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Appendix on Water Quality Analysis

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14. ABSTRACT
This program simulates the sequential operation of reservoir systems for flood control and conservation purposes. Water quality analysis includes water temperature, three conservative and three non-conservative constituents, dissolved oxygen and a phytoplankton option. The flows to be released are determined by the program to meet at-site and downstream control point requirements. Twenty reservoirs, forty control points and any length of study period can be simulated on hourly, daily, or monthly intervals.

Reservoir inflow and quality are routed through the reservoir and the minimum allowable discharge for all downstream needs is computed. The discharge and all intervening local inflow are routed to all control points downstream of the reservoir. The thermal simulation of the reservoir and river system uses the equilibrium temperature approach. Violations of control point water quality requirements are minimized by mixing reservoir discharges from the different vertical levels allowed at the intake structure. This program is a direct expansion, in subroutine form, of the water quantity portion of computer program HEC-5

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FOREWORD

The model described in this appendix is the result of a four year project to expand the capability of the "Simulation of Flood Control and Conservation Systems" model, HEC-5, to include water quality analysis.

This document and the associated computer program are the final products of this project. The model will regulate a ten-reservoir system for water quality control, in addition to the HEC-5 objectives of conservation and flood control regulation. The model has the capability to satisfy control point objectives for temperature, three conservative constituents, three non-conservative constituents and dissolved oxygen for combinations of either tandem or parallel impoundments.

Funding for this model was provided by the Environmental and Water Quality Operational Studies (EWQOS) program, sponsored by the Office, Chief of Engineers, and managed by the U. S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. The model has been developed by contract under the project administration of Mr. R.G. Willey.

This appendix is a supplement to the April 1982, HEC-5 Users Manual (and Exhibit 8 from March 1985), and any references to HEC-5, within the document, refer to the program for quantity regulation. Information regarding error corrections can be given to or obtained from the Hydrologic Engineering Center by contacting Mr. R.G. Willey at (916) 551-1748.

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SIMULATION OF FLOOD CONTROL AND CONSERVATION SYSTEMS

APPENDIX ON WATER QUALITY ANALYSIS

1. INTRODUCTION

1.1 Origin of Program

The flow simulation capability of this program (i.e., flow simulation module or HEC-5) was developed at The Hydrologic Engineering Center (HEC) by Mr. Bill S. Eichert. The initial version was written for flood control operation of a single flood event and was released as HEC-5, "Reservoir System Operation for Flood Control," in May 1973. The flow simulation module was then expanded to include operation for conservation purposes and for period-of-record routings. This revised program was referred to as HEC-5C up to the February 1978 version. Further revisions to the flow simulation module were made and the revised program was referred to as the June 1979 version of HEC-5 [HEC 1979].

In March 1979, the HEC contracted with Resource Management Associates, Inc. to add to the HEC-5 program the capability of simulating temperature in a single reservoir (i.e., temperature simulation module or HEC-5Q).

In November 1979, the HEC contracted with Dr. James H. Duke, Jr. to add the capability to simulate conservative and non-conservative constituents, including dissolved oxygen, in a two-reservoir system and its associated downstream river reaches. These modifications were added to the temperature simulation module and the module was structured to interact with the HEC-5 program to change flow releases if such a change would improve water quality in the downstream reaches.

In February 1982, the HEC contracted with Resource Management Associates, Inc. (RMA) and Dr. James H. Duke, Jr., to extend the November 1979 version of the model to ten reservoirs of an arbitrary tandem and parallel configuration and to perform additional modifications. The capabilities of the total model, that have resulted from all of these modifications, are documented herein.

1.2 Purpose of Program

The flow simulation module was developed to assist in planning studies for evaluating proposed reservoirs in a system and to assist in sizing the flood control and conservation storage requirements for each project recommended for the system. The program can also be useful for selecting proper reservoir operational releases for hydropower, water supply, and flood control.

The water quality simulation module was developed so that temperature and selected conservative and non-conservative constituents, including dissolved oxygen, could be readily included as a consideration in planning studies. The water quality simulation module accepts system flows generated by the flow simulation module and computes the vertical distribution of temperature and other constituents in the reservoirs and the water quality in the associated downstream reaches.

The water quality simulation module also selects the gate openings for reservoir selective withdrawal structures to meet user-specified water quality objectives at downstream control points. If the objectives cannot be satisfied, the model will compute the increase in flow (if any) necessary to satisfy the downstream objective.

With these capabilities, the planner may evaluate the effects on water quality of proposed reservoir-stream system modifications and determine how a reservoir intake structure should be operated to achieve desired water quality objectives within the system.

The water quality simulation module will operate in any of three modes: a calibration mode, an annual simulation mode and a long-term mode. In the calibration mode, historical flow, water quality and reservoir operations are furnished so that simulations can be made to determine the necessary values of module parameters such as decay rates and dispersion coefficients.

In the annual simulation mode, the model is executed on a daily basis to determine the effects of reservoir operations on reservoir water quality and the water quality in the associated downstream reaches. The long-term simulation mode provides simulations similar to the annual simulation mode except that the time steps are longer, generally thirty days, so that the effects of reservoir operations on water quality can be examined over a long planning horizon of ten years or more.

1.3 Hardware and Software Requirements

The program, now written in FORTRAN77, was developed on the CDC Cyber 205, PRIME 550 and HARRIS 500 computer systems. The storage requirements are 68,387K words of memory on 64 bit computers (i.e., CDC) and 1000K words of memory on 24 bit computers (i.e., HARRIS). A current version of the program is maintained for Corps use on the CDC and HARRIS computer systems.

The water quality simulation module is an integral part of the flow simulation module and is not designed to be run independently of the flow module. Twelve data and scratch files are required for water quality simulation module operation, in addition to the files required for the flow simulation module. A total of 31 data and scratch files are required for operation of both the flow and water quality modules.

2. WATER QUALITY SIMULATION MODULE CONCEPTS

2.1 General Capabilities and Limitations

The water quality simulation module is currently limited to a system containing no more than ten reservoirs which may be in either tandem or parallel configuration. The most upstream point, or points, of any system must be defined by reservoirs. The total stream reservoir system may contain a total of thirty control points. These control points may be placed at any desirable location provided that the following guidelines are followed:

a. The most downstream point in the system must be defined by a control point.

b. The confluence of the two streams, on which parallel reservoirs are located, must be defined by a control point.

c. The end of the stream reach above tandem reservoirs must be defined by a control point.

The quality simulation may be performed on only a portion of the total system simulated by the flow simulation module; however, the quality simulation portion must begin at the upstream limits of the total system and cannot be fragmented.

The water quality simulation module uses flow data from the flow simulation module and the specification of these data must match the mode in which the water quality simulation module is operating. For the calibration and annual simulation modes, flow data must be furnished at intervals of one day and simulations are limited to periods contained in one calendar year. For the long term mode, flow data must be furnished at longer intervals (generally 30 days) and the period of simulation is unlimited.

Reservoir dimension limitations include the following:

(1) 50 volume elements[1] per reservoir
(2) One flood control outlet
(3) One uncontrolled spillway
(4) A selective withdrawal system composed of two wet wells containing up to eight ports each

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[1]The number of volume elements is controlled by the total depth and the element thickness in the reservoir.

Stream dimension limitations include the following:

(1) 300 volume elements[1]
(2) 3 locations between adjacent control points for allocating local flows

Water quality capabilities include two alternative simulation options. With option number one, the variable constituents include:

(1) Water temperature which must always be simulated
(2) Up to 3 conservative constituents
(3) Up to 3 non-conservative constituents may be simulated with the following restrictions:

    (a) A maximum of two oxygen consuming constituents may be simulated
    (b) Only one non-conservative constituent not connected with the dissolved oxygen cycle may be simulated

(4) Dissolved oxygen may be simulated within the following restriction:

    At least one oxygen consuming constituent must be simulated as a non-conservative constituent

The second water quality option, referred to as the phytoplankton option, requires the following eight constituents.

(1) Water temperature
(2) Total dissolved solids
(3) Nitrate nitrogen
(4) Phosphate phosphorus
(5) Phytoplankton
(6) Carbonaceous BOD
(7) Ammonia nitrogen
(8) Dissolved oxygen

None of these constituents may be omitted. The phytoplankton option is designed to provide a more realistic representation of the lake environment and the forces affecting dissolved oxygen.

2.2 Reservoir Hydraulics

The reservoirs are represented conceptually by a series of one-dimensional horizontal slices such as those shown in Figure 1. Each horizontal slice or layered volume element is characterized by an area, thickness and volume. In the aggregate the assemblage of layered volume elements is a geometric representation, in discretized form, of the prototype reservoir. This one-dimensional representation has been shown to adequately represent water quality conditions in many reservoirs by Eiker [Corps 1974], Baca [1977], and WRE [1968, 1969a, 1969b].

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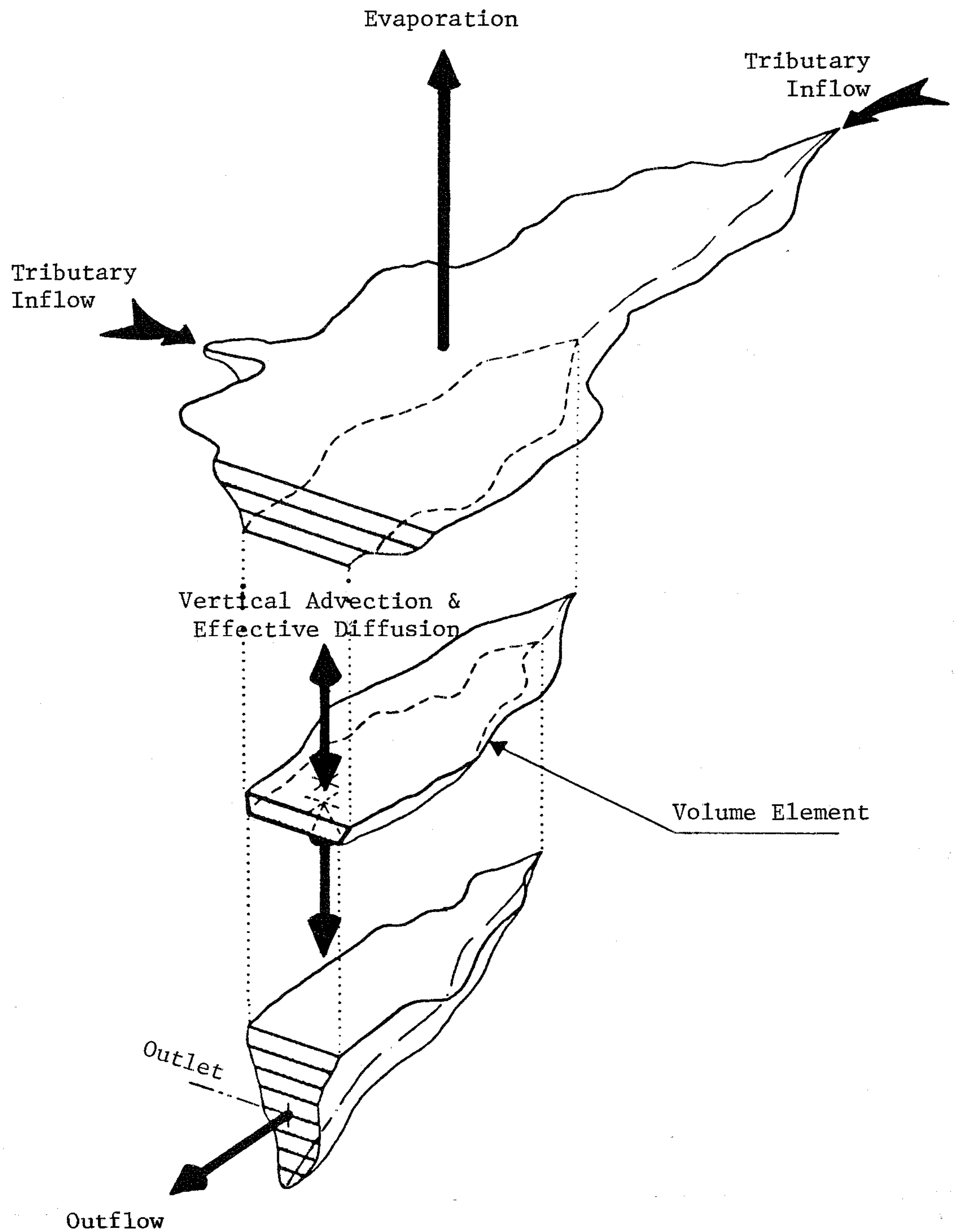
[1]The number of volume elements is controlled by the total stream length and the element length in the stream.

FIGURE 1

Geometric Representation of a Stratified Reservoir and Mass Transport Mechanisms



Within each element, the water is assumed to be fully mixed. This implies that only the vertical dimension is retained during the computation. Each horizontal layer is assumed to be completely homogeneous with all isopleths parallel to the water surface both laterally and longitudinally. External inflows and withdrawals occur as sources or sinks within each layer are instantaneously dispersed and homogeneously mixed throughout each element from the headwaters of the impoundment to the dam. It is not possible, therefore, to look at longitudinal variations in water quality constituents in a reservoir. Module results are most representative of conditions in the main reservoir body.

Vertical advection is governed by the location of inflow to, and outflow from, the reservoir. Thus the computation of the zones of distribution and withdrawal for inflows and outflows are of considerable significance in operation of the model. The WES withdrawal method is used for determining the allocation of outflow. The Debler inflow allocation method is used for the placement of inflows. These methods are described in the following sections.

2.2.1 WES Withdrawal Allocation Method

The outflow component of the model incorporates the selective withdrawal techniques developed by Bohan [1973]. Laboratory investigations were conducted to determine the withdrawal zone characteristics created in a randomly density-stratified impoundment by releasing flow through a submerged orifice. From these investigations generalized relationships were developed for describing the vertical limits of the withdrawal zone and the vertical velocity distribution within the zone.

A definition sketch of variables for orifice flow is shown in Figure 2. The following transcendental equation defines the zero velocity limits of the withdrawal zone.

$$V_o = \frac{Z^2}{A_o} \sqrt{\left(\frac{\Delta\rho'}{\rho_o} \right) g\, Z} \tag{1}$$

where:

- V_o = average velocity through the orifice in m/sec
- Z = vertical distance from the elevation of the orifice center line to the upper or lower limit of the zone of withdrawal in meters
- A_o = area of the orifice opening in m^2
- $\Delta\rho'$ = density of fluid between the elevations of the orifice center line and the upper or lower limit of the zone of withdrawal in kg/m^3*
- ρ_o = fluid density of the elevation of the orifice center line in kg/m^3
- g = acceleration due to gravity in m/sec^2

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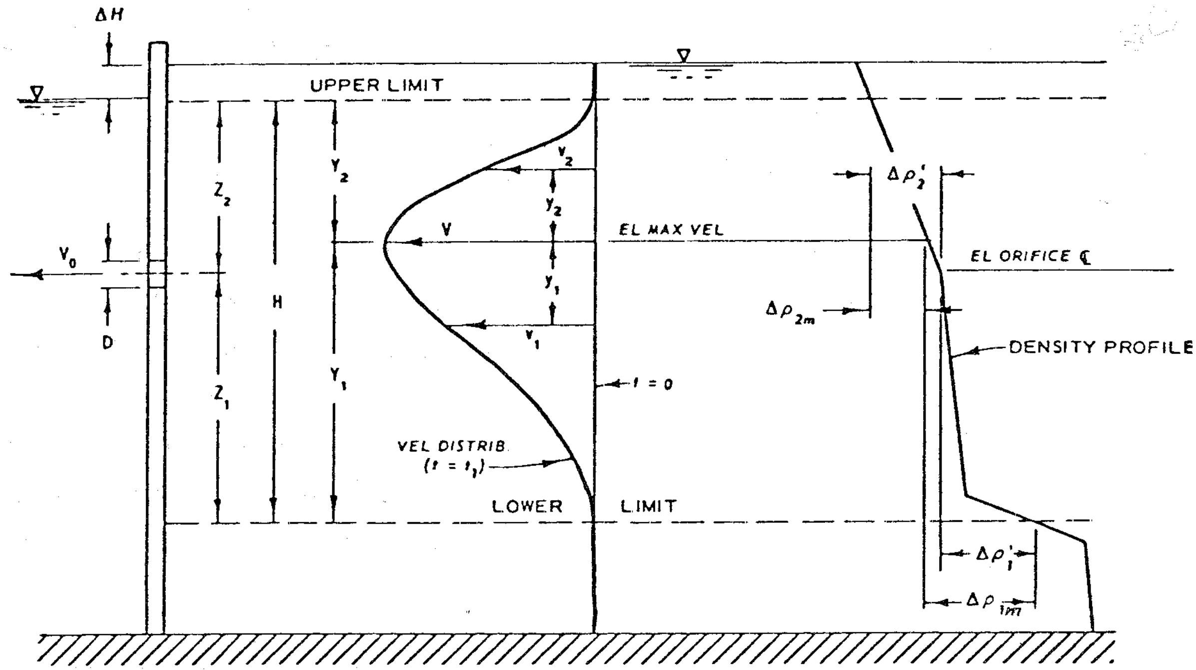
*All water densities in the water quality simulation module are computed solely as a function of water temperature.

FIGURE 2

Definition Sketch of Variables for Orifice Flow



With knowledge of the withdrawal limits, the velocity profile due to outflow can be determined. First, the location of the maximum velocity is determined by:

$$\frac{Y_1}{H} = [\sin(1.57 \frac{Z_1}{H})]^2 \qquad (2)$$

where:

Y_1 = vertical distance from the elevation of the maximum velocity V to the lower limit of the zone of withdrawal in meters
H = thickness of the withdrawal zone in meters
Z_1 = vertical distance from the elevation of the orifice center line to the lower limit of the zone of withdrawal in meters

The distribution of velocities within the withdrawal zone is then determined by:

$$\frac{v}{V} = (1 - \frac{y\Delta\rho}{Y\Delta\rho_m})^2 \qquad (3)$$

where:

v = local normalized velocity in the zone of withdrawal at a distance y from the elevation of the maximum velocity V
V = maximum velocity in the zone of withdrawal in m/sec
y = vertical distance from the elevation of the maximum velocity V to that of the corresponding local velocity v in meters
Y = vertical distance from the elevation of the maximum velocity V to the limit of the zone of withdrawal in meters
$\Delta\rho$ = density difference of fluid between the elevation of the maximum velocity V and the corresponding local velocity V in kg/m^3
$\Delta\rho_m$ = density difference of fluid between the elevation of the maximum velocity V and the limit of the zone of withdrawal in kg/m^3

This equation can be used to describe both the upper and lower sections of a velocity distribution using the elevation of the maximum velocity V as the reference elevation, except for conditions in which the withdrawal zone is limited by either the free surface or the bottom boundary. For conditions where the free surface and bottom boundary limit the withdrawal zone, the velocity distribution is computed by:

$$\frac{v}{V} = 1 - (\frac{y\Delta\rho}{Y\Delta\rho_m})^2 \qquad (4)$$

For a situation in which only one limit (upper or lower) is affected by a boundary (free surface or bottom boundary), equation (3) can be used to determine the velocity distribution from the elevation of maximum velocity V to the limit unaffected by a boundary, and equation (4) can be used to determine the velocity distribution from the elevation of maximum velocity V to the limit affected by a boundary. The flow from each layer is then the product of the velocity in the layer, the width of the layer and the thickness of the layer. A flow-weighted average is applied to water quality profiles to determine the value of the release content of each constitutent for each time step.

2.2.2 Allocation of Inflow

The allocation of inflows is based on the assumption that the inflow water will seek a level of like density within the lake. If the inflow water density is outside the range of densities found within the lake, the inflow is deposited at either the surface or the bottom depending on whether the inflow water density is less than the minimum or greater than the maximum water density found within the lake.

Once the entry level is established, the inflow water is allocated to the individual elements by one of two methods. If the inflow enters a zone of convective mixing, the inflow is distributed uniformly throughout the convectively mixed zone. If the inflow enters a stratified region of the lake, the inflow is distributed uniformly within a flow field, the thickness of which is determined by Debler's criteria [1959].

The thickness of the flow field is determined by:

$$D = 2.88 \left(\frac{Q}{W} \times \frac{\rho}{g\beta}\right)^{1/2} \tag{5}$$

where:

D = thickness of the flow field in meters
Q = inflow rate in m^3/sec
W = effective width* of reservoir at the inflow level in meters
β = density gradient at the withdrawal location in kg/m^4
g = acceleration due to gravity in m/sec^2
ρ = water density at the outlet location in kg/m^3

Once the thickness of the flow field is established, the water is deposited to the elements about the entry level assuming a uniform velocity distribution.

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*The effective width of the flow field is defined as the reservoir area at the entry level divided by the effective reservoir length at the inflow location.

2.2.3 Vertical Advection

Vertical advection is the net interelement flow and is one of two transport mechanisms used in the module to transport water quality constituents between elements. The vertical advection is defined as the interelement flows which result in a continuity of flow in all elements. Beginning with the lowermost element, the vertical advection is calculated by algebraically summing the inflows and outflows. Any flow imbalance is accounted for by vertical advection into or out of the element above. This process is repeated for all remaining elements taking into account the vertical advection from or to the element below. Any resulting flow imbalance in the surface element is accounted for by an increase or decrease in the lake volume.

2.2.4 Effective Diffusion

Effective diffusion is the other transport mechanism used in the module to transport water quality constituents between elements. The effective diffusion is composed of molecular and turbulent diffusion and convective mixing.

Wind- and flow-induced turbulent diffusion and convective mixing are the dominant components of effective diffusion in the epilimnion of most reservoirs. In quiescent, well-stratified reservoirs, molecular diffusion may be a significant component in the metalimnion and hypolimnion. For deep, well-stratified reservoirs with significant inflows to or withdrawals from the hypolimnion, flow-induced turbulence in the hypolimnion dominates. For weakly stratified reservoirs, wind-induced or wind- and flow-induced turbulent diffusion will be the dominant component of the effective diffusion throughout the reservoir.

One of two methods may be selected by the user to calculate effective diffusion coefficients: the stability method or the wind method.

(1) Stability Method - The stability method of computing the effective diffusion coefficients is appropriate for most deep, well stratified reservoirs and shallower reservoirs where wind mixing is not the dominant turbulent mixing force. This method is based on the assumption that mixing will be at a minimum when the density gradient or water column stability is at a maximum.

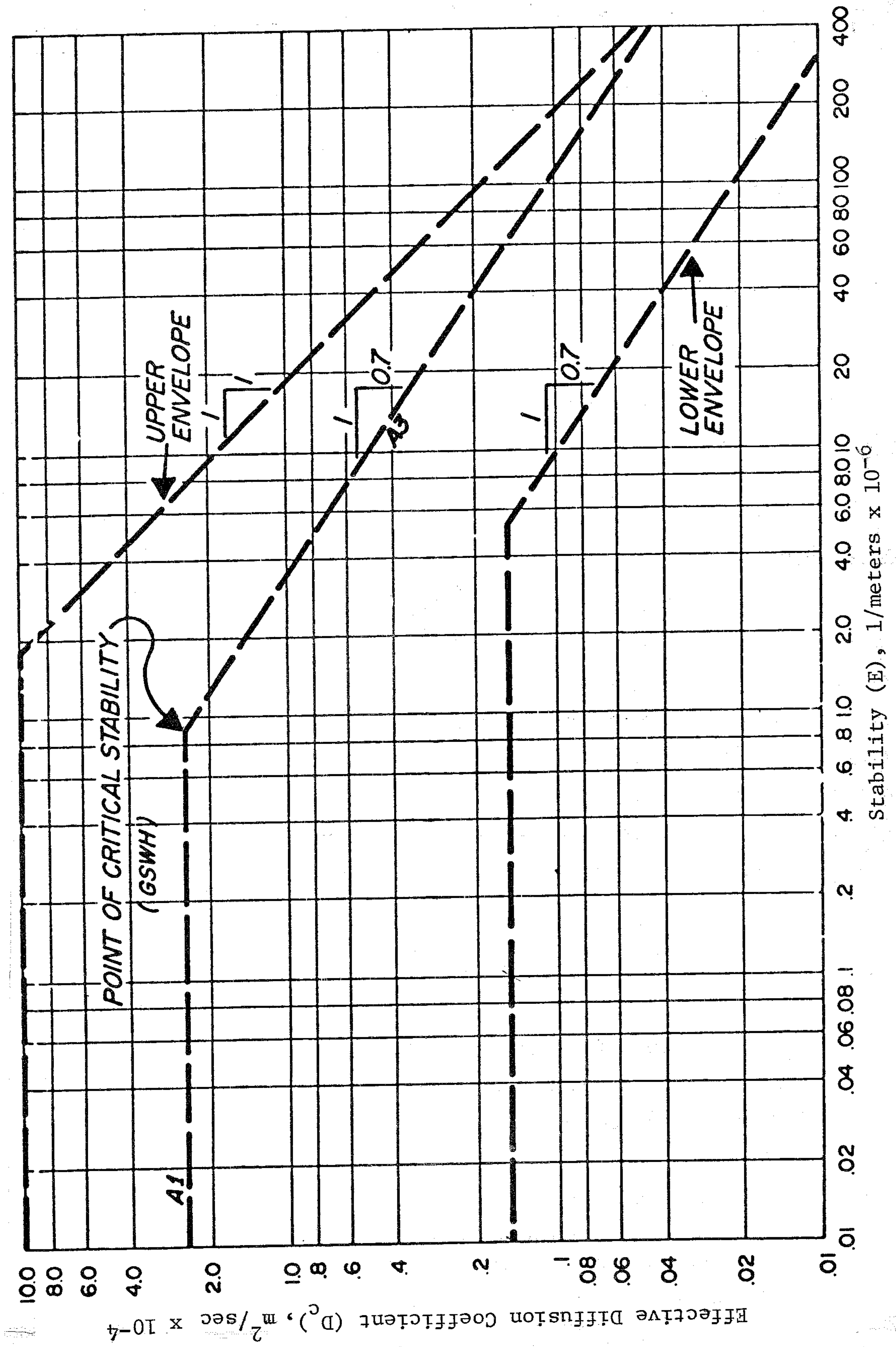
The relationship between stability and the effective diffusion is shown graphically in Figure 3. This figure shows the range of effective diffusion coefficients reported by WRE [1969b] and were deduced from data collected in reservoirs of the Pacific Northwest. Effective diffusion coefficients for reservoirs in other regions may fall below the lower envelope of values shown on Figure 3. The relationship between effective diffusion and stability is shown below.

$$D_c = A_1 \quad \text{when } E \leq E_{crit} \qquad (6)$$

$$D_c = A_2 E^{A_3} \quad \text{when } E > E_{crit} \qquad (7)$$

FIGURE 3

Log of Effective Diffusion Versus Log of Density Gradient



where:

D_c = effective diffusion coefficient in m^2/sec
A_1 = maximum effective diffusion coefficient in m^2/sec

$$E = \frac{1}{\rho} \times \frac{\partial \rho}{\partial z}$$

E = water column stability or normalized density gradient in 1/meter

E_{crit} = water column critical stability in 1/meter
A_2, A_3 = empirical constants

A typical density profile for a stratified reservoir and the resulting effective diffusion coefficient distribution are shown in Figure 4.

(2) Wind Method - The wind method for computing effective diffusion coefficients is appropriate for reservoirs in which wind mixing appears to be the dominant component of turbulent diffusion. This method assumes that wind-induced mixing is greater at the surface and diminishes exponentially with depth. The following empirical expression which is a combination of wind-induced diffusion and a minimum diffusion term representing the combined effects of all other mixing phenomena is used to calculate the effective diffusion coefficient:

$$D_c = D_{min} + A_1 V_w e^{-kd} \tag{8}$$

where:

D_{min} = minimum effective diffusion coefficient in m^2/sec
A_1 = empirical coefficient in meters
V_w = wind speed in m/sec
k = A_2/d_t
A_2 = empirical coefficient
d_t = depth of the thermocline in meters or six meters during unstratified conditions
d = depth of specific layer in meters

Typical values reported by Baca [1977] for the minimum effective diffusion coefficient and the empirical coefficients required by equation (8) are presented in Table 1. Within the model the actual diffusion coefficient, D_c, is constrained by a maximum Dmax, which is usually about 5×10^{-4}. The shape of the diffusion coefficient as a function of depth is shown in Figure 5 for two different cases.

FIGURE 4

Effective Diffusion Coefficients vs. Depth for Stability Method

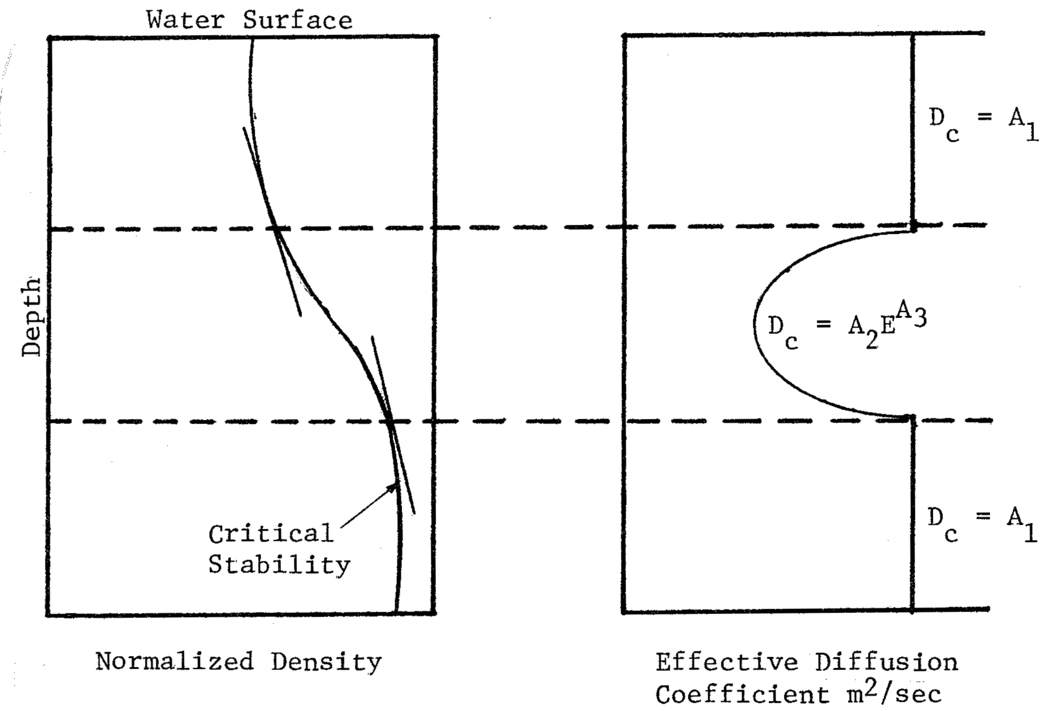


FIGURE 5

Diffusion Coefficient vs. Depth for Wind Method

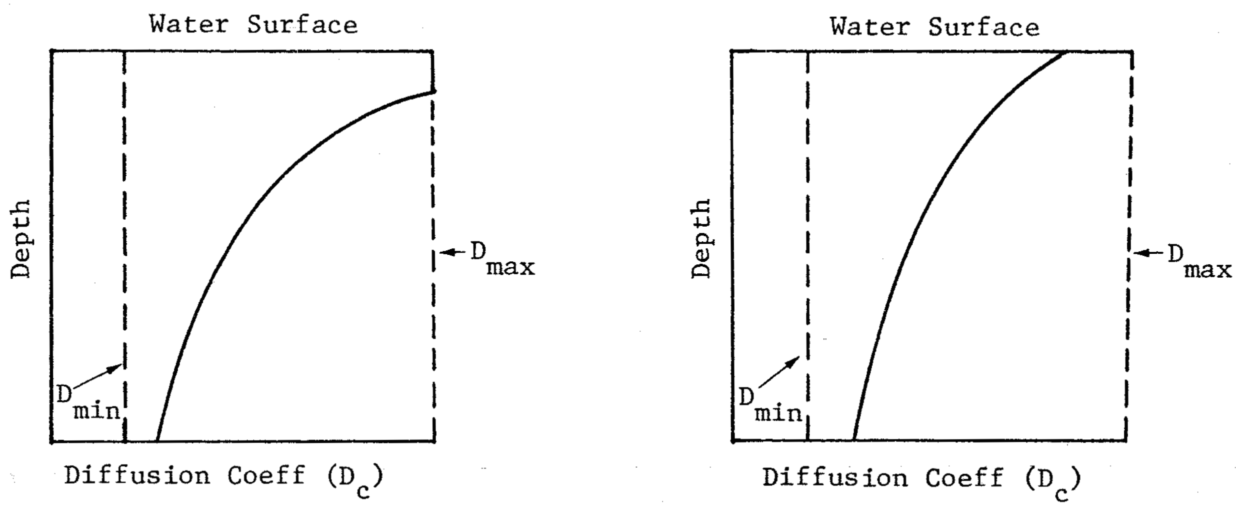


TABLE 1

Minimum Effective Diffusion Coefficient and Empirical Coefficient for Wind Mixing Method

Coefficient	Well-Mixed Reservoirs	Stratified Reservoirs
Minimum Effective Diffusion Coeff (D_{min})	$1x10^{-5}$ to $5x10^{-5}$	$1x10^{-6}$ to $1x10^{-7}$
Empirical Coeff (A_1)	$1x10^{-4}$ to $2x10^{-4}$	$1x10^{-5}$ to $5x10^{-5}$
Empirical Coeff (A_2)	4.6	4.6

2.3 Stream Hydraulics

The stream system is represented conceptually as a linear network of segments or volume elements. Each element is characterized by length, width, cross section area, hydraulic radius, Manning's n and the relationship between flow and depth (see Figure 6).

Flow rates at stream control points are calculated within the flow simulation module by using one of the hydrologic routing methods. Within the flow simulation module, incremental local flows (i.e., inflow between adjacent control points) are assumed to be deposited at the control point. Within the water quality simulation module, the incremental local flow may be divided into components and placed at different locations within the stream reach (i.e., that portion of the stream bounded by the two control points). A flow balance is used to determine the flow rate at element boundaries. Any flow imbalance (i.e., flow at upstream control point plus the increment local flow not equal to the flow at the downstream control point) is distributed uniformly to the flows at each element boundary. Once interelement flows are established, the depth, surface width and cross section area are computed at each element boundary (assuming normal flow).

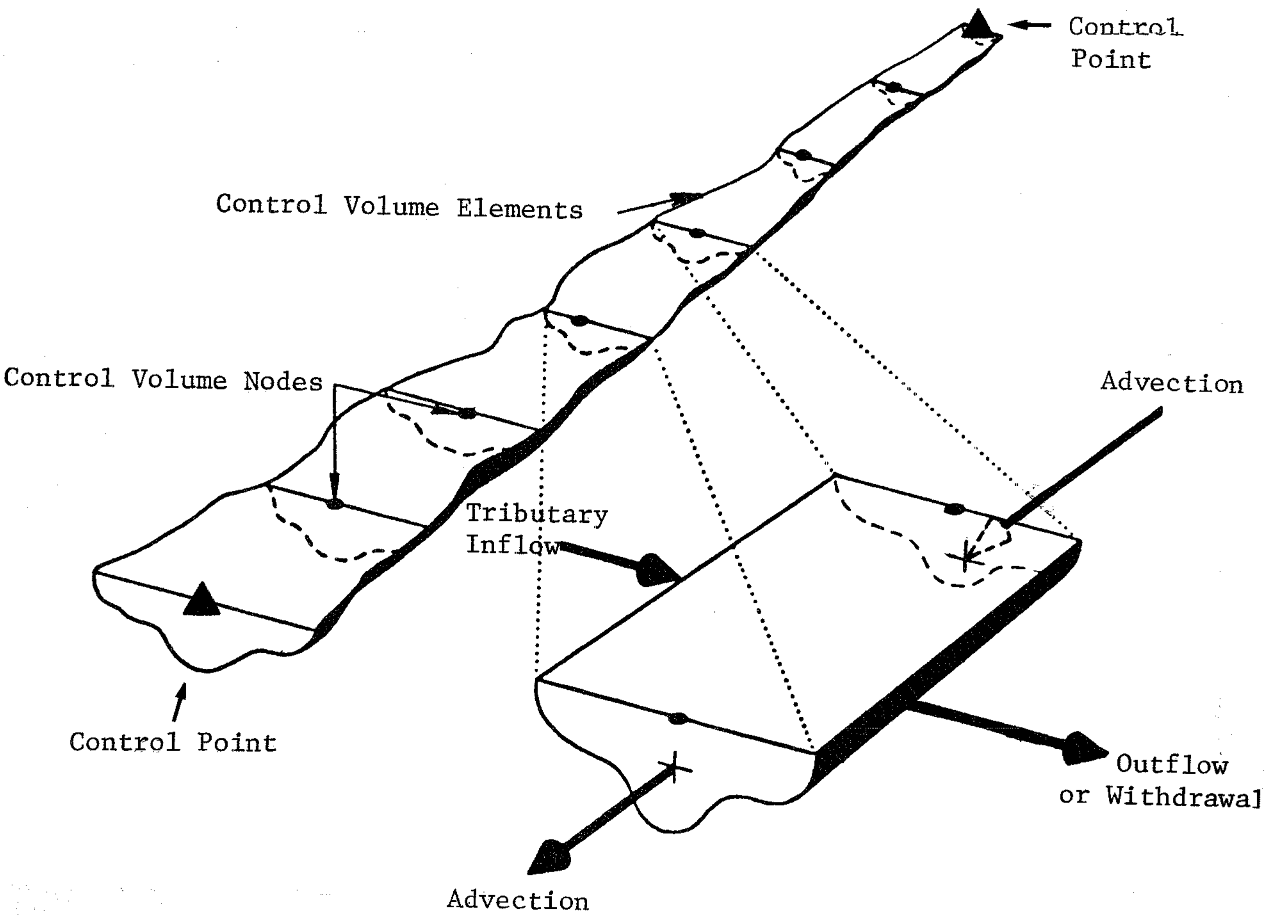
All additional stream hydraulic data required to represent the mass transfers needed to simulate stream water quality can be calculated using these three relationships and the input channel geometry.

2.4 Thermal Analysis

Both the streams and reservoirs are represented by an assemblage of fluid elements linked together by interelement flow and diffusion (stream diffusion is assumed near zero). The interelement mass transports and the fundamental principle of conservation of heat can be represented by the following differential equation model for the dynamics of temperature within each fluid element.

FIGURE 6

Geometric Representation of Stream System and Mass Transport Mechanisms



$$V \frac{\partial T}{\partial t} = \Delta z \cdot Q_z \frac{\partial T}{\partial t} + \Delta z \cdot A_z \cdot D_z \frac{\partial^2 T}{\partial z^2} + Q_i \cdot T_i - Q_o \cdot T \frac{A_h H}{\rho \cdot c} - T \frac{\partial V}{\partial t} \quad (9)$$

where:

- T = temperature in degrees Celsius
- V = volume of the fluid element in m^3
- t = time in seconds
- z = space coordinate in meters (vertical for the reservoir and horizontal for the stream)
- Q_z = interelement flow in m^3/sec
- A_z = element surface area normal to the direction of flow in m^2
- D_z = effective diffusion coefficient in m^2/sec
- Q_i = lateral inflow in m^3/sec
- T_i = inflow water temperature in degrees Celsius
- Q_o = lateral outflow in m^3/sec
- A_h = element surface area in m^2
- H = external heat sources and sinks in $kcal/m^2/sec$
- ρ = water density in kg/m^3
- c = specific heat of water in kcal/kg/°C

This equation represents the dynamics of heat within the fluid element. The set of equations for all elements within the reservoir or stream system represents the dynamics of heat within that system. All of the terms on the right side of equation (9) represent physical heat transfers including the external heat sources and sinks.

The external heat sources and sinks that are considered in the module are assumed to occur at the air-water interface. The rate of heat transfer per unit of surface area can be expressed as the sum of the following heat exchange components:

$$H_n = H_s - H_{sr} + H_a - H_{ar} \pm H_c - H_{br} - H_e \quad (10)$$

where:

- H_n = the net heat transfer
- H_s = the short wave solar radiation arriving at the water surface
- H_{sr} = the reflected short wave radiation
- H_a = the long wave atmospheric radiation
- H_{ar} = the reflected long wave radiation
- H_c = the heat transfer due to conduction
- H_{br} = the back radiation from the water surface
- H_e = the heat loss due to evaporation

All units are in $kcal/m^2/sec$

Complete discussions of the individual terms have been presented by Anderson [1954] and by the Tennessee Valley Authority [1972].

The method used in the module to evaluate the net rate of heat transfer at the air-water interface has been developed by Edinger and Geyer [1965]. Their method utilizes the concepts of equilibrium temperature and coefficient of surface heat exchange. The equilibrium temperature is defined as the water temperature at which the net rate of heat exchange between a water surface and the atmosphere is zero. The coefficient of surface heat exchange is the rate at which the heat transfer process proceeds. The equation describing this relationship is:

$$H_n = K_e\ (T_e - T_s) \tag{11}$$

where:

H_n = net rate of heat transfer in kcal/m^2/sec
K_e = coefficient of surface heat exchange in kcal/m^2/sec/°C
T_e = equilibrium temperature in degress Celsius
T_s = surface temperature in degrees Celsius

A Heat Exchange Program which computes these terms is available at the HEC [Corps 1974].

All heat transfer mechanisms, except short wave solar radiation, apply at the water surface. Short wave radiation penetrates the water surface and may affect water temperatures several meters below the surface. The depth of penetration is a function of adsorption and scattering properties of the water [Hutchinson 1957]. This phenomenon is unimportant in the stream routines since elements are assumed vertically mixed.

In the reservoir routines, however, the short wave solar radiation may penetrate several elements. The amount of heat which reaches each element is determined by:

$$I = (1 - \beta)\ I_o e^{-kz} \tag{12}$$

where:

I = light energy at any depth in kcal/m^2/sec
β = fraction of the radiation absorbed in the top foot of depth
I_o = light energy at the water surface in kcal/m^2/sec
k = light extinction coefficient in 1/meter
z = depth in meters

Combining equations (11) and (12) for the reservoir surface element, the external heat source and sink term becomes:

$$H = K_e(T_e - T_s) - (1 - \beta)\ I_o e^{-k\Delta z} \tag{13}$$

and the external heat source for all remaining reservoir elements becomes:

$$I = I_z(1 - e^{-k\Delta z}) \tag{14}$$

where:

I_z = the light intensity at the top of the element in kcal/m^2/sec

2.5 WATER QUALITY ANALYSIS

2.5.1 Physical and Chemical Constituents

Water quality constituents other than temperature are represented by equation (9) with minor modifications:

a. The definition of the variable T is generalized to represent the concentration of any water quality constituent.

b. The distributed heat gain/loss term $\frac{A_h H}{\rho \bullet c}$ is:

   (1) Eliminated for conservative constituents
   (2) Replaced by a first order kinetic decay formulation, $-K_1 T$, for non-conservative constituents where K_1 is the decay rate in 1/day.
   (3) Replaced by a first order reaeration term, $As \bullet K_2(DO^* - DO) - SO$, for dissolved oxygen where As is the element surface area, K_2 is the reaeration rate, DO^* is the dissolved oxygen saturation concentration at the ambient temperature, DO is the existing dissolved oxygen concentration, and SO is the benthic uptake rate.

The reservoir reaeration rate is computed as follows:

$$K_2 = (a + bW^2)/\Delta z \tag{15}$$

where:

K_2 = reaeration rate in 1/day at 20•C
a,b = empirical coefficients derived by curve fit from Kanwisher [1963] to be 0.50 and 0.025, respectively.
W = wind speed in meters per second
Δz = surface element thickness in meters

The stream reaeration rate is computed using the O'Conner-Dobbins [1958] method:

$$K_2 = \frac{(D_m U)^{0.5}}{D^{1.5}} \tag{16}$$

where:

K_2 = reaeration rate in 1/day at 20•C
D_m = molecular diffusion coefficient in meters^2/day
U = flow velocity in meters/second
D = average stream depth in meters

The rates at which chemical and biological processes take place are normally a function of temperature. To account for this temperature dependence, all first order kinetic rates are adjusted for local ambient temperatures using a multiplicative correction factor:

$$\theta = T_c^{(T-20)} \tag{17}$$

where:

θ = reaeration rate multiplicative correction factor
T_c = empirically determined temperature correction factor
T = local ambient water temperature in °C

2.5.2 Phytoplankton Analysis

When the phytoplankton option is selected, the distributed heat gain/loss term is replaced by:

<u>Nitrate Nitrogen</u>...$+ V \cdot KNH_3 \cdot NH_3 - V \cdot KB \cdot PN \cdot P \cdot PG(1-FN)$ (18)

where:

KNH_3 = ammonia decay rate adjusted to ambient temperature
NH_3 = ammonia concentration
KB = phytoplankton activity rate at ambient temperature
PN = nitrogen fraction of phytoplankton (PN=0.08)
PG = phytoplankton growth rate
P = phytoplankton concentration
FN = ammonia fraction of available nitrogen

<u>Phosphate Phosphorous</u>...$+ V \cdot KB \cdot PP \cdot P\ (PR+PM-PG) + SP$ (19)

where:

PP = phosphorus fraction of phytoplankton (PP=0.012)
PR = phytoplankton respiration rate
PM = phytoplankton mortality rate
SP = benthic source rate for phosphorus

<u>Phytoplankton</u>...$+ V \cdot KB \cdot P\ (PG-PR-PM) - \frac{\partial}{\partial z} (P \cdot A_z) \cdot PS$ (20)

where:

PG = phytoplankton growth rate

$$= P_{max} \left| \frac{C}{C_2 + C} \right| \min \tag{21}$$

P_{max} = maximum phytoplankton growth rate
C = nutrient concentration or light intensity
C_2 = half saturation constant for phytoplankton utilizing nutrients or light
PS = phytoplankton settling rate

Ammonia Nitrogen...+ V•KB•PN•P (PR+PM-PG•FN) + SN (22)

where:

SN = benthic source rate for ammonia nitrogen

Dissolved Oxygen...+ As•K_2 (DO^*-DO) - V•KL•L - V•KB•P (PR•O2R+PM•O2R-PG•O2G) - V•KNH_3•NH_3•O2N-SO (23)

where:

KL = BOD decay rate at ambient temperature

O2R = ratio between oxygen consumed and phytoplankton respiration and decay (O2R = 1.6)
O2G = ratio between oxygen produced and phytoplankton growth (O2G = 1.6)
O2N = ratio between oxygen consumed and ammonia decay (O2N = 4.6)

Computation of the reaeration rate for dissolved oxygen and the first order rate adjustment for the ambient temperature is the same as for the non-phytoplankton option except for the temperature adjustment for phytoplankton growth and respiration. The ambient temperature adjustment factors for phytoplankton growth utilizes the temperature limit approach which assumes that the rate at which a reaction takes place is a function of two exponential expressions similar to those depicted in Figure 7. The temperature tolerances define the functions used to modify the growth and respiration rates. The temperatures T1 and T4 are the lower and upper tolerance limits, respectively, for growth, and T2 and T3 define the optimum range at which the growth is a maximum. The upper range of the optimum temperature T3 and the upper tolerance limit T4 for phytoplankton respiration and mortality processes are assumed outside the range of normal prototype temperatures.

2.6 SOLUTION TECHNIQUES

2.6.1 Reservoir

A Gaussian reduction scheme is used for solving the differential equations which represent the response of the water quality constituents within the reservoirs. Equation (9) is rewritten in a form where a "forward time and central difference" scheme is used to describe all the derivative processes. For element i adjacent to elements i-1 and i+1 (see Figure 8), the general mass balance equation becomes:

$$V_i \left[\frac{\delta T}{\delta T} \right]_i = T_{i-1} \left\{ \left[\frac{A_z D_z}{\Delta z} \right]_i + Qu_i \right\} - T_i \left\{ \left[\frac{A_z D_z}{\Delta z} \right]_i + \left[\frac{A_z D_z}{\Delta z} \right]_{i+1} + Qd_i + Qu_{i+1} + Q_w + \frac{\delta V}{\delta t} \right\}$$

$$+ T_{i+1} \left\{ \left[\frac{A_z D_z}{\Delta z} \right]_{i+1} + Qd_{i+1} \right\} + \sum Q_x T_x + \frac{H}{\rho c} \quad (24)$$

FIGURE 7

RATE COEFFICIENT TEMPERATURE
ADJUSTMENT FUNCTION

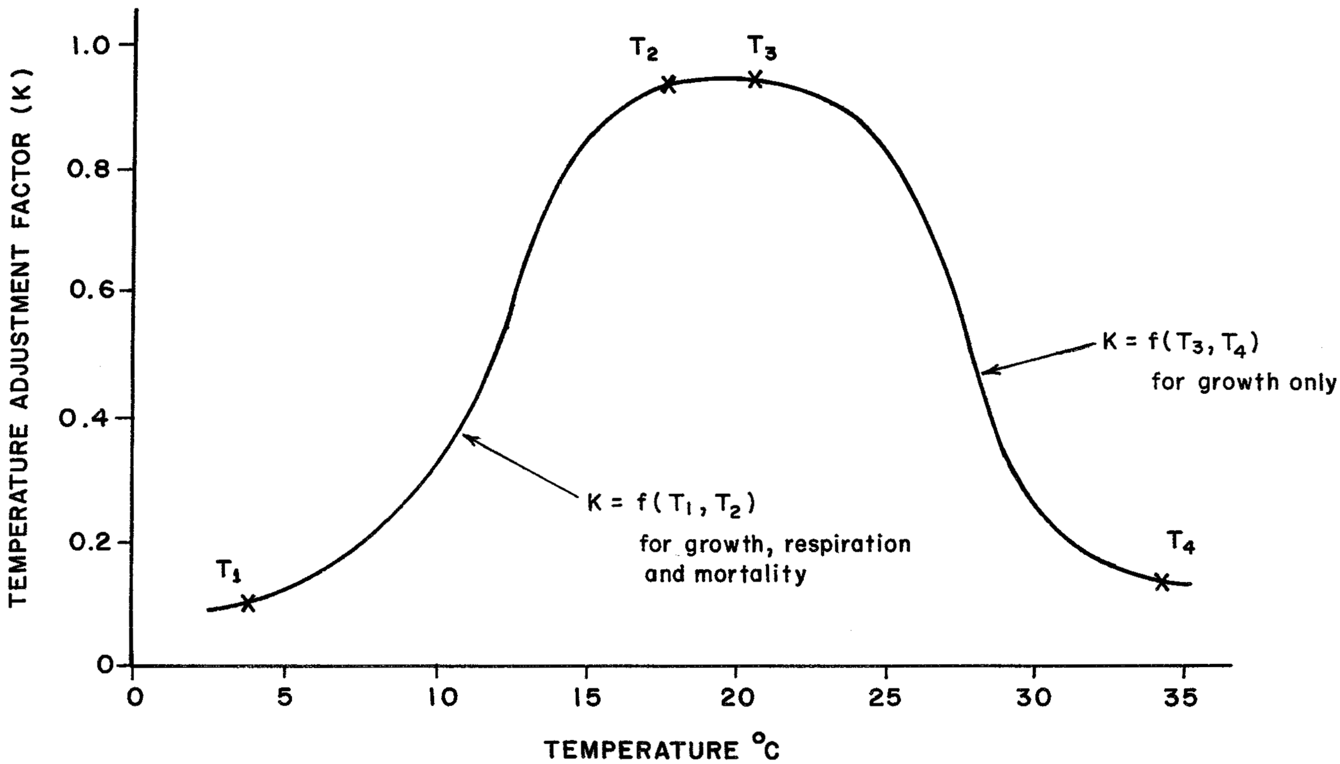
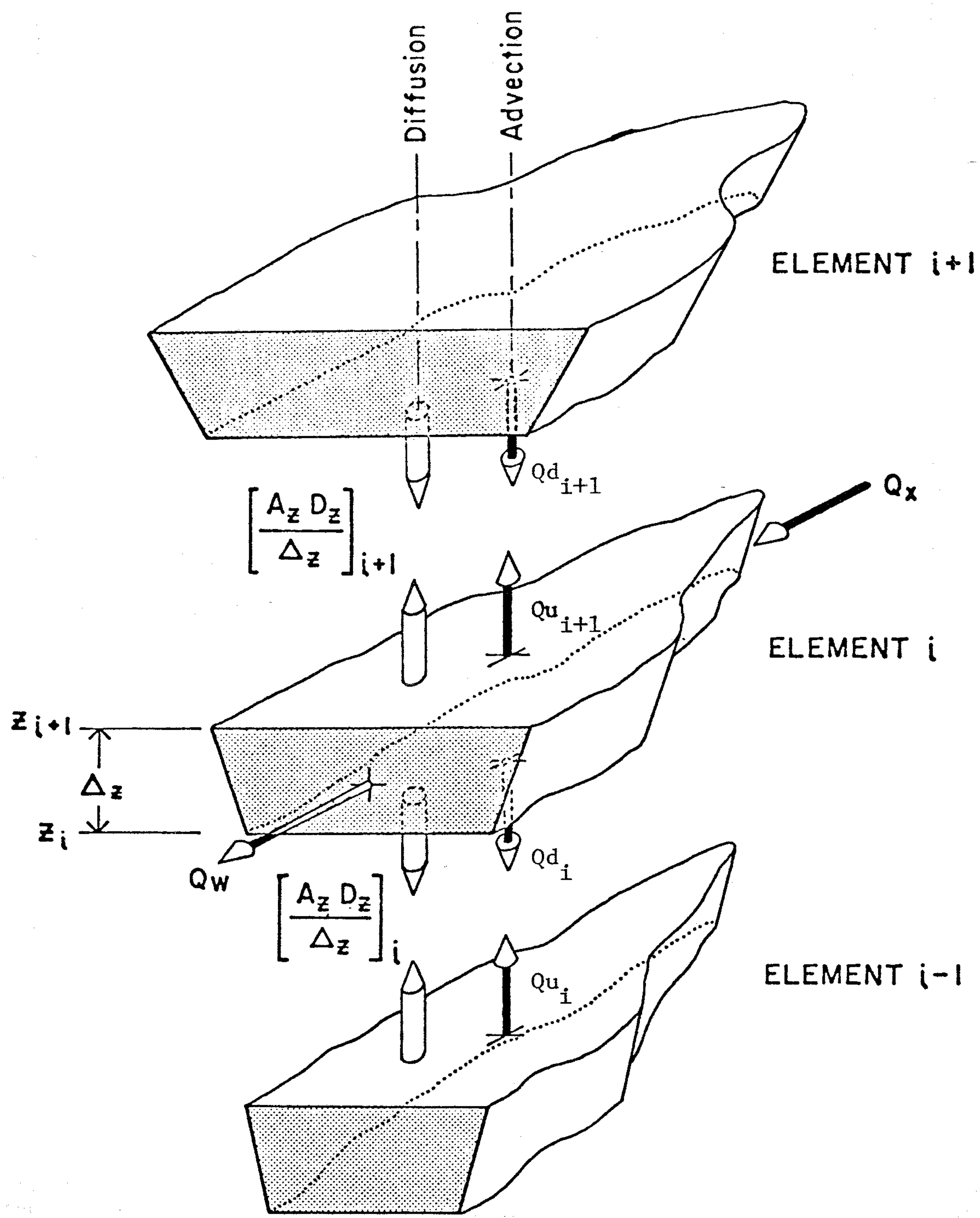


FIGURE 8

Physical Mass Transfers Between Elements



where:

subscripts i, i-1, i+1 denote element numbers

V = volume of the fluid element in m^3
T = temperature in degrees Celsius or water quality constituent concentration, milligrams/liter
t = computation time step in seconds
A_z = element area at the fluid element boundary in m^2
D_z = effective diffusion coefficient in m^2/sec
Δz = element thickness (length is stream) in meters
Q_u = upward advective flow (stream flow) between elements in m^3/sec
Q_d = downward advective flow between elements in m^3/sec
Q_w = rate of flow removal from the element in m^3/sec
Q_x = rate of inflow to the element in m^3/sec
T_x = inflow water temperature in degrees Celsius or constituent concentration in milligrams/liter
H = external sources and sinks of heat in kcal/sec
ρ = water density in kg/m^3
c = specific heat of water in kcal/kg/°C

Recall that the $\frac{H}{\rho \cdot c}$ term is replaced by $-k_1T$ or $k_2(0^*-0)$ for nonconservative water quality constituents and dissolved oxygen respectively. A finite difference equation of this type is formed for each element and integrated with respect to time. The system of finite difference mass balance equations represents the response of water quality within the entire reservoir, and with the aid of a numerical integration technique, the equations are solved with respect to time.

The heat or mass balance at any element, i, can take the form:

$$v_i\dot{c}_i = c_{i-1}s_{i-1} - c_is_i + c_{i+1}s_{i+1} + p_i \qquad (25)$$

where:
v_i = volume of element i
$\dot{c}_i$ = time rate of temperature or water quality constituent concentration in element i
c_i = temperature or constituent concentration in element i
s_i = the bracketed terms of the mass balance equations (i.e., advection, diffusion and change of volume)
p_i = the constant term for each element i (i.e., sources and sinks)

The complete system of mass balance equations for the n elements can be written in the matrix form:

$$[v]\ \{\dot{c}\} = [s]\ \{c\} + \{p\} \qquad (26)$$

where:

[v] = an n x n matrix with the element volumes on the diagonal and zeroes elsewhere
{$\dot{c}$} = a column matrix of the rates of change for temperature or constituent concentrations in each of the n elements
[s] = an n x n matrix of the coefficients which multiply the temperature or constituent concentrations
{c} = a column matrix of the temperature or constituent concentrations in each segment
{p} = a column matrix of the constant terms for each segment

To integrate the basic equation over time, the following numerical approximation for each element is made.

$$c_{t+\Delta t} = c_t + \frac{\Delta t}{2}\,(\dot{c}_t + \dot{c}_{t+\Delta t}) \tag{27}$$

where:

$c_t, c_{t+\Delta t}$ = temperature or constituent concentration at the beginning and end of an integration interval, respectively
$\dot{c}_t, \dot{c}_{t+\Delta t}$ = rate of change of temperature or constituent concentration at the beginning and end of an integration interval, respectively
Δt = the length of an integration interval

At any point in time c_t and $\dot{c}_t$ are known, thus the expression becomes:

$$c_{t+\Delta t} = B + \frac{\Delta t}{2}\,\dot{c}_{t+\Delta t} \tag{28}$$

where:

$$B = c_t + \frac{\Delta t}{2}\,\dot{c}_t$$

Equation (27) rewritten in matrix form is:

$$\{c\} = \{B\} + \frac{\Delta t}{2}\,\{\dot{c}\} \tag{29}$$

where:

{c} = a column matrix of temperatures or constituent concentrations at the end of the time interval
{B} = a column matrix of the terms defined in Equation (28)
{$\dot{c}$} = a column matrix of the time rate of change in temperature or constituent concentrations

Substituting Equation (29) into Equation (26):

$$[v]\ \{c\} = [s]\ \{B\} + \frac{\Delta t}{2}\ [s]\ \{\dot{c}\} + \{p\} \tag{30}$$

or:

$$[s^*]\ \{\dot{c}\} = \{p^*\} \tag{31}$$

where:

$$[s^*] = [v] - \frac{\Delta t}{2}\ [s]$$

$$\{p^*\} = [s]\ \{B\} + \{p\}$$

Equation (31) forms the basis for a solution, as there is only one unknown in the equation (i.e., $\{\dot{c}\}$). The following recursive scheme can be used for the numerical solution of equation (31).

