880E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.644E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.132E+03	0.132E+05	0.111E+05	0.415E+03	0.535E+04	0.462E+04	0.000E+00

RPSINK	RNSINK	RSSINK
0.225E+03	0.136E+05	0.477E+05
TPSUNK	TNSUNK	TSSUNK
0.113E+04	0.719E+05	0.240E+06
TPNET	TNNET	TSNET
0.113E+04	0.719E+05	0.233E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN
4	1	2	0.000E+00	0.688E+00	0.533E+00	0.533E+00
4	2	5	0.300E+04	0.236E+02	0.996E+00	0.996E+00
4	3	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4	5	4	-0.300E+04	0.253E+02	0.996E+00	0.996E+00

********** BOUNDARY VALUES **********

TPBD	AVPBD	TKNBD	NO3BD	NH3BD	TSBD	AVSBD	CLBD
0.415E-02	0.104E-02	0.125E+00	0.272E+00	0.124E-01	0.134E+01	0.668E+00	0.527E+01

AVPBD	AVNBD	AVSBD	TUPBD	TUNBD	TUSBD	CLBD
0.104E-02	0.284E+00	0.668E+00	0.289E-02	0.102E+00	0.640E+00	0.527E+01

PHYTO	A	PSABD	NSABD	SSABD
1	0.200E+00	0.750E-03	0.400E-01	0.140E+00
2	0.449E-02	0.150E-02	0.800E-01	0.000E+00
3	0.197E-01	0.150E-02	0.800E-01	0.000E+00
4	0.481E-02	0.200E-02	0.800E-01	0.000E+00
5	0.826E-03	0.200E-02	0.800E-01	0.000E+00

HERB ZOO	Z1BD
1	0.563E-02

CARN ZOO	Z2BD
1	0.260E-01

********** DAY = 5. SEGMENT = 5 **********

TEMPERATURE = 0.708E+00
LIGHT INTENSITY = 0.106E+02
XTINC COEFF = 0.935E+00

TOTAL PHYTO = 0.793E+00
TOTAL ZOO = 0.291E-01

	TOTAL P	TOTAL N	TOTAL S
WATER	0.971E-02	0.551E+00	0.863E+00
SEDIMENT	0.406E+02	0.461E+03	0.165E+03

AVP	AVN	AVS	TUP	TUN	TUS	CL
0.492E-02	0.317E+00	0.386E+00	0.365E-02	0.197E+00	0.380E+00	0.789E+01

	SURPLUS P	SURPLUS N	SURPLUS S
MG/L	0.676E-03	0.276E-01	0.729E-01

MG/MG TOT PHYTO 0.853E-03 0.348E-01 0.919E-01

PRIM PROD RATE (MG C/M**3/HR) = 0.148E+02
INTEGRAL PRIM PROD RATE (MG C/M**3) = 0.123E+02

PHYTO	A	FCROP	PSA	PSA/PSAMIN	NSA	NSA/NSAMIN	SSA	SSA/SSA
1	0.685E+00	0.863E+00	0.112E-02	0.223E+01	0.411E-01	0.411E+01	0.141E+00	0.404E+
2	0.118E-01	0.149E-01	0.247E-02	0.247E+01	0.780E-01	0.390E+01	0.000E+00	0.000E+
3	0.658E-01	0.829E-01	0.247E-02	0.247E+01	0.790E-01	0.395E+01	0.000E+00	0.000E+
4	0.293E-01	0.369E-01	0.560E-02	0.560E+01	0.760E-01	0.380E+01	0.000E+00	0.000E+
5	0.161E-02	0.203E-02	0.495E-02	0.495E+01	0.758E-01	0.379E+01	0.000E+00	0.000E+

PHYTO	SPGR	BPI	R2PS	R2NS	R2SS	TWGTA	RLIGHT
1	0.752E-02	0.292E-01	0.752E-02	0.103E-01	0.103E-01	0.325E+00	0.175E-01
2	0.676E-02	0.430E-03	0.676E-02	0.845E-02	0.990E+02	0.271E+00	0.175E-01
3	0.710E-02	0.245E-02	0.710E-02	0.890E-02	0.990E+02	0.325E+00	0.175E-01
4	0.682E-02	0.119E-02	0.760E-02	0.682E-02	0.990E+02	0.190E+00	0.305E-01
5	0.681E-02	0.606E-04	0.739E-02	0.681E-02	0.990E+02	0.190E+00	0.305E-01

HERB ZOO	Z1	RZ1	Z1LSS1	TWGTZ1
1	0.800E-02	0.377E-01	0.813E-02	0.271E+00

CARN ZOO	Z2	RZ2	Z2LSS1	TWGTZ2
1	0.211E-01	0.000E+00	0.813E-02	0.271E+00

***** LOADINGS (KG/DAY) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.441E+02	0.234E+04	0.206E+04	0.177E+03	0.643E+03	0.205E+04	0.000E+00
ATMOSPHERIC	0.133E+02	0.196E+04	0.182E+03	0.325E+02	0.883E+03	0.182E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.173E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.574E+02	0.430E+04	0.397E+04	0.209E+03	0.153E+04	0.223E+04	0.000E+00

***** LOADING INTEGRALS (KG) *****

	WAVP	WAVN	WAVS	WTUP	WTUN	WTUS	WCL
TRIBUTARY	0.220E+03	0.117E+05	0.103E+05	0.885E+03	0.321E+04	0.102E+05	0.000E+00
ATMOSPHERIC	0.665E+02	0.980E+04	0.910E+03	0.162E+03	0.441E+04	0.910E+03	0.000E+00
SEDIMENT	0.000E+00	0.000E+00	0.853E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTAL	0.287E+03	0.215E+05	0.197E+05	0.105E+04	0.763E+04	0.112E+05	0.000E+00

RPSINK	RNSINK	RSSINK
0.399E+03	0.205E+05	0.412E+05
TPSUNK	TNSUNK	TSSUNK
0.205E+04	0.109E+06	0.206E+06
TPNET	TNNET	TSNET
0.205E+04	0.109E+06	0.198E+06

SEGMENT	INTERACTION	INTERACTING SEGMENT	FLOW (M**3/SEC)	DIFFUSION (M**3/SEC)	ALPHA	ALPHAIN

5	1	3	-0.307E+03	0.406E+00	0.100E-02	0.662E-03
5	2	4	-0.300E+04	0.236E+02	0.400E-02	0.393E-02
5	3	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5	4	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5	5	5	0.331E+04	0.107E+02	0.998E+00	0.998E+00

********** BOUNDARY VALUES **********

TPBD	AVPBD	TKNBD	NO3BD	NH3BD	TSBD	AVSBD	CLBD
0.518E-02	0.104E-02	0.196E+00	0.293E+00	0.109E-01	0.139E+01	0.693E+00	0.527E+01

AVPBD	AVNBD	AVSBD	TUPBD	TUNBD	TUSBD	CLBD
0.104E-02	0.304E+00	0.693E+00	0.375E-02	0.166E+00	0.651E+00	0.527E+01

PHYTO	A	PSABD	NSABD	SSABD
1	0.327E+00	0.750E-03	0.400E-01	0.140E+00
2	0.576E-02	0.150E-02	0.800E-01	0.000E+00
3	0.309E-01	0.150E-02	0.800E-01	0.000E+00
4	0.283E-01	0.200E-02	0.800E-01	0.000E+00
5	0.506E-02	0.200E-02	0.800E-01	0.000E+00

HERB ZOO	Z1BD
1	0.111E-01

CARN ZOO	Z2BD
1	0.316E-01