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Operation manual for the VIMS combined Hydrodynamic-Ecosystem Model (HEM)

Virginia Institute of Marine Science

Operation Manual
for
the VIMS Combined
Hydrodynamic-Ecosystem Model (HEM)

prepared for the

Virginia State Water Control Board

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Table of Contents

List of Figures

List of Tables

I. INTRODUCTION

Since about 1970, VIMS has been developing water quality simulation models for the Virginia State Water Control Board under the Cooperative State Agencies (CSA) agreement. Under this agreement, VIMS has conducted field programs and developed and validated a number of water quality models. In order to make this accumulated experience available to the State Water Control Board and others, VIMS has prepared a users' manual and sample cases for the combined hydrodynamic-ecosystem model (HEM).

This model is intended for use in simulating water quality conditions in a tidal estuary. It is suitable for relatively elongated estuaries possessing a viable phytoplankton population.

It is assumed that the reader is a professional in the field of water quality analysis and prediction. Accordingly, this manual will not dwell on the staging of field studies or the need to document and understand the biochemical processes at work in the estuary. Instead the manual will concentrate on implementing the hydrodynamic-ecosystem model. The following chapters will explain the underlying physics and biochemistry incorporated in this model, describe the data necessary to run the model, and explain how to prepare the input files. Next, the procedures of calibration, verification and sensitivity analysis will be discussed in detail. Finally, the input files and output results for a test case will be presented.

II. MODEL DEVELOPMENT

The model 'package' consists of a hydrodynamic submodel and a water quality submodel, linked externally. The linkage between the two consists of geometric information as well as a time-series record of water velocity and tidal height, which is generated by the hydrodynamic submodel and output to a direct-access file. This file is read sequentially by the water quality submodel and used in the calculation of transport processes. This external linkage has the advantages of speed and economy, since the hydrodynamic submodel, once validated, needs to be rerun only once for each hydrographic condition, from which several water quality model runs may be made.

Both submodels need a variety of inputs. The following discussion will explain what inputs are needed and how each of these enters the calculations.

A. Geometric Inputs

It is assumed that a one dimensional representation of the estuary is adequate for analysis, i.e. variation of parameters with cross-stream distance or depth must be less important than variations along the length of the stream.

Model development begins with determination of the geometric representation to be used as a model framework. Consider a hypothetical tidal creek as in Fig. 1. The curved line running the length of the creek marks off distances relative to the mouth of the creek. Any point in the creek can be located with reference to the axis of the streambed. The transverse solid lines illustrate the resolution of the creek into discrete volumes in order to have a manageable system of equations to solve. Since there is a finite number of such transects, these can be identified by number, starting at the upstream end. Each of these transects has a cross-sectional area A_i and mean depth H_i, where the subscript i refers to the identifying number of the transect. The transect number 1 is reserved as an artificial transect for model calculations. Additionally, the volume of water between transects i and i+1 has volume V_i and surface area SA_i. If the creek is divided into N segments, it will have N+1 transects.

It is assumed that the important variables (those being modeled) in segment volume V_i are adequately represented by the value at the center of the volume, i.e. on the axis and halfway between the limiting transects (see Fig. 1). For each component to be modeled, there will be an equation to be solved for each of the N volumes.

The fully defined system will consist of all required information to describe N segments and N+1 transects, as in Fig. 1.

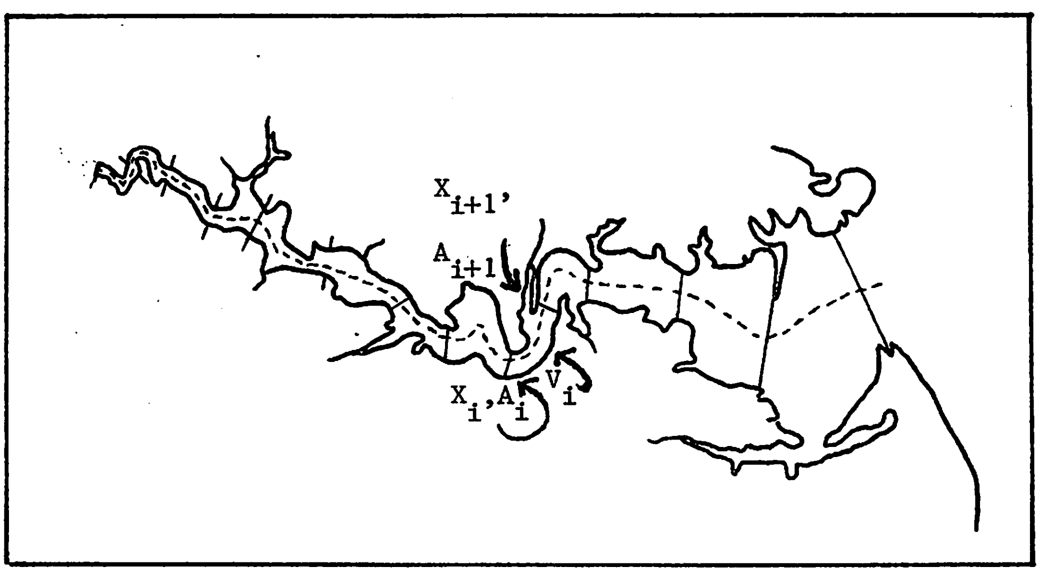


Fig. 1. Segmentation of stream into compartments for modeling purposes.

B. Hydrodynamic Inputs

The hydrodynamic submodel performs dynamic calculations to predict the water flow under the driving influences of tidal variation, freshwater inflow, and wind stress at the air-water surface.

The unknown quantities to be predicted are volume transport at each transect (Q_i) and tidal height at each mid-segment (Y_i). In addition, water velocity U_i is derived from these quantities. The two principles used to derive the equations are the continuity principle and Newton's second law. Continuity means that water is neither created nor destroyed: if the flow into a segment does not equal the flow out, then the water surface must rise or fall. Newton's second law states that the water will change its velocity (speed up or slow down) if the applied forces are not in balance.

The continuity principle is illustrated in Fig. 2. At some instant, the flow into segment i is Q_i while the flow outward is Q_{i+1} (The sign convention employed makes down-estuary flow positive). As can be seen from the figure

$$Q_i - Q_{i+1} = (SA_i + ST_i)\frac{\Delta Y_i}{\Delta t} + q_i \qquad (2\text{-}1)$$

where SA_i is the surface area of the ith segment, ST_i is the surface area of the side embayments, ΔY_i is the change of water surface elevation over time interval Δt and q_i is the laterally introduced fresh water inflow.

Newton's second law is illustrated in Fig. 3. The most relevant forces are the tilt of the water surface and friction. At transect i,

$$\frac{dQ_i}{dt} = - g\, A_i \left(\frac{\Delta Y}{\Delta x}\right)_i - F_i + T_i + D_i + M_i \qquad (2\text{-}2)$$

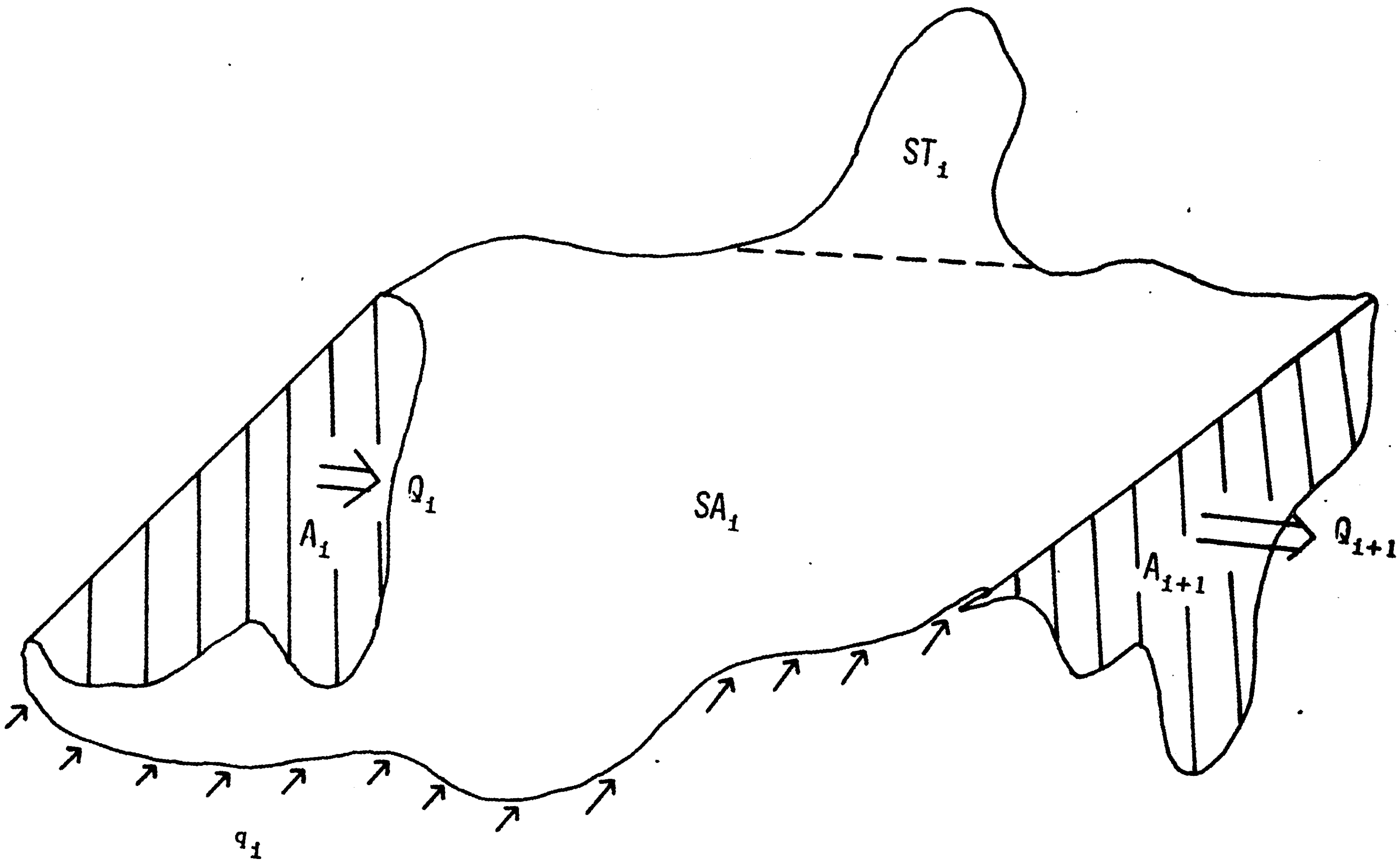


Fig. 2

Definitions of Variables Used in the Continuity Equation.

where the spatial gradient, $(\frac{\Delta Y}{\Delta x})_i$ must be expressed in terms of Y_{i-1} and Y_i. Referring to Fig. 3, the distance between mid-segments is $0.5\ (x_{i+1} - x_{i-1})$, so that

$$(\frac{\Delta Y}{\Delta x})_i = \frac{Y_i - Y_{i-1}}{0.5(x_{i+1} - x_{i-1})} = \frac{Y_i - Y_{i-1}}{\Delta x_i} \qquad (2\text{-}3)$$

In the momentum equation, Q_i is the volume flow rate and F_i is an opposing frictional force and T_i is a wind stress force. The term D_i represents a force present in saline water caused by the horizontal variation of salinity and therefore density

$$D_i = \frac{gk}{1+k(S_{i-1} + S_i)/2} \frac{(S_i - S_{i-1})d_c}{\Delta x_i} A_i \qquad (2\text{-}4)$$

where k is the conversion factor from salinity to density and d_c is the distance from the water surface to the centroid of the cross-section. In the above equations, A_i, SA_i and ST_i are not necessarily constant in time: they can vary with Y_{i-1} and Y_i which are time-variable. The frictional term F_i is a function of flow:

$$F_i = g\, n^2_i \frac{Q_i}{A_i} \left| Q_i \right| R_i^{-4/3} \qquad (2\text{-}5)$$

where n_i is the Manning roughness coefficient and g is the gravitational acceleration. This term has units of force per unit mass. The wind stress term is:

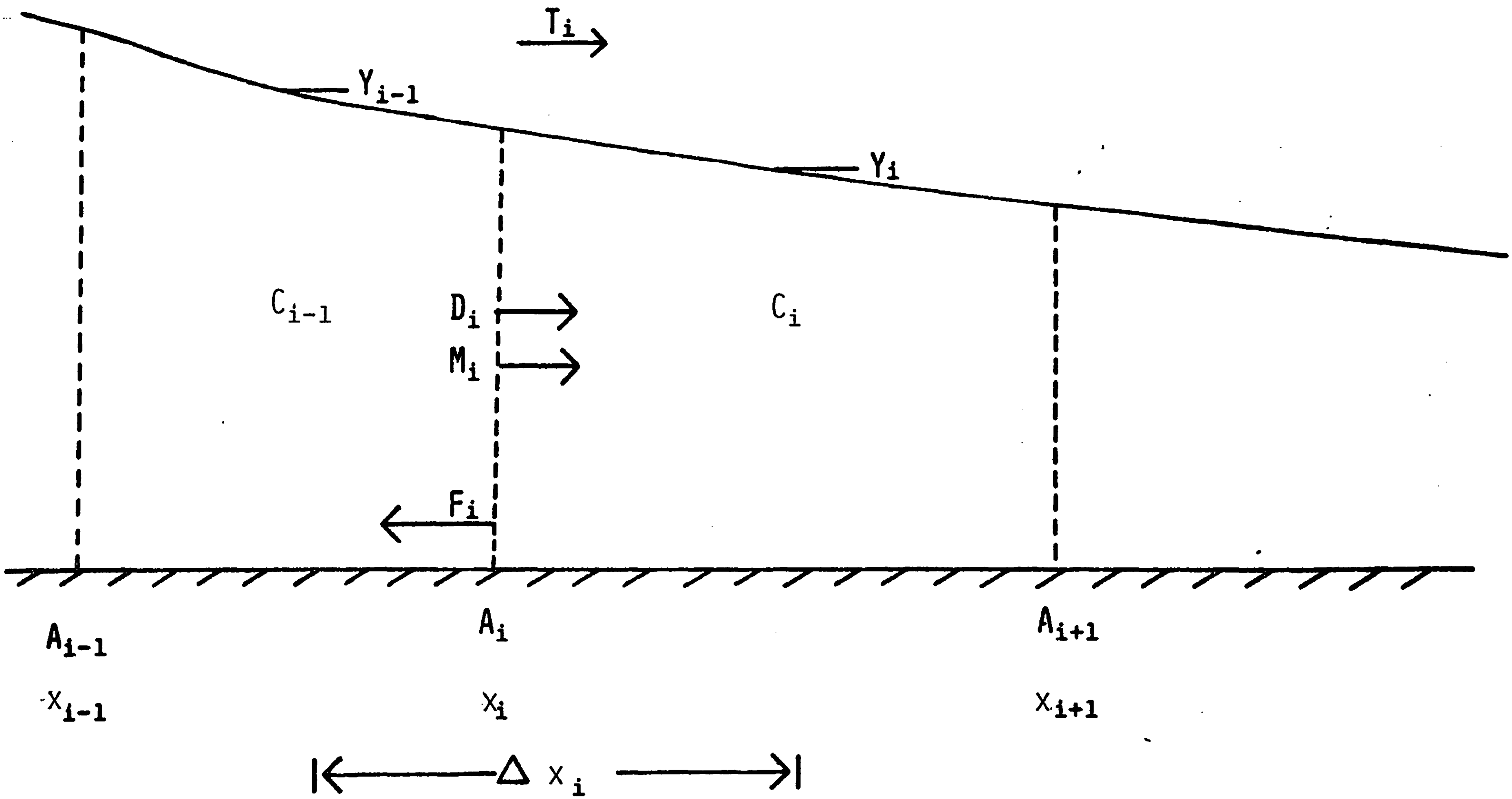


Figure 3. Conceptual Layout of Variables Appearing in the Momentum Equation.

$$T_i = \frac{W B_i}{\rho} \qquad (2\text{-}6)$$

where W is an the wind stress at the free surface, B_i is the transect width and ρ is the water density. In this model the stress W is not allowed to vary spatially, since the water bodies to which it would be applied are much smaller than meteorological systems. The final term, M_i, represents the momentum source due to lateral inflow.

The hydrodynamic submodel is intended to simulate tidal motion. For this purpose an oscillating tide is imposed at the downstream boundary as a driving force. This can be either an actual record of tidal height or a synthetic tide calculated as a sum of harmonics. The upstream boundary condition is an imposed fresh water inflow.

For N segments there will be a set of 2N equations linking the flows and the tidal heights. The details of the computer algorithms will be given in a later section.

C. Transport Processes

Consider the two connected segments shown in Fig. 3. The bounding transects are labeled i-1, i and i+1. If one is modeling some quantity (this could be salinity or dissolved oxygen, for example) then the concentrations in the two segments are C_{i-1} and C_i respectively. The concentration C_i can change due to:

- o external sources or sinks:
- o internal transformations:
- o transport from adjacent segments.

External sources and sinks are assumed to be distributed evenly throughout the segment volume V_i as soon as they are introduced. Hence these can be simply identified by the subscript i. Transformations can likewise be described by the mid-segment values, i.e. (say) C_i is transmuted to (say) C_i'. Transport processes, however, occur at the transects dividing two elements and therefore require more elaborate notation to describe.

Two types of transport are important: advection and dispersion. The mass of a species transported across a transect i is simply the product $Q_i C_{bi}$, where Q_i is the volume rate of flow across the transect and C_{bi} is the concentration of species C at that transect. The difficulty is that the quantities C_{bi} are unknown: they must be approximated from the mid-segment values. The form used for expressing C_{bi} is

$$C_{bi} = \alpha_i C_{i-1} + (1 - \alpha_i)\, C_i \qquad (2\text{-}7)$$

The quantity, α_i, is called the interpolation factor and is usually determined in the process of calibration. Clearly a value of 0.5 would represent a linear interpolation, but it is seldom possible to use that value. It is normally necessary to weight the upstream segment more heavily than the downstream in order to ensure numerical stability, i.e. to keep the solution from 'blowing up'. One specifies the quantity, a_i, as an input constant. Then, since the flow oscillates, $\alpha_i = a_i$ if $Q_i > 0$, $\alpha_i = 1 - a_i$ if $Q_i < 0$.

Dispersive transport between two segments depends on the gradient of the concentration at the transect, i.e. $E_i A_i (\frac{\Delta C}{\Delta x})_i$, where E_i is a dispersion coefficient, A_i is the transect cross-sectional area and $(\frac{\Delta C}{\Delta x})_i$ is the longitudinal gradient of C at transect i. This latter quantity must be expressed in terms of C_{i-1} and C_i. Using the same argument as used in equation 2-3 for surface elevation, one can approximate $(\frac{\Delta C}{\Delta x})_i$ by

$$(\frac{\Delta C}{\Delta x})_i = \frac{C_i - C_{i-1}}{0.5\ (x_{i+1} - x_{i-1})} = \frac{C_i - C_{i-1}}{\Delta x_i} \tag{2-8}$$

Transport of a so-called conservative substance is included in the hydrodynamic submodel in order to validate the transport calculations prior to running the water quality submodel.

Using the above definitions for transport into or out of a segment, the rate of change of mass m of a component in segment i is

$$\frac{\Delta(V_i C_i)}{\Delta t} = Q_i \quad (\alpha_i C_{i-1} + (1-\alpha_i)C_i) - Q_{i+1}(\alpha_{i+1}C_i + (1-\alpha_i) \tag{2-9}$$

$$C_{i+1}) - \frac{E_i A_i}{\Delta x_i}(C_i - C_{i-1}) + \frac{E_{i+1}A_{i+1}}{\Delta x_{i+1}}(C_{i+1} - C_i)$$

D. Biochemical Processes

The term 'ecosystem' as used in this report refers to the aquatic phytoplankton population and its physical substrate. Phytoplankton utilize sunlight and nutrients in the growth process. Their success in reproduction depends on many factors, not least of which are limitations of the requisite nutrients or sunlight. Since the chemical elements incorporated in living phytoplankton cannot be created or destroyed, one can simulate the cycling of these chemicals, including the living phytoplankton as one stage in their respective transformations. The water quality submodel consists of eight interlinked components as shown in Fig. 4. There is a nitrogen loop and a

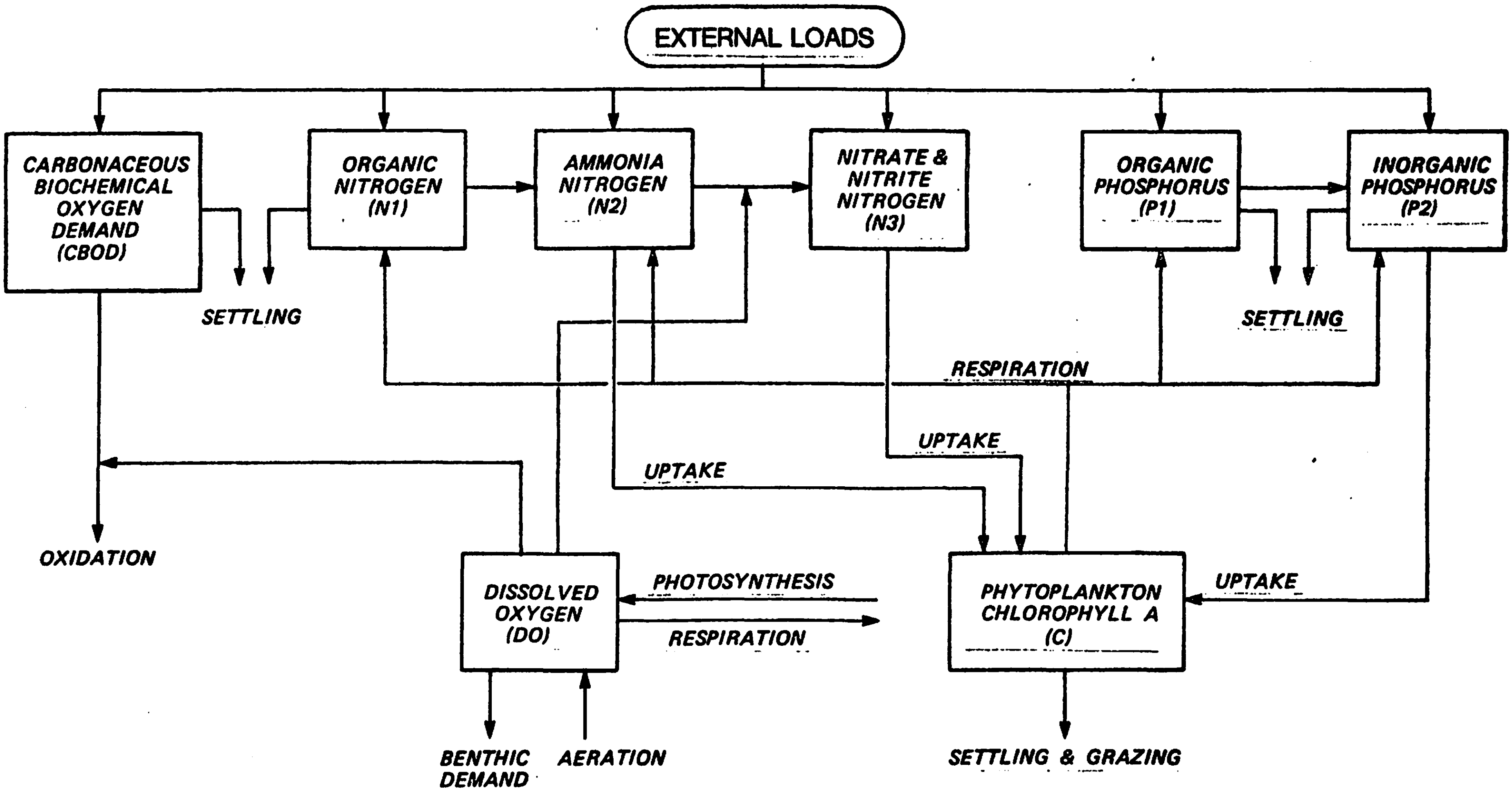


Figure 4 . Schematic of ecosystem model.

phosphorus loop, both beginning and ending with chlorophyll 'a', which is an index of phytoplankton population. Oxygen and carbon, on the other hand, are theoretically available from the atmosphere in unlimited quantities, so that effectively there is no loop. Dissolved oxygen is impacted by photosynthesis, carbon oxidation and ammonia oxidation as well as its own source and sink terms.

For the sake of generality the term representing external sources and sinks must be added to the preceding equation. In addition nonconservative substances undergoing transformation and/or decay require terms for internal sources and sinks. A general expression for rate of change of a substance is then

$$\frac{\Delta(V_i C_i)}{\Delta t} = \text{Transport} + S_o \qquad (2\text{-}10)$$

The external and internal source terms, S_o, can be positive or negative: they are unique for each of the water quality components.

Given sunlight and nutrients (nitrogen and phosphorus in dissolved mineral form), phytoplankton tend to grow. Limited availability of any one of these three quantities, **viz** sunlight, nitrogen and phosphorus, or a number of other so-called micronutrients (which are not included in the model) can inhibit the growth of phytoplankton.

In the case of nutrients, phytoplankton can be a source as well as a sink, through processes of death and respiration. Nitrogen and phosphorus exist in the form of one of a number of species or as part of the living matter. These nutrients therefore are recycled, but the loops are not necessarily closed, since other processes such as settling and interaction with bottom sediments can be significant.

Dissolved oxygen and carbonaceous biochemical oxygen demand are included in the model. Dissolved oxygen is an indicator of water quality and is affected by the nutrient-chlorophyll cycles of photosynthesis and respiration and by oxidation of aquatic ammonia and carbonaceous organic matter.

The specific forms of the source and sink terms for each of the ecosystem model components are discussed below. In these equations multiplication is represented by an asterisk, division by a horizontal or slashed line and exponentiation by a superscript.

1) **Phytoplankton or Chlorophyll 'a'** - The phytoplankton population, quantified as the concentration of chlorophyll 'a', occupies a central role in the schematic ecosystem as indicated in Fig. 4 and influences, to a greater or lesser extent, all of the remaining non-conservative dissolved constituents. The source/sink term for phytoplankton is expressed

$$So = V*CH*(G-R-P-Ksch/h) + WCH \qquad (2\text{-}11)$$

in which

V = segment volume (m^3)

CH = chlorophyll 'a' concentration (ug/l)

G = growth rate of phytoplankton (1/day)

R = respiration rate of phytoplankton (1/day)

P = mortality rate due to predation and other factors (1/day)

Ksch = settling rate of phytoplankton (m/day)

h = local depth (m)

WCH = external loading of chlorophyll 'a' (mg/day)

Phytoplankton growth is dependent upon nutrient availability, ambient light, and temperature. The functional relationships used in the model generally follow the forms of DiToro, et al (1971) and are as follows:

$$G = kgr * \theta_1^{T-20} * L(Ia,Is,ke,CH,h) * N(N2,N3,P2) \qquad (2\text{-}12)$$

Temperature effect | Light effect | Nutrient effect

in which

kgr = optimum growth rate at 20°C (1/day/C)

θ_1 = a constant

T = temperature (C)

L = attenuation of growth due to suboptimal lighting

N = attenuation of growth due to nutrient limitations

$$L = \frac{2.7183}{k_e h} * (\exp(-I_t/I_s * \exp(k_e * h)) - \exp(-I_t/I_s)) \qquad (2\text{-}13)$$

$$k_e = k_e' + 0.018 * CH \qquad (2\text{-}14)$$

$$I_t = I_a * \left[\frac{24}{TD-TU}\right] * \sin\left[\pi\frac{t-TU}{TD-TU}\right] \quad \text{if } TU<t<TD\text{, but} \qquad (2\text{-}15)$$

$$I_t = 0 \quad \text{if} \quad t < TU \quad \text{or} \quad t > TD$$

in which

k_e' = light extinction coefficient at zero chlorophyll concentration (1/meter)

k_e = light extinction coefficient corrected for self-shading of plankton (1/meter)

h = depth of water column (meters)

I_s = optimum solar radiation rate (langleys/day)

I_t = solar radiation at time t

I_a = total daily solar radiation (langleys/day)

TU = time of sunrise, in hours

TD = time of sunset, in hours

t = time of day in hours

The nutrient effect, N, is based on the minimum limiting nutrient concept. The coefficient N is set equal to the lesser of the following two expressions:

$$\frac{N2 + N3}{K_{mn} + N2 + N3} \text{ (nitrogen limitation) and}$$

$$\frac{P2}{Kmp + P2} \text{ (phosphorus limitation)} \qquad (2\text{-}16)$$

In these expressions

N2 = ammonia nitrogen concentration (mg/l)

N3 = nitrite-nitrate nitrogen concentration (mg/l)

P2 = orthophosphorus concentration (mg/l)

Kmn = half-saturation concentration for inorganic nitrogen uptake (mg/l)

Kmp = half-saturation concentration for orthophosphorus uptake (mg/1)

The respiration rate, R, is function of temperature.

$$R = R(20)*\ \theta_2^{T-20}, \text{ in which} \qquad (2\text{-}17)$$

R(20) = respiration rate at 20°C (1/day)

θ_2 = a constant

The mortality rate, P, is a function of temperature

$$P = P(20)*\ \theta_3^{T-20}, \qquad \text{in which}$$

P(20) = mortality rate at 20°C (1/day)

θ_3 = a constant.

2) **Organic Nitrogen** - The source/sink term for organic nitrogen is expressed

$$So = V*(-\frac{Kn12*N1}{Kh12+N1} + an*(R + ar*P)*Fn*CH - N1*Kn11/h + BENN1/h) + WN1 \qquad (2\text{-}18)$$

in which

N1 = concentration of organic nitrogen (mg/1)

Kn12 = hydrolysis rate of organic nitrogen to ammonia (mg/1/day) = $K_{n12}(20)*\ \theta_4^{T-20}$

$K_{n12}(20)$ = hydrolysis rate at 20°C(mg/1/day)

θ_4 = a constant

Kh12 = half saturation concentration for hydrolysis (mg/1)

an = ratio of nitrogen to chlorophyll in phytoplankton (mgN/μg Chl)

Fn = fraction of metabolically produced nitrogen recycled to the organic pool

ar = proportion of consumed phytoplankton recycled by zooplankton

Kn11 = settling rate of organic nitrogen (m/day)

BENN1 = benthic flux of organic nitrogen ($gm/m^2/day$)

WN1 = external loading of organic nitrogen (gm/day)

3) **Ammonia Nitrogen** - The source/sink term for ammonia nitrogen is expressed

$$So = V*\left(-\frac{Kn23*N2}{Kh23 + N2} + \frac{Kn12*N1}{Kh12 + N1} + an*(R+ar*P)*(1-Fn)*CH - an*G*PR*CH + BENN2/h\right) + WN2 \qquad (2-19)$$

in which

N2 = concentration of ammonia nitrogen (mg/l)

Kn23 = nitrification rate of ammonia to nitrate nitrogen (mg/l/day) = $K_{n23}(20) * \theta_5^{T-20}$

$K_{n23}(20)$ = nitrification rate at $20^{\circ}C$(mg/l/day)

θ_5 = a constant

Kh23 = half-saturation concentration for nitrification (mg/l)

BENN2 = benthic flux of ammonia nitrogen ($gm/m^2/day$)

PR = preference of phytoplankton for ammonia uptake

$$= \frac{N2*N3}{(Kmn + N2)*(Kmn + N3)} + \frac{N2*Kmn}{(N2 + N3)*(Kmn + N3)} \qquad (2-20)$$

WN2 = external loading of ammonia nitrogen (gm/day)

4) **Nitrate Plus Nitrite Nitrogen** - The source/sink term for nitrate plus nitrite nitrogen is expressed

$$So = V*[\frac{Kn23*N2}{Kh23 + N2} - an*G*(1-PR)*CH - N3*Kn33/h + BENN3/h] + WN3 \qquad (2-21)$$

in which

N3 = concentration of nitrate plus nitrite nitrogen (mg/1)

Kn33 = denitrification rate or loss coefficient of nitrate plus nitrite nitrogen (m/day)

BENN3 = benthic flux of nitrate plus nitrite nitrogen ($gm/m^2/day$)

WN3 = external loading of nitrate plus nitrite nitrogen (gm/day)

5) **Organic Phosphorus** - The source/sink term for organic phosphorus is expressed

$$So = V*(- \frac{Kp12*P1}{Khp12+P1} + ap * (R + ar*P)*Fp*CH - P1*Kp11/h + BENP1/h) + WP1 \qquad (2-22)$$

in which

P1 = concentration of organic phosphorus (mg/1)

Kp12 = first order hydrolysis rate of organic to inorganic phosphorus (mg/1/day) = $Kp12(20)* 6^{T-20}$

Kp12(20) = mineralization rate at $20^{o}C$

Khp12 = half-saturation for mineralization (mg/1)

6 = a constant

ap = ratio of organic phosphorus to chlorophyll in phytoplankton (mg P/μg Chl)

Fp = fraction of metabolically produced phosphorus recycled to the organic pool

Kp11 = settling rate of organic phosphorus (m/day)

BENP1 = benthic flux of organic phosphorus ($gm/m^2/day$)

WP1 = external loading of organic phosphorus (gm/day)

6) **Orthophosphorus** - The source/sink term for orthophosphorus is expressed

$$So = V*(\frac{kp12*P1}{Khp12+P1} + ap*(R+ar*P)*(1-Fp)*CH - ap*G*CH - P2*Kp22/h + BENP2/h)+WP2 \qquad (2-23)$$

in which

P2 = concentration of orthophosphorus (mg/l)

Kp22 = settling rate of inorganic phosphorus (m/day)

BENP2 = benthic flux of inorganic phosphorus ($gm/m^2/day$)

WP2 = external loading of orthophosphorus (gm/day)

7) **Carbonaceous Biochemical Oxygen Demand** - The source/sink term for CBOD is expressed

$$So = V*(- Kc*CBOD + ac*aco*(ar\ P)*CH - CBOD*Ksc/h)+ WCBOD \qquad (2-24)$$

in which

CBOD = concentration of carbonaceous biochemical oxygen demand (mg/l)

Kc = first order decay rate of CBOD (1/day)

ac = ratio of carbon to chlorophyll in phytoplankton (mg C/μg CH)

aco = ratio of oxygen demand to organic carbon recycled = 2.67

Ksc = settling rate of CBOD (m/day)

WCBOD = external loading of CBOD (gm/day)

The CBOD decay rate is assumed to be temperature-dependent. This temperature dependence is expressed

$$Kc = Kc(20) * 7^{T-20} \tag{2-25}$$

in which

Kc(20) = decay rate of CBOD at 20^{o}C.