1. Form the vector {B} from the initial condition or the solution just completed.

2. Form the known hydraulic solution and known boundary conditions; define the conditions which will exist at the end of the interval.

3. With known values of [v], [s], and {p}, form $[s^*]$ and $\{p^*\}$.

4. Solve for $\{\dot{c}\}$ at time $(t + \Delta t)$.

5. Compute {c} by substitution in equation (29).

The above recursive scheme is that used in many computer codes and has proven to be very stable.

2.6.2 Stream

A linear programming algorithm is used to solve a fully implicit backward difference in space, forward difference in time, and finite difference approximation of equation (24). This approximation has the general form:

$$a_{i,i-1}C_{i-1}^{t+1} + a_{i,i}C_i^{t+1} + a_{i,i+1}C_{i+i}^{t+1} - C_i^t = b_i \tag{32}$$

where the "a" terms are coefficients formed from the area, dispersion coefficients, flows, lengths of the computational elements, and time step for each volume element; the "C" terms are the unknown temperatures and constituent concentrations in each volume element; the "b" terms are constants formed from initial conditions or previously computed conditions, tributary inputs of heat or mass loads and, depending upon the context (see below), the reservoir releases.

Two matrix formats are used in the stream water quality simulation module. The first can be used to solve for temperature and constituent concentrations given all external input. This format is

$$|A|\vec{c} = \vec{b} \tag{33}$$

where $|A|$ is the matrix of coefficient; $\vec{c}$ is the vector of unknown temperatures or constituent concentrations; and $\vec{b}$ is the vector of constants. Expanding the notation yields:

$$|A| = \begin{bmatrix} a_{11} & a_{12} & 0 & & & & \\ a_{21} & a_{22} & a_{23} & 0 & & & \\ 0 & a_{32} & a_{33} & a_{34} & \cdot & & \\ & \cdot & \cdot & \cdot & \cdot & \cdot & \\ & & \cdot & \cdot & \cdot & \cdot & \cdot \\ & & 0 & a_{m-1,m-2} & a_{m-1,m-1} & a_{m-1,m} & 0 \\ & & & & a_{m,m-1} & a_{m,m} & \end{bmatrix} \tag{34}$$

$$\vec{c} = \begin{bmatrix} c_1 \\ c_2 \\ \cdot \\ \cdot \\ \cdot \\ c_m \end{bmatrix} \qquad \vec{b} = \begin{bmatrix} b_1 \\ b_2 \\ \cdot \\ \cdot \\ \cdot \\ b_m \end{bmatrix}$$

In this format, the $|A|$ matrix is a tri-diagonal matrix consisting of m x m elements, where m is the number of stream elements. The vectors $\vec{c}$ and $\vec{b}$ both consist of m elements.

The $|A|$ matrix will not necessarily be tri-diagonal in a given application of the stream water quality simulation module to a particular stream system but the matrix will be symmetrical about the principal diagonal and will always be a square matrix.

This format is used in the water quality simulation module to compute the final results after all reservoir operations have been completed. In effect, the linear programming algorithm is used simply as a matrix solver for a simulation model.

The second, and more complex, matrix format used in the water quality simulation module is for determining the temperature and constituent concentrations that must come from the reservoirs to satisfy all water quality targets in the stream system. In effect then, the second format is used to (1) determine which control point controls the release for each constituent and (2) determine the reservoir release water quality that most closely satisfies the targets at the controlling points.

This decision making capability is achieved by (1) transforming the constituent concentrations at each control point into a specification of the target and the deviation of the concentration above or below the target and (2) making the concentrations in the reservoir releases unknown so that they can be computed.

The transformation used at control points to specify the target is:

$$C_i^{t+1} = C_{oi} + C_{+i}^{t+1} - C_{-i}^{t+1} \tag{35}$$

where:

C_i^{t+1} = temperature in degrees Celsius or constituent concentration in milligrams/liter
C_{oi} = target temperature in degrees Celsius or constituent concentration in milligrams/liter
C_{+i}^{t+1} = deviation of simulated temperature or constituent concentration above the control point target
C_{-i}^{t+1} = deviation of simulated temperature or constituent concentration below the control point target

This transformation is substituted into equation (32) to yield the following equation which is applied to those volume elements that are located at control points:

$$a_{i,i-1}C_{i-1}^{t+1} + a_{i,i}C_{+i}^{t+1} - a_{i,i}C_{-i}^{t+1} + a_{i,i+1}C_{i+1}^{t+1} - C_i^{t} = b_i - a_{i,i}C_{oi} \tag{36}$$

where the $(a_{i,i}C_{oi})$ term has been moved to the right hand side of the equation since it is known. Thus, the m x m simulation matrix has now been transposed into a m x n rectangular matrix, where n = m + NCP and NCP is the number of control points.

Equation (36) is the general form of the equation used for all volume elements in formulating decision making problems. It includes, as variables, the constituent concentrations in the reservoir releases, although the inclusion is not obvious. For those volume elements that are just below reservoirs, the C_{i-1}^{t+1} concentrations represent the constituent concentrations in the reservoir releases. In the simulation model, where the reservoir release constituent concentrations are known, the $a_{i,i-1}C_{i-1}^{t+1}$ terms were included in the $\vec{b}$ vector for those volume elements just below reservoirs. For the decision making model, the $a_{i,i-1}C_{i-1}^{t+1}$ terms are included as unknowns. Thus the m x n simulation matrix has been made even more elongated in variables and n is now m + NCP + NRES, where NRES is the number of reservoirs in the system.

One additional set of equations is included in the water quality simulation module to ensure that realistic results are obtained in computing reservoir release water quality. These equations are applied to define the range of constituent concentrations that may be released from the reservoirs. Normally the range is defined by two inequalities:

$$C_r^{t+1} \geq C_{min}^{t+1} \tag{37}$$

$$C_r^{t+1} \leq C_{max}^{t+1} \tag{38}$$

where:

C_{min}^{t+1} = minimum temperature or constituent concentration in reservoir water quality profile

C_{max}^{t+1} = maximum temperature or constituent concentration in reservoir water quality profile

C_r^{t+1} = final computed temperature or constituent concentration in reservoir release

In practice, these inequalities are written as equalities by adding slack and surplus variables.

$$C_r - X_{surplus}^{t+1} = C_{min}^{t+1} \tag{39}$$

$$C_r + X_{slack}^{t+1} = C_{max}^{t+1} \tag{40}$$

Although the slack and surplus variables have meaning, in the water quality simulation routine they are added as a computational necessity.

With the problem so formulated, the $|A|$ matrix of equation (34) consists of (m + 2 * NRES) rows and (m + NCP + NRES) unknowns, and the $\vec{b}$ vector consists of (m + 2 * NRES) constants. The $|A|$ matrix may be conceptually partitioned as shown in Figure 9, where it is assumed that reservoirs are above volume elements 1 and 3, that these reservoirs are in tandem and that volume elements 1, 3, 7 and m are control points.

	Stream Water Constituent Concentration Variables*	Variables for Negative Deviations at Control Points	Reservoir Release Variables	Slack and Surplus Variables
Element Numbers	a_{11} a_{12}	$-a_{11}$	$a_{0,1}$	
	a_{21} a_{22}	$-a_{21}$		
	a_{33} a_{34}	$-a_{33}$	$a_{2,3}$	
	a_{43} a_{44} a_{45}	$-a_{43}$		
	. . .			
	a_{65} a_{66} a_{67}	$-a_{67}$		
	a_{76} a_{77} a_{78}	$-a_{77}$		
	a_{87} a_{88} a_{89}	$-a_{87}$		
	. . .	$-a_{m-1,m}$		
	$a_{m-1,m}$ a_{mm}	$-a_{m,m}$		
Inequality Statements			+1	-1
			+1	+1
			+1	-1
			+1	+1

* Variables 1, 3, 7 and m are expressed as deviations from target concentrations at the respective control points.

FIGURE 9

Structure of |A| Matrix for Two Tandem Reservoir, Four Control Point System with m Volume Elements

There are a number of solutions that will satisfy a matrix that is not square (i.e., m x m). The purpose of using a linear programming solution is to select the solution that best satisfies the objectives of the reservoir operation on downstream water quality. However, it is known that one class of solutions will never appear: at no time will the variables that describe the positive and the negative deviations from the control point target constituent concentrations appear simultaneously in the solution. At all times, one or the other deviation will appear, but not both. It is also known that the reservoir release constituent concentrations will always appear in the final solution. Thus, selecting the solution that best satisfies the objectives of the reservoir operation on downstream water quality reduces to selecting which control point deviation variable appears in the final solution and the numerical value attached to that variable. Once this numerical value is known, it is known that the deviation of the opposite sign is zero so that the actual control point constituent concentration can be computed using equation (35).

The objective function is used in a linear programming formulation to quantitatively describe the desirabiity of any given solution to a formulated problem. In the water quality simulation module, a minimization routine is used which is expressed as:

$$\text{minimize } z = \vec{p}\,\vec{c} \tag{41}$$

The actual value of z is immaterial to the water quality simulation module; it is just an index by which the desirability of the solution is determined. The vector $\vec{c}$ is the same vector $\vec{c}$ in equation (33) except that, as previously described, it includes the variables representing:

1. The deviations from the control point targets for those volume elements that represent control points

2. The constituent concentrations in all other volume elements

3. The constituent concentrations in the reservoir releases.

The vector $\vec{p}$ represents the penalty associated with the appearance of a given variable in the final solution. Logically, the penalties in $\vec{p}$ are nonzero only at control points and are applied only for the variables that represent deviations from the target.

The water quality simulation module is structured flexibly so that different penalties can be assigned for each control point, for each constituent and for each deviation, above and below. The magnitude of the penalty is unimportant, as long as it is nonzero where necessary and realistically represents the desired policy. For instance, for a temperature target expressed as "the temperature at control point I shall not exceed 20°C, or

$$TI \le 20,$$

the penalty for the positive deviation at control point I could be set to 1.0, and the penalty for the negative deviation could be set to 0.0. Obviously, when trying to minimize z, as shown in equation (41), the linear programming algorithm would try to ensure that the variable representing the negative deviation would appear in the final solution since a lower value of the index z would result.

If it was twice as important that the target temperature at control point I be maintained than at another control point, say J, then the penalty associated with a positive deviation from the target at I could be set to 2.0, and the penalty associated with a similar positive deviation at J could be set to 1.0. Of course, the penalties associated with negative deviations at both I and J would be set to 0.0.

Similar logic is used for setting penalties for constituents that must always exceed a target value, such as dissolved oxygen. The nonzero penalties are applied to the variables representing negative deviations, and the variables that represent positive deviations are given penalties of 0.

In specifying the penalties for violating control point targets, the relative importance of one unit of measure for the various constituents must be considered. As an example, the importance of a one mg/l violation of a total dissolved solids target value would normally be much less than a one mg/l violation of a dissolved oxygen target; therefore, the penalties for violating dissolved oxygen targets would normally be much greater than those for total dissolved solids.

2.6.3 Gate Selection

The port selection algorithm serves to determine which ports should be open and what flow rate should pass through each open port in order to maximize a function of the downstream water quality concentrations. Solution of this problem is accomplished by using mathematical optimization techniques. The objective function is related to meeting downstream target qualities subject to various hydraulic constraints on the individual ports.

Kaplan [1974] solved a similar, although more difficult, problem by including in the constraint set upper and lower bounds on the release concentration of each water quality constituent. Kaplan also considered as part of his objective function the reservoir water quality that resulted from any particular operation strategy. A penalty function approach was used to incorporate the many constraints into the objective function, which could then be solved as an unconstrained nonlinear problem. For the problem of interest with respect to HEC-5Q, with appropriate transformations it is possible to formulate a quadratic objective function with linear constraints. Mathematical optimization techniques are available to exploit the special structure of this problem and to solve it efficiently.

The hydraulic structure under consideration is composed of two wet wells, containing up to eight ports each, and a flood control outlet. It is assumed that releases through any of these ports (including the flood control outlet) leave the reservoir through a common pipe. At any given time, only one port in either wet well and the flood control outlet may be operated. Hence, the algorithm provides flows through three ports at most.

The HEC-5 model also provides for releases through an uncontrolled spillway. These releases are not a part of the gate selection algorithm, but the water quality of the spillway releases are considered by the gate selection algorithm.

The algorithm proceeds by considering a sequence of problems, each representing a different combination of open ports. For each combination, the optimal allocation of total flow to ports is determined. The combination of open ports with the highest water quality index defines the optimal operation strategy for the time period under consideration.

There are four different types of combinations of open ports. For one-port problems all of the flow is taken from a single port, and the water quality index is computed. For two-port problems combinations of one port in each wet well and combinations of each port with the flood gate are considered. For three-port problems combinations of one port in each wet well and the floodgate are considered. The total flow to be released downstream is specified external to the port selection module, but if the flow alteration option is selected, then the flow can be treated as an additional decision variable; and the flow for which the water quality index is maximized is also determined.

For each combination of open ports, a sequence of flow allocation strategies is generated using a gradient method, a gradient projection method, or a Newton projection method as appropriate. The value of any flow allocation strategy is determined by evaluation of a water quality index subject to the hydraulic constraints of the system. The sequence converges to the optimal allocation strategy for the particular combination of open ports.

To evaluate the water quality index for a feasible flow allocation strategy, first the release concentration for every water quality constituent is computed.

$$R_c = \frac{\sum_{p=1}^{N_p} (\Phi_{cp} Q_p) \ ; \ c=1,\ N_c}{\sum_{p=1}^{N_p} Q_p} \qquad (42)$$

where:

R_c = release concentration for constituent c
c = index for constituents
p = index for open ports
N_p = number of open ports
Φ_{cp} = concentration of constituent c at port p
Q_p = flow rate through port p
N_c = number of constituents under consideration

The deviation of release qualities from downstream target qualities can be computed.

$$D_c = R_c - T_c; \qquad c = 1,\ N_c \qquad (43)$$

where:

D_c = deviation of constituent C
T_c = downstream target quality for constituent C

The subindex S_c for each constituent can be determined by:

$$S_c = f(D_c); \qquad c = 1, N_c \tag{44}$$

Where the function f takes the form of the sixth order polynominal:

$$f(D_c) = a + bD_c + cD_c^2 + dD_c^3 + eD_c^4 + fD_c^5 \tag{45}$$

In selecting these coefficients, the magntiude and importance of the water quality parameter should be considered. To aid in the coefficient selection process, Table 2, Figure 10 and the following discussion are provided.

TABLE 2. Typical Coefficients in Constitutent Suboptimization Function

Curve Number	Coefficient a*	b	c	d	e	f
1	100	0.0	- 0.1	0.0	0.000	0
2	100	0.0	- 2.0	0.0	0.000	0
3	100	0.0	- 10.0	0.0	0.000	0
4	100	- 3.2	- 0.7	- 0.1	- 0.005	0
5	100	3.2	- 0.7	0.1	- 0.005	0

*a should always equal 100

Curves 1 through 3 are functions where equal weight is given to deviation on either side of the target concentration. Under normal conditions, this type of function should be used.

Curve number 1 would be used for a quality parameter such as TDS since wide variations from the target are normally allowable. For a parameter such as nitrate where the concentration is low, curve number 3 would be appropriate. Curve number 2 might be used for temperature or other paramters where the concentration range is 5 to 25.

Curves number 4 and 5 are functions where deviations about the target are not weighted equally. Curve number 4 could be used for a toxic parameter where the lowest discharge concentration would be desirable, conversely, curve 5 could be used for a parameter where a higher concentration is always desirable. Curve 5 might be appropriate for dissolved oxygen in some applications.

In summary, almost any shape of function can be developed (a curve fit routine will be very helpful) using the sixth order polynomial function. In developing these functions, the importance of the parameter and the normal anticipated concentration magnitude are the major considerations. Keep in mind that the weighting factor can be set to zero if the quality parameter is unimportant.

Finally, the scalar water quality index can be determined by:

$$Z = \sum_{c=1}^{N_c} W_c \; S_c \qquad (46)$$

where:

Z = water quality index
W_c = weighting factor for constituent c
S_c = subindex for constituent c and:

$$\sum_{c=1}^{N_c} W_c = 1 \qquad (47)$$

In summary, the problem of determining the optimal allocation of flows to ports for a particular combination of open ports and for a specified total flow rate Q can be expressed as follows:

$$\underset{Q_p}{\text{MAX}} \quad \left(\sum_{c=1}^{N_c} W_c \; S_c \right) \qquad (48)$$

Subject to:

$$\sum_{p=1}^{N_p} Q_p = Q$$

$$F_{min,p} \le Q_p \le F_{max,p} \; ; \; p=1, \; N_p$$

where F_{min} and F_{max} are the minimum and maximum acceptable flow rates through a port.

When an acceptable flow range Q_{lower} to Q_{upper} is specified, then the problem is written as:

$$\underset{Q_p}{\text{MAX}} \quad \left(\sum_{c=1}^{N_c} W_c \; S_c \right)$$

Subject to:

$$Q_{lower} \le \sum_{p=1}^{N_p} Q_p \le Q_{upper}$$

$$F_{min,p} \le Q_p \le F_{max,p} \; ; \; p=1, \; N_p$$

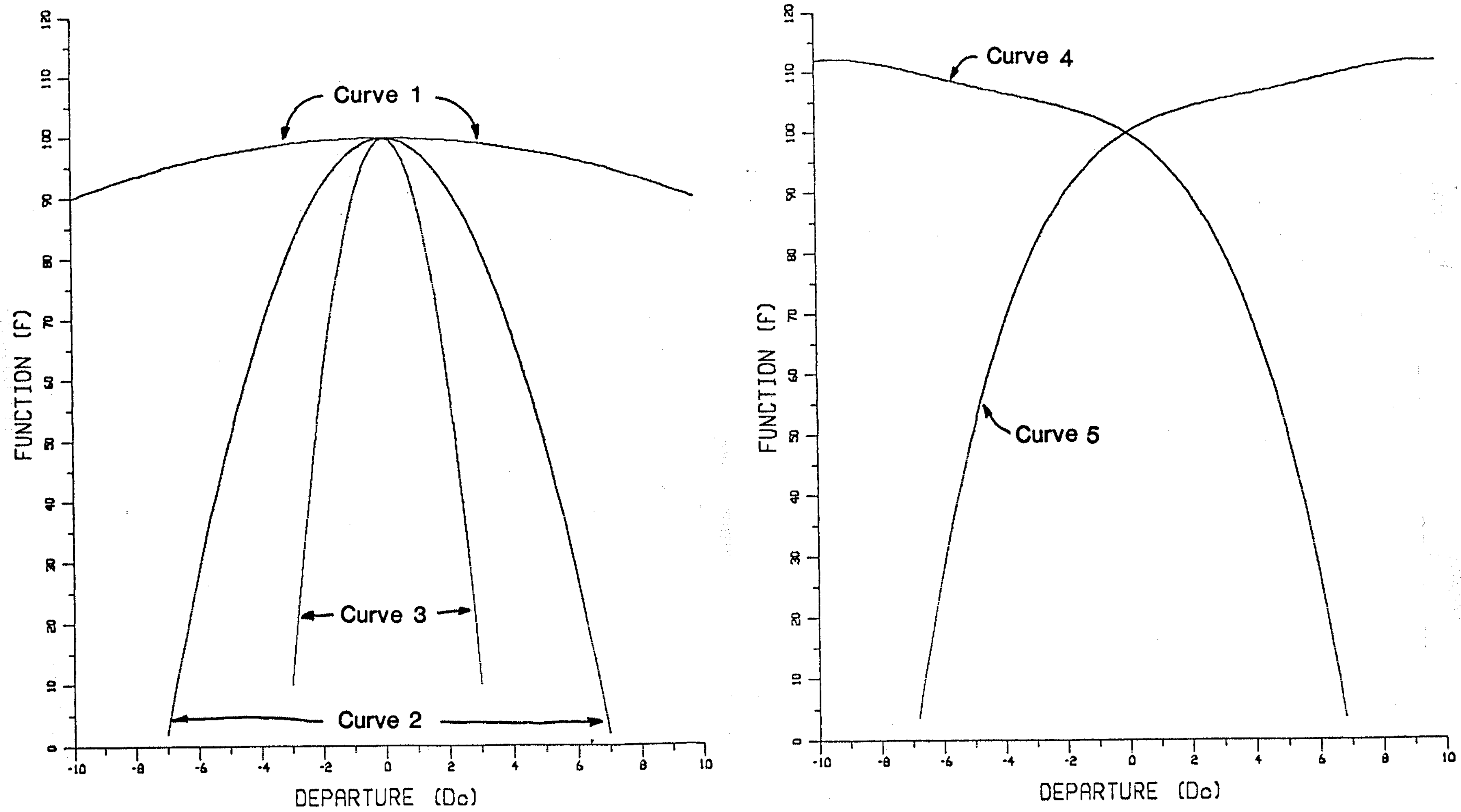


FIGURE 10. Relationship Between the Deivation from the Release Target Quality and the Suboptimization Function for the Coefficients Presented in Table 2

These problems are solved very efficiently by using mathematical optimization techniques that take advantage of the problem structure, namely a quadratic objective function with linear constraints.

2.6.4 Flow Alteration Routine

The flow alteration routine is designed to change the reservoir releases, computed by the flow simulation module, to better satisfy the stream control point water quality objectives. There are two flow alteration routines contained in HEC-5Q. The first is contained in the selective withdrawal algorithm and is described in Section 2.6.3, Gate Selection. Flows are increased in the gate selection algorithm if increasing the flow will result in releases that better meet the reservoir release targets called for by the stream linear programming algorithm.

The second flow alteration routine computes increases in reservoir releases to ensure that control point targets are met insofar as is possible. The routine is designed about a mass balance for all reservoir releases and all control points affected by those releases. Tributary inflows and other flow changes are included. Second order effects, such as reaeration and external heating due to increased or decreased stream surface area, are not included.

The procedure is as follows:

1. The relative mass that needs to be added in the flow at the control point (for those constituents below the target) or reduced in the flow at the control point (for those constituents above the target) is computed using:

$$\Delta M = Q_{cp} \, (C_o - C_{cp}) \tag{49}$$

where:

Q_{cp} = flow at the control point as determined by the flow simulation module
C_o = target constituent concentration at the control point
C_{cp} = computed constituent concentration at the control point

2. The average reservoir release concentration is computed for all reservoirs for which the constituent concentration in the releases is greater than the target concentration at the control point of interest (for those constituents below the target) or for which the constituent concentration in the releases is less than the target at the control point of interest (for those constituents above the target). Thus:

$$\bar{C}_R = \sum_{i=1}^{n} Q_{Ri} \, C_i \Big/ \sum_{i=1}^{n} Q_{Ri} \tag{50}$$

where:

$\bar{C}_R$ = average constituent concentration in reservoir releases for only those reservoirs releasing flow with constituent concentrations adequate to dilute the control point concentration and bring it to the target
Q_{Ri} = flow release from reservoir i
C_i = constituent concentration in release from reservoir i
n = number of reservoirs

The sums are taken only over those reservoirs i that are capable of diluting the control point constituent concentration that is of poorer quality than the target concentration.

3. The total dilution flow requirement is then computed by the following quotient:

$$Q_A = \frac{\Delta M}{\bar{C}_R} \tag{51}$$

where Q_A is the total flow release needed to bring the constituent concentration at the control point of interest to the target.

4. The flow Q_A is then apportioned to the reservoirs capable of bringing the control point constituent concentration to the target in proportion to the flows originally computed for those reservoirs by the flow simulation module.

Thus the flow augmentation requirement can be computed for each control point and for each constituent. The various computed flow rates are then combined by using the coefficients of the linear programming objective function and the deviation of the respective constituent concentrations from the target concentrations at each respective control point as follows:

$$Q_k = \frac{1}{\sum_{i=1}^{N_{cp}} \sum_{j=1}^{N_{cc}} P_{ij} (C_{ij} - C_{io})} \sum_{i=1}^{N_{cp}} \sum_{j=1}^{N_{cp}} Q_k \cdot P_{ij} (C_{ij} - C_{io}) \tag{52}$$

where:

Q_k = flow release from reservoir k
N_{cp} = number of control points affected by both reservoirs
N_{cc} = number of constituents
P_{ij} = linear programming objective function coefficient for constituent j at control point i.
C_{ij} = computed concentration of constituent j at control point i
C_{io} = target concentration of constituent i

Once the Q_k is determined, using equation (51), the flow simulation module is recalled, and the daily computations for flow and water quality are solved again for the final results.

3 INPUT STRUCTURE

3.1 Organization of Input

The input structure is designed to be flexible with respect to specifying characteristics of the reservoir system and other inputs to the system. Each input record is described in detail in Exhibit 3. The last two pages of the exhibit are a "Summary of Input Records." The summary shows the order in which the records should be placed.

3.2 Type of Input Records

The various types of records used are identified by two characters in columns 1 and 2. These characters are read by the computer to identify the record. Types of records are as follows:

a. Title Records - TI. Three title records are required.

b. Job Control Records - JA. This record is required and specifies length of simulation, number of control points, and water temperature units.

c. Water Quality Constituent Records - QC. This record identifies which water quality constituents will be modeled. It provides control over the number of records to be read.

d. Reservoir Records - L1 through CR. These records are used to control the reservoir simulation and describe the characteristics of the reservoir. All records except L5, L6 and L7 are required. Required records define the printout interval (L1 record), miscellaneous physical constants (L2 record), effective reservoir length (LR record), effective diffusion coefficients (L3 and L4 records), effective reservoir width (L8 records), initial reservoir temperature and water quality profiles (L9 - SC records), and various modeling coefficients (K1 - CR records). Optional records (L5, L6 and L7) define the characteristics of the flood control outlet, the uncontrolled spillway and the wet wells. These records are optional to the extent that the reservoir is not required to have all outlet options. Records TQ, C1 - SC, and K1 - CR are optional in that they are not required if only temperature is simulated.

e. Stream Records - S1 through CT. All stream records are required. These records define printout controls and the amount of channel geometry data (S1 record), reach limits and local inflow locations (S2 cards), reaeration controls (SR and SK records), channel cross section geometry data (S3 records), typical energy grade line elevations (S4 records), nonconservative constituent decay rates (KR records) and water quality objectives (CT records).

f. Local Inflow Temperature - I1 through I4. Record I1 is required to define the period of the inflow. Each tributary inflow point requires an I2 record plus sets of either I3 or I4 records (but not both) to define water quality over the period of record.

g. Water Surface Heat Exchange - EZ and ET. One EZ record identifies the station for the ET records which follow. One ET record defining surface heat exchange characteristics is required for each day of simulation.

h. Optimization Objective Functions and Relative Weights - PL and WT. These records define the shape of the objective function for each constituent (water quality index) and the relative weight between constituents.

i. Gate Operations - G1 and G2. These records define the operation schedule for the wet wells, flood control outlet and uncontrolled spillway. The values can be actual flows or relative weightings.

4. OUTPUT

Options to control output from the water quality simulation module are limited to omitting the printout of channel cross section geometry and defining the frequency (in time and space) at which temperature and water quality simulation results are printed. These options are specified by use of the L1 and S1 records.

The sequence of printout from the water quality simulation module is: (a) miscellaneous information transferred from the flow simulation module, (b) job titles and simulation control data, (c) reservoir related input data, (d) stream related input data, (e) input water quality objectives at control points, (f) results of the reservoir water quality simulation, and (g) results of the stream water quality simulation. Items (a) through (e) are printed at the beginning of the run prior to the actual water quality analysis. Items (f) and (g) are printed during each simulation iteration. During the simulation and in-between the printed reservoir and stream results, selected data transferred from the flow simulation module to the water quality module may be printed. A detailed description of these items that appear in the output is provided below.

a. Flow Simulation Module Geometry and Flow Data. The geometry and flow data transferred from the flow simulation module to the water quality simulation module includes:

(1) Job titles

(2) Miscellaneous reservoir and stream channel discharge control data and routing information.

(3) The elevation versus storage versus surface area tables defining the reservoir geometry.

The printout of some of the above data may be suppressed at the users option (JA card, Field 7).

b. Job Titles and Simulation Controls. Selected information from data records TI through TQ are printed. Simulation controls include the length of simulation, input units, and identification of water quality constituents to be simulated.

c. Reservoir Related Input Data. The reservoir related data include data from records L1 through CR, I1 through I4, and data transferred from the flow simulation module. These data include:

(1) Miscellaneous geometric data, reservoir light attenuation characteristics and diffusion coefficients.

(2) Outlet characteristics of the flood control outlet, uncontrolled spillway and the wet wells of the reservoir's selective withdrawal structure.

(3) Table of reservoir geometry data and initial temperature and water quality data which includes both the input data and interpolated data for each fluid element. The geometry data includes elevation, area, volume and width at the dam.

(4) Reservoir inflow water quality data.

d. Stream Related Input Data. The stream related data include data from the S1 through I4 records. These data include:

(1) Miscellaneous print and read controls.

(2) Control point locations, fluid element lengths, location of local inflows and the fraction of the incremental local inflow discharged at the various locations.

(3) Stream channel cross section geometry tables. These tables define the relationship between elevation and area, hydraulic radius to the two-thirds power, width, Manning's n and flow. The printout of these geometry tables may be suppressed at the users option.

(4) Tributary inflow water quality data.

e. Water Quality Objectives at Control Points. The water quality objectives include data input on the CT records. These data include the control point objectives and the objective function parameters.

f. Results of the Reservoir Simulation. The results of the reservoir simulation are printed at intervals specified by the user. This output is printed during the appropriate simulation iteration and includes:

(1) Equilibrium temperature, heat exchange rates, short wave solar radiation and wind speed. (These data are input via the ET records.)

(2) The reservoir inflow rate, outflow rates through the various outlets, mean outflow temperature and water quality, outflow temperature and water quality objectives and the reservoir elevation, surface area and volume.

(3) Computed reservoir temperature and water quality profiles.

g. Results of the Stream Simulation. The results of the stream simulation are printed at intervals specified by the user. This output is printed during the appropriate simulation iteration and includes:

(1) Equilibrium temperature, heat exchange rates, short wave solar radiation and wind speed. (These data are input via the ET records.)

(2) Reservoir outflow rates, temperature and water quality.

(3) Local inflow rates, temperature and water quality.

(4) Computed stream temperature and water quality distributions.

(5) Stream temperature and water quality targets.

An example of the output from this module is provided in Test Problem 1 of Exhibit 1.

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EXHIBIT 1

TEST PROBLEMS

HEC-5
SIMULATION OF FLOOD CONTROL AND CONSERVATION SYSTEMS

APPENDIX ON WATER QUALITY ANALYSIS

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EXHIBIT 1
TEST PROBLEMS

EXHIBIT 1
TEST PROBLEMS

INTRODUCTION

Input for six water quality test problems are shown in this exhibit along with a general description of each. Output for Test Problem 1 is also shown as an illustration of typical output.

TEST PROBLEM 1 - Standard Parallel Reservoir Case

a. The system simulated in this test of the water quality simulation module consists of two parallel reservoirs and the downstream system. The system diagram is shown on the following page.

b. The reservoir characteristics are:

	Baker Reservoir	Smith Reservoir
Reservoir depth	250 ft	115 ft
Reservoir capacity	1,688,00 ac-ft	1,130 ac-ft
Flood control outlet	Yes	No
Uncontrolled Spillway	No	Yes
Number of wet wells	2	2
Gates per wet well	4	4

c. The stream system consists of a 5.5 mile stretch from Baker Reservoir to the confluence with the stream on which the Smith Reservoir is located. Smith Reservoir is 4.7 miles above the confluence. The energy grade line (EGL) slope from Baker reservoir to the confluence is 0.00065. The EGL slope from the Smith reservoir to the confluence is 0.0014. From the confluence (CP #30) to CP #40, the EGL slope is 0.00057 and from CP #40 to river mile 30.4 the EGL slope is 0.00065. Below river mile 30.4, to the end of the system, the EGL slope is 0.000076.

d. Tributary inflows are input to the stream system at two points, RM 45 and RM 30.

e. Temperature, total dissolved solids (TDS), carbonaceous BOD and dissolved oxygen are simulated. Local inflow temperature values for both of the two reservoirs and for the stream system are furnished as departures from the equilibrium temperature. Similarly, carbonaceous BOD is furnished as five-day values and a factor of 1.463, based on a bottle BOD decay rate of 0.23 per day, is used to convert the five-day values to ultimate values. TDS and dissolved oxygen concentrations were furnished in mg/1.

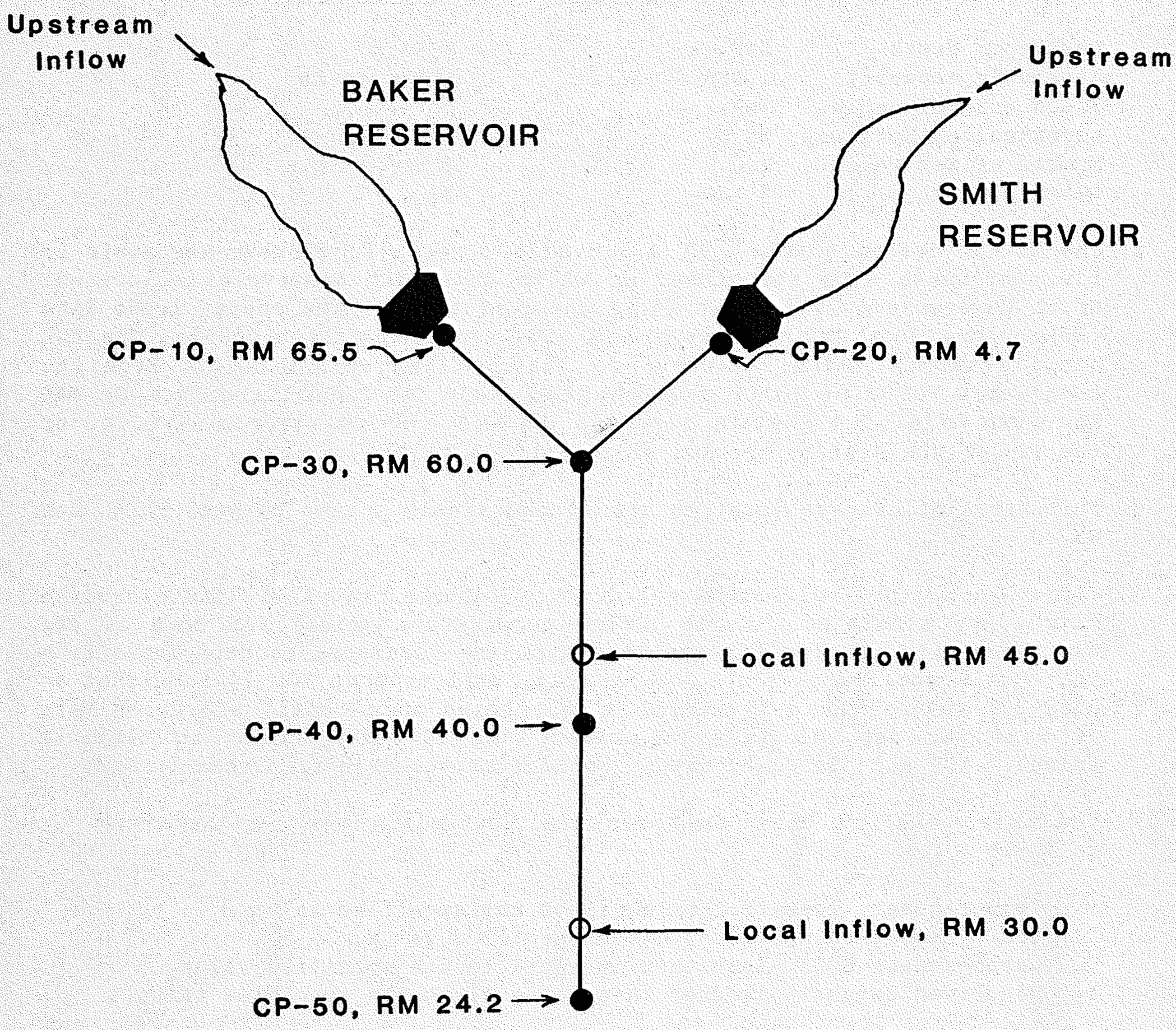
f. The water quality objectives for the control points are expressed as follows:

1. Temperature: less than or equal to the specified value
2. TDS: less than or equal to the specified value
3. Carbonaceous BOD: less than or equal to the specified value
4. Dissolved oxygen: greater than or equal to the specified value.

Different weights are place on each constituent at each control point (see CT cards in input data listing).

g. The recommended weights and objective parameters were used for the gate selection routine (see WT and PL cards).

A complete listing of the input data file follows. Following the data listing, selected simulation results are presented as an illustration of example output. The simulation results that have been omitted are the repetitive printed tables that show simulated stream and reservoir water quality on days after day 130. A complete output listing is included with the computer source code distribution.



EXAMPLE PARALLEL RESERVOIR PROBLEM

```
T1      TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
T2      PARALLEL RIVER SYSTEM
T3      TEST PROBLEM 1
J1       0       5       5       3       4       2       0       0
J2      36       0       0       0       0       0       0
J9
RL      10 1200000       0  100000  200000 1500000 1600000
RO       3      30      40      50
RS       7     100    6300   31300   88000  188000  563000 1688000
RQ       7       0   20000   30000   40000   50000   50000   50000
RA       7      10     500    1500    3000    5000   10000   20000
RE       7     800     825     850     870     900     950    1030
R3       2       2       2       2      99      99      99      99      99      99
R3      99      99
CP      10   20000     300     200
IDCP10-BAKER DAM
RT      10      30     2.2     .25      12       0
RL      20  550000       0    2000  550000  952000 1130000
RO       3      30      40      50
RS       8    2000   20000   52000  113000  209000  320000  550000  800000 1130000
RQ       8       0    5680    5680    5680    5680    5680   29180   59680  104980
RA       8     150    2100    4500    7600   11800   17000   22400   28600   37200
RE       8     892     910     920     930     940     950   962.5     970     980
R3       2       2       2       2      99      99      99      99      99      99
R3      99      99
CP      20   20000      30      20
IDCP20-SMITH DAM
RT      20      30     2.2     .25      12       0
CP      30   30000     300     200
IDCP30-CONF RM60
RT      30      40     2.2     .25      12       0
CP      40   30000     300     200
ID CP40 ** RM 40
RT      40      50     2.2     .25      12       0
CP      50   50000     300     200
IDCP50 ** RM24.2
RT      50       0       0       0       0       0
ED
BF       0     120       0       074050100     120      24
NOLIST
IN      10  1MAY74    2059    1814    2125    2243    1947    1836    1735    1587
IN    1549    1509    1413    4584    7520    5061    3549    2931    2801    3866
IN    2752    2293    1962    1793    2476    2528    1958    1650    1462    1344
IN    1810    3581    3367    7629    5501    3699    3057    2603    2294    2073
IN    1894    1750    1596    1423    1313    1251    1052    1312    2547    2301
IN    1803    1360    1185    1200    1456    2434    4601    3121    2769    2230
IN    1846    2107    1918   15259    7046    4185    3113    3167    2814    2295
IN    1910    1606    1448    1535    1368    1196    1039    1032    1013     940
IN     890     890     865     826     783     826     928     847     788     829
IN     804     806     945     801     712     751     914     911     935     792
IN     747     717     823    1416     997     806     759     732     683     653
IN     633     639     621     644     604     598     598     596     601     642
IN     662     838     756    1130    1138    1202    1774    2727    2659    1566
```

IN	20	1MAY74	430	816	668	1979	1523	1195	1065	847
IN	698	569	455	402	472	424	415	956	613	510
IN	434	381	361	327	289	338	758	355	262	202
IN	169	133	163	192	203	181	166	212	1017	639
IN	639	366	255	194	236	596	432	284	251	745
IN	348	226	179	198	198	164	155	159	177	888
IN	348	386	197	133	134	141	181	407	212	145
IN	126	122	112	108	89	80	87	80	69	68
IN	64	58	47	53	49	39	43	46	60	60
IN	56	50	49	41	43	39	39	43	39	39
IN	47	47	49	43	47	96	151	112	473	212
IN	297	405	201	128	100	79	64	89	102	90
IN	88	165	95	83	184	1167	463	601	676	665
IN	40	1MAY74	645	588	561	488	452	440	425	405
IN	406	398	380	923	1207	1171	1161	1075	1190	1601
IN	1685	1941	1849	1752	1784	1322	645	397	366	458
IN	669	1011	1113	1740	1529	1352	1273	1219	1171	908
IN	575	431	407	375	357	348	243	231	469	598
IN	671	585	369	237	288	360	546	768	900	874
IN	829	712	549	2648	1733	1751	1617	1671	1565	1433
IN	922	465	361	384	353	328	298	305	296	285
IN	279	235	143	142	139	150	226	282	276	191
IN	106	139	183	220	269	268	278	283	311	249
IN	178	172	162	177	135	119	117	117	130	164
IN	161	166	160	117	61	42	51	141	142	108
IN	87	235	418	701	621	790	976	1222	1532	1570
IN	50	1MAY74	3317	3816	3333	3150	2843	2861	2976	2831
IN	3011	3250	3265	4695	13438	10915	9154	8282	7643	7539
IN	6757	6013	4768	3744	3530	3463	3178	2914	2592	2150
IN	1941	1852	1735	1747	1903	2065	1847	1399	1148	1035
IN	978	844	714	809	784	873	969	816	1405	1972
IN	2159	1563	1308	1482	1621	1469	1155	1353	975	1469
IN	1483	1761	1469	4196	7637	5846	5734	4803	4285	3660
IN	3314	2783	1990	1912	1651	1441	937	893	1209	1028
IN	980	990	1160	785	550	695	679	705	701	786
IN	566	627	774	742	696	661	613	578	630	914
IN	930	930	918	981	1006	881	924	829	857	780
IN	684	606	637	670	578	562	558	486	458	440
IN	621	825	1619	2200	2012	1742	1687	2852	4965	4311
QA	10	1MAY74	1270	1320	1360	1410	1440	1470	1480	1480
QA	1480	1480	1790	2190	2480	3480	4490	4420	4300	4210
QA	4130	3960	3720	3370	2470	1910	1950	1940	1890	1570
QA	1270	1680	2210	2480	4000	5510	5350	4400	2930	1970
QA	1570	1570	1570	1560	1560	1530	1510	1480	1830	2690
QA	3120	2840	1640	819	854	900	1540	2750	3250	2860
QA	2100	2030	2030	3600	9280	11000	7280	4130	3250	2180
QA	1750	1470	1210	1290	1320	1320	1290	1270	1230	948
QA	570	600	610	610	621	631	642	707	764	753
QA	741	730	730	741	730	719	707	707	775	775
QA	819	786	494	819	865	654	865	831	797	764
QA	719	685	494	631	580	521	346	540	486	486
QA	521	600	438	797	1410	2000	2050	2130	3460	4590

```
QA    20  1MAY74    1236     521     387     405     442     949    1602    1572
QA  1528    1040     600     593     590     488     390     497     600     600
QA   597     495     310     220     220     220     226     325     420     417
QA   403     400     286     165     110     110     110     110     275     540
QA   637     627     518     420     420     420     420     320     227     330
QA   430     423     226     110     110     110     110     105     316     440
QA   440     437     430     226     110     110     110     110     110     110
QA   110     105     110     110     110     110     110     110     110     110
QA   110     110     110     110     110     110      75      35      35      35
QA    35      35      35      35      35      35      35      35      35      35
QA    35      35      35      35      36      38      62      85     105     125
QA   182     240     240     240     235     230     178     125     125     125
QA   125     125     125     125     285     463     601     676     665     655
EJ
TI        FICTICIOUS PARALLEL RIVER BASIN TEST OF HEC-5Q WITH WATER QUALITY
TI        RESERVOIRS ARE FICTICIOUS ALSO ** C.P. OF 10, 20, 30, 40 AND 50
TI        CONSTITUENTS ARE TEMPERATURE, TDS, CARBONACEOUS BOD AND OXYGEN
JA        740501  740831       5       2       F       1
EZ             1
ET           116   67.59   105.5  2350.0    8.53
ET           117   75.54    75.0  2350.5    5.56
ET           118   72.51   155.0  2250.2   11.54
ET           119   73.50   195.0  2250.1   13.59
ET           120   74.51   125.5  2250.3    8.54
ET           121   64.56   135.8  2350.6   12.55
ET           122   62.54   115.4  2450.1   10.51
ET           123   65.54   125.3  2350.9   10.50
ET           124   60.56   105.7  2450.1   10.54
ET           125   63.56   105.6  2450.1    9.55
ET           126   57.50   125.1  2450.3   12.50
ET           127   58.55    85.7  2550.6    8.58
ET           128   66.56    95.8  2450.1    7.52
ET           129   66.56   135.3  2450.0   11.58
ET           130   67.58    95.1  2450.6    7.55
ET           131   70.53   135.1  2450.9   10.59
ET           132   66.58   145.4  2450.1   12.51
ET           133   62.56   145.1  2550.4   13.50
ET           134   72.50   145.0  2450.1   11.53
ET           135   71.59   175.2  2450.3   13.52
ET           136   74.51   135.5  2450.6    9.56
ET           137   78.51   175.4  2450.2   10.55
ET           138   75.56   125.7  2450.3    8.59
ET           139   72.54   135.9  2550.7    9.50
ET           140   73.53   115.8  2550.2    8.55
ET           141   81.53    95.9  2550.9    5.56
ET           142   77.55   145.0  2450.5    8.58
ET           143   73.54   145.7  2550.6   10.51
ET           144   68.59   155.9  2550.9   12.51
ET           145   67.54    95.2  2650.1    8.51
ET           146   69.55    95.3  2650.0    7.52
ET           147   64.59   115.9  2650.5   10.56
ET           148   71.57    95.5  2650.2    7.57
ET           149   73.54   145.0  2550.2   10.52
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ET	150	80.54	105.4	2550.5	6.51
ET	151	77.53	135.9	2550.9	8.54
ET	152	70.57	135.4	2550.9	10.59
ET	153	72.59	125.6	2650.7	9.56
ET	154	78.51	85.5	2650.4	5.50
ET	155	79.57	95.9	2550.9	6.59
ET	156	76.56	135.5	2550.6	8.53
ET	157	77.55	135.5	2550.1	8.50
ET	158	75.53	175.0	2550.3	11.53
ET	159	78.50	135.6	2550.9	8.54
ET	160	82.50	135.6	2550.4	7.57
ET	161	77.57	215.1	2550.9	13.52
ET	162	69.53	175.9	2650.5	13.57
ET	163	71.57	115.4	2650.6	8.58
ET	164	73.56	105.8	2650.3	7.56
ET	165	79.58	95.8	2650.5	5.55
ET	166	72.52	155.5	2650.4	10.55
ET	167	71.52	145.3	2650.1	10.52
ET	168	71.56	115.0	2650.7	8.54
ET	169	73.53	125.3	2650.5	8.58
ET	170	77.59	125.1	2650.1	8.51
ET	171	82.54	145.8	2550.0	8.55
ET	172	77.57	195.4	2550.1	12.54
ET	173	81.55	105.0	2550.8	6.52
ET	174	72.52	145.9	2650.9	10.51
ET	175	71.55	155.0	2650.8	11.52
ET	176	71.52	125.3	2650.1	9.50
ET	177	77.58	95.6	2650.1	6.53
ET	178	75.59	125.3	2650.7	8.53
ET	179	74.59	125.5	2650.1	8.58
ET	180	74.58	135.1	2650.1	8.54
ET	181	74.58	215.0	2550.0	14.58
ET	182	80.55	135.6	2550.8	8.51
ET	183	80.59	185.1	2550.8	10.57
ET	184	83.54	205.0	2450.3	10.56
ET	185	83.50	205.2	2450.8	10.56
ET	186	82.50	145.0	2550.8	7.58
ET	187	83.57	105.5	2550.4	5.57
ET	188	89.50	85.1	2550.7	4.54
ET	189	89.52	105.4	2550.9	4.52
ET	190	86.57	145.1	2450.9	6.55
ET	191	82.55	165.3	2450.5	8.57
ET	192	77.54	165.3	2550.5	10.55
ET	193	79.50	105.1	2550.9	6.58
ET	194	87.51	85.2	2550.5	4.50
ET	195	82.50	165.8	2450.9	9.56
ET	196	78.59	165.8	2450.7	10.53
ET	197	76.58	145.4	2550.0	9.58
ET	198	85.58	95.6	2550.9	4.59
ET	199	83.50	145.6	2450.7	7.57
ET	200	81.54	205.3	2450.6	11.50
ET	201	77.55	145.3	2450.5	9.51
ET	202	77.58	125.0	2550.5	8.50

ET	203	82.52	105.7	2450.6	6.52
ET	204	79.54	125.5	2450.3	7.59
ET	205	80.52	115.4	2450.2	6.55
ET	206	84.59	85.9	2450.7	4.50
ET	207	89.54	85.8	2450.1	3.51
ET	208	88.57	95.9	2350.6	4.55
ET	209	82.58	135.1	2350.5	7.58
ET	210	78.56	155.3	2350.3	8.53
ET	211	77.51	155.5	2350.2	9.52
ET	212	79.53	125.3	2350.3	7.57
ET	213	83.59	105.3	2350.8	5.55
ET	214	84.54	115.8	2350.0	5.58
ET	215	79.54	175.7	2250.5	10.54
ET	216	76.56	175.7	2350.9	10.55
ET	217	75.50	115.1	2350.3	7.56
ET	218	79.52	105.2	2350.8	6.59
ET	219	84.54	95.9	2250.2	4.57
ET	220	83.50	105.5	2250.9	5.59
ET	221	83.53	95.9	2250.4	5.58
ET	222	78.55	135.9	2250.7	8.59
ET	223	78.58	165.9	2250.5	9.54
ET	224	83.56	115.8	2150.0	5.58
ET	225	82.54	125.9	2150.5	6.55
ET	226	79.58	135.4	2250.7	7.56
ET	227	81.59	95.2	2250.6	5.55
ET	228	85.58	85.2	2150.8	4.55
ET	229	79.57	155.6	2150.0	8.57
ET	230	87.54	75.6	2150.9	3.52
ET	231	86.54	75.1	2150.0	3.57
ET	232	90.50	65.8	2150.1	2.53
ET	233	85.53	85.0	2150.1	4.58
ET	234	85.52	85.0	2150.5	4.53
ET	235	84.58	95.2	2050.7	4.57
ET	236	82.52	115.2	2050.5	5.58
ET	237	87.52	75.2	2050.9	3.52
ET	238	86.52	85.3	2050.6	4.51
ET	239	80.53	155.8	2050.4	8.58
ET	240	79.58	145.3	2050.1	8.59
ET	241	79.51	145.2	1950.7	8.58
ET	242	80.52	125.7	1950.4	6.59
ET	243	77.59	155.1	1950.6	9.56
ET	244	76.55	115.8	1950.0	6.50
ET	245	73.52	115.2	1950.1	7.54
ET	246	65.54	145.9	2050.9	12.50
ET	247	67.58	105.8	2050.9	8.55
ET	248	69.56	85.2	1950.8	6.50
ET	249	70.57	95.1	1950.5	7.55
ET	250	78.58	75.3	1950.2	4.55
ET	251	84.57	55.1	1850.7	2.51
ET	252	86.58	55.5	1850.6	2.57
ET	253	82.51	65.2	1850.6	3.59
ET	254	78.58	95.0	1850.5	5.50
ET	255	77.58	155.8	1750.7	8.58

ET	256	76.50	155.9	1750.1	9.56
ET	257	68.51	105.2	1850.9	7.57
ET	258	68.50	95.7	1850.5	6.59
ET	259	71.50	85.1	1750.5	5.54
ET	260	70.58	115.5	1750.5	8.51
ET	261	71.53	105.1	1750.1	7.54
ET	262	74.53	85.9	1750.1	5.51
ET	263	73.53	115.4	1650.7	7.55
ET	264	64.59	105.9	1750.2	8.58
ET	265	60.57	105.2	1750.1	9.53
ET	266	57.50	75.9	1750.6	7.54
ET	267	59.59	75.2	1750.0	6.51
ET	268	62.56	115.1	1650.1	9.54
ET	269	65.51	115.0	1650.5	9.52
ET	270	70.54	85.4	1550.5	5.53
ET	271	72.54	125.1	1550.2	8.53
ET	272	63.56	165.7	1550.3	13.51
ET	273	56.54	115.4	1550.0	11.53
ET	-274	53.71	104.9	1568.0	10.72
EZ	-2				
ET	116	67.19	100.5	2335.0	8.43
ET	117	75.04	77.0	2331.5	5.26
ET	118	72.91	155.0	2291.2	11.34
ET	119	73.40	196.0	2278.1	13.89
ET	120	74.01	127.5	2294.3	8.64
ET	121	64.06	138.8	2385.6	12.35
ET	122	62.44	111.4	2409.1	10.31
ET	123	65.44	126.3	2385.9	10.60
ET	124	60.66	107.7	2456.1	10.34
ET	125	63.36	102.6	2457.1	9.35
ET	126	57.60	124.1	2466.3	12.60
ET	127	58.75	89.7	2507.6	8.88
ET	128	66.16	90.8	2484.1	7.72
ET	129	66.36	138.3	2446.0	11.48
ET	130	67.68	96.1	2494.6	7.85
ET	131	70.23	130.1	2473.9	10.09
ET	132	66.18	147.4	2470.1	12.21
ET	133	62.56	144.1	2518.4	13.40
ET	134	72.00	149.0	2492.1	11.23
ET	135	71.49	175.2	2472.3	13.02
ET	136	74.91	133.5	2480.6	9.06
ET	137	78.21	176.4	2413.2	10.65
ET	138	75.06	127.7	2486.3	8.59
ET	139	72.84	131.9	2525.7	9.60
ET	140	73.33	118.8	2544.2	8.55
ET	141	81.63	95.9	2508.9	5.46
ET	142	77.95	142.0	2476.5	8.68
ET	143	73.94	148.7	2521.6	10.31
ET	144	68.99	151.9	2563.9	12.01
ET	145	67.24	99.2	2614.1	8.21
ET	146	69.55	97.3	2617.0	7.72
ET	147	64.69	119.9	2640.5	10.76
ET	148	71.17	97.5	2626.2	7.47
ET	149	73.54	145.0	2558.2	10.02

ET	150	80.04	107.4	2543.5	6.31
ET	151	77.13	137.9	2528.9	8.64
ET	152	70.47	132.4	2598.9	10.09
ET	153	72.09	120.6	2629.7	9.06
ET	154	78.21	86.5	2621.4	5.50
ET	155	79.57	99.9	2598.9	6.09
ET	156	76.06	133.5	2597.6	8.93
ET	157	77.65	133.5	2579.1	8.50
ET	158	75.63	175.0	2568.3	11.63
ET	159	78.80	137.6	2562.9	8.34
ET	160	82.00	138.6	2539.4	7.67
ET	161	77.77	212.1	2535.9	13.02
ET	162	69.73	170.9	2626.5	13.27
ET	163	71.67	119.4	2644.6	8.88
ET	164	73.76	105.8	2658.3	7.56
ET	165	79.68	93.8	2632.5	5.75
ET	166	72.72	153.5	2601.4	10.85
ET	167	71.62	145.3	2627.1	10.72
ET	168	71.26	110.0	2663.7	8.34
ET	169	73.63	124.3	2646.5	8.88
ET	170	77.79	129.1	2600.1	8.21
ET	171	82.04	144.8	2542.0	8.05
ET	172	77.67	199.4	2553.1	12.44
ET	173	81.25	107.0	2592.8	6.22
ET	174	72.32	143.9	2625.9	10.51
ET	175	71.35	151.0	2647.8	11.52
ET	176	71.62	129.3	2649.1	9.80
ET	177	77.68	96.6	2622.1	6.13
ET	178	75.09	129.3	2628.7	8.93
ET	179	74.39	127.5	2615.1	8.88
ET	180	74.98	130.1	2601.1	8.84
ET	181	74.88	210.0	2568.0	14.18
ET	182	80.55	135.6	2566.8	8.01
ET	183	80.89	185.1	2524.8	10.67
ET	184	83.64	204.0	2486.3	10.76
ET	185	83.70	200.2	2483.8	10.56
ET	186	82.60	140.0	2503.8	7.58
ET	187	83.17	106.5	2566.4	5.97
ET	188	89.10	87.1	2546.7	4.14
ET	189	89.42	102.4	2502.9	4.72
ET	190	86.77	141.1	2467.9	6.85
ET	191	82.85	165.3	2461.5	8.77
ET	192	77.04	165.3	2538.5	10.65
ET	193	79.90	105.1	2557.9	6.38
ET	194	87.21	86.2	2531.5	4.30
ET	195	82.40	168.8	2466.9	9.26
ET	196	78.49	168.8	2498.7	10.43
ET	197	76.98	140.4	2528.0	9.08
ET	198	85.08	91.6	2508.9	4.79
ET	199	83.80	141.6	2436.7	7.47
ET	200	81.34	201.3	2425.6	11.30
ET	201	77.05	147.3	2496.5	9.51
ET	202	77.18	127.0	2509.5	8.30

ET	203	82.02	109.7	2467.6	6.22
ET	204	79.34	124.5	2445.3	7.29
ET	205	80.82	119.4	2435.2	6.85
ET	206	84.99	86.9	2450.7	4.50
ET	207	89.44	81.8	2408.1	3.71
ET	208	88.47	90.9	2398.6	4.25
ET	209	82.58	133.1	2372.5	7.18
ET	210	78.96	151.3	2377.3	8.93
ET	211	77.41	150.5	2393.2	9.42
ET	212	79.23	127.3	2391.3	7.67
ET	213	83.59	103.3	2373.8	5.55
ET	214	84.94	111.8	2329.0	5.68
ET	215	79.84	175.7	2297.5	10.04
ET	216	76.86	172.7	2324.9	10.85
ET	217	75.70	118.1	2364.3	7.76
ET	218	79.32	102.2	2340.8	6.09
ET	219	84.34	95.9	2296.2	4.97
ET	220	83.50	107.5	2261.9	5.59
ET	221	83.93	98.9	2259.4	5.08
ET	222	78.15	134.9	2266.7	8.19
ET	223	78.78	161.9	2230.5	9.64
ET	224	83.66	114.8	2198.0	5.88
ET	225	82.54	122.9	2195.5	6.55
ET	226	79.68	132.4	2210.7	7.76
ET	227	81.79	96.2	2219.6	5.35
ET	228	85.68	86.2	2188.8	4.25
ET	229	79.77	152.6	2150.0	8.77
ET	230	87.04	73.6	2159.9	3.42
ET	231	86.54	73.1	2158.0	3.47
ET	232	90.10	67.8	2142.1	2.93
ET	233	85.53	89.0	2121.1	4.38
ET	234	85.12	89.0	2106.5	4.43
ET	235	84.78	95.2	2088.7	4.77
ET	236	82.42	110.2	2072.5	5.88
ET	237	87.62	71.2	2069.9	3.22
ET	238	86.02	88.3	2042.6	4.21
ET	239	80.53	159.8	2012.4	8.88
ET	240	79.48	145.3	2004.1	8.19
ET	241	79.11	149.2	1979.7	8.48
ET	242	80.02	122.7	1985.4	6.89
ET	243	77.29	150.1	1973.6	9.06
ET	244	76.95	112.8	1979.0	6.80
ET	245	73.62	110.2	1992.1	7.34
ET	246	65.34	149.9	2008.9	12.30
ET	247	67.48	102.8	2007.9	8.05
ET	248	69.66	89.2	1996.8	6.60
ET	249	70.47	99.1	1948.5	7.05
ET	250	78.08	71.3	1920.2	4.05
ET	251	84.67	58.1	1888.7	2.71
ET	252	86.58	50.5	1870.6	2.17
ET	253	82.51	63.2	1844.6	3.09
ET	254	78.78	98.0	1817.5	5.50
ET	255	77.58	150.8	1779.7	8.88

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ET           256   76.30   152.9  1764.1    9.26
ET           257   68.81   104.2  1823.9    7.67
ET           258   68.40    92.7  1819.5    6.89
ET           259   71.20    85.1  1791.5    5.84
ET           260   70.88   113.5  1763.5    8.01
ET           261   71.83   105.1  1738.1    7.14
ET           262   74.23    83.9  1717.1    5.21
ET           263   73.63   110.4  1677.7    7.05
ET           264   64.69   107.9  1709.2    8.68
ET           265   60.17   102.2  1716.1    9.13
ET           266   57.00    77.9  1727.6    7.34
ET           267   59.29    71.2  1705.0    6.31
ET           268   62.06   114.1  1649.1    9.84
ET           269   65.01   115.0  1620.5    9.22
ET           270   70.84    87.4  1585.5    5.93
ET           271   72.84   129.1  1529.2    8.43
ET           272   63.36   163.7  1549.3   13.71
ET           273   56.34   119.4  1576.0   11.63
ET          -274   53.71   104.9  1568.0   10.72
QC             1       0       0       0       1       0       1
TQ    TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
TQ    CARBONACEOUS BOD IN MG/L
TQ    DISSOLVED OXYGEN IN MG/L L1            10       1
L2    10       5              10      .4       1       2
LR     2   10000       1    5000
L3           .01    1.-6    1.-4       0     -.7
L5    50   50000     825
L7    10    2000     820     860     900     940
L7    10    2000     840     880     920     960
L8           200     400     800    1400    2000    3000    5000
PL  0.25     100           -4.00
PL  0.05     100           -0.20
PL  0.20     100           -8.00
PL  0.25     100     3.2   -0.70    0.10   -0.05
L9            40      41      42      43      45      48      60
C1          120.    120.    120.    120.    120.    180.    180.
C5           0.5     0.5     0.5     0.5     0.5     0.5     0.5
C7           9.1     9.1     9.1     9.1     9.1     9.1     9.1
SA           100     100     100     100     100     100     100
DK                   0.1           1.463
L2    20       2               5      .4       1       1
LR     3  60000.
L3           .01    1.-6    1.-4       0     -.7
L5     1      10   895.5
L6   870   99300   962.5
L7   7.9    2840   895.5   909.5   923.5   937.5
L7   7.9    2840   902.5   916.5   930.5   944.5
L8           410     460     500     550     600     650     700     750
PL  0.25     100           -4.00
PL  0.05     100           -0.20
PL  0.20     100           -8.00
PL  0.25     100     3.2   -0.70    0.10   -0.05
L9            54      55      57      57      57      57      57      57
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C1		160	190	190	190	190	190	190	190
C5		.3	.3	.3	.3	.3	.3	.3	.3
C7		8.4	8.7	9.2	9.2	9.2	9.2	9.2	9.2
SA		100	100	100	100	100	100	100	100
DK			.2		1.463				
CR		1.047	1.047	1.047	1.0159				
S1		10	1	0	10	20	1		
S2	10	65.5	30	60	1.5				
S2	20	4.7	30	0.	1.5				
S2	30	60	40	40	2	45	3		
S2	40	40	50	24.2	1.975	30	4		
SR	10	30	2	7					
SK		1.	1.	1.	1.	1.	1.	1.	1.
SR	20	30	1	2					
SR	-30	50	1	4					
S3	10	65.5	844.0	0.	0.	0.	.050		
S3			844.2	0.	.21	5.0	.050		
S3			844.6	4.0	.35	20.0	.050		
S3			845.0	14.0	.61	29.0	.050		
S3			846.0	54.0	1.04	50.0	.050		
S3			847.0	114.0	1.40	67.0	.050		
S3			848.0	194.0	1.55	99.0	.050		
S3			849.0	305.0	1.84	121.0	.050		
S3			850.0	440.0	2.02	152.0	.050		
S3			851.0	605.0	2.20	185.0	.050		
S3			852.0	827.0	2.17	264.0	.050		
S3			853.0	1100.0	2.52	279.0	.050		
S3			854.0	1384.0	2.87	288.0	.050		
S3			855.0	1677.0	3.15	301.0	.050		
S3			856.0	1985.0	3.40	316.0	.050		
S3			857.0	2308.0	3.67	326.0	.050		
S3			858.0	2634.0	3.99	326.0	.050		
S3			859.0	2960.0	4.30	326.0	.050		
S3			861.0	3612.0	4.88	326.0	.050		
S3			863.0	4264.0	5.41	326.0	.050		
S3	30	60.	825.4	0.	0.	0.	.050		
S3			825.6	1.0	.22	9.0	.050		
S3			826.0	10.0	.43	33.0	.050		
S3			826.4	27.0	.64	52.0	.050		
S3			827.4	92.0	1.13	77.0	.050		
S3			828.4	179.0	1.51	96.0	.050		
S3			829.4	287.0	1.79	119.0	.050		
S3			830.4	418.0	2.08	138.0	.050		
S3			831.4	563.0	2.38	152.0	.050		
S3			832.4	723.0	2.65	166.0	.050		
S3			833.4	893.0	2.95	174.0	.050		
S3			834.4	1071.0	3.23	183.0	.050		
S3			835.4	1258.0	3.48	191.0	.050		
S3			836.4	1455.0	3.64	207.0	.050		
S3			837.4	1675.0	3.68	234.0	.050		
S3			838.4	1922.0	3.83	253.0	.050		
S3			839.4	2175.0	4.16	253.0	.050		
S3			840.4	2428.0	4.48	253.0	.050		

S3			842.4	2934.0	5.08	253.0	.050
S3			844.4	3440.0	5.65	253.0	.050
S3	20	4.7	859.6	0.	0.	0.	0.050
S3			859.8	1.5	0.16	24.	0.050
S3			860.2	22.0	0.46	70.	0.050
S3			860.6	56.1	0.73	104.	0.050
S3			861.6	178.2	1.28	128.	0.050
S3			862.6	307.7	1.82	134.	0.050
S3			863.6	442.8	2.28	140.	0.050
S3			864.6	583.8	2.57	142.	0.050
S3			865.6	729.1	2.97	147.	0.050
S3			866.6	878.1	3.19	149.	0.050
S3			867.6	1030.6	3.49	156.	0.050
S3			868.6	1186.8	3.78	162.	0.050
S3			869.6	1346.6	4.06	168.	0.050
S3			870.6	1510.1	4.32	174.	0.050
S3			871.6	1677.2	4.57	180.	0.050
S3			872.6	1848.0	4.81	186.	0.050
S3			873.6	2022.4	5.04	192.	0.050
S3			874.6	2200.5	5.27	198.	0.050
S3			876.6	2567.5	5.69	210.	0.050
S3			878.6	2949.1	6.10	222.	0.050
S3	30	0.	825.4	0.	0.	0.	.050
S3			825.6	1.0	.22	9.0	.050
S3			826.0	10.0	.43	33.0	.050
S3			826.4	27.0	.64	52.0	.050
S3			827.4	92.0	1.13	77.0	.050
S3			828.4	179.0	1.51	96.0	.050
S3			829.4	287.0	1.79	119.0	.050
S3			830.4	418.0	2.08	138.0	.050
S3			831.4	563.0	2.38	152.0	.050
S3			832.4	723.0	2.65	166.0	.050
S3			833.4	893.0	2.95	174.0	.050
S3			834.4	1071.0	3.23	183.0	.050
S3			835.4	1258.0	3.48	191.0	.050
S3			836.4	1455.0	3.64	207.0	.050
S3			837.4	1675.0	3.68	234.0	.050
S3			838.4	1922.0	3.83	253.0	.050
S3			839.4	2175.0	4.16	253.0	.050
S3			840.4	2428.0	4.48	253.0	.050
S3			842.4	2934.0	5.08	253.0	.050
S3			844.4	3440.0	5.65	253.0	.050
S3	40	40.0	765.0	0.	0.	0.	.050
S3			765.2	1.0	.22	9.0	.050
S3			765.6	10.0	.43	33.0	.050
S3			766.0	27.0	.64	52.0	.050
S3			767.0	92.0	1.13	77.0	.050
S3			768.0	179.0	1.51	96.0	.050
S3			769.0	287.0	1.79	119.0	.050
S3			770.0	418.0	2.08	138.0	.050
S3			771.0	563.0	2.38	152.0	.050
S3			772.0	723.0	2.65	166.0	.050
S3			773.0	893.0	2.95	174.0	.050
S3			774.0	1071.0	3.23	183.0	.050

S3			775.0	1258.0	3.48	191.0	.050
S3			776.0	1455.0	3.64	207.0	.050
S3			777.0	1675.0	3.68	234.0	.050
S3			778.0	1922.0	3.83	253.0	.050
S3			779.0	2175.0	4.16	253.0	.050
S3			780.0	2428.0	4.48	253.0	.050
S3			782.0	2934.0	5.08	253.0	.050
S3			784.0	3440.0	5.65	253.0	.050
S3	50	32.0	730.6	0.	0.	0.	.050
S3			730.8	0.	.21	2.0	.050
S3			731.2	2.0	.44	6.0	.050
S3			731.6	6.0	.45	19.0	.050
S3			732.6	74.0	.84	96.0	.050
S3			733.6	177.0	1.37	109.0	.050
S3			734.6	291.0	1.80	120.0	.050
S3			735.6	421.0	2.12	135.0	.050
S3			736.6	565.0	2.44	147.0	.050
S3			737.6	715.0	2.74	155.0	.050
S3			738.6	878.0	2.99	168.0	.050
S3			739.6	1050.0	3.26	176.0	.050
S3			740.6	1230.0	3.51	184.0	.050
S3			741.6	1418.0	3.74	193.0	.050
S3			742.6	1618.0	3.83	212.0	.050
S3			743.6	1844.0	3.86	239.0	.050
S3			744.6	2094.0	4.05	253.0	.050
S3			745.6	2347.0	4.37	253.0	.050
S3			747.6	2853.0	4.98	253.0	.050
S3			749.6	3359.0	5.55	253.0	.050
S3	50	30.4	722.9	0.	0.	0.	.030
S3			723.1	2.0	.22	15.0	.030
S3			723.5	14.0	.45	45.0	.030
S3			723.9	37.0	.64	74.0	.030
S3			724.9	130.0	1.12	111.0	.030
S3			725.9	271.0	1.43	167.0	.030
S3			726.9	462.0	1.72	218.0	.030
S3			727.9	701.0	2.04	257.0	.030
S3			728.9	978.0	2.34	287.0	.030
S3			729.9	1275.0	2.59	310.0	.030
S3			730.9	1599.0	2.79	337.0	.030
S3			731.9	1964.0	2.71	418.0	.030
S3			732.9	2394.0	2.98	444.0	.030
S3			733.9	2851.0	3.24	469.0	.030
S3			734.9	3342.0	3.39	518.0	.030
S3			735.9	3887.0	3.54	571.0	.030
S3			736.9	4482.0	3.74	610.0	.030
S3			737.9	5100.0	4.01	627.0	.030
S3			739.9	6390.0	4.49	662.0	.030
S3			741.9	7745.0	4.96	692.0	.030
S3	50	28.4	725.3	0.	0.	0.	.030
S3			725.5	4.0	.23	30.0	.030
S3			725.9	22.0	.48	59.0	.030
S3			726.3	51.0	.67	90.0	.030
S3			727.3	167.0	1.13	139.0	.030

S3			728.3	375.0	1.37	249.0	.030
S3			729.3	644.0	1.75	289.0	.030
S3			730.3	946.0	2.13	313.0	.030
S3			731.3	1271.0	2.46	336.0	.030
S3			732.3	1617.0	2.76	357.0	.030
S3			733.3	1985.0	3.03	379.0	.030
S3			734.3	2387.0	3.20	428.0	.030
S3			735.3	2831.0	3.41	463.0	.030
S3			736.3	3311.0	3.55	497.0	.030
S3			737.3	3824.0	3.73	527.0	.030
S3			738.3	4370.0	3.86	575.0	.030
S3			739.3	4985.0	3.99	634.0	.030
S3			740.3	5632.0	4.20	659.0	.030
S3			742.3	7002.0	4.58	709.0	.030
S3			744.3	8458.0	5.02	742.0	.030
S3	50	26.3	722.7	0.	0.	0.	.030
S3			722.8	1.0	.22	9.0	.030
S3			723.2	8.0	.45	26.0	.030
S3			723.7	22.0	.62	45.0	.030
S3			724.7	92.0	1.00	94.0	.030
S3			725.7	219.0	1.22	167.0	.030
S3			726.7	436.0	1.38	265.0	.030
S3			727.7	751.0	1.58	365.0	.030
S3			728.7	1158.0	1.86	441.0	.030
S3			729.7	1628.0	2.17	496.0	.030
S3			730.7	2254.0	2.19	729.0	.030
S3			731.7	3038.0	2.44	809.0	.030
S3			732.7	3867.0	2.74	858.0	.030
S3			733.7	4756.0	3.00	913.0	.030
S3			734.7	5699.0	3.23	981.0	.030
S3			735.7	6697.0	3.45	1022.0	.030
S3			736.7	7750.0	3.68	1067.0	.030
S3			737.7	8825.0	3.97	1083.0	.030
S3			739.7	11032.0	4.51	1117.0	.030
S3			741.7	13278.0	5.08	1129.0	.030
S3	50	24.2	721.6	0.	0.	0.	.030
S3			721.8	6.0	.22	56.0	.030
S3			722.2	50.0	.47	150.0	.030
S3			722.6	118.0	.69	190.0	.030
S3			723.6	354.0	1.13	270.0	.030
S3			724.6	656.0	1.41	358.0	.030
S3			725.6	1079.0	1.60	484.0	.030
S3			726.6	1606.0	1.88	568.0	.030
S3			727.6	2215.0	2.16	648.0	.030
S3			728.6	2903.0	2.41	730.0	.030
S3			729.6	3687.0	2.62	834.0	.030
S3			730.6	4563.0	2.87	914.0	.030
S3			731.6	5511.0	3.10	994.0	.030
S3			732.6	6555.0	3.32	1081.0	.030
S3			733.6	7684.0	3.50	1191.0	.030
S3			734.6	8885.0	3.80	1211.0	.030
S3			735.6	10105.0	4.09	1229.0	.030
S3			736.6	11341.0	4.38	1242.0	.030

S3			738.6	13849.0	4.93	1266.0	.030		
S3			740.6	16405.0	5.45	1289.0	.030		
S4		854	835	870	835	775	743	742	741	740
S4		739.5							
KR			0.10		1.463				
KR			0.15		1.463				
KR			0.20		1.463				
KR			0.25		1.463				
CT	10	740101	40.	3.	0.				
CT		740318	45.	3.	0.				
CT		740723	50.	3.	0.				
CT		741017	45.	3.	0.				
CT		741206	40.	3.	0.				
CT		-741231	40.	3.	0.				
CT		740101	150.	1.	0.				
CT		-741231	150.	1.	0.				
CT		740101	0.1	1.	0.				
CT		-741231	0.1	1.	0.				
CT		740101	5.	0.	30.				
CT		-741231	5.	0.	30.				
CT	20	740101	45	4	0				
CT		740318	50	4	0				
CT		740723	55	4	0				
CT		741017	50	4	0				
CT		741206	45	4	0				
CT		-741231	42	4	0				
CT		740101	160	.8	0				
CT		-741231	160	.8	0				
CT		740101	.05	.15	0				
CT		-741231	.05	.15	0				
CT		740101	4	0	50				
CT		-741231	4	0	50				
CT	30	740101	45.	3.	0.	10	20		
CT		740510	50.	3.	0.				
CT		740531	60.	3.	0.				
CT		741001	55.	3.	0.				
CT		-741231	45.	3.	0.				
CT		740101	160.	1.	0.				
CT		-741231	160.	1.	0.				
CT		740101	.15	4.	0.				
CT		-741231	.15	4.	0.				
CT		740101	4.5	4.	0.				
CT		-741231	4.5	4.	0.				
CT	40	740101	45.	3.	0.	10	20		
CT		740504	50.	3.	0.				
CT		740514	55.	3.	0.				
CT		740515	60.	3.	0.				
CT		741005	55.	3.	0.				
CT		741109	50.	3.	0.				
CT		741214	45.	3.	0.				
CT		-741231	45.	3.	0.				
CT		740101	170.	1.	0.				
CT		-741231	170.	1.	0.				

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CT        740101     0.2       1.       0.
CT       -741231     0.2       1.       0.
CT        740101     5.5       0.      30.
CT       -741231     5.5       0.      30.
CT    50  740101     50.       3.       0.       10       20
CT        740506     55.       3.       0.
CT        740510     60.       3.       0.
CT        740515     65.       3.       0.
CT        740708     70.       3.       0.
CT        740924     65.       3.       0.
CT        741018     60.       3.       0.
CT        741112     55.       3.       0.
CT        741206     50.       3.       0.
CT       -741231     50.       3.       0.
CT        740101    190.       1.       0.
CT       -741231    190.       1.       0.
CT        740101     0.3       1.       0.
CT       -741231     0.3       1.       0.
CT        740101     6.0       0.      30.
CT       -741231     6.0       0.      30.
I1        740101  741231
I2                     0 TRIB 1 ... LEFT INFLOW RATE ... RES # 1
I4        740101    -0.5  740408     -0.5  740422     -0.7  740708     -0.3
I4        740826    -0.3  741231     -0.5      -1
I2             2       0 TRIB 1 ... LEFT INFLOW TEMPERATURE
I4        740101    -1.5  740408     -1.5  740422     -5.0  740708      -8.
I4        740826     -5.  741231     -1.5      -1
I2                     0 TRIB 1 ... LEFT INFLOW - TOTAL DISSOIVED SOLIDS
I4        740101    105.  741231     105.      -1
I2                     0 TRIB 1 ... LEFT INFLOW - CARBONACEOUS BOD
I4        740101     0.5  741231      0.5      -1
I2                     0 TRIB 1 ... LEFT INFLOW - DISSOLVED OXYGEN
I4        740101    12.8  740115     13.1  740215     12.4  740315     11.8
I4        740415    11.7  740515      9.3  740615      8.9  740715      8.2
I4        740815     7.8  740915      9.7  741015     10.0  741115     11.0
I4        741215    12.4  741231     12.8      -1
I2                     0 TRIB 2 ... RIGHT INFLOW RATE ... RES # 1
I4        740101    -0.5  740408     -0.5  740422     -0.7  740708     -0.7
I4        740826    -0.7  741231     -0.5      -1
I2             2       0 TRIB 2 ... RIGHT INFLOW TEMPERATURE
I4        740101    -0.1  740125      2.0  740210      1.2  740224     -1.8
I4        740310     0.1  740324    -10.4  740414    -15.8  740428    -24.3
I4        740512   -15.6  740527    -16.0  740609    -11.0  740623    -15.6
I4        740714    -9.1  740728    -12.3  740811    -10.3  740825    -15.0
I4        740908   -15.5  740922    -17.8  741014    -11.1  741028     -6.1
I4        741110    -6.5  741124     -4.4  741208     -6.2  741231      1.5
I4            -1
I2                     0 TRIB 2 ... RIGHT INFLOW - TDS
I4        740101     140  740115      110  740215      240  740315      400
I4        740415     130  740515     1095  740615       80  740715      100
I4        740815      70  740915       50  741015      100  741115       90
I4        741215     310  741231      360      -1
I2                     0 TRIB 2 ... RIGHT INFLOW - CBOD
I4        740101      .2  740115       .2  740215       .4  740315       .5
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I4        740415      .2  740515     1.8  740615      .1  740715      .2
I4        740815      .1  740915      .1  741015      .2  741115      .1
I4        741215      .5  741231      .6      -1
I2                     0 TRIB 2 ... RIGHT INFLOW - DISSOLVED OXYGEN
I4        740101    13.1  740115    13.1  740215    12.4  740315    11.8
I4        740415    11.8  740515     9.4  740615     9.0  740715     8.3
I4        740815     7.8  740915     9.7  741015    10.0  741115    11.0
I4        741215    12.4  741231    12.8      -1
I2                     0 TRIB 3 INFLOW RATE - RM 45 & RES # 2
I4        740101      -1  741231     -1.      -1
I2             1       OTRIB 3 - RM 45
I4        740101    -1.5  740408    -1.5  740422    -3.0  740708     -4.
I4        740826     -3.  741231    -1.5      -1
I2                     0 TRIB 3 - RM 45 - TOTAL DISSOLVED SOLIDS
I4        740101    160.  741231    160.      -1
I2                     0 TRIB 3 - RM 45 - CARBONACEOUS BOD
I4        740101     0.6  741231     0.6      -1
I2                     0 TRIB 3 - RM 45 - DISSOLVED OXYGEN
I4        740101    12.8  740115    13.1  740215    12.4  740315    11.8
I4        740415    11.7  740515     9.3  740615     8.9  740715     8.2
I4        740815     7.8  740915     9.7  741015    10.0  741115    11.0
I4        741215    12.4  741231    12.8      -1
I2                     0 TRIB 4 INFLOW RATE - RM 30
I4        740826     -1.  741231     -1.      -1
I2             1       OTRIB 4 - RM 30
I4        740101    -1.5  740408    -1.5  740422    -3.0  740708     -6.
I4        740826     -5.  741231    -1.5      -1
I2                     0 TRIB 4 - RM 30 - TOTAL DISSOLVED SOLIDS
I4        740101    160.  741231    160.      -1
I2                     0 TRIB 4 - RM 30 - CARBONACEOUS BOD
I4        740101     0.6  741231     0.6      -1
I2                     0 TRIB 4 - RM 30 - DISSOLVED OXYGEN
I4        740101    12.8  740115    13.1  740215    12.4  740315    11.8
I4        740415    11.7  740515     9.3  740615     8.9  740715     8.2
I4        740815     7.8  740915     9.7  741015    10.0  741115    11.0
I4        741215    12.4  741231    12.8      -1
ER
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* HEC-5Q SIMULATION OF FLOOD CONTROL AND CONSERVATION SYSTEMS *          *  U.S. ARMY CORPS OF ENGINEERS       *
* (INCLUDING WATER QUALITY ANALYSIS)                          *          *  THE HYDROLOGIC ENGINEERING CENTER  *
* OCTOBER 1985                                                *          *  609 SECOND STREET, SUITE D         *
*                                                             *          *  DAVIS, CALIFORNIA  95616           *
* RUN DATE 16 MAY 86  TIME   9:42:40                          *          *  (916) 551-1748  (FTS) 460-1748     *
*************************************************************          **************************************


                    X     X XXXXXXX  XXXXX         XXXXXXX    XXX
                    X     X X     X X     X        X     X   X   X
                    X     X X       X              X        X     X
                    XXXXXXX XXXXX   X       XXXXX  XXXXXX   X     X
                    X     X X       X                    X  X   X X
                    X     X X     X X     X        X     X   X   X
                    X     X XXXXXXX  XXXXX          XXXXX     XXX X


          ******************************************************************************************
          *                                                                                        *
          *                                                                                        *
          *                                                                                        *
          *    MODELING CAPABILITIES OF THIS VERSION ARE:                                          *
          *    MAXIMUM NUMBER OF RESERVOIRS=15, CONTROL POINTS=25, DIVERSIONS=10, POWER PLANTS= 7  *
          *                                                                                        *
          *    INPUT INSTRUCTIONS FOR THE FIRST FIELD OF THE CC CARD HAVE BEEN CHANGED.  SEE THE   *
          *    OCTOBER 1984 OR THE JANUARY 1985 EXHIBIT 8 (HEC-5 USERS MANUAL) FOR NEW INPUT.      *
          *                                                                                        *
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HEC-5 SIMULATION OF FLOOD CONTROL
     AND CONSERVATION SYSTEMS

SEGMENTED VERSION   (UPDATED      MARCH 1985)

MAX DIMENSION LIMITS ARE CURRENTLY SET AT   15  RESERVOIRS AND   25  CONTROL POINTS


*INPUT LISTING FROM PRERD

      TO SUPPRESS LISTING, INSERT NOLIST CARD INTO INPUT DECK AT DESIRED POINT


T1    TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
T2    PARALLEL RIVER SYSTEM
T3    TEST PROBLEM 1
J1     0       5       5       3       4       2       0       0
J2    36       0       0       0       0       0       0
J9

RL    10 1200000       0  100000  200000 1500000 1600000
RO     3      30      40      50
RS     7     100    6300   31300   88000  188000  563000 1688000
RQ     7       0   20000   30000   40000   50000   50000   50000
RA     7      10     500    1500    3000    5000   10000   20000
RE     7     800     825     850     870     900     950    1030
R3     2       2       2       2      99      99      99      99      99      99
R3    99      99

CP    10   20000     300     200
IDCP10-BAKER DAM
RT    10      30     2.2     .25      12       0

RL    20  550000       0    2000  550000  952000 1130000
RO     3      30      40      50
RS     8    2000   20000   52000  113000  209000  320000  550000  800000 1130000
RQ     8       0    5680    5680    5680    5680    5680   29180   59680  104980
RA     8     150    2100    4500    7600   11800   17000   22400   28600   37200
RE     8     892     910     920     930     940     950   962.5     970     980
R3     2       2       2       2      99      99      99      99      99      99
R3    99      99
```

```
CP    20   20000     30      20
IDCP20-SMITH DAM
RT    20      30     2.2     .25     12      0

CP    30   30000     300     200
IDCP30-CONF RM60
RT    30      40     2.2     .25     12      0

CP    40   30000     300     200
ID CP40 ** RM 40
RT    40      50     2.2     .25     12      0

CP    50   50000     300     200
IDCP50 ** RM24.2
RT    50       0      0       0       0      0
ED
BF     0     120      0      074050100     120     24
NOLIST


 START COMPUTATIONS FOR JOB NUMBER  1  FOR  1  FLOODS READ


NRES=       2  NCPT=        5

FIXED DIM.   -  DIVS.= 10    PWR. =  7
DYNAMIC DIM. -  RES =  2    CPTS.=  5    PERS.=  121


NOTE ** RA, RE AND R3 CARDS ARE REQUIRED FOR TEMPERATURE SIMULATION


MX=      10   IF MUSK ROUT K LESS THAN     16.00                                  *** CAUTION ***

NOTE ** RA, RE AND R3 CARDS ARE REQUIRED FOR TEMPERATURE SIMULATION


MX=      20   IF MUSK ROUT K LESS THAN     16.00                                  *** CAUTION ***
MX=      30   IF MUSK ROUT K LESS THAN     16.00                                  *** CAUTION ***
MX=      40   IF MUSK ROUT K LESS THAN     16.00                                  *** CAUTION ***
```

```
*FLOWS

   FLOFMT   NPER  NPSTO  CNSTI      FLDAT    EPER    IPER . MINPER  NDAYWK  ONESUM
BF     0.   120.     0.   0.00 74050100.    120.      24        0      0.       0.
IN    10  1MAY74  2059.0   1814.0   2125.0   2243.0   1947.0   1836.0   1735.0   1587.0   1549.0   1509.0
                  1413.0   4584.0   7520.0   5061.0   3549.0   2931.0   2801.0   3866.0   2752.0   2293.0
                  1962.0   1793.0   2476.0   2528.0   1958.0   1650.0   1462.0   1344.0   1810.0   3581.0
                  3367.0   7629.0   5501.0   3699.0   3057.0   2603.0   2294.0   2073.0   1894.0   1750.0
                  1596.0   1423.0   1313.0   1251.0   1052.0   1312.0   2547.0   2301.0   1803.0   1360.0
                  1185.0   1200.0   1456.0   2434.0   4601.0   3121.0   2769.0   2230.0   1846.0   2107.0
                  1918.0  15259.0   7046.0   4185.0   3113.0   3167.0   2814.0   2295.0   1910.0   1606.0
                  1448.0   1535.0   1368.0   1196.0   1039.0   1032.0   1013.0    940.0    890.0    890.0
                   865.0    826.0    783.0    826.0    928.0    847.0    788.0    829.0    804.0    806.0
                   945.0    801.0    712.0    751.0    914.0    911.0    935.0    792.0    747.0    717.0
                   823.0   1416.0    997.0    806.0    759.0    732.0    683.0    653.0    633.0    639.0
                   621.0    644.0    604.0    598.0    598.0    596.0    601.0    642.0    662.0    838.0
                                                                                            SUM=    234248.
IN    20  1MAY74   430.0    816.0    668.0   1979.0   1523.0   1195.0   1065.0    847.0    698.0    569.0
                   455.0    402.0    472.0    424.0    415.0    956.0    613.0    510.0    434.0    381.0
                   361.0    327.0    289.0    338.0    758.0    355.0    262.0    202.0    169.0    133.0
                   163.0    192.0    203.0    181.0    166.0    212.0   1017.0    639.0    639.0    366.0
                   255.0    194.0    236.0    596.0    432.0    284.0    251.0    745.0    348.0    226.0
                   179.0    198.0    198.0    164.0    155.0    159.0    177.0    888.0    348.0    386.0
                   197.0    133.0    134.0    141.0    181.0    407.0    212.0    145.0    126.0    122.0
                   112.0    108.0     89.0     80.0     87.0     80.0     69.0     68.0     64.0     58.0
                    47.0     53.0     49.0     39.0     43.0     46.0     60.0     60.0     56.0     50.0
                    49.0     41.0     43.0     39.0     39.0     43.0     39.0     39.0     47.0     47.0
                    49.0     43.0     47.0     96.0    151.0    112.0    473.0    212.0    297.0    405.0
                   201.0    128.0    100.0     79.0     64.0     89.0    102.0     90.0     88.0    165.0
                                                                                            SUM=     34776.
IN    40  1MAY74   645.0    588.0    561.0    488.0    452.0    440.0    425.0    405.0    406.0    398.0
                   380.0    923.0   1207.0   1171.0   1161.0   1075.0   1190.0   1601.0   1685.0   1941.0
                  1849.0   1752.0   1784.0   1322.0    645.0    397.0    366.0    458.0    669.0   1011.0
                  1113.0   1740.0   1529.0   1352.0   1273.0   1219.0   1171.0    908.0    575.0    431.0
                   407.0    375.0    357.0    348.0    243.0    231.0    469.0    598.0    671.0    585.0
                   369.0    237.0    288.0    360.0    546.0    768.0    900.0    874.0    829.0    712.0
                   549.0   2648.0   1733.0   1751.0   1617.0   1671.0   1565.0   1433.0    922.0    465.0
                   361.0    384.0    353.0    328.0    298.0    305.0    296.0    285.0    279.0    235.0
                   143.0    142.0    139.0    150.0    226.0    282.0    276.0    191.0    106.0    139.0
                   183.0    220.0    269.0    268.0    278.0    283.0    311.0    249.0    178.0    172.0
                   162.0    177.0    135.0    119.0    117.0    117.0    130.0    164.0    161.0    166.0
                   160.0    117.0     61.0     42.0     51.0    141.0    142.0    108.0     87.0    235.0
                                                                                            SUM=     73148.
```

IN	50	1MAY74	3317.0	3816.0	3333.0	3150.0	2843.0	2861.0	2976.0	2831.0	3011.0	3250.0		
			3265.0	4695.0	13438.0	10915.0	9154.0	8282.0	7643.0	7539.0	6757.0	6013.0		
			4768.0	3744.0	3530.0	3463.0	3178.0	2914.0	2592.0	2150.0	1941.0	1852.0		
			1735.0	1747.0	1903.0	2065.0	1847.0	1399.0	1148.0	1035.0	978.0	844.0		
			714.0	809.0	784.0	873.0	969.0	816.0	1405.0	1972.0	2159.0	1563.0		
			1308.0	1482.0	1621.0	1469.0	1155.0	1353.0	975.0	1469.0	1483.0	1761.0		
			1469.0	4196.0	7637.0	5846.0	5734.0	4803.0	4285.0	3660.0	3314.0	2783.0		
			1990.0	1912.0	1651.0	1441.0	937.0	893.0	1209.0	1028.0	980.0	990.0		
			1160.0	785.0	550.0	695.0	679.0	705.0	701.0	786.0	566.0	627.0		
			774.0	742.0	696.0	661.0	613.0	578.0	630.0	914.0	930.0	930.0		
			918.0	981.0	1006.0	881.0	924.0	829.0	857.0	780.0	684.0	606.0		
			637.0	670.0	578.0	562.0	558.0	486.0	458.0	440.0	621.0	825.0		
													SUM=	265843.
QA	10	1MAY74	1270.0	1320.0	1360.0	1410.0	1440.0	1470.0	1480.0	1480.0	1480.0	1480.0		
			1790.0	2190.0	2480.0	3480.0	4490.0	4420.0	4300.0	4210.0	4130.0	3960.0		
			3720.0	3370.0	2470.0	1910.0	1950.0	1940.0	1890.0	1570.0	1270.0	1680.0		
			2210.0	2480.0	4000.0	5510.0	5350.0	4400.0	2930.0	1970.0	1570.0	1570.0		
			1570.0	1560.0	1560.0	1530.0	1510.0	1480.0	1830.0	2690.0	3120.0	2840.0		
			1640.0	819.0	854.0	900.0	1540.0	2750.0	3250.0	2860.0	2100.0	2030.0		
			2030.0	3600.0	9280.0	11000.0	7280.0	4130.0	3250.0	2180.0	1750.0	1470.0		
			1210.0	1290.0	1320.0	1320.0	1290.0	1270.0	1230.0	948.0	570.0	600.0		
			610.0	610.0	621.0	631.0	642.0	707.0	764.0	753.0	741.0	730.0		
			730.0	741.0	730.0	719.0	707.0	707.0	775.0	775.0	819.0	786.0		
			494.0	819.0	865.0	654.0	865.0	831.0	797.0	764.0	719.0	685.0		
			494.0	631.0	580.0	521.0	346.0	540.0	486.0	486.0	521.0	600.0		
													SUM=	225847.
QA	20	1MAY74	1236.0	521.0	387.0	405.0	442.0	949.0	1602.0	1572.0	1528.0	1040.0		
			600.0	593.0	590.0	488.0	390.0	497.0	600.0	600.0	597.0	495.0		
			310.0	220.0	220.0	220.0	226.0	325.0	420.0	417.0	403.0	400.0		
			286.0	165.0	110.0	110.0	110.0	110.0	275.0	540.0	637.0	627.0		
			518.0	420.0	420.0	420.0	420.0	320.0	227.0	330.0	430.0	423.0		
			226.0	110.0	110.0	110.0	110.0	105.0	316.0	440.0	440.0	437.0		
			430.0	226.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	105.0		
			110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0		
			110.0	110.0	110.0	110.0	75.0	35.0	35.0	35.0	35.0	35.0		
			35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0		
			35.0	35.0	36.0	38.0	62.0	85.0	105.0	125.0	182.0	240.0		
			240.0	240.0	235.0	230.0	178.0	125.0	125.0	125.0	125.0	125.0		
													SUM=	33957.
EJ		0.00												

```
*INTAB


J1 METRIC  ISTMO   NULEV  LEVCON  LEVTFC  LEVBUF  LEVPBS
        0      5       5       3       4       2       3
J2 IFCAST  CFLOD  RATCHG   IPRIO   IOPMD  ISCHED   NCPTR
        1   1.00    0.96       0       0       0       0
J3 IPRINT  PRCOL  IPLOTJ  FLONAT  CRITPR  ILOCAL  NOROUT  INFLOW
      511   130.       0      0.      0.       0      24       0
J4 IANDAM  ECFCT  IPRECN  BCRFAC  COSFAC   PCVAL  PEPVAL  PESVAL  PEBVAL
        0    1.0       0    1.00    1.00     0.0     0.0     0.0     0.0

USER ID     QMAX  QMDRAT   QMIND   QMINR    LQCP   RTLQ  QLAG

     10   20000.      1.    300.    200.       0  0.000   0.CP10-BAKER DAM
     20   20000.      1.     30.     20.       0  0.000   0.CP20-SMITH DAM
     30   30000.      1.    300.    200.       0  0.000   0.CP30-CONF RM60
     40   30000.      1.    300.    200.       0  0.000   0. CP40 ** RM 40
     50   50000.      1.    300.    200.       0  0.000   0.CP50 ** RM24.2

USER ID COMP ID     RTFR    RTTO    RTMD       X       K     LAG

      10      1      10.     30.    2.20    0.25  12.000       0
      20      2      20.     30.    2.20    0.25  12.000       0
      30      3      30.     40.    2.20    0.25  12.000       0
      40      4      40.     50.    2.20    0.25  12.000       0
      50      5      50.      0.    0.00    0.00   0.000       0

USER ID COMP ID    STOR1  STORL-1        -2         -3         -4         -5

     10       1 1200000.        0.   100000.    200000.   1500000.   1600000.
     20       2  550000.        0.     2000.    550000.    952000.   1130000.


USER ID   LOCATIONS RESERVOIR IS SERVING

     10     10.     30.     40.     50.
     20     20.     30.     40.     50.
```

```
RESERVOIR DATA

USER ID=      10   COMP ID=       1

RS   STORAGES=            100.      6300.     31300.     88000.    188000.
                       563000.   1688000.

RQ   Q CAPACITIES=          0.     20000.     30000.     40000.     50000.
                        50000.     50000.

RA   AREAS=                10.       500.      1500.      3000.      5000.
                        10000.     20000.

RE   ELEVATIONS=        800.00     825.00     850.00     870.00     900.00
                        950.00    1030.00

USER ID=      20   COMP ID=       2

RS   STORAGES=           2000.     20000.     52000.    113000.    209000.
                       320000.    550000.    800000.

RQ   Q CAPACITIES=          0.      5680.      5680.      5680.      5680.
                         5680.     29180.     59680.

RA   AREAS=               150.      2100.      4500.      7600.     11800.
                        17000.     22400.     28600.

RE   ELEVATIONS=        892.00     910.00     920.00     930.00     940.00
                        950.00     962.50     970.00
```

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DATA FROM HYDRAULIC ROUTINE

* TITLE
               TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
               PARALLEL RIVER SYSTEM
               TEST PROBLEM 1

* METRIC          0


* RESERVOIR C.P.        10


* NELV, CAPIN
                  7       1200000.


* ELEVAC, CAPCTY, SURARA
                  800.0          100.0          10.0
                  825.0         6300.0         500.0
                  850.0        31300.0        1500.0
                  870.0        88000.0        3000.0
                  900.0       188000.0        5000.0
                  950.0       563000.0       10000.0
                 1030.0      1688000.0       20000.0


* RESERVOIR C.P.        20


* NELV, CAPIN
                  8        550000.


* ELEVAC, CAPCTY, SURARA
                  892.0         2000.0         150.0
                  910.0        20000.0        2100.0
                  920.0        52000.0        4500.0
                  930.0       113000.0        7600.0
                  940.0       209000.0       11800.0
                  950.0       320000.0       17000.0
                  962.5       550000.0       22400.0
                  970.0       800000.0       28600.0
```

FICTICIOUS PARALLEL RIVER BASIN TEST OF HEC-5Q WITH WATER QUALITY
RESERVOIRS ARE FICTICIOUS ALSO ** C.P. OF 10, 20, 30, 40 AND 50
CONSTITUENTS ARE TEMPERATURE, TDS, CARBONACEOUS BOD AND OXYGEN

DAYS OF SIMULATION	123
FIRST DAY OF SIMULATION	121 (74/ 5/ 1)
FINAL DAY OF SIMULATION	243 (74/ 8/31)
NUMBER OF CONTROL POINTS	5
NUMBER OF RESERVOIRS	2
INPUT UNITS (ENGLISH=0/METRIC=1)	0
WATER TEMPERATURE UNITS	F

IN ADDITION TO TEMPERATURE, THE FOLLOWING CONSTITUENTS ARE BEING SIMULATED. (EXCEPT AS NOTED)

TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
CARBONACEOUS BOD IN MG/L
DISSOLVED OXYGEN IN MG/L

*****   INDICATES QUALITY DATA WILL BE READ BUT NOT SIMULATED

RESERVOIR RELATED DATA

PRINTOUT INTERVAL, DAYS	10
VERTICAL LAYER PRINTOUT INTERVAL	1

RESERVOIR NUMBER 1

CONTROL POINT I.D.	10
LAYER THICKNESS, FT	5.0
MAXIMUM WATER SURFACE ELEVATION, FT	1030.0
BOTTOM ELEVATION, FT	800.0
STARTING RESERVOIR VOLUME, ACFT	1200000.
SECCHI DISK DEPTH, FT	10.0
DEPTH OF INITIAL SOLAR ENERGY ABSORPTION, FT	1.00
FRACTION OF SOLAR ENERGY ABSORBED	0.40
METEOROLOGICAL DATA ZONE	2

INFLOW I.D.	EFFECTIVE RES. LENGTH,FT
2	10000.
1	5000.

WATER COLUMN MINIMUM STABILITY, KG/M3/M	0.10E-01
WATER COLUMN CRITICAL STABILITY (GSWH), KG/M3/M	0.10E-05
MAXIMUM ALLOWABLE DISPERSION (A1), M2/SEC	0.10E-03
COEFFICIENT RELATING GRADIENT TO DISPERSION (A3)	-0.70E+00

OUTLET CHARACTERISTICS

	VIRTUAL WIDTH, FT	MAXIMUM FLOW, CFS	ELEMENT	ELEVATION, FT
F.C. OUTLET	50.00	50000.00	6	825.00
WET WELL 1	10.00	2000.00	5	820.00
			13	860.00
			21	900.00
			29	940.00
WET WELL 2	10.00	2000.00	9	840.00
			17	880.00
			25	920.00
			33	960.00

GATE SELECTION SUBOPTIMIZATION FUNCTION

CONSTITUENT	WEIGHTING	POLYNOMIAL FUNCTION COEFFICIENTS				
1	2.50E-01	1.00E+02	0.00E+00	-4.00E+00		
2	5.00E-02	1.00E+02	0.00E+00	-2.00E-01		
6	2.00E-01	1.00E+02	0.00E+00	-8.00E+00		
8	2.50E-01	1.00E+02	3.20E+00	-7.00E-01	1.00E-01	-5.00E-02

RESERVOIR GEOMETRY AND INITIAL TEMPERATURE

ELEMENT	ELEVATION FT	AREA ACRE	VOLUME ACFT	ELEMENT VOL ACFT	WIDTH FT	TEMPERATURE F
1	800.0	10.	100.	388.	200.	40.00
2	805.0	105.	388.	764.	240.	40.20
3	810.0	200.	1152.	1240.	280.	40.40
4	815.0	296.	2392.	1716.	320.	40.60
5	820.0	391.	4108.	2192.	360.	40.80
6	825.0	486.	6300.	2944.	400.	41.00
7	830.0	692.	9244.	3972.	480.	41.20
8	835.0	897.	13216.	5000.	560.	41.40
9	840.0	1103.	18216.	6028.	640.	41.60
10	845.0	1308.	24244.	7056.	720.	41.80
11	850.0	1514.	31300.	9221.	800.	42.00
12	855.0	2175.	40521.	12524.	950.	42.25
13	860.0	2835.	53045.	15826.	1100.	42.50
14	865.0	3495.	68871.	19129.	1250.	42.75
15	870.0	4156.	88000.	20094.	1400.	43.00
16	875.0	3882.	108094.	18723.	1500.	43.33
17	880.0	3608.	126818.	17352.	1600.	43.67
18	885.0	3333.	144170.	15981.	1700.	44.00
19	890.0	3059.	160151.	14610.	1800.	44.33
20	895.0	2785.	174761.	13239.	1900.	44.67
21	900.0	2511.	188000.	15048.	2000.	45.00
22	905.0	3509.	203048.	20037.	2100.	45.30
23	910.0	4506.	223085.	25027.	2200.	45.60
24	915.0	5504.	248112.	30016.	2300.	45.90
25	920.0	6502.	278128.	35005.	2400.	46.20
26	925.0	7500.	313133.	39995.	2500.	46.50
27	930.0	8498.	353128.	44984.	2600.	46.80
28	935.0	9496.	398112.	49973.	2700.	47.10
29	940.0	10494.	448085.	54963.	2800.	47.40
30	945.0	11491.	503048.	59952.	2900.	47.70
31	950.0	12489.	563000.	62938.	3000.	48.00
32	955.0	12686.	625938.	63922.	3125.	48.75
33	960.0	12883.	689860.	64905.	3250.	49.50
34	965.0	13079.	754765.	65888.	3375.	50.25
35	970.0	13276.	820652.	66871.	3500.	51.00
36	975.0	13473.	887524.	67854.	3625.	51.75
37	980.0	13669.	955378.	68838.	3750.	52.50
38	985.0	13866.	1024216.	69821.	3875.	53.25
39	990.0	14062.	1094037.	70804.	4000.	54.00
40	995.0	14259.	1164841.	71787.	4125.	54.75
41	1000.0	14456.	1236628.	72771.	4250.	55.50
42	1005.0	14652.	1309399.	73754.	4375.	56.25
43	1010.0	14849.	1383152.	74737.	4500.	57.00
44	1015.0	15046.	1457890.	75720.	4625.	57.75
45	1020.0	15242.	1533610.	76703.	4750.	58.50
46	1025.0	15439.	1610313.	77687.	4875.	59.25
47	1030.0	15636.	1688000.	77687.	5000.	60.00

INITIAL RESERVOIR WATER QUALITY DATA

ELEMENT	ELEV	CONS.1	CONS.2	CONS.3	NONCONS.1	NONCONS.2(NBOD)	NONCONS.3(CBOD)	OXYGEN	O2 SOURCE/SINK
1	800.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
2	805.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
3	810.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
4	815.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
5	820.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
6	825.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
7	830.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
8	835.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
9	840.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
10	845.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
11	850.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
12	855.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
13	860.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
14	865.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
15	870.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
16	875.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
17	880.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
18	885.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
19	890.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
20	895.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
21	900.0	120.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
22	905.0	126.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
23	910.0	132.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
24	915.0	138.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
25	920.0	144.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
26	925.0	150.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
27	930.0	156.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
28	935.0	162.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
29	940.0	168.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
30	945.0	174.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
31	950.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
32	955.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
33	960.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
34	965.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
35	970.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
36	975.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
37	980.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
38	985.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
39	990.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
40	995.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
41	1000.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
42	1005.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
43	1010.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
44	1015.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
45	1020.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
46	1025.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00
47	1030.0	180.00	0.00	0.00	0.00	0.50	0.00	9.1	100.00

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CONSTITUENT NO. 1  IS     TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
CONSTITUENT NO. 2  IS NOT BEING SIMULATED
CONSTITUENT NO. 3  IS NOT BEING SIMULATED
CONSTITUENT NO. 4  IS NOT BEING SIMULATED
CONSTITUENT NO. 5  IS     CARBONACEOUS BOD IN MG/L
CONSTITUENT NO. 6  IS NOT BEING SIMULATED
CONSTITUENT NO. 7  IS     DISSOLVED OXYGEN IN MG/L


DECAY RATES AND CONVERSION FACTORS ARE

    CONSTITUENT NO. 4 DECAY RATE =          0.0000
    CONSTITUENT NO. 5 DECAY RATE =          0.1000
    CONSTITUENT NO. 6 DECAY RATE =          0.0000
    CONSTITUENT NO. 5 CONVERSION FACTOR =   1.4630
    CONSTITUENT NO. 6 CONVERSION FACTOR =   2.2700
```

RESERVOIR NUMBER 2

CONTROL POINT I.D.	20
LAYER THICKNESS, FT	2.0
MAXIMUM WATER SURFACE ELEVATION, FT	970.0
BOTTOM ELEVATION, FT	892.0
STARTING RESERVOIR VOLUME, ACFT	550000.
SECCHI DISK DEPTH, FT	5.0
DEPTH OF INITIAL SOLAR ENERGY ABSORPTION, FT	1.00
FRACTION OF SOLAR ENERGY ABSORBED	0.40
METEOROLOGICAL DATA ZONE	1

INFLOW I.D.	EFFECTIVE RES. LENGTH,FT
3	60000.