7 = a constant

8) **Dissolved Oxygen** - The source/sink term for dissolved oxygen is expressed

$$So = V*(- Kc*CBOD - ano* \frac{Kn23*N2}{Kh23 + N2} + aco*ac*PQ*G*CH$$

$$- aco*ac/RQ*R*CH$$

$$+ Kr*(DOs - DO) - BENDO/h) + WDO \tag{2-26}$$

in which

DO = dissolved oxygen concentration (mg/1)

ano = ratio of oxygen consumed per unit of ammonia nitrified = 4.33

PQ = photosynthesis quotient (moles O_2/mole C)

RQ = respiration quotient (moles CO_2/mole O_2)

Kr = reaeration rate (1/day)

DOs = saturation concentration of DO (mg/1)

BENDO = sediment oxygen demand (gm/m^2/day)

WDO = concentration (mg/1) of dissolved oxygen in external loading multiplied by flow rate (m^3/day)

The expression utilized to compute the reaeration coefficient, Kr, represents reaeration of turbulence generated by bottom friction (O'Connor and Dobbins: 1958) and that by surface wind stress. The expression is

$$Kr(20) = Kro*u^{1/2}* h^{-3/2} + WREA/h \qquad (2-27)$$

in which

Kr(20) = reaeration rate at 20 C

Kro = proportionality constant

u = mean cross sectional velocity (m/sec)

WREA = wind-induced reaeration (m/day)

The reaeration rate is assumed to be temperature-dependent. The reaeration rate at any temperature, T, is obtained through the expression

$$Kr = Kr(20)* 1.024^{(T-20)} \qquad (2-28)$$

Saturation dissolved oxygen concentration, DOs, is calculated as a function of water temperature from a polynomial fitted to the tables of Carritt and Green (1967).

$$DOs = 14.6244 - 0.367134*T + 0.004497*T^2 - 0.0966*S + 0.00205*S*T + 0.0002739*S^2 \qquad (2-29)$$

where S is salinity in parts per thousand.

III. Hydrodynamic Model Description and Operating Instructions.

A. Program Organization

Language - Computer programs are written in FORTRAN 77 as published in 1978 by ANSI (ANSI x 3.9 - 1978 Programming Language Fortran).

Data File Management - Program input and output require several input files as itemized in Table III-1. Each of these files is specified in the program by a logical unit number as listed in the table. The job control necessary for setting up a run is not discussed here, since it is machine-specific. It is helpful to note, however, that on many machines output (logical unit 6) can either be sent straight to a line printer or stored as a direct access file for review before a hard copy is made. Likewise logical unit 5 could be a card reader rather than a direct access file.

Table III-1. Data File Organization for Hydrodynamic Model

Description	Logical Unit	Read or Write	Remarks
Main Hydrodynamic Model Input	5	Read	
Model Output	6	Write	Option: direct to printer
Hydro Calculations for Driving Water Quality Model	7	Write	Binary
Time Series of Tidal Data	13	Read	Optional
Channel Geometry	15	Read	
Freshwater Inflow Time Series	17	Read	Optional

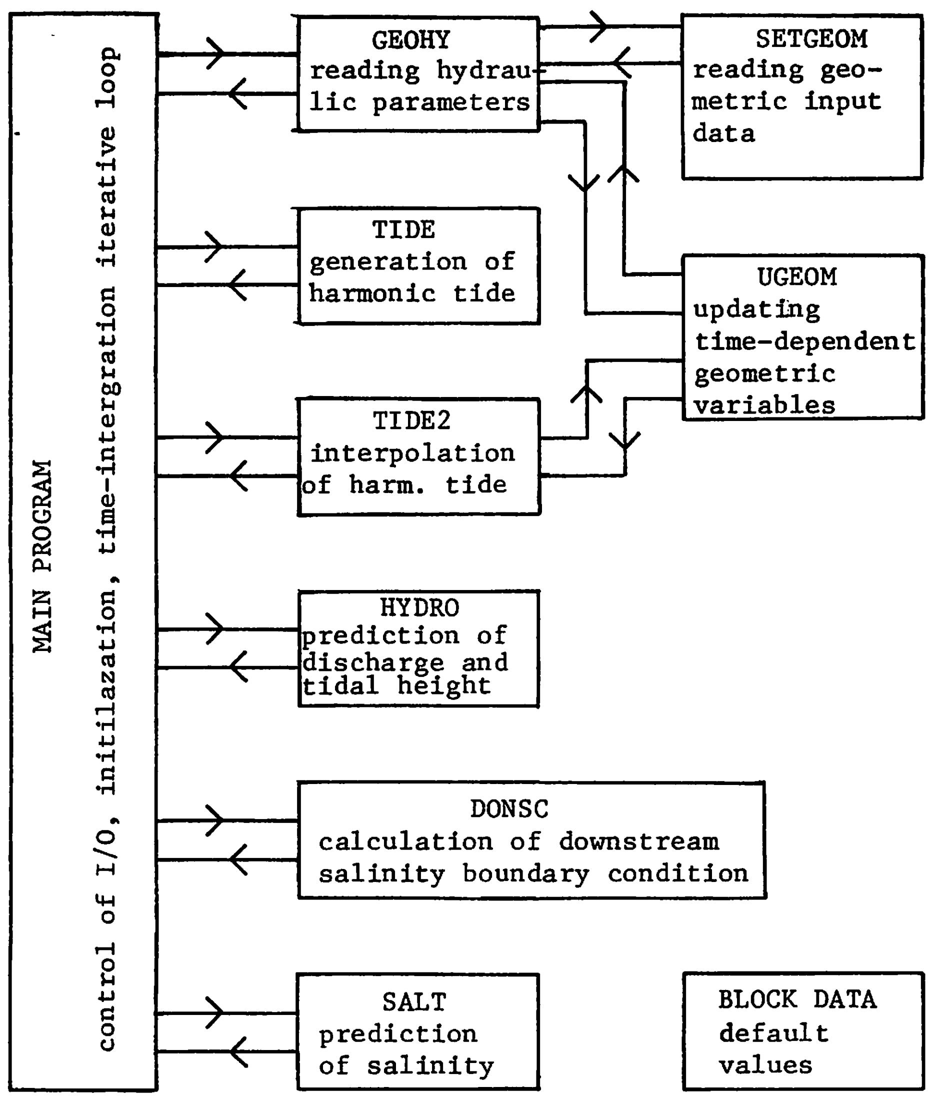
Storage Requirements - Storage requirements should pose no serious problem for the operation of the model, since present-day main frame computers are capable of handling several jobs at once, automatically allocating storage capacity as needed. About 23200 bytes are needed for computational procedures and another 8000 for data.

Program Organization - Both the hydrodynamic and water quality models are organized like a vertical "tree". The main program calls subroutines to read input devices, takes care of initialization and then commences a time integration loop. Inside this loop a subroutine is called to predict each component at the forward time step. Printout commands come from the main program. Figure 5 shows the internal flow of control for the hydrodynamic model.

Program Logic

Data Group Concept - Most of the model inputs are delimited according to so-called data groups. Each data group contains a particular type of input. It is preceded by a header line identifying the data group by number, specifying the number of inputs contained (for arrays) and identifying the group by alpha code for convenience of the user. With certain restrictions, data groups may be skipped (so that default values are used) or reordered, since each group is identified by header information. Default values will be noted in the input data description.

Data Input Organization - At the beginning of a computer run, certain essential control information is read by the computer program, which then shifts control to other subroutines to complete the input. Table III-1 lists the input data organization for the hydrodynamic model, including the logical unit number.



Hydrodynamic Model Flow Diagram

Figure 5. Subroutine Organization for Hydrodynamic Model.

B. Data Input Description and Glossary

Given the previous general description of input organization, it is now necessary to itemize the input data line by line with definitions and units where needed.

Data Description

a) Main input data file (logical unit 5). This file contains the main inputs needed for operation of the model.

inputs	**format**
ISALT,IQUAL,IVAR,ITIDE	4I5

ISALT = 1 if salinity is to be modeled: otherwise salinity not modeled.

IQUAL = 1 causes hydrodynamic output to be written in binary format to be passed to water quality model. Otherwise it is not output.

IVAR = 1 means that fresh water inflow is to vary daily and is to be read from logical unit 17: otherwise a constant value is read from unit 5 and kept throughout run.

ITIDE = 1 means that observed tides are input from logical unit 13: otherwise nine tidal amplitudes and phases are read in from unit 5.

NOTE: At this point control passes to subroutine GEOHY

TITLE	35A2

TITLE is an alpha line describing the run.

ML, MU	2I5

ML = transect number of farthest upstream transect. For proper operation, ML$\geq$2.

MU = transect number of farthest downstream transect. Dimension statements presently implemented limit MU to a maximum value of 20.

Several data groups are read in succession. Each of these begins with a line containing:

NDG, NS, NAME 2I5, 30A2

NDG = identifying data group number.

NS = number of inputs to be read. This input is a dummy unless indicated below.

NAME is alpha information for convenience of user.

NDG = 1: DIST(I), I=ML,MU 7F10.0

Transect distances in km, starting with the upstream transect and decreasing in value toward the downstream end.

NDG = 2: ARD(I), I=ML,MU 7F10.0

The land drainage areas feeding into each segment I from between transect I and transect I+1. Default value is 0.

NDG = 3: Q1(I), I=ML,MU 7F10.0

The initial values of volume flow at the transects in cubic meters per second. **NOTE** if IVAR≠1, then Q1(ML) is the discharge at ML for the entire run. Default value is 0.

NDG = 4: Y1(I) I=ML,MU-1 7F10.0

The initial tidal heights in the model segments, in meters. Default value is 0.

NDG = 5: S1(I), I=ML,MU-1 7F10.0

The initial values of salinity in the model segments. Default value is 0.

NDG = 6: not implemented.

NDG = 7: FMANN(7), I=ML,MU 7F10.0

Manning friction coefficients at the model transect. Default value is 0.02.

NDG = 8: ALPH(I), I=ML,MU 7F10.0

Interpolation flow weighting factor for advective transport at model transects.

NDG = 99:

Causes completion of printout and initialization. Further read statements for this logical unit come from the main program.

If ITIDE≠1, then the following inputs are read:

AMPL(I), PHASE(I), I=1,9 2F10.2

The amplitudes and phases for the nine most important tidal components, in the following order: M2, S2, N2, K1, M4, 01, MM, SSA, SA. These are defined in Table III-2. Amplitudes are in cm and phases are in radian measure. The time argument in the program is

COS(PHASE (I) + TIME x SIGMA(I)),

where SIGMA(I) is the angular frequency of the Ith tidal component. If TIME=0 and PHASE(I)=0, tidal height will be a maximum.

Table III-2

Table of Astronomical Tidal Components

Designation	Name	Period (hours)
M2	lunar semidiurnal	12.42
S2	solar semidiurnal	12.00
N2	lunar elliptic semidiurnal	12.66

K1	lunar-solar declinatinal diurnal	23.93
M4	lunar quarter-diurnal	6.21
O1	lunar declinational diurnal	25.82
MM	lunar monthly	661.3
SSA	solar semi-annual	4383.
SA	solar annual	8766.

The above nine lines of input should be omitted if ITIDE=1. The next input is:

WIND F10.0

The uniform wind stress in dynes/m^2.

SMAX, TOFH 2F10.0

The maximum salinity at the downstream segment and the time in hours after slack before flood required for the salinity to reach this maximum value.

EBASE, AK 2F10.0

The minimum dispersion coefficient at slack tide and the multiplier in the Taylor dispersion coefficient, i.e. the dispersion coefficient $E(I) = EBASE + AK * |U| x\ n\ x\ R^{5/6}$ where U is the tidal current, n the Manning roughness and R the hydraulic radius.

DCAY F10.0

Decay constant in day^{-1}. A non-zero value may be assigned if model is used to simulate the transport and dispersion of some quantity with a first order decay, in place of salinity.

DTIME, TMAX, DTT, NP 3F10.0, I10

DTIME is starting time of model run, in days. DTIME can be Julian day plus decimal part of day, or simply the decimal part of the day.

TMAX is duration of model run, in days.

DTT is time step in days.

NP is the number of times during the run when results will be printed out.

TOUT(I), I=1, NP 7F10.0

The times after the beginning of the model run when model results will be printed out. 0<TOUT(I)≤TMAX. A maximum of 30 times may be specified and the last one should be TMAX.

NSBH, NSEH, NSH (needed if IQUAL=1) 3I10

NSBH is the integration time step at which the hydrodynamic model will begin to write binary output for the water quality model.

NSEH is the time step number at which the binary output will cease. Output will be passed every NHS time steps. It follows that the integration time step in the water quality model should equal NHS*DTT.

b) Logical unit 15. Channel Geometry

Subroutine SETGEOM reads channel geometry. This file is organized into a title line plus two data groups.

TITLE 1X, 35A2

Line of alpha information for user convenience. Each data group is introduced by a line as follows:

NDG, NS, NAME 2I5, 30A2

NDG is an identifying number for the data group and NS is the number of inputs in the arrays. NAME is alpha information for user convenience.

NDG=1: transect data. These include:

AM(I), I=ML,MU 7F10.0

Transect cross-sectional area at mean tide level, in square meters.

HM(I), I=ML,MU 7F10.0

Transect mean depth in meters.

DCM(I), I=ML,MU 7F10.0

Depth of transect centroid in meters. (used to calculate density-gradient pressure term).

NDG=2: segment data. These are

SAM(I), I=ML,MU-1 7F10.0

The model segment surface area, in square meters.

VOLM(I), I=ML,MU-1 7F10.0

The model segment volume at mean tide level, in cubic meters.

c) Logical unit 13. Observed tide input.

If ITIDE=1, the tidal input for driving the hydrodynamic model is read in from a separate file. The first line of this file has control information.

NPERL, CONV, DTSTIN, FMT I5, 2F10.3, 6A4

NPERL is the number of observed tide heights per line of input. CONV is a conversion factor for converting tidal heights from whatever unit is used in the input file to centimeters. The time interval between these observed inputs DTSTIN is in seconds and need not be a multiple of DTT. FMT, the format for a single line of tidal input should include enclosing parentheses, e.g. (10F6.2). The remainder of this file is the actual tide data, arranged in the format indicated by FMT.

These tide data can be in any convenient unit, provided CONV is set to convert them to cm.

d) Logical unit 17. Time dependent headwater discharge.

If IVAR=1, then the volume rate of flow across transect ML varies daily. For each day or fraction of a day of the run there is one line of input:

Q2(ML) 9XF6.2

C. Organizing and Controlling a Computer Run

In all probability all the files involved in making a computer run will be held on disk storage. While the details of the instructions needed for file manipulation will depend on the machine, the required tasks can be described in general terms. Certain files must be opened, either for reading or writing and then a command must be given to initiate execution.

1. Open main input data file (logical unit 5) for reading.
2. Open tidal time series file (logical unit 13) for reading if this option is chosen (ITIDE = 1).
3. Open freshwater inflow time series (logical unit 17) if this option is chosen. (IVAR = 1)
4. Open main output file for writing of printer-width output (logical unit 6).
5. Open output file for binary writing of hydrodynamic predictions (logical unit 7) if this option is chosen (IQUAL=1)
6. Commence execution of run.
7. Close I/O files (this is done automatically by some systems in response to the Fortran STOP command).
8. (optional) line-printer copy of output.

IV. Water Quality Model Description and Operating Instructions

A. Program Organization

Language - Computer programs are written in FORTRAN 77 as published in 1978 by ANSI (ANSI x 3.9 - 1978 Programming Language Fortran).

Data File Management - Program input and output require several input files as itemized in Table IV-1. Each of these files is specified in the program by a logical unit number as listed in the table. The job control necessary for setting up a run is not discussed here, since it is machine-specific. It is helpful to note, however, that on many machines output (logical unit 6) can either be sent straight to a line printer or stored as a direct access file for preview before a hard copy is made. Likewise logical unit 5 could be a card reader rather than a direct access file.

Table IV-1. Data File Organization for Water Quality Model

Description	Logical Unit	Read or Write	Remarks
Main Water Quality Input	5	Read	
Model Output	6	Write	Option: direct to printer
Hydrodynamic Time Series Data	7	Read	Binary file
Nonpoint Source Data	15	Read	

Storage Requirements - Storage requirements will pose no serious problem for the operation of the model, since present-day main-frame computers are capable of handling several jobs at once, automatically allocating storage capacity as needed. About 38200 bytes are needed for computational procedures and another 12100 for data.

Program Organization - Both the hydrodynamic and water quality models are organized like a vertical "tree". The main program calls subroutines to read input devices, takes care of initialization and then commences a time integration loop. Inside this loop a subroutine is called to predict each component at the forward time step. Printout commands come from the main program. Fig. 6 shows the internal flow of control for the water quality model.

Program Logic

Data Group Concept - Most of the model inputs are delimited according to so-called **data groups.** Each data group contains a particular type of input. It is preceded by a header line identifying the data group by number, specifying the number of inputs contained (for arrays) and identifying the group by alpha code for convenience of the user. With certain restrictions, data groups may be skipped (so that default values are used) or reordered, since each group is identified by header information. Default values will be given in the input data listing.

Data Input Organization - At the beginning of a computer run, certain essential control information is read by the computer program, which then shifts control to other subroutines to complete the input. Table IV-1 lists the input data organization for the water quality model, including the logical unit number.

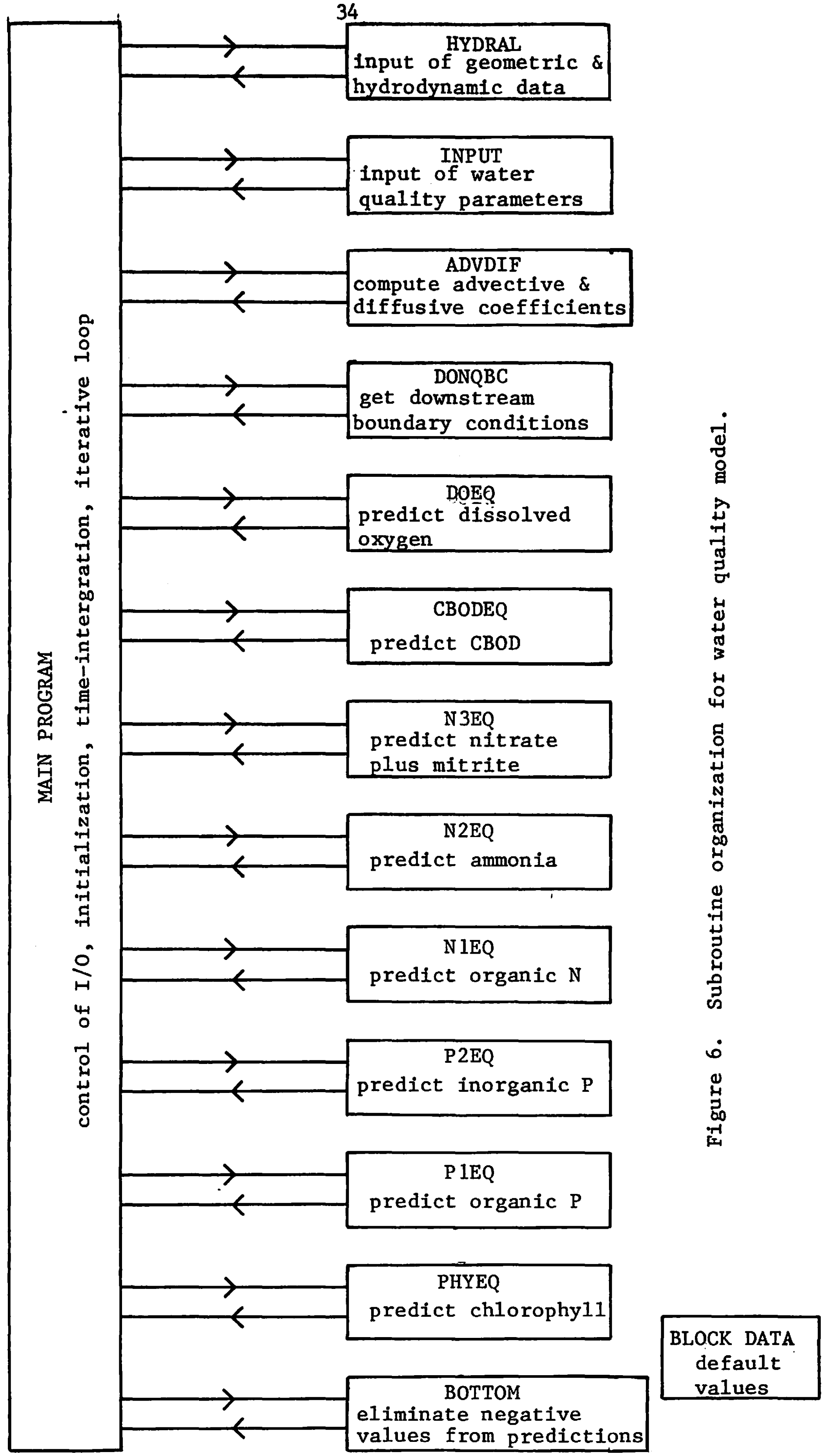


Figure 6. Subroutine organization for water quality model.

B. Data Input Description and Glossary

Having given a previous general description of input organization, it is now necessary to itemize the input data line by line with definitions and units where needed.

Water Quality Model Inputs	**Format**
Main Input File (logical unit 5)	
TMAX, DTT, NTPRIN, TIMDEP	2F10.0, 3I5

TMAX is the duration of the run in days and DTT is the time step in days. NTPRIN is the number of times during the run when the output will be printed and TIMDEP is an integer indicating whether water quality input conditions, such as nonpoint sources, are time-dependent (TIMDEP=1) or not

TT(I),I=1,NTPRIN — 7F10.3

The time in days at which the results will be printed out $0<TT(I)\leq TMAX$. The last TT should equal TMAX.

TLAG — F10.3

The time in hours from slack before flood to recovering downstream boundary conditions.

THEN12, THEN23, THEP12 — 7F10.3

The exponential base for temperature dependence of rate constants respectively, of nitrogen hydrolysis, nitrification and organic phosphorus mineralization.

NS2 — I5

The number of segments for which nutrient transfer coefficients will be read. Setting NS2=2 establishes uniform values, otherwise NS2 should equal MU.

XKN12(I),I=2,NS2 — 7F10.3

The hydrolysis rate in mg/l-day

XKN23(I),I=2,NS2 7F10.3

The nitrification rate in mg/l-day

XKP12(I),I=2,NS2 7F10.3

The phosphorus mineralization rate in mg/l-day

NOTE: The transect limits ML & MU have already been passed to the water quality model by means of the binary file containing the time-dependent hydraulic data.

XKH12,XKH23,XKHP12 3F10.3

Half-saturation concentrations for hydrolysis and nitrification, respectively, followed by the half-saturation concentration for phosphorus mineralization, all in mg/l.

NS2 I5

The number of segments for which settling and loss rates will be specified. Setting NS2=2 establishes uniform values, otherwise NS2 should equal MU.

KN11(I),I=2,NS2 7F10.3

Organic N settling rate in m/day.

KN33(I),I=2,NS2 7F10.3

Nitrate loss coefficient (denitrification rate) in m/day.

KP11(I),I=2,NS2 7F10.3

Organic phosphorus settling rate in m/day.

KP22(I),I=2,NS2 7F10.3

Inorganic phosphorus settling rate in m/day.

KCBOD(I),I=2,NS2 7F10.3

Ultimate carbonaceous BOD settling rate in m/day.

AC,AN,AP,PQ,RQ,KMN,KMP 7F10.0

AC,AN & AP are the carbon/chlorophyll, nitrogen/chlorophyll and phosphorus/chlorophyll ratios, respectively, in mg/ug.

PQ is the ratio of oxygen produced to carbon fixed, in moles per mole.

RQ is the ratio of carbon dioxide liberated to oxygen consumed, in moles per mole.

KMN & KMP are the Michaelis constants for growth limitation due to nitrogen and phosphorus, respectively, in mg/l.

XKCG,RIS,RRESP,KCS,KGRAZ,FRON,FROP 7F10.0

XKCG is the optimum growth rate at $20^{o}C$ in 1/days.

RIS is the saturation light intensity, in langleys/day.

RRESP is the endogenous respiration rate at $20^{o}C$ in 1/day.

KCS is the settling rate in m/day.

KGRAZ is the grazing and other mortality rate at $20^{o}C$ in 1/days.

FRON is the fraction of metabolically produced nitrogen recycled to the organic pool.

FROP is the fraction of metabolically produced phosphorus recycled to the organic pool.

THETAG,THETAR,THETAD 3F10.0

THETAG is the exponential base for temperature dependence of growth rate.

THETAR is the exponential base for temperature dependence of respiration rate.

THETAD is the exponential base for temperature dependence of grazing and other mortality.

NOTE: At this point control passes to subroutine HYDRAL.

TITLE 1X,35A2

Alpha information describing the run.

ALPHA(I),I=ML,MU 14F5.2

The interpolation factors for weighting of upstream flow in mass transport calculations.

NOTE: Control now passes back to the main program and thence to subroutine INPUT.

TITLE 1X,35A2

Alpha information for identifying the run.

NDG,NS2,NAME 2I5,30A2

NDG is an integer identifying a particular data group while NS2 tells how many numbers will be input. NAME is alpha information for convenience of the user. There are ten possible data groups.

NDG=1 Boundary conditions (NS2 for this data group may be arbitrarily specified.

N1UP,N1D 2F10.0

Upstream and downstream boundary conditions for organic N.

N2UP,N2D 2F10.0

Upstream and downstream boundary conditions for ammonia.

N3UP,N3D 2F10.0

Upstream and downstream boundary conditions for nitrate plus nitrite.

P1UP,P1D 2F10.0

Upstream and downstream boundary conditions for organic phosphorus.

P2UP,P2D 2F10.0

Upstream and downstream boundary conditions for inorganic phosphorus.

CUP,CD 2F10.0

Upstream and downstream boundary conditions for chlorophyll.

CBODUP,CBODD 2F10.0

Upstream and downstream boundary conditions for ultimate CBOD.

DOUP,DOD 2F10.0

Upstream and downstream boundary conditions for dissolved oxygen.

NDG=3: Initial Conditions

N1(I),I=ML,MU 14F5.0

Organic nitrogen initial conditions

N2(I),I=ML,MU 14F5.0

Ammonia initial conditions

N3(I),I=ML,MU 14F5.0

Nitrate plus nitrite initial conditions. Default value for all three nitrogen species is 0.1 mg/l.

P1(I),I=ML,MU 14F5.0

Organic phosphorus initial conditions

P2(I),I=ML,MU 14F5.0

Inorganic phosphorus initial conditions. Default value for both organic and inorganic phosphorus is 0.1 mg/l.

C(I),I=ML,MU 14F5.0

Chlorophyll initial conditions. Default value is 10 micrograms per liter.

CBOD(I),I=ML,MU 14F5.0

CBOD initial conditions. Default value is 2.0 mg/l.

DO(I),I=ML,MU 14F5.0

Dissolved oxygen initial conditions. Default value is 7.0 mg/l.

NOTE: Default values are used if this data group is omitted.

NDG=4: Wasteloads Input

NS2 = number of segments in which point source will be specified. For each of these NS2 segments there will be one line of input. If there are no point sources, the entire data group may be omitted.

K,PSQ(K),PSN1(K),PSN2(K),PSN3(K), 5X,I5,8F7.1

PSP1(K),PSP2(K),PSBOD(K),PSDO(K),

K is the segment number; $ML \leq K < MU$. PSQ(K) is the point source discharge in cubic meters per second. PSN1(K), PSN2(K), PSN3(K), PSP1(K), PSP2(K) & PSBOD(K) are the point source discharges in kg/day for organic N, ammonia N, nitrate plus nitrite N, organic P, inorganic P and BOD respectively. PSDO(K) is the dissolved oxygen concentration in the effluent in mg/l.

NSG=5: Nonpoint (distributed) sources

NS2 = number of segments in which nonpoint source will be specified. For each of these segments there will be one line of input. If there are no nonpoint sources, the data group may be omitted. **NOTE** these data are contained in a separate file accessed as Unit 15.

K,DSQ(K),DSN1(K),DSN2(K),DSN3(K),DSP1(K), I5,9F7.2

DSP2(K),DSC(K),DSBOD(K),DSDO(K)

K is the segment number; $ML \leq K < MU$. DSQ(K) is the distributed flow rate in cubic meters per second. DSN1(K), DSN2(K), DSN3(K), DSP1(K), DSP2(K), & DSBOD(K) are the distributed sources of organic N, ammonia, N, nitrite plus nitrite N, organic P, inorganic P and ultimate CBOD respectively in kg/day. DSC is the distributed source of chlorophyll in gm/day and DSDO is the concentration of dissolved oxygen of the distributed source, in mg/l.

NDG=6: BOD decay coefficients at 20°C

XCKC(I),I=ML,MU 14F5.0

The array of decay coefficients for each segment at 20°C.

TCCKC F10.0

The exponential base for temperature correction.

RKRO F10.0

The coefficient in reaeration formula.

NDG=7: Turbidity

TURB(I),I=ML,MU 14F5.0

Extinction coefficient for each segment in 1/m. Default value isis 1.0/m.

NDG=8: Benthic Fluxes.

Negative values are losses to sediment and positive values are sources from sediment. Each of the following inputs is expressed in $gm/m^2/day$ at 20 deg. C.

XBENN1(I),I=ML,MU 14F5.0

Organic nitrogen benthic exchange.

XBENN2(I),I=ML,MU 14F5.0

Ammonia nitrogen benthic exchange.

XBENN3(I),I=ML,MU 14F5.0

Nitrate plus nitrite nitrogen benthic exchange.

XBENP1(I),I=ML,MU 14F5.0

Organic P benthic exchange.

XBENP2(I),I=ML,MU 14F5.0

Inorganic P benthic exchange.

XBENDOC(I),F=ML,MU 14F5.0

Ultimate CBOD benthic exchange.

XBENDO(I),I=ML,MU 14F5.0

Dissolved oxygen benthic exchange.

(negative sediment oxygen demand)

TCBN1,TCBN2,TCBN3,TCBP1,TCBP2,TCBOC,TCBDO 7F10.0

Exponential bases for temperature correction for each of the above, respectively.

NDG=9: Sunlight parameters

NS2 is flag for specifying whether day length is to be changed.

If NS2=1 the following line is read

RIA,TFM,TU,TD 4F10.0

RIA is the total radiation over one day.

TFM is the time (in hours) from midnight to the beginning of the model run.

TU & TD are the respective times of sunrise and sunset, in hour.

If NS2=1, the following line is read.

RIA F10.0

The total radiation over one day.

NOTE: The first time INPUT is called, NS2 must be set to 1. For subsequent calls, one can either update solar radiation only ($NS2 \neq 1$) or update solar radiation, sunrise time and sunset time. (NS2=1) However, if the latter option is chosen, TFM must be reset to its initial value.

NDG=10. Wind reaeration

WREA(I),I=ML,MU 14F5.0

The wind-induced contribution to reaeration in m/day for each segment. Default value is 0.

NDG=2: Temperature (NS2 may be arbitrarily specified)

TEMP F10.0

NOTE: This data group must be read after data group 8 (bottom exchanges, including SOD) and 6 (BOD decay rate), since these parameters must be temperature-corrected.

NDG=99. Exit subroutine INPUT.

If the time-varying option has been chosen (TIMDEP=1), subroutine INPUT is called at 0000 hours of each day of the model simulation. Any previous input will be retained unless or until explicitly overwritten by a read instruction in subroutine INPUT. As a minimum, two lines of input are needed for each simulated day, for example:

DAY N NOTHING CHANGED TODAY

then, in columns 4 and 5:

99.

C. Organizing and Controlling a Computer Run

As with the hydrodynamic sub-model, all the files involved in making a computer run will be held on disk storage. Without being specific to any particular machine, one can enumerate the steps necessary for a computer run.

1. Open main input file for reading (logical unit 5).

2. Open binary file to read hydrodynamic data (logical unit 7).

3. Open nonpoint source input file (logical unit 15).

4. Open file to store page width output. (logical unit 6).

5. Initiate execution of program.

6. Close I/O files (some machines will do this in response to the Fortran STOP command).

7. (optional) line-printer copy of output file.

D. Some Special Cases

There are situations where many of the eight components of the ecosystem model are of no interest. In such cases the input parameters can be modified to suppress unwanted components. Four special cases will be considered.

- o CBOD-DO model
- o CBOD-NBOD-DO model
- o Nitrogen Cycle Suppressed
- o Phosphorus Cycle Suppressed;

The approach used in setting up these special cases is to eliminate a maximum number of input constants so as to achieve a ´clean´ printout with a minimum of extraneous data.

1. CBOD-DO model. It is possible to zero out the chlorophyll and nutrient dynamics and calculate only the impact of CBOD point and nonpoint sources. To achieve this simplification, the following changes should be made in the input data:

- o set all nutrient transfer coefficients equal to zero.
- o set all settling rates equal to zero **except** for CBOD.

- o set all phytoplankton-related constants equal to zero **except** for respiration quotient and saturation light intensity.
- o set all boundary conditions equal to zero **except** for CBOD and DO.
- o set all initial conditions equal to zero **except** for CBOD and DO.
- o set all point and nonpoint sources equal to zero **except** for CBOD and DO.

2. CBOD-NBOD-DO model. Although NBOD as such is not modeled, the model includes the oxygen consumption accompanying nitrification. To run this type of simplification, the following changes should be made in the input data:

- o set the organic N hydrolysis rate and the P mineralization rates equal to zero.
- o set all settling rates equal to zero except for CBOD.
- o set all phytoplankton-related constants equal to zero except for respiration quotient and saturation light intensity.
- o set all boundary conditions equal to zero except for ammonia, CBOD and DO. Divide the desired NBOD boundary condition by 4.33 and input it as ammonia.
- o set all initial conditions equal to zero except for ammonia, CBOD and DO. Divide the desired NBOD initial conditions by 4.33 and input them as ammonia .
- o set all point and nonpoint sources equal to zero except for ammonia, CBOD and DO. Divide the NBOD point and nonpoint sources by 4.33 and input them as ammonia.

The resulting ammonia predictions will yield NBOD predictions when multiplied by 4.33. The saturation concentration limiting nitrification rate (KH23) will still be in effect.

3. Nitrogen Cycle Suppressed. In cases where nitrogen scarcity is known not to limit phytoplankton growth rate and the influence of nitrification on dissolved oxygen is not of concern, it is possible to suppress this loop of the modeling predictions. The following changes should be made in model input.

- o set the hydrolysis and nitrification rates equal to zero.
- o set the settling constants for organic N and nitrate plus nitrite (actually denitrification) equal to zero.
- o set the nitrogen to chlorophyll ratio equal to zero.
- o set all nitrogen boundary conditions and initial conditions equal to zero, and point and nonpoint sources equal to zero.

4. Phosphorus Cycle Suppressed. In cases where phosphorus scarcity is known not to inhibit phytoplankton growth, it is possible to suppress this loop of the modeling predictions. The following changes should be made in the model input.

- o set the mineralization rate equal to zero.
- o set the organic P and inorganic P settling rates equal to zero.
- o set the phosphorus to chlorophyll ratio equal to zero.
- o set all phosphorus boundary conditions and initial conditions equal to zero and point and nonpoint sources equal to zero.

V. MODEL APPLICATION

A model can be viewed as an analytical tool for extending present knowledge forward into an unknown or hypothetical situation. That is, modelling is a kind of extrapolation technique. In many applications, much depends on the reliability of this method. The costs of treatment facilities, of borrowed money, and of the chemicals and energy needed to construct and operate a treatment system typically are very large compared to the cost of a modelling program. Nevertheless, the model results can play a large part in management decisions, and therefore, it is likely that model predictions will be scrutinized. In addition to veracity, an acceptable model should be sensitive to some coefficients and less so to others based on present scientific knowledge of natural systems. The modeler is limited in his range of parameters by the necessity to justify the results to himself, to the scientific and engineering communities, and to managers and other interested parties, some of whom may take an adversary position.