WATER COLUMN MINIMUM STABILITY, KG/M3/M	0.10E-01
WATER COLUMN CRITICAL STABILITY (GSWH), KG/M3/M	0.10E-05
MAXIMUM ALLOWABLE DISPERSION (A1), M2/SEC	0.10E-03
COEFFICIENT RELATING GRADIENT TO DISPERSION (A3)	-0.70E+00

OUTLET CHARACTERISTICS

	VIRTUAL WIDTH, FT	MAXIMUM FLOW, CFS	ELEMENT	ELEVATION, FT
F.C. OUTLET	1.00	10.00	3	895.50
SPILLWAY	870.00	99300.00	36	962.50
WET WELL 1	7.90	2840.00	3	895.50
			10	909.50
			17	923.50
			24	937.50
WET WELL 2	7.90	2840.00	6	902.50
			13	916.50
			20	930.50
			27	944.50

GATE SELECTION SUBOPTIMIZATION FUNCTION

CONSTITUENT	WEIGHTING	POLYNOMIAL FUNCTION COEFFICIENTS				
1	2.50E-01	1.00E+02	0.00E+00	-4.00E+00		
2	5.00E-02	1.00E+02	0.00E+00	-2.00E-01		
6	2.00E-01	1.00E+02	0.00E+00	-8.00E+00		
8	2.50E-01	1.00E+02	3.20E+00	-7.00E-01	1.00E-01	-5.00E-02

RESERVOIR GEOMETRY AND INITIAL TEMPERATURE

ELEMENT	ELEVATION FT	AREA ACRE	VOLUME ACFT	ELEMENT VOL ACFT	WIDTH FT	TEMPERATURE F
1	892.0	150.	2000.	2489.	410.	54.00
2	894.0	339.	2489.	867.	416.	54.11
3	896.0	528.	3356.	1244.	421.	54.22
4	898.0	717.	4600.	1622.	427.	54.33
5	900.0	906.	6222.	2000.	432.	54.44
6	902.0	1094.	8222.	2378.	438.	54.56
7	904.0	1283.	10600.	2756.	443.	54.67
8	906.0	1472.	13356.	3133.	449.	54.78
9	908.0	1661.	16489.	3511.	454.	54.89
10	910.0	1850.	20000.	4240.	460.	55.00
11	912.0	2390.	24240.	5320.	468.	55.40
12	914.0	2930.	29560.	6400.	476.	55.80
13	916.0	3470.	35960.	7480.	484.	56.20
14	918.0	4010.	43440.	8560.	492.	56.60
15	920.0	4550.	52000.	9720.	500.	57.00
16	922.0	5170.	61720.	10960.	510.	57.00
17	924.0	5790.	72680.	12200.	520.	57.00
18	926.0	6410.	84880.	13440.	530.	57.00
19	928.0	7030.	98320.	14680.	540.	57.00
20	930.0	7650.	113000.	16080.	550.	57.00
21	932.0	8430.	129080.	17640.	560.	57.00
22	934.0	9210.	146720.	19200.	570.	57.00
23	936.0	9990.	165920.	20760.	580.	57.00
24	938.0	10770.	186680.	22320.	590.	57.00
25	940.0	11550.	209000.	22920.	600.	57.00
26	942.0	11370.	231920.	22560.	610.	57.00
27	944.0	11190.	254480.	22200.	620.	57.00
28	946.0	11010.	276680.	21840.	630.	57.00
29	948.0	10830.	298520.	21480.	640.	57.00
30	950.0	10650.	320000.	23780.	650.	57.00
31	952.0	13130.	343780.	28740.	658.	57.00
32	954.0	15610.	372520.	33700.	666.	57.00
33	956.0	18090.	406220.	38660.	674.	57.00
34	958.0	20570.	444880.	43620.	682.	57.00
35	960.0	23050.	488500.	48580.	690.	57.00
36	962.0	25530.	537080.	54553.	698.	57.00
37	964.0	29023.	591633.	61878.	710.	57.00
38	966.0	32854.	653511.	69540.	723.	57.00
39	968.0	36686.	723051.	77202.	737.	57.00
40	970.0	40517.	800253.	77202.	750.	57.00

INITIAL RESERVOIR WATER QUALITY DATA

ELEMENT	ELEV	CONS.1	CONS.2	CONS.3	NONCONS.1	NONCONS.2(NBOD)	NONCONS.3(CBOD)	OXYGEN	O2 SOURCE/SINK
1	892.0	160.00	0.00	0.00	0.00	0.30	0.00	8.4	100.00
2	894.0	163.33	0.00	0.00	0.00	0.30	0.00	8.4	100.00
3	896.0	166.67	0.00	0.00	0.00	0.30	0.00	8.5	100.00
4	898.0	170.00	0.00	0.00	0.00	0.30	0.00	8.5	100.00
5	900.0	173.33	0.00	0.00	0.00	0.30	0.00	8.5	100.00
6	902.0	176.67	0.00	0.00	0.00	0.30	0.00	8.6	100.00
7	904.0	180.00	0.00	0.00	0.00	0.30	0.00	8.6	100.00
8	906.0	183.33	0.00	0.00	0.00	0.30	0.00	8.6	100.00
9	908.0	186.67	0.00	0.00	0.00	0.30	0.00	8.7	100.00
10	910.0	190.00	0.00	0.00	0.00	0.30	0.00	8.7	100.00
11	912.0	190.00	0.00	0.00	0.00	0.30	0.00	8.8	100.00
12	914.0	190.00	0.00	0.00	0.00	0.30	0.00	8.9	100.00
13	916.0	190.00	0.00	0.00	0.00	0.30	0.00	9.0	100.00
14	918.0	190.00	0.00	0.00	0.00	0.30	0.00	9.1	100.00
15	920.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
16	922.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
17	924.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
18	926.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
19	928.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
20	930.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
21	932.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
22	934.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
23	936.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
24	938.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
25	940.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
26	942.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
27	944.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
28	946.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
29	948.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
30	950.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
31	952.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
32	954.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
33	956.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
34	958.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
35	960.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
36	962.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
37	964.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
38	966.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
39	968.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00
40	970.0	190.00	0.00	0.00	0.00	0.30	0.00	9.2	100.00

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CONSTITUENT NO. 1  IS     TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
CONSTITUENT NO. 2  IS NOT BEING SIMULATED
CONSTITUENT NO. 3  IS NOT BEING SIMULATED
CONSTITUENT NO. 4  IS NOT BEING SIMULATED
CONSTITUENT NO. 5  IS     CARBONACEOUS BOD IN MG/L
CONSTITUENT NO. 6  IS NOT BEING SIMULATED
CONSTITUENT NO. 7  IS     DISSOLVED OXYGEN IN MG/L


DECAY RATES AND CONVERSION FACTORS ARE

    CONSTITUENT NO. 4 DECAY RATE =          0.0000
    CONSTITUENT NO. 5 DECAY RATE =          0.2000
    CONSTITUENT NO. 6 DECAY RATE =          0.0000
    CONSTITUENT NO. 5 CONVERSION FACTOR =   1.4630
    CONSTITUENT NO. 6 CONVERSION FACTOR =   2.2700


THERMAL ADJUSTMENT FACTORS FOR

    CONSTITUENT NO. 4 DECAY RATE =          1.0470
    CONSTITUENT NO. 5 DECAY RATE =          1.0470
    CONSTITUENT NO. 6 DECAY RATE =          1.0470
    OXYGEN REAERATION RATE =                1.0159
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STREAM RELATED DATA

PRINTOUT INTERVAL, DAYS	10
PRINTOUT INTERVAL, ELEMENTS	1
CROSS SECTION PRINT CONTROL	0
NUMBER OF CROSS SECTIONS	10
POINTS DEFINING CROSS SECTION GEOMETRY	20
X-SECTION WIDTH ADJUSTMENT RATIO	1.00

STREAM REACH DATA

REACH	UP STREAM CP.	UP STREAM LOC.	DOWN STREAM CP.	DOWN STREAM LOC.	ELT LENGTH MILE		TRIB LOCATIONS AND NUMBER					
1	10	65.5	30	60.0	1.50	0.0	0	0.0	0	0.0	0	
2	20	4.7	30	0.0	1.50	0.0	0	0.0	0	0.0	0	
3	30	60.0	40	40.0	2.00	45.0	3	0.0	0	0.0	0	
4	40	40.0	50	24.2	1.97	30.0	4	0.0	0	0.0	0	

METEOROLOGICAL AND REAERATION CONTROLS

ELEMENT	LOCATION		MET.ZONE	K2 METHOD	K2(IF SET)
1	64.81	10	2	(INPUT K2 DIRECTLY)	1.00
2	63.44		2	(INPUT K2 DIRECTLY)	1.00
3	62.06		2	(INPUT K2 DIRECTLY)	1.00
4	60.69	30	2	(INPUT K2 DIRECTLY)	1.00
5	3.92	20	1	(O'CONNER AND DOBBINS)	
6	2.35		1	(O'CONNER AND DOBBINS)	
7	0.78	30	1	(O'CONNER AND DOBBINS)	
8	59.00	30	1	(LANGBIEN AND DURUM)	
9	57.00		1	(LANGBIEN AND DURUM)	
10	55.00		1	(LANGBIEN AND DURUM)	
11	53.00		1	(LANGBIEN AND DURUM)	
12	51.00		1	(LANGBIEN AND DURUM)	
13	49.00		1	(LANGBIEN AND DURUM)	
14	47.00		1	(LANGBIEN AND DURUM)	
15	45.00		1	(LANGBIEN AND DURUM)	
16	43.00		1	(LANGBIEN AND DURUM)	
17	41.00	40	1	(LANGBIEN AND DURUM)	
18	39.01	40	1	(LANGBIEN AND DURUM)	
19	37.04		1	(LANGBIEN AND DURUM)	
20	35.06		1	(LANGBIEN AND DURUM)	
21	33.09		1	(LANGBIEN AND DURUM)	
22	31.11		1	(LANGBIEN AND DURUM)	
23	29.14		1	(LANGBIEN AND DURUM)	
24	27.16		1	(LANGBIEN AND DURUM)	
25	25.19	50	1	(LANGBIEN AND DURUM)	

DECAY RATES FOR STREAM REACHES

REACH NO	CONS 4	CONS 5	CONS 6	CONVERSION FACTORS	
1	0.000	0.100	0.000	1.463	2.270
2	0.000	0.150	0.000	1.463	2.270
3	0.000	0.200	0.000	1.463	2.270
4	0.000	0.250	0.000	1.463	2.270

CONTROL POINT 10

TEMPERATURE OBJECTIVES, F

DATE	TARGET	WEIGHTING		RESERVOIRS SPECIFIED FOR FLOW AUGMENTATION CONTROL				
740101	40.00	3.00	0.00	0	0	0	0	0
740318	45.00	3.00	0.00	0	0	0	0	0
740723	50.00	3.00	0.00					
741017	45.00	3.00	0.00					
741206	40.00	3.00	0.00					
-741231	40.00	3.00	0.00					

TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY

DATE	TARGET	WEIGHTING	
740101	150.00	1.00	0.00
-741231	150.00	1.00	0.00

CARBONACEOUS BOD IN MG/L

DATE	TARGET	WEIGHTING	
740101	0.10	1.00	0.00
-741231	0.10	1.00	0.00

DISSOLVED OXYGEN IN MG/L

DATE	TARGET	WEIGHTING	
740101	5.00	0.00	30.00
-741231	5.00	0.00	30.00

CONTROL POINT 20

TEMPERATURE OBJECTIVES, F

DATE	TARGET	WEIGHTING		RESERVOIRS SPECIFIED FOR FLOW AUGMENTATION CONTROL				
740101	45.00	4.00	0.00	0	0	0	0	0
740318	50.00	4.00	0.00	0	0	0	0	0
740723	55.00	4.00	0.00					
741017	50.00	4.00	0.00					
741206	45.00	4.00	0.00					
-741231	42.00	4.00	0.00					

TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY

DATE	TARGET	WEIGHTING	
740101	160.00	0.80	0.00
-741231	160.00	0.80	0.00

CARBONACEOUS BOD IN MG/L

DATE	TARGET	WEIGHTING	
740101	0.05	0.15	0.00
-741231	0.05	0.15	0.00

DISSOLVED OXYGEN IN MG/L

DATE	TARGET	WEIGHTING	
740101	4.00	0.00	50.00
-741231	4.00	0.00	50.00

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CONTROL POINT  30

     TEMPERATURE OBJECTIVES, F
          DATE       TARGET           WEIGHTING               RESERVOIRS SPECIFIED FOR FLOW AUGMENTATION CONTROL
        740101        45.00       3.00         0.00                 10      20       0       0       0
        740510        50.00       3.00         0.00                  0       0       0       0       0
        740531        60.00       3.00         0.00
        741001        55.00       3.00         0.00
       -741231        45.00       3.00         0.00

         TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
          DATE       TARGET           WEIGHTING
        740101       160.00       1.00         0.00
       -741231       160.00       1.00         0.00

         CARBONACEOUS BOD IN MG/L
          DATE       TARGET           WEIGHTING
        740101         0.15       4.00         0.00
       -741231         0.15       4.00         0.00

         DISSOLVED OXYGEN IN MG/L
          DATE       TARGET           WEIGHTING
        740101         4.50       4.00         0.00
       -741231         4.50       4.00         0.00
CONTROL POINT  40

     TEMPERATURE OBJECTIVES, F
          DATE       TARGET           WEIGHTING               RESERVOIRS SPECIFIED FOR FLOW AUGMENTATION CONTROL
        740101        45.00       3.00         0.00                 10      20       0       0       0
        740504        50.00       3.00         0.00                  0       0       0       0       0
        740514        55.00       3.00         0.00
        740515        60.00       3.00         0.00
        741005        55.00       3.00         0.00
        741109        50.00       3.00         0.00
        741214        45.00       3.00         0.00
       -741231        45.00       3.00         0.00

         TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
          DATE       TARGET           WEIGHTING
        740101       170.00       1.00         0.00
       -741231       170.00       1.00         0.00

         CARBONACEOUS BOD IN MG/L
          DATE       TARGET           WEIGHTING
        740101         0.20       1.00         0.00
       -741231         0.20       1.00         0.00

         DISSOLVED OXYGEN IN MG/L
          DATE       TARGET           WEIGHTING
        740101         5.50       0.00        30.00
       -741231         5.50       0.00        30.00
```

CONTROL POINT 50

TEMPERATURE OBJECTIVES, F

DATE	TARGET	WEIGHTING	
740101	50.00	3.00	0.00
740506	55.00	3.00	0.00
740510	60.00	3.00	0.00
740515	65.00	3.00	0.00
740708	70.00	3.00	0.00
740924	65.00	3.00	0.00
741018	60.00	3.00	0.00
741112	55.00	3.00	0.00
741206	50.00	3.00	0.00
-741231	50.00	3.00	0.00

RESERVOIRS SPECIFIED FOR FLOW AUGMENTATION CONTROL

10	20	0	0	0
0	0	0	0	0

TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY

DATE	TARGET	WEIGHTING	
740101	190.00	1.00	0.00
-741231	190.00	1.00	0.00

CARBONACEOUS BOD IN MG/L

DATE	TARGET	WEIGHTING	
740101	0.30	1.00	0.00
-741231	0.30	1.00	0.00

DISSOLVED OXYGEN IN MG/L

DATE	TARGET	WEIGHTING	
740101	6.00	0.00	30.00
-741231	6.00	0.00	30.00

```
FIRST DAY OF INFLOW QUALITY RECORD       740101
LAST DAY OF INFLOW QUALITY RECORD        741231
TOTAL NUMBER OF DAYS                        365

TRIB  1 ...   2 CARDS READ FOR  TRIB 1 ... LEFT INFLOW RATE ... RES # 1
TRIB  1 ...   2 CARDS READ FOR  TRIB 1 ... LEFT INFLOW TEMPERATURE
TRIB  1 ...   1 CARDS READ FOR  TRIB 1 ... LEFT INFLOW - TOTAL DISSOLVE
TRIB  1 ...   1 CARDS READ FOR  TRIB 1 ... LEFT INFLOW - CARBONACEOUS B
TRIB  1 ...   4 CARDS READ FOR  TRIB 1 ... LEFT INFLOW - DISSOLVED OXYG
TRIB  2 ...   2 CARDS READ FOR  TRIB 2 ... RIGHT INFLOW RATE ... RES #
TRIB  2 ...   7 CARDS READ FOR  TRIB 2 ... RIGHT INFLOW TEMPERATURE
TRIB  2 ...   4 CARDS READ FOR  TRIB 2 ... RIGHT INFLOW - TDS
TRIB  2 ...   4 CARDS READ FOR  TRIB 2 ... RIGHT INFLOW - CBOD
TRIB  2 ...   4 CARDS READ FOR  TRIB 2 ... RIGHT INFLOW - DISSOLVED OXY
TRIB  3 ...   1 CARDS READ FOR  TRIB 3 INFLOW RATE - RM 45 & RES # 2
TRIB  3 ...   2 CARDS READ FOR TRIB 3 - RM 45
TRIB  3 ...   1 CARDS READ FOR  TRIB 3 - RM 45 - TOTAL DISSOLVED SOLIDS
TRIB  3 ...   1 CARDS READ FOR  TRIB 3 - RM 45 - CARBONACEOUS BOD
TRIB  3 ...   4 CARDS READ FOR  TRIB 3 - RM 45 - DISSOLVED OXYGEN
TRIB  4 ...   1 CARDS READ FOR  TRIB 4 INFLOW RATE - RM 30
TRIB  4 ...   2 CARDS READ FOR TRIB 4 - RM 30
TRIB  4 ...   1 CARDS READ FOR  TRIB 4 - RM 30 - TOTAL DISSOLVED SOLIDS
TRIB  4 ...   1 CARDS READ FOR  TRIB 4 - RM 30 - CARBONACEOUS BOD
TRIB  4 ...   4 CARDS READ FOR  TRIB 4 - RM 30 - DISSOLVED OXYGEN

TIME (YEAR/MONTH/DAY) VS. INFLOW QUALITY AT CONTROL   POINTS

TRIB  1 ...  TRIB 1 ... LEFT INFLOW RATE ... RES # 1INFLOW RATE AS FRACTION OF LOCAL FLOW
       TIME     VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE
   74/ 1/ 1     -0.50   74/ 4/ 8    -0.50   74/ 4/22    -0.70   74/ 7/ 8    -0.30   74/ 8/26    -0.30   74/12/31    -0.50

TRIB  1 ...  TRIB 1 ... LEFT INFLOW TEMPERATURE     TEMPERATURE (F) AS DEPARTURE FRO EQUILIBRIUM TEMPERATURE
       TIME     VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE
   74/ 1/ 1     -1.50   74/ 4/ 8    -1.50   74/ 4/22    -5.00   74/ 7/ 8    -8.00   74/ 8/26    -5.00   74/12/31    -1.50

TRIB  1 ...  TRIB 1 ... LEFT INFLOW - TOTAL DISSOLVE    TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
       TIME     VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE
   74/ 1/ 1    105.00   74/12/31   105.00

TRIB  1 ...  TRIB 1 ... LEFT INFLOW - CARBONACEOUS B    CARBONACEOUS BOD IN MG/L
       TIME     VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE
   74/ 1/ 1      0.50   74/12/31     0.50

TRIB  1 ...  TRIB 1 ... LEFT INFLOW - DISSOLVED OXYGDISSOLVED OXYGEN, MG/L
       TIME     VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE       TIME    VALUE
   74/ 1/ 1     12.80   74/ 1/15    13.10   74/ 2/15    12.40   74/ 3/15    11.80   74/ 4/15    11.70   74/ 5/15     9.30
   74/ 6/15      8.90   74/ 7/15     8.20   74/ 8/15     7.80   74/ 9/15     9.70   74/10/15    10.00   74/11/15    11.00
   74/12/15     12.40   74/12/31    12.80
```

TRIB 2 ... TRIB 2 ... RIGHT INFLOW RATE ... RES # INFLOW RATE AS FRACTION OF LOCAL FLOW

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	-0.50	74/ 4/ 8	-0.50	74/ 4/22	-0.70	74/ 7/ 8	-0.70	74/ 8/26	-0.70	74/12/31	-0.50

TRIB 2 ... TRIB 2 ... RIGHT INFLOW TEMPERATURE TEMPERATURE (F) AS DEPARTURE FRO EQUILIBRIUM TEMPERATURE

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	-0.10	74/ 1/25	2.00	74/ 2/10	1.20	74/ 2/24	-1.80	74/ 3/10	0.10	74/ 3/24	-10.40
74/ 4/14	-15.80	74/ 4/28	-24.30	74/ 5/12	-15.60	74/ 5/27	-16.00	74/ 6/ 9	-11.00	74/ 6/23	-15.60
74/ 7/14	-9.10	74/ 7/28	-12.30	74/ 8/11	-10.30	74/ 8/25	-15.00	74/ 9/ 8	-15.50	74/ 9/22	-17.80
74/10/14	-11.10	74/10/28	-6.10	74/11/10	-6.50	74/11/24	-4.40	74/12/ 8	-6.20	74/12/31	1.50

TRIB 2 ... TRIB 2 ... RIGHT INFLOW - TDS TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	140.00	74/ 1/15	110.00	74/ 2/15	240.00	74/ 3/15	400.00	74/ 4/15	130.00	74/ 5/15	1095.00
74/ 6/15	80.00	74/ 7/15	100.00	74/ 8/15	70.00	74/ 9/15	50.00	74/10/15	100.00	74/11/15	90.00
74/12/15	310.00	74/12/31	360.00								

TRIB 2 ... TRIB 2 ... RIGHT INFLOW - CBOD CARBONACEOUS BOD IN MG/L

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	0.20	74/ 1/15	0.20	74/ 2/15	0.40	74/ 3/15	0.50	74/ 4/15	0.20	74/ 5/15	1.80
74/ 6/15	0.10	74/ 7/15	0.20	74/ 8/15	0.10	74/ 9/15	0.10	74/10/15	0.20	74/11/15	0.10
74/12/15	0.50	74/12/31	0.60								

TRIB 2 ... TRIB 2 ... RIGHT INFLOW - DISSOLVED OXYDISSOLVED OXYGEN, MG/L

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	13.10	74/ 1/15	13.10	74/ 2/15	12.40	74/ 3/15	11.80	74/ 4/15	11.80	74/ 5/15	9.40
74/ 6/15	9.00	74/ 7/15	8.30	74/ 8/15	7.80	74/ 9/15	9.70	74/10/15	10.00	74/11/15	11.00
74/12/15	12.40	74/12/31	12.80								

TRIB 3 ... TRIB 3 INFLOW RATE - RM 45 & RES # 2 INFLOW RATE AS FRACTION OF LOCAL FLOW

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	-1.00	74/12/31	-1.00								

TRIB 3 ... TRIB 3 - RM 45 TEMPERATURE (F) AS DEPARTURE FRO EQUILIBRIUM TEMPERATURE

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	-1.50	74/ 4/ 8	-1.50	74/ 4/22	-3.00	74/ 7/ 8	-4.00	74/ 8/26	-3.00	74/12/31	-1.50

TRIB 3 ... TRIB 3 - RM 45 - TOTAL DISSOLVED SOLIDS TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	160.00	74/12/31	160.00								

TRIB 3 ... TRIB 3 - RM 45 - CARBONACEOUS BOD CARBONACEOUS BOD IN MG/L

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	0.60	74/12/31	0.60								

TRIB 3 ... TRIB 3 - RM 45 - DISSOLVED OXYGEN DISSOLVED OXYGEN, MG/L

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE
74/ 1/ 1	12.80	74/ 1/15	13.10	74/ 2/15	12.40	74/ 3/15	11.80	74/ 4/15	11.70	74/ 5/15	9.30
74/ 6/15	8.90	74/ 7/15	8.20	74/ 8/15	7.80	74/ 9/15	9.70	74/10/15	10.00	74/11/15	11.00
74/12/15	12.40	74/12/31	12.80								

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TRIB  4 ...  TRIB 4 INFLOW RATE - RM 30          INFLOW RATE AS FRACTION OF LOCAL FLOW
     TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE
  74/ 8/26   -1.00   74/12/31   -1.00

TRIB  4 ... TRIB 4 - RM 30                       TEMPERATURE (F) AS DEPARTURE FRO EQUILIBRIUM TEMPERATURE
     TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE
  74/ 1/ 1   -1.50   74/ 4/ 8   -1.50   74/ 4/22   -3.00   74/ 7/ 8   -6.00   74/ 8/26   -5.00   74/12/31   -1.50

TRIB  4 ...  TRIB 4 - RM 30 - TOTAL DISSOLVED SOLIDS    TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
     TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE
  74/ 1/ 1  160.00   74/12/31  160.00

TRIB  4 ...  TRIB 4 - RM 30 - CARBONACEOUS BOD          CARBONACEOUS BOD IN MG/L
     TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE
  74/ 1/ 1    0.60   74/12/31    0.60

TRIB  4 ...  TRIB 4 - RM 30 - DISSOLVED OXYGEN      DISSOLVED OXYGEN, MG/L
     TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE      TIME    VALUE
  74/ 1/ 1   12.80   74/ 1/15   13.10   74/ 2/15   12.40   74/ 3/15   11.80   74/ 4/15   11.70   74/ 5/15    9.30
  74/ 6/15    8.90   74/ 7/15    8.20   74/ 8/15    7.80   74/ 9/15    9.70   74/10/15   10.00   74/11/15   11.00
  74/12/15   12.40   74/12/31   12.80

*RTCOF


ROUTING COEFFICIENTS FROM RES      10 TO MY
MY=    30 0.1837 0.4898 0.3265
MY=    40 0.0337 0.1799 0.3599 0.3199 0.1066
MY=    50 0.0062 0.0496 0.1652 0.2938 0.2938 0.1567 0.0348

ROUTING COEFFICIENTS FROM RES      20 TO MY
MY=    30 0.1837 0.4898 0.3265
MY=    40 0.0337 0.1799 0.3599 0.3199 0.1066
MY=    50 0.0062 0.0496 0.1652 0.2938 0.2938 0.1567 0.0348
          FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY  121
          C.P. ID       QL         QN         DQ           C.P. ID       QL         QN         DQ

              10   2059.00    1270.00       0.00              20    430.00    1236.00       0.00
              30      0.00    2506.00       0.00              40    645.00    3151.00       0.00
              50   3317.00    6468.00       0.00
```

120 DAYS OF INFLOW DATA BYPASSED ON RESERVOIR INFLOW DATA TAPE

INFLOWS TO RESERVOIR 1 CHANGED BY 0.74 ON DAY 121

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 122

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	1814.00	1320.00	0.00	20	816.00	521.00	0.00
30	0.00	2383.86	0.00	40	588.00	3071.57	0.00
50	3816.00	6952.41	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.74 ON DAY 122

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 123

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	2125.00	1360.00	0.00	20	668.00	387.00	0.00
30	0.00	1994.35	0.00	40	561.00	2904.65	0.00
50	3333.00	6394.29	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.75 ON DAY 123

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 124

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	2243.00	1410.00	0.00	20	1979.00	405.00	0.00
30	0.00	1723.78	0.00	40	488.00	2521.60	0.00
50	3150.00	6019.97	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.75 ON DAY 124

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 125

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	1947.00	1440.00	0.00	20	1523.00	442.00	0.00
30	0.00	1815.01	0.00	40	452.00	2229.41	0.00
50	2843.00	5395.82	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.75 ON DAY 125

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 126

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	1836.00	1470.00	0.00	20	1195.00	949.00	0.00
30	0.00	1968.82	0.00	40	440.00	2243.00	0.00
50	2861.00	5136.51	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.75 ON DAY 126

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 127

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	1735.00	1480.00	0.00	20	1065.00	1602.00	0.00
30	0.00	2407.75	0.00	40	425.00	2447.25	0.00
50	2976.00	5233.97	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.76 ON DAY 127

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 128

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	1587.00	1480.00	0.00	20	847.00	1572.00	0.00
30	0.00	2953.59	0.00	40	405.00	2811.54	0.00
50	2831.00	5298.53	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.76 ON DAY 128

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 129

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	1549.00	1480.00	0.00	20	698.00	1528.00	0.00
30	0.00	3100.49	0.00	40	406.00	3283.38	0.00
50	3011.00	5832.93	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.76 ON DAY 129

FLOW DATA FROM HEC-5 QUANTITY SIMULATION FOR DAY 130

C.P. ID	QL	QN	DQ	C.P. ID	QL	QN	DQ
10	1509.00	1480.00	0.00	20	569.00	1040.00	0.00
30	0.00	2915.50	0.00	40	398.00	3467.47	0.00
50	3250.00	6474.95	0.00				

INFLOWS TO RESERVOIR 1 CHANGED BY 0.77 ON DAY 130

RESERVOIR MODEL RESULTS

RESERVOIR NO 1 .. CONTROL POINT 10

JULIAN DATE 130

METEOROLOGICAL DATA	EQUILIBRIUM TEMPERATURE, F	67.7
	HEAT EXCHANGE COEFFICIENT, BTU/FT2/DAY/F	96.1
	SHORT WAVE SOLAR RADIATION, BTU/FT2/DAY	2495.
	WIND SPEED, MPH	7.8
	EVAPORATION RATE, AC.FT/DAY	87.38

INFLOW DATA

TRIB NO	FLOW CFS	TEMP F	CONS.1 MG/L	CONS.2 MG/L	CONS.3 MG/L	NONCON.1 MG/L	NONCON.2 MG/L	NONCON.3 MG/L	OXYGEN MG/L
2	810.1	51.1	950.2	0.00	0.00	0.00	1.07	0.00	9.8
1	698.9	62.0	105.0	0.00	0.00	0.00	0.34	0.00	9.7

OUTFLOW INFORMATION

OUTLET	FLOW CFS	TEMP F	CONS.1 MG/L	CONS.2 MG/L	CONS.3 MG/L	NONCON.1 MG/L	NONCON.2 MG/L	NONCON.3 MG/L	OXYGEN MG/L
WET WELL NO 1	292.5	45.0	150.5	0.00	0.00	0.00	0.32	0.00	8.8
WET WELL NO 2	1187.4	44.0	156.9	0.00	0.00	0.00	0.33	0.00	8.9
TOTAL OUTFLOW	1480.0	44.2	155.6	0.00	0.00	0.00	0.33	0.00	8.9
OBJECTIVES		41.8*	146.9*	0.00	0.00	0.00	0.27*	0.00	8.8*

* INCLUDED IN WITHDRAWAL QUALITY OPTIMIZATION

RESERVOIR INFORMATION	WATER SURFACE ELEVATION, FT	997.95
	RESERVOIR SURFACE AREA, AC	14376.
	RESERVOIR STORAGE VOLUME, ACFT	1207466.

RESERVOIR WATER QUALITY

DEPTH	TEMP	CONS.1	CONS.2	CONS.3	NONCON.1	NONCON.2	NONCON.3	OXYGEN
FT	F	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
2.5	59.0	176.3	0.00	0.00	0.00	0.25	0.00	9.8
7.5	59.0	176.3	0.00	0.00	0.00	0.25	0.00	9.8
12.5	58.1	177.1	0.00	0.00	0.00	0.25	0.00	9.6
17.5	55.0	177.9	0.00	0.00	0.00	0.26	0.00	9.0
22.5	52.9	178.4	0.00	0.00	0.00	0.27	0.00	8.8
27.5	51.4	180.9	0.00	0.00	0.00	0.27	0.00	8.8
32.5	50.3	181.7	0.00	0.00	0.00	0.28	0.00	8.8
37.5	49.4	184.5	0.00	0.00	0.00	0.29	0.00	8.8
42.5	48.7	182.0	0.00	0.00	0.00	0.29	0.00	8.8
47.5	48.2	178.3	0.00	0.00	0.00	0.29	0.00	8.8
52.5	47.9	172.4	0.00	0.00	0.00	0.29	0.00	8.8
57.5	47.5	167.2	0.00	0.00	0.00	0.29	0.00	8.8
62.5	47.3	162.4	0.00	0.00	0.00	0.29	0.00	8.8
67.5	47.0	158.5	0.00	0.00	0.00	0.29	0.00	8.8
72.5	46.7	155.1	0.00	0.00	0.00	0.29	0.00	8.8
77.5	46.5	152.4	0.00	0.00	0.00	0.29	0.00	8.8
82.5	46.2	150.3	0.00	0.00	0.00	0.29	0.00	8.8
87.5	46.0	148.9	0.00	0.00	0.00	0.29	0.00	8.8
92.5	45.7	148.2	0.00	0.00	0.00	0.30	0.00	8.8
97.5W1	45.4	148.5	0.00	0.00	0.00	0.30	0.00	8.8
102.5	44.7	151.2	0.00	0.00	0.00	0.31	0.00	8.8
107.5	44.1	154.2	0.00	0.00	0.00	0.31	0.00	8.8
112.5	43.7	157.0	0.00	0.00	0.00	0.32	0.00	8.9
117.5W2	43.4	159.6	0.00	0.00	0.00	0.32	0.00	8.9
122.5	43.1	161.6	0.00	0.00	0.00	0.32	0.00	8.9
127.5	43.0	162.9	0.00	0.00	0.00	0.32	0.00	8.9
132.5	42.9	163.7	0.00	0.00	0.00	0.33	0.00	8.9
137.5	42.8	164.5	0.00	0.00	0.00	0.33	0.00	8.9
142.5	42.8	165.5	0.00	0.00	0.00	0.33	0.00	8.9
147.5	42.7	166.7	0.00	0.00	0.00	0.33	0.00	8.9
152.5	42.5	168.7	0.00	0.00	0.00	0.33	0.00	8.9
157.5	42.4	170.3	0.00	0.00	0.00	0.33	0.00	8.9
162.5	42.3	171.6	0.00	0.00	0.00	0.33	0.00	8.9
167.5	42.2	172.9	0.00	0.00	0.00	0.33	0.00	8.9
172.5	42.1	174.1	0.00	0.00	0.00	0.33	0.00	8.9
177.5	42.0	175.5	0.00	0.00	0.00	0.33	0.00	8.9
182.5	42.0	176.6	0.00	0.00	0.00	0.33	0.00	8.9
187.5	41.9	177.6	0.00	0.00	0.00	0.33	0.00	8.9
192.5	41.9	178.3	0.00	0.00	0.00	0.33	0.00	8.9
197.5	41.9	178.7	0.00	0.00	0.00	0.34	0.00	8.9

RESERVOIR MODEL RESULTS

RESERVOIR NO 2 .. CONTROL POINT 20

JULIAN DATE 130

METEOROLOGICAL DATA	EQUILIBRIUM TEMPERATURE, F	67.6
	HEAT EXCHANGE COEFFICIENT, BTU/FT2/DAY/F	95.1
	SHORT WAVE SOLAR RADIATION, BTU/FT2/DAY	2451.
	WIND SPEED, MPH	7.6
	EVAPORATION RATE, AC.FT/DAY	124.38

INFLOW DATA

TRIB NO	FLOW CFS	TEMP F	CONS.1 MG/L	CONS.2 MG/L	CONS.3 MG/L	NONCON.1 MG/L	NONCON.2 MG/L	NONCON.3 MG/L	OXYGEN MG/L
3	569.0	64.3	160.0	0.00	0.00	0.00	0.41	0.00	9.7

OUTFLOW INFORMATION

OUTLET	FLOW CFS	TEMP F	CONS.1 MG/L	CONS.2 MG/L	CONS.3 MG/L	NONCON.1 MG/L	NONCON.2 MG/L	NONCON.3 MG/L	OXYGEN MG/L
WET WELL NO 1	1040.0	56.2	185.2	0.00	0.00	0.00	0.09	0.00	8.7
TOTAL OUTFLOW	1040.0	56.2	185.2	0.00	0.00	0.00	0.09	0.00	8.7
OBJECTIVES		55.3*	180.9*	0.00	0.00	0.00	0.08*	0.00	8.4*

* INCLUDED IN WITHDRAWAL QUALITY OPTIMIZATION

RESERVOIR INFORMATION	WATER SURFACE ELEVATION, FT	962.39
	RESERVOIR SURFACE AREA, AC	26029.
	RESERVOIR STORAGE VOLUME, ACFT	548959.

RESERVOIR WATER QUALITY

DEPTH	TEMP	CONS.1	CONS.2	CONS.3	NONCON.1	NONCON.2	NONCON.3	OXYGEN
FT	F	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
1.0	62.7	189.7	0.00	0.00	0.00	0.07	0.00	9.8
3.0	62.7	189.7	0.00	0.00	0.00	0.07	0.00	9.8
5.0	62.8	189.7	0.00	0.00	0.00	0.07	0.00	9.8
7.0	62.7	189.7	0.00	0.00	0.00	0.07	0.00	9.8
9.0	62.4	189.7	0.00	0.00	0.00	0.07	0.00	9.8
11.0	61.8	189.7	0.00	0.00	0.00	0.07	0.00	9.7
13.0	60.2	189.6	0.00	0.00	0.00	0.07	0.00	9.5
15.0	59.2	189.4	0.00	0.00	0.00	0.07	0.00	9.3
17.0	58.6	189.3	0.00	0.00	0.00	0.07	0.00	9.2
19.0	58.2	189.3	0.00	0.00	0.00	0.07	0.00	9.1
21.0	57.9	189.2	0.00	0.00	0.00	0.07	0.00	9.0
23.0	57.8	189.2	0.00	0.00	0.00	0.07	0.00	9.0
25.0	57.7	189.2	0.00	0.00	0.00	0.07	0.00	9.0
27.0	57.6	189.1	0.00	0.00	0.00	0.07	0.00	9.0
29.0	57.5	189.1	0.00	0.00	0.00	0.07	0.00	9.0
31.0	57.4	189.0	0.00	0.00	0.00	0.07	0.00	8.9
33.0	57.4	189.0	0.00	0.00	0.00	0.07	0.00	8.9
35.0	57.3	188.9	0.00	0.00	0.00	0.07	0.00	8.9
37.0	57.2	188.9	0.00	0.00	0.00	0.07	0.00	8.9
39.0	57.2	188.8	0.00	0.00	0.00	0.08	0.00	8.9
41.0	57.1	188.6	0.00	0.00	0.00	0.08	0.00	8.9
43.0	57.1	188.5	0.00	0.00	0.00	0.08	0.00	8.9
45.0	57.0	188.3	0.00	0.00	0.00	0.08	0.00	8.8
47.0	56.9	188.0	0.00	0.00	0.00	0.08	0.00	8.8
49.0	56.8	187.6	0.00	0.00	0.00	0.08	0.00	8.8
51.0	56.6	187.2	0.00	0.00	0.00	0.08	0.00	8.8
53.0	56.4	186.5	0.00	0.00	0.00	0.08	0.00	8.7
55.0	56.2	185.8	0.00	0.00	0.00	0.08	0.00	8.7
57.0	56.1	185.2	0.00	0.00	0.00	0.08	0.00	8.6
59.0	55.9	184.6	0.00	0.00	0.00	0.08	0.00	8.6
61.0	55.8	184.0	0.00	0.00	0.00	0.08	0.00	8.6
63.0	55.7	183.6	0.00	0.00	0.00	0.08	0.00	8.5
65.0W1	55.6	183.1	0.00	0.00	0.00	0.08	0.00	8.5
67.0	55.6	182.7	0.00	0.00	0.00	0.08	0.00	8.5
69.0	55.4	181.8	0.00	0.00	0.00	0.08	0.00	8.5

STREAM MODEL RESULTS

JULIAN DATE 130

METEOROLOGICAL DATA (MET.ZONE 1)	EQUILIBRIUM TEMPERATURE, F	67.6
	HEAT EXCHANGE COEFFICIENT, BTU/FT2/DAY/F	95.1
	SHORT WAVE SOLAR RADIATION, BTU/FT2/DAY	2451.
	WIND SPEED, MPH	7.6

RESERVOIR RELEASES

RESERVOIR NO	FLOW CFS	TEMP F	CONS.1 MG/L	CONS.2 MG/L	CONS.3 MG/L	NONCON.1 MG/L	NONCON.2 MG/L	NONCON.3 MG/L	OXYGEN MG/L
10	1480.0	44.2	155.6	0.00	0.00	0.00	0.33	0.00	8.9
20	1040.0	56.2	185.2	0.00	0.00	0.00	0.09	0.00	8.7

LOCAL FLOWS AND WATER QUALITY

C.P. NO	FLOW CFS	TEMP F	CONS.1 MG/L	CONS.2 MG/L	CONS.3 MG/L	NONCON.1 MG/L	NONCON.2 MG/L	NONCON.3 MG/L	OXYGEN MG/L
40	398.0	64.3	160.0	0.00	0.00	0.00	0.41	0.00	9.7
50	3250.0	63.9	160.0	0.00	0.00	0.00	0.41	0.00	9.7

STREAM WATER QUALITY

LOCATION MILE		TEMP F	CONS.1 MG/L	CONS.2 MG/L	CONS.3 MG/L	NONCON.1 MG/L	NONCON.2 MG/L	NONCON.3 MG/L	OXYGEN MG/L	MEAN FLOW CFS	W/S ELEV. FT
64.81 C10		44.8	155.5	0.00	0.00	0.00	0.33	0.00	9.0	1480.0	849.8
63.44		45.2	155.5	0.00	0.00	0.00	0.33	0.00	9.1	1538.0	845.0
62.06		45.6	155.4	0.00	0.00	0.00	0.33	0.00	9.2	1596.1	840.2
60.69 C30		46.0	155.3	0.00	0.00	0.00	0.33	0.00	9.3	1654.2	836.5
3.92 C20		56.4	185.3	0.00	0.00	0.00	0.09	0.00	8.9	1040.0	858.0
2.35		56.6	185.3	0.00	0.00	0.00	0.09	0.00	9.1	1094.4	847.1
0.78 C30		57.1	185.3	0.00	0.00	0.00	0.09	0.00	9.1	1148.8	838.4
59.00 C30		51.6	169.7	0.00	0.00	0.00	0.22	0.00	9.3	2915.5	832.1
57.00		51.8	169.8	0.00	0.00	0.00	0.22	0.00	9.4	2930.9	826.0
55.00		52.0	169.8	0.00	0.00	0.00	0.21	0.00	9.5	2946.3	819.9
53.00		52.2	169.8	0.00	0.00	0.00	0.21	0.00	9.6	2961.7	813.8
51.00		52.4	169.8	0.00	0.00	0.00	0.21	0.00	9.7	2977.0	807.8
49.00		52.6	169.8	0.00	0.00	0.00	0.21	0.00	9.8	2992.4	801.7
47.00		52.8	169.8	0.00	0.00	0.00	0.21	0.00	9.9	3007.8	795.6
45.00		53.0	169.8	0.00	0.00	0.00	0.21	0.00	10.0	3023.2	789.5
43.00	T 3	54.4	168.7	0.00	0.00	0.00	0.23	0.00	10.0	3436.6	783.7
41.00 C40		54.6	168.7	0.00	0.00	0.00	0.23	0.00	10.0	3452.0	777.9
39.01 C40		54.7	168.7	0.00	0.00	0.00	0.23	0.00	10.1	3467.4	770.6
37.04		54.9	168.7	0.00	0.00	0.00	0.23	0.00	10.1	3437.1	762.2
35.06		55.0	168.7	0.00	0.00	0.00	0.23	0.00	10.1	3406.8	753.8
33.09		55.1	168.7	0.00	0.00	0.00	0.23	0.00	10.1	3376.5	745.3
31.11		55.7	168.7	0.00	0.00	0.00	0.22	0.00	10.2	3346.2	738.9
29.14	T 4	59.8	164.4	0.00	0.00	0.00	0.31	0.00	9.9	6565.8	736.7
27.16		60.1	164.4	0.00	0.00	0.00	0.31	0.00	9.9	6535.5	735.4
25.19 C50		60.3	164.4	0.00	0.00	0.00	0.30	0.00	9.9	6505.2	733.1

T = TRIBUTARY LOCATION
C = CONTROL POINT
C* = END OF REACH

TARGETS

C.P.	TEMP	CONS.1	CONS.2	CONS.3	NONCON.1	NONCON.2	NONCON.3	OXYGEN
NO	F	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
10	45.0	150.0	0.00	0.00	0.00	0.10	0.00	5.0
20	50.0	160.0	0.00	0.00	0.00	0.05	0.00	4.0
30	50.0	160.0	0.00	0.00	0.00	0.15	0.00	4.5
40	50.0	170.0	0.00	0.00	0.00	0.20	0.00	5.5
50	60.0	190.0	0.00	0.00	0.00	0.30	0.00	6.0

TEST PROBLEM 2 - Standard Tandem Reservoir Case

a. The system simulated in this test of the water quality simulation module consists of two tandem reservoirs, the reach of the stream between the reservoirs and a reach of stream below the more downstream reservoir. The system diagram is shown on the following page.

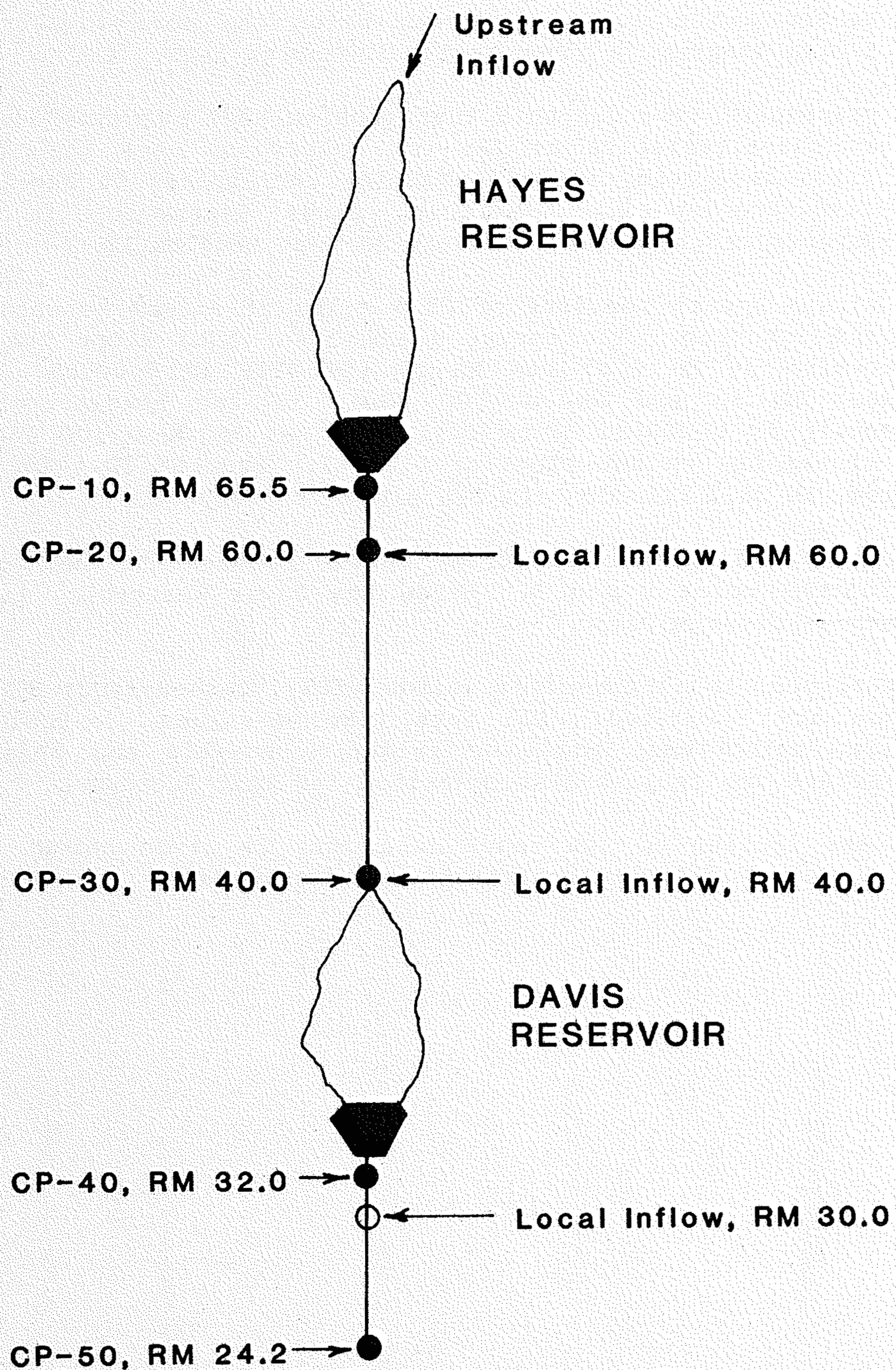
b. The reservoirs used for this test problem have the same sizes, depths and outlet characteristics as the two reservoirs used for Test Problem 1. The Hayes Reservoir, in this example, corresponds to the Baker Reservoir in Test Problem 1. Similarly, Davis Reservoir, in this example, corresponds to the Smith reservoir in Test Problem 1.

c. The stream system consists of 25.5 miles of stream between the Hayes and Davis Reservoirs. The energy grade line (EGL) slope between the Hayes Reservoir, at RM 65.5 and RM 60 (CP #20) is 0.00065. The EGL slope between RM 60 and RM 40 (CP #30), in the headwaters of the Davis Reservoir is 0.00057. From Davis dam, at RM 32.0 (CP #40) to RM 30.4, the stream has an EGL slope of 0.00012. From RM 30.4 to the end of the system, RM 24.2 (CP #5), the EGL slope is 0.000076.

d. Tributary inflows to the stream system between the two reservoirs occur at control point 20 and 30. Below the Davis Reservoir, tributary inflow occurs at river mile 30.0.

e. Temperature, total dissolved solids (TDS), carbonaceous BOD and dissolved oxygen are simulated. All data, inflow values, control points, water quality objectives, and gate selection weights and objective function parameters are furnished as described for Test Problem 1.

A complete listing of the input data file is given below. A complete output listing is included with the computer source code distribution.



EXAMPLE TANDEM RESERVOIR PROBLEM

```
T1     TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
T2     TANDEM RIVER SYSTEM
T3     TEST PROBLEM 2
J1       0       5       5       3       4       2       0       0
J2      36       0       0       0       0       0       0
J9
RL      10 1200000       0  100000  200000 1500000 1600000
RO       3      20      30      40
RS       7     100    6300   31300   88000  188000  563000 1688000
RQ       7       0   20000   30000   40000   50000   50000   50000
RA       7      10     500    1500    3000    5000   10000   20000
RE       7     800     825     850     870     900     950    1030
R3       2       2       2       2      99      99      99      99      99      99
R3      99      99
CP      10   15000     300     200
IDCP10-HAYES DAM
RT      10      20     2.2     .25      12       0
CP      20   12000     300     200
ID CP20 ** RM 60
RT      20      30     2.2     .25      12       0
CP      30   12000     300     200
ID CP30 ** RM 40
RT      30      40     2.2     .25      12       0
RL      40  550000       0    2000  550000  952000 1130000
RO       1      50
RS       8    2000   20000   52000  113000  209000  320000  550000  800000 1130000
RQ       8       0    5680    5680    5680    5680    5680   29180   59680  104980
RA       8     150    2100    4500    7600   11800   17000   22400   28600   37200
RE       8     892     910     920     930     940     950   962.5     970     980
R3       2       2       2       2      99      99      99      99      99      99
R3      99      99
CP      40   10000     300     200
IDCP40-DAVIS DAM
RT      40      50     2.2     .25      12       0
CP      50   50000     300     200
IDCP50 ** RM24.2
RT      50       0       0       0       0       0
ED
BF       0     120       0       074050100     120      24
NOLIST
IN      10  1MAY74    2059    1814    2125    2243    1947    1836    1735    1587
IN    1549    1509    1413    4584    7520    5061    3549    2931    2801    3866
IN    2752    2293    1962    1793    2476    2528    1958    1650    1462    1344
IN    1810    3581    3367    7629    5501    3699    3057    2603    2294    2073
IN    1894    1750    1596    1423    1313    1251    1052    1312    2547    2301
IN    1803    1360    1185    1200    1456    2434    4601    3121    2769    2230
IN    1846    2107    1918   15259    7046    4185    3113    3167    2814    2295
IN    1910    1606    1448    1535    1368    1196    1039    1032    1013     940
IN     890     890     865     826     783     826     928     847     788     829
IN     804     806     945     801     712     751     914     911     935     792
IN     747     717     823    1416     997     806     759     732     683     653
IN     633     639     621     644     604     598     598     596     601     642
IN     662     838     756    1130    1138    1202    1774    2727    2659    1566
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IN	20	1MAY74	645	588	561	488	452	440	425	405
IN	406	398	380	923	1207	1171	1161	1075	1190	1601
IN	1685	1941	1849	1752	1784	1322	645	397	366	458
IN	669	1011	1113	1740	1529	1352	1273	1219	1171	908
IN	575	431	407	375	357	348	243	231	469	598
IN	671	585	369	237	288	360	546	768	900	874
IN	829	712	549	2648	1733	1751	1617	1671	1565	1433
IN	922	465	361	384	353	328	298	305	296	285
IN	279	235	143	142	139	150	226	282	276	191
IN	106	139	183	220	269	268	278	283	311	249
IN	178	172	162	177	135	119	117	117	130	164
IN	161	166	160	117	61	42	51	141	142	108
IN	87	235	418	701	621	790	976	1222	1532	1570
IN	30	1MAY74	645	588	561	488	452	440	425	405
IN	406	398	380	923	1207	1171	1161	1075	1190	1601
IN	1685	1941	1849	1752	1784	1322	645	397	366	458
IN	669	1011	1113	1740	1529	1352	1273	1219	1171	908
IN	575	431	407	375	357	348	243	231	469	598
IN	671	585	369	237	288	360	546	768	900	874
IN	829	712	549	2648	1733	1751	1617	1671	1565	1433
IN	922	465	361	384	353	328	298	305	296	285
IN	279	235	143	142	139	150	226	282	276	191
IN	106	139	183	220	269	268	278	283	311	249
IN	178	172	162	177	135	119	117	117	130	164
IN	161	166	160	117	61	42	51	141	142	108
IN	87	235	418	701	621	790	976	1222	1532	1570
IN	50	1MAY74	3317	3816	3333	3150	2843	2861	2976	2831
IN	3011	3250	3265	4695	13438	10915	9154	8282	7643	7539
IN	6757	6013	4768	3744	3530	3463	3178	2914	2592	2150
IN	1941	1852	1735	1747	1903	2065	1847	1399	1148	1035
IN	978	844	714	809	784	873	969	816	1405	1972
IN	2159	1563	1308	1482	1621	1469	1155	1353	975	1469
IN	1483	1761	1469	4196	7637	5846	5734	4803	4285	3660
IN	3314	2783	1990	1912	1651	1441	937	893	1209	1028
IN	980	990	1160	785	550	695	679	705	701	786
IN	566	627	774	742	696	661	613	578	630	914
IN	930	930	918	981	1006	881	924	829	857	780
IN	684	606	637	670	578	562	558	486	458	440
IN	621	825	1619	2200	2012	1742	1687	2852	4965	4311
QA	10	1MAY74	1270	1320	1360	1410	1440	1470	1480	1480
QA	1480	1480	1790	2190	2480	3480	4490	4420	4300	4210
QA	4130	3960	3720	3370	2470	1910	1950	1940	1890	1570
QA	1270	1680	2210	2480	4000	5510	5350	4400	2930	1970
QA	1570	1570	1570	1560	1560	1530	1510	1480	1830	2690
QA	3120	2840	1640	819	854	900	1540	2750	3250	2860
QA	2100	2030	2030	3600	9280	11000	7280	4130	3250	2180
QA	1750	1470	1210	1290	1320	1320	1290	1270	1230	948
QA	570	600	610	610	621	631	642	707	764	753
QA	741	730	730	741	730	719	707	707	775	775
QA	819	786	494	819	865	654	865	831	797	764
QA	719	685	494	631	580	521	346	540	486	486
QA	521	600	438	797	1410	2000	2050	2130	3460	4590
EJ										

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TI        FICTICIOUS TANDEM RIVER BASIN TEST OF HEC-5Q WITH WATER QUALITY
TI        RESERVOIRS ARE FICTICIOUS ALSO ** C.P. OF 10, 20, 30, 40 AND 50
TI        CONSTITUENTS ARE TEMPERATURE, TDS, CARBONACEOUS BOD AND OXYGEN
JA        740501  740831       5        2        F        1
EZ             1
ET           116   67.59   105.5  2350.0    8.53
ET           117   75.54    75.0  2350.5    5.56
ET           118   72.51   155.0  2250.2   11.54
ET           119   73.50   195.0  2250.1   13.59
ET           120   74.51   125.5  2250.3    8.54
ET           121   64.56   135.8  2350.6   12.55
ET           122   62.54   115.4  2450.1   10.51
ET           123   65.54   125.3  2350.9   10.50
ET           124   60.56   105.7  2450.1   10.54
ET           125   63.56   105.6  2450.1    9.55
ET           126   57.50   125.1  2450.3   12.50
ET           127   58.55    85.7  2550.6    8.58
ET           128   66.56    95.8  2450.1    7.52
ET           129   66.56   135.3  2450.0   11.58
ET           130   67.58    95.1  2450.6    7.55
ET           131   70.53   135.1  2450.9   10.59
ET           132   66.58   145.4  2450.1   12.51
ET           133   62.56   145.1  2550.4   13.50
ET           134   72.50   145.0  2450.1   11.53
ET           135   71.59   175.2  2450.3   13.52
ET           136   74.51   135.5  2450.6    9.56
ET           137   78.51   175.4  2450.2   10.55
ET           138   75.56   125.7  2450.3    8.59
ET           139   72.54   135.9  2550.7    9.50
ET           140   73.53   115.8  2550.2    8.55
ET           141   81.53    95.9  2550.9    5.56
ET           142   77.55   145.0  2450.5    8.58
ET           143   73.54   145.7  2550.6   10.51
ET           144   68.59   155.9  2550.9   12.51
ET           145   67.54    95.2  2650.1    8.51
ET           146   69.55    95.3  2650.0    7.52
ET           147   64.59   115.9  2650.5   10.56
ET           148   71.57    95.5  2650.2    7.57
ET           149   73.54   145.0  2550.2   10.52
ET           150   80.54   105.4  2550.5    6.51
ET           151   77.53   135.9  2550.9    8.54
ET           152   70.57   135.4  2550.9   10.59
ET           153   72.59   125.6  2650.7    9.56
ET           154   78.51    85.5  2650.4    5.50
ET           155   79.57    95.9  2550.9    6.59
ET           156   76.56   135.5  2550.6    8.53
ET           157   77.55   135.5  2550.1    8.50
ET           158   75.53   175.0  2550.3   11.53
ET           159   78.50   135.6  2550.9    8.54
ET           160   82.50   135.6  2550.4    7.57
ET           161   77.57   215.1  2550.9   13.52
ET           162   69.53   175.9  2650.5   13.57
ET           163   71.57   115.4  2650.6    8.58
ET           164   73.56   105.8  2650.3    7.56
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ET	165	79.58	95.8	2650.5	5.55
ET	166	72.52	155.5	2650.4	10.55
ET	167	71.52	145.3	2650.1	10.52
ET	168	71.56	115.0	2650.7	8.54
ET	169	73.53	125.3	2650.5	8.58
ET	170	77.59	125.1	2650.1	8.51
ET	171	82.54	145.8	2550.0	8.55
ET	172	77.57	195.4	2550.1	12.54
ET	173	81.55	105.0	2550.8	6.52
ET	174	72.52	145.9	2650.9	10.51
ET	175	71.55	155.0	2650.8	11.52
ET	176	71.52	125.3	2650.1	9.50
ET	177	77.58	95.6	2650.1	6.53
ET	178	75.59	125.3	2650.7	8.53
ET	179	74.59	125.5	2650.1	8.58
ET	180	74.58	135.1	2650.1	8.54
ET	181	74.58	215.0	2550.0	14.58
ET	182	80.55	135.6	2550.8	8.51
ET	183	80.59	185.1	2550.8	10.57
ET	184	83.54	205.0	2450.3	10.56
ET	185	83.50	205.2	2450.8	10.56
ET	186	82.50	145.0	2550.8	7.58
ET	187	83.57	105.5	2550.4	5.57
ET	188	89.50	85.1	2550.7	4.54
ET	189	89.52	105.4	2550.9	4.52
ET	190	86.57	145.1	2450.9	6.55
ET	191	82.55	165.3	2450.5	8.57
ET	192	77.54	165.3	2550.5	10.55
ET	193	79.50	105.1	2550.9	6.58
ET	194	87.51	85.2	2550.5	4.50
ET	195	82.50	165.8	2450.9	9.56
ET	196	78.59	165.8	2450.7	10.53
ET	197	76.58	145.4	2550.0	9.58
ET	198	85.58	95.6	2550.9	4.59
ET	199	83.50	145.6	2450.7	7.57
ET	200	81.54	205.3	2450.6	11.50
ET	201	77.55	145.3	2450.5	9.51
ET	202	77.58	125.0	2550.5	8.50
ET	203	82.52	105.7	2450.6	6.52
ET	204	79.54	125.5	2450.3	7.59
ET	205	80.52	115.4	2450.2	6.55
ET	206	84.59	85.9	2450.7	4.50
ET	207	89.54	85.8	2450.1	3.51
ET	208	88.57	95.9	2350.6	4.55
ET	209	82.58	135.1	2350.5	7.58
ET	210	78.56	155.3	2350.3	8.53
ET	211	77.51	155.5	2350.2	9.52
ET	212	79.53	125.3	2350.3	7.57
ET	213	83.59	105.3	2350.8	5.55
ET	214	84.54	115.8	2350.0	5.58
ET	215	79.54	175.7	2250.5	10.54
ET	216	76.56	175.7	2350.9	10.55
ET	217	75.50	115.1	2350.3	7.56
ET	218	79.52	105.2	2350.8	6.59

ET	219	84.54	95.9	2250.2	4.57
ET	220	83.50	105.5	2250.9	5.59
ET	221	83.53	95.9	2250.4	5.58
ET	222	78.55	135.9	2250.7	8.59
ET	223	78.58	165.9	2250.5	9.54
ET	224	83.56	115.8	2150.0	5.58
ET	225	82.54	125.9	2150.5	6.55
ET	226	79.58	135.4	2250.7	7.56
ET	227	81.59	95.2	2250.6	5.55
ET	228	85.58	85.2	2150.8	4.55
ET	229	79.57	155.6	2150.0	8.57
ET	230	87.54	75.6	2150.9	3.52
ET	231	86.54	75.1	2150.0	3.57
ET	232	90.50	65.8	2150.1	2.53
ET	233	85.53	85.0	2150.1	4.58
ET	234	85.52	85.0	2150.5	4.53
ET	235	84.58	95.2	2050.7	4.57
ET	236	82.52	115.2	2050.5	5.58
ET	237	87.52	75.2	2050.9	3.52
ET	238	86.52	85.3	2050.6	4.51
ET	239	80.53	155.8	2050.4	8.58
ET	240	79.58	145.3	2050.1	8.59
ET	241	79.51	145.2	1950.7	8.58
ET	242	80.52	125.7	1950.4	6.59
ET	243	77.59	155.1	1950.6	9.56
ET	244	76.55	115.8	1950.0	6.50
ET	245	73.52	115.2	1950.1	7.54
ET	246	65.54	145.9	2050.9	12.50
ET	247	67.58	105.8	2050.9	8.55
ET	248	69.56	85.2	1950.8	6.50
ET	249	70.57	95.1	1950.5	7.55
ET	250	78.58	75.3	1950.2	4.55
ET	251	84.57	55.1	1850.7	2.51
ET	252	86.58	55.5	1850.6	2.57
ET	253	82.51	65.2	1850.6	3.59
ET	254	78.58	95.0	1850.5	5.50
ET	255	77.58	155.8	1750.7	8.58
ET	256	76.50	155.9	1750.1	9.56
ET	257	68.51	105.2	1850.9	7.57
ET	258	68.50	95.7	1850.5	6.59
ET	259	71.50	85.1	1750.5	5.54
ET	260	70.58	115.5	1750.5	8.51
ET	261	71.53	105.1	1750.1	7.54
ET	262	74.53	85.9	1750.1	5.51
ET	263	73.53	115.4	1650.7	7.55
ET	264	64.59	105.9	1750.2	8.58
ET	265	60.57	105.2	1750.1	9.53
ET	266	57.50	75.9	1750.6	7.54
ET	267	59.59	75.2	1750.0	6.51
ET	268	62.56	115.1	1650.1	9.54
ET	269	65.51	115.0	1650.5	9.52
ET	270	70.54	85.4	1550.5	5.53
ET	271	72.54	125.1	1550.2	8.53
ET	272	63.56	165.7	1550.3	13.51

ET	273	56.54	115.4	1550.0	11.53
ET	-274	53.71	104.9	1568.0	10.72
EZ	-2				
ET	116	67.19	100.5	2335.0	8.43
ET	117	75.04	77.0	2331.5	5.26
ET	118	72.91	155.0	2291.2	11.34
ET	119	73.40	196.0	2278.1	13.89
ET	120	74.01	127.5	2294.3	8.64
ET	121	64.06	138.8	2385.6	12.35
ET	122	62.44	111.4	2409.1	10.31
ET	123	65.44	126.3	2385.9	10.60
ET	124	60.66	107.7	2456.1	10.34
ET	125	63.36	102.6	2457.1	9.35
ET	126	57.60	124.1	2466.3	12.60
ET	127	58.75	89.7	2507.6	8.88
ET	128	66.16	90.8	2484.1	7.72
ET	129	66.36	138.3	2446.0	11.48
ET	130	67.68	96.1	2494.6	7.85
ET	131	70.23	130.1	2473.9	10.09
ET	132	66.18	147.4	2470.1	12.21
ET	133	62.56	144.1	2518.4	13.40
ET	134	72.00	149.0	2492.1	11.23
ET	135	71.49	175.2	2472.3	13.02
ET	136	74.91	133.5	2480.6	9.06
ET	137	78.21	176.4	2413.2	10.65
ET	138	75.06	127.7	2486.3	8.59
ET	139	72.84	131.9	2525.7	9.60
ET	140	73.33	118.8	2544.2	8.55
ET	141	81.63	95.9	2508.9	5.46
ET	142	77.95	142.0	2476.5	8.68
ET	143	73.94	148.7	2521.6	10.31
ET	144	68.99	151.9	2563.9	12.01
ET	145	67.24	99.2	2614.1	8.21
ET	146	69.55	97.3	2617.0	7.72
ET	147	64.69	119.9	2640.5	10.76
ET	148	71.17	97.5	2626.2	7.47
ET	149	73.54	145.0	2558.2	10.02
ET	150	80.04	107.4	2543.5	6.31
ET	151	77.13	137.9	2528.9	8.64
ET	152	70.47	132.4	2598.9	10.09
ET	153	72.09	120.6	2629.7	9.06
ET	154	78.21	86.5	2621.4	5.50
ET	155	79.57	99.9	2598.9	6.09
ET	156	76.06	133.5	2597.6	8.93
ET	157	77.65	133.5	2579.1	8.50
ET	158	75.63	175.0	2568.3	11.63
ET	159	78.80	137.6	2562.9	8.34
ET	160	82.00	138.6	2539.4	7.67
ET	161	77.77	212.1	2535.9	13.02
ET	162	69.73	170.9	2626.5	13.27
ET	163	71.67	119.4	2644.6	8.88
ET	164	73.76	105.8	2658.3	7.56
ET	165	79.68	93.8	2632.5	5.75
ET	166	72.72	153.5	2601.4	10.85

ET	167	71.62	145.3	2627.1	10.72
ET	168	71.26	110.0	2663.7	8.34
ET	169	73.63	124.3	2646.5	8.88
ET	170	77.79	129.1	2600.1	8.21
ET	171	82.04	144.8	2542.0	8.05
ET	172	77.67	199.4	2553.1	12.44
ET	173	81.25	107.0	2592.8	6.22
ET	174	72.32	143.9	2625.9	10.51
ET	175	71.35	151.0	2647.8	11.52
ET	176	71.62	129.3	2649.1	9.80
ET	177	77.68	96.6	2622.1	6.13
ET	178	75.09	129.3	2628.7	8.93
ET	179	74.39	127.5	2615.1	8.88
ET	180	74.98	130.1	2601.1	8.84
ET	181	74.88	210.0	2568.0	14.18
ET	182	80.55	135.6	2566.8	8.01
ET	183	80.89	185.1	2524.8	10.67
ET	184	83.64	204.0	2486.3	10.76
ET	185	83.70	200.2	2483.8	10.56
ET	186	82.60	140.0	2503.8	7.58
ET	187	83.17	106.5	2566.4	5.97
ET	188	89.10	87.1	2546.7	4.14
ET	189	89.42	102.4	2502.9	4.72
ET	190	86.77	141.1	2467.9	6.85
ET	191	82.85	165.3	2461.5	8.77
ET	192	77.04	165.3	2538.5	10.65
ET	193	79.90	105.1	2557.9	6.38
ET	194	87.21	86.2	2531.5	4.30
ET	195	82.40	168.8	2466.9	9.26
ET	196	78.49	168.8	2498.7	10.43
ET	197	76.98	140.4	2528.0	9.08
ET	198	85.08	91.6	2508.9	4.79
ET	199	83.80	141.6	2436.7	7.47
ET	200	81.34	201.3	2425.6	11.30
ET	201	77.05	147.3	2496.5	9.51
ET	202	77.18	127.0	2509.5	8.30
ET	203	82.02	109.7	2467.6	6.22
ET	204	79.34	124.5	2445.3	7.29
ET	205	80.82	119.4	2435.2	6.85
ET	206	84.99	86.9	2450.7	4.50
ET	207	89.44	81.8	2408.1	3.71
ET	208	88.47	90.9	2398.6	4.25
ET	209	82.58	133.1	2372.5	7.18
ET	210	78.96	151.3	2377.3	8.93
ET	211	77.41	150.5	2393.2	9.42
ET	212	79.23	127.3	2391.3	7.67
ET	213	83.59	103.3	2373.8	5.55
ET	214	84.94	111.8	2329.0	5.68
ET	215	79.84	175.7	2297.5	10.04
ET	216	76.86	172.7	2324.9	10.85
ET	217	75.70	118.1	2364.3	7.76
ET	218	79.32	102.2	2340.8	6.09
ET	219	84.34	95.9	2296.2	4.97
ET	220	83.50	107.5	2261.9	5.59

ET	221	83.93	98.9	2259.4	5.08
ET	222	78.15	134.9	2266.7	8.19
ET	223	78.78	161.9	2230.5	9.64
ET	224	83.66	114.8	2198.0	5.88
ET	225	82.54	122.9	2195.5	6.55
ET	226	79.68	132.4	2210.7	7.76
ET	227	81.79	96.2	2219.6	5.35
ET	228	85.68	86.2	2188.8	4.25
ET	229	79.77	152.6	2150.0	8.77
ET	230	87.04	73.6	2159.9	3.42
ET	231	86.54	73.1	2158.0	3.47
ET	232	90.10	67.8	2142.1	2.93
ET	233	85.53	89.0	2121.1	4.38
ET	234	85.12	89.0	2106.5	4.43
ET	235	84.78	95.2	2088.7	4.77
ET	236	82.42	110.2	2072.5	5.88
ET	237	87.62	71.2	2069.9	3.22
ET	238	86.02	88.3	2042.6	4.21
ET	239	80.53	159.8	2012.4	8.88
ET	240	79.48	145.3	2004.1	8.19
ET	241	79.11	149.2	1979.7	8.48
ET	242	80.02	122.7	1985.4	6.89
ET	243	77.29	150.1	1973.6	9.06
ET	244	76.95	112.8	1979.0	6.80
ET	245	73.62	110.2	1992.1	7.34
ET	246	65.34	149.9	2008.9	12.30
ET	247	67.48	102.8	2007.9	8.05
ET	248	69.66	89.2	1996.8	6.60
ET	249	70.47	99.1	1948.5	7.05
ET	250	78.08	71.3	1920.2	4.05
ET	251	84.67	58.1	1888.7	2.71
ET	252	86.58	50.5	1870.6	2.17
ET	253	82.51	63.2	1844.6	3.09
ET	254	78.78	98.0	1817.5	5.50
ET	255	77.58	150.8	1779.7	8.88
ET	256	76.30	152.9	1764.1	9.26
ET	257	68.81	104.2	1823.9	7.67
ET	258	68.40	92.7	1819.5	6.89
ET	259	71.20	85.1	1791.5	5.84
ET	260	70.88	113.5	1763.5	8.01
ET	261	71.83	105.1	1738.1	7.14
ET	262	74.23	83.9	1717.1	5.21
ET	263	73.63	110.4	1677.7	7.05
ET	264	64.69	107.9	1709.2	8.68
ET	265	60.17	102.2	1716.1	9.13
ET	266	57.00	77.9	1727.6	7.34
ET	267	59.29	71.2	1705.0	6.31
ET	268	62.06	114.1	1649.1	9.84
ET	269	65.01	115.0	1620.5	9.22
ET	270	70.84	87.4	1585.5	5.93
ET	271	72.84	129.1	1529.2	8.43
ET	272	63.36	163.7	1549.3	13.71
ET	273	56.34	119.4	1576.0	11.63
ET	-274	53.71	104.9	1568.0	10.72

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QC             1       0       0       0       1       0       1
TQTOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
TQCARBONACEOUS BOD IN MG/L
TQDISSOLVED OXYGEN IN MG/L
L1            10       1
L2    10       5              10      .4       1       2
LR     1   10000
L3           .01    1.-6    1.-4       0     -.7
L5    50   50000     825
L7    10    2000     820     860     900     940
L7    10    2000     840     880     920     960
L8           200     400     800    1400    2000    3000    5000
PL  0.25     100           -4.00
PL  0.05     100           -0.20
PL  0.20     100           -8.00
PL  0.25     100     3.2   -0.70    0.10   -0.05
L9            40      41      42      43      45      48      60
C1          105.    110.    115.    120.    125.    135.    145.
C5           1.5     1.5     1.0     0.5     1.0     2.5     2.5
C7           6.0     6.0     6.5     7.5     8.5     9.0     9.5
SA                      100          100       100     100     100     100     100
DK                   0.1             1.463
L2    40       2   60000       5      .4       1       1
LR
L3           .01    1.-6    1.-4       0     -.7
L5   50.   5000.    895.
L6   870   99300   962.5
L7   7.9    2840   895.5   909.5   923.5   937.5
L7   7.9    2840   902.5   916.5   930.5   944.5
L8           410     460     500     550     600     650     700     750
PL  0.25     100           -4.00
PL  0.05     100           -0.20
PL  0.20     100           -8.00
PL  0.25     100     3.2   -0.70    0.10   -0.05
L9            54      55      57      57      57      57      57      57
C1           150     155     160     165     170     180     190     200
C5           1.0     1.0     1.0     1.5     2.0     2.5     3.0     3.0
C7           5.5     5.5     6.0     6.5     7.0     8.0     9.0     9.5
SA           100     100     100     100     100     100     100
DK                    .2            1.463
CR         1.047   1.047   1.047  1.0159
S1            10       1      -1       8      20       1
S2    10    65.5      20      60     1.5                                       2
S2    20    60.0      30      40     1.5                                       3
S2     0       0       0       0
S2    40      32      50    24.2   1.975      30       4
SR    10      20       2       7
SK            1.      1.      1.      1.      1.      1.
SR    20      30       2       2
SR   -40      50       1       2
S3    10    65.5   844.0      0.      0.      0.    .050
S3          65.5   844.2      0.     .21     5.0    .050
S3          65.5   844.6     4.0     .35    20.0    .050
S3          65.5   845.0    14.0     .61    29.0    .050
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S3		65.5	846.0	54.0	1.04	50.0	.050
S3		65.5	847.0	114.0	1.40	67.0	.050
S3		65.5	848.0	194.0	1.55	99.0	.050
S3		65.5	849.0	305.0	1.84	121.0	.050
S3		65.5	850.0	440.0	2.02	152.0	.050
S3		65.5	851.0	605.0	2.20	185.0	.050
S3		65.5	852.0	827.0	2.17	264.0	.050
S3		65.5	853.0	1100.0	2.52	279.0	.050
S3		65.5	854.0	1384.0	2.87	288.0	.050
S3		65.5	855.0	1677.0	3.15	301.0	.050
S3		65.5	856.0	1985.0	3.40	316.0	.050
S3		65.5	857.0	2308.0	3.67	326.0	.050
S3		65.5	858.0	2634.0	3.99	326.0	.050
S3		65.5	859.0	2960.0	4.30	326.0	.050
S3		65.5	861.0	3612.0	4.88	326.0	.050
S3		65.5	863.0	4264.0	5.41	326.0	.050
S3	20	60.0	825.4	0.	0.	0.	.050
S3		60.0	825.6	1.0	.22	9.0	.050
S3		60.0	826.0	10.0	.43	33.0	.050
S3		60.0	826.4	27.0	.64	52.0	.050
S3		60.0	827.4	92.0	1.13	77.0	.050
S3		60.0	828.4	179.0	1.51	96.0	.050
S3		60.0	829.4	287.0	1.79	119.0	.050
S3		60.0	830.4	418.0	2.08	138.0	.050
S3		60.0	831.4	563.0	2.38	152.0	.050
S3		60.0	832.4	723.0	2.65	166.0	.050
S3		60.0	833.4	893.0	2.95	174.0	.050
S3		60.0	834.4	1071.0	3.23	183.0	.050
S3		60.0	835.4	1258.0	3.48	191.0	.050
S3		60.0	836.4	1455.0	3.64	207.0	.050
S3		60.0	837.4	1675.0	3.68	234.0	.050
S3		60.0	838.4	1922.0	3.83	253.0	.050
S3		60.0	839.4	2175.0	4.16	253.0	.050
S3		60.0	840.4	2428.0	4.48	253.0	.050
S3		60.0	842.4	2934.0	5.08	253.0	.050
S3		60.0	844.4	3440.0	5.65	253.0	.050
S3	30	40.0	765.0	0.	0.	0.	.050
S3		40.0	765.2	1.0	.22	9.0	.050
S3		40.0	765.6	10.0	.43	33.0	.050
S3		40.0	766.0	27.0	.64	52.0	.050
S3		40.0	767.0	92.0	1.13	77.0	.050
S3		40.0	768.0	179.0	1.51	96.0	.050
S3		40.0	769.0	287.0	1.79	119.0	.050
S3		40.0	770.0	418.0	2.08	138.0	.050
S3		40.0	771.0	563.0	2.38	152.0	.050
S3		40.0	772.0	723.0	2.65	166.0	.050
S3		40.0	773.0	893.0	2.95	174.0	.050
S3		40.0	774.0	1071.0	3.23	183.0	.050
S3		40.0	775.0	1258.0	3.48	191.0	.050
S3		40.0	776.0	1455.0	3.64	207.0	.050
S3		40.0	777.0	1675.0	3.68	234.0	.050
S3		40.0	778.0	1922.0	3.83	253.0	.050
S3		40.0	779.0	2175.0	4.16	253.0	.050
S3		40.0	780.0	2428.0	4.48	253.0	.050

S3		40.0	782.0	2934.0	5.08	253.0	.050
S3		40.0	784.0	3440.0	5.65	253.0	.050
S3	40	32.0	730.6	0.	0.	0.	.050
S3		32.0	730.8	0.	.21	2.0	.050
S3		32.0	731.2	2.0	.44	6.0	.050
S3		32.0	731.6	6.0	.45	19.0	.050
S3		32.0	732.6	74.0	.84	96.0	.050
S3		32.0	733.6	177.0	1.37	109.0	.050
S3		32.0	734.6	291.0	1.80	120.0	.050
S3		32.0	735.6	421.0	2.12	135.0	.050
S3		32.0	736.6	565.0	2.44	147.0	.050
S3		32.0	737.6	715.0	2.74	155.0	.050
S3		32.0	738.6	878.0	2.99	168.0	.050
S3		32.0	739.6	1050.0	3.26	176.0	.050
S3		32.0	740.6	1230.0	3.51	184.0	.050
S3		32.0	741.6	1418.0	3.74	193.0	.050
S3		32.0	742.6	1618.0	3.83	212.0	.050
S3		32.0	743.6	1844.0	3.86	239.0	.050
S3		32.0	744.6	2094.0	4.05	253.0	.050
S3		32.0	745.6	2347.0	4.37	253.0	.050
S3		32.0	747.6	2853.0	4.98	253.0	.050
S3		32.0	749.6	3359.0	5.55	253.0	.050
S3	50	30.4	722.9	0.	0.	0.	.030
S3		30.4	723.1	2.0	.22	15.0	.030
S3		30.4	723.5	14.0	.45	45.0	.030
S3		30.4	723.9	37.0	.64	74.0	.030
S3		30.4	724.9	130.0	1.12	111.0	.030
S3		30.4	725.9	271.0	1.43	167.0	.030
S3		30.4	726.9	462.0	1.72	218.0	.030
S3		30.4	727.9	701.0	2.04	257.0	.030
S3		30.4	728.9	978.0	2.34	287.0	.030
S3		30.4	729.9	1275.0	2.59	310.0	.030
S3		30.4	730.9	1599.0	2.79	337.0	.030
S3		30.4	731.9	1964.0	2.71	418.0	.030
S3		30.4	732.9	2394.0	2.98	444.0	.030
S3		30.4	733.9	2851.0	3.24	469.0	.030
S3		30.4	734.9	3342.0	3.39	518.0	.030
S3		30.4	735.9	3887.0	3.54	571.0	.030
S3		30.4	736.9	4482.0	3.74	610.0	.030
S3		30.4	737.9	5100.0	4.01	627.0	.030
S3		30.4	739.9	6390.0	4.49	662.0	.030
S3		30.4	741.9	7745.0	4.96	692.0	.030
S3	50	28.4	725.3	0.	0.	0.	.030
S3		28.4	725.5	4.0	.23	30.0	.030
S3		28.4	725.9	22.0	.48	59.0	.030
S3		28.4	726.3	51.0	.67	90.0	.030
S3		28.4	727.3	167.0	1.13	139.0	.030
S3		28.4	728.3	375.0	1.37	249.0	.030
S3		28.4	729.3	644.0	1.75	289.0	.030
S3		28.4	730.3	946.0	2.13	313.0	.030
S3		28.4	731.3	1271.0	2.46	336.0	.030
S3		28.4	732.3	1617.0	2.76	357.0	.030
S3		28.4	733.3	1985.0	3.03	379.0	.030
S3		28.4	734.3	2387.0	3.20	428.0	.030

S3		28.4	735.3	2831.0	3.41	463.0	.030	
S3		28.4	736.3	3311.0	3.55	497.0	.030	
S3		28.4	737.3	3824.0	3.73	527.0	.030	
S3		28.4	738.3	4370.0	3.86	575.0	.030	
S3		28.4	739.3	4985.0	3.99	634.0	.030	
S3		28.4	740.3	5632.0	4.20	659.0	.030	
S3		28.4	742.3	7002.0	4.58	709.0	.030	
S3		28.4	744.3	8458.0	5.02	742.0	.030	
S3	50	26.3	722.7	0.	0.	0.	.030	
S3		26.3	722.8	1.0	.22	9.0	.030	
S3		26.3	723.2	8.0	.45	26.0	.030	
S3		26.3	723.7	22.0	.62	45.0	.030	
S3		26.3	724.7	92.0	1.00	94.0	.030	
S3		26.3	725.7	219.0	1.22	167.0	.030	
S3		26.3	726.7	436.0	1.38	265.0	.030	
S3		26.3	727.7	751.0	1.58	365.0	.030	
S3		26.3	728.7	1158.0	1.86	441.0	.030	
S3		26.3	729.7	1628.0	2.17	496.0	.030	
S3		26.3	730.7	2254.0	2.19	729.0	.030	
S3		26.3	731.7	3038.0	2.44	809.0	.030	
S3		26.3	732.7	3867.0	2.74	858.0	.030	
S3		26.3	733.7	4756.0	3.00	913.0	.030	
S3		26.3	734.7	5699.0	3.23	981.0	.030	
S3		26.3	735.7	6697.0	3.45	1022.0	.030	
S3		26.3	736.7	7750.0	3.68	1067.0	.030	
S3		26.3	737.7	8825.0	3.97	1083.0	.030	
S3		26.3	739.7	11032.0	4.51	1117.0	.030	
S3		26.3	741.7	13278.0	5.08	1129.0	.030	
S3	50	24.2	721.6	0.	0.	0.	.030	
S3		24.2	721.8	6.0	.22	56.0	.030	
S3		24.2	722.2	50.0	.47	150.0	.030	
S3		24.2	722.6	118.0	.69	190.0	.030	
S3		24.2	723.6	354.0	1.13	270.0	.030	
S3		24.2	724.6	656.0	1.41	358.0	.030	
S3		24.2	725.6	1079.0	1.60	484.0	.030	
S3		24.2	726.6	1606.0	1.88	568.0	.030	
S3		24.2	727.6	2215.0	2.16	648.0	.030	
S3		24.2	728.6	2903.0	2.41	730.0	.030	
S3		24.2	729.6	3687.0	2.62	834.0	.030	
S3		24.2	730.6	4563.0	2.87	914.0	.030	
S3		24.2	731.6	5511.0	3.10	994.0	.030	
S3		24.2	732.6	6555.0	3.32	1081.0	.030	
S3		24.2	733.6	7684.0	3.50	1191.0	.030	
S3		24.2	734.6	8885.0	3.80	1211.0	.030	
S3		24.2	735.6	10105.0	4.09	1229.0	.030	
S3		24.2	736.6	11341.0	4.38	1242.0	.030	
S3		24.2	738.6	13849.0	4.93	1266.0	.030	
S3		24.2	740.6	16405.0	5.45	1289.0	.030	
S4		854	835	775	743	742	741	740
S4		739.5						
KR			0.10		1.463			
KR			0.15		1.463			
KR			0.25		1.463			
CT	10	740101	40.	3.	0.			
CT		740318	45.	3.	0.			

CT		740723	50.	3.	0.
CT		741017	45.	3.	0.
CT		741206	40.	3.	0.
CT		-741231	40.	3.	0.
CT		740101	150.	1.	0.
CT		-741231	150.	1.	0.
CT		740101	0.1	1.	0.
CT		-741231	0.1	1.	0.
CT		740101	5.	0.	30.
CT		-741231	5.	0.	30.
CT	20	740101	45	4	0
CT		740318	50	4	0
CT		740723	55	4	0
CT		741017	50	4	0
CT		741206	45	4	0
CT		-741231	42	4	0
CT		740101	160	.8	0
CT		-741231	160	.8	0
CT		740101	.05	.15	0
CT		-741231	.05	.15	0
CT		740101	4	0	50
CT		-741231	4	0	50
CT	30	740101	45.	3.	0.
CT		740510	50.	3.	0.
CT		740531	60.	3.	0.
CT		741001	55.	3.	0.
CT		-741231	45.	3.	0.
CT		740101	160.	1.	0.
CT		-741231	160.	1.	0.
CT		740101	.15	4.	0.
CT		-741231	.15	4.	0.
CT		740101	4.5	4.	0.
CT		-741231	4.5	4.	0.
CT	40	740101	45.	3.	0.
CT		740504	50.	3.	0.
CT		740514	55.	3.	0.
CT		740515	60.	3.	0.
CT		741005	55.	3.	0.
CT		741109	50.	3.	0.
CT		741214	45.	3.	0.
CT		-741231	45.	3.	0.
CT		740101	170.	1.	0.
CT		-741231	170.	1.	0.
CT		740101	0.2	1.	0.
CT		-741231	0.2	1.	0.
CT		740101	5.5	0.	30.
CT		-741231	5.5	0.	30.
CT	50	740101	50.	3.	0.
CT		740506	55.	3.	0.
CT		740510	60.	3.	0.
CT		740515	65.	3.	0.
CT		740708	70.	3.	0.
CT		740924	65.	3.	0.
CT		741018	60.	3.	0.

```
CT      741112     55.      3.      0.
CT      741206     50.      3.      0.
CT     -741231     50.      3.      0.
CT      740101    190.      1.      0.
CT     -741231    190.      1.      0.
CT      740101     0.3      1.      0.
CT     -741231     0.3      1.      0.
CT      740101     6.0      0.     30.
CT     -741231     6.0      0.     30.
I1      740101  741231
I2                   0 TRIB 1 INFLOW RATE - RES #1
I4      740101      -1  741231     -1.      -1
I2           2       0 UPPER INFLOW
I4      740101    -1.5  740408    -1.5  740422    -5.0  740708      -8.
I4      740826     -5.  741231    -1.5      -1
I2                   0 UPPER INFLOW - TOTAL DISSOLVED SOLIDS
I4      740101    105.  741231    105.      -1
I2                   0 UPPER INFLOW - CARBONACEOUS BOD
I4      740101     0.5  741231     0.5      -1
I2                   0 UPPER INFLOW - DISSOLVED OXYGEN
I4      740101    12.8  740115    13.1  740215    12.4  740315     11.8
I4      740415    11.7  740515     9.3  740615     8.9  740715      8.2
I4      740815     7.8  740915     9.7  741015    10.0  741115     11.0
I4      741215    12.4  741231    12.8      -1
I2                   0 TRIB 2 INFLOW RATE - RM 60
I4      740101      -1  741231     -1.      -1
I2           2       0 TRIB 2 - RM 60
I4      740101    -1.5  740408    -1.5  740422    -5.0  740708      -8.
I4      740826     -5. 741231    -1.5      -1
I2                   0 TRIB 2 - RM 60 - TDS
I4      740101    150.  741231    150.      -1
I2                   0 TRIB 2 - RM 60 - CBOD
I4      740101     0.5  741231     0.5      -1
I2                   0 TRIB 2 - RM 60 - DO
I4      740101    12.6  740115    12.7  740215    13.0  740315     12.6
I4      740415    11.5  740515     9.1  740615     8.6  740715      7.7
I4      740815     7.7  740915     9.0  741015     9.7  741115     11.1
I4      741215    12.6  741231    12.6      -1
I2                   0 TRIB 3 INFLOW RATE - RM 40
I4      740101      -1  741231     -1.      -1
I2           1       0 TRIB 3 - RM 40
I4      740101    -1.5  740408    -1.5  740422    -5.0  740708      -8.
I4      740826     -5.  741231    -1.5      -1
I2                   0 TRIB 3 - RM 40 - TDS
I4      740101    150.  741231    150.      -1
I2                   0 TRIB 3 - RM 40 - CBOD
I4      740101     0.5  741231     0.5      -1
I2                   0 TRIB 3 - RM 40 - DO
I4      740101    12.6  740115    12.7  740215    13.0  740315     12.6
I4      740415    11.5  740515     9.1  740615     8.6  740715      7.7
I4      740815     7.7  740915     9.0  741015     9.7  741115     11.1
I4      741215    12.6  741231    12.6      -1
I2                   0 TRIB 4 INFLOW RATE - RM 30
I4      740101      -1  741231     -1.      -1
```

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I2            1        0 TRIB 4 - RM 30
I4       740101     -1.5  740408    -1.5  740422    -3.0  740708      -6.
I4       740826      -5.  741231    -1.5      -1
I2                     0 TRIB 4 - RM 30 - TOTAL DISSOLVED SOLIDS
I4       740101     160.  741231    160.      -1
I2                     0 TRIB 4 - RM 30 - CARBONACEOUS BOD
I4       740101      0.6  741231     0.6      -1
I2           -1        0 TRIB 4 - RM 30 - DISSOLVED OXYGEN
I4       740101     100.  741231    100.      -1
ER
```

TEST PROBLEM 3 - Parallel Reservoirs with Calibration Option

The system simulated in this test of the water quality module consists of the same reservoir and stream configuration as Test Problem 1. The unique input to this test problem includes selecting the calibration option (J9 card, Field 4) and specifying the gate operation cards (G1 and G2 cards).

A complete listing of the input data deck is given below. A complete output listing is included with the computer source code distribution.

```
T1     TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
T2     PARALLEL RIVER SYSTEM...CALIBRATION OPTION
T3     TEST PROBLEM 3
J1      0       5       5       3       4       2       0       0
J2     36       0       0       0       0       0       0
J9              0       0       1
RL     10 1200000       0  100000  200000 1500000 1600000
RO      3      30      40      50
RS      7     100    6300   31300   88000  188000  563000 1688000
RQ      7       0   20000   30000   40000   50000   50000   50000
RA      7      10     500    1500    3000    5000   10000   20000
RE      7     800     825     850     870     900     950    1030
R3      2       2       2       2      99      99      99      99      99      99
R3     99      99
CP     10   20000     300     200
IDCP10-BAKER DAM
RT     10      30     2.2     .25      12       0
RL     20  550000       0    2000  550000  952000 1130000
RO      3      30      40      50
RS      8    2000   20000   52000  113000  209000  320000  550000  800000 1130000
RQ      8       0    5680    5680    5680    5680    5680   29180   59680  104980
RA      8     150    2100    4500    7600   11800   17000   22400   28600   37200
RE      8     892     910     920     930     940     950   962.5     970     980
R3      2       2       2       2      99      99      99      99      99      99
R3     99      99
CP     20   20000     300     200
IDCP20-SMITH DAM
RT     20      30     2.2     .25      12       0
CP     30   30000     300     200
IDCP30-CONF RM60
RT     30      40     2.2     .25      12       0
CP     40   30000     300     200
ID CP40 ** RM 40
RT     40      50     2.2     .25      12       0
CP     50   50000     300     200
IDCP50 ** RM24.2
RT     50       0       0       0       0       0
ED
BF      0     120       0     074050100     120      24
NOLIST
IN     10  1MAY74    2059    1814    2125    2243    1947    1836    1735    1587
IN   1549    1509    1413    4584    7520    5061    3549    2931    2801    3866
IN   2752    2293    1962    1793    2476    2528    1958    1650    1462    1344
IN   1810    3581    3367    7629    5501    3699    3057    2603    2294    2073
IN   1894    1750    1596    1423    1313    1251    1052    1312    2547    2301
IN   1803    1360    1185    1200    1456    2434    4601    3121    2769    2230
IN   1846    2107    1918   15259    7046    4185    3113    3167    2814    2295
IN   1910    1606    1448    1535    1368    1196    1039    1032    1013     940
IN    890     890     865     826     783     826     928     847     788     829
IN    804     806     945     801     712     751     914     911     935     792
IN    747     717     823    1416     997     806     759     732     683     653
IN    633     639     621     644     604     598     598     596     601     642
IN    662     838     756    1130    1138    1202    1774    2727    2659    1566
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IN	20	1MAY74	430	816	668	1979	1523	1195	1065	847
IN	698	569	455	402	472	424	415	956	613	510
IN	434	381	361	327	289	338	758	355	262	202
IN	169	133	163	192	203	181	166	212	1017	639
IN	639	366	255	194	236	596	432	284	251	745
IN	348	226	179	198	198	164	155	159	177	888
IN	348	386	197	133	134	141	181	407	212	145
IN	126	122	112	108	89	80	87	80	69	68
IN	64	58	47	53	49	39	43	46	60	60
IN	56	50	49	41	43	39	39	43	39	39
IN	47	47	49	43	47	96	151	112	473	212
IN	297	405	201	128	100	79	64	89	102	90
IN	88	165	95	83	184	1167	463	601	676	665
IN	40	1MAY74	645	588	561	488	452	440	425	405
IN	406	398	380	923	1207	1171	1161	1075	1190	1601
IN	1685	1941	1849	1752	1784	1322	645	397	366	458
IN	669	1011	1113	1740	1529	1352	1273	1219	1171	908
IN	575	431	407	375	357	348	243	231	469	598
IN	671	585	369	237	288	360	546	768	900	874
IN	829	712	549	2648	1733	1751	1617	1671	1565	1433
IN	922	465	361	384	353	328	298	305	296	285
IN	279	235	143	142	139	150	226	282	276	191
IN	106	139	183	220	269	268	278	283	311	249
IN	178	172	162	177	135	119	117	117	130	164
IN	161	166	160	117	61	42	51	141	142	108
IN	87	235	418	701	621	790	976	1222	1532	1570
IN	50	1MAY74	3317	3816	3333	3150	2843	2861	2976	2831
IN	3011	3250	3265	4695	13438	10915	9154	8282	7643	7539
IN	6757	6013	4768	3744	3530	3463	3178	2914	2592	2150
IN	1941	1852	1735	1747	1903	2065	1847	1399	1148	1035
IN	978	844	714	809	784	873	969	816	1405	1972
IN	2159	1563	1308	1482	1621	1469	1155	1353	975	1469
IN	1483	1761	1469	4196	7637	5846	5734	4803	4285	3660
IN	3314	2783	1990	1912	1651	1441	937	893	1209	1028
IN	980	990	1160	785	550	695	679	705	701	786
IN	566	627	774	742	696	661	613	578	630	914
IN	930	930	918	981	1006	881	924	829	857	780
IN	684	606	637	670	578	562	558	486	458	440
IN	621	825	1619	2200	2012	1742	1687	2852	4965	4311
QA	10	1MAY74	1270	1320	1360	1410	1440	1470	1480	1480
QA	1480	1480	1790	2190	2480	3480	4490	4420	4300	4210
QA	4130	3960	3720	3370	2470	1910	1950	1940	1890	1570
QA	1270	1680	2210	2480	4000	5510	5350	4400	2930	1970
QA	1570	1570	1570	1560	1560	1530	1510	1480	1830	2690
QA	3120	2840	1640	819	854	900	1540	2750	3250	2860
QA	2100	2030	2030	3600	9280	11000	7280	4130	3250	2180
QA	1750	1470	1210	1290	1320	1320	1290	1270	1230	948
QA	570	600	610	610	621	631	642	707	764	753
QA	741	730	730	741	730	719	707	707	775	775
QA	819	786	494	819	865	654	865	831	797	764
QA	719	685	494	631	580	521	346	540	486	486
QA	521	600	438	797	1410	2000	2050	2130	3460	4590

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QA   20  1MAY74    1236     521     387     405     442     949    1602    1572
QA 1528    1040     600     593     590     488     390     497     600     600
QA  597     495     310     220     220     220     226     325     420     417
QA  403     400     286     165     110     110     110     110     275     540
QA  637     627     518     420     420     420     420     320     227     330
QA  430     423     226     110     110     110     110     105     316     440
QA  440     437     430     226     110     110     110     110     110     110
QA  110     105     110     110     110     110     110     110     110     110
QA  110     110     110     110     110     110      75      35      35      35
QA   35      35      35      35      35      35      35      35      35      35
QA   35      35      35      35      36      38      62      85     105     125
QA  182     240     240     240     235     230     178     125     125     125
QA  125     125     125     125     285     463     601     676     665     655
EJ
TI      PARALLEL RIVER BASIN TEST WITH PRESET GATE OPERATION (CAL.MODE)
TI      RESERVOIRS ARE FICTICIOUS ALSO ** C.P. OF 10, 20, 30, 40 AND 50
TI      CONSTITUENTS ARE TEMPERATURE, TDS, CARBONACEOUS BOD AND OXYGEN
JA      740501  740831       5       2       F       0
EZ          -1
ET         121   64.06   138.8  2385.6   12.35
ET         122   62.44   111.4  2409.1   10.31
ET         123   65.44   126.3  2385.9   10.60
ET         124   60.66   107.7  2456.1   10.34
ET         125   63.36   102.6  2457.1    9.35
ET         126   57.60   124.1  2466.3   12.60
ET         127   58.75    89.7  2507.6    8.88
ET         128   66.16    90.8  2484.1    7.72
ET         129   66.36   138.3  2446.0   11.48
ET         130   67.68    96.1  2494.6    7.85
ET         131   70.23   130.1  2473.9   10.09
ET         132   66.18   147.4  2470.1   12.21
ET         133   62.56   144.1  2518.4   13.40
ET         134   72.00   149.0  2492.1   11.23
ET         135   71.49   175.2  2472.3   13.02
ET         136   74.91   133.5  2480.6    9.06
ET         137   78.21   176.4  2413.2   10.65
ET         138   75.06   127.7  2486.3    8.59
ET         139   72.84   131.9  2525.7    9.60
ET         140   73.33   118.8  2544.2    8.55
ET         141   81.63    95.9  2508.9    5.46
ET         142   77.95   142.0  2476.5    8.68
ET         143   73.94   148.7  2521.6   10.31
ET         144   68.99   151.9  2563.9   12.01
ET         145   67.24    99.2  2614.1    8.21
ET         146   69.55    97.3  2617.0    7.72
ET         147   64.69   119.9  2640.5   10.76
ET         148   71.17    97.5  2626.2    7.47
ET         149   73.54   145.0  2558.2   10.02
ET         150   80.04   107.4  2543.5    6.31
ET         151   77.13   137.9  2528.9    8.64
ET         152   70.47   132.4  2598.9   10.09
ET         153   72.09   120.6  2629.7    9.06
ET         154   78.21    86.5  2621.4    5.50
ET         155   79.57    99.9  2598.9    6.09
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ET	156	76.06	133.5	2597.6	8.93
ET	157	77.65	133.5	2579.1	8.50
ET	158	75.63	175.0	2568.3	11.63
ET	159	78.80	137.6	2562.9	8.34
ET	160	82.00	138.6	2539.4	7.67
ET	161	77.77	212.1	2535.9	13.02
ET	162	69.73	170.9	2626.5	13.27
ET	163	71.67	119.4	2644.6	8.88
ET	164	73.76	105.8	2658.3	7.56
ET	165	79.68	93.8	2632.5	5.75
ET	166	72.72	153.5	2601.4	10.85
ET	167	71.62	145.3	2627.1	10.72
ET	168	71.26	110.0	2663.7	8.34
ET	169	73.63	124.3	2646.5	8.88
ET	170	77.79	129.1	2600.1	8.21
ET	171	82.04	144.8	2542.0	8.05
ET	172	77.67	199.4	2553.1	12.44
ET	173	81.25	107.0	2592.8	6.22
ET	174	72.32	143.9	2625.9	10.51
ET	175	71.35	151.0	2647.8	11.52
ET	176	71.62	129.3	2649.1	9.80
ET	177	77.68	96.6	2622.1	6.13
ET	178	75.09	129.3	2628.7	8.93
ET	179	74.39	127.5	2615.1	8.88
ET	180	74.98	130.1	2601.1	8.84
ET	181	74.88	210.0	2568.0	14.18
ET	182	80.55	135.6	2566.8	8.01
ET	183	80.89	185.1	2524.8	10.67
ET	184	83.64	204.0	2486.3	10.76
ET	185	83.70	200.2	2483.8	10.56
ET	186	82.60	140.0	2503.8	7.58
ET	187	83.17	106.5	2566.4	5.97
ET	188	89.10	87.1	2546.7	4.14
ET	189	89.42	102.4	2502.9	4.72
ET	190	86.77	141.1	2467.9	6.85
ET	191	82.85	165.3	2461.5	8.77
ET	192	77.04	165.3	2538.5	10.65
ET	193	79.90	105.1	2557.9	6.38
ET	194	87.21	86.2	2531.5	4.30
ET	195	82.40	168.8	2466.9	9.26
ET	196	78.49	168.8	2498.7	10.43
ET	197	76.98	140.4	2528.0	9.08
ET	198	85.08	91.6	2508.9	4.79
ET	199	83.80	141.6	2436.7	7.47
ET	200	81.34	201.3	2425.6	11.30
ET	201	77.05	147.3	2496.5	9.51
ET	202	77.18	127.0	2509.5	8.30
ET	203	82.02	109.7	2467.6	6.22
ET	204	79.34	124.5	2445.3	7.29
ET	205	80.82	119.4	2435.2	6.85
ET	206	84.99	86.9	2450.7	4.50
ET	207	89.44	81.8	2408.1	3.71
ET	208	88.47	90.9	2398.6	4.25
ET	209	82.58	133.1	2372.5	7.18

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ET          210   78.96   151.3  2377.3    8.93
ET          211   77.41   150.5  2393.2    9.42
ET          212   79.23   127.3  2391.3    7.67
ET          213   83.59   103.3  2373.8    5.55
ET          214   84.94   111.8  2329.0    5.68
ET          215   79.84   175.7  2297.5   10.04
ET          216   76.86   172.7  2324.9   10.85
ET          217   75.70   118.1  2364.3    7.76
ET          218   79.32   102.2  2340.8    6.09
ET          219   84.34    95.9  2296.2    4.97
ET          220   83.50   107.5  2261.9    5.59
ET          221   83.93    98.9  2259.4    5.08
ET          222   78.15   134.9  2266.7    8.19
ET          223   78.78   161.9  2230.5    9.64
ET          224   83.66   114.8  2198.0    5.88
ET          225   82.54   122.9  2195.5    6.55
ET          226   79.68   132.4  2210.7    7.76
ET          227   81.79    96.2  2219.6    5.35
ET          228   85.68    86.2  2188.8    4.25
ET          229   79.77   152.6  2150.0    8.77
ET          230   87.04    73.6  2159.9    3.42
ET          231   86.54    73.1  2158.0    3.47
ET          232   90.10    67.8  2142.1    2.93
ET          233   85.53    89.0  2121.1    4.38
ET          234   85.12    89.0  2106.5    4.43
ET          235   84.78    95.2  2088.7    4.77
ET          236   82.42   110.2  2072.5    5.88
ET          237   87.62    71.2  2069.9    3.22
ET          238   86.02    88.3  2042.6    4.21
ET          239   80.53   159.8  2012.4    8.88
ET         -240   79.48   145.3  2004.1    8.19
QC            1       0       0       0       1       0       1
TQ    TOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
TQ    CARBONACEOUS BOD IN MG/L
TQ    DISSOLVED OXYGEN IN MG/L
L1           10       1
L2    10      5              10      .6       2       1
LR     2  10000       1    5000
L3          .01    1.-6    1.-4       0     -.7
L5    50  50000     825
L7    10   2000     820     860     900     940
L7    10   2000     840     880     920     960
L8          200     400     800    1400    2000    3000    5000
PL  0.25    100           -4.00
PL  0.05    100           -0.20
PL  0.20    100           -8.00
PL  0.25    100     3.2   -0.70    0.10   -0.05
L9           40      41      42      43      45      48      60
C1         120.    120.    120.    120.    120.    180.    180.
C5          0.5     0.5     0.5     0.5     0.5     0.5     0.5
C7          9.1     9.1     9.1     9.1     9.1     9.1     9.1
SA          100     100     100     100     100     100     100
DK                  0.1           1.463
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L2	20	2		5	.6	2	1		
LR	3	60000.							
L3		.01	1.-6	1.-4	0	-.7			
L5	1	10	895.5						
L6	870	99300	962.5						
L7	7.9	2840	895.5	909.5	923.5	937.5			
L7	7.9	2840	902.5	916.5	930.5	944.5			
L8		410	460	500	550	600	650	700	750
PL	0.25	100		-4.00					
PL	0.05	100		-0.20					
PL	0.20	100		-8.00					
PL	0.25	100	3.2	-0.70	0.10	-0.05			
L9		54	55	57	57	57	57	57	57
C1		160	190	190	190	190	190	190	190
C5		.3	.3	.3	.3	.3	.3	.3	.3
C7		8.4	8.7	9.2	9.2	9.2	9.2	9.2	9.2
SA		100	100	100	100	100	100	100	100
DK			.2		1.463				
CR		1.047	1.047	1.047	1.0159				
S1		10	1	0	10	20	1		
S2	10	65.5	30	60	1.5				
S2	20	4.7	30	0.	1.5				
S2	30	60	40	40	2	45	3		
S2	40	40	50	24.2	1.975	30	4		
SR	10	30	1	2					
SR	20	30	1	2					
SR	30	40	1	2					
SR	-40	50	1	2					
S3	10	65.5	844.0	0.	0.	0.	.050		
S3			844.2	0.	.21	5.0	.050		
S3			844.6	4.0	.35	20.0	.050		
S3			845.0	14.0	.61	29.0	.050		
S3			846.0	54.0	1.04	50.0	.050		
S3			847.0	114.0	1.40	67.0	.050		
S3			848.0	194.0	1.55	99.0	.050		
S3			849.0	305.0	1.84	121.0	.050		
S3			850.0	440.0	2.02	152.0	.050		
S3			851.0	605.0	2.20	185.0	.050		
S3			852.0	827.0	2.17	264.0	.050		
S3			853.0	1100.0	2.52	279.0	.050		
S3			854.0	1384.0	2.87	288.0	.050		
S3			855.0	1677.0	3.15	301.0	.050		
S3			856.0	1985.0	3.40	316.0	.050		
S3			857.0	2308.0	3.67	326.0	.050		
S3			858.0	2634.0	3.99	326.0	.050		
S3			859.0	2960.0	4.30	326.0	.050		
S3			861.0	3612.0	4.88	326.0	.050		
S3			863.0	4264.0	5.41	326.0	.050		
S3	30	60.	825.4	0.	0.	0.	.050		
S3			825.6	1.0	.22	9.0	.050		
S3			826.0	10.0	.43	33.0	.050		
S3			826.4	27.0	.64	52.0	.050		
S3			827.4	92.0	1.13	77.0	.050		
S3			828.4	179.0	1.51	96.0	.050		

S3			829.4	287.0	1.79	119.0	.050
S3			830.4	418.0	2.08	138.0	.050
S3			831.4	563.0	2.38	152.0	.050
S3			832.4	723.0	2.65	166.0	.050
S3			833.4	893.0	2.95	174.0	.050
S3			834.4	1071.0	3.23	183.0	.050
S3			835.4	1258.0	3.48	191.0	.050
S3			836.4	1455.0	3.64	207.0	.050
S3			837.4	1675.0	3.68	234.0	.050
S3			838.4	1922.0	3.83	253.0	.050
S3			839.4	2175.0	4.16	253.0	.050
S3			840.4	2428.0	4.48	253.0	.050
S3			842.4	2934.0	5.08	253.0	.050
S3			844.4	3440.0	5.65	253.0	.050
S3	20	4.7	859.6	0.	0.	0.	0.050
S3			859.8	1.5	0.16	24.	0.050
S3			860.2	22.0	0.46	70.	0.050
S3			860.6	56.1	0.73	104.	0.050
S3			861.6	178.2	1.28	128.	0.050
S3			862.6	307.7	1.82	134.	0.050
S3			863.6	442.8	2.28	140.	0.050
S3			864.6	583.8	2.57	142.	0.050
S3			865.6	729.1	2.97	147.	0.050
S3			866.6	878.1	3.19	149.	0.050
S3			867.6	1030.6	3.49	156.	0.050
S3			868.6	1186.8	3.78	162.	0.050
S3			869.6	1346.6	4.06	168.	0.050
S3			870.6	1510.1	4.32	174.	0.050
S3			871.6	1677.2	4.57	180.	0.050
S3			872.6	1848.0	4.81	186.	0.050
S3			873.6	2022.4	5.04	192.	0.050
S3			874.6	2200.5	5.27	198.	0.050
S3			876.6	2567.5	5.69	210.	0.050
S3			878.6	2949.1	6.10	222.	0.050
S3	30	0.	825.4	0.	0.	0.	.050
S3			825.6	1.0	.22	9.0	.050
S3			826.0	10.0	.43	33.0	.050
S3			826.4	27.0	.64	52.0	.050
S3			827.4	92.0	1.13	77.0	.050
S3			828.4	179.0	1.51	96.0	.050
S3			829.4	287.0	1.79	119.0	.050
S3			830.4	418.0	2.08	138.0	.050
S3			831.4	563.0	2.38	152.0	.050
S3			832.4	723.0	2.65	166.0	.050
S3			833.4	893.0	2.95	174.0	.050
S3			834.4	1071.0	3.23	183.0	.050
S3			835.4	1258.0	3.48	191.0	.050
S3			836.4	1455.0	3.64	207.0	.050
S3			837.4	1675.0	3.68	234.0	.050
S3			838.4	1922.0	3.83	253.0	.050
S3			839.4	2175.0	4.16	253.0	.050
S3			840.4	2428.0	4.48	253.0	.050
S3			842.4	2934.0	5.08	253.0	.050
S3			844.4	3440.0	5.65	253.0	.050

S3	40	40.0	765.0	0.	0.	0.	.050
S3			765.2	1.0	.22	9.0	.050
S3			765.6	10.0	.43	33.0	.050
S3			766.0	27.0	.64	52.0	.050
S3			767.0	92.0	1.13	77.0	.050
S3			768.0	179.0	1.51	96.0	.050
S3			769.0	287.0	1.79	119.0	.050
S3			770.0	418.0	2.08	138.0	.050
S3			771.0	563.0	2.38	152.0	.050
S3			772.0	723.0	2.65	166.0	.050
S3			773.0	893.0	2.95	174.0	.050
S3			774.0	1071.0	3.23	183.0	.050
S3			775.0	1258.0	3.48	191.0	.050
S3			776.0	1455.0	3.64	207.0	.050
S3			777.0	1675.0	3.68	234.0	.050
S3			778.0	1922.0	3.83	253.0	.050
S3			779.0	2175.0	4.16	253.0	.050
S3			780.0	2428.0	4.48	253.0	.050
S3			782.0	2934.0	5.08	253.0	.050
S3			784.0	3440.0	5.65	253.0	.050
S3	50	32.0	730.6	0.	0.	0.	.050
S3			730.8	0.	.21	2.0	.050
S3			731.2	2.0	.44	6.0	.050
S3			731.6	6.0	.45	19.0	.050
S3			732.6	74.0	.84	96.0	.050
S3			733.6	177.0	1.37	109.0	.050
S3			734.6	291.0	1.80	120.0	.050
S3			735.6	421.0	2.12	135.0	.050
S3			736.6	565.0	2.44	147.0	.050
S3			737.6	715.0	2.74	155.0	.050
S3			738.6	878.0	2.99	168.0	.050
S3			739.6	1050.0	3.26	176.0	.050
S3			740.6	1230.0	3.51	184.0	.050
S3			741.6	1418.0	3.74	193.0	.050
S3			742.6	1618.0	3.83	212.0	.050
S3			743.6	1844.0	3.86	239.0	.050
S3			744.6	2094.0	4.05	253.0	.050
S3			745.6	2347.0	4.37	253.0	.050
S3			747.6	2853.0	4.98	253.0	.050
S3			749.6	3359.0	5.55	253.0	.050
S3	50	30.4	722.9	0.	0.	0.	.030
S3			723.1	2.0	.22	15.0	.030
S3			723.5	14.0	.45	45.0	.030
S3			723.9	37.0	.64	74.0	.030
S3			724.9	130.0	1.12	111.0	.030
S3			725.9	271.0	1.43	167.0	.030
S3			726.9	462.0	1.72	218.0	.030
S3			727.9	701.0	2.04	257.0	.030
S3			728.9	978.0	2.34	287.0	.030
S3			729.9	1275.0	2.59	310.0	.030
S3			730.9	1599.0	2.79	337.0	.030
S3			731.9	1964.0	2.71	418.0	.030
S3			732.9	2394.0	2.98	444.0	.030
S3			733.9	2851.0	3.24	469.0	.030

S3			734.9	3342.0	3.39	518.0	.030
S3			735.9	3887.0	3.54	571.0	.030
S3			736.9	4482.0	3.74	610.0	.030
S3			737.9	5100.0	4.01	627.0	.030
S3			739.9	6390.0	4.49	662.0	.030
S3			741.9	7745.0	4.96	692.0	.030
S3	50	28.4	725.3	0.	0.	0.	.030
S3			725.5	4.0	.23	30.0	.030
S3			725.9	22.0	.48	59.0	.030
S3			726.3	51.0	.67	90.0	.030
S3			727.3	167.0	1.13	139.0	.030
S3			728.3	375.0	1.37	249.0	.030
S3			729.3	644.0	1.75	289.0	.030
S3			730.3	946.0	2.13	313.0	.030
S3			731.3	1271.0	2.46	336.0	.030
S3			732.3	1617.0	2.76	357.0	.030
S3			733.3	1985.0	3.03	379.0	.030
S3			734.3	2387.0	3.20	428.0	.030
S3			735.3	2831.0	3.41	463.0	.030
S3			736.3	3311.0	3.55	497.0	.030
S3			737.3	3824.0	3.73	527.0	.030
S3			738.3	4370.0	3.86	575.0	.030
S3			739.3	4985.0	3.99	634.0	.030
S3			740.3	5632.0	4.20	659.0	.030
S3			742.3	7002.0	4.58	709.0	.030
S3			744.3	8458.0	5.02	742.0	.030
S3	50	26.3	722.7	0.	0.	0.	.030
S3			722.8	1.0	.22	9.0	.030
S3			723.2	8.0	.45	26.0	.030
S3			723.7	22.0	.62	45.0	.030
S3			724.7	92.0	1.00	94.0	.030
S3			725.7	219.0	1.22	167.0	.030
S3			726.7	436.0	1.38	265.0	.030
S3			727.7	751.0	1.58	365.0	.030
S3			728.7	1158.0	1.86	441.0	.030
S3			729.7	1628.0	2.17	496.0	.030
S3			730.7	2254.0	2.19	729.0	.030
S3			731.7	3038.0	2.44	809.0	.030
S3			732.7	3867.0	2.74	858.0	.030
S3			733.7	4756.0	3.00	913.0	.030
S3			734.7	5699.0	3.23	981.0	.030
S3			735.7	6697.0	3.45	1022.0	.030
S3			736.7	7750.0	3.68	1067.0	.030
S3			737.7	8825.0	3.97	1083.0	.030
S3			739.7	11032.0	4.51	1117.0	.030
S3			741.7	13278.0	5.08	1129.0	.030
S3	50	24.2	721.6	0.	0.	0.	.030
S3			721.8	6.0	.22	56.0	.030
S3			722.2	50.0	.47	150.0	.030
S3			722.6	118.0	.69	190.0	.030
S3			723.6	354.0	1.13	270.0	.030
S3			724.6	656.0	1.41	358.0	.030
S3			725.6	1079.0	1.60	484.0	.030
S3			726.6	1606.0	1.88	568.0	.030

S3			727.6	2215.0	2.16	648.0	.030			
S3			728.6	2903.0	2.41	730.0	.030			
S3			729.6	3687.0	2.62	834.0	.030			
S3			730.6	4563.0	2.87	914.0	.030			
S3			731.6	5511.0	3.10	994.0	.030			
S3			732.6	6555.0	3.32	1081.0	.030			
S3			733.6	7684.0	3.50	1191.0	.030			
S3			734.6	8885.0	3.80	1211.0	.030			
S3			735.6	10105.0	4.09	1229.0	.030			
S3			736.6	11341.0	4.38	1242.0	.030			
S3			738.6	13849.0	4.93	1266.0	.030			
S3			740.6	16405.0	5.45	1289.0	.030			
S4		854	835	870	835	775	743	742	741	740
S4		739.5								
KR			0.10		1.463					
KR			0.15		1.463					
KR			0.20		1.463					
KR			0.25		1.463					
CT	10	740101	40.	3.	0.					
CT		740318	45.	3.	0.					
CT		740723	50.	3.	0.					
CT		741017	45.	3.	0.					
CT		741206	40.	3.	0.					
CT		-741231	40.	3.	0.					
CT		740101	150.	1.	0.					
CT		-741231	150.	1.	0.					
CT		740101	0.1	1.	0.					
CT		-741231	0.1	1.	0.					
CT		740101	5.	0.	30.					
CT		-741231	5.	0.	30.					
CT	20	740101	45	4	0					
CT		740318	50	4	0					
CT		740723	55	4	0					
CT		741017	50	4	0					
CT		741206	45	4	0					
CT		-741231	42	4	0					
CT		740101	160	.8	0					
CT		-741231	160	.8	0					
CT		740101	.05	.15	0					
CT		-741231	.05	.15	0					
CT		740101	4	0	50					
CT		-741231	4	0	50					
CT	30	740101	45.	3.	0.					
CT		740510	50.	3.	0.					
CT		740531	60.	3.	0.					
CT		741001	55.	3.	0.					
CT		-741231	45.	3.	0.					
CT		740101	160.	1.	0.					
CT		-741231	160.	1.	0.					
CT		740101	.15	4.	0.					
CT		-741231	.15	4.	0.					
CT		740101	4.5	4.	0.					
CT		-741231	4.5	4.	0.					

```
CT    40  740101     45.       3.       0.
CT        740504     50.       3.       0.
CT        740514     55.       3.       0.
CT        740515     60.       3.       0.
CT        741005     55.       3.       0.
CT        741109     50.       3.       0.
CT        741214     45.       3.       0.
CT       -741231     45.       3.       0.
CT        740101    170.       1.       0.
CT       -741231    170.       1.       0.
CT        740101     0.2       1.       0.
CT       -741231     0.2       1.       0.
CT        740101     5.5       0.      30.
CT       -741231     5.5       0.      30.
CT    50  740101     50.       3.       0.
CT        740506     55.       3.       0.
CT        740510     60.       3.       0.
CT        740515     65.       3.       0.
CT        740708     70.       3.       0.
CT        740924     65.       3.       0.
CT        741018     60.       3.       0.
CT        741112     55.       3.       0.
CT        741206     50.       3.       0.
CT       -741231     50.       3.       0.
CT        740101    190.       1.       0.
CT       -741231    190.       1.       0.
CT        740101     0.3       1.       0.
CT       -741231     0.3       1.       0.
CT        740101     6.0       0.      30.
CT       -741231     6.0       0.      30.
I1        740101  741231
I2                     0 TRIB 1 ... BAKER INFLOW RATE ... RES # 1
I4        740101    -0.5  740408    -0.5  740422    -0.7  740708    -0.3
I4        740826    -0.3  741231    -0.5      -1
I2             1       0 TRIB 1 ... BAKER INFLOW TEMPERATURE
I4        740101    -1.5  740408    -1.5  740422    -5.0  740708     -8.
I4        740826     -5.  741231    -1.5      -1
I2                     0 TRIB 1 ... BAKER INFLOW - TOTAL DISSOLVED SOLIDS
I4        740101    105.  741231    105.      -1
I2                     0 TRIB 1 ... BAKER INFLOW - CARBONACEOUS BOD
I4        740101     0.5  741231     0.5      -1
I2                     0 TRIB 1 ... BAKER INFLOW - DISSOLVED OXYGEN
I4        740101    12.8  740115    13.1  740215    12.4  740315    11.8
I4        740415    11.7  740515     9.3  740615     8.9  740715     8.2
I4        740815     7.8  740915     9.7  741015    10.0  741115    11.0
I4        741215    12.4  741231    12.8      -1
I2                     0 TRIB 2 ... SMITH INFLOW RATE ... RES # 1
I4        740101    -0.5  740408    -0.5  740422    -0.7  740708    -0.7
I4        740826    -0.7  741231    -0.5      -1
I2             1       0 TRIB 2 ... SMITH INFLOW TEMPERATURE
I4        740101    -0.1  740125     2.0  740210     1.2  740224    -1.8
I4        740310     0.1  740324   -10.4  740414   -15.8  740428   -24.3
I4        740512   -15.6  740527   -16.0  740609   -11.0  740623   -15.6
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I4         740714     -9.1  740728    -12.3  740811    -10.3  740825    -15.0
I4         740908    -15.5  740922    -17.8  741014    -11.1  741028     -6.1
I4         741110     -6.5  741124     -4.4  741208     -6.2  741231      1.5
I4             -1
I2                       0 TRIB 2 ... SMITH INFLOW - TDS
I4         740101      140  740115      110  740215      240  740315      400
I4         740415      130  740515     1095  740615       80  740715      100
I4         740815       70  740915       50  741015      100  741115       90
I4         741215      310  741231      360       -1
I2                       0 TRIB 2 ... SMITH INFLOW - CBOD
I4         740101       .2  740115       .2  740215       .4  740315       .5
I4         740415       .2  740515      1.8  740615       .1  740715       .2
I4         740815       .1  740915       .1  741015       .2  741115       .1
I4         741215       .5  741231       .6       -1
I2                       0 TRIB 2 ... SMITH INFLOW - DISSOLVED OXYGEN
I4         740101     13.1  740115     13.1  740215     12.4  740315     11.8
I4         740415     11.8  740515      9.4  740615      9.0  740715      8.3
I4         740815      7.8  740915      9.7  741015     10.0  741115     11.0
I4         741215     12.4  741231     12.8       -1
I2                       0 TRIB 3 INFLOW RATE - RM 45 & RES # 2
I4         740101       -1  741231      -1.       -1
I2              1        0TRIB 3 - RM 45
I4         740101     -1.5  740408     -1.5  740422     -3.0  740708      -4.
I4         740826      -3.  741231     -1.5       -1
I2                       0 TRIB 3 - RM 45 - TOTAL DISSOLVED SOLIDS
I4         740101     160.  741231     160.       -1
I2                       0 TRIB 3 - RM 45 - CARBONACEOUS BOD
I4         740101      0.6  741231      0.6       -1
I2                       0 TRIB 3 - RM 45 - DISSOLVED OXYGEN
I4         740101     12.8  740115     13.1  740215     12.4  740315     11.8
I4         740415     11.7  740515      9.3  740615      8.9  740715      8.2
I4         740815      7.8  740915      9.7  741015     10.0  741115     11.0
I4         741215     12.4  741231     12.8       -1
I2                       0 TRIB 4 INFLOW RATE - RM 30
I4         740826      -1.  741231      -1.       -1
I2              1        0TRIB 4 - RM 30
I4         740101     -1.5  740408     -1.5  740422     -3.0  740708      -6.
I4         740826      -5.  741231     -1.5       -1
I2                       0 TRIB 4 - RM 30 - TOTAL DISSOLVED SOLIDS
I4         740101     160.  741231     160.       -1
I2                       0 TRIB 4 - RM 30 - CARBONACEOUS BOD
I4         740101      0.6  741231      0.6       -1
I2                       0 TRIB 4 - RM 30 - DISSOLVED OXYGEN
I4         740101     12.8  740115     13.1  740215     12.4  740315     11.8
I4         740415     11.7  740515      9.3  740615      8.9  740715      8.2
I4         740815      7.8  740915      9.7  741015     10.0  741115     11.0
I4         741215     12.4  741231     12.8       -1
G1740501   740831
G2      20 740501   740515        0        0        2        2        1        3
G2      10 740501   740520        0        0        1        1        2        3
G2      20 740516   740620        0        0        3        3        1        1
G2      20 740621   740831        0        0        2        3        2        2
G2      10 740521   740710        0        0        2        2        3        3
G2      10 740711  -740831        0        0        2        1        4        2
ER
```

TEST PROBLEM 4 - Tandem Reservoirs with Phytoplankton Option

The system simulated in this test of the water quality module consists of the same reservoir and stream configuration as Test Problem 2. The unique input to this test problem, includes selecting the phytoplankton option (QC card, Field 9), omitting constituent title card (TQ cards), and specifying the necessary stream objective function values (CT cards) and the local inflow quality cards (I1-I4 cards).

A complete listing of the input data deck is given below. A complete output listing is included with the computer source code distribution.