A. Model Calibration

Many parameters and rate constants must be specified in order to run the water quality model. Most of these model inputs will be estimated from the available literature and then altered to produce the best agreement with observation. If any errors are made in the field data or the analysis of same (the known quantities) the effect will be felt on the estimated inputs (the unknowns).

Once a full suite of model inputs has been asembled (see Chapter IV), model testing can begin. Both the hydrodynamic and water quality models will need to be calibrated by adjusting certain input parameters until the model predictions correspond to the observed conditions. The adjustable parameters are those which are estimated or only known within some limits.

The hydrodynamic model is straightforward to calibrate, since only a couple of parameters can be adjusted and since it lacks the feedback loops present in the water quality model. Typically, one adjusts friction coefficients in order to match the observed phase and amplitude of tidal height and current, and then one adjusts dispersion coefficients and open boundary time lag to reproduce the observed dispersion of salinity, dye, or some other tracer.

Water quality model calibration is more involved. Since the model components are interconnected, altering one rate constant will often affect several model components. These responses can be anticipated in the first place by referring to the ecosystem model flow diagram (see Fig. 4). In the second place, one can use hand calculations to anticipate the magnitude of the response of various components to the change of a particular parameter or rate constant. These estimates will often exaggerate the actual response by a factor of two or three (owing to negative feedback and transport processes), but can be useful nonetheless.

Graphical presentation of calibration results is not only essential for report generation, but highly useful during the calibration process. One can see very quickly where model results and data agree well and where they do not, and one can gain useful insights into the phytoplankton and nutrient dynamics. Examples of longitudinal profiles of the various water quality components are shown in the appendix in

Figures A-1 and A-2 as part of the demonstration run. Observed values could easily be added to this kind of plot. Figures A-3 and A-4 show temporal plots of Chlorophyll and Dissolved Oxygen for selected model segments.

B. Model Verification

There are so many unknown input constants that conceivably more than one combination of parameters can produce a satisfactory calibration. Alternatively, an error in observation in the calibration data set can skew the parameters in a manner that becomes apparent only when another field data set is tested. Likewise a parameter might not be critical for the conditions existing at the time of the calibration run, yet become critical in other circumstances. For all these reasons, a calibrated model must be tested against an entirely separate set of observations, to insure that a range of field conditions can be modelled successfully. This process is called verification. If verification is not successful, further adjustment might be necessary to match one or more data sets. The similitude of the verification runs will probably not be as good as that of the calibration. This is normal and to be expected when pushing the model to reproduce a wider range of natural conditions.

Among the natural variables influencing water quality, water temperature and decay rates seem particularly significant. Therefore one should plan to gather verification data at different times in the seasonal cycle, if possible, in order to test the model against a wide range of values of these parameters.

The verification run could be for a separate period with different natural conditions from the calibration period or it could a continuous simulation over several months. The latter approach can be used even if the verification data are not continuous over this time span, but only intermittent. However, the parameters that are held constant during such extended runs (because of lack of data) should not be both highly variable with time and critical for the results. This second consideration leads to the subject of model sensitivity.

C. Sensitivity Studies

In this imperfect world, the data available for a water quality model study might be both incomplete and imprecise. Some of the model inputs will have to be estimated, while others are taken from measurements with unavoidable errors. Much caution is needed to insure that estimated quantities do not dominate the output to the extent that minor alterations of an input parameter will completely change the nature of the result. On the other hand, there are instances when past modelling experience indicates that the model should be sensitive to a particular parameter. There are also fundamental limiting cases to which the model should adhere, such as the cessation of phytoplankton growth resulting from the depletion of inoganic phosphorus. Thus, many modellers will want to examine the sensitivity of the model to various input parameters.

The procedure for sensitivity tests is simply to rerun the calibration with a single input altered. Generally it is most satisfactory to run sensitivity tests in pairs, with the given parameter shifted both up and down in separate tests. Sample sensitivity tests are included in the demonstration run (Appendix A), with the results shown graphically in Figures A-5 to A-7 and in tabular form in Table A-8.

Referemces

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APPENDIX A

Water Quality Model Demonstration

A demonstration case was set up to illustrate use of the model. Although this demonstration does not include every option available, it does utilize the most important processes: phytoplankton growth and respiration, nutrient recycling, oxygen demand and tidal transport. The hydrodynamic and water quality models must be run separately. Each of these has its own input files and line-printer output. Table A-1 itemizes the rate constants and parameters used in the water quality model. This is not an input file but rather a tabular summary of the necessary parameters. Tables A-2 and A-3 are input files required by the hydrodynamic model. Table A-2 lists the hydraulic input data and table A-3 lists the input channel geometry. At run time, an output file is generated which echoes the input data and displays the model predictions for those times specified in the input file. The printout includes the average, maximum and minimum for the last two tidal cycles of the model run. The printout is shown in table A-4. The hydrodynamic model additionally generates a binary file of predicted flow and tidal elevation for feeding directly to the water quality model. This file is not displayed here. The water quality input file is listed in table A-5. When the water quality model is run, a printout file is generated which displays all the input data and the model predictions for any time specified by the input file. For example the user can choose to display the model predictions on a hourly basis, or at slack tides, or at a specific time of day, or any combination of these. In any event, the model will calculate the average, maximum and minmum for each segment for the last two tidal cycles (about twenty-five hours) of the model run. The printout for this model run is displayed in table A-6. Note that model predictions are generated for early stages of the model run and again on an hourly basis near the end of the run. These tables can be used to check the integrity of the source code because the data input in these input files should result in the same printout independent of machine or operating system. Figures A-1 and A-2 display graphically the model prediction for average conditions during the last twenty-four hours of this model run. Although plotting capability is not included in the model package, graphical display of results is used here since it is such a useful and even necessary way of showing model predictions. Figures A-3 and A-4 show temporal plots of Chlorophyll and Dissolved Oxygen, respectively.

Three pairs of sensitivity runs were made using the above demonstration run as a basis. The runs were made in pairs, with a parameter varied from the base condition in both positive and negative directions. The conditions are itemized in table A-7. The results of these sensitivity runs are shown graphically in Figures A-5 to A-7 where the daily averages for the last day of the model run are compared. Table A-8 summarizes the results displayed in these figures.

Table A-1. PARAMETERS AND RATE CONSTANTS FOR WATER QUALITY DEMONSTRATION

Quantity	Units	Model Name	Value
Carbon-Chlorophyll Ratio	mg/ug	AC	0.042
Nitrogen-Chlorophyll Ratio	mg/ug	AN	0.007
Phosphorus-Chlorophyll Ratio	mg/ug	AP	0.001
Photosynthesis Quotient	-	PQ	1.0
Respiratory Quotient	-	RQ	1.0
Michaelis Constant for Nitrogen Inhibition	mg/l	KMN	0.025
Michaelis Constant for Phosphorus Inhibition	mg/l	KMP	0.001
Optimum Phytoplankton Growth Rate at 20^{o} C	1/day	XKCG	2.5
Saturation Light Level	langleys/day	RIS	250
Respiration Rate at 20 deg C	1/day	RRESP	0.25
Phytoplankton Settling Rate	m/day	XKCS	0.1

Table A-1 (Cont'd)

Grazing and Other Death Factors	1/day	XKGRAZ	0.02
Fraction of Nitrogen Recycled to Organic Pool	-	FRON	1.0
Fraction of Phosphorus Recycled to Organic Pool	-	FROP	1.0
Hydrolysis Rate	mg/l/day at 20C	XKN12	0.075
Half Saturation Concentration for Hydrolysis	mg/l	XKH12	1.0
Nitrification Rate	mg/l/day at 20C	XKN23	0.09
Half Saturation Concentration for Nitrification	mg/l	XKH23	1.0
Organic Phosphorus Minerali-zation Rate	mg/l/day at 20C	XKP12	0.22
Organic Phosphorus Settling Rate	m/day	KP11	0.1
Half Saturation Concentration for Mineralization	mg/l	XKHP12	1.0
Organic Nitrogen Settling Rate	m/day	KN33	0.1

Table A-1 (Cont'd)

Bottom Exchange Rates	gm/sq m/day		
Dissolved Oxygen		XBENDO	-1.3
Organic Nitrogen		XBENN1	0.
Ammonia		XBENN2	0.05
Nitrate-Nitrite		XBENN3	0.
Organic Phosphorus		XBENP1	0.
Ortho Phosphorus		XBENP2	0.005
Ultimate CBOD		XBENOC	0.
CBOD Decay Rate at 20 °C	1/day	XCKC	0.08
Exponential Base for			
Temperature Dependence of	-		
BOD decay rate		TCCKC	1.05
Nitrogen Hydrolysis Rate		THEN12	1.05
Nitrification Rate		THEN23	1.05
Organic Phosphorus Mineralization Rate		THEP12	1.05
Phytoplankton Growth Rate		THETAG	1.068
Respiration Rate		THETAR	1.045
Grazing and Other Death Factors		THETAD	1.000
SOD		TCBDO	1.065

TABLE A-2

HYDRODYNAMIC INPUT DATA

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
    1    1    0    0
  IDEALIZED GEOMETRY FOR DEMONSTRATING MODEL
    2   19
    1   20  TRANSECT DISTANCES
    9.5       9.0       8.5       8.0       7.5       7.0       6.5
    6.0       5.5       5.0       4.5       4.0       3.5       3.0
    2.5       2.0       1.5       1.0       0.5       0.0
    2   20  INCR DRAINAGE AREAS UPST OF TRANS NO
       1.0        0.        0.        0.        0.        0.        0.
        0.        0.        0.        0.        0.        0.        0.
        0.        0.        0.        0.        0.        0.
    3   20    INITIAL DISCHARGES
       1.0        0.        0.        0.        0.        0.        0.
        0.        0.        0.        0.        0.        0.        0.
        0.        0.        0.        0.        0.        0.
    4   19   INITIAL ELEVATIONS
    -0.326    -0.326    -0.326    -0.326    -0.326    -0.326    -0.326
    -0.326    -0.326    -0.326    -0.326    -0.326    -0.326    -0.326
    -0.326    -0.326    -0.326    -0.326    -0.326
    5   19   INITIAL CONCENTRATIONS
        0.        0.        0.        0.        0.        0.        0.
        0.        0.        0.        0.        0.        0.        0.
        0.        0.        0.        0.        0.
    7   20    MANNING ROUGHNESS
      .030      .030      .030      .030      .030      .030      .030
      .030      .030      .030      .030      .030      .030      .030
      .030      .030      .030      .030      .030      .030
    8   20   ADVECTIVE WEIGHTING FACTORS
      0.52      0.52      0.52      0.52      0.52      0.52      0.52
      0.52      0.52      0.52      0.52      0.52      0.52      0.52
      0.52      0.52      0.52      0.52      0.52      0.52      0.52
   99
    35.5    3.1416     TIDAL HARMONICS USED TO GENERATE TIDE
      0.        0.     AMPLITUDE IN CM
      0.        0.     PHASE IN RADIANS
      0.        0.     COSINE FUNCTIONS GENERATED INTERNALLY
      0.        0.
      0.        0.
      0.        0.
      0.        0.
      0.        0.
        0.   WINDSTRESS
        5.       3.0
       1.0      100.     EBASE,AK
        0.      DECAY

         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
```

Table A-2 (Cont'd)

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012



       0.      21.0 .00138888        28    START,DURATION,DT(DA),NTOUT
     0.80      0.90      1.00     20.00     20.04     20.08     20.12
    20.16     20.21     20.25     20.29     20.33     20.38     20.42
    20.46     20.50     20.54     20.58     20.62     20.67     20.71
    20.75     20.79     20.83     20.88     20.92     20.96     21.00
        1     15120        15    NSBH,NSEH,NHS
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
```

TABLE A-3

GEOMETRIC INPUT DATA

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
   HYDRODYNAMIC MODEL DEMONSTRATION CHANNEL GEOMETRY
    1   20          TRANSECT GEOMETRIC DATA
      393.      393.      393.      393.      393.      393.      393.
      393.      393.      393.      393.      393.      393.      393.
      393.      393.      393.      393.      393.      393.
      3.93      3.93      3.93      3.93      3.93      3.93      3.93
      3.93      3.93      3.93      3.93      3.93      3.93      3.93
      3.93      3.93      3.93      3.93      3.93      3.93
       2.0       2.0       2.0       2.0       2.0       2.0       2.0
       2.0       2.0       2.0       2.0       2.0       2.0       2.0
       2.0       2.0       2.0       2.0       2.0       2.0
    2   19          REACH GEOMETRIC DATA
     5.0E4     5.0E4     5.0E4     5.0E4     5.0E4     5.0E4     5.0E4
     5.0E4     5.0E4     5.0E4     5.0E4     5.0E4     5.0E4     5.0E4
     5.0E4     5.0E4     5.0E4     5.0E4     5.0E4
    1.96E5    1.96E5    1.96E5    1.96E5    1.96E5    1.96E5    1.96E5
    1.96E5    1.96E5    1.96E5    1.96E5    1.96E5    1.96E5    1.96E5
    1.96E5    1.96E5    1.96E5    1.96E5    1.96E5
   99
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
```

TABLE A-4

HYDRODYNAMIC MODEL PRINTOUT

SALT IS MODELLED
HYDRAULICS WILL BE PASSED TO WATER QUALITY PROGRAM
TIDAL HEIGHTS ARE GENERATED BY HARMONICS
1
IDEALIZED GEOMETRY FOR DEMONSTRATING MODEL
******** UPSTREAM BOUNDARY TRANSECT NO.= 2 ******
******** DOWNSTRM BOUNDARY TRANSECT NO.= 19 ******

INPUT DATA GROUP = 1 NUMBER OF POINTS IN THIS GROUP = 20 TRANSECT DISTANCES

INPUT DATA GROUP = 2 NUMBER OF POINTS IN THIS GROUP = 20 INCR DRAINAGE AREAS UPST OF TRANS NO

TRANS NO.	DIST FROM MOUTH KILO M.	DRAINAGE AREA KM**2
2	9.50	1.00
3	9.00	0.00
4	8.50	0.00
5	8.00	0.00
6	7.50	0.00
7	7.00	0.00
8	6.50	0.00
9	6.00	0.00
10	5.50	0.00
11	5.00	0.00
12	4.50	0.00
13	4.00	0.00
14	3.50	0.00
15	3.00	0.00
16	2.50	0.00
17	2.00	0.00
18	1.50	0.00
19	1.00	0.00

INPUT DATA GROUP = 3 NUMBER OF POINTS IN THIS GROUP = 20 INITIAL DISCHARGES

INPUT DATA GROUP = 4 NUMBER OF POINTS IN THIS GROUP = 19 INITIAL ELEVATIONS

INPUT DATA GROUP = 5 NUMBER OF POINTS IN THIS GROUP = 19 INITIAL CONCENTRATIONS

INPUT DATA GROUP = 7 NUMBER OF POINTS IN THIS GROUP = 20 MANNING ROUGHNESS

INPUT DATA GROUP = 8 NUMBER OF POINTS IN THIS GROUP = 20 ADVECTIVE WEIGHTING FACTORS

********************INITIAL CONDITIONS******************

REACH NO.	SURFACE ELEVATION METER	DISCHARGE M**3.0	SALINITY PPT	PPT	MANNING COEF.	WEIGHTING FACTOR
2	-0.33	1.00	0.00		0.0300	0.52
3	-0.33	0.00	0.00		0.0300	0.52
4	-0.33	0.00	0.00		0.0300	0.52
5	-0.33	0.00	0.00		0.0300	0.52
6	-0.33	0.00	0.00		0.0300	0.52
7	-0.33	0.00	0.00		0.0300	0.52
8	-0.33	0.00	0.00		0.0300	0.52
9	-0.33	0.00	0.00		0.0300	0.52
10	-0.33	0.00	0.00		0.0300	0.52
11	-0.33	0.00	0.00		0.0300	0.52
12	-0.33	0.00	0.00		0.0300	0.52
13	-0.33	0.00	0.00		0.0300	0.52
14	-0.33	0.00	0.00		0.0300	0.52
15	-0.33	0.00	0.00		0.0300	0.52
16	-0.33	0.00	0.00		0.0300	0.52
17	-0.33	0.00	0.00		0.0300	0.52
18	-0.33	0.00	0.00		0.0300	0.52
19	-0.33	0.00	0.00		0.0300	0.52

STEADY CONDITIONS

1

HYDRODYNAMIC MODEL DEMONSTRATION CHANNEL GEOMETRY

INPUT DATA GRUP= 1 NUMBER OF POINT IN THIS GRO UP= 20 TRANSECT GEOMETRIC DATA

TRANS NO.	CONVEY. AREA SQUARE METER	TRANSECT DEPTH SQUARE METER	CENTROID DEPTH METER	1000 M**2
2	393.00	3.93	2.00	
3	393.00	3.93	2.00	
4	393.00	3.93	2.00	
5	393.00	3.93	2.00	
6	393.00	3.93	2.00	
7	393.00	3.93	2.00	
8	393.00	3.93	2.00	
9	393.00	3.93	2.00	
10	393.00	3.93	2.00	
11	393.00	3.93	2.00	
12	393.00	3.93	2.00	
13	393.00	3.93	2.00	
14	393.00	3.93	2.00	
15	393.00	3.93	2.00	
16	393.00	3.93	2.00	
17	393.00	3.93	2.00	
18	393.00	3.93	2.00	
19	393.00	3.93	2.00	

INPUT DATA GRUP= 2 NUMBER OF POINT IN THIS GRO UP= 19 REACH GEOMETRIC DATA

REACH NO.	SURFACE AREA SQUARE METER	VOLUME CU. METER
2	50000.00	196000.00
3	50000.00	196000.00
4	50000.00	196000.00
5	50000.00	196000.00
6	50000.00	196000.00
7	50000.00	196000.00
8	50000.00	196000.00
9	50000.00	196000.00
10	50000.00	196000.00

11	50000.00	196000.00
12	50000.00	196000.00
13	50000.00	196000.00
14	50000.00	196000.00
15	50000.00	196000.00
16	50000.00	196000.00
17	50000.00	196000.00
18	50000.00	196000.00

DAYS FROM START =   0.0HEADWATER FLOW =   1.00 (M**3/SEC)

********************AMPLITUDES AND PHASES OF TIDAL CONSTITUENTS AT DOWNSTREAM BOUNDARY****************

TIDAL AMPLITUDES (CM) AND PHASES (RAD.)

M2	35.50	3.142
S2	0.00	0.000
N2	0.00	0.000
K1	0.00	0.000
M4	0.00	0.000
O1	0.00	0.000
MM	0.00	0.000
SSA	0.00	0.000
SA	0.00	0.000

**********WIND STRESS(DYNE/CM**2)= 0.00**********

***** MAXIMUM SALINITY AT DOWNSTREAM SEGMENT= 5.00*****
***** TIME INTERVAL FROM SBF TO REACH MAX. SALINITY(HRS)=3.00 *****

MINIMUM DISPERSION COEFFICIENT AT SLACK TIDE IN M**2/SEC = 1.00
MULTIPLIER FOR TAYLOR DISPERSION = 100.00

DYE DECAY RATE = 0.000 PER DAY

STARTING DAY OF RUN = 0.000
NUMBER OF DAYS TO BE RUN = 21.0
TIME INCREMENT IN DAYS = 0.00139
NUMBER OF TIMES TO PRINT OUTPUT = 28

OUTPUT PRINTED ON DAYS

0.800	0.900	1.000	20.000	20.040	20.080	20.120
20.160	20.210	20.250	20.290	20.330	20.380	20.420
20.460	20.500	20.540	20.580	20.620	20.670	20.710
20.750	20.790	20.830	20.880	20.920	20.960	21.000

NOTE: Some of the sample outputs have been omitted in the following pages.

****** CONDITIONS AT 0.800 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.347	1.00	0.00	0.00	9.25
3	9.00	0.347	1.69	0.00	0.00	8.75
4	8.50	0.347	2.39	0.01	0.00	8.25
5	8.00	0.347	3.08	0.01	0.00	7.75
6	7.50	0.346	3.78	0.01	0.00	7.25
7	7.00	0.346	4.47	0.01	0.00	6.75
8	6.50	0.346	5.16	0.01	0.00	6.25
9	6.00	0.346	5.86	0.01	0.00	5.75
10	5.50	0.345	6.55	0.02	0.00	5.25
11	5.00	0.345	7.24	0.02	0.00	4.75
12	4.50	0.345	7.94	0.02	0.01	4.25
13	4.00	0.344	8.63	0.02	0.07	3.75
14	3.50	0.344	9.32	0.02	0.26	3.25
15	3.00	0.343	10.02	0.02	0.80	2.75
16	2.50	0.342	10.71	0.03	1.94	2.25
17	2.00	0.342	11.41	0.03	3.59	1.75
18	1.50	0.341	12.10	0.03	4.88	1.25
19	1.00	0.340	12.80	0.03	5.00	-0.25

****** CONDITIONS AT 0.900 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.032	1.00	0.00	0.00	9.25
3	9.00	0.032	3.52	0.01	0.00	8.75
4	8.50	0.032	6.03	0.02	0.00	8.25
5	8.00	0.032	8.55	0.02	0.00	7.75
6	7.50	0.032	11.07	0.03	0.00	7.25
7	7.00	0.032	13.58	0.03	0.00	6.75
8	6.50	0.032	16.10	0.04	0.00	6.25
9	6.00	0.031	18.61	0.05	0.00	5.75
10	5.50	0.031	21.12	0.05	0.00	5.25
11	5.00	0.031	23.63	0.06	0.00	4.75
12	4.50	0.030	26.14	0.07	0.00	4.25
13	4.00	0.030	28.65	0.07	0.01	3.75
14	3.50	0.029	31.15	0.08	0.06	3.25
15	3.00	0.028	33.66	0.09	0.22	2.75
16	2.50	0.028	36.16	0.09	0.71	2.25
17	2.00	0.027	38.66	0.10	1.80	1.75
18	1.50	0.026	41.16	0.10	3.30	1.25
19	1.00	0.025	43.66	0.11	5.00	-0.25

****** CONDITIONS AT 1.000 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	-0.328	1.00	0.00	0.00	9.25
3	9.00	-0.328	2.15	0.01	0.00	8.75
4	8.50	-0.328	3.29	0.01	0.00	8.25
5	8.00	-0.328	4.44	0.01	0.00	7.75
6	7.50	-0.328	5.58	0.02	0.00	7.25
7	7.00	-0.328	6.72	0.02	0.00	6.75
8	6.50	-0.328	7.86	0.02	0.00	6.25
9	6.00	-0.327	9.00	0.02	0.00	5.75
10	5.50	-0.327	10.13	0.03	0.00	5.25
11	5.00	-0.327	11.26	0.03	0.00	4.75
12	4.50	-0.326	12.39	0.03	0.00	4.25
13	4.00	-0.326	13.51	0.04	0.00	3.75
14	3.50	-0.326	14.62	0.04	0.00	3.25
15	3.00	-0.325	15.73	0.04	0.03	2.75
16	2.50	-0.325	16.83	0.05	0.05	2.25
17	2.00	-0.324	17.92	0.05	0.63	1.75
18	1.50	-0.324	19.00	0.05	0.36	1.25
19	1.00	-0.323	20.07	0.06	5.00	-0.25

****** CONDITIONS AT 20.000 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.239	1.00	0.00	0.00	9.25
3	9.00	0.239	2.88	0.01	0.00	8.75
4	8.50	0.239	4.76	0.01	0.00	8.25
5	8.00	0.238	6.65	0.02	0.00	7.75
6	7.50	0.238	8.53	0.02	0.00	7.25
7	7.00	0.238	10.41	0.02	0.00	6.75
8	6.50	0.238	12.29	0.03	0.00	6.25
9	6.00	0.237	14.17	0.03	0.01	5.75
10	5.50	0.237	16.05	0.04	0.03	5.25
11	5.00	0.237	17.93	0.04	0.06	4.75
12	4.50	0.236	19.81	0.05	0.14	4.25
13	4.00	0.236	21.69	0.05	0.30	3.75
14	3.50	0.235	23.57	0.06	0.61	3.25
15	3.00	0.234	25.45	0.06	1.18	2.75
16	2.50	0.234	27.33	0.07	2.11	2.25
17	2.00	0.233	29.22	0.07	3.36	1.75
18	1.50	0.232	31.10	0.07	4.50	1.25
19	1.00	0.231	32.99	0.08	5.00	-0.25

****** CONDITIONS AT 20.120 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	-0.239	1.00	0.00	0.00	9.25
3	9.00	-0.239	2.96	0.01	0.00	8.75
4	8.50	-0.239	4.92	0.01	0.00	8.25
5	8.00	-0.239	6.87	0.02	0.00	7.75
6	7.50	-0.239	8.83	0.02	0.00	7.25
7	7.00	-0.239	10.78	0.03	0.00	6.75
8	6.50	-0.239	12.73	0.03	0.00	6.25
9	6.00	-0.239	14.68	0.04	0.00	5.75
10	5.50	-0.239	16.63	0.05	0.01	5.25
11	5.00	-0.239	18.57	0.05	0.02	4.75
12	4.50	-0.239	20.50	0.06	0.05	4.25
13	4.00	-0.239	22.43	0.06	0.10	3.75
14	3.50	-0.239	24.35	0.07	0.20	3.25
15	3.00	-0.239	26.27	0.07	0.40	2.75
16	2.50	-0.239	28.18	0.08	0.71	2.25
17	2.00	-0.239	30.07	0.08	1.45	1.75
18	1.50	-0.240	31.96	0.09	1.81	1.25
19	1.00	-0.240	33.83	0.09	5.00	-0.25

****** CONDITIONS AT 20.250 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	-0.266	1.00	0.00	0.00	9.25
3	9.00	-0.266	-0.67	-0.00	0.00	8.75
4	8.50	-0.266	-2.34	-0.01	0.00	8.25
5	8.00	-0.266	-4.01	-0.01	0.00	7.75
6	7.50	-0.266	-5.68	-0.02	0.00	7.25
7	7.00	-0.266	-7.35	-0.02	0.00	6.75
8	6.50	-0.265	-9.02	-0.02	0.00	6.25
9	6.00	-0.265	-10.69	-0.03	0.00	5.75
10	5.50	-0.265	-12.35	-0.03	0.01	5.25
11	5.00	-0.264	-14.02	-0.04	0.02	4.75
12	4.50	-0.264	-15.69	-0.04	0.04	4.25
13	4.00	-0.263	-17.36	-0.05	0.09	3.75
14	3.50	-0.263	-19.03	-0.05	0.19	3.25
15	3.00	-0.262	-20.71	-0.06	0.37	2.75
16	2.50	-0.261	-22.38	-0.06	0.65	2.25
17	2.00	-0.260	-24.06	-0.07	1.34	1.75
18	1.50	-0.259	-25.73	-0.07	1.80	1.25
19	1.00	-0.258	-27.42	-0.07	5.00	-0.25

****** CONDITIONS AT 20.330 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.250	1.00	0.00	0.00	9.25
3	9.00	0.250	-0.85	-0.00	0.00	8.75
4	8.50	0.250	-2.70	-0.01	0.00	8.25
5	8.00	0.250	-4.55	-0.01	0.00	7.75
6	7.50	0.250	-6.40	-0.02	0.00	7.25
7	7.00	0.250	-8.25	-0.02	0.00	6.75
8	6.50	0.249	-10.10	-0.02	0.00	6.25
9	6.00	0.249	-11.94	-0.03	0.01	5.75
10	5.50	0.249	-13.79	-0.03	0.03	5.25
11	5.00	0.249	-15.63	-0.04	0.06	4.75
12	4.50	0.249	-17.47	-0.04	0.15	4.25
13	4.00	0.248	-19.30	-0.05	0.31	3.75
14	3.50	0.248	-21.13	-0.05	0.63	3.25
15	3.00	0.248	-22.96	-0.05	1.23	2.75
16	2.50	0.248	-24.78	-0.06	2.20	2.25
17	2.00	0.247	-26.60	-0.06	3.51	1.75
18	1.50	0.247	-28.41	-0.07	4.66	1.25
19	1.00	0.247	-30.22	-0.07	5.00	-0.25

****** CONDITIONS AT 20.500 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.290	1.00	0.00	0.00	9.25
3	9.00	0.290	2.48	0.01	0.00	8.75
4	8.50	0.290	3.96	0.01	0.00	8.25
5	8.00	0.290	5.44	0.01	0.00	7.75
6	7.50	0.290	6.91	0.02	0.00	7.25
7	7.00	0.290	8.39	0.02	0.00	6.75
8	6.50	0.289	9.87	0.02	0.00	6.25
9	6.00	0.289	11.35	0.03	0.01	5.75
10	5.50	0.289	12.83	0.03	0.03	5.25
11	5.00	0.288	14.31	0.03	0.07	4.75
12	4.50	0.288	15.79	0.04	0.16	4.25
13	4.00	0.287	17.27	0.04	0.34	3.75
14	3.50	0.287	18.76	0.04	0.68	3.25
15	3.00	0.286	20.24	0.05	1.31	2.75
16	2.50	0.285	21.73	0.05	2.32	2.25
17	2.00	0.285	23.22	0.06	3.60	1.75
18	1.50	0.284	24.71	0.06	4.67	1.25
19	1.00	0.283	26.21	0.06	5.00	-0.25

****** CONDITIONS AT 20.620 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	-0.176	1.00	0.00	0.00	9.25
3	9.00	-0.175	3.26	0.01	0.00	8.75
4	8.50	-0.176	5.51	0.01	0.00	8.25
5	8.00	-0.176	7.76	0.02	0.00	7.75
6	7.50	-0.176	10.02	0.03	0.00	7.25
7	7.00	-0.176	12.27	0.03	0.00	6.75
8	6.50	-0.176	14.52	0.04	0.00	6.25
9	6.00	-0.176	16.77	0.04	0.00	5.75
10	5.50	-0.176	19.01	0.05	0.01	5.25
11	5.00	-0.176	21.25	0.06	0.03	4.75
12	4.50	-0.176	23.48	0.06	0.06	4.25
13	4.00	-0.176	25.71	0.07	0.12	3.75
14	3.50	-0.176	27.94	0.07	0.24	3.25
15	3.00	-0.177	30.16	0.08	0.46	2.75
16	2.50	-0.177	32.37	0.09	0.84	2.25
17	2.00	-0.178	34.57	0.09	1.63	1.75
18	1.50	-0.178	36.77	0.10	2.27	1.25
19	1.00	-0.179	38.95	0.10	5.00	-0.25

****** CONDITIONS AT 20.750 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	-0.312	1.00	0.00	0.00	9.25
3	9.00	-0.311	-0.24	-0.00	0.00	8.75
4	8.50	-0.311	-1.48	-0.00	0.00	8.25
5	8.00	-0.311	-2.72	-0.01	0.00	7.75
6	7.50	-0.311	-3.97	-0.01	0.00	7.25
7	7.00	-0.311	-5.21	-0.01	0.00	6.75
8	6.50	-0.311	-6.45	-0.02	0.00	6.25
9	6.00	-0.310	-7.69	-0.02	0.00	5.75
10	5.50	-0.310	-8.93	-0.02	0.01	5.25
11	5.00	-0.310	-10.17	-0.03	0.02	4.75
12	4.50	-0.309	-11.41	-0.03	0.04	4.25
13	4.00	-0.309	-12.66	-0.03	0.08	3.75
14	3.50	-0.308	-13.90	-0.04	0.17	3.25
15	3.00	-0.307	-15.14	-0.04	0.33	2.75
16	2.50	-0.307	-16.39	-0.05	0.57	2.25
17	2.00	-0.306	-17.64	-0.05	1.26	1.75
18	1.50	-0.305	-18.89	-0.05	1.39	1.25
19	1.00	-0.304	-20.14	-0.06	5.00	-0.25

****** CONDITIONS AT 20.880 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.188	1.00	0.00	0.00	9.25
3	9.00	0.188	-1.18	-0.00	0.00	8.75
4	8.50	0.188	-3.37	-0.01	0.00	8.25
5	8.00	0.188	-5.55	-0.01	0.00	7.75
6	7.50	0.188	-7.74	-0.02	0.00	7.25
7	7.00	0.188	-9.92	-0.02	0.00	6.75
8	6.50	0.188	-12.10	-0.03	0.00	6.25
9	6.00	0.188	-14.28	-0.03	0.01	5.75
10	5.50	0.188	-16.45	-0.04	0.02	5.25
11	5.00	0.188	-18.63	-0.05	0.06	4.75
12	4.50	0.187	-20.80	-0.05	0.13	4.25
13	4.00	0.187	-22.97	-0.06	0.27	3.75
14	3.50	0.187	-25.13	-0.06	0.55	3.25
15	3.00	0.187	-27.28	-0.07	1.08	2.75
16	2.50	0.187	-29.44	-0.07	1.97	2.25
17	2.00	0.187	-31.58	-0.08	3.23	1.75
18	1.50	0.187	-33.72	-0.08	4.49	1.25
19	1.00	0.187	-35.85	-0.09	5.00	-0.25

****** CONDITIONS AT 21.000 DAYS AFTER COMPUTATION BEGINS******

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.329	1.00	0.00	0.00	9.25
3	9.00	0.329	2.02	0.00	0.00	8.75
4	8.50	0.329	3.04	0.01	0.00	8.25
5	8.00	0.328	4.06	0.01	0.00	7.75
6	7.50	0.328	5.08	0.01	0.00	7.25
7	7.00	0.328	6.11	0.01	0.00	6.75
8	6.50	0.328	7.13	0.02	0.00	6.25
9	6.00	0.328	8.15	0.02	0.01	5.75
10	5.50	0.327	9.17	0.02	0.03	5.25
11	5.00	0.327	10.20	0.02	0.08	4.75
12	4.50	0.326	11.22	0.03	0.17	4.25
13	4.00	0.326	12.25	0.03	0.37	3.75
14	3.50	0.325	13.27	0.03	0.74	3.25
15	3.00	0.325	14.30	0.03	1.42	2.75
16	2.50	0.324	15.33	0.04	2.48	2.25
17	2.00	0.324	16.36	0.04	3.78	1.75
18	1.50	0.323	17.40	0.04	4.78	1.25
19	1.00	0.322	18.43	0.04	5.00	-0.25

***** DAILY AVERAGE *****

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	-0.009	1.00	0.00	0.00	9.25
3	9.00	-0.009	0.96	0.00	0.00	8.75
4	8.50	-0.009	0.92	0.00	0.00	8.25
5	8.00	-0.009	0.88	0.00	0.00	7.75
6	7.50	-0.009	0.84	0.00	0.00	7.25
7	7.00	-0.009	0.80	0.00	0.00	6.75
8	6.50	-0.009	0.76	0.00	0.00	6.25
9	6.00	-0.009	0.72	0.00	0.01	5.75
10	5.50	-0.009	0.68	0.00	0.02	5.25
11	5.00	-0.009	0.64	0.00	0.04	4.75
12	4.50	-0.009	0.61	0.00	0.09	4.25
13	4.00	-0.009	0.57	0.00	0.20	3.75
14	3.50	-0.009	0.53	0.00	0.41	3.25
15	3.00	-0.009	0.49	0.00	0.79	2.75
16	2.50	-0.009	0.45	0.00	1.40	2.25
17	2.00	-0.009	0.41	0.00	2.41	1.75
18	1.50	-0.009	0.37	0.00	3.17	1.25
19	1.00	-0.010	0.33	0.00	5.00	-0.25

***** DAILY MAXIMUM *****

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	0.362	1.00	0.00	0.00	9.25
3	9.00	0.361	3.54	0.01	0.00	8.75
4	8.50	0.361	6.07	0.02	0.00	8.25
5	8.00	0.361	8.61	0.02	0.00	7.75
6	7.50	0.361	11.14	0.03	0.00	7.25
7	7.00	0.361	13.67	0.04	0.00	6.75
8	6.50	0.361	16.20	0.04	0.00	6.25
9	6.00	0.360	18.73	0.05	0.01	5.75
10	5.50	0.360	21.26	0.05	0.03	5.25
11	5.00	0.360	23.79	0.06	0.08	4.75
12	4.50	0.359	26.31	0.07	0.18	4.25
13	4.00	0.359	28.83	0.07	0.39	3.75
14	3.50	0.358	31.35	0.08	0.80	3.25
15	3.00	0.358	33.87	0.09	1.52	2.75
16	2.50	0.357	36.38	0.09	2.63	2.25
17	2.00	0.356	38.90	0.10	3.94	1.75
18	1.50	0.356	41.40	0.11	4.88	1.25
19	1.00	0.355	43.91	0.11	5.00	-0.25

***** DAILY MINIMUM *****

	DISTANCE	SURFACE ELEVATION	DISCHARGE	TIDAL VELOCITY	SALINITY	MID-DISTANCE
2	9.50	-0.363	1.00	0.00	0.00	9.25
3	9.00	-0.363	-1.54	-0.00	0.00	8.75
4	8.50	-0.363	-4.07	-0.01	0.00	8.25
5	8.00	-0.363	-6.61	-0.02	0.00	7.75
6	7.50	-0.363	-9.14	-0.02	0.00	7.25
7	7.00	-0.362	-11.68	-0.03	0.00	6.75
8	6.50	-0.362	-14.21	-0.04	0.00	6.25
9	6.00	-0.362	-16.74	-0.04	0.00	5.75
10	5.50	-0.361	-19.27	-0.05	0.01	5.25
11	5.00	-0.361	-21.79	-0.06	0.02	4.75
12	4.50	-0.360	-24.32	-0.06	0.04	4.25
13	4.00	-0.360	-26.84	-0.07	0.07	3.75
14	3.50	-0.359	-29.35	-0.07	0.15	3.25
15	3.00	-0.358	-31.86	-0.08	0.30	2.75
16	2.50	-0.358	-34.37	-0.09	0.47	2.25
17	2.00	-0.357	-36.87	-0.09	1.21	1.75
18	1.50	-0.356	-39.36	-0.10	0.88	1.25
19	1.00	-0.355	-41.85	-0.11	5.00	-0.25

TABLE A-5. WATER QUALITY INPUT DATA FILE

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
       21. .0208333   28    1
      0.25      0.50      1.00     2.000     20.04     20.08     20.12
     20.16     20.21     20.25     20.29     20.33     20.38     20.42
     20.46     20.50     20.54     20.58     20.62     20.67     20.71
     20.75     20.79     20.83     20.88     20.92     20.96     21.00
        3.
     1.050     1.050     1.050
    2
    0.0750
    0.0900
    0.2200
        1.        1.       1.
    2
       .10
       .00
       .10
       .00
       .10
      .042      .007     .0010       1.0        1.      .025      .001
       2.5      250.      .250       0.1       .02        1.        1.
   1.068     1.045     1.000
GEOMETRY AND INITIAL CONDITIONS
  .52  .52  .52  .52  .52  .52  .52  .52  .52  .52  .52  .52  .52  .52
  .52  .52  .52  .52
AUGUST 19 INPUTS
    1    1 BOUNDARY CONDITIONS
      .376       0.3
      .094       0.1
      0.56      1.10
      .014      0.01
      .076      0.03
       3.3       26.
       1.1       2.0
       6.8       8.0
    3   18  INITIAL CONDITIONS
 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
 0.25 0.25 0.25 0.25
  6.2  4.3  2.4  1.1  0.2  0.2  0.2  0.2  0.1  0.2  0.2  0.2  0.2  0.1
  0.2  0.2  0.2  0.1
  6.0  4.7  3.4  2.4  1.1  1.0  1.0  1.0  0.2  1.1  1.0  1.0  1.0  0.2
  1.0  1.0  1.0  0.2
  0.1  0.1  0.1  0.1  0.1  0.1 0.01 0.01  0.1  0.1  0.1 0.01 0.01  0.1
  0.1 0.01 0.01  0.1
  0.5  0.4  0.2  0.1 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05
 0.05 0.05 0.05 0.05
  10.  39.  39.  73.  73.  65.  26.  26.  40.  73.  65.  26.  26.  40.
  65.  26.  26.  40.
   7.  12.  18.  26.  16.  14.  12.  12.  12.  16.  14.  12.  12.  12.
  14.  12.  12.  12.
   8.  10.  12.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.
  15.  15.  15.  15.
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
```

Table A-5 (Cont'd)

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
    4    1  POINT SOURCE
         8    0.1     0.0  150.     183.      0.0     100.    300.     4.8
    6   18 BOD DECAY
  .08  .08  .08  .08  .08  .08  .08  .08  .08  .08  .08  .08  .08  .08
  .08  .08  .08  .08
     1.05
    3.933
    7   18 LIGHT EXTINCTION
  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5
  2.5  2.5  2.5  2.5
    8   18  BENTHIC AND AREAL FLUXES
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0
 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05
 0.05 0.05 0.05 0.05 0.05
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0
 .003 .003 .003 .003 .003 .003 .003 .003 .003 .003 .003 .003 .003 .003
 .003 .003 .003 .003
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0
 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3 -1.3
 -1.3 -1.3 -1.3 -1.3
      1.0       1.0       1.0       1.0       1.0       1.0       1.0
    2    1 TEMPERATURE
     28.5
    9    1 SOLAR RADIATION PARAMETERS
     540.      15.       5.3      18.7
   10   18  WIND-INDUCED REAERATION
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.00 0.00 0.00 0.00
   99
  AUG 20 INPUTS
    9    2  SOLAR RADIATION
     510.
   99
  AUG 21 INPUTS
    9    2  SOLAR RADIATION
     510.
   99
  AUG 22 INPUTS
    9    2  SOLAR RADIATION
     500.
   99
  AUG 23 INPUTS
    9    2  SOLAR RADIATION
     300.
   99
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
```

```
Table A-5 (Cont'd)  AUG 24 INPUTS
   9     2   SOLAR RADIATION
     525.
   99
  AUG 25 INPUTS
   9     2   SOLAR RADIATION
     525.
   99
  AUG 26 INPUTS
   9     2   SOLAR RADIATION
     555.
   99
  AUG 27 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  AUG 28 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  AUG 29 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  AUG 29 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  AUG 30 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  AUG 31 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  SEP 01 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  SEP 02 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  SEP 03 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
  SEP 04 INPUTS
   9     2   SOLAR RADIATION
     500.
   99
```

Table A-5 (Cont'd)