```
T1    TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
T2    TANDEM RIVER SYSTEM...PHYTOPLANKTON OPTION
T3    TEST PROBLEM 4
J1     0       5       5       3       4       2       0       0
J2    36       0       0       0       0       0       0
J9
RL    10 1200000       0  100000  200000 1500000 1600000
RO     3       2       3       4
RS     7     100    6300   31300   88000  188000  563000 1688000
RQ     7       0   20000   30000   40000   50000   50000   50000
RA     7      10     500    1500    3000    5000   10000   20000
RE     7     800     825     850     870     900     950    1030
R3     2       2       2       2      99      99      99      99      99      99
R3    99      99
CP    10   15000     300     200
IDCP10-HAYES DAM
RT    10      20     2.2     .25      12       0
CP    20   12000     300     200
ID  CP20 ** RM60
RT    20      30     2.2     .25      12       0
CP    30   12000     300     200
ID  CP30 ** RM40
RT    30      40     2.2     .25      12       0
RL    40  550000       0    2000  550000  952000 1130000
RO     1       5
RS     8    2000   20000   52000  113000  209000  320000  550000  800000 1130000
RQ     8       0    5680    5680    5680    5680    5680   29180   59680  104980
RA     8     150    2100    4500    7600   11800   17000   22400   28600   37200
RE     8     892     910     920     930     940     950   962.5     970     980
R3     2       2       2       2      99      99      99      99      99      99
R3    99      99
CP    40   10000     300     200
IDCP40-DAVIS DAM
RT    40      50     2.2     .25      12       0
CP    50   50000     300     200
IDCP50 ** RM24.2
RT    50       0       0       0       0       0
ED
BF     0     120       0       074050100     120      24
NOLIST
IN    10  1MAY74    2059    1814    2125    2243    1947    1836    1735    1587
IN  1549    1509    1413    4584    7520    5061    3549    2931    2801    3866
IN  2752    2293    1962    1793    2476    2528    1958    1650    1462    1344
IN  1810    3581    3367    7629    5501    3699    3057    2603    2294    2073
IN  1894    1750    1596    1423    1313    1251    1052    1312    2547    2301
IN  1803    1360    1185    1200    1456    2434    4601    3121    2769    2230
IN  1846    2107    1918   15259    7046    4185    3113    3167    2814    2295
IN  1910    1606    1448    1535    1368    1196    1039    1032    1013     940
IN   890     890     865     826     783     826     928     847     788     829
IN   804     806     945     801     712     751     914     911     935     792
IN   747     717     823    1416     997     806     759     732     683     653
IN   633     639     621     644     604     598     598     596     601     642
IN   662     838     756    1130    1138    1202    1774    2727    2659    1566
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IN	20	1MAY74	645	588	561	488	452	440	425	405
IN	406	398	380	923	1207	1171	1161	1075	1190	1601
IN	1685	1941	1849	1752	1784	1322	645	397	366	458
IN	669	1011	1113	1740	1529	1352	1273	1219	1171	908
IN	575	431	407	375	357	348	243	231	469	598
IN	671	585	369	237	288	360	546	768	900	874
IN	829	712	549	2648	1733	1751	1617	1671	1565	1433
IN	922	465	361	384	353	328	298	305	296	285
IN	279	235	143	142	139	150	226	282	276	191
IN	106	139	183	220	269	268	278	283	311	249
IN	178	172	162	177	135	119	117	117	130	164
IN	161	166	160	117	61	42	51	141	142	108
IN	87	235	418	701	621	790	976	1222	1532	1570
IN	30	1MAY74	645	588	561	488	452	440	425	405
IN	406	398	380	923	1207	1171	1161	1075	1190	1601
IN	1685	1941	1849	1752	1784	1322	645	397	366	458
IN	669	1011	1113	1740	1529	1352	1273	1219	1171	908
IN	575	431	407	375	357	348	243	231	469	598
IN	671	585	369	237	288	360	546	768	900	874
IN	829	712	549	2648	1733	1751	1617	1671	1565	1433
IN	922	465	361	384	353	328	298	305	296	285
IN	279	235	143	142	139	150	226	282	276	191
IN	106	139	183	220	269	268	278	283	311	249
IN	178	172	162	177	135	119	117	117	130	164
IN	161	166	160	117	61	42	51	141	142	108
IN	87	235	418	701	621	790	976	1222	1532	1570
IN	50	1MAY74	3317	3816	3333	3150	2843	2861	2976	2831
IN	3011	3250	3265	4695	13438	10915	9154	8282	7643	7539
IN	6757	6013	4768	3744	3530	3463	3178	2914	2592	2150
IN	1941	1852	1735	1747	1903	2065	1847	1399	1148	1035
IN	978	844	714	809	784	873	969	816	1405	1972
IN	2159	1563	1308	1482	1621	1469	1155	1353	975	1469
IN	1483	1761	1469	4196	7637	5846	5734	4803	4285	3660
IN	3314	2783	1990	1912	1651	1441	937	893	1209	1028
IN	980	990	1160	785	550	695	679	705	701	786
IN	566	627	774	742	696	661	613	578	630	914
IN	930	930	918	981	1006	881	924	829	857	780
IN	684	606	637	670	578	562	558	486	458	440
IN	621	825	1619	2200	2012	1742	1687	2852	4965	4311
QA	10	1MAY74	1270	1320	1360	1410	1440	1470	1480	1480
QA	1480	1480	1790	2190	2480	3480	4490	4420	4300	4210
QA	4130	3960	3720	3370	2470	1910	1950	1940	1890	1570
QA	1270	1680	2210	2480	4000	5510	5350	4400	2930	1970
QA	1570	1570	1570	1560	1560	1530	1510	1480	1830	2690
QA	3120	2840	1640	819	854	900	1540	2750	3250	2860
QA	2100	2030	2030	3600	9280	11000	7280	4130	3250	2180
QA	1750	1470	1210	1290	1320	1320	1290	1270	1230	948
QA	570	600	610	610	621	631	642	707	764	753
QA	741	730	730	741	730	719	707	707	775	775
QA	819	786	494	819	865	654	865	831	797	764
QA	719	685	494	631	580	521	346	540	486	486
QA	521	600	438	797	1410	2000	2050	2130	3460	4590

EJ

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TI        FICTICIOUS TANDEM RIVER BASIN TEST OF HEC-5Q WITH WATER QUALITY
TI        UPPER AND LOWER RESERVOIRS ARE FICTICIOUS ALSO
TI        PHYTOPLANKTON OPTION
JA        740501  740831       5       2       F       0
EZ            -1
ET           121   64.06   138.8  2385.6   12.35
ET           122   62.44   111.4  2409.1   10.31
ET           123   65.44   126.3  2385.9   10.60
ET           124   60.66   107.7  2456.1   10.34
ET           125   63.36   102.6  2457.1    9.35
ET           126   57.60   124.1  2466.3   12.60
ET           127   58.75    89.7  2507.6    8.88
ET           128   66.16    90.8  2484.1    7.72
ET           129   66.36   138.3  2446.0   11.48
ET           130   67.68    96.1  2494.6    7.85
ET           131   70.23   130.1  2473.9   10.09
ET           132   66.18   147.4  2470.1   12.21
ET           133   62.56   144.1  2518.4   13.40
ET           134   72.00   149.0  2492.1   11.23
ET           135   71.49   175.2  2472.3   13.02
ET           136   74.91   133.5  2480.6    9.06
ET           137   78.21   176.4  2413.2   10.65
ET           138   75.06   127.7  2486.3    8.59
ET           139   72.84   131.9  2525.7    9.60
ET           140   73.33   118.8  2544.2    8.55
ET           141   81.63    95.9  2508.9    5.46
ET           142   77.95   142.0  2476.5    8.68
ET           143   73.94   148.7  2521.6   10.31
ET           144   68.99   151.9  2563.9   12.01
ET           145   67.24    99.2  2614.1    8.21
ET           146   69.55    97.3  2617.0    7.72
ET           147   64.69   119.9  2640.5   10.76
ET           148   71.17    97.5  2626.2    7.47
ET           149   73.54   145.0  2558.2   10.02
ET           150   80.04   107.4  2543.5    6.31
ET           151   77.13   137.9  2528.9    8.64
ET           152   70.47   132.4  2598.9   10.09
ET           153   72.09   120.6  2629.7    9.06
ET           154   78.21    86.5  2621.4    5.50
ET           155   79.57    99.9  2598.9    6.09
ET           156   76.06   133.5  2597.6    8.93
ET           157   77.65   133.5  2579.1    8.50
ET           158   75.63   175.0  2568.3   11.63
ET           159   78.80   137.6  2562.9    8.34
ET           160   82.00   138.6  2539.4    7.67
ET           161   77.77   212.1  2535.9   13.02
ET           162   69.73   170.9  2626.5   13.27
ET           163   71.67   119.4  2644.6    8.88
ET           164   73.76   105.8  2658.3    7.56
ET           165   79.68    93.8  2632.5    5.75
ET           166   72.72   153.5  2601.4   10.85
ET           167   71.62   145.3  2627.1   10.72
ET           168   71.26   110.0  2663.7    8.34
ET           169   73.63   124.3  2646.5    8.88
```

ET	170	77.79	129.1	2600.1	8.21
ET	171	82.04	144.8	2542.0	8.05
ET	172	77.67	199.4	2553.1	12.44
ET	173	81.25	107.0	2592.8	6.22
ET	174	72.32	143.9	2625.9	10.51
ET	175	71.35	151.0	2647.8	11.52
ET	176	71.62	129.3	2649.1	9.80
ET	177	77.68	96.6	2622.1	6.13
ET	178	75.09	129.3	2628.7	8.93
ET	179	74.39	127.5	2615.1	8.88
ET	180	74.98	130.1	2601.1	8.84
ET	181	74.88	210.0	2568.0	14.18
ET	182	80.55	135.6	2566.8	8.01
ET	183	80.89	185.1	2524.8	10.67
ET	184	83.64	204.0	2486.3	10.76
ET	185	83.70	200.2	2483.8	10.56
ET	186	82.60	140.0	2503.8	7.58
ET	187	83.17	106.5	2566.4	5.97
ET	188	89.10	87.1	2546.7	4.14
ET	189	89.42	102.4	2502.9	4.72
ET	190	86.77	141.1	2467.9	6.85
ET	191	82.85	165.3	2461.5	8.77
ET	192	77.04	165.3	2538.5	10.65
ET	193	79.90	105.1	2557.9	6.38
ET	194	87.21	86.2	2531.5	4.30
ET	195	82.40	168.8	2466.9	9.26
ET	196	78.49	168.8	2498.7	10.43
ET	197	76.98	140.4	2528.0	9.08
ET	198	85.08	91.6	2508.9	4.79
ET	199	83.80	141.6	2436.7	7.47
ET	200	81.34	201.3	2425.6	11.30
ET	201	77.05	147.3	2496.5	9.51
ET	202	77.18	127.0	2509.5	8.30
ET	203	82.02	109.7	2467.6	6.22
ET	204	79.34	124.5	2445.3	7.29
ET	205	80.82	119.4	2435.2	6.85
ET	206	84.99	86.9	2450.7	4.50
ET	207	89.44	81.8	2408.1	3.71
ET	208	88.47	90.9	2398.6	4.25
ET	209	82.58	133.1	2372.5	7.18
ET	210	78.96	151.3	2377.3	8.93
ET	211	77.41	150.5	2393.2	9.42
ET	212	79.23	127.3	2391.3	7.67
ET	213	83.59	103.3	2373.8	5.55
ET	214	84.94	111.8	2329.0	5.68
ET	215	79.84	175.7	2297.5	10.04
ET	216	76.86	172.7	2324.9	10.85
ET	217	75.70	118.1	2364.3	7.76
ET	218	79.32	102.2	2340.8	6.09
ET	219	84.34	95.9	2296.2	4.97
ET	220	83.50	107.5	2261.9	5.59
ET	221	83.93	98.9	2259.4	5.08
ET	222	78.15	134.9	2266.7	8.19
ET	223	78.78	161.9	2230.5	9.64

ET		224	83.66	114.8	2198.0	5.88			
ET		225	82.54	122.9	2195.5	6.55			
ET		226	79.68	132.4	2210.7	7.76			
ET		227	81.79	96.2	2219.6	5.35			
ET		228	85.68	86.2	2188.8	4.25			
ET		229	79.77	152.6	2150.0	8.77			
ET		230	87.04	73.6	2159.9	3.42			
ET		231	86.54	73.1	2158.0	3.47			
ET		232	90.10	67.8	2142.1	2.93			
ET		233	85.53	89.0	2121.1	4.38			
ET		234	85.12	89.0	2106.5	4.43			
ET		235	84.78	95.2	2088.7	4.77			
ET		236	82.42	110.2	2072.5	5.88			
ET		237	87.62	71.2	2069.9	3.22			
ET		238	86.02	88.3	2042.6	4.21			
ET		239	80.53	159.8	2012.4	8.88			
ET		-240	79.48	145.3	2004.1	8.19			
QC		1	1	1	1	1	1	1	1
L1		10	1						
L2	10	5		10	.6	2	1		
LR	1	10000							
L3		.01	1.-6	1.-4	0	-.7			
L5	50	50000	825						
L7	10	2000	820	860	900	940			
L7	10	2000	840	880	920	960			
L8		200	400	800	1400	2000	3000	5000	
PL	0.25	100		-4.00					
PL	0.05	100		-0.20					
PL	0.10	100		-8.00					
PL	0.10	100		-8.00					
PL	0.05	100		-8.00					
PL	0.20	100		-8.00					
PL	0.20	100	-22.60	-18.80	-6.55	-0.77			
PL	0.25	100	3.20	-0.70	0.10	-0.05			
L9		40	41	42	43	45	48	60	
C1		105.	105.	105.	105.	105.	105.	105.	
C2		.1	.1	.1	.1	.05	.02	.02	
C3		.05	.05	.05	.05	.05	.02	.02	
C4		.1	.1	.1	.1	.2	.3	.5	
C5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	
C6		.1	.1	.1	.1	.1	.05	.05	
C7		9.1	9.1	9.1	9.1	9.1	9.1	9.1	
SA		100	100	100	100	100	100	100	
SB		10	10	10	10	10	10	10	
SC		5	5	5	5	5	5	5	
K1		-1	-1	-1	-1	-1	-1	-1	32.
K2									
K2									
K3		-1	-1	-1	-1				
DK			.2	.1	1.463				
L2	40	2	60000	5	.6	2	1		
LR									
L3		.01	1.-6	1.-4	0	-.7			
L5	1	10	895.5						

L6	870	99300	962.5							
L7	7.9	2840	895.5	909.5	923.5	937.5				
L7	7.9	2840	902.5	916.5	930.5	944.5				
L8		410	460	500	550	600	650	700	750	
PL	0.25	100		-4.00						
PL	0.05	100		-0.20						
PL	0.10	100		-8.00						
PL	0.10	100		-8.00						
PL	0.05	100		-8.00						
PL	0.20	100		-8.00						
PL	0.20	100	-22.60	-18.80	-6.55	-0.77				
PL	0.25	100	3.20	-0.70	0.10	-0.05				
L9		54	55	57	57	57	57	57	57	
C1		105.	105.	105.	105.	105.	105.	105.	105.	
C2		.1	.1	.1	.1	.05	.02	.02	.02	
C3		.05	.05	.05	.05	.05	.02	.02	.02	
C4		.1	.1	.1	.1	.2	.3	.5	.5	
C5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	.5	
C6		.1	.1	.1	.1	.1	.05	.05	.05	
C7		9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	
SA		100	100	100	100	100	100	100	100	
SB		10	10	10	10	10	10	10	10	
SC		5	5	5	5	5	5	5	5	
K1		-1	-1	-1	-1	-1	-1	-1	32.5	
K2										
K2										
K3		-1	-1	26	34					
DK			.2	.1	1.463					
CR		1.047	1.047	1.047	1.0159					
S1		10	1	-1	8	20	1			
S2	10	65.5	20	60	1.5					2
S2	20	60.0	30	40	1.5					3
S2	0	0	0	0	1					
S2	40	32	50	24.2	1.975	30	4			
SR	10	20	1	2						
SR	20	30	1	2						
SR	-40	50	1	2						
S3	10	65.5	844.0	0.	0.	0.	.050			
S3		65.5	844.2	0.	.21	5.0	.050			
S3		65.5	844.6	4.0	.35	20.0	.050			
S3		65.5	845.0	14.0	.61	29.0	.050			
S3		65.5	846.0	54.0	1.04	50.0	.050			
S3		65.5	847.0	114.0	1.40	67.0	.050			
S3		65.5	848.0	194.0	1.55	99.0	.050			
S3		65.5	849.0	305.0	1.84	121.0	.050			
S3		65.5	850.0	440.0	2.02	152.0	.050			
S3		65.5	851.0	605.0	2.20	185.0	.050			
S3		65.5	852.0	827.0	2.17	264.0	.050			
S3		65.5	853.0	1100.0	2.52	279.0	.050			
S3		65.5	854.0	1384.0	2.87	288.0	.050			
S3		65.5	855.0	1677.0	3.15	301.0	.050			
S3		65.5	856.0	1985.0	3.40	316.0	.050			
S3		65.5	857.0	2308.0	3.67	326.0	.050			
S3		65.5	858.0	2634.0	3.99	326.0	.050			

S3		65.5	859.0	2960.0	4.30	326.0	.050
S3		65.5	861.0	3612.0	4.88	326.0	.050
S3		65.5	863.0	4264.0	5.41	326.0	.050
S3	20	60.0	825.4	0.	0.	0.	.050
S3		60.0	825.6	1.0	.22	9.0	.050
S3		60.0	826.0	10.0	.43	33.0	.050
S3		60.0	826.4	27.0	.64	52.0	.050
S3		60.0	827.4	92.0	1.13	77.0	.050
S3		60.0	828.4	179.0	1.51	96.0	.050
S3		60.0	829.4	287.0	1.79	119.0	.050
S3		60.0	830.4	418.0	2.08	138.0	.050
S3		60.0	831.4	563.0	2.38	152.0	.050
S3		60.0	832.4	723.0	2.65	166.0	.050
S3		60.0	833.4	893.0	2.95	174.0	.050
S3		60.0	834.4	1071.0	3.23	183.0	.050
S3		60.0	835.4	1258.0	3.48	191.0	.050
S3		60.0	836.4	1455.0	3.64	207.0	.050
S3		60.0	837.4	1675.0	3.68	234.0	.050
S3		60.0	838.4	1922.0	3.83	253.0	.050
S3		60.0	839.4	2175.0	4.16	253.0	.050
S3		60.0	840.4	2428.0	4.48	253.0	.050
S3		60.0	842.4	2934.0	5.08	253.0	.050
S3		60.0	844.4	3440.0	5.65	253.0	.050
S3	30	40.0	765.0	0.	0.	0.	.050
S3		40.0	765.2	1.0	.22	9.0	.050
S3		40.0	765.6	10.0	.43	33.0	.050
S3		40.0	766.0	27.0	.64	52.0	.050
S3		40.0	767.0	92.0	1.13	77.0	.050
S3		40.0	768.0	179.0	1.51	96.0	.050
S3		40.0	769.0	287.0	1.79	119.0	.050
S3		40.0	770.0	418.0	2.08	138.0	.050
S3		40.0	771.0	563.0	2.38	152.0	.050
S3		40.0	772.0	723.0	2.65	166.0	.050
S3		40.0	773.0	893.0	2.95	174.0	.050
S3		40.0	774.0	1071.0	3.23	183.0	.050
S3		40.0	775.0	1258.0	3.48	191.0	.050
S3		40.0	776.0	1455.0	3.64	207.0	.050
S3		40.0	777.0	1675.0	3.68	234.0	.050
S3		40.0	778.0	1922.0	3.83	253.0	.050
S3		40.0	779.0	2175.0	4.16	253.0	.050
S3		40.0	780.0	2428.0	4.48	253.0	.050
S3		40.0	782.0	2934.0	5.08	253.0	.050
S3		40.0	784.0	3440.0	5.65	253.0	.050
S3	40	32.0	730.6	0.	0.	0.	.050
S3		32.0	730.8	0.	.21	2.0	.050
S3		32.0	731.2	2.0	.44	6.0	.050
S3		32.0	731.6	6.0	.45	19.0	.050
S3		32.0	732.6	74.0	.84	96.0	.050
S3		32.0	733.6	177.0	1.37	109.0	.050
S3		32.0	734.6	291.0	1.80	120.0	.050
S3		32.0	735.6	421.0	2.12	135.0	.050
S3		32.0	736.6	565.0	2.44	147.0	.050
S3		32.0	737.6	715.0	2.74	155.0	.050
S3		32.0	738.6	878.0	2.99	168.0	.050

S3		32.0	739.6	1050.0	3.26	176.0	.050
S3		32.0	740.6	1230.0	3.51	184.0	.050
S3		32.0	741.6	1418.0	3.74	193.0	.050
S3		32.0	742.6	1618.0	3.83	212.0	.050
S3		32.0	743.6	1844.0	3.86	239.0	.050
S3		32.0	744.6	2094.0	4.05	253.0	.050
S3		32.0	745.6	2347.0	4.37	253.0	.050
S3		32.0	747.6	2853.0	4.98	253.0	.050
S3		32.0	749.6	3359.0	5.55	253.0	.050
S3	50	30.4	722.9	0.	0.	0.	.030
S3		30.4	723.1	2.0	.22	15.0	.030
S3		30.4	723.5	14.0	.45	45.0	.030
S3		30.4	723.9	37.0	.64	74.0	.030
S3		30.4	724.9	130.0	1.12	111.0	.030
S3		30.4	725.9	271.0	1.43	167.0	.030
S3		30.4	726.9	462.0	1.72	218.0	.030
S3		30.4	727.9	701.0	2.04	257.0	.030
S3		30.4	728.9	978.0	2.34	287.0	.030
S3		30.4	729.9	1275.0	2.59	310.0	.030
S3		30.4	730.9	1599.0	2.79	337.0	.030
S3		30.4	731.9	1964.0	2.71	418.0	.030
S3		30.4	732.9	2394.0	2.98	444.0	.030
S3		30.4	733.9	2851.0	3.24	469.0	.030
S3		30.4	734.9	3342.0	3.39	518.0	.030
S3		30.4	735.9	3887.0	3.54	571.0	.030
S3		30.4	736.9	4482.0	3.74	610.0	.030
S3		30.4	737.9	5100.0	4.01	627.0	.030
S3		30.4	739.9	6390.0	4.49	662.0	.030
S3		30.4	741.9	7745.0	4.96	692.0	.030
S3	50	28.4	725.3	0.	0.	0.	.030
S3		28.4	725.5	4.0	.23	30.0	.030
S3		28.4	725.9	22.0	.48	59.0	.030
S3		28.4	726.3	51.0	.67	90.0	.030
S3		28.4	727.3	167.0	1.13	139.0	.030
S3		28.4	728.3	375.0	1.37	249.0	.030
S3		28.4	729.3	644.0	1.75	289.0	.030
S3		28.4	730.3	946.0	2.13	313.0	.030
S3		28.4	731.3	1271.0	2.46	336.0	.030
S3		28.4	732.3	1617.0	2.76	357.0	.030
S3		28.4	733.3	1985.0	3.03	379.0	.030
S3		28.4	734.3	2387.0	3.20	428.0	.030
S3		28.4	735.3	2831.0	3.41	463.0	.030
S3		28.4	736.3	3311.0	3.55	497.0	.030
S3		28.4	737.3	3824.0	3.73	527.0	.030
S3		28.4	738.3	4370.0	3.86	575.0	.030
S3		28.4	739.3	4985.0	3.99	634.0	.030
S3		28.4	740.3	5632.0	4.20	659.0	.030
S3		28.4	742.3	7002.0	4.58	709.0	.030
S3		28.4	744.3	8458.0	5.02	742.0	.030
S3	50	26.3	722.7	0.	0.	0.	.030
S3		26.3	722.8	1.0	.22	9.0	.030
S3		26.3	723.2	8.0	.45	26.0	.030
S3		26.3	723.7	22.0	.62	45.0	.030
S3		26.3	724.7	92.0	1.00	94.0	.030

S3		26.3	725.7	219.0	1.22	167.0	.030	
S3		26.3	726.7	436.0	1.38	265.0	.030	
S3		26.3	727.7	751.0	1.58	365.0	.030	
S3		26.3	728.7	1158.0	1.86	441.0	.030	
S3		26.3	729.7	1628.0	2.17	496.0	.030	
S3		26.3	730.7	2254.0	2.19	729.0	.030	
S3		26.3	731.7	3038.0	2.44	809.0	.030	
S3		26.3	732.7	3867.0	2.74	858.0	.030	
S3		26.3	733.7	4756.0	3.00	913.0	.030	
S3		26.3	734.7	5699.0	3.23	981.0	.030	
S3		26.3	735.7	6697.0	3.45	1022.0	.030	
S3		26.3	736.7	7750.0	3.68	1067.0	.030	
S3		26.3	737.7	8825.0	3.97	1083.0	.030	
S3		26.3	739.7	11032.0	4.51	1117.0	.030	
S3		26.3	741.7	13278.0	5.08	1129.0	.030	
S3	50	24.2	721.6	0.	0.	0.	.030	
S3		24.2	721.8	6.0	.22	56.0	.030	
S3		24.2	722.2	50.0	.47	150.0	.030	
S3		24.2	722.6	118.0	.69	190.0	.030	
S3		24.2	723.6	354.0	1.13	270.0	.030	
S3		24.2	724.6	656.0	1.41	358.0	.030	
S3		24.2	725.6	1079.0	1.60	484.0	.030	
S3		24.2	726.6	1606.0	1.88	568.0	.030	
S3		24.2	727.6	2215.0	2.16	648.0	.030	
S3		24.2	728.6	2903.0	2.41	730.0	.030	
S3		24.2	729.6	3687.0	2.62	834.0	.030	
S3		24.2	730.6	4563.0	2.87	914.0	.030	
S3		24.2	731.6	5511.0	3.10	994.0	.030	
S3		24.2	732.6	6555.0	3.32	1081.0	.030	
S3		24.2	733.6	7684.0	3.50	1191.0	.030	
S3		24.2	734.6	8885.0	3.80	1211.0	.030	
S3		24.2	735.6	10105.0	4.09	1229.0	.030	
S3		24.2	736.6	11341.0	4.38	1242.0	.030	
S3		24.2	738.6	13849.0	4.93	1266.0	.030	
S3		24.2	740.6	16405.0	5.45	1289.0	.030	
S4		854	835	775	743	742	741	740
S4		739.5						
KR			0.10	.2	1.463			
KR			0.15	.2	1.463			
KR			0.25	.2	1.463			
CT	10	740101	40.	3.	0.			
CT		740318	45.	3.	0.			
CT		740723	50.	3.	0.			
CT		741017	45.	3.	0.			
CT		741206	40.	3.	0.			
CT		-741231	40.	3.	0.			
CT		740101	150.	1.	0.			
CT		-741231	150.	1.	0.			
CT		740101	.01	1.	0.			
CT		-741231	.01	1.	0.			
CT		740101	.001	1.	0.			
CT		-741231	.001	1.	0.			
CT		740101	.001	1.	0.			
CT		-741231	.001	1.	0.			
CT		740101	0.1	1.	0.			

CT		-741231	0.1	1.	0.
CT		740101	.10	1.	0.
CT		-741231	.10	1.	0.
CT		740101	5.	0.	30.
CT		-741231	5.	0.	30.
CT	20	740101	45	4	0
CT		740318	50	4	0
CT		740723	55	4	0
CT		741017	50	4	0
CT		741206	45	4	0
CT		-741231	42	4	0
CT		740101	160	.8	0
CT		-741231	160	.8	0
CT		740101	.01	1.	0.
CT		-741231	.01	1.	0.
CT		740101	.001	1.	0.
CT		-741231	.001	1.	0.
CT		740101	.001	1.	0.
CT		-741231	.001	1.	0.
CT		740101	.05	.15	0
CT		-741231	.05	.15	0
CT		740101	.10	1.	0.
CT		-741231	.10	1.	0.
CT		740101	4	0	50
CT		-741231	4	0	50
CT	30	740101	45.	3.	0.
CT		740510	50.	3.	0.
CT		740531	60.	3.	0.
CT		741001	55.	3.	0.
CT		-741231	45.	3.	0.
CT		740101	160.	1.	0.
CT		-741231	160.	1.	0.
CT		740101	.01	1.	0.
CT		-741231	.01	1.	0.
CT		740101	.001	1.	0.
CT		-741231	.001	1.	0.
CT		740101	.001	1.	0.
CT		-741231	.001	1.	0.
CT		740101	.15	4.	0.
CT		-741231	.15	4.	0.
CT		740101	.10	1.	0.
CT		-741231	.10	1.	0.
CT		740101	4.5	4.	0.
CT		-741231	4.5	4.	0.
CT	40	740101	45.	3.	0.
CT		740504	50.	3.	0.
CT		740514	55.	3.	0.
CT		740515	60.	3.	0.
CT		741005	55.	3.	0.
CT		741109	50.	3.	0.
CT		741214	45.	3.	0.
CT		-741231	45.	3.	0.
CT		740101	170.	1.	0.
CT		-741231	170.	1.	0.

```
CT        740101    .01        1.       0.
CT       -741231    .01        1.       0.
CT        740101    .001       1.       0.
CT       -741231    .001       1.       0.
CT        740101    .001       1.       0.
CT       -741231    .001       1.       0.
CT        740101    0.2        1.       0.
CT       -741231    0.2        1.       0.
CT        740101     .10       1.       0.
CT       -741231     .10       1.       0.
CT        740101    5.5        0.      30.
CT       -741231    5.5        0.      30.
CT    50  740101    50.        3.       0.
CT        740506    55.        3.       0.
CT        740510    60.        3.       0.
CT        740515    65.        3.       0.
CT        740708    70.        3.       0.
CT        740924    65.        3.       0.
CT        741018    60.        3.       0.
CT        741112    55.        3.       0.
CT        741206    50.        3.       0.
CT       -741231    50.        3.       0.
CT        740101   190.        1.       0.
CT       -741231   190.        1.       0.
CT        740101    .01        1.       0.
CT       -741231    .01        1.       0.
CT        740101    .001       1.       0.
CT       -741231    .001       1.       0.
CT        740101    .001       1.       0.
CT       -741231    .001       1.       0.
CT        740101     0.3       1.       0.
CT       -741231     0.3       1.       0.
CT        740101     .10       1.       0.
CT       -741231     .10       1.       0.
CT        740101     6.0       0.      30.
CT       -741231     6.0       0.      30.
I1        740101  741231
I2                      0 TRIB 1 INFLOW RATE - RES #1
I4        740101       -1  741231     -1.       -1
I2             1        0 HAYES INFLOW.. TEMP
I4        740101     -1.5  740408     -1.5  740422     -5.0  740708      -8.
I4        740826      -5.  741231     -1.5      -1
I2                      0 HAYES INFLOW - TDS
I4        740101     105.  741231     105.      -1
I2                      0 TYPICAL NO3 - N
I4        740101     .10   741231     .10       -1
I2                      0 TYPICAL PO4 - P
I4        740101     .03   741231     .03       -1
I2                      0 TYPICAL PHYTOPLANKTON
I4        740101     .25   741231     .25       -1
I2                      0 HAYES INFLOW - CBOD
I4        740101      0.5   41231      0.5      -1
I2                      0 TYPICAL NH3 - N
I4        740101     .03   741231     .03       -1
```

```
I2                        0 HAYES INFLOW - DO
I4        740101     12.8  740115     13.1  740215     12.4  740315     11.8
I4        740415     11.7  740515      9.3  740615      8.9  740715      8.2
I4        740815      7.8  740915      9.7  741015     10.0  741115     11.0
I4        741215     12.4  741231     12.8       -1
I2                        0 TRIB 2 INFLOW RATE - RM 60
I4        740101       -1  741231      -1.       -1
I2             1          0 TRIB 2 - RM 60.. TEMP
I4        740101     -1.5  740408     -1.5  740422     -5.0  740708      -8.
I4        740826      -5.  741231     -1.5       -1
I2                        0 TRIB 2 - RM 60 - TDS
I4        740101     150.  741231     150.       -1
I2                        0 TYPICAL NO3 - N
I4        740101     .10   741231     .10        -1
I2                        0 TYPICAL PO4 - P
I4        740101     .03   741231     .03        -1
I2                        0 TYPICAL PHYTOPLANKTON
I4        740101     .25   741231     .25        -1
I2                        0 TRIB 2 - RM 60 - CBOD
I4        740101      0.5  741231      0.5       -1
I2                        0 TYPICAL NH3 - N
I4        740101     .03   741231     .03        -1
I2                        0 TRIB 2 - RM 60 - DO
I4        740101     12.6  740115     12.7  740215     13.0  740315     12.6
I4        740415     11.5  740515      9.1  740615      8.6  740715      7.7
I4        740815      7.7  740915      9.0  741015      9.7  741115     11.1
I4        741215     12.6  741231     12.6       -1
I2                        0 TRIB 3 INFLOW RATE - RM 40
I4        740101       -1  741231      -1.       -1
I2             1          0 TRIB 3 - RM 40.. TEMP
I4        740101     -1.5  740408     -1.5  740422     -5.0  740708      -8.
I4        740826      -5.  741231     -1.5       -1
I2                        0 TRIB 3 - RM 40 - TDS
I4        740101     150.  741231     150.       -1
I2                        0 TYPICAL NO3 - N
I4        740101     .10   741231     .10        -1
I2                        0 TYPICAL PO4 - P
I4        740101     .03   741231     .03        -1
I2                        0 TYPICAL PHYTOPLANKTON
I4        740101     .25   741231     .25        -1
I2                        0 TRIB 3 - RM 40 - CBOD
I4        740101      0.5  741231      0.5       -1
I2                        0 TYPICAL NH3 - N
I4        740101     .03   741231     .03        -1
I2                        0 TRIB 3 - RM 40 - DO
I4        740101     12.6  740115     12.7  740215     13.0  740315     12.6
I4        740415     11.5  740515      9.1  740615      8.6  740715      7.7
I4        740815      7.7  740915      9.0  741015      9.7  741115     11.1
I4        741215     12.6  741231     12.6       -1
I2                        0 TRIB 4 INFLOW RATE - RM 30
I4        740101       -1  741231      -1.       -1
I2             1          OTRIB 4 - RM 30.. TEMP
I4        740101     -1.5  740408     -1.5  740422     -3.0  740708      -6.
I4        740826     -5.   741231     -1.5       -1
```

```
I2                       0 TRIB 4 - RM 30 - TDS
I4        740101    160.  741231    160.      -1
I2                       0 TYPICAL NO3 - N
I4        740101    .10   741231    .10       -1
I2                       0 TYPICAL PO4 - P
I4        740101    .03   741231    .03       -1
I2                       0 TYPICAL PHYTOPLANKTON
I4        740101    .25   741231    .25       -1
I2                       0 TRIB 4 - RM 30 - CBOD
I4        740101     0.6  741231     0.6      -1
I2                       0 TYPICAL NH3 - N
I4        740101    .03   741231    .03       -1
I2            -1         0 TRIB 4 - RM 30 - DO
I4        740101    100.  741231    100.      -1
ER
```

TEST PROBLEM 5 - Tandem Reservoirs with Steady State Option

The system simulated in this test of the water quality module consists of the same reservoir and stream configuration as Test Problem 2. The unique input to this test problem, includes selecting the steady state option (J9 card, Field 3), and specifying the time series (IN cards) and reservoir releases (QA cards) on a monthly basis (BF card, Fields 2 and 6 = 5's and Field 7 = 720 hours).

A complete listing of the input data deck is given below. A complete output listing is included with the computer source code distribution.

```
T1    TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
T2    TANDEM RIVER SYSTEM...STEADY STATE CONDITIONS
T3    TEST PROBLEM 5
J1     0       5       5       3       4       2       0       0
J2     0       0       0       0       0       0       0
J9                     1       0
RL    10 1200000       0  100000  200000 1500000 1600000
RO     3      20      30      40
RS     7     100    6300   31300   88000  188000  563000 1688000
RQ     7       0   20000   30000   40000   50000   50000   50000
RA     7      10     500    1500    3000    5000   10000   20000
RE     7     800     825     850     870     900     950    1030
R3     2       2       2       2      99      99      99      99      99      99
R3    99      99
CP    10   15000     300     200
IDCP10-HAYES DAM
RT    10      20     2.2     .25      12       0
CP    20   12000     300     200
ID  CP20 ** RM60
RT    20      30     2.2     .25      12       0
CP    30   12000     300     200
ID  CP30 ** RM40
RT    30      40     2.2     .25      12       0
RL    40  550000       0    2000  550000  952000 1130000
RO     1      50
RS     8    2000   20000   52000  113000  209000  320000  550000  800000 1130000
RQ     8       0    5680    5680    5680    5680    5680   29180   59680  104980
RA     8     150    2100    4500    7600   11800   17000   22400   28600   37200
RE     8     892     910     920     930     940     950   962.5     970     980
R3     2       2       2       2      99      99      99      99      99      99
R3    99      99
CP    40   10000     300     200
IDCP40-DAVIS DAM
RT    40      50     2.2     .25      12       0
CP    50   50000     300     200
IDCP50 ** RM24.2
RT    50       0       0       0       0       0
ED
BF     0       5       0       074050100       5     720
NOLIST
IN    10  1MAY74    2524    2426    2099     759    3154
IN    20  1MAY74     913     716     642     170    1203
IN    30  1MAY74     913     716     642     167    1203
IN    50  1MAY74    4641    1361    2134     726    2991
QA    10  1MAY74    2380    2347    2128     673    2898
EJ
TI        FICTICIOUS TANDEM RIVER BASIN TEST OF HEC-5Q WITH WATER QUALITY
TI        RESERVOIRS ARE FICTICIOUS ALSO ** C.P. OF 10, 20, 30, 40 AND 50
TI        CONSTITUENTS ARE TEMPERATURE, TDS, CARBONACEOUS BOD AND OXYGEN
JA        740501  740828       5       2       F       0
EZ            -1
```

ET	121	64.06	138.8	2385.6	12.35
ET	122	62.44	111.4	2409.1	10.31
ET	123	65.44	126.3	2385.9	10.60
ET	124	60.66	107.7	2456.1	10.34
ET	125	63.36	102.6	2457.1	9.35
ET	126	57.60	124.1	2466.3	12.60
ET	127	58.75	89.7	2507.6	8.88
ET	128	66.16	90.8	2484.1	7.72
ET	129	66.36	138.3	2446.0	11.48
ET	130	67.68	96.1	2494.6	7.85
ET	131	70.23	130.1	2473.9	10.09
ET	132	66.18	147.4	2470.1	12.21
ET	133	62.56	144.1	2518.4	13.40
ET	134	72.00	149.0	2492.1	11.23
ET	135	71.49	175.2	2472.3	13.02
ET	136	74.91	133.5	2480.6	9.06
ET	137	78.21	176.4	2413.2	10.65
ET	138	75.06	127.7	2486.3	8.59
ET	139	72.84	131.9	2525.7	9.60
ET	140	73.33	118.8	2544.2	8.55
ET	141	81.63	95.9	2508.9	5.46
ET	142	77.95	142.0	2476.5	8.68
ET	143	73.94	148.7	2521.6	10.31
ET	144	68.99	151.9	2563.9	12.01
ET	145	67.24	99.2	2614.1	8.21
ET	146	69.55	97.3	2617.0	7.72
ET	147	64.69	119.9	2640.5	10.76
ET	148	71.17	97.5	2626.2	7.47
ET	149	73.54	145.0	2558.2	10.02
ET	150	80.04	107.4	2543.5	6.31
ET	151	77.13	137.9	2528.9	8.64
ET	152	70.47	132.4	2598.9	10.09
ET	153	72.09	120.6	2629.7	9.06
ET	154	78.21	86.5	2621.4	5.50
ET	155	79.57	99.9	2598.9	6.09
ET	156	76.06	133.5	2597.6	8.93
ET	157	77.65	133.5	2579.1	8.50
ET	158	75.63	175.0	2568.3	11.63
ET	159	78.80	137.6	2562.9	8.34
ET	160	82.00	138.6	2539.4	7.67
ET	161	77.77	212.1	2535.9	13.02
ET	162	69.73	170.9	2626.5	13.27
ET	163	71.67	119.4	2644.6	8.88
ET	164	73.76	105.8	2658.3	7.56
ET	165	79.68	93.8	2632.5	5.75
ET	166	72.72	153.5	2601.4	10.85
ET	167	71.62	145.3	2627.1	10.72
ET	168	71.26	110.0	2663.7	8.34
ET	169	73.63	124.3	2646.5	8.88
ET	170	77.79	129.1	2600.1	8.21
ET	171	82.04	144.8	2542.0	8.05
ET	172	77.67	199.4	2553.1	12.44
ET	173	81.25	107.0	2592.8	6.22
ET	174	72.32	143.9	2625.9	10.51

ET	175	71.35	151.0	2647.8	11.52
ET	176	71.62	129.3	2649.1	9.80
ET	177	77.68	96.6	2622.1	6.13
ET	178	75.09	129.3	2628.7	8.93
ET	179	74.39	127.5	2615.1	8.88
ET	180	74.98	130.1	2601.1	8.84
ET	181	74.88	210.0	2568.0	14.18
ET	182	80.55	135.6	2566.8	8.01
ET	183	80.89	185.1	2524.8	10.67
ET	184	83.64	204.0	2486.3	10.76
ET	185	83.70	200.2	2483.8	10.56
ET	186	82.60	140.0	2503.8	7.58
ET	187	83.17	106.5	2566.4	5.97
ET	188	89.10	87.1	2546.7	4.14
ET	189	89.42	102.4	2502.9	4.72
ET	190	86.77	141.1	2467.9	6.85
ET	191	82.85	165.3	2461.5	8.77
ET	192	77.04	165.3	2538.5	10.65
ET	193	79.90	105.1	2557.9	6.38
ET	194	87.21	86.2	2531.5	4.30
ET	195	82.40	168.8	2466.9	9.26
ET	196	78.49	168.8	2498.7	10.43
ET	197	76.98	140.4	2528.0	9.08
ET	198	85.08	91.6	2508.9	4.79
ET	199	83.80	141.6	2436.7	7.47
ET	200	81.34	201.3	2425.6	11.30
ET	201	77.05	147.3	2496.5	9.51
ET	202	77.18	127.0	2509.5	8.30
ET	203	82.02	109.7	2467.6	6.22
ET	204	79.34	124.5	2445.3	7.29
ET	205	80.82	119.4	2435.2	6.85
ET	206	84.99	86.9	2450.7	4.50
ET	207	89.44	81.8	2408.1	3.71
ET	208	88.47	90.9	2398.6	4.25
ET	209	82.58	133.1	2372.5	7.18
ET	210	78.96	151.3	2377.3	8.93
ET	211	77.41	150.5	2393.2	9.42
ET	212	79.23	127.3	2391.3	7.67
ET	213	83.59	103.3	2373.8	5.55
ET	214	84.94	111.8	2329.0	5.68
ET	215	79.84	175.7	2297.5	10.04
ET	216	76.86	172.7	2324.9	10.85
ET	217	75.70	118.1	2364.3	7.76
ET	218	79.32	102.2	2340.8	6.09
ET	219	84.34	95.9	2296.2	4.97
ET	220	83.50	107.5	2261.9	5.59
ET	221	83.93	98.9	2259.4	5.08
ET	222	78.15	134.9	2266.7	8.19
ET	223	78.78	161.9	2230.5	9.64
ET	224	83.66	114.8	2198.0	5.88
ET	225	82.54	122.9	2195.5	6.55
ET	226	79.68	132.4	2210.7	7.76
ET	227	81.79	96.2	2219.6	5.35
ET	228	85.68	86.2	2188.8	4.25

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ET               229   79.77   152.6  2150.0    8.77
ET               230   87.04    73.6  2159.9    3.42
ET               231   86.54    73.1  2158.0    3.47
ET               232   90.10    67.8  2142.1    2.93
ET               233   85.53    89.0  2121.1    4.38
ET               234   85.12    89.0  2106.5    4.43
ET               235   84.78    95.2  2088.7    4.77
ET               236   82.42   110.2  2072.5    5.88
ET               237   87.62    71.2  2069.9    3.22
ET               238   86.02    88.3  2042.6    4.21
ET               239   80.53   159.8  2012.4    8.88
ET               240   79.48   145.3  2004.1    8.19
ET               241   79.11   149.2  1979.7    8.48
ET               242   80.02   122.7  1985.4    6.89
ET              -243   77.29   150.1  1973.6    9.06
QC                 1       0       0       0       1       0       1
TQTOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
TQCARBONACEOUS BOD IN MG/L
TQDISSOLVED OXYGEN IN MG/L
L1                 1       1
L2      10         5              10      .6       2       1
LR       1     10000
L3               .01    1.-6    1.-4       0     -.7
L5      50     50000     825
L7      10      2000     820     860     900     940
L7      10      2000     840     880     920     960
L8               200     400     800    1400    2000    3000    5000
PL    0.25       100           -4.00
PL    0.05       100           -0.20
PL    0.20       100           -8.00
PL    0.25       100     3.2   -0.70    0.10   -0.05
L9                40      41      42      43      45      48      60
C1              105.    105.    105.    105.    105.    105.    105.
C5               0.5     0.5     0.5     0.5     0.5     0.5     0.5
C7               9.1     9.1     9.1     9.1     9.1     9.1     9.1
SA               100     100     100     100     100     100     100
DK                       0.1           1.463
L2      40         2   60000       5      .6       2       1
LR
L3               .01    1.-6    1.-4       0     -.7
L5       1        10   895.5
L6     870     99300   962.5
L7     7.9      2840   895.5   909.5   923.5   937.5
L7     7.9      2840   902.5   916.5   930.5   944.5
L8               410     460     500     550     600     650     700     750
PL    0.25       100           -4.00
PL    0.05       100           -0.20
PL    0.20       100           -8.00
PL    0.25       100     3.2   -0.70    0.10   -0.05
L9                54      55      57      57      57      57      57      57
C1               160     190     190     190     190     190     190     190
C5                .3      .3      .3      .3      .3      .3      .3      .3
C7               8.4     8.7     9.2     9.2     9.2     9.2     9.2     9.2
SA               100     100     100     100     100     100     100
```

DK			.2		1.463			
CR		1.047	1.047	1.047	1.0159			
S1		1	1	-1	8	20	1	
S2	10	65.5	20	60	1.5			2
S2	20	60.0	30	40	1.5			3
S2	0	0	0	0				
S2	40	32	50	24.2	1.975	30	4	
SR	10	20	1	2				
SR	20	30	1	2				
SR	-40	50	1	2				
S3	10	65.5	844.0	0.	0.	0.	.050	
S3		65.5	844.2	0.	.21	5.0	.050	
S3		65.5	844.6	4.0	.35	20.0	.050	
S3		65.5	845.0	14.0	.61	29.0	.050	
S3		65.5	846.0	54.0	1.04	50.0	.050	
S3		65.5	847.0	114.0	1.40	67.0	.050	
S3		65.5	848.0	194.0	1.55	99.0	.050	
S3		65.5	849.0	305.0	1.84	121.0	.050	
S3		65.5	850.0	440.0	2.02	152.0	.050	
S3		65.5	851.0	605.0	2.20	185.0	.050	
S3		65.5	852.0	827.0	2.17	264.0	.050	
S3		65.5	853.0	1100.0	2.52	279.0	.050	
S3		65.5	854.0	1384.0	2.87	288.0	.050	
S3		65.5	855.0	1677.0	3.15	301.0	.050	
S3		65.5	856.0	1985.0	3.40	316.0	.050	
S3		65.5	857.0	2308.0	3.67	326.0	.050	
S3		65.5	858.0	2634.0	3.99	326.0	.050	
S3		65.5	859.0	2960.0	4.30	326.0	.050	
S3		65.5	861.0	3612.0	4.88	326.0	.050	
S3		65.5	863.0	4264.0	5.41	326.0	.050	
S3	20	60.0	825.4	0.	0.	0.	.050	
S3		60.0	825.6	1.0	.22	9.0	.050	
S3		60.0	826.0	10.0	.43	33.0	.050	
S3		60.0	826.4	27.0	.64	52.0	.050	
S3		60.0	827.4	92.0	1.13	77.0	.050	
S3		60.0	828.4	179.0	1.51	96.0	.050	
S3		60.0	829.4	287.0	1.79	119.0	.050	
S3		60.0	830.4	418.0	2.08	138.0	.050	
S3		60.0	831.4	563.0	2.38	152.0	.050	
S3		60.0	832.4	723.0	2.65	166.0	.050	
S3		60.0	833.4	893.0	2.95	174.0	.050	
S3		60.0	834.4	1071.0	3.23	183.0	.050	
S3		60.0	835.4	1258.0	3.48	191.0	.050	
S3		60.0	836.4	1455.0	3.64	207.0	.050	
S3		60.0	837.4	1675.0	3.68	234.0	.050	
S3		60.0	838.4	1922.0	3.83	253.0	.050	
S3		60.0	839.4	2175.0	4.16	253.0	.050	
S3		60.0	840.4	2428.0	4.48	253.0	.050	
S3		60.0	842.4	2934.0	5.08	253.0	.050	
S3		60.0	844.4	3440.0	5.65	253.0	.050	
S3	30	40.0	765.0	0.	0.	0.	.050	
S3		40.0	765.2	1.0	.22	9.0	.050	
S3		40.0	765.6	10.0	.43	33.0	.050	
S3		40.0	766.0	27.0	.64	52.0	.050	

S3		40.0	767.0	92.0	1.13	77.0	.050
S3		40.0	768.0	179.0	1.51	96.0	.050
S3		40.0	769.0	287.0	1.79	119.0	.050
S3		40.0	770.0	418.0	2.08	138.0	.050
S3		40.0	771.0	563.0	2.38	152.0	.050
S3		40.0	772.0	723.0	2.65	166.0	.050
S3		40.0	773.0	893.0	2.95	174.0	.050
S3		40.0	774.0	1071.0	3.23	183.0	.050
S3		40.0	775.0	1258.0	3.48	191.0	.050
S3		40.0	776.0	1455.0	3.64	207.0	.050
S3		40.0	777.0	1675.0	3.68	234.0	.050
S3		40.0	778.0	1922.0	3.83	253.0	.050
S3		40.0	779.0	2175.0	4.16	253.0	.050
S3		40.0	780.0	2428.0	4.48	253.0	.050
S3		40.0	782.0	2934.0	5.08	253.0	.050
S3		40.0	784.0	3440.0	5.65	253.0	.050
S3	40	32.0	730.6	0.	0.	0.	.050
S3		32.0	730.8	0.	.21	2.0	.050
S3		32.0	731.2	2.0	.44	6.0	.050
S3		32.0	731.6	6.0	.45	19.0	.050
S3		32.0	732.6	74.0	.84	96.0	.050
S3		32.0	733.6	177.0	1.37	109.0	.050
S3		32.0	734.6	291.0	1.80	120.0	.050
S3		32.0	735.6	421.0	2.12	135.0	.050
S3		32.0	736.6	565.0	2.44	147.0	.050
S3		32.0	737.6	715.0	2.74	155.0	.050
S3		32.0	738.6	878.0	2.99	168.0	.050
S3		32.0	739.6	1050.0	3.26	176.0	.050
S3		32.0	740.6	1230.0	3.51	184.0	.050
S3		32.0	741.6	1418.0	3.74	193.0	.050
S3		32.0	742.6	1618.0	3.83	212.0	.050
S3		32.0	743.6	1844.0	3.86	239.0	.050
S3		32.0	744.6	2094.0	4.05	253.0	.050
S3		32.0	745.6	2347.0	4.37	253.0	.050
S3		32.0	747.6	2853.0	4.98	253.0	.050
S3		32.0	749.6	3359.0	5.55	253.0	.050
S3	50	30.4	722.9	0.	0.	0.	.030
S3		30.4	723.1	2.0	.22	15.0	.030
S3		30.4	723.5	14.0	.45	45.0	.030
S3		30.4	723.9	37.0	.64	74.0	.030
S3		30.4	724.9	130.0	1.12	111.0	.030
S3		30.4	725.9	271.0	1.43	167.0	.030
S3		30.4	726.9	462.0	1.72	218.0	.030
S3		30.4	727.9	701.0	2.04	257.0	.030
S3		30.4	728.9	978.0	2.34	287.0	.030
S3		30.4	729.9	1275.0	2.59	310.0	.030
S3		30.4	730.9	1599.0	2.79	337.0	.030
S3		30.4	731.9	1964.0	2.71	418.0	.030
S3		30.4	732.9	2394.0	2.98	444.0	.030
S3		30.4	733.9	2851.0	3.24	469.0	.030
S3		30.4	734.9	3342.0	3.39	518.0	.030
S3		30.4	735.9	3887.0	3.54	571.0	.030
S3		30.4	736.9	4482.0	3.74	610.0	.030
S3		30.4	737.9	5100.0	4.01	627.0	.030

S3		30.4	739.9	6390.0	4.49	662.0	.030
S3		30.4	741.9	7745.0	4.96	692.0	.030
S3	50	28.4	725.3	0.	0.	0.	.030
S3		28.4	725.5	4.0	.23	30.0	.030
S3		28.4	725.9	22.0	.48	59.0	.030
S3		28.4	726.3	51.0	.67	90.0	.030
S3		28.4	727.3	167.0	1.13	139.0	.030
S3		28.4	728.3	375.0	1.37	249.0	.030
S3		28.4	729.3	644.0	1.75	289.0	.030
S3		28.4	730.3	946.0	2.13	313.0	.030
S3		28.4	731.3	1271.0	2.46	336.0	.030
S3		28.4	732.3	1617.0	2.76	357.0	.030
S3		28.4	733.3	1985.0	3.03	379.0	.030
S3		28.4	734.3	2387.0	3.20	428.0	.030
S3		28.4	735.3	2831.0	3.41	463.0	.030
S3		28.4	736.3	3311.0	3.55	497.0	.030
S3		28.4	737.3	3824.0	3.73	527.0	.030
S3		28.4	738.3	4370.0	3.86	575.0	.030
S3		28.4	739.3	4985.0	3.99	634.0	.030
S3		28.4	740.3	5632.0	4.20	659.0	.030
S3		28.4	742.3	7002.0	4.58	709.0	.030
S3		28.4	744.3	8458.0	5.02	742.0	.030
S3	50	26.3	722.7	0.	0.	0.	.030
S3		26.3	722.8	1.0	.22	9.0	.030
S3		26.3	723.2	8.0	.45	26.0	.030
S3		26.3	723.7	22.0	.62	45.0	.030
S3		26.3	724.7	92.0	1.00	94.0	.030
S3		26.3	725.7	219.0	1.22	167.0	.030
S3		26.3	726.7	436.0	1.38	265.0	.030
S3		26.3	727.7	751.0	1.58	365.0	.030
S3		26.3	728.7	1158.0	1.86	441.0	.030
S3		26.3	729.7	1628.0	2.17	496.0	.030
S3		26.3	730.7	2254.0	2.19	729.0	.030
S3		26.3	731.7	3038.0	2.44	809.0	.030
S3		26.3	732.7	3867.0	2.74	858.0	.030
S3		26.3	733.7	4756.0	3.00	913.0	.030
S3		26.3	734.7	5699.0	3.23	981.0	.030
S3		26.3	735.7	6697.0	3.45	1022.0	.030
S3		26.3	736.7	7750.0	3.68	1067.0	.030
S3		26.3	737.7	8825.0	3.97	1083.0	.030
S3		26.3	739.7	11032.0	4.51	1117.0	.030
S3		26.3	741.7	13278.0	5.08	1129.0	.030
S3	50	24.2	721.6	0.	0.	0.	.030
S3		24.2	721.8	6.0	.22	56.0	.030
S3		24.2	722.2	50.0	.47	150.0	.030
S3		24.2	722.6	118.0	.69	190.0	.030
S3		24.2	723.6	354.0	1.13	270.0	.030
S3		24.2	724.6	656.0	1.41	358.0	.030
S3		24.2	725.6	1079.0	1.60	484.0	.030
S3		24.2	726.6	1606.0	1.88	568.0	.030
S3		24.2	727.6	2215.0	2.16	648.0	.030
S3		24.2	728.6	2903.0	2.41	730.0	.030
S3		24.2	729.6	3687.0	2.62	834.0	.030
S3		24.2	730.6	4563.0	2.87	914.0	.030

S3		24.2	731.6	5511.0	3.10	994.0	.030	
S3		24.2	732.6	6555.0	3.32	1081.0	.030	
S3		24.2	733.6	7684.0	3.50	1191.0	.030	
S3		24.2	734.6	8885.0	3.80	1211.0	.030	
S3		24.2	735.6	10105.0	4.09	1229.0	.030	
S3		24.2	736.6	11341.0	4.38	1242.0	.030	
S3		24.2	738.6	13849.0	4.93	1266.0	.030	
S3		24.2	740.6	16405.0	5.45	1289.0	.030	
S4		854	835	775	743	742	741	740
S4		739.5						
KR			0.10		1.463			
KR			0.15		1.463			
KR			0.25		1.463			
CT	10	740101	40.	3.	0.			
CT		740318	45.	3.	0.			
CT		740723	50.	3.	0.			
CT		741017	45.	3.	0.			
CT		741206	40.	3.	0.			
CT		-741231	40.	3.	0.			
CT		740101	150.	1.	0.			
CT		-741231	150.	1.	0.			
CT		740101	0.1	1.	0.			
CT		-741231	0.1	1.	0.			
CT		740101	5.	0.	30.			
CT		-741231	5.	0.	30.			
CT	20	740101	45	4	0			
CT		740318	50	4	0			
CT		740723	55	4	0			
CT		741017	50	4	0			
CT		741206	45	4	0			
CT		-741231	42	4	0			
CT		740101	160	.8	0			
CT		-741231	160	.8	0			
CT		740101	.05	.15	0			
CT		-741231	.05	.15	0			
CT		740101	4	0	50			
CT		-741231	4	0	50			
CT	30	740101	45.	3.	0.			
CT		740510	50.	3.	0.			
CT		740531	60.	3.	0.			
CT		741001	55.	3.	0.			
CT		-741231	45.	3.	0.			
CT		740101	160.	1.	0.			
CT		-741231	160.	1.	0.			
CT		740101	.15	4.	0.			
CT		-741231	.15	4.	0.			
CT		740101	4.5	4.	0.			
CT		-741231	4.5	4.	0.			
CT	40	740101	45.	3.	0.			
CT		740504	50.	3.	0.			
CT		740514	55.	3.	0.			
CT		740515	60.	3.	0.			
CT		741005	55.	3.	0.			
CT		741109	50.	3.	0.			

```
CT         741214     45.        3.        0.
CT        -741231     45.        3.        0.
CT         740101    170.        1.        0.
CT        -741231    170.        1.        0.
CT         740101     0.2        1.        0.
CT        -741231     0.2        1.        0.
CT         740101     5.5        0.       30.
CT        -741231     5.5        0.       30.
CT      50 740101     50.        3.        0.
CT         740506     55.        3.        0.
CT         740510     60.        3.        0.
CT         740515     65.        3.        0.
CT         740708     70.        3.        0.
CT         740924     65.        3.        0.
CT         741018     60.        3.        0.
CT         741112     55.        3.        0.
CT         741206     50.        3.        0.
CT        -741231     50.        3.        0.
CT         740101    190.        1.        0.
CT        -741231    190.        1.        0.
CT         740101     0.3        1.        0.
CT        -741231     0.3        1.        0.
CT         740101     6.0        0.       30.
CT        -741231     6.0        0.       30.
I1         740101  741231
I2                      0 TRIB 1 INFLOW RATE - RES #1
I4         740101      -1  741231      -1.        -1
I2              1       0 HAYES INFLOW
I4         740101    -1.5  740408     -1.5  740422     -5.0  740708      -8.
I4         740826     -5.  741231     -1.5        -1
I2                      0 HAYES INFLOW - TOTAL DISSOLVED SOLIDS
I4         740101    105.  741231     105.        -1
I2                      0 HAYES INFLOW - CARBONACEOUS BOD
I4         740101     0.5  741231      0.5        -1
I2                      0 HAYES INFLOW - DISSOLVED OXYGEN
I4         740101    12.8  740115     13.1  740215     12.4  740315     11.8
I4         740415    11.7  740515      9.3  740615      8.9  740715      8.2
I4         740815     7.8  740915      9.7  741015     10.0  741115     11.0
I4         741215    12.4  741231     12.8        -1
I2                      0 TRIB 2 INFLOW RATE - RM 60
I4         740101      -1  741231      -1.        -1
I2              1       0 TRIB 2 - RM 60
I4         740101    -1.5  740408     -1.5  740422     -5.0  740708      -8.
I4         740826     -5.  741231     -1.5        -1
I2                      0 TRIB 2 - RM 60 - TDS
I4         740101    150.  741231     150.        -1
I2                      0 TRIB 2 - RM 60 - CBOD
I4         740101     0.5  741231      0.5        -1
I2                      0 TRIB 2 - RM 60 - DO
I4         740101    12.6  740115     12.7  740215     13.0  740315     12.6
I4         740415    11.5  740515      9.1  740615      8.6  740715      7.7
I4         740815     7.7  740915      9.0  741015      9.7  741115     11.1
I4         741215    12.6  741231     12.6        -1
I2                      0 TRIB 3 INFLOW RATE - RM 40
I4         740101      -1  741231      -1.        -1
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I2           1      0 TRIB 3 - RM 40
I4      740101   -1.5  740408   -1.5  740422   -5.0  740708     -8.
I4      740826    -5.  741231   -1.5      -1
I2                  0 TRIB 3 - RM 40 - TDS
I4      740101   150.  741231   150.      -1
I2                  0 TRIB 3 - RM 40 - CBOD
I4      740101    0.5  741231    0.5      -1
I2                  0 TRIB 3 - RM 40 - DO
I4      740101   12.6  740115   12.7  740215   13.0  740315    12.6
I4      740415   11.5  740515    9.1  740615    8.6  740715     7.7
I4      740815    7.7  740915    9.0  741015    9.7  741115    11.1
I4      741215   12.6  741231   12.6      -1
I2                  0 TRIB 4 INFLOW RATE - RM 30
I4      740101     -1  741231    -1.      -1
I2           1      0TRIB 4 - RM 30
I4      740101   -1.5  740408   -1.5  740422   -3.0  740708     -6.
I4      740826    -5.  741231   -1.5      -1
I2                  0 TRIB 4 - RM 30 - TOTAL DISSOLVED SOLIDS
I4      740101   160.  741231   160.      -1
I2                  0 TRIB 4 - RM 30 - CARBONACEOUS BOD
I4      740101    0.6  741231    0.6      -1
I2          -1      0 TRIB 4 - RM 30 - DISSOLVED OXYGEN
I4      740101   100.  741231   100.      -1
ER
```

TEST PROBLEM 6 - Tandem Reservoirs with Steady State Option and Flow Augmentation

The system simulated in this test of the water quality module consists of the same reservoir and stream configuration as Test Problem 2. The unique input to this test problem, includes selecting the steady state and flow augmentation options (J9 card, Fields 2 and 3) and specifying the same input changes as Test Problem 5.