```
  SEP 05 INPUTS
    9     2  SOLAR RADIATION
      500.
   99
  SEP 06 INPUTS
    9     2  SOLAR RADIATION
      500.
   99
  SEP 07 INPUTS
    9     2  SOLAR RADIATION
      500.
   99
  SEP 08 INPUTS
    9     2 - SOLAR RADIATION
      500.
   99
  SEP 09 INPUTS
    9     2  SOLAR RADIATION
      500.
   99
```

Table A-6. Water Quality Model Printout

1STATION NUMBER OF UPSTREAM BOUNDARY= 2 STATION NUMBER OF DOWNSTREAM BOUNDARY = 19

NUMBER OF DAYS TO BE RUN= 21.00 TIME INCREMENT IN DAYS=0.020833

TIME DEPENDENT CONDITIONS

OUTPUT WILL BE PRINTED 28 TIMES AT DAYS*

0.250	0.500	1.000	2.000	20.040	20.080	20.120
20.160	20.210	20.250	20.290	20.330	20.380	20.420
20.460	20.500	20.540	20.580	20.620	20.670	20.710
20.750	20.790	20.830	20.860	20.920	20.960	21.000

**********TIME FOR DOWNSTREAM CONDITIONS TO RECOVER TOTHOSE OF OPEN BAY**********
3.00HOURS

*****EXPONENTIAL TEMPERATURE DEPENDENT COEFFICIENTS****
FOR N12= 1.0500
FOR N23= 1.0500
FOR P12= 1.0500

NUTRIENT TRANSFER COEFFICIENTS: (PER DAY AT 20 DEG C)

KN12	KN23	KP12
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200
0.0750	0.0900	0.2200

*NOTE: Some of the sample outputs have been omitted in the following pages.

0.0750 0.0900 0.2200

HALF-SATURATION CONCENTRATION FOR HYDROLYSIS (MG/L) 1.000
HALF-SATURATION CONCENTRATION FOR NITRIFICATION (MG/L) 1.000
HALF-SATURATION CONCENTRATION FOR ORG. PHOSPHORUS (MG/L) 1.000

*****SETTLING RATES (M/DAY)*****

	KN11	KN33	KP11	KP22	KCBODS
2	0.10000	0.00000	0.10000	0.00000	0.10000
3	0.10000	0.00000	0.10000	0.00000	0.10000
4	0.10000	0.00000	0.10000	0.00000	0.10000
5	0.10000	0.00000	0.10000	0.00000	0.10000
6	0.10000	0.00000	0.10000	0.00000	0.10000
7	0.10000	0.00000	0.10000	0.00000	0.10000
8	0.10000	0.00000	0.10000	0.00000	0.10000
9	0.10000	0.00000	0.10000	0.00000	0.10000
10	0.10000	0.00000	0.10000	0.00000	0.10000
11	0.10000	0.00000	0.10000	0.00000	0.10000
12	0.10000	0.00000	0.10000	0.00000	0.10000
13	0.10000	0.00000	0.10000	0.00000	0.10000
14	0.10000	0.00000	0.10000	0.00000	0.10000
15	0.10000	0.00000	0.10000	0.00000	0.10000
16	0.10000	0.00000	0.10000	0.00000	0.10000
17	0.10000	0.00000	0.10000	0.00000	0.10000
18	0.10000	0.00000	0.10000	0.00000	0.10000
19	0.10000	0.00000	0.10000	0.00000	0.10000

PHYTOPLANKTON COEFFICIENTS

CARBON/CHLOROPHYLL RATIO (MG C TO MICROGM CHL)	0.04200
NITROGEN/CHLOROPHYLL RATIO (MG N TO MICROGM CHL)	0.00700
PHOSPHORUS/CHLOROPHYLL RATIO (MG P TO MICROGM CHL)	0.00100
PHOTOSYNTHESIS QUOTIENT	1.00000
RESPIRATION QUOTIENT	1.00000
HALF-SATURATION CONSTANT FOR NITROGEN UPTAKE (MG/L)	0.02500
HALF-SATURATION CONSTANT FOR PHOSPHORUS UPTAKE (MG/L)	0.00100
MAXIMUM GROWTH RATE (1/DAY AT 20 C)	2.50000

SATURATION LIGHT INTENSITY (LANGLEYS/DAY)	250.0
RESPIRATION RATE (1/DAY AT 20 C)	0.25000
SETTLING RATE (METERS/DAY)	0.10000
GRAZING AND OTHER DEATH FACTORS =	0.020
FRACTION NITROGEN RECYCLED TO ORGANIC POOL	1.00000
FRACTION PHOSPHORUS RECYCLED TO ORGANIC POOL	1.00000
EXPONENTIAL BASE FOR GROWTH	1.06800
EXPONENTIAL BASE FOR RESPIRATION	1.04500
EXPONENTIAL BASE FOR GRAZING ETC.	1.00000

1

GEOMETRY AND INITIAL CONDITIONS

REACH NO.	KM. FROM MOUTH	CROSS SECTION SQ. METER	TRANSECT DEPTH METER	REACH DEPTH METER	REACH VOLUME CUBIC METER
2	9.50	360.40	3.60	3.59	0.1797E+06
3	9.00	360.40	3.60	3.59	0.1797E+06
4	8.50	360.40	3.60	3.59	0.1797E+06
5	8.00	360.40	3.60	3.59	0.1797E+06
6	7.50	360.40	3.60	3.59	0.1797E+06
7	7.00	360.40	3.60	3.59	0.1797E+06
8	6.50	360.40	3.60	3.59	0.1797E+06
9	6.00	360.40	3.60	3.59	0.1797E+06
10	5.50	360.40	3.60	3.59	0.1797E+06
11	5.00	360.40	3.60	3.59	0.1797E+06
12	4.50	360.40	3.60	3.59	0.1797E+06
13	4.00	360.40	3.60	3.59	0.1797E+06
14	3.50	360.40	3.60	3.59	0.1797E+06
15	3.00	360.40	3.60	3.59	0.1797E+06
16	2.50	360.40	3.60	3.59	0.1797E+06
17	2.00	360.40	3.60	3.59	0.1797E+06
18	1.50	360.40	3.60	3.59	0.1797E+06
19	1.00	360.40	3.60	3.59	0.1797E+06

REACH NO.	TIDAL VELO. M. PER SEC.	DISPERSION M**2 PER SEC.	ALPHA
2	0.00	0.0	0.520
3	0.00	0.0	0.520
4	0.00	0.0	0.520
5	0.00	0.0	0.520

6	0.00	0.0	0.520
7	0.00	0.0	0.520
8	0.00	0.0	0.520
9	0.00	0.0	0.520
10	0.00	0.0	0.520
11	0.00	0.0	0.520
12	0.00	0.0	0.520
13	0.00	0.0	0.520
14	0.00	0.0	0.520
15	0.00	0.0	0.520
16	0.00	0.0	0.520
17	0.00	0.0	0.520
18	0.00	0.0	0.520
19	0.00	0.0	0.520

AUGUST 19 INPUTS

INPUT DATA GROUP= 1 NUMBER OF POINT IN THIS GROUP= 1 BOUNDARY CONDITIONS

*****BOUNDARY CONCENTRATIONS*****

	ORG N	NH4 N	NO3 N	ORG P	PO4 P	CHL A	CBODU	DO
UPSTREAM	0.376	0.094	0.560	0.014	0.076	3.300	1.100	6.800
DOWNSTREAM	0.300	0.100	1.100	0.010	0.030	26.000	2.000	8.000

INPUT DATA GROUP= 3 NUMBER OF POINT IN THIS GROUP= 18 INITIAL CONDITIONS

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.250	6.200	6.000	0.100	0.500	10.000	7.000	8.000
3	8.750	0.250	4.300	4.700	0.100	0.400	39.000	12.000	10.000
4	8.250	0.250	2.400	3.400	0.100	0.200	39.000	18.000	12.000
5	7.750	0.250	1.100	2.400	0.100	0.100	73.000	26.000	15.000
6	7.250	0.250	0.200	1.100	0.100	0.050	73.000	16.000	15.000
7	6.750	0.250	0.200	1.000	0.100	0.050	65.000	14.000	15.000
8	6.250	0.250	0.200	1.000	0.010	0.050	26.000	12.000	15.000
9	5.750	0.250	0.200	1.000	0.010	0.050	26.000	12.000	15.000

10	5.250	0.250	0.100	0.200	0.100	0.050	40.000	12.000	15.000
11	4.750	0.250	0.200	1.100	0.100	0.050	73.000	16.000	15.000
12	4.250	0.250	0.200	1.000	0.100	0.050	65.000	14.000	15.000
13	3.750	0.250	0.200	1.000	0.010	0.050	26.000	12.000	15.000
14	3.250	0.250	0.200	1.000	0.010	0.050	26.000	12.000	15.000
15	2.750	0.250	0.100	0.200	0.100	0.050	40.000	12.000	15.000
16	2.250	0.250	0.200	1.000	0.100	0.050	65.000	14.000	15.000
17	1.750	0.250	0.200	1.000	0.010	0.050	26.000	12.000	15.000
18	1.250	0.250	0.200	1.000	0.010	0.050	26.000	12.000	15.000
19	-0.250	0.250	0.100	0.200	0.100	0.050	40.000	12.000	15.000

INPUT DATA GROUP= 4 . NUMBER OF POINT IN THIS GROUP= 1 POINT SOURCE

REACH	QWAST	WN1	WN2	WN3	WP1	WP2	WBOD	DOWAST
	M**3/S	KG/DY	KG/DY	KG/DY	KG/DY	KG/DY	KG/DY	MG/L
8	0.1	0.0	150.0	183.0	0.0	100.0	300.0	4.8

INPUT DATA GROUP= 6 NUMBER OF POINT IN THIS GROUP= 18 BOD DECAY

REACH NO.	CBOD DECAY AT 20 DEG. CENT.
2	0.080
3	0.080
4	0.080
5	0.080
6	0.080
7	0.080
8	0.080
9	0.080
10	0.080
11	0.080
12	0.080
13	0.080
14	0.080
15	0.080
16	0.080
17	0.080

18	0.080
19	0.080

EXPONENTIAL BASE FOR TEMPERATURE DEPENDENCE: 1.05000
PROPORTIONALITY CONSTANT FOR REAERATION: 3.93

INPUT DATA GROUP= 7 NUMBER OF POINT IN THIS GROUP= 18 LIGHT EXTINCTION

REACH NO.	LIGHT EXTINCTION (1/METER)
2	2.50
3	2.50
4	2.50
5	2.50
6	2.50
7	2.50
8	2.50
9	2.50
10	2.50
11	2.50
12	2.50
13	2.50
14	2.50
15	2.50
16	2.50
17	2.50
18	2.50
19	2.50

INPUT DATA GROUP= 8 NUMBER OF POINT IN THIS GROUP= 18 BENTHIC AND AREAL FLUXES

RELEASE RATE (GM/M**2/DAY AT 20 DEG. CENT.)

REACH NO.	BENN1	BENN2	BENN3	BENP1	BENP2	BENOC	BENDO
2	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
3	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
4	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
5	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000

6	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
7	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
8	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
9	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
10	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
11	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
12	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
13	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
14	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
15	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
16	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
17	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
18	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000
19	0.0000	0.0500	0.0000	0.0000	0.0030	0.0000	-1.3000

TEMPERATURE DEPENDENCE BASES

TCBN1	TCBN2	TCBN3	TCBP1	TCBP2	TCBOC	TCBDO
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

INPUT DATA GROUP= 2 NUMBER OF POINT IN THIS GROUP= 1 TEMPERATURE

TEMPERATURE= 28.50 DEGREES CENTIGRADE
NOTE: READ TEMP AFTER BOD DECAY AND SOD

INPUT DATA GROUP= 9 NUMBER OF POINT IN THIS GROUP= 1 SOLAR RADIATION PARAMETERS

HOURS FROM MIDNITE TO MODEL START = 15.00
HOURS FROM MIDNITE TO SUN UP = 5.30
HOURS FROM MIDNITE TO SUN DOWN = 18.70
SOLAR RADIATION TOTAL OVER ONE DAY = 540.00

INPUT DATA GROUP= 10 NUMBER OF POINT IN THIS GROUP= 18 WIND-INDUCED REAERATION

REACH NO.	REAERATION (METER/DAY)
2	0.0000

3	0.0000
4	0.0000
5	0.0000
6	0.0000
7	0.0000
8	0.0000
9	0.0000
10	0.0000
11	0.0000
12	0.0000
13	0.0000
14	0.0000
15	0.0000
16	0.0000
17	0.0000
18	0.0000
19	0.0000

******CONCENTRATION AT 0.25 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.257	5.589	5.556	0.089	0.468	13.145	7.021	7.781
3	8.750	0.268	3.920	4.486	0.095	0.365	38.802	12.566	9.816
4	8.250	0.274	1.906	3.042	0.096	0.169	48.555	18.967	12.092
5	7.750	0.292	0.635	1.855	0.097	0.077	73.023	21.728	14.285
6	7.250	0.286	0.091	0.929	0.087	0.053	63.526	13.244	14.425
7	6.750	0.274	0.231	1.038	0.055	0.081	43.885	12.552	14.526
8	6.250	0.262	0.310	1.057	0.019	0.145	26.421	11.941	14.605
9	5.750	0.276	0.106	0.660	0.075	0.030	46.584	12.663	14.528
10	5.250	0.286	0.140	0.737	0.102	0.058	60.303	13.785	14.485
11	4.750	0.283	0.190	1.215	0.060	0.049	55.444	13.801	14.480
12	4.250	0.266	0.161	0.783	0.037	0.050	30.247	11.284	14.577
13	3.750	0.267	0.157	0.306	0.037	0.050	32.441	11.918	14.481
14	3.250	0.278	0.136	0.688	0.080	0.051	47.321	12.102	14.286
15	2.750	0.275	0.157	0.894	0.050	0.048	39.885	11.361	13.829
16	2.250	0.272	0.173	1.099	0.010	0.044	27.337	9.412	12.816
17	1.750	0.279	0.113	0.779	0.024	0.040	23.086	6.312	11.007
18	1.250	0.299	0.110	1.070	0.031	0.034	33.882	3.931	8.832
19	-0.250	0.300	0.100	1.100	0.010	0.030	26.000	2.000	8.000

AUG 20 INPUTS

INPUT DATA GROUP= 9 NUMBER OF POINT IN THIS GROUP= 2 SOLAR RADIATION

SOLAR RADIATION TOTAL OVER ONE DAY = 510.00

******CONCENTRATION AT 0.50 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.263	5.309	5.329	0.078	0.454	10.453	6.241	7.142
3	8.750	0.277	4.434	4.853	0.088	0.411	28.876	10.230	8.272
4	8.250	0.286	2.803	3.739	0.091	0.259	36.365	15.340	9.797
5	7.750	0.314	1.446	2.681	0.095	0.144	56.321	20.759	11.584
6	7.250	0.322	0.548	1.588	0.095	0.091	61.692	16.833	12.583
7	6.750	0.315	0.205	1.084	0.087	0.026	56.314	13.886	13.029
8	6.250	0.237	0.451	1.339	0.043	0.226	36.254	12.623	13.483
9	5.750	0.280	0.308	1.109	0.033	0.139	30.737	11.898	13.573
10	5.250	0.290	0.188	0.681	0.068	0.092	37.220	11.885	13.488
11	4.750	0.310	0.172	0.399	0.081	0.070	51.002	13.312	13.213
12	4.250	0.310	0.171	0.956	0.079	0.061	50.838	12.978	13.230
13	3.750	0.291	0.175	0.950	0.049	0.055	37.673	12.090	13.430
14	3.250	0.235	0.173	0.913	0.041	0.054	33.286	11.708	13.469
15	2.750	0.288	0.147	0.692	0.060	0.056	35.544	11.616	13.452
16	2.250	0.295	0.158	0.333	0.062	0.056	39.909	11.734	13.155
17	1.750	0.236	0.166	0.890	0.045	0.053	34.236	11.315	13.213
18	1.250	0.285	0.161	0.893	0.035	0.050	28.936	10.020	12.438
19	-0.250	0.283	0.145	0.903	0.030	0.045	27.787	8.356	11.551

******CONCENTRATION AT 1.00 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.276	4.594	4.821	0.063	0.415	13.747	5.618	6.805
3	8.750	0.295	4.294	4.830	0.076	0.404	29.756	8.945	7.764
4	8.250	0.317	2.968	3.957	0.083	0.286	41.386	13.307	9.035
5	7.750	0.357	1.632	2.916	0.088	0.171	57.649	17.257	10.500
6	7.250	0.374	0.720	1.921	0.088	0.114	64.434	15.893	11.745
7	6.750	0.365	0.242	1.267	0.079	0.034	60.623	13.503	12.472
8	6.250	0.333	0.554	1.597	0.054	0.326	47.442	12.682	12.894
9	5.750	0.318	0.361	1.265	0.045	0.218	41.421	11.707	13.004
10	5.250	0.326	0.202	0.926	0.059	0.133	44.458	11.468	12.991
11	4.750	0.344	0.127	0.903	0.068	0.086	51.513	11.906	12.883
12	4.250	0.346	0.102	0.916	0.067	0.065	52.117	11.808	12.869
13	3.750	0.331	0.103	0.909	0.056	0.055	46.257	11.386	12.895
14	3.250	0.323	0.102	0.877	0.050	0.051	42.555	11.032	12.874
15	2.750	0.321	0.096	0.807	0.052	0.051	41.579	10.769	12.792
16	2.250	0.322	0.093	0.834	0.050	0.049	41.795	10.337	12.539
17	1.750	0.316	0.099	0.874	0.043	0.047	38.574	9.618	12.155
18	1.250	0.314	0.087	0.915	0.034	0.040	36.518	7.928	11.378
19	-0.250	0.306	0.090	0.958	0.026	0.036	32.670	6.159	10.338

AUG 21 INPUTS

INPUT DATA GROUP= 9 NUMBER OF POINT IN THIS GROUP= 2 SOLAR RADIATION

SOLAR RADIATION TOTAL OVER ONE DAY = 510.00

******CONCENTRATION AT 20.04 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.423	0.070	0.988	0.018	0.088	18.552	0.649	6.164
3	8.750	0.480	0.057	1.262	0.022	0.104	25.541	0.536	6.039
4	8.250	0.570	0.052	1.667	0.028	0.145	32.839	0.496	5.926
5	7.750	0.683	0.079	2.230	0.034	0.237	39.746	0.562	5.729
6	7.250	0.808	0.191	2.970	0.040	0.415	45.802	0.808	5.411
7	6.750	0.932	0.413	3.820	0.046	0.683	50.780	1.243	5.024
8	6.250	1.044	1.032	5.058	0.050	1.215	54.630	2.438	4.739
9	5.750	1.132	0.724	4.930	0.054	1.086	57.342	1.909	4.599
10	5.250	1.191	0.528	4.753	0.056	1.000	59.001	1.650	4.708
11	4.750	1.215	0.353	4.434	0.057	0.891	59.650	1.441	4.982
12	4.250	1.204	0.223	4.037	0.056	0.778	59.294	1.305	5.354
13	3.750	1.155	0.132	3.592	0.054	0.662	57.897	1.223	5.773
14	3.250	1.070	0.077	3.127	0.050	0.545	55.392	1.197	6.200
15	2.750	0.951	0.049	2.662	0.045	0.430	51.709	1.228	6.616
16	2.250	0.804	0.040	2.212	0.038	0.317	46.839	1.318	7.006
17	1.750	0.639	0.044	1.799	0.030	0.212	40.948	1.474	7.370
18	1.250	0.475	0.052	1.426	0.021	0.117	35.253	1.644	7.706
19	-0.250	0.374	0.073	1.226	0.015	0.065	30.338	1.813	7.855

******CONCENTRATION AT 20.12   DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.423	0.068	0.975	0.018	0.087	18.842	0.654	6.254
3	8.750	0.473	0.054	1.215	0.021	0.100	25.431	0.544	6.160
4	8.250	0.551	0.046	1.563	0.026	0.131	32.331	0.494	6.086
5	7.750	0.652	0.055	2.041	0.032	0.199	38.974	0.520	5.948
6	7.250	0.766	0.135	2.691	0.038	0.344	44.952	0.708	5.701
7	6.750	0.883	0.210	3.338	0.043	0.501	50.036	0.872	5.356
8	6.250	0.992	0.904	4.704	0.048	1.083	54.160	2.202	5.057
9	5.750	1.087	0.822	4.944	0.052	1.119	57.284	2.074	4.832
10	5.250	1.159	0.647	4.898	0.055	1.063	59.468	1.820	4.810
11	4.750	1.205	0.469	4.691	0.056	0.975	60.762	1.590	4.961
12	4.250	1.221	0.321	4.386	0.057	0.876	61.190	1.417	5.234
13	3.750	1.206	0.206	4.015	0.056	0.771	60.749	1.296	5.579
14	3.250	1.159	0.126	3.604	0.054	0.664	59.411	1.222	5.958
15	2.750	1.082	0.076	3.178	0.051	0.558	57.082	1.198	6.341
16	2.250	0.975	0.043	2.743	0.046	0.450	53.850	1.215	6.721
17	1.750	0.847	0.039	2.340	0.040	0.348	49.234	1.298	7.047
18	1.250	0.692	0.035	1.926	0.033	0.243	44.427	1.416	7.441
19	-0.250	0.550	0.047	1.601	0.025	0.161	38.463	1.567	7.619

******CONCENTRATION AT 20.25 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.429	0.074	0.984	0.018	0.089	17.976	0.664	6.237
3	8.750	0.482	0.060	1.230	0.022	0.102	24.467	0.549	6.105
4	8.250	0.563	0.053	1.588	0.027	0.136	31.229	0.498	5.996
5	7.750	0.668	0.065	2.082	0.033	0.208	37.745	0.528	5.823
6	7.250	0.786	0.145	2.747	0.039	0.355	43.605	0.712	5.538
7	6.750	0.906	0.258	3.468	0.045	0.548	48.578	0.966	5.166
8	6.250	1.019	0.979	4.868	0.049	1.146	52.594	2.325	4.832
9	5.750	1.115	0.815	5.008	0.053	1.127	55.617	2.037	4.584
10	5.250	1.137	0.646	4.962	0.056	1.075	57.705	1.802	4.573
11	4.750	1.232	0.468	4.742	0.058	0.984	58.903	1.574	4.740
12	4.250	1.245	0.320	4.421	0.058	0.882	59.235	1.405	5.030
13	3.750	1.226	0.207	4.034	0.057	0.774	58.694	1.288	5.394
14	3.250	1.173	0.129	3.608	0.055	0.663	57.245	1.219	5.792
15	2.750	1.089	0.081	3.167	0.051	0.553	54.810	1.201	6.195
16	2.250	0.974	0.055	2.722	0.046	0.442	51.414	1.230	6.593
17	1.750	0.835	0.047	2.300	0.040	0.336	46.718	1.325	6.959
18	1.250	0.659	0.048	1.855	0.031	0.223	41.199	1.483	7.390
19	-0.250	0.452	0.071	1.412	0.019	0.111	33.326	1.756	7.773

******CONCENTRATION AT 20.39   DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.433	0.078	0.996	0.018	0.091	17.241	0.656	6.107
3	8.750	0.497	0.065	1.292	0.023	0.110	24.258	0.534	5.922
4	8.250	0.598	0.065	1.739	0.029	0.160	31.504	0.501	5.746
5	7.750	0.723	0.109	2.372	0.036	0.274	38.298	0.600	5.473
6	7.250	0.860	0.262	3.211	0.043	0.495	44.157	0.922	5.075
7	6.750	0.991	0.590	4.218	0.048	0.845	48.858	1.558	4.645
8	6.250	1.104	1.070	5.265	0.053	1.284	52.356	2.493	4.350
9	5.750	1.186	0.603	4.883	0.056	1.039	54.669	1.679	4.265
10	5.250	1.235	0.474	4.714	0.058	0.982	55.873	1.561	4.469
11	4.750	1.241	0.299	4.314	0.059	0.853	55.992	1.352	4.814
12	4.250	1.205	0.188	3.864	0.056	0.731	55.009	1.250	5.245
13	3.750	1.127	0.114	3.371	0.053	0.605	52.868	1.202	5.709
14	3.250	1.009	0.075	2.869	0.048	0.480	49.497	1.222	6.175
15	2.750	0.857	0.060	2.377	0.040	0.356	44.864	1.312	6.633
16	2.250	0.678	0.061	1.908	0.031	0.237	39.098	1.473	7.076
17	1.750	0.494	0.074	1.491	0.022	0.131	32.786	1.691	7.493
18	1.250	0.347	0.091	1.185	0.013	0.052	27.596	1.899	7.829
19	-0.250	0.300	0.100	1.100	0.010	0.030	26.000	2.000	8.000

******CONCENTRATION AT 20.50 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.091	0.979	0.018	0.091	15.961	0.644	5.910
3	8.750	0.490	0.070	1.265	0.022	0.109	22.425	0.525	5.690
4	8.250	0.538	0.071	1.700	0.029	0.159	29.191	0.491	5.481
5	7.750	0.712	0.114	2.313	0.035	0.270	35.568	0.584	5.180
6	7.250	0.846	0.262	3.138	0.042	0.484	41.094	0.889	4.758
7	6.750	0.977	0.570	4.116	0.047	0.819	45.547	1.482	4.302
8	6.250	1.039	1.096	5.207	0.052	1.281	48.874	2.482	3.996
9	5.750	1.172	0.633	4.948	0.055	1.046	51.091	1.693	3.897
10	5.250	1.220	0.473	4.654	0.057	0.971	52.261	1.519	4.080
11	4.750	1.227	0.310	4.272	0.057	0.849	52.410	1.323	4.418
12	4.250	1.193	0.199	3.831	0.055	0.729	51.523	1.219	4.846
13	3.750	1.118	0.125	3.347	0.052	0.604	49.549	1.172	5.312
14	3.250	1.003	0.095	2.853	0.047	0.480	46.427	1.189	5.786
15	2.750	0.854	0.068	2.368	0.040	0.359	42.140	1.274	6.255
16	2.250	0.680	0.067	1.908	0.032	0.242	36.832	1.426	6.712
17	1.750	0.503	0.078	1.502	0.022	0.137	31.118	1.629	7.144
18	1.250	0.361	0.092	1.203	0.014	0.061	26.251	1.818	7.461
19	-0.250	0.313	0.098	1.119	0.011	0.036	25.965	1.955	7.865

******CONCENTRATION AT 20.62 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.422	0.085	0.957	0.018	0.090	14.879	0.648	5.842
3	8.750	0.473	0.075	1.191	0.021	0.104	20.284	0.535	5.626
4	8.250	0.554	0.071	1.537	0.027	0.138	26.041	0.483	5.436
5	7.750	0.657	0.087	2.018	0.032	0.210	31.642	0.510	5.190
6	7.250	0.774	0.176	2.675	0.038	0.361	36.718	0.699	4.844
7	6.750	0.892	0.280	3.363	0.044	0.540	41.053	0.904	4.414
8	6.250	1.003	0.969	4.726	0.048	1.119	44.564	2.215	4.046
9	5.750	1.098	0.852	4.923	0.052	1.131	47.223	2.017	3.782
10	5.250	1.170	0.672	4.867	0.055	1.068	49.062	1.748	3.741
11	4.750	1.213	0.497	4.657	0.056	0.978	50.112	1.519	3.885
12	4.250	1.225	0.354	4.350	0.057	0.878	50.390	1.352	4.160
13	3.750	1.205	0.245	3.978	0.056	0.772	49.892	1.239	4.515
14	3.250	1.152	0.168	3.566	0.054	0.664	48.560	1.176	4.910
15	2.750	1.069	0.118	3.139	0.050	0.555	46.465	1.164	5.334
16	2.250	0.954	0.089	2.703	0.045	0.445	43.195	1.198	5.727
17	1.750	0.820	0.076	2.293	0.039	0.340	39.807	1.297	6.204
18	1.250	0.658	0.078	1.376	0.031	0.234	34.325	1.431	6.529
19	-0.250	0.521	0.084	1.554	0.023	0.152	30.260	1.594	6.901

******CONCENTRATION AT 20.75   DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.080	0.960	0.018	0.090	16.072	0.660	6.063
3	8.750	0.478	0.068	1.139	0.021	0.103	21.835	0.543	5.887
4	8.250	0.557	0.061	1.524	0.027	0.135	27.928	0.487	5.743
5	7.750	0.639	0.072	1.993	0.032	0.203	33.861	0.506	5.544
6	7.250	0.775	0.148	2.638	0.038	0.347	39.253	0.678	5.238
7	6.750	0.894	0.239	3.316	0.044	0.518	43.876	0.866	4.842
8	6.250	1.007	0.960	4.743	0.048	1.123	47.653	2.239	4.477
9	5.750	1.105	0.842	4.965	0.052	1.138	50.539	2.028	4.190
10	5.250	1.130	0.678	4.958	0.055	1.092	52.577	1.789	4.133
11	4.750	1.228	0.505	4.775	0.057	1.008	53.803	1.559	4.259
12	4.250	1.247	0.358	4.435	0.057	0.910	54.237	1.383	4.516
13	3.750	1.233	0.244	4.124	0.057	0.805	53.884	1.262	4.857
14	3.250	1.187	0.162	3.717	0.055	0.697	52.680	1.189	5.238
15	2.750	1.110	0.109	3.291	0.052	0.588	50.714	1.166	5.649
16	2.250	1.002	0.078	2.854	0.047	0.478	47.539	1.187	6.025
17	1.750	0.872	0.064	2.433	0.041	0.371	44.086	1.273	6.474
18	1.250	0.699	0.066	1.979	0.032	0.256	38.225	1.423	6.842
19	-0.250	0.454	0.090	1.431	0.019	0.118	29.530	1.747	7.347

******CONCENTRATION AT 20.88   DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.432	0.073	0.970	0.018	0.090	17.643	0.653	6.209
3	8.750	0.494	0.058	1.245	0.022	0.107	24.690	0.529	6.065
4	8.250	0.592	0.054	1.665	0.029	0.155	32.002	0.489	5.939
5	7.750	0.716	0.089	2.272	0.035	0.264	38.887	0.573	5.714
6	7.250	0.851	0.225	3.093	0.042	0.476	44.857	0.869	5.353
7	6.750	0.982	0.533	4.094	0.047	0.816	49.682	1.472	4.938
8	6.250	1.097	1.043	5.211	0.052	1.280	53.317	2.460	4.634
9	5.750	1.184	0.603	4.900	0.055	1.058	55.763	1.684	4.520
10	5.250	1.235	0.470	4.761	0.057	1.002	57.110	1.546	4.690
11	4.750	1.248	0.298	4.396	0.057	0.879	57.381	1.335	5.003
12	4.250	1.219	0.186	3.969	0.056	0.760	56.566	1.226	5.405
13	3.750	1.147	0.111	3.491	0.053	0.635	54.608	1.173	5.843
14	3.250	1.036	0.070	2.995	0.048	0.510	51.420	1.188	6.286
15	2.750	0.838	0.054	2.496	0.041	0.385	46.911	1.273	6.725
16	2.250	0.709	0.055	2.007	0.033	0.261	41.037	1.436	7.155
17	1.750	0.514	0.068	1.551	0.022	0.144	34.334	1.667	7.576
18	1.250	0.351	0.038	1.200	0.013	0.055	28.153	1.895	7.881
19	-0.250	0.300	0.100	1.100	0.010	0.030	26.000	2.000	8.000

******CONCENTRATION AT 21.00 DAYS AFTER COMPUTATIONS BEGIN ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.066	0.952	0.018	0.088	18.493	0.641	6.241
3	8.750	0.491	0.050	1.227	0.022	0.105	25.915	0.518	6.140
4	8.250	0.591	0.045	1.654	0.029	0.155	33.613	0.482	6.050
5	7.750	0.717	0.081	2.280	0.035	0.271	40.799	0.576	5.849
6	7.250	0.854	0.224	3.125	0.042	0.493	46.962	0.892	5.501
7	6.750	0.986	0.538	4.138	0.048	0.842	51.877	1.509	5.097
8	6.250	1.099	1.021	5.206	0.052	1.286	55.509	2.453	4.828
9	5.750	1.182	0.543	4.817	0.055	1.033	57.876	1.614	4.760
10	5.250	1.228	0.404	4.639	0.057	0.965	59.079	1.468	4.964
11	4.750	1.232	0.242	4.252	0.057	0.840	59.137	1.273	5.306
12	4.250	1.193	0.141	3.807	0.055	0.719	58.030	1.178	5.721
13	3.750	1.111	0.076	3.315	0.051	0.592	55.688	1.142	6.160
14	3.250	0.938	0.048	2.809	0.046	0.466	52.014	1.176	6.593
15	2.750	0.829	0.039	2.308	0.039	0.340	46.940	1.282	7.011
16	2.250	0.644	0.045	1.830	0.030	0.218	40.606	1.462	7.403
17	1.750	0.461	0.060	1.413	0.020	0.112	33.895	1.687	7.749
18	1.250	0.331	0.078	1.140	0.013	0.042	28.657	1.873	7.953
19	-0.250	0.304	0.097	1.103	0.010	0.031	26.366	1.981	7.994

*****AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.076	0.974	0.018	0.090	17.126	0.653	6.102
3	8.750	0.434	0.063	1.235	0.022	0.105	23.635	0.536	5.941
4	8.250	0.574	0.059	1.625	0.028	0.146	30.436	0.492	5.799
5	7.750	0.687	0.085	2.175	0.034	0.237	36.916	0.550	5.577
6	7.250	0.813	0.197	2.914	0.040	0.417	42.638	0.795	5.238
7	6.750	0.937	0.402	3.751	0.046	0.674	47.375	1.198	4.832
8	6.250	1.050	1.006	4.989	0.050	1.198	51.068	2.360	4.514
9	5.750	1.140	0.721	4.915	0.054	1.088	53.704	1.863	4.339
10	5.250	1.200	0.563	4.810	0.056	1.028	55.349	1.664	4.416
11	4.750	1.227	0.390	4.516	0.057	0.922	56.034	1.447	4.655
12	4.250	1.218	0.261	4.144	0.056	0.812	55.763	1.309	5.002
13	3.750	1.172	0.168	3.715	0.054	0.696	54.507	1.226	5.403
14	3.250	1.090	0.109	3.260	0.051	0.580	52.205	1.200	5.825
15	2.750	0.976	0.076	2.799	0.046	0.464	48.831	1.233	6.251
16	2.250	0.831	0.062	2.344	0.039	0.349	44.337	1.325	6.660
17	1.750	0.673	0.063	1.925	0.031	0.242	39.159	1.478	7.066
18	1.250	0.515	0.072	1.551	0.023	0.147	33.720	1.650	7.408
19	-0.250	0.401	0.085	1.305	0.016	0.084	29.588	1.820	7.683

******* MINIMUM CONCENTRATIONS LAST DAY ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.422	0.066	0.952	0.018	0.087	14.871	0.641	5.825
3	8.750	0.472	0.050	1.177	0.021	0.099	20.284	0.518	5.603
4	8.250	0.549	0.045	1.502	0.026	0.129	26.039	0.482	5.400
5	7.750	0.647	0.053	1.951	0.032	0.192	31.609	0.498	5.130
6	7.250	0.759	0.129	2.575	0.038	0.330	36.681	0.668	4.741
7	6.750	0.875	0.171	3.177	0.043	0.463	41.042	0.764	4.284
8	6.250	0.984	0.881	4.584	0.048	1.056	44.564	2.120	3.944
9	5.750	1.030	0.517	4.803	0.051	1.016	47.223	1.566	3.728
10	5.250	1.156	0.399	4.621	0.054	0.957	49.062	1.463	3.724
11	4.750	1.204	0.235	4.198	0.056	0.823	50.034	1.265	3.885
12	4.250	1.184	0.138	3.731	0.055	0.700	50.153	1.177	4.157
13	3.750	1.095	0.075	3.225	0.051	0.571	49.346	1.142	4.495
14	3.250	0.966	0.048	2.717	0.045	0.444	46.325	1.162	4.875
15	2.750	0.800	0.039	2.223	0.037	0.320	41.631	1.164	5.289
16	2.250	0.610	0.040	1.754	0.028	0.198	35.878	1.173	5.657
17	1.750	0.429	0.039	1.349	0.018	0.094	30.004	1.240	6.119
18	1.250	0.313	0.035	1.110	0.011	0.033	25.853	1.347	6.469
19	-0.250	0.300	0.043	1.100	0.010	0.030	25.965	1.495	6.694

******* MAXIMUM CONCENTRATIONS LAST DAY ******

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.433	0.085	0.996	0.018	0.091	18.842	0.664	6.260
3	8.750	0.499	0.075	1.296	0.023	0.111	25.915	0.550	6.164
4	8.250	0.601	0.072	1.756	0.029	0.165	33.613	0.501	6.089
5	7.750	0.730	0.121	2.410	0.036	0.287	40.799	0.612	5.954
6	7.250	0.968	0.289	3.275	0.043	0.520	46.962	0.958	5.714
7	6.750	1.001	0.632	4.302	0.049	0.882	51.877	1.624	5.373
8	6.250	1.113	1.086	5.280	0.053	1.293	55.509	2.495	5.069
9	5.750	1.194	0.873	5.014	0.056	1.138	57.876	2.097	4.832
10	5.250	1.239	0.716	4.970	0.058	1.098	59.479	1.866	4.964
11	4.750	1.250	0.544	4.790	0.058	1.019	60.762	1.636	5.306
12	4.250	1.249	0.395	4.522	0.058	0.925	61.190	1.454	5.727
13	3.750	1.234	0.277	4.181	0.057	0.824	60.751	1.324	6.173
14	3.250	1.193	0.190	3.792	0.055	0.719	59.581	1.239	6.613
15	2.750	1.126	0.131	3.392	0.053	0.613	57.446	1.338	7.038
16	2.250	1.027	0.096	2.953	0.048	0.505	54.534	1.522	7.442
17	1.750	0.909	0.081	2.547	0.043	0.402	50.315	1.755	7.789
18	1.250	0.759	0.096	2.127	0.036	0.295	45.841	1.936	7.977
19	-0.250	0.609	0.100	1.763	0.028	0.205	40.651	2.000	8.000

Table A-7

List of Sensitivity Runs

Parameter Tested	Conditions Base	Low	High	Components Expected To Be Affected Significantly
CBOD Decay Rate	0.080	0.040	.120	CBOD, DO
Nitrification Rate	.090	.045	.135	Ammonia, Nitrate, DO
Phosphorus Point Source	100	0	200	Phosphorus, Chlorophyll, DO

Table A-9. Results of Sensitivity Runs

Baseline Conditions

*****AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.076	0.974	0.018	0.090	17.126	0.653	6.102
3	8.750	0.484	0.063	1.235	0.022	0.105	23.635	0.536	5.941
4	8.250	0.574	0.088	1.625	0.028	0.146	30.436	0.492	5.799
5	7.750	0.687	0.095	2.175	0.034	0.237	36.916	0.550	5.577
6	7.250	0.813	0.197	2.914	0.040	0.417	42.638	0.795	5.238
7	6.750	0.937	0.402	3.751	0.046	0.674	47.375	1.198	4.832
8	6.250	1.050	1.006	4.939	0.050	1.198	51.068	2.360	4.514
9	5.750	1.140	0.721	4.915	0.054	1.088	53.704	1.863	4.339
10	5.250	1.200	0.563	4.810	0.056	1.028	55.349	1.664	4.416
11	4.750	1.227	0.390	4.516	0.057	0.922	56.034	1.447	4.655
12	4.250	1.219	0.261	4.144	0.056	0.812	55.763	1.309	5.002
13	3.750	1.172	0.169	3.715	0.054	0.696	54.507	1.226	5.403
14	3.250	1.099	0.109	3.260	0.051	0.580	52.205	1.200	5.825
15	2.750	0.976	0.076	2.799	0.046	0.464	48.831	1.233	6.251
16	2.250	0.831	0.062	2.344	0.039	0.349	44.337	1.325	6.660
17	1.750	0.677	0.063	1.925	0.031	0.242	39.159	1.478	7.066
18	1.250	0.515	0.072	1.551	0.023	0.147	33.720	1.650	7.408
19	-0.250	0.401	0.095	1.305	0.016	0.084	29.588	1.820	7.683

Higb CBOD Decay Rate

*****AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.076	0.974	0.018	0.090	17.126	0.537	6.010
3	8.750	0.484	0.063	1.235	0.022	0.105	23.635	0.388	5.838
4	8.250	0.574	0.059	1.625	0.028	0.146	30.436	0.310	5.698
5	7.750	0.687	0.085	2.175	0.034	0.237	36.916	0.319	5.481
6	7.250	0.813	0.197	2.914	0.040	0.417	42.638	0.486	5.134
7	6.750	0.937	0.402	3.751	0.046	0.674	47.375	0.787	4.707
8	6.250	1.053	1.006	4.989	0.050	1.198	51.068	1.825	4.348
9	5.750	1.140	0.721	4.915	0.054	1.088	53.704	1.278	4.193
10	5.250	1.200	0.563	4.810	0.056	1.028	55.349	1.061	4.302
11	4.750	1.227	0.390	4.516	0.057	0.922	56.034	0.853	4.575
12	4.250	1.213	0.261	4.144	0.056	0.812	55.763	0.739	4.947
13	3.750	1.172	0.168	3.715	0.054	0.696	54.507	0.694	5.363
14	3.250	1.090	0.109	3.260	0.051	0.580	52.205	0.718	5.789
15	2.750	0.976	0.076	2.799	0.046	0.464	48.831	0.815	6.212
16	2.250	0.831	0.052	2.344	0.039	0.349	44.337	0.984	6.617
17	1.750	0.673	0.063	1.925	0.031	0.242	39.159	1.228	7.024
18	1.250	0.515	0.072	1.551	0.023	0.147	33.720	1.493	7.371
19	-0.250	0.401	0.085	1.305	0.016	0.084	29.588	1.743	7.663

Low CBOD Decay Rate

*****AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.076	0.974	0.018	0.090	17.126	0.873	6.278
3	8.750	0.434	0.063	1.235	0.022	0.105	23.635	0.846	6.169
4	8.250	0.574	0.059	1.625	0.028	0.146	30.436	0.917	6.070
5	7.750	0.687	0.085	2.175	0.034	0.237	36.916	1.132	5.896
6	7.250	0.815	0.197	2.914	0.040	0.417	42.638	1.585	5.619
7	6.750	0.937	0.402	3.751	0.046	0.674	47.375	2.232	5.288
8	6.250	1.050	1.006	4.989	0.050	1.198	51.068	3.655	5.059
9	5.750	1.140	0.721	4.915	0.054	1.088	53.704	3.315	4.891
10	5.250	1.200	0.563	4.810	0.056	1.028	55.349	3.202	4.943
11	4.750	1.227	0.390	4.516	0.057	0.922	56.034	3.004	5.139
12	4.250	1.218	0.261	4.144	0.056	0.812	55.763	2.825	5.436
13	3.750	1.172	0.158	3.715	0.054	0.696	54.507	2.648	5.788
14	3.250	1.090	0.109	3.260	0.051	0.580	52.205	2.479	6.161
15	2.750	0.976	0.076	2.799	0.046	0.464	48.831	2.325	6.538
16	2.250	0.831	0.063	2.344	0.039	0.349	44.337	2.189	6.894
17	1.750	0.673	0.063	1.925	0.031	0.242	39.159	2.092	7.239
18	1.250	0.515	0.072	1.551	0.023	0.147	33.720	2.015	7.521
19	-0.250	0.401	0.085	1.305	0.016	0.084	29.588	1.996	7.739

High Nitrification Rate

***** AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.058	0.991	0.018	0.090	17.126	0.653	6.012
3	8.750	0.494	0.042	1.255	0.022	0.105	23.635	0.536	5.820
4	8.250	0.574	0.034	1.650	0.028	0.146	30.436	0.492	5.648
5	7.750	0.697	0.040	2.219	0.034	0.237	36.916	0.550	5.392
6	7.250	0.713	0.132	3.009	0.040	0.417	42.638	0.795	4.996
7	6.750	0.957	0.241	2.912	0.046	0.674	47.375	1.198	4.497
8	6.250	1.079	0.776	3.220	0.050	1.198	51.068	2.360	4.056
9	5.750	1.140	0.473	5.163	0.054	1.088	53.704	1.863	3.882
10	5.250	1.200	0.329	5.044	0.056	1.028	55.349	1.664	4.010
11	4.750	1.227	0.193	4.713	0.057	0.922	56.034	1.447	4.326
12	4.250	1.213	0.112	4.293	0.056	0.812	55.763	1.309	4.745
13	3.750	1.172	0.056	3.817	0.054	0.696	54.507	1.226	5.205
14	3.250	1.090	0.045	3.324	0.051	0.580	52.205	1.2[illegible]	5.671
15	2.750	0.974	0.037	2.837	0.046	0.464	48.821	1.233	6.133
16	2.250	0.731	0.039	2.367	0.039	0.34[illegible]	44.337	1.325	6.572
17	1.750	0.473	0.049	1.940	0.031	0.242	39.159	1.478	7.005
18	1.250	0.614	0.063	1.599	0.023	0.147	33.720	1.650	7.372
19	-0.250	0.401	0.031	1.309	0.016	0.084	29.588	1.820	7.665

Low Nitrification Rate

*****AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.127	0.923	0.018	0.090	17.126	0.653	6.287
3	8.750	0.484	0.139	1.159	0.022	0.105	23.635	0.536	6.204
4	8.250	0.574	0.172	1.512	0.028	0.146	30.436	0.492	6.147
5	7.750	0.687	0.258	2.001	0.034	0.237	36.917	0.550	6.029
6	7.250	0.813	0.454	2.657	0.040	0.417	42.638	0.795	5.822
7	6.750	0.937	0.744	3.409	0.046	0.674	47.375	1.198	5.560
8	6.250	1.050	1.420	4.575	0.050	1.198	51.068	2.360	5.375
9	5.750	1.140	1.158	4.478	0.054	1.088	53.704	1.863	5.207
10	5.250	1.200	0.989	4.384	0.056	1.028	55.349	1.664	5.224
11	4.750	1.227	0.777	4.130	0.057	0.922	56.034	1.447	5.360
12	4.250	1.213	0.592	3.813	0.056	0.812	55.763	1.309	5.586
13	3.750	1.172	0.435	3.448	0.054	0.696	54.507	1.226	5.870
14	3.250	1.090	0.312	3.056	0.051	0.580	52.205	1.200	6.187
15	2.750	0.976	0.222	2.653	0.046	0.464	48.831	1.233	6.523
16	2.250	0.831	0.162	2.245	0.039	0.349	44.337	1.325	6.855
17	1.750	0.673	0.124	1.863	0.031	0.242	39.159	1.478	7.195
18	1.250	0.515	0.106	1.517	0.023	0.147	33.720	1.650	7.482
19	-0.250	0.401	0.101	1.239	0.016	0.084	29.588	1.820	7.718

High Point Source of Phosphorus

*****AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	9.250	0.427	0.076	0.974	0.018	0.097	17.125	0.653	6.102
3	8.750	0.494	0.063	1.235	0.022	0.124	23.634	0.536	5.941
4	8.250	0.574	0.059	1.625	0.028	0.201	30.435	0.492	5.798
5	7.750	0.667	0.085	2.175	0.034	0.375	36.915	0.550	5.577
6	7.250	0.813	0.194	2.914	0.040	0.729	42.635	0.795	5.238
7	6.750	0.937	0.402	3.751	0.046	1.237	47.372	1.198	4.832
8	6.250	1.049	1.006	4.990	0.050	2.284	51.065	2.360	4.514
9	5.750	1.139	0.721	4.915	0.054	2.065	53.701	1.863	4.339
10	5.250	1.200	0.563	4.810	0.056	1.952	55.345	1.664	4.415
11	4.750	1.227	0.290	4.517	0.057	1.749	56.030	1.447	4.655
12	4.250	1.219	0.261	4.144	0.056	1.540	55.760	1.309	5.001
13	3.750	1.172	0.168	3.715	0.054	1.321	54.504	1.226	5.403
14	3.250	1.090	0.109	3.260	0.051	1.100	52.202	1.200	5.825
15	2.750	0.975	0.076	2.799	0.046	0.878	48.828	1.233	6.251
16	2.250	0.831	0.062	2.344	0.039	0.657	44.335	1.325	6.660
17	1.750	0.672	0.063	1.925	0.031	0.450	39.156	1.478	7.066
18	1.250	0.515	0.072	1.551	0.023	0.263	33.721	1.650	7.408
19	-0.250	0.401	0.085	1.305	0.016	0.138	29.588	1.820	7.683

Low Point Source of Phosphorus

*****AVERAGE CONCENTRATIONS OVER FINAL DAY *****

	DISTANCE	ORGAN-N	NH4-N	NO3-N	ORGAN-P	INORG-P	CHLOROP	CBOD	OXYGEN
2	[illegible]	0.427	0.076	0.974	0.018	0.082	17.124	0.653	6.102
3	[illegible]	0.434	0.063	1.235	0.022	0.086	23.630	0.536	5.941
4	[illegible]	[illegible]	0.059	1.625	0.028	0.091	30.423	0.492	5.797
5	7.7[illegible]	0.487	0.085	2.175	0.034	0.099	36.881	0.550	5.574
6	7.250	0.711	0.193	2.915	0.040	0.106	42.538	0.795	5.228
7	6.750	0.935	0.405	3.753	0.046	0.112	47.176	1.198	4.812
8	6.250	1.046	1.011	4.992	0.050	0.114	50.749	2.360	4.483
9	5.750	1.104	0.727	4.919	0.053	0.112	53.286	1.863	4.299
10	[illegible]	1.173	0.571	4.815	0.056	0.106	54.833	1.664	4.368
11	4.750	1.219	0.398	4.523	0.056	0.096	55.423	1.447	4.599
12	4.[illegible]	1.209	0.269	4.153	0.056	0.085	55.062	1.309	4.938
13	3.750	1.142	0.176	3.726	0.054	0.073	53.732	1.226	5.333
14	3.250	1.090	0.115	3.271	0.050	0.062	51.388	1.200	5.751
15	[illegible]	0.964	0.031	2.811	0.045	0.052	48.024	1.233	6.178
16	2.250	0.824	0.066	2.255	0.038	0.043	43.612	1.325	6.594
17	1.750	0.662	0.044	1.933	0.031	0.037	38.588	1.478	7.013
18	1.250	0.512	0.073	1.556	0.022	0.032	33.355	1.650	7.374
19	-0.250	0.39[illegible]	0.036	1.307	0.016	0.031	29.409	1.820	7.666

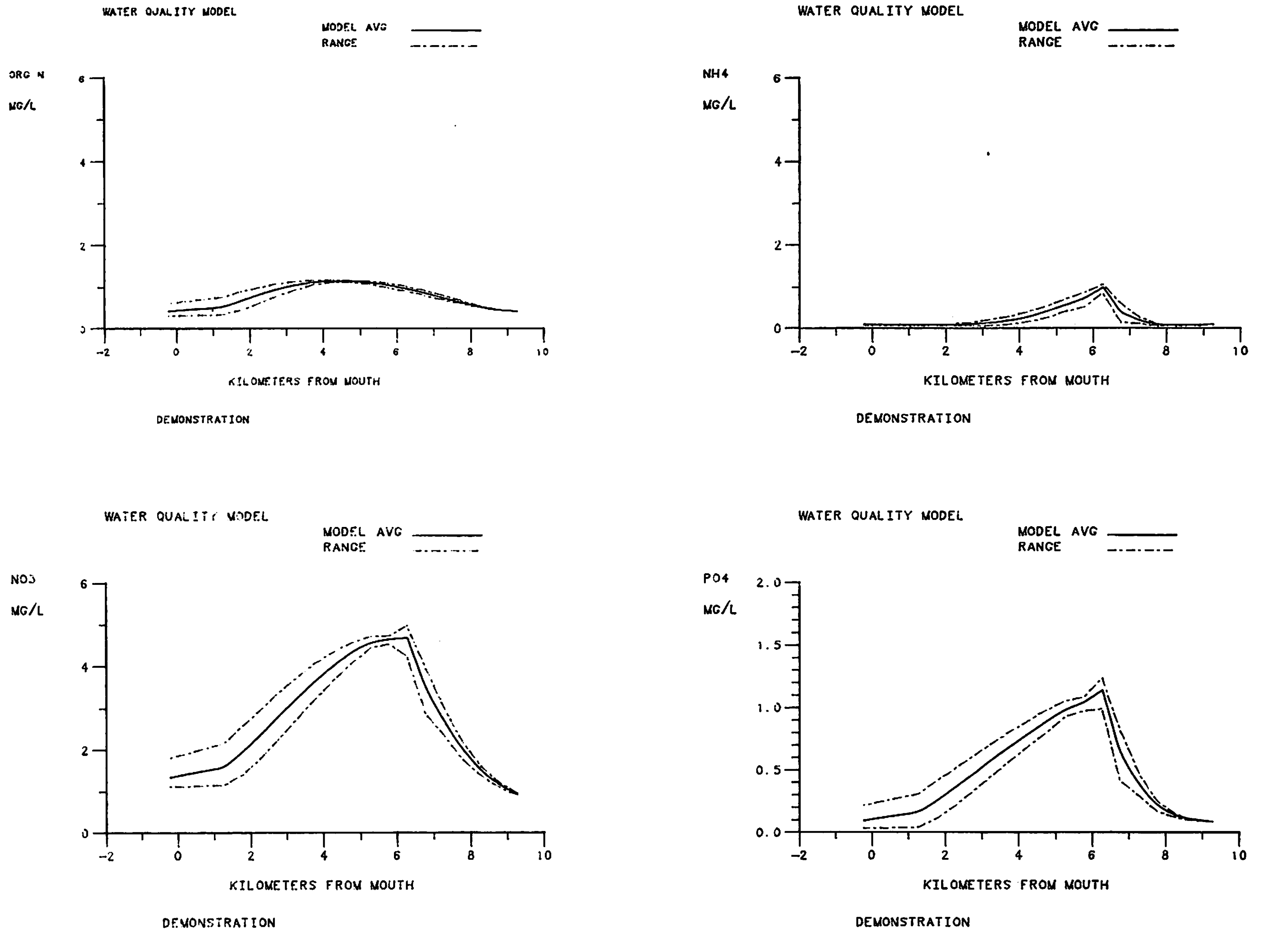


Figure A-1. Water Quality Model Demonstration Run - Nitrogen and PO_4.

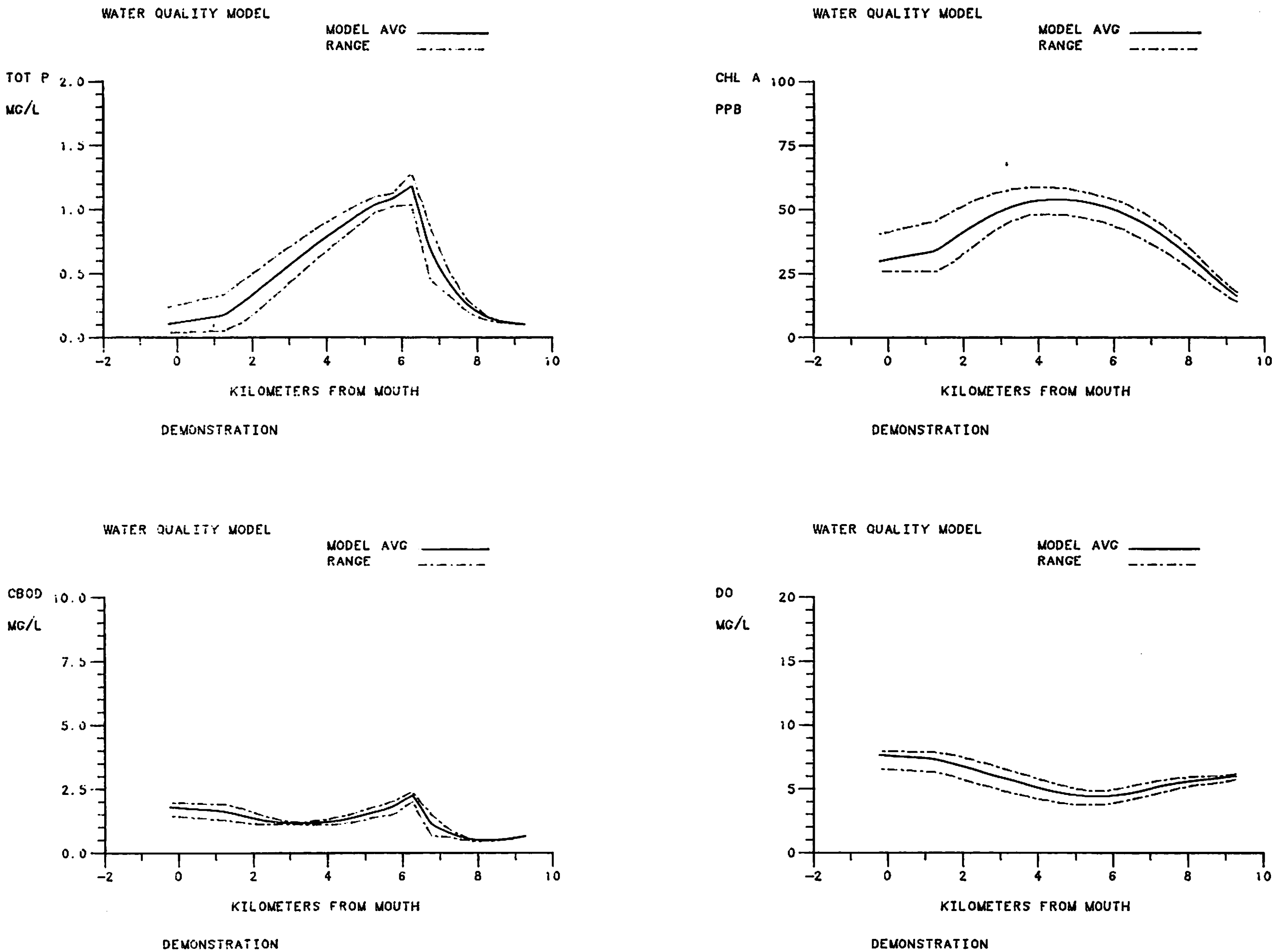


Figure A-2. Water Quality Model Demonstration Run - Total P, Chlorophyll, CBOD and Dissolved Oxygen.

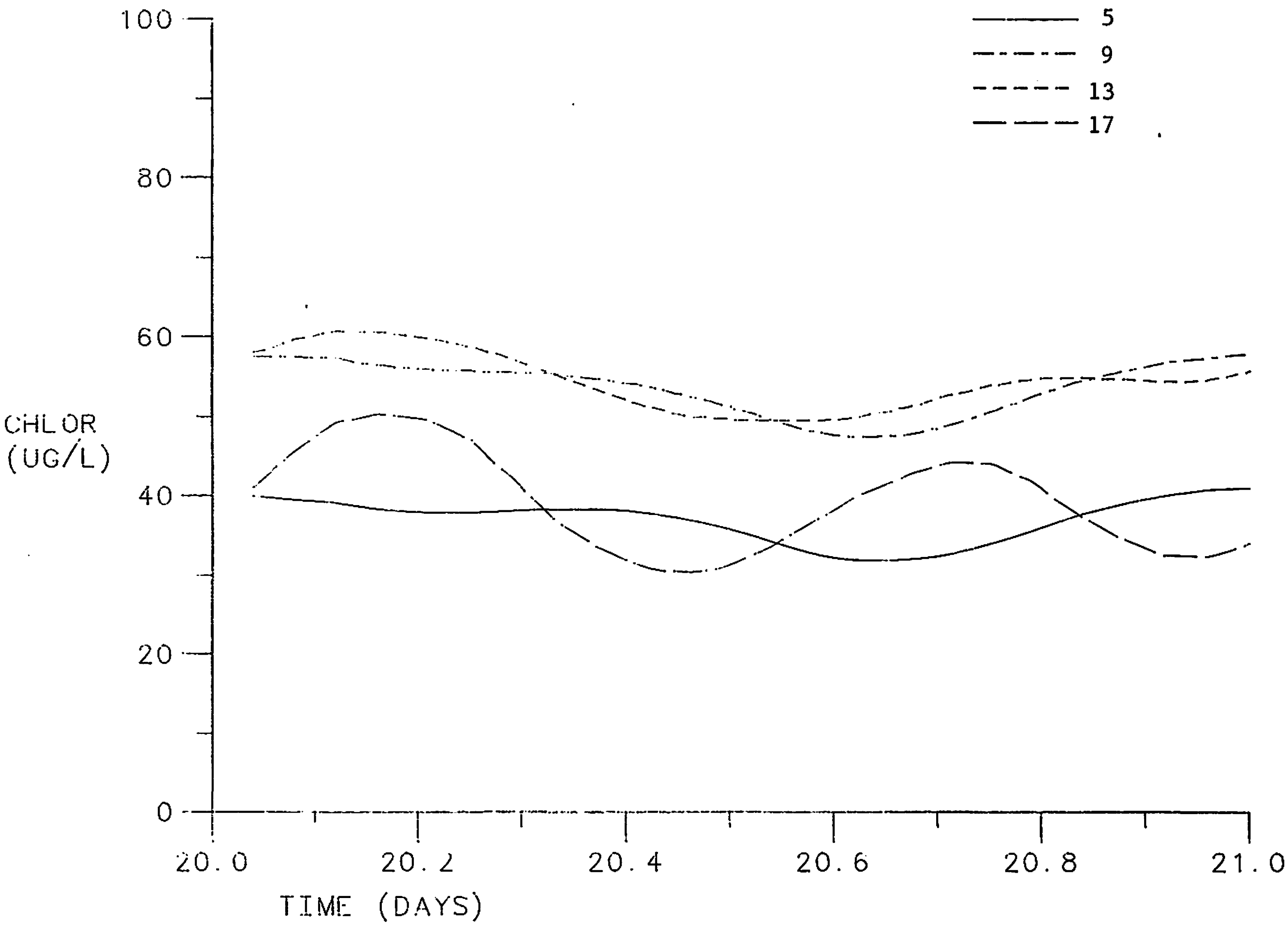


Figure A-3. Calculated chlorophyll levels versus time for selected Model Segments.

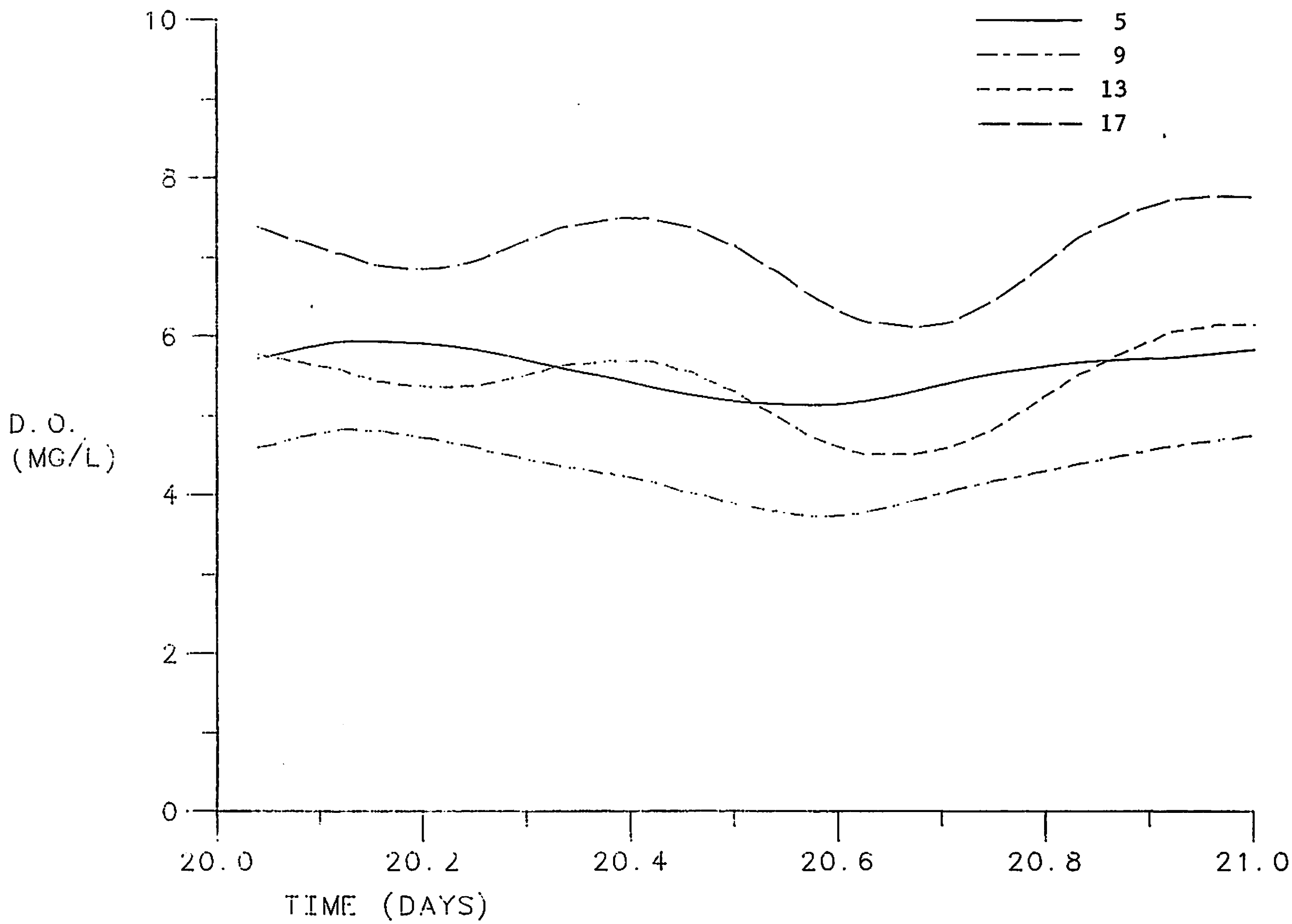


Figure A-4. Calculated dissolved oxygen levels versus time for selected model segments.

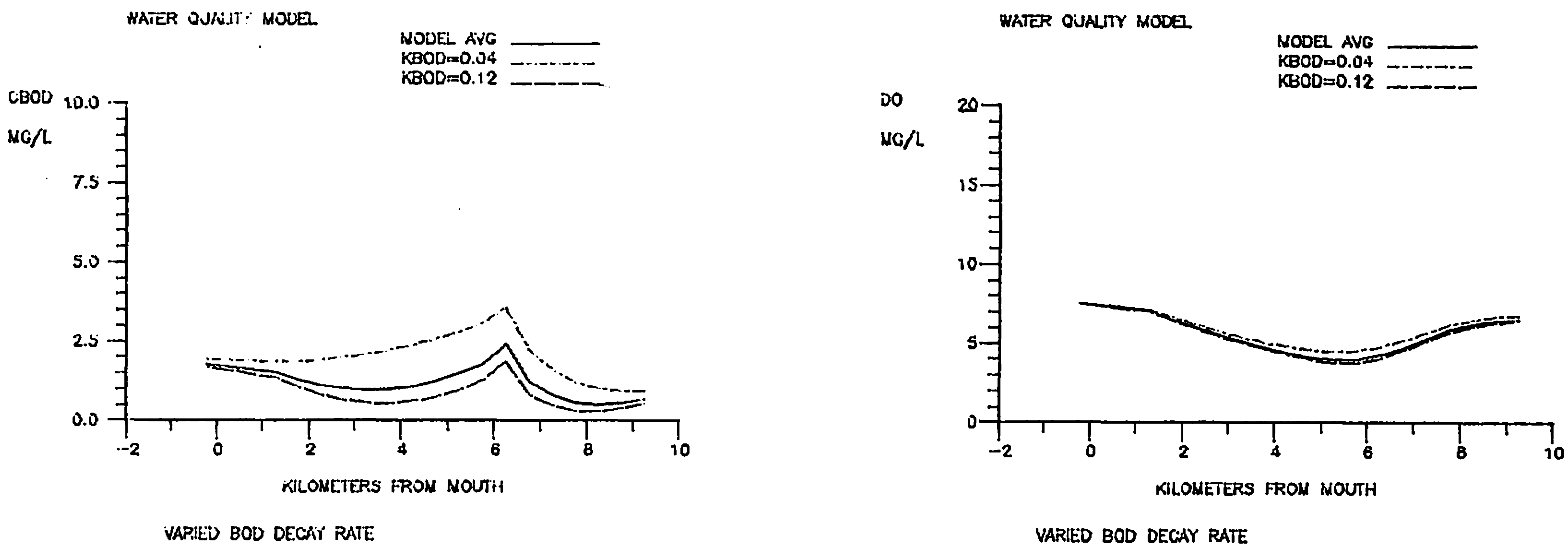
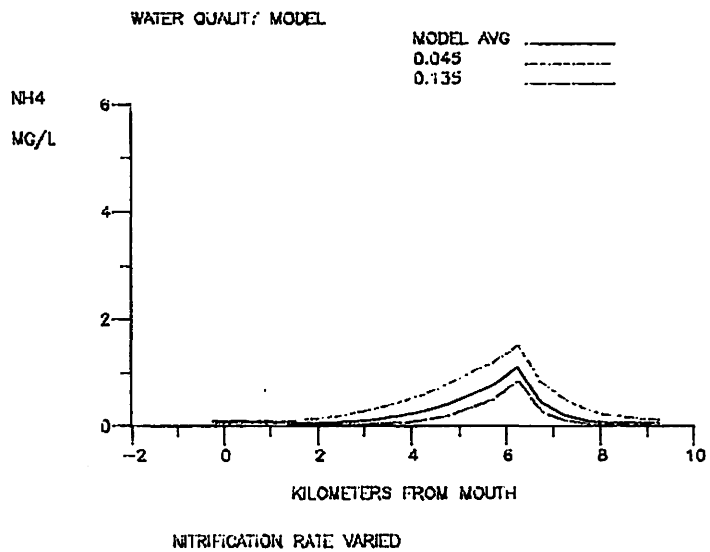
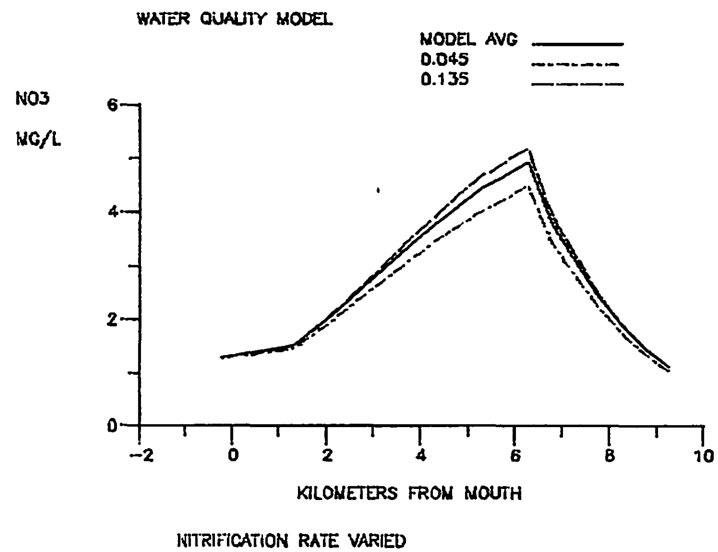


Figure A-5. Sensitivity to Variations in CBOD Decay Rate.





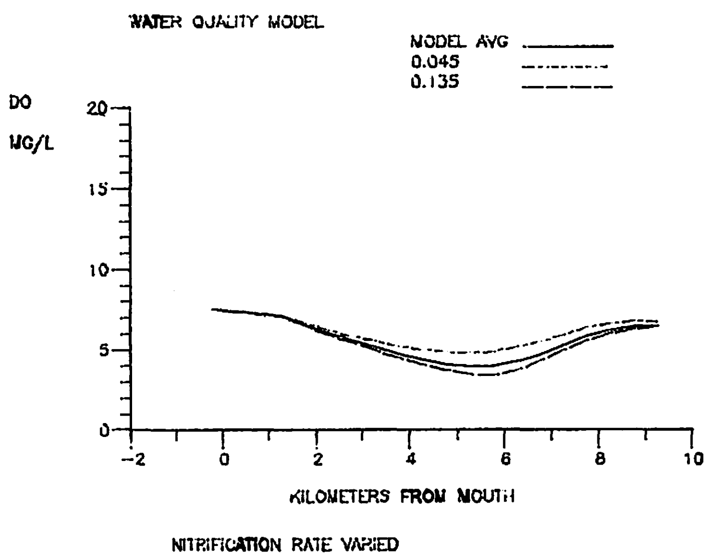


Figure A-6. Sensitivity to Variations in Nitrification Rate.

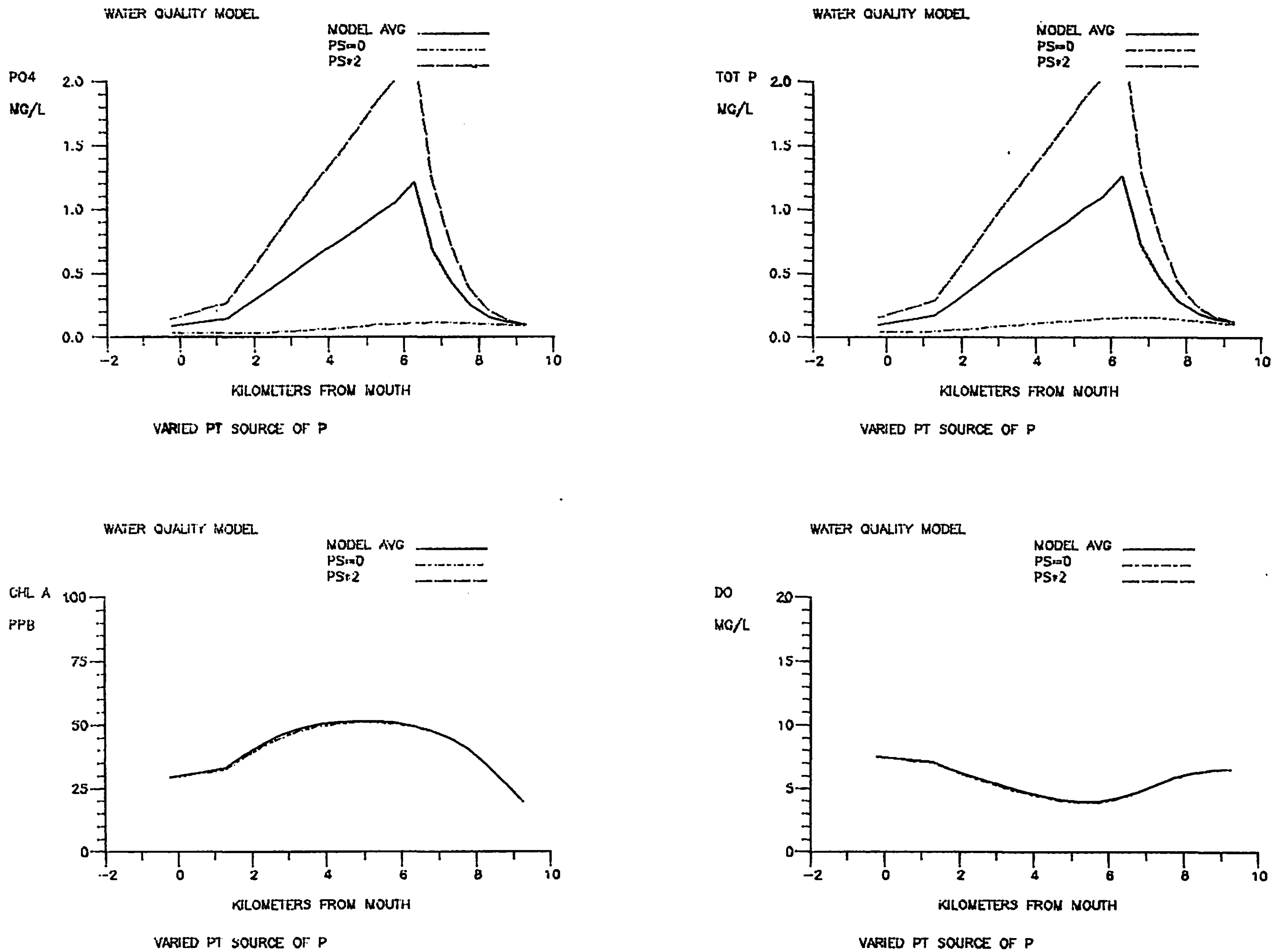


Figure A-7. Sensitivity to Variations in Phosphorus Point Source.

APPENDIX B

HYDRODYNAMIC

AND

WATER QUALITY

MODEL SOURCE CODES

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C-----------------------------------------------------------------------C
C---HYODRODYNAMIC MODEL SOURCE
C---TO INCREASE DIMENSION, CHANGE ALL LABELED COMMON, PLUS BLOCK DATA
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     2 DIST2(20),ARCO(20),VOL1(20),VOL2(20),DTX(20)
      COMMON /PARMS/ G,ML,MU,ML2,MU1,MUL,DT,WIND,YUPS,
     $DCAY,IT,IR,IW,IRTID,IRG,IRNP,EBASE,AK,MS,SK
      COMMON/HYD/Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),
     1FMANN(20),QLAT(20),ALPH(20),E(20),DIF(20),U(20),HR(20),DCM(20)
      COMMON /TDE2/ TDATA(0:24),TTBAK,DTSTIN
      DIMENSION MXY(20),MXQ(20),MXS(20),MNY(20),MNQ(20),MNS(20),
     1           AVY(20),AVQ(20),AVS(20),TOUT(120),AVU(20),
     2           MXU(20),MNU(20)
      DIMENSION AMPL(9),PHASE(9)
      CHARACTER*4 FMT(6)
C---MAIN PROGRAM
      REAL MXY,MXQ,MXS,MNY,MNQ,MNS,MXU,MNU,LT,NTC,NIH
      DATA XMIN/0.0/,XMAX/1.0/,SMIN/0.0/,SMAM/100.0/
      DATA UMIN/-0.60/,UMAX/0.60/,YMIN/-0.60/,YMAX/0.60/
C---NEXT TWO LINES MUST BE CONSISTENT WITH DIMENSIONS IN COMMON BLOCKS
      DATA MXY,MXQ,MXS,AVY,AVQ,AVS,AVU,MXU/160*0.0/
      DATA MNY,MNU,MNQ,MNS/40*800.0,20*900000.0,20*60.0/
C---SK SET TO ZERO FOR DYE SIMULATION:FOR SALINITY USE 0.8
      DATA G,SK/9.8,0.0/
      IR=5
      IHOUT=7      /*LOGICAL UNIT FOR PASSING HYDRO OUTPUT TO WQ MODEL
      IRTID=13      /*TIDAL DATA KEPT IN A SEPARATE FILE
      IRG=15     /*CHANNEL GEOMETRY KEPT IN A SEPARATE FILE
      IRNP=17     /*TIME-DEP HEADWATER DISCH FROM SEP FILE
C---THIS FILE COULD BE NONPOINT SOURCE FILE
      IW=6
      TP=0.
      READ (IR,9) TSALT,IQUAL,IVAR,ITIDE
 9    FORMAT (10I5)
      IF (ISALT.EQ.1) THEN
        WRITE (IW,*) 'SALT IS MODELLED'
      ELSE
        WRITE (IW,*) 'SALT IS NOT MODELLED'
      END IF
      IF (IQUAL.EQ.1) THEN
        WRITE (IW,*)
     $  ' HYDRAULICS WILL BE PASSED TO WATER QUALITY PROGRAM'
      ELSE
        WRITE (IW,*)
     $  ' HYDRAULICS WILL NOT BE PASSED TO WATER QUALITY PROGRAM'
      END IF
      IF (ITIDE.EQ.1) THEN
        WRITE(IW,*) ' OBSERVED TIDAL HEIGHTS ARE INPUT'
      ELSE
        WRITE (IW,*) ' TIDAL HEIGHTS ARE GENERATED BY HARMONICS'
      END IF
 17   FORMAT (9X,F6.2,48X,F6.2)
 18   FORMAT (/' DAYS FROM START = ',F6.1,
     $'HEADWATER FLOW = ',F6.2,'  (M**3/SEC) ')
```

```
      CALL GEOHY(IVAR)
      WRITE (IW,18) TP,Q2(ML)
C---BINARY OUTPUT OF HYDRAULICS TO BE READ BY WQ MODEL
       IF(IQUAL.EQ.1)THEN
        WRITE(IHOUT)ML,MU,DIST
        WRITE(IHOUT)ARCC,VOL2,U,E,HR,SAM
       END IF
C---READ IN AMPLITUDES AND PHASES OF TIDAL COMPONENTS
C---OR FIRST SET OF TIDE DATA
      IF (ITIDE.NE.1) THEN
        READ (IR,35) (AMPL(I),PHASE(I),I=1,9)
 35     FORMAT (2F10.2)
        WRITE (IW,15)
15    FORMAT(//1X,20('*'),'AMPLITUDES AND PHASES OF TIDAL CONSTITUENTS
     1AT DOWNSTREAM BOUNDARY',20('*')/)
        WRITE (IW,16) (AMPL(I),PHASE(I),I=1,9)
 16     FORMAT (/' TIDAL AMPLITUDES (CM) AND PHASES (RAD.)'/
     $5X,'M2 ',F10.2,F17.3,/5X,'S2 ',F10.2,F17.3,/5X,'N2 ',
     $F10.2,F17.3/5X,'K1 ',F10.2,F17.3/5X,'M4 ',F10.2,F17.3/5X,'O1 ',
     $F10.2,F17.3/5X,'MM ',F10.2,F17.3/5X,'SSA',F10.2,F17.3/
     $5X,'SA ',F10.2,F17.3)
      ELSE
C---ASSIGN INITIAL BOUNDARY HEIGHT TO TDATA(0)
C---NTC=NUMBER OF CALLS TO TIDE INTERPOLATION SUBROUTINE
        NTC=0.
        TDATA(0)=Y1(MU)*100.
        READ(IRTID,719)NPERL,CONV,DTSTIN,FMT
 719    FORMAT(I5,2F10.3,6A4)
        WRITE(IW,821)NPERL,FMT,DTSTIN,CONV
 821    FORMAT(5X,I5,' TIDAL HEIGHTS PER LINE IN FORMAT',5X,6A4,
     $  'TIME INTERVAL',F10.1,' SEC'/,' FACTOR TO CONVERT TO CM ',F10.4)
         READ(IRTID,FMT) (TDATA(I),I=1,NPERL)
         WRITE (IW,21) (TDATA(I),I=1,NPERL)
 21     FORMAT (//' AT MODEL STARTUP, THE TIDAL INPUT IS',
     $  /12F7.3,/12F7.3)
           DO 2105 I=1,NPERL
 2105        TDATA(I)=TDATA(I)*CONV
      END IF
C---READ WIND STRESS IN DYNES/CM**2
      READ(IR,2) WIND
      WRITE(IW,5) WIND
5     FORMAT(//1X,10('*'),'WIND STRESS(DYNE/CM**2)=',F5.2,10('*')/)
C---CONVERT WIND TO DYNES/M**2
      WIND=WIND/10000.
C---READ SALINITY CONCENTRATION AT THE OPEN MOUTH AND THE NO OF HOURS
C---AFTER FLOOD TIDE (TOFH) IT TAKES TO REACH SMAX.
      READ(IR,2) SMAX,TOFH
2     FORMAT(7F10.0)
      WRITE(IW,1) SMAX,TOFH
1     FORMAT(/' ***** MAXIMUM SALINITY AT DOWNSTREAM SEGMENT=',F5.2,'***
     1**'/1X,'***** TIME INTERVAL FROM SBF TO REACH MAX. SALINITY(HRS)='
     2,F4.2,' *****')
C---INPUT PARAMETERS RELATED TO DISPERSION COEFFICIENT
C AK ON ORDER OF 30-60
```

```
      READ(IR,2) EBASE,AK
      WRITE(IW,8) EBASE,AK
8     FORMAT(/1X,'MINIMUM DISPERSION COEFFICIENT AT SLACK TIDE IN M**2/S
     1EC =',F5.2,/1X,'MULTIPLIER FOR TAYLOR DISPERSION =',F7.2)
C---READ DYE DECAY RATE PER DAY.  CONVERT TO PER SECOND.
      READ(IR,2) DCAY
      WRITE(IW,102) DCAY
      DCAY=DCAY/86400.
      READ(IR,3) DTIME,TMAX,DTT,NP
3     FORMAT(3F10.0,I10)
      WRITE(IW,4) DTIME,TMAX,DTT,NP
 4    FORMAT (//' STARTING DAY OF RUN = ',F8.3,
     $/,' NUMBER OF DAYS TO BE RUN = ',F5.1,
     $/,' TIME INCREMENT IN DAYS = ',F7.5,
     $/,' NUMBER OF TIMES TO PRINT OUTPUT = ',I5)
 102  FORMAT (//' DYE DECAY RATE = ',F6.3,' PER DAY')
C---TIME AT WHICH OUTPUT TO BE PRINTED
      READ(IR,2)(TOUT(I),I=1,NP)
      WRITE (IW,103)
      WRITE (IW,104) (TOUT(I),I=1,NP)
 103  FORMAT (/' OUTPUT PRINTED ON DAYS')
 104  FORMAT (7F11.3)
C---READ TIMES TO PASS HYDRAULICS TO WATER QUALITY MODEL
      IF (IQUAL.EQ.1) THEN
        READ (IR,11) NSBH,NSEH,NHS
        WRITE (IW,10) NSBH,NSEH,NHS
      END IF
 10   FORMAT (//' BEGIN PASSING HYDRAULICS AT STEP ',I10,
     $/' STOP PASSING HYDRAULICS AT STEP ',I10,
     $/' PASS HYDRAULICS EVERY ',I5,' STEPS')
 11   FORMAT (3I10)
      DT=DTT*86400.0        /* DT IS TIME STEP IN DAYS
C---NITT=INTEGER ITERATIONS PER DAY
      NITT=(1.+0.5*DTT)/DTT
      TMAX1=TMAX-1.0        /* TIME AVERAGE CALCULATED FROM TMAX1 TO TMAX
      ITMAX=(TMAX+0.5*DTT)/DTT
      ITPL=(TMAX1+0.5*DTT)/DTT
      TOFH=TOFH/DT
      SMST=3600.*TOFH
      IF (SMST.LT.1.) SMST=1.
      DO 6 K=ML2,MU
6     DTX(K)=DT/DX(K)
100   IT=0
      AVN=0.
      TIME=0.
      TTBAK=TIME
      TTFOR=DTSTIN*FLOAT(NPERL)+TTBAK
      KWT=1
      ITPRIN=(TOUT(KWT)+0.5*DTT)/DTT
      J=1
C---TIME INTEGRATION LOOP STARTS HERE
200   IT=IT+1
      TP=IT*DTT
C     WRITE(IW,*)IT,TP
```

```
C---TIME IS IN SECONDS, DTIME IS IN DAYS FOR TIDAL  PREDICTION
      DTIME=DTIME+DTT
      TIME=TIME+DT
      IF (MOD(IT,NITT).EQ.0) THEN
C---READ FROM A NONPOINT-SOURCE FILE
        IF (IVAR.EQ.1) THEN
          READ (IRNP,17) Q2(ML)
          WRITE (IW,13) TP,Q2(ML)
        END IF
      END IF
        IF (ITIDE.EQ.1) THEN
         IF(TIME.GE.TTFOR)THEN
          TTBAK=TTFOR
          TTFOR=TTBAK+DTSTIN*FLOAT(NPERL)
          TDATA(0)=TDATA(NPERL)
          READ(IRTID,FMT) (TDATA(I),I=1,NPERL)
 19       FORMAT(12F6.1)
C         WRITE(IW,FMT) (TDATA(I),I=1,NPERL)
 20       FORMAT (//' AT TIME ',F6.1,' THE TIDAL HEIGHTS ARE',
     $    /12F7.3,/12F7.3)
           DO 205 I=1,NPERL
             TDATA(I)=TDATA(I)*CONV
 205        CONTINUE
        END IF
      END IF
      IF (ITIDE.NE.1) THEN
        Y2(MU)=TIDE(DTIME,AMPL,PHASE)
      ELSE
        CALL TIDE2(Y2(MU),TIME)
      END IF
      CALL HYDRO
C---COMPUTE TAYLOR'S DISPERSION FOR SALT OR QUALITY MODEL
      IF (ISALT.EQ.1.OR.IQUAL.EQ.1) THEN
        DO 7 I=ML,MU
 7      E(I)=EBASE+AK*ABS(U(I))*FMANN(I)*HR(I)**.833
      END IF
      IF (ISALT.EQ.1) THEN
        CALL OCNSC (SMST,SMAX,DS)
       CALL SALT(0.,SMAX)
      END IF
C---SHIFT TIME STEP
      DO 210 K=ML,MU
      Y1(K)=Y2(K)
      Q1(K)=Q2(K)
      VOL1(K)=VOL2(K)
      S1(K)=S2(K)
      U(K)=Q2(K)/ARCO(K)
210   CONTINUE
C---PASS HYDRAULICS TO WATER QUALITY MODEL
      IF (IQUAL.EQ.1) THEN
        IF (IT.GE.NSBH.AND.IT.LE.NSEH) THEN
C---COMPUTE VELOCITY AT UPSTREAM  TRANSECT
          IF (MOD(IT,NHS).EQ.0) WRITE(IHOUT) ARCO,VOL2,U,E,HR,SAM
        END IF
```

```
      END IF
  211 CONTINUE
  300 CONTINUE
      IF(IT.LT.ITPL) GO TO 310
C---COMPUTE AVERAGE, MAXIMUM AND MINIMUM
      TPP=TP-TMAX1
      AVN=AVN+1.0
      DO 215 K=ML,MU
      AVY(K)=AVY(K)+Y2(K)
      AVQ(K)=AVQ(K)+Q2(K)
      AVS(K)=AVS(K)+S2(K)
      AVU(K)=AVU(K)+U(K)
      IF(Q2(K).LT.MNQ(K)) MNQ(K)=Q2(K)
      IF(Q2(K).GT.MXQ(K)) MXQ(K)=Q2(K)
      IF(S2(K).LT.MNS(K)) MNS(K)=S2(K)
      IF(S2(K).GT.MXS(K)) MXS(K)=S2(K)
      IF(Y2(K).LT.MNY(K)) MNY(K)=Y2(K)
62    IF(Y2(K).GT.MXY(K)) MXY(K)=Y2(K)
64    IF(U(K).LT.MNU(K)) MNU(K)=U(K)
66    IF(U(K).GT.MXU(K)) MXU(K)=U(K)
215   CONTINUE
310   CONTINUE
      IF(IT-ITPRIN) 200,350,600
350   WRITE(IW,23) TOUT(KWT)
 23   FORMAT(//6('*'),' CONDITIONS AT ',F7.3,2X,
     1'DAYS AFTER COMPUTATION BEGINS',6('*')/)
      WRITE(IW,22)
22    FORMAT(10X,'DISTANCE',5X,'SURFACE ELEVATION',5X,'DISCHARGE',5X,
     1         'TIDAL VELOCITY',5X,'SALINITY',5X,'MID-DISTANCE'/)
      WRITE(IW,24)(I,DIST(I),Y2(I),Q2(I),U(I),S2(I),DIST2(I),
     $I=ML,MU)
24    FORMAT(1X,I5,4X,F8.2,14X,F6.3,6X,F10.2,10X,F8.2,8X,F6.2,8X,F6.2)
      IF(IT.LT.ITMAX) GO TO 390
      DO 360 K=ML,MU
      AVY(K)=AVY(K)/AVN
      AVQ(K)=AVQ(K)/AVN
      AVS(K)=AVS(K)/AVN
      AVU(K)=AVU(K)/AVN
360   CONTINUE
      WRITE(IW,26)
      WRITE(IW,22)
      WRITE(IW,28)(I,DIST(I),AVY(I),AVQ(I),AVU(I),AVS(I),DIST2(I),
     $I=ML,MU)
28    FORMAT(1X,I5,4X,F8.2,14X,F6.3,6X,F10.2,10X,F8.2,8X,F6.2,8X,F6.2)
      WRITE(IW,30)
30    FORMAT(//'***** DAILY MAXIMUM *****')
      WRITE(IW,22)
      WRITE(IW,28)(I,DIST(I),MXY(I),MXQ(I),MXU(I),MXS(I),DIST2(I),
     $I=ML,MU)
      WRITE(IW,32)
32    FORMAT(//'***** DAILY MINIMUM *****')
      WRITE(IW,22)
      WRITE(IW,28)(I,DIST(I),MNY(I),MNQ(I),MNU(I),MNS(I),DIST2(I),
     $I=ML,MU)
```

```
26    FORMAT(1H1,'***** DAILY AVERAGE *****')
      GO TO 600
390   KWT=KWT+1
      ITPRIN=(TOUT(KWT)+0.5*DTT)/DTT
      GO TO 200
 600  CONTINUE
      IF (ICUAL.EQ.1) ENDFILE(IHOUT)
      STOP
      END
C-----------------------------------------------------------------------C
      SUBROUTINE DONSC(SMST,SMAX,DS)
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     1DIST2(20),ARCO(20),VOL1(20),VOL2(20),DTX(20)
      COMMON/HYD/Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),
     1FMANN(20),QLAT(20),ALPH(20),F(20),DIF(20),U(20),HR(20),DCM(20)
      COMMON /PARMS/ G,ML,MU,ML2,MU1,MUL,DT,WIND,YUPS,
     2DCAY,IT,IR,IW,IRTID,IRG,IRNP,EBASE,AK,MS,SK
      DATA NCOUNT/1000/
      IF(Q1(MU) .LT. 0.0) GO TO 10
C---EBB---TIDE CACULATION
      NCOUNT=0
      CHANGE=DTX(MU)*Q1(MU)/ARCO(MU)
      S2(MU)=S1(MU)-(S1(MU)-S1(MU1))*CHANGE
      GO TO 100
C---FLOOD---TIDE CACULATION
 10   IF(NCOUNT.EQ.0) GO TO 11
      IF(NCOUNT.LT.SMST) GO TO 12
      S2(MU)=SMAX
      GO TO 100
 11   DS=(SMAX-S1(MU))/SMST
 12   NCOUNT=NCOUNT+1
      S2(MU)=S1(MU)+DS
 100  CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------C
      SUBROUTINE SALT(B1,B2)
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     1DIST2(20),ARCO(20),VOL1(20),VOL2(20),DTX(20)
      COMMON/HYD/Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),
     1FMANN(20),QLAT(20),ALPH(20),F(20),DIF(20),U(20),HR(20),DCM(20)
      COMMON /PARMS/ G,ML,MU,ML2,MU1,MUL,DT,WIND,YUPS,
     1DCAY,IT,IR,IW,IRTID,IRG,IRNP,EBASE,AK,MS,SK
      DIMENSION P(120),Q(120)
C---COMPUTES CONCENTRATION IN SEGMENT ML BASED ON
C UPSTREAM BOUNDARY Q(ML-1)=S(BOUNDARY).
      Q(ML-1)=B1
      P(ML-1)=0.
      DIF(ML)=0.
      GAMA=ALPH(ML)
      IF(Q2(ML) .LT. 0.0) GAMA=1.0-ALPH(ML)
      DELT=1.0-GAMA
      DO 100 K=ML,MU1
      K2=K+1
```

```
      DIF(K2)=F(K2)*ARCD(K2)/DX(K2)
      GAMA2=ALPH(K2)
      IF(Q2(K2) .LT. 0.0) GAMA2=1.0-ALPH(K2)
      DELT2=1.0-GAMA2
      DIV=1.0+DT/VOL2(K)*(GAMA2*Q2(K2)-DELT*Q2(K)+DIF(K)+DIF(K2))
      AA=DT/VOL2(K)*(DIF(K2)-DELT2*Q2(K2))/DIV
      BB= DT/VOL2(K)*(DIF(K)+GAMA*Q2(K))/DIV
C---*** CALCULATE CC ***
      CC=VOL1(K)*S1(K)*(1.0-DCAY*DT)/VOL2(K)/DIV
      DIV=1.0-BB*P(K-1)
      P(K)=AA/DIV
      Q(K)=(CC+BB*Q(K-1))/DIV
      GAMA=GAMA2
      DELT=DELT2
100   CONTINUE
      DO 200 M=1,MUL
      K=MU-M
      S2(K)=P(K)*S2(K+1)+Q(K)
      IF (S2(K).LT.0.) S2(K)=0.
200   CONTINUE
C---SPECIAL ASSIGNMENT FOR LONGITUDINAL DYE PLOTS
      S2(1)=B1
      S2(MU)=B2
      RETURN
      END
C-----------------------------------------------------------------------C
      FUNCTION TIDE(TIME,AMPL,PHASE)
C     CALCULATE DOWNSTREAM SURFACE ELEVATION
      DIMENSION AMPL(9),PHASE(9),SIGMA(9)
C SIGMA CORRESPONDS TO SPEED IN RADIANS/DAY
C M2,S2,N2,K1,M4,O1,MM,SSA,SA
      DATA SIGMA /12.141,12.56637,11.913,6.3,24.282,5.84,
     $0.228,0.034,0.017/
      SUM=0.
      DO 10 N=1,9
  10  SUM=SUM+AMPL(N)*COS(PHASE(N)+TIME*SIGMA(N))
      TIDE=SUM/100.0
      RETURN
      END
C-----------------------------------------------------------------------C
      SUBROUTINE TIDE2 (Y,T)
      COMMON /TDE2/ TDATA(0:24),TTBAK,DTSTIN
      XJ=(T-TTBAK)/DTSTIN  /*XJ IS BETWEEN J & J+1
      J=XJ
      W2=XJ-FLOAT(J)         /*INTERPOLATION WEIGHTING FUNCTIONS
      W1=1.-W2
      Y=TDATA(J)*W1+TDATA(J+1)*W2
      Y=Y/100.
      RETURN
      END
C-----------------------------------------------------------------------C
      SUBROUTINE HYDRO
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     2 DIST2(20),ARCD(20),VOL1(20),VOL2(20),DTX(20)
```

```
      COMMON /PARMS/ G,ML,MU,ML2,MU1,MUL,DT,WIND,YUPS,
     $ DCAY,IT,IR,IW,IRTID,IRG,IRNP,EBASE,AK,MS,SK
      COMMON/HYD/Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),
     1FMANN(20),QLAT(20),ALPH(20),E(20),DIF(20),U(20),HR(20),DCM(20)
      DIMENSION P(100),D(100),CQ(100),FRIC(20)
C *** CALCULATE CQ'S ***
      DO 10 K=ML2,MU
      K1=K-1
      K2=K+1
      IF (K.LT.MU) THEN
        ADV=DTX(K)/4.0*((Q1(K1)+Q1(K))*(U(K1)+U(K))-(Q1(K)+Q1(K2))
     1  *(U(K)+U(K2)))
      ELSE .
        ADV=DTX(K)/4.0*((Q1(K1)+Q1(K))*(U(K1)+U(K))-(3.*Q1(K)-Q1(K1))
     $  *(3.*U(K)-U(K1)))
      END IF
      SUM=DT*G*FMANN(K)*FMANN(K)/HR(K)**1.333
      FRIC(K)=1.+SUM*ABS(U(K))
      DENS=G*SK*DCM(K)*ARCO(K)*(S1(K)-S1(K1))/(DIST2(K)*(1.+0.5*(S1(K)
     & +S1(K1))))
      CQ(K)=Q1(K)+ADV+DT*(WIND*BM(K)+DENS)
10    CONTINUE
C *** CALCULATE RECURSION COEFFICIENTS ***
      DIV=SAM(ML)/DT+DTX(ML2)*G*ARCO(ML2)/FRIC(ML2)
      P(ML)=DTX(ML2)*G*ARCO(ML2)/DIV/FRIC(ML2)
      D(ML)=(Q2(ML)-CQ(ML2)/FRIC(ML2)+SAM(ML)
     1  /DT*Y1(ML)+QLAT(ML))/DIV
      DTXGA=DTX(ML2)*G*ARCO(ML2)/FRIC(ML2)
      DO 20 K=ML2,MU1
      K2=K+1
      DTXGA2=DTX(K2)*G*ARCO(K2)/FRIC(K2)
      SURF=SAM(K)/DT
      DIV=SURF+DTXGA+DTXGA2
      AA=DTXGA2/DIV
      BB=DTXGA/DIV
      CC=(SURF*Y1(K)+CQ(K)/FRIC(K)-CQ(K2)/FRIC(K2)+QLAT(K))/DIV
      DIV=1.0-BB*P(K-1)
      P(K)=AA/DIV
      D(K)=(CC+BB*D(K-1))/DIV
      DTXGA=DTXGA2
20    CONTINUE
C---MUL=MU-ML
C *** CALCULATE WATER SURFACE ELEVATION ***
      DO 30 M=1,MUL
      K=MU-M
30    Y2(K)=P(K)*Y2(K+1)+D(K)
C---UPDATE VOLUME, CONVEYANCE AREA AND HYDRAULIC RADIUS
      CALL UGEOM
C *** CALCULATE DISCHARGES*****
      DO 40 K=ML2,MU
      K1=K-1
      Q2(K)=Q2(K1)+QLAT(K1)-(VOL2(K1)-VOL1(K1))/DT
 40   CONTINUE
      RETURN
```

```
      END
C-----------------------------------------------------------------------C
      SUBROUTINE UGEOM
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     $DIST2(20),ARCO(20),VOL1(20),VOL2(20),DTX(20)
      COMMON /BGCAL/AM(20),VOLM(20)
      COMMON /PARMS/ G,ML,MU,ML2,MU1,MUL,DT,WIND,YUPS,
     $DCAY,IT,IR,IW,IRTID,IRG,IRNP,EBASE,AK,MS,SK
      COMMON /HYD/ Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),
     $FMANN(20),QLAT(20),ALPH(20),E(20),DIF(20),U(20),HR(20),DCM(20)
C------GENERALIZED VOLUME AND AREA CORRECTION FOR TIDAL VARIATION------
C------ASSUMES CONSTANT CHANNEL WIDTH AND SURFACE AREA------
      Y2(ML-1)=Y2(ML)
      DO 99 I=ML,MU
      IM1=I-1
      YAV=(Y2(I)+Y2(IM1))/2.
      ARCO(I)=AM(I)+YAV*BM(I)
      HR(I)=ARCO(I)/BM(I)
      IF(HR(I).LT.0.01)HR(I)=0.01
       IF(I.EQ.MU)GO TO 99
      VOL2(I)=VOLM(I)+Y2(I)*SAM(I)
 99   CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------C
      SUBROUTINE GEOHY(IVAR)
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     2 DIST2(20),ARCO(20),VOL1(20),VOL2(20),DTX(20)
      COMMON /PARMS/ G,ML,MU,ML2,MU1,MUL,DT,WIND,YUPS,
     $DCAY,IT,IR,IW,IRTID,IRG,IRNP,EBASE,AK,MS,SK
      COMMON/HYD/Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),
     1FMANN(20),QLAT(20),ALPH(20),E(20),DIF(20),U(20),HR(20),DCM(20)
      DIMENSION TITLE(35),NAME(30)
      READ(IR,1) TITLE
1     FORMAT(1X,35A2)
      WRITE(IW,2)
2     FORMAT(1H1)
 12   FORMAT (7F10.2)
      WRITE(IW,1) TITLE
      READ(IR,4) ML,MU
4     FORMAT(2I5)
      WRITE(IW,6) ML,MU
6     FORMAT(5X,'******** UPSTREAM BOUNDARY TRANSECT NO.=',I5,'  ******'
     1     /,5X,'******** DOWNSTRM BOUNDARY TRANSECT NO.=',I5,'  ******')
      ML2=ML+1
      MS=MU+1
      MU1=MU-1
      MUL=MU-ML
100   READ(IR,8) NDG,NS,NAME
8     FORMAT(2I5,30A2)
      IF(NDG-99) 200,300,400
200   WRITE(IW,10) NDG,NS,NAME
 10   FORMAT (//1X,'INPUT DATA GROUP = ',I4,
     $4X,'NUMBER OF POINTS IN THIS GROUP = ',I4,4X,30A2)
```

```
      GO TO (11,21,31,41,51,61,71,81),NDG
11    READ(IR,20)(DIST(I),I=ML,MU)
20    FORMAT(7F10.0)
 14   FORMAT (1X,I4,F15.2)
      DO 16 I=ML2,MU1
16    DX(I)=(DIST(I-1)-DIST(I+1))/2.0*1000.0
      DX(MU)=(DIST(MU1)-DIST(MU))*1000.0
      GO TO 100
 21   READ(IR,20)(ARD(I),I=ML,MU)
      WRITE(IW,22)
 22   FORMAT (//' TRANS NO. DIST FROM MOUTH  DRAINAGE AREA'/
     $14X,'KILO M.',11X,'KM**2')
      WRITE (IW,24) (I,DIST(I),ARD(I),I=ML,MU)
 24   FORMAT (1X,I4,F15.2,2X,F15.2)
      GO TO 100
 31   READ (IR,20) (Q1(I),I=ML,MU)
      GO TO 100
 41   READ (IR,20) (Y1(I),I=ML,MU)
      GO TO 100
51    READ(IR,20)(S1(I),I=ML,MU)
 61   GO TO 100
71    READ(IR,20)(FMANN(I),I=ML,MU)
      GO TO 100
81    READ(IR,20)(ALPH(I),I=ML,MU)
      GO TO 100
300   WRITE(IW,52)
52    FORMAT(//1X,20('*'),'INITIAL CONDITIONS',20('*')/1X,'REACH NO.',5X
     1  ,'SURFACE ELEVATION',5X,'DISCHARGE',7X,'SALINITY',5X,'MANNING CO
     2EF.',5X,'WEIGHTING FACTOR'/20X,'METER',12X,'M**3.0',9X,'PPT',4X,'P
     3PT')
      WRITE(IW,54)(I,Y1(I),Q1(I),S1(I), FMANN(I),ALPH(I),I=ML,MU)
54    FORMAT(1X,I5,13X,F6.2,6X,F12.2,7X,F6.2,13X,F6.4,14X,F4.2)
400   DO 500 I=ML,MU1
      DIST2(I)=(DIST(I)+DIST(I+1))/2.
500   CONTINUE
      DIST2(MU)=0.5*(DIST(MU)-DIST(MU1))
 17   FORMAT (9X,F6.2,49X,F6.2)
      IF (IVAR.EQ.1) THEN
        WRITE (IW,*) 'TIME-VARIABLE CONDITIONS'
C---TIME-VARIABLE UPSTREAM DISCHARGE READ FROM SEPARATE FILE
        READ (IRNP,17) Q2(ML)    /*HEADWATER DISCH READ FROM A SEP FILE
C-----IF TIME-DEPENDENT
      ELSE
        WRITE (IW,*) 'STEADY CONDITIONS'
          Q2(ML)=Q1(ML)      /*STEADY DISCH INCLUDED IN MAIN FILE
      END IF
      DO 501 I=ML,MU
 501  Y2(I)=Y1(I)
C---CHANNEL---GEOMETRY READ FROM SEPARATE FILE
      CALL SETGEOM(IRG,IW,ML,MU,MU1)
C---NOW---VOLUME VOL2 AND ARC0 INITIALIZED
      CALL UGEOM
C---SET INITIAL VELOCITIES,VOLUMES
      DO 502 I=ML,MU
```

```
      VOL1(I)=VOL2(I)
 502  U(I)=Q1(I)/ARCO(I)
      RETURN
      END
C-----------------------------------------------------------------C
      SUBROUTINE SETGEOM(IR,IW,ML,MU,MU1)
C     LOGICAL UNIT IS PASSED FROM MAIN PROGRAM. NORMALLY THESE DATA WILL
BE
C     IN A SEPARATE FILE FROM OTHER INPUTS, BUT THIS COULD BE CHANGED
C     BY USER.
      COMMON/HYD/Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),FMANN
     1           (20),QLAT(20),ALPH(20),E(20),DIF(20),
     2      .    U(20),HR(20),DCM(20)
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     2 DIST2(20),ARCO(20),VOL1(20),VOL2(20),DTX(20)
      COMMON /BGCAL/AM(20),VOLM(20)
      DIMENSION TITLE(35),NAME(30)
C---DCM(DEPTH OF CHANNEL CENTROID) IS NEEDED FOR DENSITY GRADIENT TERM
      DIMENSION HM(20)
      READ(IR,1) TITLE
1     FORMAT(1X,35A2)
      WRITE(IW,2)
2     FORMAT(1H1)
      WRITE(IW,1) TITLE
100   READ(IR,8,END=300) NDG,NS,NAME
8     FORMAT(2I5,30A2)
      IF(NDG.GE.99)RETURN
200   WRITE(IW,10) NDG,NS,NAME
10    FORMAT(//1X,'INPUT DATA GRUP=',I4,4X,'NUMBER OF POINT IN THIS GRO
     1UP=',I4,4X,30A2//)
      GO TO (11,21),NDG
 11   CONTINUE
20    FORMAT(7F10.0)
      READ(IR,20)(AM(I)   ,I=ML,MU)
      READ(IR,20)(HM(I)   ,I=ML,MU)
      READ(IR,20)(DCM(I)  ,I=ML,MU)
C     REACH SURFACE AREA IN UNIS OF 1000 SQUARE METER
      WRITE(IW,12)
12    FORMAT(1X,'TRANS NO.',1X,'CONVEY. AREA',3X,
     1'TRANSECT DEPTH',2X,'CENTROID DEPTH',
     2/14X,'SQUARE METER',3X,'SQUARE METER'
     3,3X,'METER',9X,'1000 M**2')
      WRITE(IW,14) (I,AM(I),HM(I),DCM(I),I=ML,MU)
14    FORMAT(1X,I4,3F15.2)
C-----CHANNEL WIDTH IS DERIVED FROM CONVEYANCY AREA AND TRANSECT DEPTH
C-----TIME-DEPENDENT CROSS-SECTIONAL AREA MUST BE INITIALIZED
      DO 18 I=ML,MU
      BM(I)=AM(I)/HM(I)
      ARCO(I)=AM(I)
18    CONTINUE
      GO TO 100
C     SAM AND VOLM ARE SURFACE AREA AND REACH VOLUME AT MEAN WATER LEVEL
21    READ(IR,20)(SAM(I),I=ML,MU1)
      READ(IR,20)(VOLM(I),I=ML,MU1)
```

```
      WRITE(IW,22)
  22  FORMAT(1X,'REACH NO.',' SURFACE AREA',6X,'VOLUME',
     2 /,7X,' SQUARE METER',5X,' CU. METER')
      WRITE(IW,16)(I,SAM(I),VOLM(I),I=ML,MU1)
 16   FORMAT(1X,I4,2F15.2)
C------INITIALIZE VOLUME ARRAY------
      DO 25 I=ML,MU1
      VOL2(I)=VOLM(I)
   25 CONTINUE
      GO TO 100
 300  RETURN
      END
C-------------------------------------------------------------------C
      BLOCK DATA
      COMMON /GEOM/ DIST(20),DX(20),SAM(20),BM(20),ARD(20),
     2 DIST2(20),ARCO(20),VOL1(20),VOL2(20),DTX(20)
      COMMON/HYD/Y1(20),Y2(20),Q1(20),Q2(20),S1(20),S2(20),
     1FMANN(20),QLAT(20),ALPH(20),E(20),DIF(20),U(20),HR(20),DCM(20)
      DATA FMANN/20*0.02/
      DATA ARD /20*0.0/
      DATA Y1,Q1,S1,U/80*0.0/
      DATA QLAT/20*0.0/
      DATA E /20*0.0/
      DATA VOL1,VOL2/40*0.0/
      END
C-------------------------------------------------------------------C
```

```
C-----------------------------------------------------------------------
C---WATER QUALITY SOURCE
C---TO INCREASE DIMENSIONS, CHANGE ALL LABELED COMMON PLUS BLOCK DATA
C---HYDRAULIC AND GEOMETRIC PARAMETERS
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     1H1(20),U(20),E(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON/BEN/BENDO(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENDO(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
C---COMPUTATION PARAMETERS
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /BNDS/ N1UP,N2UP,N3UP,P1UP,P2UP,CUP,CBODUP,
     $DOUP,N1UA,N2UA,N3UA,P1UA,P2UA,CUA,CBODUA,DOUA,
     $N1D,N2D,N3D,P1D,P2D,CD,CBODD,DOD,DTX,MCOUNT
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
C---WATER QUALITY PARAMETERS
      COMMON/BODDO/CBOD(20),WBOD(20),DO(20),DOWAST(20),
     1              CKC(20),CK2(20),WPEA(20),RKRD
      COMMON/PHOSP/P1(20),P2(20),WP1(20),WP2(20),KP12(20),XKHP12
      COMMON/NITRO/N1(20),N2(20),N3(20),WN1(20),WN2(20),WN3(20),
     $KN12(20),KN23(20),PRE2(20),PRE3(20),XKH12,XKH23
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON /MINMAX/ MNN1(20),MNN2(20),MNN3(20),MNP1(20),
     $MNP2(20),MNC(20),MNCBD(20),MNDO(20),
     2MXN1(20),MXN2(20),MXN3(20),MXP1(20),MXP2(20),MXC(20),
     3MXCBD(20),MXDO(20)
      COMMON/RATE/KN11(20),KN33(20),KP11(20),KP22(20),KCBODS(20),
     1XKN12(20),XKN23(20),XKP12(20)
      COMMON /BSKIP/SKPNPC,SKPNP,SKPP
C---DIMENSIONS IN NEXT TWO LINES MUST AGREE WITH COMMON
      DIMENSION AVN1(20),AVN2(20),AVN3(20),AVP1(20),AVP2(20),
     1AVC(20),AVCBOD(20),AVDO(20),TT(30)
      REAL N1,N2,N3,N1UP,N2UP,N3UP,N1D,N2D,N3D
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,KCS,
     1KGRAZ,KCBODS,N1UA,N2UA,N3UA
      INTEGER TIMDEP
      REAL MNN1,MXN1,MNN2,MXN2,MNN3,MXN3,MNP1,MXP1,MNP2,MXP2,
     1MNC,MXC,MNCBD,MXCBD,MNDO,MXDO
C---IR IS LOGICAL UNIT FOR INPUT FILE
C---IW IS LOGICAL UNIT FOR PRINTOUT
C---IH IS LOGICAL UNIT FOR HYDRODYNAMIC INPUT
C---INPS IS LOGICAL UNIT FOR NONPOINT SOURCE
      DATA IR,IW,IH,INPS,NPONT/5,6,7,15,1/,PLITE/0./
      READ(IH) ML,MU,DIST
 10   FORMAT(2I10,F10.0)
      WRITE(IW,20)ML,MU
 20   FORMAT(1H1,'STATION NUMBER OF UPSTREAM BOUNDARY=',I5,10X,'STATION
     1NUMBER OF DOWNSTREAM BOUNDARY =',I5)
C  TIMDEP=1 MEANS TIME DEPENDENT CONDITIONS
```

```
      READ(IR,30) TMAX,DTT,NTPRIN,TIMDEP
 30   FORMAT(2F10.0,3I5)
      WRITE(IW,40) TMAX,DTT
 40   FORMAT(/1X,'NUMBER OF DAYS TO BE RUN=',F6.2,2X,
     1' TIME INCREMENT IN DAYS=',F8.6/)
   41 FORMAT(7I10)
      IF (TIMDEP.NE.1) WRITE(IW,50)
      IF (TIMDEP.EQ.1) WRITE(IW,60)
 50   FORMAT (/1X,'STEADY CONDITIONS')
 60   FORMAT (/1X,'TIME DEPENDENT CONDITIONS')
C---MS=MU+1
      ML2=ML+1
      MU1=MU-1
      MUL=MU-ML
C---TIME STEP SIZE PUT IN VARIOUS UNITS, FOR CONVENIENCE
      DT=DTT*86400.0
      DT2=0.5*DT
      DTH=DTT*24.
      DTD=DTT
      NTSD=(1.+0.5*DTT)/DTT
      TMAX1=TMAX-1.0
      ITMAX=(TMAX+0.5*DTT)/DTT      /*TOTAL NUMBER OF INTEGRATION TIME S
C---TIMES ON WHICH OUTPUT TO BE PRINTED
      READ(IR,80)(TT(I),I=1,NTPRIN)
 80   FORMAT(7F10.3)
      WRITE (IW,42) NTPRIN
 42   FORMAT (/1X,'OUTPUT WILL BE PRINTED',I3,' TIMES AT DAYS')
      WRITE (IW,80) (TT(I),I=1,NTPRIN)
      READ(IR,80)TLAG
      MCOUNT=(3600.*TLAG+0.5*DT)/DT
      IF(MCOUNT.EQ.0) MCOUNT=1
      WRITE(IW,150)TLAG
 150  FORMAT(/1X,10(1H*),61HTIME FOR DOWNSTREAM CONDITIONS TO RECOVER T
     1THOSE OF OPEN BAY,10(1H*)/20X,F5.2,5HHOURS/)
C---READ THE NUTRIENT TRANSFER COEFFICIENTS
       READ(IR,90)THEN12,THEN23,THEP12
       WRITE(IW,33)THEN12,THEN23,THEP12
   33  FORMAT(/,'*****EXPONENTIAL TEMPERATURE DEPENDENT COEFFICIENTS***
     & ',/,5X,'FOR N12=',F7.4,/,5X,'FOR N23=',F7.4,/,5X,'FOR P12=',
     & F7.4)
C---NUTRIENT-RELATED COEFFICIENTS
       READ(IR,320) NS2
       READ(IR,90)(XKN12(I),I=2,NS2)
       READ(IR,90)(XKN23(I),I=2,NS2)
       READ(IR,90)(XKP12(I),I=2,NS2)
       IF(NS2.GT.2) GO TO 160
       DO 161 I=ML,MU
       XKN12(I)=XKN12(2)
       XKN23(I)=XKN23(2)
  161  XKP12(I)=XKP12(2)
  160  CONTINUE
      WRITE(IW,152)
       DO 152 I=ML,MU
       WRITE(IW,154) XKN12(I),XKN23(I),XKP12(I)
```

```
 152   CONTINUE
 153   FORMAT(3X,'NUTRIENT TRANSFER COEFFICIENTS: KN12 ',6X,
     1 'KN23 ',6X,'KP12  (PER DAY AT 20 DEG C)')
 154   FORMAT(31X,F10.4,F10.4,F10.4)
       READ(IR,90) XKH12,XKH23,XKHP12
       WRITE(IW,581) XKH12
 581 FORMAT(/' HALF-SATURATION CONCENTRATION FOR HYDROLYSIS ',
     1'(MG/L)',3X,F10.3)
       WRITE(IW,582) XKH23
 582 FORMAT(' HALF-SATURATION CONCENTRATION FOR NITRIFICATION ',
     1'(MG/L)',F10.3)
       WRITE(IW,583) XKHP12
 583 FORMAT(' HALF-SATURATION CONCENTRATION FOR ORG. PHOSPHORUS ',
     1'(MG/L)',F10.3)
       READ (IR,320) NS2
       READ (IR,80) (KN11(I),I=2,NS2)
       READ (IR,80) (KN33(I),I=2,NS2)
       READ (IR,80) (KP11(I),I=2,NS2)
       READ (IR,80) (KP22(I),I=2,NS2)
       READ(IR,80)(KCBODS(I),I=2,NS2)
       IF(NS2.GT.2) GO TO 240
       DO 232 I=ML,MU
       KN11(I)=KN11(2)
       KN33(I)=KN33(2)
       KP11(I)=KP11(2)
       KP22(I)=KP22(2)
 232   KCBODS(I)=KCBODS(2)
 240   WRITE (IW,250)
 250   FORMAT(//20X,'*****SETTLING RATES (M/DAY)*****'/11X,
     1'KN11',6X,'KN33',6X,'KP11',6X,'KP22',6X,'KCBODS')
       DO 260 I=ML,MU
 260   WRITE (IW,270) I,KN11(I),KN33(I),KP11(I) ,KP22(I),KCBODS(I)
 270   FORMAT (I5,2X,5F10.5)
 280   DO 290 I=ML,MU
       KCBODS(I)=KCBODS(I)*DTD
       KN11(I)=KN11(I)*DTD
       KN33(I)=KN33(I)*DTD
       KP11(I)=KP11(I)*DTD
 290   KP22(I)=KP22(I)*DTD
 320   FORMAT(10I5)
C---READ THE PHYTOPLANKTON RELATED COEFFICIENTS
 530   READ (IR,540) AC,AN,AP,PQ,RQ,KMN,KMP,XKCG,RIS,RRESP,
     +XKCS,XKGRAZ,FRON,FROP,THETAG,THETAR,THETAD
 540   FORMAT(7F10.0)
       WRITE (IW,550)
       WRITE (IW,551) AC,AN,AP
       WRITE (IW,552) PQ,RQ
       WRITE (IW,553) KMN,KMP
       WRITE (IW,554) XKCG,RIS
       WRITE (IW,555) RRESP
       WRITE (IW,556) XKCS
 550   FORMAT (//' PHYTOPLANKTON COEFFICIENTS')
 551   FORMAT (/' CARBON/CHLOROPHYLL RATIO (MG C TO MICROGM CHL) ',
     $F17.5,/' NITROGEN/CHLOROPHYLL RATIO (MG N TO MICROGM CHL) ',
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     $F15.5,/' PHOSPHORUS/CHLOROPHYLL RATIO (MG P TO MICROGM CHL) ',
     $F13.5)
  552 FORMAT (' PHOTOSYNTHESIS QUOTIENT ',30X,F10.5/
     $' RESPIRATION QUOTIENT ',33X,F10.5)
  553 FORMAT (' HALF-SATURATION CONSTANT FOR NITROGEN UPTAKE (MG/L) ',
     $F12.5,/' HALF-SATURATION CONSTANT FOR PHOSPHORUS UPTAKE (MG/L) ',
     $F10.5)
  554 FORMAT (' MAXIMUM GROWTH RATE (1/DAY AT 20 C) ',18X,F10.5,
     $/' SATURATION LIGHT INTENSITY (LANGLEYS/DAY) ',12X,F10.1)
  555 FORMAT (' RESPIRATION RATE (1/DAY AT 20 C) ',21X,F10.5)
  556 FORMAT (' SETTLING RATE (METERS/DAY) ',27X,F10.5)
      WRITE (IW,570) XKGRAZ
  570 FORMAT (10X,' GRAZING AND OTHER DEATH FACTORS = ',13X,F6.3)
      PRCY=.4
      WRITE (IW,557) FRON,FROP
  557 FORMAT(' FRACTION NITROGEN RECYCLED TO ORGANIC POOL',F22.5,
     $/' FRACTION PHOSPHORUS RECYCLED TO ORGANIC POOL',F20.5)
      WRITE (IW,558) THETAG,THETAR,THETAD
  558 FORMAT (' EXPONENTIAL BASE FOR GROWTH ',26X,F10.5,
     $/' EXPONENTIAL BASE FOR RESPIRATION ',21X,F10.5,
     $/' EXPONENTTAL BASE FOR GRAZING ETC. ',20X,F10.5)
      PQ=PQ*AC*2.67
      KCS=XKCS*DTD
      SKPNPC=AC*AN*AP        /*FLOATING PT FLAG FOR SKIPPING NUTRIENT CYCL
      SKPNP=AN*AP
      SKPP=AP
C---HYDRAL READS HYDRAULIC DATA FROM UNIT IH
C---HYDRAL READS INTERPOLATION FACTORS FROM UNIT IR
      CALL HYDRAL
      DTX=DT/(DX(MU)+DX(MU-1))*2.0
  590 IT=0                       /*INITIALIZATION
      TP=0.0
      AVN=0.0
      DO 600 K=ML,MU
      AVN1(K)=0.0
      AVN2(K)=0.0
      AVN3(K)=0.0
      AVP1(K)=0.0
      AVP2(K)=0.0
      AVCBOD(K)=0.0
      AVDO(K)=0.0
  600 AVC(K)=0.0
      CALL INPUT                         /*INITIALIZATION
C ICSI COUNTS STEPS FOR SUBROUTINE INPUT.  IT WILL CORRECT
C SO THAT INPUT IS READ AT MIDNIGHT AFTER FIRST INPUT.
      ICSI=TFM/DTH
      KWT=1
      ITPRIN=TT(KWT)/DTT+0.1
      P(ML)=0.0
      CALL ADVDIF
C---ADVANCE TIME BY ONE STEP DT
  631 IT=IT+1
      ICSI=ICSI+1
C SAVE OLD VOLUMES AND OBTAIN HYDRAULICS FOR THIS TIME STEP
```

```
      DO 620 I=ML,MU
 620  VOLO(I)=VOL(I)
      READ (IH) ARCD,VOL,U,E,H1,SAM        /*BINARY READ FROM UNIT IH
      E(ML)=0.
      DO 610 I=ML,MU1
 610  HA(I)=VOL(I)/SAM(I)
      VOL(MU)=VOL(MU1)
      HA(MU)=HA(MU1)
      TP=IT*DTT
      TI=IT                                /*TIME FROM START,IN DAYS
      TH=TFM+TI*DTH
      TH=AMOD(TH,24.)
      ITH=MOD(ICSI,NTSD)                   /*TIME IN HRS FROM PREV MIDNIGH
      IF (ITH.EQ.0.AND.TIMDEP.EQ.1) CALL INPUT     /*ONCE PER DAY
 700  CALL ADVDIF
C---CALCULATE GROWTH OF PHYTOPLANKTON
      IF (TH.GT.TU.AND.TH.LT.TD) THEN      /*DAYLIGHT HOURS
C---CALCULATE LIGHT INHIBITION
        RLITE=RIN*SIN(PTT*(TH-TU))
        DO 750 M=ML,MU
        TUB=TURB(M)*HA(M)
        IF (C(M).GT.0.) TUB=TUB+HA(M)*C(M)*0.018
C---CALCULATE NUTRIENT LIMITING TERMS
        IF (N2(M).LE.0.) THEN
          IF (N3(M).LE.0.) THEN
            FN=0.
          ELSE
            FN=N3(M)/(N3(M)+KMN)
          END IF
        ELSE
          IF (N3(M).LE.0.) THEN
            FN=N2(M)/(N2(M)+KMN)
          ELSE
            FN=(N2(M)+N3(M))/(N2(M)+N3(M)+KMN)
          END IF
        END IF
        IF (P2(M).GT.0.) THEN
          FP=P2(M)/(P2(M)+KMP)
        ELSE
          FP=0.
        END IF
        ALI=RLITE/EXP(TUB)
C---MINIMUM OF FN,FP USED IN GROWTH RATE
        GC(M)=AMIN1(FN,FP)*KCG/TUB*(1.0/EXP(ALI)-1.0/EXP(RLITE))
C---PREFERENCE FOR VARIOUS SPECIES OF N
        IF (N2(M).LE.0.) THEN
          PREF2(M)=0.
        ELSE IF (N3(M).LE.0.) THEN
          PREF2(M)=1.
        ELSE
          PREF2(M)=N2(M)*N3(M)/((KMN+N2(M))*(KMN+N3(M)))
     1    +N2(M)*KMN/((N2(M)+N3(M))*(KMN+N3(M)))
        END IF
        PREF3(M)=1.0-PREF2(M)
```

```
 750    CONTINUE
      ELSE
C---NIGHT-TIME HOURS: ZERO GROWTH
        DO 770 M=ML,MU
 770    GC(M)=0.0
      END IF
C---SOLVE THE MASS BALANCE EQUATIONS
C---SET UP DOWNSTREAM BOUNDARY CONDITIONS
C O(ML-1) = UPSTREAM BOUNDARY
      CALL DONQBC
 772  O(ML-1)=DOUP
      CALL DOEQ                      /*ONE SUBROUTINE PER MODEL COMPONENT
 774  O(ML-1)=CBODUP
      CALL CBODEQ
      IF(SKPNPC.LE.0.)GO TO 788
      IF(AN.LE.0.)GO TO 782
 776  O(ML-1)=N3UP
      CALL N3EQ
 778  O(ML-1)=N2UP
      CALL N2EQ
 780  O(ML-1)=N1UP
      CALL N1EQ
      IF(AP.LE.0.) GO TO 788
 782  O(ML-1)=P2UP
      CALL P2EQ
 784  O(ML-1)=P1UP
      CALL P1EQ
 786  O(ML-1)=CUP
      CALL PHYEQ
C---NEGATIVE PREDICTED VALUES SCREENED OUT
 788  CALL BOTTOM
C---COMPUTE AVERAGE CONCENTRATIONS OVER LAST DAY OF RUN
      IF (TP.LE.TMAX1) GO TO 830       /*TMAX1=TMAX-1.
      AVN=AVN+1.
      DO 790 K=ML,MU
      AVN1(K)=AVN1(K)+N1(K)
      AVN2(K)=AVN2(K)+N2(K)
      AVN3(K)=AVN3(K)+N3(K)
      AVP1(K)=AVP1(K)+P1(K)
      AVP2(K)=AVP2(K)+P2(K)
      AVC(K)=AVC(K)+C(K)
      AVCBOD(K)=AVCBOD(K)+CBOD(K)
      AVDO(K)=AVDO(K)+DO(K)
  790 CONTINUE
      IF(TP.LE.TMAX1) GO TO 830
      DO 800 K=ML,MU                /*CALCULATE MAX & MIN OVER LAST DAY
      IF (N1(K).LT.MNN1(K))
     1MNN1(K)=N1(K)
      IF (N2(K).LT.MNN2(K))
     1MNN2(K)=N2(K)
      IF (N3(K).LT.MNN3(K))
     1MNN3(K)=N3(K)
      IF (P1(K).LT.MNP1(K))
     1MNP1(K)=P1(K)
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```
      IF (P2(K).LT.MNP2(K))
     1MNP2(K)=P2(K)
      IF (C(K).LT.MNC(K))
     1MNC(K)=C(K)
      IF (CBOD(K).LT.MNCBD(K))
     1MNCBD(K)=CBOD(K)
      IF (DO(K).LT.MNDO(K))
     1MNDO(K)=DO(K)
      IF (N1(K).GT.MXN1(K))
     1MXN1(K)=N1(K)
      IF (N2(K).GT.MXN2(K))
     1MXN2(K)=N2(K)
      IF (N3(K).GT.MXN3(K))
     1MXN3(K)=N3(K)
      IF (P1(K).GT.MXP1(K))
     1MXP1(K)=P1(K)
      IF (P2(K).GT.MXP2(K))
     1MXP2(K)=P2(K)
      IF (C(K).GT.MXC(K))
     1MXC(K)=C(K)
      IF (CBOD(K).GT.MXCBD(K))
     1MXCBD(K)=CBOD(K)
      IF (DO(K).GT.MXDO(K))
     1MXDO(K)=DO(K)
800   CONTINUE
830   IF(IT-ITPRIN) 651,840,999        /*TIME STEP AT WHICH TO PRINT OUT
840   WRITE(IW,850) TT(KWT)            /*SPECIFIED TIME FOR PRINTOUT
850    FORMAT(///,6('*'),'CONCENTRATION AT',F6.2,2X,
     $' DAYS AFTER COMPUTATIONS BEGIN ******')
      WRITE(IW,860)
860   FORMAT(7X,'DISTANCE',3X,'ORGAN-N',5X,'NH4-N',5X,'NO3-N',
     13X,'ORGAN-P',3X,'INORG-P',3X,'CHLOROP',6X,'CBOD',4X,'OXYGEN')
      WRITE(IW,870)(I,DIST(I),N1(I),N2(I),N3(I),P1(I),P2(I),C(I),
     1CBOD(I),DO(I),I=ML,MU)
870   FORMAT (1X,I4,9F10.3)
      IF(IT.LT.ITMAX) GO TO 930        /*END OF RUN
      DO 880 K=ML,MU
      AVN1(K)=AVN1(K)/AVN
      AVN2(K)=AVN2(K)/AVN
      AVN3(K)=AVN3(K)/AVN
      AVP1(K)=AVP1(K)/AVN
      AVP2(K)=AVP2(K)/AVN
      AVC(K)=AVC(K)/AVN
      AVCBOD(K)=AVCBOD(K)/AVN
880   AVDO(K)=AVDO(K)/AVN
      WRITE(IW,890)
 890  FORMAT(1H1,' *****AVERAGE CONCENTRATIONS OVER FINAL DAY *****')
      WRITE (IW,860)
      WRITE(IW,870)(I,DIST(I),AVN1(I),AVN2(I),AVN3(I),AVP1(I),AVP
     12(I),AVC(I),AVCBOD(I),AVDO(I),I=ML,MU)
      WRITE(IW,900)
900   FORMAT (/1X,'******* MINIMUM CONCENTRATIONS  LAST DAY ******')
      WRITE(IW,860)
      WRITE(IW,870)(I,DIST(I),MNN1(I),MNN2(I),MNN3(I),MNP1(I),MNP
```

```
     12(I),MNC(I),MNCBD(I),MNDO(I),I=ML,MU)
      WRITE (IW,910)
 910  FORMAT (/1X,'******* MAXIMUM CONCENTRATIONS  LAST DAY ******')
      WRITE(IW,860)
      WRITE(IW,870)(I,DIST(I),MXN1(I),MXN2(I),MXN3(I),MXP1(I),MXP
     12(I),MXC(I),MXCBD(I),MXDO(I),I=ML,MU)
      STOP
 930  CONTINUE
      KWT=KWT+1          /*ADVANCE PRINTOUT COUNTER AND LOOP BACK
      ITPRIN=(TT(KWT)+0.5*DTT)/DTT
      GO TO 651
 999  STOP
      END -
C-----------------------------------------------------------------------
      SUBROUTINE ADVDIF
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     1H1(20),U(20),E(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
C EVALUATE ADVECTIVE WEIGHTING FACTORS AND COMPUTE ADVECTIVE TERMS
      DO 1 I=ML,MU1
      I1=I+1
      IF (U(I).GT.0.) THEN
        GAM=ALPHA(I)
      ELSE
        GAM=CALPHA(I)
      END IF
      IF (U(I1).GT.0.) THEN
        GAM1=ALPHA(I1)
      ELSE
        GAM1=CALPHA(I1)
      END IF
      DEL=1.-GAM
      DEL1=1.-GAM1
      DIV(I)=1.+DT*(GAM1*U(I1)*ARCO(I1)-DEL*U(I)*ARCO(I))/VOL(I)
      AA(I)=-1.*DT*DEL1*U(I1)*ARCO(I1)/VOL(I)/DIV(I)
 1    BB(I)=DT*GAM*U(I)*ARCO(I)/VOL(I)/DIV(I)
C NOW EVALUATE DISPERSION TERMS
      DO 2 I=ML,MU1
      I1=I+1
      DIF(I)=DT*E(I)*ARCO(I)/VOL(I)/DX1(I)
 2    DIF1(I)=DT*E(I1)*ARCO(I1)/VOL(I)/DX1(I1)
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE DONQBC
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     *GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /BNDS/ N1UP,N2UP,N3UP,P1UP,P2UP,CUP,CBODUP,
     *DOUP,N1UA,N2UA,N3UA,P1UA,P2UA,CUA,CBODUA,DOUA,
     *N1D,N2D,N3D,P1D,P2D,CD,CBODD,DOD,DTX,MCOUNT
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
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 1H1(20),U(20),E(20),SAM(20),QWAST(20),VOLD(20),DX1(20)
  COMMON/BODDO/CBOD(20),WBOD(20),DO(20),DOWAST(20),
 1             CKC(20),CK2(20),WREA(20),RKRO
  COMMON/NITRO/N1(20),N2(20),N3(20),WN1(20),WN2(20),WN3(20),
 $KN12(20),KN23(20),PRE2(20),PRE3(20),XKH12,XKH23
  COMMON/PHOSP/P1(20),P2(20),WP1(20),WP2(20),KP12(20),XKHP12
  COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
  REAL N1,N2,N3,N10,N20,N30
  DATA NCOUNT/10000/
  IF(U(MU).LT.0.0) GO TO 10
  NCOUNT=0
  CHANGE=DTX*U(MU)
  CBOD(MU)=CBOD(MU)-(CBOD(MU)-CBOD(MU-1))*CHANGE
  DO(MU)=DO(MU)-(DO(MU)-DO(MU-1))*CHANGE
  N1(MU)=N1(MU)-(N1(MU)-N1(MU-1))*CHANGE
  N2(MU)=N2(MU)-(N2(MU)-N2(MU-1))*CHANGE
  N3(MU)=N3(MU)-(N3(MU)-N3(MU-1))*CHANGE
  P1(MU)=P1(MU)-(P1(MU)-P1(MU-1))*CHANGE
  P2(MU)=P2(MU)-(P2(MU)-P2(MU-1))*CHANGE
  C(MU)=C(MU)-(C(MU)-C(MU-1))*CHANGE
  RETURN
10 IF(NCOUNT.EQ.0) GO TO 11
  IF(NCOUNT.LT.MCOUNT) GO TO 12
  CBOD(MU)=CBOD0
  DO(MU)=DO0
  N1(MU)=N10
  N2(MU)=N20
  N3(MU)=N30
  P1(MU)=P10
  P2(MU)=P20
  C(MU)=C0
  RETURN
11 DCBOD=(CBOD0-CBOD(MU))/MCOUNT
  DDO=(DO0-DO(MU))/MCOUNT
  DN1=(N10-N1(MU))/MCOUNT
  DN2=(N20-N2(MU))/MCOUNT
  DN3=(N30-N3(MU))/MCOUNT
  DP1=(P10-P1(MU))/MCOUNT
  DP2=(P20-P2(MU))/MCOUNT
  DC=(C0-C(MU))/MCOUNT
12 NCOUNT=NCOUNT+1
  CBOD(MU)=CBOD(MU)+DCBOD
  DO(MU)=DO(MU)+DDO
  N1(MU)=N1(MU)+DN1
  N2(MU)=N2(MU)+DN2
  N3(MU)=N3(MU)+DN3
  P1(MU)=P1(MU)+DP1
  P2(MU)=P2(MU)+DP2
  C(MU)=C(MU)+DC
  RETURN
  END
C----------------------------------------------------------------------
  SUBROUTINE DOEQ
  COMMON/BODDO/CBOD(20),WBOD(20),DO(20),DOWAST(20),
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     1               CKC(20),CK2(20),WREA(20),RKRO
      COMMON/NITRO/N1(20),N2(20),N3(20),WN1(20),WN2(20),WN3(20),
     $KN12(20),KN23(20),PRE2(20),PRE3(20),XKH12,XKH23
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     $H1(20),U(20),E(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/BEN/BENDO(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENDO(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
      REAL N1,N2,N3
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,KCS,
     1KGRAZ,KCBODS
C FIRST COMPUTE REAERATION COEFFICIENTS
      DOS=14.62-TEMP1+TEMP2
      UH=ABS(U(ML))/H1(ML)/2.
      DO 1 K=ML2,MU
      UHAS=SQRT(UH+0.5*ABS(U(K))/H1(K))
      K1=K-1
        CK2(K1)=((RKRO*UHAS+WREA(K1))/HA(K1))*DTD*1.024**(TEMP-20.)
 1    UH=ABS(U(K))/H1(K)/2.
C SOD INPUT AS A NEGATIVE VALUE
      DO 100 M=ML,MU1
      SO=VOLO(M)*(CK2(M)*(DOS-DO(M))-CKC(M)*CBOD(M)-4.33*KN23(M)*N2(M)/
     $(XKH23+N2(M))+(GC(M)*PQ-TRESP)*C(M)+BENDO(M)/HA(M))+DOWAST(M)
      CC=(DIF1(M)*(DO(M+1)-DO(M))-DIF(M)*(DO(M)-DO(M-1))+
     $(SO+VOLO(M)*DO(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
      DO 105 M=1,MUL
      K=MU-M
      DO(K)=P(K)*DO(K+1)+Q(K)
105   CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE CBODRW
      COMMON/BODDO/CBOD(20),WBOD(20),DO(20),DOWAST(20),
     1               CKC(20),CK2(20),WREA(20),RKRO
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     $H1(20),U(20),E(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
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     $DEATHC,RRFSP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/BEN/BENOD(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENOD(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
      COMMON/RATE/KN11(20),KN33(20),KP11(20),KP22(20),KCBODS(20),
     1XKN12(20),XKN23(20),XKP12(20)
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,
     1KCS,KGRAZ,KCBODS
      DO 100 M=ML,MU1
      SO=VOLO(M)*(DETHCC*C(M)-(CKC(M)+KCBODS(M)/HA(M))*CBOD(M)
     $+2.67*BENOC(M)/HA(M))+WBOD(M)
      CC=(DIF1(M)*(CBOD(M+1)-CBOD(M))-DIF(M)*(CBOD(M)-CBOD(M-1))+
     $(SO+VOLO(M)*CBOD(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
      DO 105 M=1,MUL
      K=MU-M
      CBOD(K)=P(K)*CBOD(K+1)+Q(K)
C     IF (CBOD(K).LE.0.00001) CBOD(K)=0.0
105   CONTINUE
      RETURN
      END
C----------------------------------------------------------------------
      SUBROUTINE N3EQ
      COMMON/NITRO/N1(20),N2(20),N3(20),WN1(20),WN2(20),WN3(20),
     $KN12(20),KN23(20),PRE2(20),PRE3(20),XKH12,XKH23
      COMMON/PHYTO/C(20),GC(20),TUPP(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     *H1(20),U(20),I(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/BEN/BENOD(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENOD(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
      COMMON/RATE/KN11(20),KN33(20),KP11(20),KP22(20),KCBODS(20),
     1XKN12(20),XKN23(20),XKP12(20)
      REAL N1,N2,N3
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,KCS,
     1KGRAZ,KCBODS
      DO 100 M=ML,MU1
      SO=VOLO(M)*(KN23(M)*N2(M)/(XKH23+N2(M))-PRE3(M)*AN*GC(M)*C(M)+
     $(BENN3(M)-KN33(M)*N3(M))/HA(M))+WN3(M)
      CC=(DIF1(M)*(N3(M+1)-N3(M))-DIF(M)*(N3(M)-N3(M-1))+
     $(SO+VOLO(M)*N3(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
```

```
      DO 105 M=1,MUL
      K=MU-M
      N3(K)=P(K)*N3(K+1)+Q(K)
C     IF (N3(K).LE.0.00001) N3(K)=0.0
105   CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE N2EQ
      COMMON/NITRO/N1(20),N2(20),N3(20),WN1(20),WN2(20),WN3(20),
     $KN12(20),KN23(20),PRE2(20),PRE3(20),XKH12,XKH23
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     $H1(20),U(20),E(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,PRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/BEN/BENDO(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENDO(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
      REAL N1,N2,N3
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCO,KCS,
     1KGRAZ,KCBODS
      DO 100 M=ML,MU1
      SO=VOLO(M)*(KN12(M)*N1(M)/(XKH12+N1(M))-KN23(M)*N2(M)/
     $(XKH23+N2(M))-PRE2(M)*AN*GC(M)*C(M)+BENN2(M)/HA(M))+WN2(M)
      CC=(DIF1(M)*(N2(M+1)-N2(M))-DIF(M)*(N2(M)-N2(M-1))+
     $(SO+VOLO(M)*N2(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
      DO 105 M=1,MUL
      K=MU-M
      N2(K)=P(K)*N2(K+1)+Q(K)
C     IF (N2(K).LE.0.00001) N2(K)=0.0
105   CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE N1EQ
      COMMON/NITRO/N1(20),N2(20),N3(20),WN1(20),WN2(20),WN3(20),
     $KN12(20),KN23(20),PRE2(20),PRE3(20),XKH12,XKH23
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     $H1(20),U(20),E(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
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     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/BEN/BENDD(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENDD(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENDC(20),BENDC(20)
      COMMON/RATE/KN11(20),KN33(20),KP11(20),KP22(20),KCBODS(20),
     1XKN12(20),XKN23(20),XKP12(20)
      REAL N1,N2,N3
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,KCS,
     1KGRAZ,KCBODS
      DO 100 M=ML,MU1
      SO=VOLO(M)*(DEATHCN*C(M)-KN12(M)*N1(M)/(XKH12+N1(M))+
     $(BENN1(M)-KN11(M)*N1(M))/HA(M))+WN1(M)
      CC=(DIF1(M)*(N1(M+1)-N1(M))-DIF(M)*(N1(M)-N1(M-1))+
     $(SO+VOLO(M)*N1(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
      DO 105 M=1,MUL
      K=MU-M
      N1(K)=P(K)*N1(K+1)+Q(K)
C     IF (N1(K).LE.0.00001) N1(K)=0.0
105   CONTINUE
      RETURN
      END
C------------------------------------------------------------------------
      SUBROUTINE P2EQ
      COMMON/PHOSP/P1(20),P2(20),WP1(20),WP2(20),KP12(20),XKHP12
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     *H1(20),U(20),E(20),SAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/BEN/BENDD(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENDD(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENDC(20),BENDC(20)
      COMMON/RATE/KN11(20),KN33(20),KP11(20),KP22(20),KCBODS(20),
     1XKN12(20),XKN23(20),XKP12(20)
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,KCS,
     1KGRAZ,KCBODS
      DO 100 M=ML,MU1
      SO=VOLO(M)*((KP12(M)*P1(M))/(XKHP12+P1(M))-AP*GC(M)*C(M)
     $ +(BENP2(M)-KP22(M)*P2(M))/HA(M))+WP2(M)
      CC=(DIF1(M)*(P2(M+1)-P2(M))-DIF(M)*(P2(M)-P2(M-1))+
     $(SO+VOLO(M)*P2(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
      DO 105 M=1,MUL
```

```
      K=MU-M
      P2(K)=P(K)*P2(K+1)+Q(K)
C     IF (P2(K).LE.0.00001) P2(K)=0.0
105   CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE P1EQ
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/PHOSP/P1(20),P2(20),WP1(20),WP2(20),KP12(20),XKHP12
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     1H1(20),U(20),E(20),SAM(20),QWAST(20),VOLD(20),DX1(20)
      COMMON/BEN/BENOD(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENOD(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
      COMMON/RATE/KN11(20),KN33(20),KP11(20),KP22(20),KCBODS(20),
     1XKN12(20),XKN23(20),XKP12(20)
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,KCS,
     1KGRAZ,KCBODS
      DO 100 M=ML,MU1
      SO=VOLD(M)*(DEATHCP*C(M)-(KP12(M)*P1(M))/(XKHP12+P1(M))
     $ +(BENP1(M)-KP11(M)*P1(M))/HA(M))+WP1(M)
      CC=(DIF1(M)*(P1(M+1)-P1(M))-DIF(M)*(P1(M)-P1(M-1))+
     $(SO+VOLD(M)*P1(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
      DO 105 M=1,MUL
      K=MU-M
      P1(K)=P(K)*P1(K+1)+Q(K)
C     IF (P1(K).LE.0.00001) P1(K)=0.0
105   CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE PHYEQ
      COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     $H1(20),U(20),E(20),SAM(20),QWAST(20),VOLD(20),DX1(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/BEN/BENOD(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
```

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     $BENP2(20),XCKC(20),XBENDO(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
      REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,KCS,
     1KGRAZ,KCBODS
      DO 100 M=ML,MU1
      SO=VOLO(M)*(GC(M)-DEATHC-KGRAZ-KCS/HA(M))*C(M)+WC(M)
      CC=(DIF1(M)*(C(M+1)-C(M))-DIF(M)*(C(M)-C(M-1))+
     $(SO+VOLO(M)*C(M))/VOL(M))/DIV(M)
      P(M)=AA(M)/(1.0-BB(M)*P(M-1))
      Q(M)=(CC+BB(M)*Q(M-1))/(1.0-BB(M)*P(M-1))
100   CONTINUE
      DO 105 M=1,MUL
      K=MU-M
      C(K)=P(K)*C(K+1)+Q(K)
C     IF (C(K).LE. 0.00001) C(K)=0.0
105   CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE BOTTOM
      COMMON /BODDO/ X1(141)
      COMMON /PHOSP/ X2(101)
      COMMON /NITRO/ X3(202)
      COMMON /PHYTO/ X4(80)
C---SUBROUTINE TO BRING NEGATIVE PREDICTED VALUES UP TO ZERO
      DO 100 I=1,20
      J=I+20
      K=I+40
      IF(X1(I).LT.0.)X1(I)=0.
      IF(X1(K).LT.0.)X1(K)=0.
      IF(X2(I).LT.0.)X2(I)=0.
      IF(X2(J).LT.0.)X2(J)=0.
      IF(X3(I).LT.0.)X3(I)=0.
      IF(X3(J).LT.0.)X3(J)=0.
      IF(X3(K).LT.0.)X3(K)=0.
      IF(X4(I).LT.0.)X4(I)=0.
  100 CONTINUE
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE HYDRAL
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON/HYDG/DIST(20),DX(20),ARCO(20),VOL(20),HA(20),
     1H1(20),U(20),E(20),FAM(20),QWAST(20),VOLO(20),DX1(20)
      COMMON/BEN/BENDO(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
     $BENP2(20),XCKC(20),XBENDO(20),XBENN1(20),XBENN2(20),XBENN3(20),
     $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
      COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
     $ALPHA(20),CALPHA(20),P(20),Q(20)
      COMMON/BODDO/CBOD(20),WBOD(20),DO(20),DOWAST(20),
     1             CKC(20),CK2(20),WREA(20),RKRO
      DIMENSION TITLE(35),NAME(30)
C---READ AND COMPUTE HYDRAULIC AND GEOMETRIC DATA
```