A complete listing of the input data deck is given below. A complete output listing is included with the computer source code distribution.

```
T1      TESTING HEC5Q WATER QUALITY SIMULATION CAPABILITY
T2      TANDEM RIVER SYSTEM...STEADY STATE CONDITIONS...FLOW AUGMENTATION OPTION
T3      TEST PROBLEM 6
J1       0       5       5       3       4       2       0       0
J2       0       0       0       0       0       0       0
J9               1       1       0
RL      10 1200000       0  100000  200000 1500000 1600000
RO       3      20      30      40
RS       7     100    6300   31300   88000  188000  563000 1688000
RQ       7       0   20000   30000   40000   50000   50000   50000
RA       7      10     500    1500    3000    5000   10000   20000
RE       7     800     825     850     870     900     950    1030
R3       2       2       2       2      99      99      99      99      99      99
R3      99      99
CP      10   15000     300     200
IDCP10-HAYES DAM
RT      10      20     2.2     .25      12       0
CP      20   12000     300     200
ID   CP20 ** RM60
RT      20      30     2.2     .25      12       0
CP      30   12000     300     200
ID   CP30 ** RM40
RT      30      40     2.2     .25      12       0
RL      40  550000       0    2000  550000  952000 1130000
RO       1      50
RS       8    2000   20000   52000  113000  209000  320000  550000  800000 1130000
RQ       8       0    5680    5680    5680    5680    5680   29180   59680  104980
RA       8     150    2100    4500    7600   11800   17000   22400   28600   37200
RE       8     892     910     920     930     940     950   962.5     970     980
R3       2       2       2       2      99      99      99      99      99      99
R3      99      99
CP      40   10000     300     200
IDCP40-DAVIS DAM
RT      40      50     2.2     .25      12       0
CP      50   50000     300     200
IDCP50 ** RM24.2
RT      50       0       0       0       0       0
ED
BF       0       5       0       074050100       5     720
NOLIST
IN      10  1MAY74    2524    2426    2099     759    3154
IN      20  1MAY74     913     716     642     170    1203
IN      30  1MAY74     913     716     642     167    1203
IN      50  1MAY74    4641    1361    2134     726    2991
QA      10  1MAY74    2380    2347    2128     673    2898
EJ
TI          FICTICIOUS TANDEM RIVER BASIN TEST OF HEC-5Q WITH WATER QUALITY
TI          RESERVOIRS ARE FICTICIOUS ALSO ** C.P. OF 10, 20, 30, 40 AND 50
TI          CONSTITUENTS ARE TEMPERATURE, TDS, CARBONACEOUS BOD AND OXYGEN
JA          740501  740828       5       2       F       0
EZ              -1
```

ET	121	64.06	138.8	2385.6	12.35
ET	122	62.44	111.4	2409.1	10.31
ET	123	65.44	126.3	2385.9	10.60
ET	124	60.66	107.7	2456.1	10.34
ET	125	63.36	102.6	2457.1	9.35
ET	126	57.60	124.1	2466.3	12.60
ET	127	58.75	89.7	2507.6	8.88
ET	128	66.16	90.8	2484.1	7.72
ET	129	66.36	138.3	2446.0	11.48
ET	130	67.68	96.1	2494.6	7.85
ET	131	70.23	130.1	2473.9	10.09
ET	132	66.18	147.4	2470.1	12.21
ET	133	62.56	144.1	2518.4	13.40
ET	134	72.00	149.0	2492.1	11.23
ET	135	71.49	175.2	2472.3	13.02
ET	136	74.91	133.5	2480.6	9.06
ET	137	78.21	176.4	2413.2	10.65
ET	138	75.06	127.7	2486.3	8.59
ET	139	72.84	131.9	2525.7	9.60
ET	140	73.33	118.8	2544.2	8.55
ET	141	81.63	95.9	2508.9	5.46
ET	142	77.95	142.0	2476.5	8.68
ET	143	73.94	148.7	2521.6	10.31
ET	144	68.99	151.9	2563.9	12.01
ET	145	67.24	99.2	2614.1	8.21
ET	146	69.55	97.3	2617.0	7.72
ET	147	64.69	119.9	2640.5	10.76
ET	148	71.17	97.5	2626.2	7.47
ET	149	73.54	145.0	2558.2	10.02
ET	150	80.04	107.4	2543.5	6.31
ET	151	77.13	137.9	2528.9	8.64
ET	152	70.47	132.4	2598.9	10.09
ET	153	72.09	120.6	2629.7	9.06
ET	154	78.21	86.5	2621.4	5.50
ET	155	79.57	99.9	2598.9	6.09
ET	156	76.06	133.5	2597.6	8.93
ET	157	77.65	133.5	2579.1	8.50
ET	158	75.63	175.0	2568.3	11.63
ET	159	78.80	137.6	2562.9	8.34
ET	160	82.00	138.6	2539.4	7.67
ET	161	77.77	212.1	2535.9	13.02
ET	162	69.73	170.9	2626.5	13.27
ET	163	71.67	119.4	2644.6	8.88
ET	164	73.76	105.8	2658.3	7.56
ET	165	79.68	93.8	2632.5	5.75
ET	166	72.72	153.5	2601.4	10.85
ET	167	71.62	145.3	2627.1	10.72
ET	168	71.26	110.0	2663.7	8.34
ET	169	73.63	124.3	2646.5	8.88
ET	170	77.79	129.1	2600.1	8.21
ET	171	82.04	144.8	2542.0	8.05
ET	172	77.67	199.4	2553.1	12.44
ET	173	81.25	107.0	2592.8	6.22
ET	174	72.32	143.9	2625.9	10.51

ET	175	71.35	151.0	2647.8	11.52
ET	176	71.62	129.3	2649.1	9.80
ET	177	77.68	96.6	2622.1	6.13
ET	178	75.09	129.3	2628.7	8.93
ET	179	74.39	127.5	2615.1	8.88
ET	180	74.98	130.1	2601.1	8.84
ET	181	74.88	210.0	2568.0	14.18
ET	182	80.55	135.6	2566.8	8.01
ET	183	80.89	185.1	2524.8	10.67
ET	184	83.64	204.0	2486.3	10.76
ET	185	83.70	200.2	2483.8	10.56
ET	186	82.60	140.0	2503.8	7.58
ET	187	83.17	106.5	2566.4	5.97
ET	188	89.10	87.1	2546.7	4.14
ET	189	89.42	102.4	2502.9	4.72
ET	190	86.77	141.1	2467.9	6.85
ET	191	82.85	165.3	2461.5	8.77
ET	192	77.04	165.3	2538.5	10.65
ET	193	79.90	105.1	2557.9	6.38
ET	194	87.21	86.2	2531.5	4.30
ET	195	82.40	168.8	2466.9	9.26
ET	196	78.49	168.8	2498.7	10.43
ET	197	76.98	140.4	2528.0	9.08
ET	198	85.08	91.6	2508.9	4.79
ET	199	83.80	141.6	2436.7	7.47
ET	200	81.34	201.3	2425.6	11.30
ET	201	77.05	147.3	2496.5	9.51
ET	202	77.18	127.0	2509.5	8.30
ET	203	82.02	109.7	2467.6	6.22
ET	204	79.34	124.5	2445.3	7.29
ET	205	80.82	119.4	2435.2	6.85
ET	206	84.99	86.9	2450.7	4.50
ET	207	89.44	81.8	2408.1	3.71
ET	208	88.47	90.9	2398.6	4.25
ET	209	82.58	133.1	2372.5	7.18
ET	210	78.96	151.3	2377.3	8.93
ET	211	77.41	150.5	2393.2	9.42
ET	212	79.23	127.3	2391.3	7.67
ET	213	83.59	103.3	2373.8	5.55
ET	214	84.94	111.8	2329.0	5.68
ET	215	79.84	175.7	2297.5	10.04
ET	216	76.86	172.7	2324.9	10.85
ET	217	75.70	118.1	2364.3	7.76
ET	218	79.32	102.2	2340.8	6.09
ET	219	84.34	95.9	2296.2	4.97
ET	220	83.50	107.5	2261.9	5.59
ET	221	83.93	98.9	2259.4	5.08
ET	222	78.15	134.9	2266.7	8.19
ET	223	78.78	161.9	2230.5	9.64
ET	224	83.66	114.8	2198.0	5.88
ET	225	82.54	122.9	2195.5	6.55
ET	226	79.68	132.4	2210.7	7.76
ET	227	81.79	96.2	2219.6	5.35
ET	228	85.68	86.2	2188.8	4.25

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ET           229   79.77   152.6  2150.0    8.77
ET           230   87.04    73.6  2159.9    3.42
ET           231   86.54    73.1  2158.0    3.47
ET           232   90.10    67.8  2142.1    2.93
ET           233   85.53    89.0  2121.1    4.38
ET           234   85.12    89.0  2106.5    4.43
ET           235   84.78    95.2  2088.7    4.77
ET           236   82.42   110.2  2072.5    5.88
ET           237   87.62    71.2  2069.9    3.22
ET           238   86.02    88.3  2042.6    4.21
ET           239   80.53   159.8  2012.4    8.88
ET           240   79.48   145.3  2004.1    8.19
ET           241   79.11   149.2  1979.7    8.48
ET           242   80.02   122.7  1985.4    6.89
ET          -243   77.29   150.1  1973.6    9.06
QC             1       0       0       0       1       0       1
TQTOTAL DISSOLVED SOLIDS IN MG/L, COMPUTED AS 0.62 X CONDUCTIVITY
TQCARBONACEOUS BOD IN MG/L
TQDISSOLVED OXYGEN IN MG/L
L1             1       1
L2    10       5              10      .6       2       1
LR     1   10000
L3           .01    1.-6    1.-4       0     -.7
L5    50   50000     825
L7    10    2000     820     860     900     940
L7    10    2000     840     880     920     960
L8           200     400     800    1400    2000    3000    5000
PL  0.25     100           -4.00
PL  0.05     100           -0.20
PL  0.20     100           -8.00
PL  0.25     100     3.2   -0.70    0.10   -0.05
L9            40      41      42      43      45      48      60
C1          105.    105.    105.    105.    105.    105.    105.
C5           0.5     0.5     0.5     0.5     0.5     0.5     0.5
C7           9.1     9.1     9.1     9.1     9.1     9.1     9.1
SA           100     100     100     100     100     100     100
DK                   0.1           1.463
L2    40       2   60000       5      .6       2       1
LR
L3           .01    1.-6    1.-4       0     -.7
L5     1      10   895.5
L6   870   99300   962.5
L7   7.9    2840   895.5   909.5   923.5   937.5
L7   7.9    2840   902.5   916.5   930.5   944.5
L8           410     460     500     550     600     650     700     750
PL  0.25     100           -4.00
PL  0.05     100           -0.20
PL  0.20     100           -8.00
PL  0.25     100     3.2   -0.70    0.10   -0.05
L9            54      55      57      57      57      57      57      57
C1           160     190     190     190     190     190     190     190
C5            .3      .3      .3      .3      .3      .3      .3      .3
C7           8.4     8.7     9.2     9.2     9.2     9.2     9.2     9.2
SA           100     100     100     100     100     100     100
```

DK			.2		1.463			
CR		1.047	1.047	1.047	1.0159			
S1		1	1	-1	8	20	1	
S2	10	65.5	20	60	1.5			2
S2	20	60.0	30	40	1.5			3
S2	0	0	0	0				
S2	40	32	50	24.2	1.975	30	4	
SR	10	20	1	2				
SR	20	30	1	2				
SR	-40	50	1	2				
S3	10	65.5	844.0	0.	0.	0.	.050	
S3		65.5	844.2	0.	.21	5.0	.050	
S3		65.5	844.6	4.0	.35	20.0	.050	
S3		65.5	845.0	14.0	.61	29.0	.050	
S3		65.5	846.0	54.0	1.04	50.0	.050	
S3		65.5	847.0	114.0	1.40	67.0	.050	
S3		65.5	848.0	194.0	1.55	99.0	.050	
S3		65.5	849.0	305.0	1.84	121.0	.050	
S3		65.5	850.0	440.0	2.02	152.0	.050	
S3		65.5	851.0	605.0	2.20	185.0	.050	
S3		65.5	852.0	827.0	2.17	264.0	.050	
S3		65.5	853.0	1100.0	2.52	279.0	.050	
S3		65.5	854.0	1384.0	2.87	288.0	.050	
S3		65.5	855.0	1677.0	3.15	301.0	.050	
S3		65.5	856.0	1985.0	3.40	316.0	.050	
S3		65.5	857.0	2308.0	3.67	326.0	.050	
S3		65.5	858.0	2634.0	3.99	326.0	.050	
S3		65.5	859.0	2960.0	4.30	326.0	.050	
S3		65.5	861.0	3612.0	4.88	326.0	.050	
S3		65.5	863.0	4264.0	5.41	326.0	.050	
S3	20	60.0	825.4	0.	0.	0.	.050	
S3		60.0	825.6	1.0	.22	9.0	.050	
S3		60.0	826.0	10.0	.43	33.0	.050	
S3		60.0	826.4	27.0	.64	52.0	.050	
S3		60.0	827.4	92.0	1.13	77.0	.050	
S3		60.0	828.4	179.0	1.51	96.0	.050	
S3		60.0	829.4	287.0	1.79	119.0	.050	
S3		60.0	830.4	418.0	2.08	138.0	.050	
S3		60.0	831.4	563.0	2.38	152.0	.050	
S3		60.0	832.4	723.0	2.65	166.0	.050	
S3		60.0	833.4	893.0	2.95	174.0	.050	
S3		60.0	834.4	1071.0	3.23	183.0	.050	
S3		60.0	835.4	1258.0	3.48	191.0	.050	
S3		60.0	836.4	1455.0	3.64	207.0	.050	
S3		60.0	837.4	1675.0	3.68	234.0	.050	
S3		60.0	838.4	1922.0	3.83	253.0	.050	
S3		60.0	839.4	2175.0	4.16	253.0	.050	
S3		60.0	840.4	2428.0	4.48	253.0	.050	
S3		60.0	842.4	2934.0	5.08	253.0	.050	
S3		60.0	844.4	3440.0	5.65	253.0	.050	
S3	30	40.0	765.0	0.	0.	0.	.050	
S3		40.0	765.2	1.0	.22	9.0	.050	
S3		40.0	765.6	10.0	.43	33.0	.050	
S3		40.0	766.0	27.0	.64	52.0	.050	

S3		40.0	767.0	92.0	1.13	77.0	.050
S3		40.0	768.0	179.0	1.51	96.0	.050
S3		40.0	769.0	287.0	1.79	119.0	.050
S3		40.0	770.0	418.0	2.08	138.0	.050
S3		40.0	771.0	563.0	2.38	152.0	.050
S3		40.0	772.0	723.0	2.65	166.0	.050
S3		40.0	773.0	893.0	2.95	174.0	.050
S3		40.0	774.0	1071.0	3.23	183.0	.050
S3		40.0	775.0	1258.0	3.48	191.0	.050
S3		40.0	776.0	1455.0	3.64	207.0	.050
S3		40.0	777.0	1675.0	3.68	234.0	.050
S3		40.0	778.0	1922.0	3.83	253.0	.050
S3		40.0	779.0	2175.0	4.16	253.0	.050
S3		40.0	780.0	2428.0	4.48	253.0	.050
S3		40.0	782.0	2934.0	5.08	253.0	.050
S3		40.0	784.0	3440.0	5.65	253.0	.050
S3	40	32.0	730.6	0.	0.	0.	.050
S3		32.0	730.8	0.	.21	2.0	.050
S3		32.0	731.2	2.0	.44	6.0	.050
S3		32.0	731.6	6.0	.45	19.0	.050
S3		32.0	732.6	74.0	.84	96.0	.050
S3		32.0	733.6	177.0	1.37	109.0	.050
S3		32.0	734.6	291.0	1.80	120.0	.050
S3		32.0	735.6	421.0	2.12	135.0	.050
S3		32.0	736.6	565.0	2.44	147.0	.050
S3		32.0	737.6	715.0	2.74	155.0	.050
S3		32.0	738.6	878.0	2.99	168.0	.050
S3		32.0	739.6	1050.0	3.26	176.0	.050
S3		32.0	740.6	1230.0	3.51	184.0	.050
S3		32.0	741.6	1418.0	3.74	193.0	.050
S3		32.0	742.6	1618.0	3.83	212.0	.050
S3		32.0	743.6	1844.0	3.86	239.0	.050
S3		32.0	744.6	2094.0	4.05	253.0	.050
S3		32.0	745.6	2347.0	4.37	253.0	.050
S3		32.0	747.6	2853.0	4.98	253.0	.050
S3		32.0	749.6	3359.0	5.55	253.0	.050
S3	50	30.4	722.9	0.	0.	0.	.030
S3		30.4	723.1	2.0	.22	15.0	.030
S3		30.4	723.5	14.0	.45	45.0	.030
S3		30.4	723.9	37.0	.64	74.0	.030
S3		30.4	724.9	130.0	1.12	111.0	.030
S3		30.4	725.9	271.0	1.43	167.0	.030
S3		30.4	726.9	462.0	1.72	218.0	.030
S3		30.4	727.9	701.0	2.04	257.0	.030
S3		30.4	728.9	978.0	2.34	287.0	.030
S3		30.4	729.9	1275.0	2.59	310.0	.030
S3		30.4	730.9	1599.0	2.79	337.0	.030
S3		30.4	731.9	1964.0	2.71	418.0	.030
S3		30.4	732.9	2394.0	2.98	444.0	.030
S3		30.4	733.9	2851.0	3.24	469.0	.030
S3		30.4	734.9	3342.0	3.39	518.0	.030
S3		30.4	735.9	3887.0	3.54	571.0	.030
S3		30.4	736.9	4482.0	3.74	610.0	.030
S3		30.4	737.9	5100.0	4.01	627.0	.030

S3		30.4	739.9	6390.0	4.49	662.0	.030
S3		30.4	741.9	7745.0	4.96	692.0	.030
S3	50	28.4	725.3	0.	0.	0.	.030
S3		28.4	725.5	4.0	.23	30.0	.030
S3		28.4	725.9	22.0	.48	59.0	.030
S3		28.4	726.3	51.0	.67	90.0	.030
S3		28.4	727.3	167.0	1.13	139.0	.030
S3		28.4	728.3	375.0	1.37	249.0	.030
S3		28.4	729.3	644.0	1.75	289.0	.030
S3		28.4	730.3	946.0	2.13	313.0	.030
S3		28.4	731.3	1271.0	2.46	336.0	.030
S3		28.4	732.3	1617.0	2.76	357.0	.030
S3		28.4	733.3	1985.0	3.03	379.0	.030
S3		28.4	734.3	2387.0	3.20	428.0	.030
S3		28.4	735.3	2831.0	3.41	463.0	.030
S3		28.4	736.3	3311.0	3.55	497.0	.030
S3		28.4	737.3	3824.0	3.73	527.0	.030
S3		28.4	738.3	4370.0	3.86	575.0	.030
S3		28.4	739.3	4985.0	3.99	634.0	.030
S3		28.4	740.3	5632.0	4.20	659.0	.030
S3		28.4	742.3	7002.0	4.58	709.0	.030
S3		28.4	744.3	8458.0	5.02	742.0	.030
S3	50	26.3	722.7	0.	0.	0.	.030
S3		26.3	722.8	1.0	.22	9.0	.030
S3		26.3	723.2	8.0	.45	26.0	.030
S3		26.3	723.7	22.0	.62	45.0	.030
S3		26.3	724.7	92.0	1.00	94.0	.030
S3		26.3	725.7	219.0	1.22	167.0	.030
S3		26.3	726.7	436.0	1.38	265.0	.030
S3		26.3	727.7	751.0	1.58	365.0	.030
S3		26.3	728.7	1158.0	1.86	441.0	.030
S3		26.3	729.7	1628.0	2.17	496.0	.030
S3		26.3	730.7	2254.0	2.19	729.0	.030
S3		26.3	731.7	3038.0	2.44	809.0	.030
S3		26.3	732.7	3867.0	2.74	858.0	.030
S3		26.3	733.7	4756.0	3.00	913.0	.030
S3		26.3	734.7	5699.0	3.23	981.0	.030
S3		26.3	735.7	6697.0	3.45	1022.0	.030
S3		26.3	736.7	7750.0	3.68	1067.0	.030
S3		26.3	737.7	8825.0	3.97	1083.0	.030
S3		26.3	739.7	11032.0	4.51	1117.0	.030
S3		26.3	741.7	13278.0	5.08	1129.0	.030
S3	50	24.2	721.6	0.	0.	0.	.030
S3		24.2	721.8	6.0	.22	56.0	.030
S3		24.2	722.2	50.0	.47	150.0	.030
S3		24.2	722.6	118.0	.69	190.0	.030
S3		24.2	723.6	354.0	1.13	270.0	.030
S3		24.2	724.6	656.0	1.41	358.0	.030
S3		24.2	725.6	1079.0	1.60	484.0	.030
S3		24.2	726.6	1606.0	1.88	568.0	.030
S3		24.2	727.6	2215.0	2.16	648.0	.030
S3		24.2	728.6	2903.0	2.41	730.0	.030
S3		24.2	729.6	3687.0	2.62	834.0	.030
S3		24.2	730.6	4563.0	2.87	914.0	.030

S3		24.2	731.6	5511.0	3.10	994.0	.030	
S3		24.2	732.6	6555.0	3.32	1081.0	.030	
S3		24.2	733.6	7684.0	3.50	1191.0	.030	
S3		24.2	734.6	8885.0	3.80	1211.0	.030	
S3		24.2	735.6	10105.0	4.09	1229.0	.030	
S3		24.2	736.6	11341.0	4.38	1242.0	.030	
S3		24.2	738.6	13849.0	4.93	1266.0	.030	
S3		24.2	740.6	16405.0	5.45	1289.0	.030	
S4		854	835	775	743	742	741	740
S4		739.5						
KR			0.10		1.463			
KR			0.15		1.463			
KR			0.25		1.463			
CT	10	740101	40.	3.	0.			
CT		740318	45.	3.	0.			
CT		740723	50.	3.	0.			
CT		741017	45.	3.	0.			
CT		741206	40.	3.	0.			
CT		-741231	40.	3.	0.			
CT		740101	150.	1.	0.			
CT		-741231	150.	1.	0.			
CT		740101	0.1	1.	0.			
CT		-741231	0.1	1.	0.			
CT		740101	5.	0.	30.			
CT		-741231	5.	0.	30.			
CT	20	740101	45	4	0			
CT		740318	50	4	0			
CT		740723	55	4	0			
CT		741017	50	4	0			
CT		741206	45	4	0			
CT		-741231	42	4	0			
CT		740101	160	.8	0			
CT		-741231	160	.8	0			
CT		740101	.05	.15	0			
CT		-741231	.05	.15	0			
CT		740101	4	0	50			
CT		-741231	4	0	50			
CT	30	740101	45.	3.	0.			
CT		740510	50.	3.	0.			
CT		740531	60.	3.	0.			
CT		741001	55.	3.	0.			
CT		-741231	45.	3.	0.			
CT		740101	160.	1.	0.			
CT		-741231	160.	1.	0.			
CT		740101	.15	4.	0.			
CT		-741231	.15	4.	0.			
CT		740101	4.5	4.	0.			
CT		-741231	4.5	4.	0.			
CT	40	740101	45.	3.	0.			
CT		740504	50.	3.	0.			
CT		740514	55.	3.	0.			
CT		740515	60.	3.	0.			
CT		741005	55.	3.	0.			
CT		741109	50.	3.	0.			