```
C READ INITIAL CONDITIONS
      READ (IH) ARCO,VOL,U,E,H1,SAM
      DO 14 I=ML,MU
 14   VOLO(I)=VOL(I)
      E(ML)=0.
      DO 12 I=ML,MU1
 12   HA(I)=VOL(I)/SAM(I)
      VOL(MU)=VOL(MU1)
      HA(MU)=HA(MU1)
  1   READ(IR,2) TITLE
  2   FORMAT(1X,35A2)
      WRITE(IW,4)
  4   FORMAT(1H1)
      WRITE(IW,2) TITLE
      WRITE(IW,26)
 26   FORMAT (1X,'REACH NO. KM. FROM MOUTH CROSS SECTION  TRANSECT DEPT
     $   REACH DEPTH   REACH VOLUME',/26X,'    SQ. METER          METER
     $       METER         CUBIC METER')
 28   FORMAT (1X,I4,4F15.2,6X,E12.4)
      WRITE(IW,28)(I,DIST(I),ARCO(I),H1(I),HA(I),VOL(I),I=ML,MU)
C---CALCULATE DISTANCE BETWEEN SUCCESSIVE TRANSECTS AND SECTION DISTANC
      DO 15 K=ML,MU
      DX(K)=(DIST(K)-DIST(K+1))*1000.0
 15   CONTINUE
      DX(MU)=DX(MU1)
      DO 17 I=ML2,MU
 17   DX1(I)=(DX(I-1)+DX(I))/2.
      DX1(ML)=DX1(ML2)
      DO 16 K=ML,MU1
 16   DIST(K)=(DIST(K)+DIST(K+1))/2.
      DIST(MU)=DIST(MU)-DIST(MU1)
      READ (IR,24) (ALPHA(I),I=ML,MU)
 24   FORMAT (14F5.2)
      WRITE(IW,30)
 30   FORMAT(//1X,'REACH NO.',2X,'TIDAL VELO.',4X,'DISPERSION',6X,'ALPH
     1 '/11X,' M. PER SEC.',3X,'M**2 PER SEC.')
      WRITE(IW,32)(I,U(I),E(I),ALPHA(I),I=ML,MU)
32    FORMAT(1X,I5,4X,F10.2,5X,F10.1,9X,F6.3)
      DO 23 K=ML,MU
 23   CALPHA(K)=1.-ALPHA(K)
 300   RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE INPUT
      COMMON /PARMS/ ML,MU,ML2,MU1,MS,DT,DTD,DT2,IR,IW,IH,INPS,
     $GAMMS,DELTMS,MUL,THEN12,THEN23,THEP12
      COMMON /BSKIP/SKPNPC,SKPNP,SKPP
      COMMON /ENDS/ N1UP,N2UP,N3UP,P1UP,P2UP,CUP,CBODUP,
     $DOUP,N1UA,N2UA,N3UA,P1UA,P2UA,CUA,CBODUA,DOUA,
     $N1D,N2D,N3D,P1D,P2D,CD,CBODD,DOD,DTX,MCOUNT
      COMMON /PLANK/ TEMP,TEMP1,TEMP2,TEM,TU,TD,PTT,XKCG,XKGRAZ,
     $DEATHC,RRESP,TRESP,AC,RQ,DEATHCP,PQ,PRCY,KGRAZ,AP,AN,
     $DEATHCN,KCG,RIS,RIN,DETHCC,KCS,THETAG,THETAR,THETAD
      COMMON/NITRO/N1(20),N2(20),N3(20),WN1(20),WN2(20),WN3(20),
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      $KN12(20),KN23(20),PRE2(20),PRE3(20)
       COMMON/PHOSP/P1(20),P2(20),WP1(20),WP2(20),KP12(20)
       COMMON/BODDO/CBOD(20),WBOD(20),DO(20),DOWAST(20),
      1              CKC(20),CK2(20),WREA(20),RKRO
       COMMON/PHYTO/C(20),GC(20),TURB(20),WC(20)
       COMMON/HYDG/DIST(20),DX(20),ARCD(20),VOL(20),HA(20),
      1H1(20),U(20),E(20),SAM(20),QWAST(20),VOLD(20),DX1(20)
       COMMON/BEN/BENDO(20),BENN1(20),BENN2(20),BENN3(20),BENP1(20),
      $BENP2(20),XCKC(20),XBENDO(20),XBENN1(20),XBENN2(20),XBENN3(20),
      $XBENP1(20),XBENP2(20),XBENOC(20),BENOC(20)
       COMMON /COMPU/ DIV(20),AA(20),BB(20),DIF(20),DIF1(20),
      $ALPHA(20),CALPHA(20),P(20),D(20)
       COMMON/RATE/KN11(20),KN33(20),KP11(20),KP22(20),KCBODS(20),
      1XKN12(20),XKN23(20),XKP12(20)
       COMMON /LOADS/ PSQ(20),PSN1(20),PSN2(20),PSN3(20),PSP1(20),
      $PSP2(20),PSBOD(20),PSDO(20),DSQ(20),DSN1(20),DSN2(20),DSN3(20),
      $DSP1(20),DSP2(20),DSC(20),DSBOD(20),DSDO(20)
       DIMENSION TITLE(35),NAME(30)
       REAL N1,N2,N3,N1UP,N2UP,N3UP,N1D,N2D,N3D
       REAL N1UA,N2UA,N3UA
       REAL KN11,KN12,KN23,KN33,KP11,KP12,KP22,KCG,KMN,KMP,KCD,
      1KCS,KGRAZ,KCBODS
       READ(IR,4) TITLE
 44    FORMAT(//1X,35A2)
 4     FORMAT (1X,35A2)
       WRITE(IW,44)TITLE
40     READ (IR,6) NDG,NS2,NAME
C***   NS2=NS+1
6      FORMAT(2I5,30A2)
       IF(NDG-99) 55,200,200
55     WRITE(IW,10)NDG,NS2,NAME
10     FORMAT(//1X,'INPUT DATA GROUP=',I4,4X,'NUMBER OF POINT IN THIS GR
      1UP=',I4,4X,30A2/)
       GO TO (91,101,111,121,131,141,151,161,171,181),NDG
C****SPECIFY BOUNDARY CONDITIONS
C SET UPSTREAM VALUES TO ZERO IF NONPOINT SOURCES ARE SPECIFIED.
 91    CONTINUE
       READ(IR,12) N1UP,N1D
       READ(IR,12) N2UP,N2D
       READ(IR,12) N3UP,N3D
       READ (IR,12) P1UP,P1D
       READ (IR,12) P2UP,P2D
       READ(IR.12) CUP,CD
       READ(IR,12) CBODUP,CBODD
       READ(IR,12)DOUP,DOD
       WRITE(IW,1)
  1    FORMAT(20X,'*****BOUNDARY CONCENTRATIONS*****')
       WRITE (IW,17)
       WRITE(IW,7)N1UP,N2UP,N3UP,P1UP,P2UP,CUP,CBODUP,DOUP
  7    FORMAT(5X,'UPSTREAM  ',8F10.3)
 17    FORMAT (/19X,'ORG N',5X,'NH4 N',5X,'NO3 N',5X,'ORG P',
      $5X,'PO4 P',5X,'CHL A',5X,'CBODU',6X,'DO')
       WRITE(IW,8)N1D,N2D,N3D,P1D,P2D,CD.CBODD,DOD
  8    FORMAT(5X,'DOWNSTREAM',8F10.3)
```

```
      GO TO 40
C ALWAYS READ TEMP AFTER BOD DECAY AND SOD
 101  READ(IR,12) TEMP
      WRITE(IW,9) TEMP
   9  FORMAT(' TEMPERATURE= ',F6.2,' DEGREES CENTIGRADE')
      WRITE (IW,*) ' NOTE: READ TEMP AFTER BOD DECAY AND SOD'
      TEMP1=0.367*TEMP
      TEMP2=0.0045*TEMP*TEMP
      DO 11 I=ML,MU
      KN12(I)=XKN12(I)*THEN12**(TEMP-20.)*DTD
      KN23(I)=XKN23(I)*THEN23**(TEMP-20.)*DTD
      KP12(I)=XKP12(I)*THEP12**(TEMP-20.)*DTD
  11  CONTINUE
      KCG=DTD*2.718*XKCG*THETAG**(TEMP-20.)
      DEATHC=PRESP*THETAR**(TEMP-20.)*DTD
      TRESP=DEATHC*AC*2.67/RQ
      KGRAZ=XKGRAZ*DTD*THETAD**(TEMP-20.)
      DEATHCP=(DEATHC+PRCY*KGRAZ)*AP
      DEATHCN=(DEATHC+PRCY*KGRAZ)*AN
      DO 145 K=ML,MU
      CKC(K)=XCKC(K)*TCCKC**(TEMP-20.0)*DTD
145   CONTINUE
      DO 165 K=ML,MU
C NEGATIVE FLUXES, INCLUDING SOD, ARE INTO SEDIMENT
      BENOD(K)=XBENOD(K)*DTD*TCBOD**(TEMP-20.0)
      BENN1(K)=XBENN1(K)*DTD*TCBN1**(TEMP-20.)
      BENN2(K)=XBENN2(K)*DTD*TCBN2**(TEMP-20.)
      BENN3(K)=XBENN3(K)*DTD*TCBN3**(TEMP-20.)
      BENP1(K)=XBENP1(K)*DTD*TCBP1**(TEMP-20.)
      BENOC(K)=XBENOC(K)*DTD*TCBOC**(TEMP-20.)
 165  BENP2(K)=XBENP2(K)*DTD*TCBP2**(TEMP-20.)
      GO TO 40
111   CONTINUE
14    FORMAT(8X,10F10.2)
C---INITIAL CONDITION
      READ(IR,32)(N1(I),I=ML,MU)
      READ(IR,32)(N2(I),I=ML,MU)
      READ(IR,32)(N3(I),I=ML,MU)
      READ(IR,32)(P1(I),I=ML,MU)
      READ(IR,32)(P2(I),I=ML,MU)
      READ(IR,32)(C(I),I=ML,MU)
      READ(IR,32)(CBOD(I),I=ML,MU)
      READ(IR,32)(DO(I),I=ML,MU)
32    FORMAT(14F5.0)
      WRITE(IW,15)
15    FORMAT(7X,'DISTANCE',3X,'ORGAN-N',5X,'NH4-N',5X,'NO3-N',
     15X,'ORGAN-P',3X,'INORG-P',3X,'CHLOROP',6X,'CBOD',4X,'OXYGEN')
      WRITE(IW,18)(I,DIST(I),N1(I),N2(I),N3(I),P1(I),P2(I),C(I),
     1CBOD(I),DO(I),I=ML,MU)
 18   FORMAT (1X,T4,9F10.3)
      GO TO 40
C---WASTE LOADS INPUT
121   WRITE(IW,20)
20    FORMAT(/1X,'REACH',4X,'QWAST',7X,'WN1',7X,'WN2',7X,'WN3',7X,
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     1'WP1',7X,'WP2',6X,'WBOD',4X,'DOWAST'/9X,'M**3/S',
     26(5X,'KG/DY'),6X,'MG/L')
      DO 125 I=1,NS2
      READ(IR,34) K,PSQ(K),PSN1(K),PSN2(K),PSN3(K),PSP1(K),PSP2(K),
     1PSBOD(K),PSDO(K)
 34   FORMAT (5X,I5,8F7.1)
      WRITE(IW,22)K,PSQ(K),PSN1(K),PSN2(K),PSN3(K),PSP1(K),PSP2(K),
     1PSBOD(K),PSDO(K)
22    FORMAT(I5,8F10.1)
      QWAST(K)=(PSQ(K)+DSQ(K))*DT
      WN1(K)=(PSN1(K)+DSN1(K))*DTD*1000.
      WN2(K)=(PSN2(K)+DSN2(K))*DTD*1000.
      WN3(K)=(PSN3(K)+DSN3(K))*DTD*1000.
      WP1(K)=(PSP1(K)+DSP1(K))*DTD*1000.
      WP2(K)=(PSP2(K)+DSP2(K))*DTD*1000.
      WBOD(K)=(PSBOD(K)+DSBOD(K))*DTD*1000.
      DOWAST(K)=(PSQ(K)*PSDO(K)+DSQ(K)*DSDO(K))*DT
125   CONTINUE
      GO TO 40
C NONPOINT (DISTRIBUTED) SOURCES
  131 CONTINUE
 37   FORMAT (I5,9F7.2)
      WRITE (IW,36)
 36   FORMAT(1X,'REACH NO.',5X,'WQNP',5X,'WN1NP',5X,'WN2NP',5X,'WN3NP
     $5X,'WP1NP',5X,'WP2NP',6X,'WCNP',4X,'WBODNP',6X,'DONP'/14X,
     $'M**3/S',6(5X,'KG/DY'),5X,'GM/DY',5X,'KG/DY',6X,'MG/L')
      DO 35 I=1,NS2
      READ (INPS,37) K,DSQ(K),DSN1(K),DSN2(K),DSN3(K),DSP1(K),DSP2(K),
     $DSC(K),DSBOD(K),DSDO(K)
      WRITE (IW,38) K,DSQ(K),DSN1(K),DSN2(K),DSN3(K),DSP1(K),DSP2(K),
     $DSC(K),DSBOD(K),DSDO(K)
      QWAST(K)=(PSQ(K)+DSQ(K))*DT
      WN1(K)=(PSN1(K)+DSN1(K))*DTD*1000.
      WN2(K)=(PSN2(K)+DSN2(K))*DTD*1000.
      WN3(K)=(PSN3(K)+DSN3(K))*DTD*1000.
      WP1(K)=(PSP1(K)+DSP1(K))*DTD*1000.
      WP2(K)=(PSP2(K)+DSP2(K))*DTD*1000.
      WBOD(K)=(PSBOD(K)+DSBOD(K))*DTD*1000.
      DOWAST(K)=(PSQ(K)*PSDO(K)+DSQ(K)*DSDO(K))*DT
      WC(K)=DSC(K)*DTD*1000.
 35   CONTINUE
 38   FORMAT (5X,I5,9F10.2)
      GO TO 40
C---BOD DECAY COEFFICIENTS AT 20 DEGREE C
141   READ(IR,32)(XCKC(I),I=ML,MU)
      WRITE(IW,24)
24    FORMAT(1X,'REACH NO.',4X,'CBOD DECAY AT 20 DEG. CENT.')
      WRITE(IW,26)(I,XCKC(I),I=ML,MU)
26    FORMAT(1X,I5,4X,F10.3)
      READ(IR,12) TCCKC
      WRITE(IW,29) TCCKC
   29 FORMAT(/' ','EXPONENTIAL BASE FOR TEMPERATURE DEPENDENCE:',2X,
     1F10.3)
      READ(IR,12) RKBC
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      WRITE(IW,31) RKRO
C RKRO = 3.93 FOR O'CONNOR-DOBBINS
 31   FORMAT (' PROPORTIONALITY CONSTANT FOR REAERATION:',F7.2)
      GO TO 40
C---TURBIDITY
151   READ(IR,32)(TURB(I),I=ML,MU)
      WRITE(IW,71)
71    FORMAT(1X,'REACH NO.',2X,'LIGHT EXTINCTION (1/METER)')
      WRITE(IW,70)(I,TURB(I),I=ML,MU)
70    FORMAT(1X,I5,6X,F10.2)
      GO TO 40
C---BENTHIC FLUXES.  NEGATIVE VALUES, INCLUDING SOD,
C INDICATE LOSS
 161  READ(IR,32)(XBENN1(I),I=ML,MU)
      READ(IR,32)(XBENN2(I),I=ML,MU)
      READ(IR,32)(XBENN3(I),I=ML,MU)
      READ(IR,32)(XBENP1(I),I=ML,MU)
      READ(IR,32)(XBENP2(I),I=ML,MU)
      READ(IR,32) (XBENOC(I),I=ML,MU)
      READ(IR,32) (XBENDO(I),I=ML,MU)
      WRITE(IW,28)
28    FORMAT(1X,'RELEASE RATE (GM/M**2/DAY AT 20 DEG. CENT.)')
      WRITE(IW,281)
 281  FORMAT(/' REACH NO.',3X,'BENN1',5X,'BENN2',5X,
     1'BENN3',5X,'BENP1',5X,'BENP2',5X,'BENOC',5X,'BENDO')
30    FORMAT(1X,I5,4X,F10.4)
      WRITE(IW,310)(I,XBENN1(I),XBENN2(I),XBENN3(I),
     1XBENP1(I),XBENP2(I),XBENOC(I),XBENDO(I),I=ML,MU)
 310  FORMAT(1X,I5,4X,7F10.4)
      READ(IR,12) TCBN1,TCBN2,TCBN3,TCBP1,TCBP2,TCBOC,TCBDO
      WRITE(IW,291)
 291  FORMAT(/' TEMPERATURE DEPENDENCE BASES'/3X,'TCBN1',5X,'TCBN2',
     $5X,'TCBN3',5X,'TCBP1',5X,'TCBP2',5X,'TCBOC',5X,'TCBDO')
      WRITE(IW,39) TCBN1,TCBN2,TCBN3,TCBP1,TCBP2,TCBOC,TCBDO
 39   FORMAT (7F10.4)
      GO TO 40
C TFM IS TIME IN HOURS FROM MIDNITE TO MODEL START
C   N.B.  IF DAYLENGTH IS CHANGED, TFM MUST AGREE WITH ORIGINAL VALUE
 171  IF (NS2.EQ.1) THEN
        READ(IR,12) RIA,TFM,TU,TD
 12     FORMAT (7F10.0)
  172   FORMAT(' SOLAR RADIATION TOTAL OVER ONE DAY =',F10.2)
        WRITE (IW,166) TFM,TU,TD
      ELSE
        READ(IR,12) RIA
      END IF
      WRITE(IW,172) RIA
 166  FORMAT (/' HOURS FROM MIDNITE TO MODEL START =',F10.2,
     $/' HOURS FROM MIDNITE TO SUN UP =',F10.2,
     $/' HOURS FROM MIDNITE TO SUN DOWN =',F10.2)
      RIN=RIA/RIS*1.5708
      RIN=RIN*24./(TD-TU)
      PTT=3.1416/(TD-TU)
      GO TO 40
```

```
 181   READ(IR,32) (WREA(I),I=ML,MU)
       WRITE(IW,33)
  33   FORMAT (1X,'REACH NO.  REAERATION (METER/DAY)')
       WRITE(IW,21) (I,WREA(I),I=ML,MU)
  21   FORMAT (I5,5X,F10.4)
       GO TO 40
 200   RETURN
       END
C-----------------------------------------------------------------------
       BLOCK DATA
       COMMON /COMPU/ CM(120)
       COMMON /NITRO/ XN(202)
       COMMON /PHOSP/ XP(101)
       COMMON /BEN/XBN(300)
       COMMON /BODDO/ XB(141)
       COMMON /PHYTO/ XPH(80)
       COMMON /MINMAX/ XMN(160),XMX(160)
       COMMON /LOADS/ XLOS(340)
       DATA XN/60*0.1,120*0.,22*1./
       DATA XP/40*0.1,60*0.,1./
       DATA XB/20*2.,20*0.,20*7.,80*0.,3.933/
       DATA XBN/300*0.0/
       DATA XPH/20*10.,20*0.,20*1..20*0./
       DATA XMN/160*10000./
       DATA XLOS/340*0./
       DATA XMX/160*-10000./
       DATA CM /40*1.,40*0.,40*0.5.40*0./
       END
C-----------------------------------------------------------------------
```