```
CT        741214    45.       3.      0.
CT       -741231    45.       3.      0.
CT        740101   170.       1.      0.
CT       -741231   170.       1.      0.
CT        740101    0.2       1.      0.
CT       -741231    0.2       1.      0.
CT        740101    5.5       0.     30.
CT       -741231    5.5       0.     30.
CT     50 740101    50.       3.      0.
CT        740506    55.       3.      0.
CT        740510    60.       3.      0.
CT        740515    65.       3.      0.
CT        740708    70.       3.      0.
CT        740924    65.       3.      0.
CT        741018    60.       3.      0.
CT        741112    55.       3.      0.
CT        741206    50.       3.      0.
CT       -741231    50.       3.      0.
CT        740101   190.       1.      0.
CT       -741231   190.       1.      0.
CT        740101    0.3       1.      0.
CT       -741231    0.3       1.      0.
CT        740101    6.0       0.     30.
CT       -741231    6.0       0.     30.
I1        740101 741231
I2                    0 TRIB 1 INFLOW RATE - RES #1
I4        740101     -1  741231     -1.      -1
I2             1      0 HAYES INFLOW
I4        740101   -1.5  740408    -1.5  740422    -5.0  740708     -8.
I4        740826    -5.  741231    -1.5      -1
I2                    0 HAYES INFLOW - TOTAL DISSOLVED SOLIDS
I4        740101   105.  741231    105.      -1
I2                    0 HAYES INFLOW - CARBONACEOUS BOD
I4        740101    0.5  741231     0.5      -1
I2                    0 HAYES INFLOW - DISSOLVED OXYGEN
I4        740101   12.8  740115    13.1  740215    12.4  740315    11.8
I4        740415   11.7  740515     9.3  740615     8.9  740715     8.2
I4        740815    7.8  740915     9.7  741015    10.0  741115    11.0
I4        741215   12.4  741231    12.8      -1
I2                    0 TRIB 2 INFLOW RATE - RM 60
I4        740101     -1  741231     -1.      -1
I2             1      0 TRIB 2 - RM 60
I4        740101   -1.5  740408    -1.5  740422    -5.0  740708     -8.
I4        740826    -5.  741231    -1.5      -1
I2                    0 TRIB 2 - RM 60 - TDS
I4        740101   150.  741231    150.      -1
I2                    0 TRIB 2 - RM 60 - CBOD
I4        740101    0.5  741231     0.5      -1
I2                    0 TRIB 2 - RM 60 - DO
I4        740101   12.6  740115    12.7  740215    13.0  740315    12.6
I4        740415   11.5  740515     9.1  740615     8.6  740715     7.7
I4        740815    7.7  740915     9.0  741015     9.7  741115    11.1
I4        741215   12.6  741231    12.6      -1
I2                    0 TRIB 3 INFLOW RATE - RM 40
I4        740101     -1  741231     -1.      -1
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I2           1       0 TRIB 3 - RM 40
I4      740101    -1.5  740408    -1.5  740422    -5.0  740708      -8.
I4      740826     -5.  741231    -1.5      -1
I2                   0 TRIB 3 - RM 40 - TDS
I4      740101    150.  741231    150.      -1
I2                   0 TRIB 3 - RM 40 - CBOD
I4      740101     0.5  741231     0.5      -1
I2                   0 TRIB 3 - RM 40 - DO
I4      740101    12.6  740115    12.7  740215    13.0  740315     12.6
I4      740415    11.5  740515     9.1  740615     8.6  740715      7.7
I4      740815     7.7  740915     9.0  741015     9.7  741115     11.1
I4      741215    12.6  741231    12.6      -1
I2                   0 TRIB 4 INFLOW RATE - RM 30
I4      740101      -1  741231     -1.      -1
I2           1       0TRIB 4 - RM 30
I4      740101    -1.5  740408    -1.5  740422    -3.0  740708      -6.
I4      740826     -5.  741231    -1.5      -1
I2                   0 TRIB 4 - RM 30 - TOTAL DISSOLVED SOLIDS
I4      740101    160.  741231    160.      -1
I2                   0 TRIB 4 - RM 30 - CARBONACEOUS BOD
I4      740101     0.6  741231     0.6      -1
I2          -1       0 TRIB 4 - RM 30 - DISSOLVED OXYGEN
I4      740101    100.  741231    100.      -1
ER
```

EXHIBIT 2
DESCRIPTION OF PROGRAM INPUT

HEC-5
SIMULATION OF FLOOD CONTROL AND CONSERVATION SYSTEMS

APPENDIX ON WATER QUALITY ANALYSIS

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EXHIBIT 2

DESCRIPTION OF PROGRAM INPUT

This exhibit contains a detailed description of each variable on each input record. The summary of input at the end of this exhibit shows the sequential arrangement of records and also serves as a "table of contents" by showing, in Field 10, the page numbers where the variables are described in this exhibit.

Variable locations for each input record are shown by field number. The records are normally divided into ten fields of eight columns each except Field 1. Variables occurring in Field 1 may normally only occupy columns 3-8 since columns 1 and 2 are reserved for the required identification characters. The different values a variable may assume and the conditions for each are described for each variable. Some variables simply indicate whether a program option is to be used or not by using numbers such as -1, 0, 1. Other variables contain numbers which express the variable magnitude. For these a + sign is shown in the description under "value" and the numerical value of the variable is entered as input. Where the variable value is to be zero, the variable may be left blank since a blank field is read as zero.

If decimal points are not provided in the data, all numbers must be right justified in the field. Any number without a sign is considered positive.

Locations of variables on records are sometimes referred to by an abbreviated designation, such as JA.4 representing the fourth field of the JA record.

1. HEC-5 INSERT

1.1 J9 RECORD

This record is inserted into the Water Quantity Simulation input file and is used to indicate that a water quality simulation is to be performed. If the J9 record is absent, no water quality simulation will be performed.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	IFLOAG	0	No flow alteration computations will performed.
		+	Flow alteration computations will be performed.
3	ISTEADY	0	Annual simulation mode (daily analysis) will be used.
		+	Long term simulation mode (monthly analysis) will be used.
4	ICALIB	0	Calibration mode is not to be used.
		+	Calibration mode is to be used.

NOTE: The longer term simulation mode and the flow alteration options are disabled when the calibration mode is being used

2. TITLE INFORMATION

2.1 TI RECORD

Three job title records required. Both alphabetic and numeric information may be used. This information will be printed as job titles on the first page of the water quality analysis output.

NOTE: The Water Quality Simulation input records follow the EJ record of the Water Quantity Simulation input file. The J9 record is inserted into the Water Quantity Simulation input file between the J8/JZ and the RL records.

3. JOB CONTROL INFORMATION

3.1 JA RECORD

Required job control.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	IDAY	+	First day of water quality simulation; year, month and day (e.g., 740501). The first day of simulation must be on or after the first day of flow simulation (FLDAT, J3.3 or BF.5).
3	LDAY	+	Last day of water quality simulation; year, month and day.
4	NCP*	+	Number of stream control points to be used in the water quality simulation.
5	NRES*	+	Number of reservoirs used in the quality simulation.
6	IC	F	Input and output water temperatures are in degrees Fahrenheit.
		C	Input and output water temperatures are in degrees Celsius.
7	IP5	0	Do not print data transferred between Water Quantity and Water Quality Simulation modules
		1	Print data transferred between Water Quantity and Water Quality Simulation modules via the file interface.
8	IHRC	+	Time interval in hours for water quality objectives and weights data (CT Record).
		0	No variation in water quality objectives and weights during any day.
9	IHRG	+	Time interval in hours for gate operation data (G2 Record).
		0	No variation in gate operation during any day.
10	NTS	+	Maximum number of time steps increments during any day.

0 24 hour quality time step will be used during the simulation. Omit JB cards.

---

* The number of control points and reservoirs used in the quality simulation may be less than the number used in the flow simulation module; however, the system defined by the water quality data must represent a portion of the larger system beginning at the upstream limits. The number of reservoirs must include any dummy reservoirs.

3.2 JB RECORD

Optional quality time step control. Required if NTS (JA.10) is greater than zero. A maximum of 12 periods may be defined.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	IT1	+	Date (year, month and day) through which the time step increments apply.
		-	Negative date indicates final JB card.
3	ITSI(1)	+	Time step increment[1] in hours for first quality time step during the day.
4	ITSI(2)	+	Time step increment[1] in hours for second quality time step during the day.
.	.		
.	.		
.	.		
.	ITSI(NTS)[2]		

[1] Time step increments may vary throughout the day, however, they must be compatible with the time step within the quantity simulation. For example, if the quantity simulation time steps are 6 hours, quality time steps of 6, 6, 6 and 6; 12 and 12; and 6, 12 and 6 would all be acceptable. Quality time steps of 8, 8 and 8 would not be acceptable. The sum of all values of ITSI for each day must equal 24 hours.

[2] NTS (JA.10) values are required for each period (including zeros if fewer than NTS times steps are required for a particular period). If NTS is greater than 8, a continuation of the JB card is required with ITSI(9) being defined in field 3.

4. WATER SURFACE HEAT EXCHANGE DATA

4.1 EZ RECORD

Required meteorological zone definition. One record must precede each set of ET records. Up to 5 zones may be specified.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	METZON	+	Meteorological zone number.
		-	Meteorological zone number. Negative value indicates final data set.
3	MINT	+	Meteorological data interval in hours.
		0	No variation in meteorological data during the day.

4.2 ET RECORD*

Required weather data. One set of ET records representing meteorological conditions is required for each day of simulation. The number of ET records required per day is controlled by MINT (EZ.3) (e.g., number of records/day = 24/MINT).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	ITIME	+	Julian date. The first observation must be on or before the first day of simulation (JA.2).
		-	Julian date; however, the negative time denotes the final ET record. The final observation must be on or after the last day of simulation (JA.3).
3	XTE	+	Equilibrium temperature in degrees Fahrenheit corresponding to ITIME (ET.2).
4	XKE	+	Coefficient of surface heat exchange in BTU/sq.ft./day/°F, corresponding to ITIME (ET.2).
5	XQNS	+	Short wave solar radiation in BTU/sq.ft./day, corresponding to ITIME (ET.2).
6	XWIND	+	Wind speed in mph, corresponding to ITIME (ET.2).

* The ET records for daily data can be easily prepared using the HEC program WEATHER (HEC, 1986) and HEATX (Corps, 1974), which are described in EXHIBIT 5 and 6, respectively. For diurnal data, an undocumented HEC utility program can be obtained by request.

5. CONSTITUENT IDENTIFICATION DATA

5.1 QC RECORD

Required for constituent identification if more than temperature is being simulated.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	ID	QC	Only if "QC" is inserted in the first two columns will a water quality simulation for constituents other than temperature occur.
2-8	CONID	1 or 0	If CONID=1, the indicated constituent will be simulated. There are seven possible constituents. Fields 2-4 are reserved for conservative constituents; Fields 5-7 are reserved for nonconservative constituents. The eighth field is reserved for dissolved oxygen. If dissolved oxygen is simulated, it is assumed that the second nonconservative constituent is carbonaceous BOD (or other oxygen consuming material) and the third nonconservative constituent is nitrogenous BOD (or other oxygen consuming material). If the third nonconservative constituent is not used for an oxygen consuming material, the CONID value (Field 7) must be zero. It can not be used for a non-oxygen consuming material.
9	IPHTYO	1	The phytoplankton option will be used. Under this option the following constituents are simulated. 1. Total dissolved solids 2. Nitrate as nitrogen 3. Phosphate as phosphorus 4. Phytoplankton 5. Carbonaceous BOD 6. Ammonia as nitrogen 7. Dissolved oxygen
		0	The number of constituents simulated is defined by CONID above.

5.2 TQ RECORD

Required constituent identification. Up to seven records, each describing a water quality constituent that is being simulated.

FIELD	VARIABLE	VALUE	DESCRIPTION
1-10	CONTTL		Alphanumeric title for each constituent that is simulated. One record is inserted for each constituent for which CONID (QC record) equals 1. No TQ record should be inserted for temperature. If the phytoplankton option is selected, these records must be omitted.

6. RESERVOIR DATA

6.1 L1 RECORD

Required printout control.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	IPRT	+	Printout interval. Reservoir simulation results will be printed on those days when the Julian date (Exhibit 3) is a multiple of IPRT.
3	IVAL	+	Printout interval. Reservoir simulation results will be printed for the IVALth space step. If IVAL=2, results for every other reservoir layer will be printed

6.2 L2 RECORD

Required miscellaneous physical constants.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	IRCP	+	Control point ID of the reservoir.
2	SDZ	+	Thickness of vertical layer in feet or meters. The thickness of the elements is normally about 1 meter; however, thickness less than 1 meter may be required to achieve the correct representation of stratification. In some instances, elements as thick as 3 meters may be used if the reservoir is deep and a relatively rough simulation is acceptable. The number of elements is also determined by the element thickness. The number of elements equals the maximum reservoir depth divided by SDZ. A maximum of 50 elements is allowed. The computer time requirement for the reservoir simulation is approximately inversely proportional to the element thickness (i.e., proportional to the number of elements).
3	RLEN(6)	+	Effective length of reservoir in feet or meters for a tandem reservoir only. This value is divided into the element surface area to obtain the width for use in the allocation of inflow to the individual elements. This width is used to allocate inflow from the upstream reach for tandem reservoirs only. Width for other reservoir inflows is defined on the following LR record. A discussion of how this width is used to allocate inflow waters is provided in Paragraph 2.2.2.
		-	The inflow will be allocated uniformly to all elements down to the level of like density within the lake.
4	EDMAX	+	Mean Secchi disk reading in feet or meters during the period when the reservoir is stratified. The Secchi disk depth is the measure of light transparency. It effects the distribution of light energy with depth and influences the location of the thermocline.
5	XQPCT	+	Fraction of the solar radiation absorbed in the top XQDEP (L2.6) depth. Usually XQPCT = .265 (.087 - .73 ln $EDMAX_{meters}$) + .614.

6.2 L2 RECORD (continued)

FIELD	VARIABLE	VALUE	DESCRIPTION
6	XQDEP	+	Depth in which XQPCT (L2.5) of the solar radiation is absorbed in feet or meters (usually .6 m or 1.9686 ft).
7	METL	+	Meteorological zone number. Must be one of the values of METZON (EZ.2).

NOTE: Records L2 through DK should be repeated successively in contiguous groups for each reservoir in the system being simulated by the water quality simulation module. A reservoir is required above each upstream reach. An upstream reservoir, however, may be a dummy which only identifies the control point and tributary identification number (e.g., only L2 and LR required). When a J5 record is inserted in the Water Quantity Simulation input file, the standard reservoir quality data need not be altered. All unnecessary data will be skipped.

6.3 LR RECORD

Required tributary identification and effective reservoir length. Zero through five tributary inflows and return flow increments are allowed at each reservoir in addition to the inflow from the upstream section for tandem reservoirs (L2.3). The same tributary identification may be used for more than one reservoir or stream location. This allows the user to input the same flow fraction and quality to any number of reservoirs or stream location. Up to 50 inflow types may be assigned, including inflow to tandem reservoirs from upstream reaches. Each tandem reservoir and each return flow reduces the number of allowable tributary identifications by one (e.g., four tandem reservoirs and two return flows would make the maximum allowable value of NRREF=44. The reduction due to return flow is in addition to the return flow increments specified by a negative tributary identification).

FIELD	VARIABLE	VALUE	DESCRIPTION
1	NRREF(1,I)	+	Tributary identification number. This number relates the tributary to the inflow quality data (records I2 through I4) (e.g., NRREF=2 would indicate the second inflow data set would apply to this tributary).
		-	Tributary identification number for return flow to the reservoir. The temperature and quality entered on the I3 or I4 records will be treated as an increment to the ambient quality, computed at the end of the previous time step at the point of withdrawal (DRTFR, DR.1). A negative value must be entered if the reservoir is specified in field 2 on any DR card. If a dummy reservoir heads a reach (i.e., reservoir removed by a J5 record), the negative tributary identification must appear in field 3. Field 1 is reserved for a normal tributary which will be ignored if the local flow is zero.
2	RLEN(I,1)	+	Effective reservoir length in feet or meters at the inflow location (see L2.3).
3,5,7,9	NRREF(2-5,I)	+,-	Tributary identification numbers for remaining tributaries and returns.
4,6,8,10	NRLEN(I,2-5)	+	Effective reservoir lengths for remaining tributaries and returns.

6.4 L3 RECORD

Effective diffusion, stability method only; one L3 record or one L4 record, but not both, is required. A discussion of theory and typical data values are provided in Paragraph 2.2.4.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	GMIN	+	Water column minimum stability in kg/cu.m./water. The water column minimum stability is the density gradient below which mixing of the water column will occur. The value is usually between 0 and 0.01 kg/m^2/meter. Larger positive values will cause the thermocline to form more quickly and delay destratification.
3	GSWH	+	Water column critical stability in kg/cu.m./meter.
4	A1	+	Diffusion coefficient when the water column stability is less than GSWH (L3.3) in sq.m./second.
5			Not used.
6	A3	-	Empirical constant for computing diffusion coefficients based on density gradients.

6.5 L4 RECORD

Effective diffusion, wind method only; one L3 or one L4 record, but not both, is required. A discussion of theory and typical data values are provided in Paragraph 2.2.4.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	GMIN	+	Water column minimum stability in kg/cu.m./meter. The water column minimum stability is the density gradient below which mixing of the water column will occur. The value is usually between zero and 0.01 kg/m^2/meter. Larger positive values will cause the thermocline to form more quickly and delay destratification.
3	GSWH	+	Minimum allowable diffusion coefficient in sq.m./second.
4	A1	+	Empirical constant for computing diffusion coefficients based on wind speed.
5	A2	+	Empirical constant for computing diffusion coefficients based on wind speed.
6	A3	+	Maximum allowable diffusion coefficient, in sq.m./second.

6.6 L5 RECORD

Flood control outlet characteristics; optional record but at least one L5, L6 or L7 record is required.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	WOUT	+	Virtual width of the flood control outlet in feet or meters. The virtual width is the actual outlet area divided by the depth of a vertical layer, SDZ (L2.2).
2	QSMAX	+	Maximum allowable flow rate through the flood control outlet in cfs or m^3/sec.
3	ELDP	+	Center-line elevation of the flood control outlet in feet or meters. The lowest elevation specified on the L5, L6 and L7 records must be greater than the minimum elevation of the reservoir elevation table (RE.2).

6.7 L6 RECORD

Uncontrolled spillway characteristics; optional record but at least one L5, L6 or L7 record is required.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	WOUT	+	Virtual width of the uncontrolled spillway in feet or meters. The virtual width is the actual outlet area divided by the depth of a vertical layer, SDZ (L2.2).
2	QSMAX	+	Maximum allowable flow rate over the uncontrolled spillway in cfs or m^3/sec.
3	ELSP	+	Center-line elevation of the uncontrolled spillway in feet or meters. The lowest elevation specified on the L5, L6 and L7 records must be greater than the minimum elevation of the reservoir elevation table (RE.2).

6.8 L7 RECORD

Wet well characteristics (a maximum of two wet wells is allowed). Optional record but at least one L5, L6 or L7 record is required.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	WOUT	+	Virtual width of each wet well port in feet or meters. The virtual width is the actual outlet area divided by the depth of a vertical layer, SDZ (L2.2). All ports within a single wet well are assumed to have the same virtual width.
2	QWMAX	+	Maximum discharge through the wet well structure with one port open in cfs or m^3/sec.
3-10	ELWW	+	Center-line elevations of the wet well ports in feet or meters beginning with the lowest port and progressing to the highest. The lowest elevation specified on the L5, L6 and L7 cards must be greater than the minimum elevation of the reservoir elevation table (RE.2).

6.9 L8 RECORD

Required reservoir widths.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	WIDE	+	Effective reservoir withdrawal width at elevations EL (RE.2 - RE.10) in feet or meters (normally the dam width at elevation EL). NK (RE.1) values. Use a second L8 record if more than 9 widths are required.

6.10 PL RECORD

Required outlet constituent suboptimization objective function parameters.

One PL record is required for temperature and additional water quality constituent being simulated.

PL records must appear in the order specified on the QC record.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	WEIT	0	The parameter will not be considered in the outlet quality optimization.
		+	Relative weight between parameters for outlet regulation optimization.
2-7	PLYNML	+ or -	a through f values for outlet constituent suboptimization objective function parameters. A discussion of the parameters for the outlet constituent suboptimization is provided in Paragraph 2.6.3.

6.11 L9 RECORD*

Required initial reservoir temperature profile.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	TEM1	+	Initial reservoir temperature at elevations EL (RE.2 - RE.10) in degrees Fahrenheit or Celsius. NK (RE.1) values. Use a second L9 record if more than 9 values are required.

6.12 C1 RECORD*

Initial reservoir conservative constituent #1 profile; required record if CONID(1) = 1 (QC.2) or required TDS profile if IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	CONS(1,J)	+	Initial concentrations for conservative constituent #1 or TDS, in appropriate units, at elevations EL (RE.2 - RE.10). NK (RE.1) values. Use a second C1 record if more than 9 values are required.

6.13 C2 RECORD*

Initial reservoir conservative constituent #2 profile; required record if CONID(2) = 1 (QC.3) or required nitrate-nitrogen profile if IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	CONS(2,J)	+	Initial concentrations for conservative constituent #2 or nitrate-nitrogen, in appropriate units, at elevation EL (RE.2 - RE.10). NK (RE.1) values. Use a second C2 record if more than 9 values are required.

6.14 C3 RECORD*

Initial reservoir conservative constituent #3 profile; required record if CONID(3) = 1 (QC.4) or required phosphate-phosphorus profile if IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	CONS(3,J)	+	Initial concentrations for conservative constituent #3 or phosphate-phosphorus, in appropriate units, at elevations EL (RE.2 - RE.10). NK (RE.1) values. Use a second C3 record if more than 9 values are required.

*The initial constituent concentration for the top elevation EL must be for a level such that the difference between the top EL and the bottom EL is evenly divisible by SDZ (L2.2).

6.15 C4 RECORD*

Initial reservoir nonconservative constituent #1 profile; required record if CONID(4) = 1 (QC.5) or required phytoplankton profile if IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	CONNON(J)	+	Initial concentrations for nonconservative constituent #1 or phytoplankton, in appropriate units, at elevations (RE.2 - RE.10). NK (RE.1) values. Use a second C4 record if more than 9 values are required.

6.16 C5 RECORD*

Initial reservoir nonconservative constituent #2 profile; required record if CONID(5) = 1 (QC.6) or required carbonaceous BOD profile if IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	CBOD(J)	+	Initial concentrations for nonconservative constituent #2 or carbonaceous BOD, in appropriate units, at elevations EL (RE.2 - RE.10). NK (RE.1) values. Use a second C5 record if more than 9 values are required.

6.17 C6 RECORD*

Initial reservoir nonconservative constituent #3 profile; required record if CONID(6) = 1 (QC.7) or required ammonia-nitrogen profile if IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	BODN(J)	+	Initial concentrations for nonconservative constituent #3 or ammonia-nitrogen, in appropriate units, at elevations EL(RE.2 - RE.10). NK (RE.1) values. Use a second C6 record if more than 9 values are required.

*The initial constituent concentration for the top elevation EL must be for a level such that the difference between the top EL and the bottom EL is evenly divisible by SDZ (L2.2).

6.18 C7 RECORD*

Initial reservoir dissolved oxygen profile; required record if CONID(7) = 1 (QC.8) or IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	OXY(J)	+	Initial concentrations for dissolved oxygen, in milligrams per liter, at elevations EL (RE.2 - RE.10). NK (RE.1) values. Use a second C7 record if more than 9 values are required.

6.19 SA RECORD

Dissolved oxygen benthic demand profile; required record if CONID(7) = 1(QC.8) or IPHYTO = 1 (QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	SSOXY(J)	+	Rate at which dissolved oxygen is consumed by the decay of benthic material in $mg/m^2/day$ at elevations EL (RE.2 - RE.10). NK (RE.1) values. Use a second SA record if more than 9 values are required.

6.20 SB RECORD

Ammonia-nitrogen benthic source profile; required record if IPHYTO=1(QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	SSNH3(J)	+	Rate at which ammonia-nitrogen is released by the decay of benthic material in $mg/m^2/day$ at elevations EL (RE.2 - RE.10). NK (RE.1) values. Use a second SB record is more than 9 values are required.

*The initial constituent concentration for the top elevation EL must be for a level such that the difference between the top EL and the bottom EL is evenly divisible by SDZ (L2.2).

6.21 SC RECORD

Phosphate-phosphorous benthic source profile; required record if IPHTYO = 1(QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	SSPO4(J)	+	Rate at which phosphate-phosphorus is released by the decay of benthic material in $mg/m^2/day$ at elevations EL (RE.2 - RE.10). NK (RE.1) values. Use a second SC record if more than 9 values are required.

6.22 K1 RECORD

Phytoplankton model coefficients; required if IPHYTO=1(QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	PMAX	+	Phytoplankton maximum growth rate in 1/day.
		-1	Default is 2.0.
3	PRESP	+	Phytoplankton respiration rate in 1/day.
		-1	Default is 0.15.
4	PSETL	+	Phytoplankton settling velocity in meters/day.
		-1	Default is 0.15.
5	PS2L	+	Light half saturation constant for algae growth in $kcal/m^2/sec$.
		-1	Default of 0.0035.
6	PS2N	+	Nitrogen half saturation constant for algae growth in mg/l.
		-1	Default of 0.06.
7	PS2P	+	Phosphorus half saturation constant for algae growth in mg/l.
		-1	Default of 0.03.
8	EXTINP	+	Phytoplankton shading/light attenuation constant 1/m/mg/l.
		-1	Default of 0.2.
9	XLAT	+	Latitude of the reservoir in degrees.

6.23 K2 RECORD

Phytoplankton model coefficients; required if IPHYTO = 1(QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	PMORT(1-9)	+	Phytoplankton mortality rate for January through September in 1/day. The mortality rate is designed to account for zooplankton grazing, chemical treatment and other factors which affect phytoplankton adversely.
			Use a second K2 record for October, November and December mortality rates in Fields 2-4.

6.24 K3 RECORD

Phytoplankton model coefficients; required if IPHYTO=1(QC.9).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	ALGT1	+	Lower temperature limit at which phytoplankton will grow at 0.1 of their maximum rate in degrees Celsius.
		-1	Default of 5.
3	ALGT2	+	Lower temperature limit at which phytoplankton will grow at 0.98 of their maximum rate in degrees Celsius.
		-1	Default of 22.
4	ALGT3	+	Upper temperature limit at which phytoplankton will grow at 0.98 of their maximum rate in degrees Celsius.
		-1	Default of 30.
5	ALGT4	+	Upper temperature limit at which phytoplankton will grow at 0.1 of their maximum rate in degrees Celsius.
		-1	Default of 40.

6.25 DK RECORD

Decay coefficients and settling rate controls for reservoirs. This record is required only if constituents other than temperature are being simulated.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	UNCNDK	+	Decay rate at 20°C standard temperature for nonconservative constituent #1 in reservoir waters. Will be set to zero under the phytoplankton option.
3	BODDK	+	Decay rate at 20°C standard temperature for nonconservative constituent #2 (carbonaceous BOD or oxygen demanding material #1) in reservoir waters (usually 0.1).
4	BODNDK	+	Decay rate at 20°C standard temperature for nonconservative constituent #3 (nitrogenous BOD or oxygen demanding material #2 or ammonia decay rate under the phytoplankton option) in reservoir waters (usually 0.05).
5	CONVR1	+	Factor to convert input nonconservative constituent #2 concentrations to ultimate oxygen demand if dissolved oxygen is being simulated. The value of CONVR1 depends on the constituent being represented. If ultimate carbonaceous BOD is represented, CONVR1 should be 1.0. If 5-day carbonaceous BOD is represented, CONVR1 should be 1.463 (default) which assumes a bottle BOD decay rate of 0.23 per day.
6	CONVR2	+	Factor to convert input nonconservative constituent #3 concentrations to ultimate oxygen demand if dissolved oxygen is being simulated. The value of CONVR2 depends on the constituent being represented. CONVR2 should be 1.0 for ultimate nitrogeneous BOD, 2.54 (default) for 5-day NBOD (assuming bottle decay rate of 0.1 per day), and 4.57 for ammonia.
7-10	NXC	0	Not a particulate parameter.
		1	Read settling rates and light extraction coefficients. Settling rates and extinction coefficient may be specified for each conservative parameter (NXC1, NXC2 and NXC3), and the first nonconservative parameter (NXC4) to represent three inorganic and one organic particulate parameter. One DS record is required for each positive value.

6.25a DS RECORD

Suspended Solids Settling Rate and Light Extraction Coefficient*
One record is required for each non zero value of NXC (DK.7-10).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2 3 4 5 6 7	T1(1) T2(1) T1(2) T2(2) T1(3) T2(3)	+	Three pairs of settling velocity in cm/sec (T1) versus temperature in °C (T2) for suspended solids. These three points define the curve from which settling velocities will be calculated for the ambient water temperature.
8	EXTINC	+	Shading/light attenuation constant in 1/m/mg/l. This constant relates light energy attenuation within the reservoir to the particulate material concentration.

* Settling rates and light attenuation constants for inorganic solids vary with particle size. Typical value recommendations by Dr. Michael Gee, HEC, are tabulated below. Volatile solids of similar size will have lower settling velocities due to smaller densities.

Class	Particle Size (mm)	Temperature* (°C)	Settling Velocity* (cm/sec)	Light Attenuation Constant (1/m/mg/l)
Colloidal	.001	--	0.000	.20-.50
Very fine silt	.004-.008	5	0.006	.10-.20
		20	0.008	
		35	0.010	
Fine silt	.008-.016	5	0.012	.05-.10
		20	0.019	
		35	0.024	
Medium silt	.016-.031	5	0.041	.02-.05
		20	0.068	
		35	0.086	
Coarse silt	.031-.0625	5	0.110	.01-.02
		20	0.180	
		35	0.230	

6.26 CR RECORD

Thermal correction factors. The CR record is required only if constituents other than temperature are being simulated. These factors adjust the decay rates and reaeration rates for ambient temperatures other than 20°C. These factors apply to both reservoir and stream computations.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	QUNCON	+	Thermal correction factor for nonconservative constituent #1 decay rate.
		-1	Default is 1.047.
3	QCBOD	+	Thermal correction factor for nonconservative constituent #2 (or carbonaceous BOD or oxygen demanding #1) decay rate.
		-1	Default of 1.047.
4	QNBOD	+	Thermal correction factor for nonconservative constituent #3 (or nitrogenous BOD or oxygen demanding material #2) decay rate.
		-1	Default of 1.047.
5	QREAIR	+	Thermal correction factor for dissolved oxygen reaeration rate.
		-1	Default of 1.0159.

7 STREAM DATA

7.1 S1 RECORD

Required stream data controls.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	IPRT	+	Temporal printout interval. Stream simulation results will be printed on those days when the Julian date (Exhibit 3) is a multiple of IPRT.
3	IVAL	+	Spatial printout interval. If IVAL = 1, computed results will be printed for every stream volume element. If IVAL = 2, computed results will be printed for every other volume element. (Recommended value: +1.)
4	IGEDA	1	Stream channel cross section geometry data will be printed. These are needed to evaluate stream hydraulic computations for depth.
		0	Channel geometry data will not be printed.
5	NBPP	+	Number of input channel cross section geometry tables; minimum of 2 and maximum of 300.
6	NELEV	+	Number of elevations defining the channel cross section data; minimum of 2 and maximum of 21.
7	VWR	+	Scaling factor (default value of 1.0) to adjust all channel cross section widths.

7.2 S2 RECORD

Reach definition and local inflow location. One record is required for each reach (i.e., I=1, NREACH). A stream reach is defined as any stream segment bounded by two control points. The reach that contains a reservoir, in a tandem reservoir system, should be characterized by a required blank S2 record.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	ICP(1,I)	+	Control point number at the upstream end of Reach I.
2	RCP(1,I)	+	River mile or kilometer at the upstream end of Reach I.
3	ICP(2,I)	+	Control point number at the downstream end of Reach I.
4	RCP(2,I)	+	River mile or kilometer at the downstream end of Reach I.
5	ELEN(I)	+	Length of stream elements for Reach I. The stream element length must be such that there are at least two computational elements in each reach and not more than 49. All stream reaches ending at the upstream end of a tandem reservoir must end with a control point that is not the confluence of two streams (junction control point).
6	RQI(1,I)[1]	+	River mile or kilometer location of local inflow point.
7	NSREF(1,I)[1]	+	Tributary identification number for inflow at location RQI(1,I) (S2.6).

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[1]The local flow (i.e. , local flow for control point ICP(2,I), S2.3) may be allocated to three locations within the reach. The location of the first two local inflow points are specified by RQI. The third (i.e., NSREF(3,I), S2.10) is allocated at location RCP(2,I), S2.4. The same tributary identification may be used for more than one stream inflow location or reservoir inflow. This allows the user to input the same flow fraction and quality at any number of stream locations and reservoirs. Up to 50 inflow types may be assigned, including inflow to tandem reservoirs from upstream reaches. Each tandem reservoir reduces the number of allowable tributary identifications by one (e.g., 4 tandem reservoirs would make the maximum allowable value of NSREF - 46).

7.2 S2 RECORD (continued)

FIELD	VARIABLE	VALUE	DESCRIPTION
8	RQI(2,I)1	+	River mile or kilometer location of local inflow point.
9	RSREF(2,I)[1]	+	Tributary identification number for inflow at location RQI(2,I) (S2.8).
10	NSREF(3,I)[1]	+	Tributary identification number for inflow at the downstream control point ICP(2,I) (S2.3).
		-	Tributary identification number for return flow to the downstream control point. The temperature and quality entered on the I3 or I4 records will be treated as an increment to the ambient quality computed at the end of the previous time step at the point of withdrawal (DRTFR,DR.1). A negative value must be entered if the control point is specified in field 2 on any DR record.

1 The local flow (i.e., local flow for control point ICP(2,I), S2.3) may be allocated to three locations within the reach. The location of the first two local inflow points are specified by RQI. The third (i.e., NSREF(3,I), S2.10) is allocated at location RCP(2,I), S2.4. If a return flow is indicated by a negative value of NSREF(3,I) (S2.10), the location of normal tributaries (maximum of 2) must be specified by RQI. The same tributary identification may be used for more than one stream inflow location or reservoir inflow. This allows the user to input the same flow fraction and quality at any number of stream locations and reservoirs. Up to 50 inflow types may be assigned, including inflow to tandem reservoirs from upstream reaches. Each tandem reservoir reduces the number of allowable tributary identifications by one (e.g., four tandem reservoirs and two return flows would make the maximum allowable value of NRREF=44. The reduction due to return flow is in addition to the return flow increments specified by a negative tributary identification).

7.3 SR RECORD

Required reaeration option, meteorological zone definition and diffusion coefficient specification

FIELD	VARIABLE	VALUE	DESCRIPTION
1	L1	+	Upstream control point from which data apply.
		-	Upstream control point. Negative value indicates final SR record.
2	L2	+	Downstream control point to which data apply.
3	METZON	+	Meteorological zone number. Must be one of the values of METZON (EZ.2).
4	KZOPP	+	Oxygen reaeration control. One of the following may be specified:
		1	Churchill, et al.
		2	O'Conner and Dobbins
		3	Owens, et al.
		4	Langbien and Durum
		5	Thackston and Krenkel
		6	Tsivoglou and Wallace
		7	Input reaeration coefficient directly. One or more SK records will be required.
		8	Reduce oxygen deficit at location RK2MI (SR.5) by the fraction RK2 (SR.6)
5	RK2MI	+	Location where the oxygen deficit will be reduced by the fraction RK2. If the reduction in the oxygen deficit is desired at a control point, the input location should be slightly below and upstream control point or slightly above a downstream control point.
		0	KZOPP (SR.4) is other than 8.
6	RK2	+	Fraction by which the oxygen deficit will be reduced.
		0	KZOPP (SR.4) is other than 8.
7	DCC	+	Diffusion coefficient in ft^2/sec or m^2/sec. This coefficient will apply to all stream elements between L1(SR.1) and L2(SR.2).
		0	No diffusion between stream elements.

SK RECORD

Element reaeration coefficient definition. SK records are required following any SR record for which direct input of the reaeration coefficient is specified (KZOPP=7, SR.4). Nine values may be specified per SK record. Repeat as necessary to define all elements bounded by L1 and L2 (SR.1 and SR.2).

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	SK2	+	Reaeration coefficient, 1/day, for each element.

7.5 S3 RECORD*

Channel cross section geometry. NELEV (S1.6) records are required for each of NBPP (S1.5) cross sections.

Records must be in upstream to downstream order, with a minimum of one cross section for each control point. At control points making the confluence of a tributary stream branch, a cross section must be provided for both the mainstem and the terminus of the tributary stream branch. Intermediate cross sections may be furnished. For parallel systems, cross section data are ordered from the most upstream mainstem control point to, and including, the confluence control point; then tributary control point cross section data are entered. Following the tributary cross section data, the cross section data for the mainstem downstream of the control point at the confluence are entered.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	NCPX	+	Control point at the cross section or the first control point downstream for cross sections not at a control point. The NCPX is required on only the first record of the data for each cross section.
2	XMX	+	River mile or kilometer location of cross section.
3	ELEV	+	Elevation in feet or meters. The elevation increments (between layers) must be identical on all cross sections.
4	A	+	Cross section flow area in sq. ft. or sq. m. below elevation ELEV (S3.2).
5	R23	+	Hydraulic radius to the 2/3 power at elevation ELEV (S3.2).
6	WD	+	Surface width in feet or meters at elevation ELEV. All cross section widths will be multiplied by VWR (S1.7).
7	AMAN	+	Manning's n at elevation ELEV (S3.2).
8	QST	+	Flow in cfs of m^3/sec at elevation ELEV (S3.3). If QST is left blank, the flow will be computed assuming normal depth.

NOTE: Dimension limitations are 50 cross sections per reach (between 2 adjacent control points) and 300 cross sections per job.

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*The S3 records can be easily prepared using HEC program GEDA [HEC 1981] which is described in Exhibit 5.

7.6 S4 RECORD

Required energy grade line elevation. S4 records should be ordered as described on the previous page for the S3 records.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2-10	ELEV	+	Stream channel energy grade line elevation in feet or meters at each channel cross section. Elevation must be input in the same order as the S3 record sets (i.e. upstream to downstream). Repeat S4 record as necessary to input NBPP (S1.5) elevations. Invert elevations may be used as an approximation of the energy grade line elevations if normal flow conditions prevail throughout the stream section. Elevations which result in negative slopes are not allowed.

7.7 KR RECORD

Decay coefficients for streams. These records are required only if nonconservative constituents other than temperature are being simulated. One record should appear for each stream reach.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	UNCONDK	+	Decay rate for nonconservative constituent #1 at standard temperature of 20°C.
		0	Phytoplankton option.
3	BODCDK	+	Decay rate for nonconservative constituent #2 at standard temperature of 20°C.
4	BODNDK	+	Decay rate for nonconservative constituent #3 (ammonia under phytoplankton option) at standard temperature of 20°C.
5	CONVR1	+	Factor to convert input nonconservative constituent #2 concentrations to ultimate oxygen demand. If dissolved oxygen is not being simulated, a value of 1.0 must appear. If dissolved oxygen is being simulated, the value of CONVR1 depends on the constituent represented by nonconservative constituent #2. If ultimate carbonaceous BOD is represented, CONVR1 should be 1.0. If 5-day carbonaceous BOD is represented, CONVR1 should be 1 .463. This factor assumes a bottle BOD decay rate K1 of 0.23 per day.
6	CONVR2	+	Factor to convert input nonconservative constituent #3 concentrations to ultimate oxygen demand. If dissolved oxygen is not being simulated, a value of 1.0 must appear. If dissolved oxygen is being simulated, the value of CONVR2 depends on the constituent represented by nonconservative constituent #2. If nitrogenous BOD is represented, CONVR2 should be 1.0. If ammonia is represented, CONVR2 should be 4.57.

7.8 CT RECORD

Stream water quality objectives and constituent weights are required for non-calibration simulations (ie., ICALIB(JA.4)=0) and are optional for calibration simulations. One set of CT records are provided for each constituent being simulated at each control point. Records must be entered by ascending time, constituent and control point. In other words, all temporal targets and weights for temperature at control point #1 must be entered before proceeding to the next parameters. After all targets and weights for each parameters are defined for control point #1, proceed to define targets and weights for the next control point. The time of the first set of water quality objectives and weights must be on or before the first day of simulation (JA.2), and will apply until overridden by subsequent sets. The number of CT records per day is controlled by IHRC (JA.8) (ie., number of records/day = 24/IHRC).

FIELD	VARIABLE	VALUE	DESCRIPTION
1	ID	+	Control point ID number. The ID is only required on the first temperature objective record for each control point.
2	ITIMCP	+	Time that the target becomes effective, year, month and day e.g., 740501). Objectives and weights are held constant until respecified by subsequent CT records.
3		-	Negative date indicates the final set of CT cards in each temporal data set.
3	CONMAX	+	Target value for temperature or constituent concentration.
4	WEITUP	+	Relative weight assigned to violation caused by exceeding the target value.
5	WEITDN	+	Relative weight assigned to violation caused by not exceeding the target value.
6-10	JREG	+	Reservoirs to be operated to meet water quality target during flow augmentation. Up to 10 upstream reservoirs may be specified for each control point on the first and second temperature records only.

8. INFLOW TEMPERATURE AND WATER QUALITY

One I1 record followed by sets of I2 and I3 records, or I2 and I4 records, are required for each tributary or reservoir inflow. The total number of data sets must equal the maximum value of NRREF (LR.1, 3, 5, 7 and 9) or NSREF (S2.7, 9 and 10). Data are ordered by time and by constituent for each control point, as was done with the CT records.

8.1 I1 RECORD

Required inflow water quality record length and input data control. The length of record can be longer than the simulation period but must include the simulation period as a minimum.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	IIDAY	+	First day of inflow water quality data; year, month and day.
3	LLDAY	+	Last day of inflow water quality data; year, month and day.
4	I3HR	0	I3 record data frequency will be based on daily time increment.
		1	I3 record data frequency will be based on hourly time increment.
5	I4HR	0	I4 record time data will be entered as yr/mo/day.
		1	I4 record time data will be entered as yr/mo/dy/hr

8.2 <u>I2 RECORD</u>

Required inflow data control and identification.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	IEQ	+	Meteorological zone number, must be one of the values of METZON (EZ.2). Inflow temperature will be computed as the departure from the equilibrium temperature.
		100+	Meteorological zone number plus 100. Inflow temperatures will be computed by a factor times the equilibrium temperature (i.e., a value of 104 would indicate that inflow temperature would be based on Zone 4 equilibrium temperatures).
		-1	Dissolved oxygen will be input as a percent of saturation.
		0	All other constituents or temperature or dissolved oxygen to be entered in standard units.
3	IDINT	+	Local inflow rate or quality data update interval in days or hours (see I1.4). Inflow data are input using a series of I3 cards under this option.
		0	Local flow inflow rate or quality data are input at variable time intervals using a series of I4 cards under this option.
4-8	CON	ALPHA	Description of inflow data.
9	RTO	+	Proportionality constant (units = 1/hr) for dampening the change in temperature or dissolved oxygen if IEQ (I2.2) is non zero.* If RTO times the time step increment exceeds 1, no dampening will occur.

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* The inflow temperature is determined by:

$$T = (T_o(1-RTO\cdot\Delta\tau) + (T_e+\Delta T)RTO\cdot\Delta\tau)$$

$$0 < RTO\cdot\Delta T \leq 1$$

where
- T = inflow temperature
- T_o = inflow temperature for previous time step
- $\Delta\tau$ = time step in hours
- T_e = equilibrium temperature
- ΔT = departure from equilibrium temperature

Dissolved oxygen concentrations are determined in a similar fashion. Dampening should be used when short meteorological data intervals (MINT, EZ.3 less than 24 hours) result in large diurnal changes in equilibrium temperature.

8.3 I3 RECORD

Inflow rate and water quality data at constant time interval (i.e., positive IDINT, I2.3). The number of I3 records is determined by the length of inflow water quality record (I1.2 and I1.3) and the inflow data update interval (I2.3). (Examples: If I3HR (I1.4) is zero, 72 days of record with 4 day update interval would require 1 + 72/4 = 19 values and a total of 2 records; If I3HR (I1.4) is one, 72 days of record with 6 hour update interval would require 1 + 72 24/6 = 289 values and a total of 29 records. Optional record.

FIELD	VARIABLE	VALUE	DESCRIPTION
1-10	CONC	+ or -	Inflow rate or water quality constituent concentration, in appropriate units. Inflow may be input as a rate (positive values of CONC) or as a fraction of the total local flow (negative values of CONC) (i.e., CONC = -.5 would indicate that one-half of the local flow would be allocated to the inflow). Temperatures may be input directly, as departures from the equilibrium temperature or as a ratio of the equilibrium temperature. Dissolved oxygen may be input as a percent of saturation. The types of data are controlled by IEQ (I2.2). Straight line interpolation is used to determine water quality constituent concentrations at intermediate times.

8.4 I4 RECORD

Inflow rate and water quality data at variable time intervals (i.e., IDINT, I2.3 = 0); optional record.

FIELD	VARIABLE	VALUE	DESCRIPTION
1			Not used.
2	ITIME	+	Time of observation. The first time of observation must be on or before IIDAY (I1.2) and the last observation on or after LLDAY (I1.3). This record may be repeated as necessary to include the entire inflow period.
		-1	Denotes the end of the data set.
3	CONC	+ or -	Inflow rate or water quality constituent concentrations, in appropriate units. Inflow may be input as a rate (positive values of CONC) or as a fraction of the total local flow (negative values of CONC) (i.e., CONC = -.5 would indicate that one-half of the local flow would be allocated to the inflow). Temperatures may be input directly, as departures from the equilibrium temperature or as a ratio of the equilibrium temperature. Dissolved oxygen may be input as a percent of saturation. The types of data are controlled by IEQ (I2.2). Straight line interpolation is used to determine water quality constituent concentrations at intermediate days.
4	ITIME	+ or -1	Sets of time and corresponding local
5	CONC	+ or -	inflow rate or water quality data.
6	ITIME		
7	CONC		
8	ITIME		
9	CONC		

If 14HR (I1.5) is zero, the time (beginning of the day) is entered as year, month and day. If 14HR is one, the time (end of the hour) is entered as year, month, day and hour (e.g., 7050112).

9 GATE OPERATIONS DATA

One G1 record, followed by as many G2 records as necessary, are required when the calibration mode is being used. These records are only needed for the calibration mode.

9.1 G1 RECORD

Length of gate operations record. The length of record can be longer than the simulation period but must include the simulation period as a minimum. Required record for the calibration mode.

FIELD	VARIABLE	VALUE	DESCRIPTION
1	IDAY	+	First day of gate operations data, year, month and day expressed as YRMODA (e.g., 760501).
2	LDAY	+	Last day of gate operations data, year, month and day expressed as YRMODA.

9.2 G2 RECORD

Optional gate operations data for model calibration (required if ICALIB (J9.4) = 1). The gate operations data on these records must start and stop on the dates given on the G1 record for all reservoirs in the system. The number of G2 records per day is controlled by IHRG (JA.9) (i.e., number of records/day = 24/IHRG).

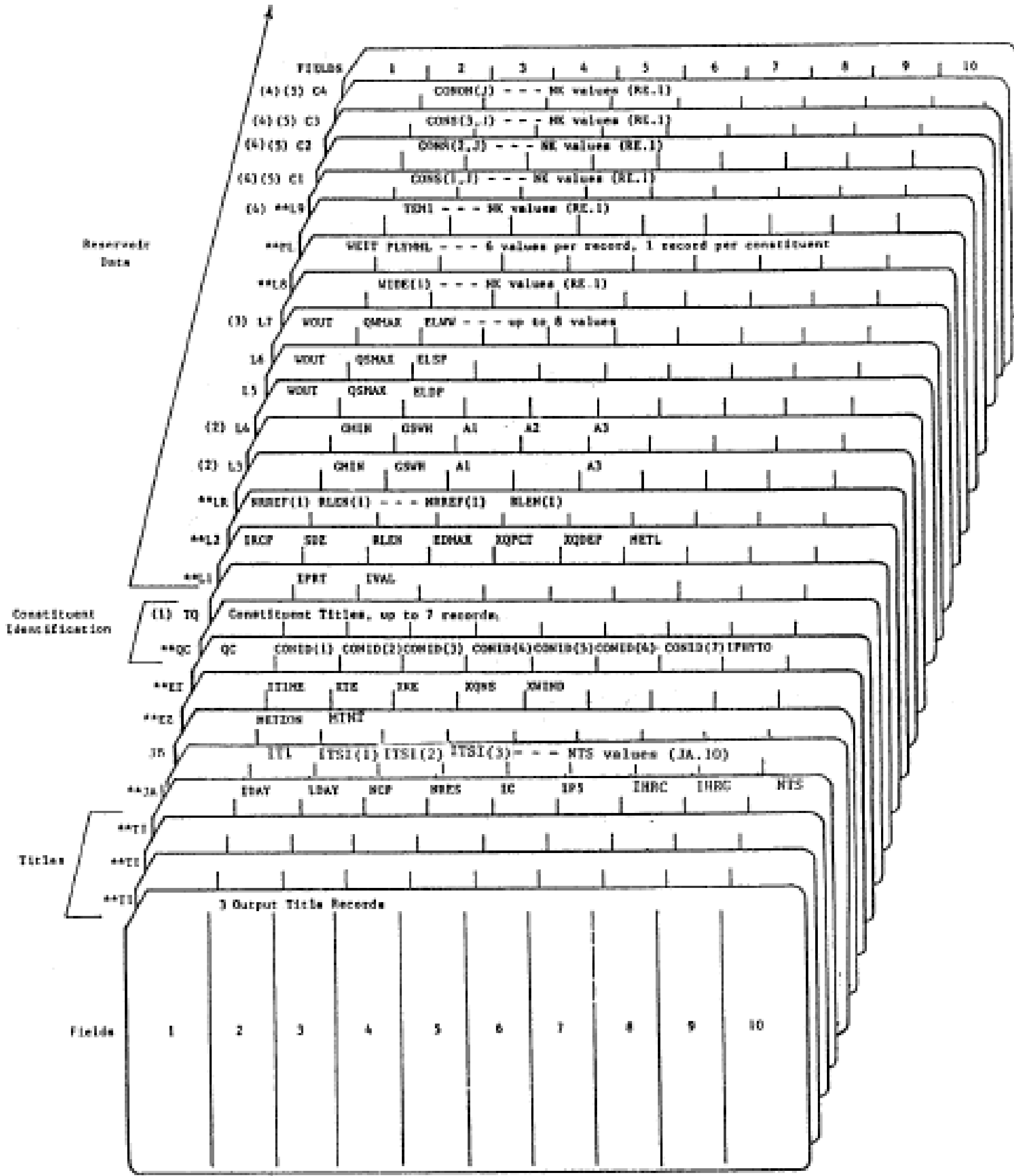
FIELD	VARIABLE	VALUE	DESCRIPTION
1	RESNO	+	Control point number for reservoir to which data pertain.
2	IIDAY	+	Starting day of period for which data on this record is applicable (YRMODA) (e.g., 760501).
3	LLDAY	+	Final day of period for which data on this record is applicable (YRMODA).
		-	Final day on last G2 record requires a negative LLDAY.
4	QFCI	+	Flow through flood control outlet for period.
5	QSPI	+	flow through spillway for period.
6	QWW1I	+	Flow through wet well #1 for period.
7	GATE1I	+	Number of the gate in wet well #1 through which flow QWW1I (G2.6) passes, numbered from bottom gate upward.
8	QWW2I	+	Flow through wet well #2 for period.
9	GATE2I	+	Number of the gate in wet well #2 through which flow GWW2I (G2.8) passes, numbered from bottom gate upward.

10 ER RECORD

The simulation will end with the appearance of an ER record.

HEC-5 WATER QUALITY SIMULATION MODULE

SUMMARY OF INPUT



** Required records

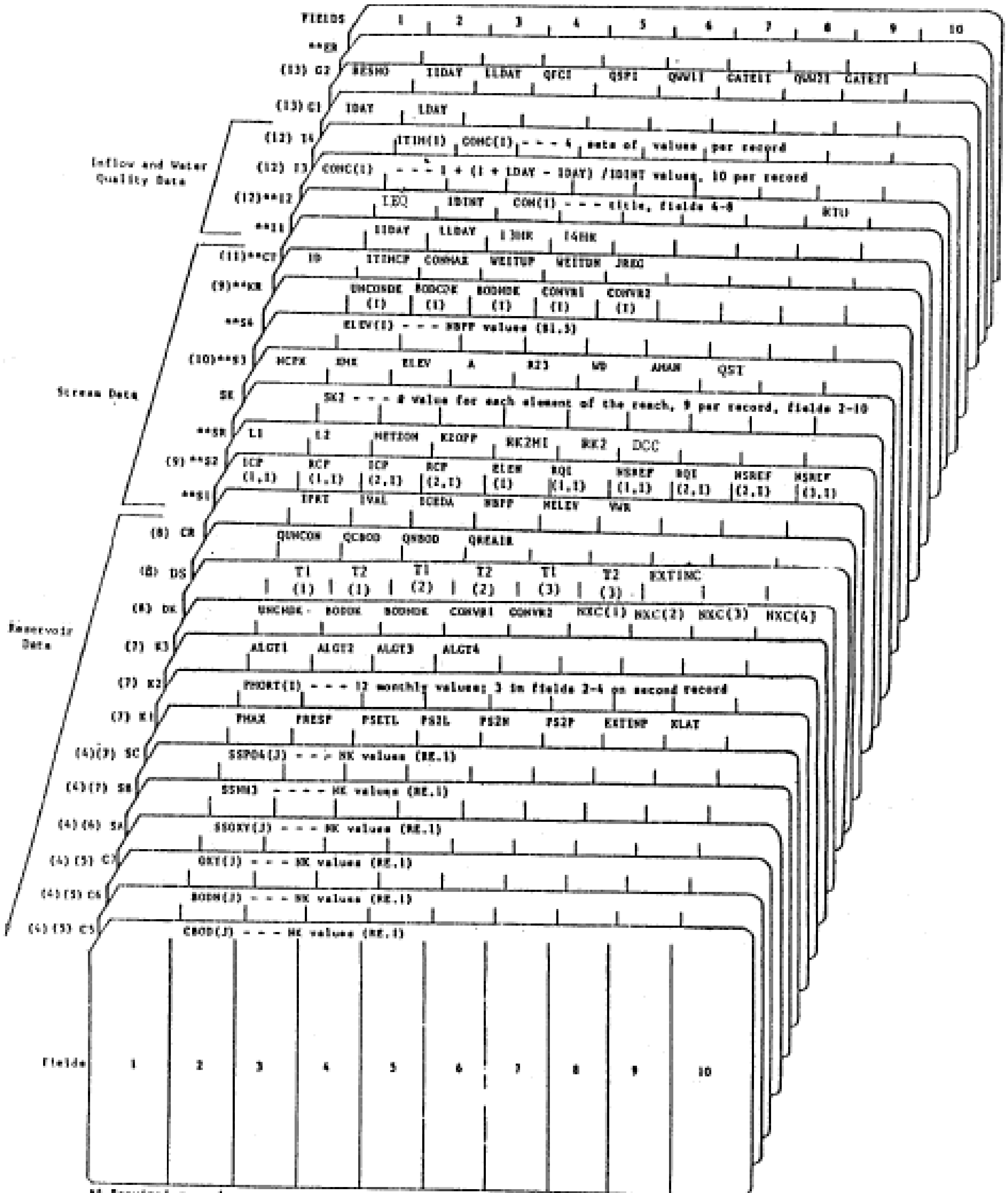
(1) Omit TQ records if IPHYTO(QC.9) is one.

(2) Either the L3 or L4 record (but not both) is required.

(3) 0, 1, or 2 L7 records are allowed.

(4) A second record may be used if more than 9 values are required to define the initial profile.

(5) Required only if constituent is being simulated.



** Required records.
(5) Required only if constituent is being simulated.
(6) Required if CONID(7) = 1 (QC.8).
(7) Required if IPHYTO = 1 (QC.9).
(8) Should not appear if only temperature is being simulated.
(9) One record is required for each reach (i.e., one fewer than the number of control points).
(10) One set of NKLEV record cards required for each of NBPP cross sections.
(11) One record for each target, constituent and control point.
(12) One I2 record combined with sets of I3 or sets of I4 records are required for each constituent including flow and for each local inflow point.
(13) Required if CALIB = 1 (J9.4).

EXHIBIT 2

EXHIBIT 3
JULIAN CALENDAR

JULIAN DATE CALENDAR

(PERPETUAL)

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3.
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

FOR LEAP YEAR USE REVERSE SIDE

JULIAN DATE CALENDAR

FOR LEAP YEARS ONLY

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	061	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244		305		366	31

(USE IN 1964, 1968, 1972, etc.)

GPO 687-010/8408

EXHIBIT 4

PROGRAM WEATHER USERS MANUAL

US Army Corps
of Engineers
Hydrologic Engineering Center

Generalized Computer Program

WEATHER

User's Manual

January 1986

CPD-52

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

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Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This manual describes the WEATHER program which provides weather input data for WQRRS and HEC-5Q. From a NOAA National Climatic Center weather data file, the program produces a file that is in the proper format for either WQRRS or HEC-5Q. The data file can be hourly or three hourly weather data, and contains air (dry bulb) temperature, wet bulb temperature, dew point temperature, wind speed, barometric pressure, and cloud cover in addition to other weather parameters.

15. SUBJECT TERMS
WEATHER, WQRRS, HEC-5Q, weather data file, National Climatic Center, hourly weather data, air (dry bulb) temperature, wet bulb temperature, dew point temperature, wind speed, barometric pressure, cloud cover, solar radiation

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
U	U	U	UU	28	19b. TELEPHONE NUMBER

Standard Form 298 (Rev. 8/98)
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WEATHER

User's Manual

January 1986

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CPD-52

10 December 1984

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WEATHER

USERS MANUAL

TABLE OF CONTENTS

WEATHER

1. INTRODUCTION

1.1 Purpose of Program

Program WEATHER was developed to assist the user of the WQRRS and the HEC-5Q models with the preparation of the required input weather data. The program reads a NOAA National Climatic Center weather data file and outputs a file in the proper input format for either the WQRRS or the HEC-5Q program.

1.2 Origin of Program

The WEATHER program was originally written by Mr. Alfred Onodera in 1974 to provide the WQRRS user with input assistance. The program has been modified by Mr. R.G. Willey to provide more flexibility of time scales and output capability for both WQRRS and HEC-5Q.

1.3 Hardware Requirements

This program is written in FORTRAN 77 without machine dependencies. The program has been tested on HARRIS and CDC equipment. There should be little, if any, problem in compilation on other computers.

2. PROGRAM CONCEPTS

The WEATHER program reads a National Climatic Center data file of hourly or three hourly weather data. The file contains air (dry bulb) temperature, wet bulb temperature, dew point temperature, wind speed, barometric pressure, and cloud cover in addition to other weather parameters. Some stations, during some years, only have three hourly data but the general format is considered to be hourly.

The WQRRS model can use hourly weather data or any multiple of hourly that divides evenly into 24 hours. The HEC-5Q model can only use daily average data. The cloud cover, which is used to predict the amount of solar radiation reaching the ground, should be averaged only during day-light hours.

The model needs an initial input record which specifies which program options the user wants to use. Based on the input from this header record, the program provides either hourly (or multiples of hourly) weather data for the WQRRS model, or the averaged daily data for either the WQRRS or the HEC-5Q models. The formats and types of weather parameters used are different for each model.

3. INPUT

The input begins with three title cards having any alpha character in columns 1-80, although it is suggested that the first two columns be used for a card I.D. Following the three titles, the initial header record contains the following:

Columns	Description
1-2	Card identification (e.g. C1).
3-8	Starting year; two digits
9-16	Starting month.
17-24	Starting day.
25-32	Last year of simulation; two digits.
33-40	Last month of simulation.
41-48	Last day of simulation.
49-56	Index which equals 1 for WQRRS output format or 0 for HEC-5Q output format.
57-64	Index which equals 1 for wet bulb input or 0 for dew point input. Only needed for WQRRS interface.

The title records and the header record are read from unit 5. The remaining input is from the National Climatic Center containing weather data in their "CD144" format. This data may need to be unblocked to 80-character (card-image) records before processing. Appendix I defines the type of available data and its format. National Climatic Center data can be ordered from Asheville, North Carolina, for non-Corps offices and from Scott Air Force Base, Illinois for Corps offices. The Corps offices should refer to Army Pamphlet 115-1 "Requests for Climatological Support to Army Activities," dated June 1983. Both offices' addresses and phone numbers are given below:

For Corps Offices

Commander
USFA Environmental Technical
Applications Center
ETAC/DO
Scott AFB, IL 62225
(704) 259-0218

For Non-Corps Offices

National Climatic Center
Federal Building
Ashville, NC 28801
(704) 259-0682

Example inputs are shown in Appendices II and III.

*This phone connects with Air Force Staff located at Asheville, NC. They can answer your questions, although you must order your data from Scott AFB.

4. OUTPUT

The program output is weather data for the input station for the exact period of interest in a format for either the WQRRS or the HEC-5Q (actually HEC-5Q type output is input to a preprocessor called HEATX, which provides output for HEC-5Q input format). The results are written to unit 7. Example outputs for unit 7 are shown in Appendices IV and V.

If your execution is unsuccessful, the following messages (from unit 6) may be helpful for editing your data:

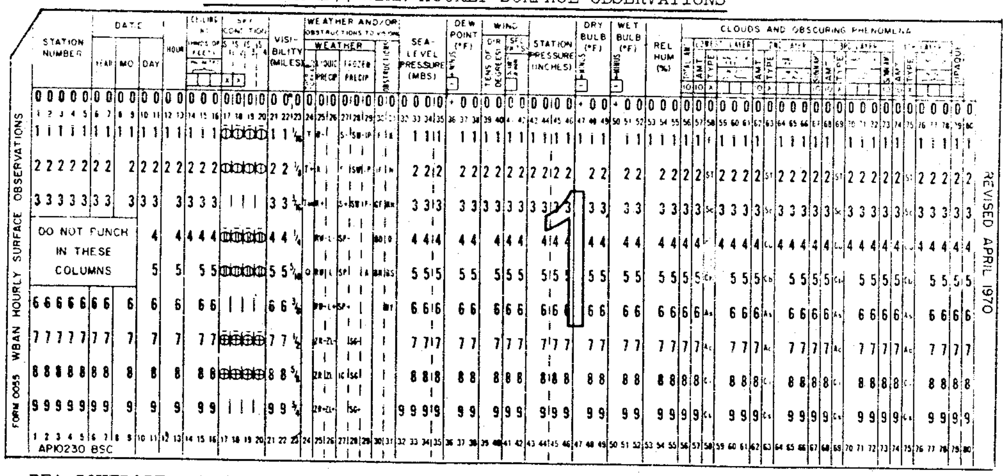
Message	Remarks
STOP 55	Starting hour must be 01 for three hour intervals and 00 for all other intervals.
STOP 200	Program read an end of file.

APPENDIX I

NATIONAL WEATHER SERVICE

CD144 REFERENCE MANUAL

CARD DECK 144 WBAN HOURLY SURFACE OBSERVATIONS



AREA COVERAGE: United States, Caribbean and Pacific Islands and other overseas stations of U. S. Weather Bureau, Air Force and Navy.

PERIOD OF RECORD: Navy Apr 1945- Weather Bureau Jan 1948- Air Force Jan 1949-
Note: Some prior periods are included in this deck. A status of the period of record for each station is maintained at the National Climatic Center, Asheville, North Carolina.

OBSERVATION TIME: Local Standard Time (LST). For information relating to changes in time of observation, refer to SUPPLEMENTARY NOTE A, page 9. Beginning 1 Jan 65, the Weather Bureau reduced the number of hourly observations punched from 24 to 8 per day. These 3-hourly observations correspond to record observations at 0000, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 GMT. As a result of special studies, some WB stations may have 24 observations per day punched.

CODES: WBAN and WMO

SOURCE: WBAN Forms 10A, 10B and 10 or similar forms. In addition to WBAN Forms for Weather Bureau, Air Force and Navy, those of FAA and Signal Corps are included. Effective 1 Apr 70, forms redesignated as MF 1-10A, 1-10B and 1-10C. MF indicates Meteorological Form.

MISSING DATA: Blanks in appropriate columns are used to indicate missing data. Identification cards were punched for missing observations at AWS stations unless a whole month's record was missing. Punching of ID cards for AWS stations was phased out from Sep-Dec 1968.

COLUMNS AND ELEMENTS PUNCHED: Columns 1-79 are punched.
Elements punched are: (Index on page 14)

Ceiling Height
Sky Condition
  Clear
  Scattered
  Broken
  Overcast
  Partial
    Obscuration
  Obscuration
Visibility
Weather and/or
Obstruction to
Vision
Thunderstorm
Tornado
Squall
Rain
Rain Showers
Freezing Rain
Drizzle
Freezing Drizzle
Snow
Snow Pellets
Ice Crystals
Snow Showers
Snow Grains
*Sleet
Hail
*Small Hail
Fog
Ice Fog
Ground Fog
Blowing Dust
Blowing Sand
Smoke and/or Haze
Dust
Blowing Snow
Blowing Spray
Sea Level Pressure
Dew Point Temperature
Wind Direction
Wind Speed
Station Pressure
Dry Bulb Temperature
Wet Bulb Temperature
Relative Humidity
Total Sky Cover
Amount, Type and Height
  of Cloud Layers
Opaque Sky Cover

*Reported as Ice Pellets, effective 1 Apr 70.

ADDITIONAL REMARKS: Card content is generally for recent years. Prior punching or processing procedures are described in "Remarks Column" or in SUPPLEMENTARY NOTES.

Effective 1 Jan 68, the Air Force began the use of the METAR Code at nearly all stations located outside the North American Continent. Observations for these stations are not available on punched cards but on magnetic tape only.

Decks with similar data are listed on page 14.

CORRECTIONS: Any errors detected in this manual should be called to the attention of the Director, National Climatic Center, Environmental Data Service, NOAA; or Chief, Data Processing Division, Environmental Technical Applications Center, USAF. Please give specific instances of error and correct information if available.

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
21-79	Missing Data	B	Blank	Unknown	Blank indicates unknown or missing data.
1-5	Station Number WBAN		00001-99999	WBAN Number	A five digit number formulated to designate the station. A list of stations with their coordinates, elevation and period of record is maintained at the NCC in Asheville, N. C.
6-7	Year		00-99	Last two digits of year	
8-9	Month		01-12	01 Jan to 12 Dec	
10-11	Day		01-31	Day of month	
12-13	Hour		00-23	LST	For information relating to time of observation changes and reduction of punches from 24 to 8 observations per day, reference SUPPLEMENTARY NOTE A, page 9 and OBSERVATION TIME, page 1.
14-16	Ceiling Height	hhh	000-990	Hundred of feet 0-99,000 feet	Reporting practices are described in SUPPLEMENTARY NOTE B, page 9.
			XXX	Unlimited	
			888	Cirroform ceiling, height unknown	Effective 1 Sep 56. Punching of 888 for Cirroform ceiling, height unknown, was discontinued on 1 Apr 70.
17-20	Sky Condition				Four column field for up to 4 layers. 0 in unused columns.
17	First Sky Cover Layer	○	0	Clear Cloud cover <.05 Columns 18-20 punched 000	Thin sky cover is a designation given any layer for which the ratio of transparency to total sky cover at that level is ½ or more.
18	Second Sky Cover Layer	−⦶	1	Thin scattered	Prior to September 1956 dark scattered, dark broken, and dark overcast were coded 3, 6, and 9, respectively.
19	Third Sky Cover Layer	⦶	2	Scattered Cloud cover .1 thru .5	
20	Fourth Sky Cover Layer	−⦷	4	Thin broken	Reporting practices of sky conditions, etc. are described in more detail in SUPPLEMENTARY NOTE C, pages 9-10.
		⦷	5	Broken Cloud cover .6 thru .9	
		−⊕	7	Thin overcast Cloud cover 1.0	
		⊕	8	Overcast Cloud cover 1.0 Columns 18-20 punched 000	
		-X	Blank	Partial Obscuration Columns 18-20 punched 0-8 0.1 or more but not all sky hidden by surface based layer	
		X	X	Obscuration All of sky hidden by a surface based layer. Columns 18-20 punched 000.	

CARD CONTENT

COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
21-23	Visibility	VVV	000-006	0 - 3/8 miles	1/16 mile increments. Refer to Code 3 on page 12.
			006-020	3/8 - 2 miles	1/8 mile increments *
			020-027	2 - 2½ miles	1/4 mile increments
			027-030	2½ - 3 miles	1/2 mile increments
			030-150	3 - 15 miles	1 mile increments
			150-950	15 - 95 miles	5 mile increments
			990	100 miles or more	Effective 1 Apr 70, visibilities greater than 7 miles will not be recorded unless a marker is located at a distance greater than 7 miles.
				Visibilities reported other than standard punched for next lower value.	*7/8 was not reported prior to Jul 52; and 1 1/8, 1 3/8, 1 5/8 and 1 7/8 until May 53. 1 1/8, 1 3/8, and 1 5/8 were punched as 1, 1¼, and 1½ until Jan 56. 7/8 and 1 7/8 are punched as 3/4 and 1 3/4.
24-31	Weather and/or Obstruction to Vision				See page 8 for intensity definition Columns 24-31.
24			0	None	
	Thunderstorm	T	1	Thunderstorm	
	Heavy/Severe Thunderstorm	T+	2	Heavy thunderstorm/ Severe thunderstorm	See note, page 8, on thunderstorm intensities. Heavy thunderstorm redefined Severe Thunderstorm 1 Jul 68.
	Tornado Waterspout	Tor	3	Tornado - Land Waterspout - Water	
	Squall	Q	5	Squall	Reported as rain or snow squalls (RQ,SQ) before 1949. Intensity reported prior to 1 Jun 51. Definition is given on page 8.
25	Liquid Precipitation		0	None	
		R-	1	Light rain	
		R	2	Moderate rain	
		R+	3	Heavy rain	
		RW-	4	Light rain showers	
		RW	5	Moderate rain showers	
		RW+	6	Heavy rain showers	
		ZR-	7	Light freezing rain	
		ZR	8	Moderate freezing rain	
		ZR+	9	Heavy freezing rain	
26	Liquid Precipitation		0	None	Codes 1, 2 and 3, light, moderate and heavy rain squalls reported prior to 1949. Drizzle intensity explained in SUPPLEMENTARY NOTE D, page 10.
		L-	4	Light drizzle	
		L	5	Moderate drizzle	
		L+	6	Heavy drizzle	
		ZL-	7	Light freezing drizzle	
		ZL	8	Moderate freezing drizzle	
		ZL+	9	Heavy freezing drizzle	

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
27	Frozen Precipitation		0	None	
		S-	1	Light snow	
		S	2	Moderate snow	
		S+	3	Heavy snow	
		SP-	4	Light snow pellets	
		SP	5	Moderate snow pellets	
		SP+	6	Heavy snow pellets	Code 7, IC - and code 9, IC +; intensity reported prior to 1 Apr 63
		IC	8	Ice crystals	
28	Frozen Precipitation		0	None	
		SW-	1	Light snow showers	
		SW	2	Moderate snow showers	
		SW+	3	Heavy snow showers	Codes 4, 5 and 6, light, moderate and heavy snow squalls reported prior to 1949.
		SG-	7	Light snow grains	
		SG	8	Moderate snow grains	
		SG+	9	Heavy snow grains	
29	Frozen Precipitation		0	None	Prior to 1 Apr 70 Ice Pellets were coded as Sleet (E-, E, E+). On this date Sleet and Small Hail were redefined as Ice Pellets.
		IP-	1	Light Ice Pellets	Ice Pellet Showers (IPW) are coded as Ice Pellets; Sleet Showers were coded as Sleet.
		IP	2	Moderate Ice Pellets	
		IP+	3	Heavy Ice Pellets	
		A	5	Hail	Hail intensities reported prior to 1 Sep 56: Codes 4, 6, 7, and 9, A-, A+, AP- and AP+.
		AP	8	Small Hail	Deleted 1 Apr 70; redefined as Ice Pellets.
30	Obstructions to Vision		0	None	SUPPLEMENTARY NOTE E, Page 10 explains the reporting practices of these elements.
		F	1	Fog	OBSTRUCTIONS TO VISION are recorded only when the visibility is less than 7 miles.
		IF	2	Ice fog	
		GF	3	Ground fog	
		BD	4	Blowing dust	
		BN	5	Blowing sand	
31	Obstructions to vision		0	None	
		K	1	Smoke	
		H	2	Haze	
		KH	3	Smoke and haze	
		D	4	Dust	
		BS	5	Blowing snow	
		BY	6	Blowing spray	Effective 1 Jul 52.

CARD CONTENT

COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
32-35	Sea Level Pressure	PPPP	0000-9999	Millibars and tenths 0000 = 1000.0 mb 9999 = 999.9 mbs.	Thousands digit not punched. Antarctic stations, see SUPPLEMENTARY NOTE H, page 11. AWS punched 3-hourly only effective 1 Jul 58.
36-38	Dew Point Temperature	$T_dT_dT_d$	000-099 X01-X99	0 to 199 Whole degrees F. -1 to -99 X in Column 36 for negative values.	Before 1949, dew point was computed with respect to ice if temperature was below 32°F. Beginning Jan 49, it was computed with respect to water regardless of temperature.
39-40	Wind Direction	dd	00-36	True direction, in tens of degrees, from which wind is blowing (Code 1, page 12 eff. 1 Jan 64)	Prior to 1964, wind directions were reported according to Code 2, page 12. See SUPPLEMENTARY NOTE H, page 11, for punching procedures at Admundsen-Scott Station, Antarctica.
41-42	Wind Speed	ff	00-99 X/	Knots X overpunch in Column 41 indicates 100 or more knots	Prior to Jan 55 in miles per hour at AF and WB stations; in knots at most Navy stations.
43-46	Station Pressure	PPPP	1000-3999	10.00 to 39.99 inches to Hundreds H_g.	Station pressure is the pressure at the assigned station elevation. AWS punched 3-hourly only effective 1 Jul 58, 6-hourly effective 1 Jan 64, and 3-hourly eff. on receipt of order dated 1 Jun 65.
47-49	Dry Bulb Temperature	TTT	000-199	Whole degrees F. 0 to 199	
			X01-X99 $\frac{X}{100}$ - $\frac{X}{199}$	-1 to -99 -100 to -199	Column 47 punched X or X overpunch for values below zero.
50-52	Wet Bulb Temperature		000-199 X01-X99	Whole degrees F. 0 to 199 -1 to -99	Column 50 punched X for minus. AWS began phasing out punching wet bulb data 1 Jul 58. WB and Navy discontinued punching wet bulb data 1 Jan 65. See SUPPLEMENTARY NOTE F, page 10 for hygrothermometer input. For methods of computation of wet bulb temperature and relative humidity, refer to page 13.
53-55	Relative Humidity	RH	000-100	0 to 100 whole percent Cols.	AWS discontinued punching Columns 53-55 1 Jul 58. WB discontinued punching Columns 53-55 1 Jan 65. NWS, effective 1 Apr 70, RH is punched only when entered on Form 1-10B; entry of RH on form is optional. Relative humidity computations respect to ice, etc. reporting practices explained in SUPPLEMENTARY NOTE F, page 10.
56-79	Clouds and Obscuring Phenomena				See SUPPLEMENTARY NOTE G, page 11 for information on cloud layers.
56	Total Sky Cover		0-9 X	Tenths 10 Tenths	

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
57	Amount of Lowest Layer		0-9 X	Tenths 10 Tenths	Weather Bureau stations reported detailed cloud observations(Cols. 56-78) only every 3 hours, based upon the time of synoptic observations, until June 1951 and Jan 1965-present. Only Col. 56, Total Sky Cover, was punched for the intermediate observations. Beginning Jun 51, complete cloud observations were reported and punched (Cols.56-79) for every record obs. as was the practice with Air Force and Navy stations. In all cards of FAA(CAA) stations, Cols. 57-78 are not punched. Note: Air Force stations coverage beginning 1 Jul 58, Cols. 57-79 were reduced from hourly to 3-hourly punching. Except for Korean and down range stations, punching of Cols. 58-61 and 63-79 was discontinued on 1 Jan 64 and Cols. 57 and 62 on 1 Jul 65.
58	Type of Cloud Lowest Layer	 F St Sc Cu Cb As Ac Ci Cs	0 1 2 3 4 5 6 7 8 9	None/clear Fog Stratus Stratocumulus Cumulus Cumulonimbus Altostratus Altocumulus Cirrus Cirrostratus	
		Stfra	X 2	Stratus Fractus	Sf was contraction prior to 1 Apr 70. Fs (Fractostratus) prior to 1 May 61.
		Cufra	X 4	Cumulus Fractus	Cf was contraction prior to 1 Apr 70. Fc (Fractocumulus prior to 1 May 61.
		Cbmam	X 5	Cumulonimbus mamma	Cm was contraction prior to 1 Apr 70.
		Ns	X 6	Nimbostratus	
		Accas	X 7	Altocumulus castellanus	Acc was contraction prior to 1 Apr 70.
		Cc	X 9	Cirrocumulus	
			X	Obscuring phenomenon other than fog	
59-61	Height of Lowest Layer		000-990	Hundreds of feet 0 to 99,000 ft.	
			888	Unknown height of a cirroform layer	Effective 1 Sep 56 through 31 Mar 70.
			XXX	Unlimited vertical visibility	Clear, no clouds reported or surface based partial obscuring phenomena (first layer only).
62	Amount of Second Layer		0-9 X	Tenths 10 tenths	
63	Type of Second Layer		0-9 X/	See Column 58	
64-66	Height of Second Layer			See Columns 59-61	

CARD CONTENT

COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
67	Summation Amount at Second Layer		0-9 X	Tenths 10 tenths	
68	Amount of Third Layer		0-9 X	Tenths 10 tenths	
69	Type of Third Layer		0-9 X/	See Column 58	
70-72	Height of Third Layer			See Columns 59-61	
73	Summation Amount at Third Layer		0-9 X	Tenths 10 tenths	
74	Amount of Fourth Layer		0-9 X	Tenths 10 tenths	
75	Type of Fourth Layer		0-9 X/	See Column 58	
76-78	Height of Fourth Layer			See Columns 59-61	
79	Total Opaque Sky Cover		0-9 X	Tenths 10 tenths	Effective Jun 51. 1 Jun 62 - Opaque Sky Cover was re-defined: Those portions of cloud layers or obscurations which hide the sky and/or higher clouds. Translucent sky cover which hides the sky but through which the sun and moon (not stars) may be dimly visible will be considered as opaque. 1 Apr 70 - Opaque Sky Cover: The amount (to the nearest tenth) of cloud layers or obscuring phenomena (aloft or surface-based) that completely hides all or a portion of the sky and/or higher clouds that may be present.
80	Not used				

METHODS FOR DETERMINING INTENSITY OF WEATHER

THUNDERSTORM

1945 -

THUNDERSTORM - Characterized by occasional or fairly frequent flashes of lightning; weak to loud peals of thunder; rainfall, if any, light or moderate, and rarely heavy; hail, if any, light or moderate; wind not in excess of 40 miles per hour or 35 knots; and no large temperature drop with passage of the storm.

Note: Wind speed changed to knots on 1 Jan 1955.

1 Jul 68 - Redefined. A thunderstorm is a local storm produced by cumulonimbus cloud, and is always accompanied by lightning and thunder, usually with strong gusts of wind, and sometimes with hail. The intensity of a thunderstorm is based on the following characteristics, observed within the previous 15 minutes: Wind gusts less than 50 knots and hail, if any, less than 3/4 inch in diameter.

HEAVY THUNDERSTORM - Characterized by nearly incessant, sharp lightning; loud peals of almost continuous thunder; heavy rain showers; hail of any intensity; wind in excess of 40 mph (35 knots) as the storm passes overhead; and a rapid drop of temperature, as much as 20°F in 5 minutes with the passage of the storm.

1 Jul 68 - Redefined as SEVERE THUNDERSTORM. The intensity is based on the following characteristics, observed within the previous 15 minutes: Wind gusts of 50 knots or greater or hail, 3/4 inch or greater.

GUSTS OF WIND

1945 - 1951

*RAIN SQUALLS, *SNOW SQUALLS, SQUALLS

Light - Gusts of 24 mph or less (21 knots)
Moderate - Gusts of 25-39 mph (22-34 knots)
Heavy - Gusts of 40 mph or more (35 knots)

*Squalls reported separately after 1948.

Intensity of squalls discontinued 1 Jun 51

GUSTS OF WIND (CONTINUED)

1 Jun 51 - A SQUALL is a strong wind that increases suddenly in speed, maintains a peak speed of 19 mph (16 knots) or more over a period of two or more minutes, and decreases in speed; similar fluctuations will occur at succeeding intervals. (reported if occurred within 15 minutes of time of observation)

1 Apr 70 - A SQUALL is a sudden increase of wind speed by at least 16 knots and rising to 22 kts or more and lasting for at least one minute. (reported if occurred within 10 min. of obs)

RATE OF FALL

1945 -

RAIN, RAIN SHOWERS, FREEZING RAIN

Also DRIZZLE (1945-1946), SNOW, SNOW SHOWERS, SNOW PELLETS, when accompanied by other precipitation or obstructions to vision.

Light - Trace to 0.10 inch per hour; maximum 0.01 inch in six minutes.

Moderate - 0.11 to 0.30 inch per hour; more than 0.01 to 0.03 inch in six min.

Heavy - More than 0.30 inch per hour; more than 0.03 inch in six minutes.

When measurement of rate of fall was impracticable, the intensity was determined visually.

Jan 47-May 51, whether alone or not, and after May 51, when accompanied by other precipitation or obstructions to vision.

DRIZZLE, FREEZING DRIZZLE

Light - Trace to 0.01 inch per hour
Moderate - More than 0.01 to 0.02 inch/hour
Heavy - More than 0.02 inch per hour.

RATE OF FALL AND ACCUMULATION

1946 -

HAIL, *SMALL HAIL, *SLEET, *ICE PELLETS

1 Apr 70 - *Sleet and *Small Hail redefined as *Ice Pellets

Light - Few pellets falling with no appreciable accumulation.
Moderate - Slow accumulation.
Heavy - Rapid accumulation.

VISIBILITY PRECIPITATION

SNOW, SNOW SHOWERS, SNOW PELLETS, DRIZZLE, FREEZING DRIZZLE, SNOW GRAINS

(when occurring alone)

Light - Visibility 5/8 mile or greater
Moderate - Visibility 5/16 - 1/2 mile, inclusive
Heavy - Visibility 1/4 mile or less

1945 - For all forms of snow, when occurring alone, intensity was determined by visibility, as shown above. Intensity of drizzle, when occurring alone, was determined by visibility in 1945 -1946 and after May 1951 -

ICE CRYSTALS with an intensity of greater than "very light" will be rarely observed. Above criteria were referred to if needed.

1 Apr 63 - Reporting of intensities of ICE CRYSTALS was discontinued.

HAZE

1945 -

HAZE - Visibility 6 miles or less, but rarely below 3 miles.

DAMP HAZE - Visibility 6 miles or less, but rarely as low as 1 1/4 miles. Not reported after 1948.

NOTE: The intensity "Very light" (less than "Light") was not used before June 1951. It is punched as "Light" for all elements.

SUPPLEMENTARY NOTE A: OBSERVATION TIME Columns 12-13
The time punched is that of the record observations, taken within 10 minutes prior to the hour punched (ex. 1355 punched 14). Prior to Jun 57, obs. were taken within 10 minutes prior to the half hour; minutes are disregarded in punching (ex. 0222 punched 02; 1428, 14. All "War Times" and "Standard Meridian Times" were converted to Local Standard Time before punching. For Air Force stations in the United States, the times were punched in accordance with the established time zones. Time entries for Air Force stations outside the United States were edited prior to punching and where necessary converted to the Local Standard Time of the nearest meridian evenly divisible by 15 degrees.

SUPPLEMENTARY NOTE B: CEILING HEIGHT Columns 14-16
Ceiling was recorded in hundreds of feet above the ground to nearest 100 feet up to 5000 feet, to nearest 500 feet up to 10,000 feet, to nearest 1000 feet above that. Before 1949, Air Force stations recorded ceilings up to and including 20,000 feet, above which point the ceiling was classified as unlimited; Weather Bureau and Navy stations recorded ceiling only up to and including 9,500 feet, above which point the ceiling was considered unlimited. Beginning in 1949, ceiling was re-defined to include the vertical visibility into obscuring phenomena not classified as thin, that, in summation with all lower layers, cover 6/10 or more of the sky. Also at that time all limits to height of ceiling were removed, so that unlimited ceiling became simply less than 6/10 sky cover, not including thin obscuration. Then, beginning 1 Jun 51, ceiling heights were no longer established solely on the basis of coverage. The ascribing of ceilings to thin broken or overcast layers was eliminated. A layer became classified as "thin" if the ratio of transparency to total coverage at that level is ½ or more.

SUPPLEMENTARY NOTE C: SKY CONDITIONS Columns 17-20
Jan 1945-Dec 1948: If there is only one cloud symbol, except for low scattered and obscured, Column 17 was punched with appropriate code, Cols. 18-19 with "X" and Col. 20 was left blank. If clouds were high (above 9,500 ft.) Col. 17 was X overpunched. If clouds were low scattered, "0" was punched in Col.17, height in Cols. 18-19, and code in Col. 20. Cols. 18-19 were left blank if height was missing. When two cloud symbols were reported, the higher cloud was punched in Col.17 and the lower in Col. 20. In 1946, obscured
(continued on next page)

TABLE OF SKY CONDITIONS

The table below shows the punching practices in Columns 17-20 for the periods Jan 45 through Dec 48, and Jan 49 through May 51.

SKY CONDITION	REMARKS	1945-1948 17	18	19	20	1949-5/51 17	18	19	20
Clear ○		0	X	X	0	0	X	X	0
Low Scattered ⦶ at 2500 ft		0	2	5	2	0	2	5	2
High Scattered ⦶ /(over 9500 ft)		X/2	X	X		0	9	9	2
Hi Sctd Lwr Sctd ⦶/95⦶ at 9500 ft		X/2	9	5	2	2	9	5	2
Broken at 12000 ft 12 ⦷		5	X	X		0	X	X	5
High Brkn Lwr Brkn⦷/⦷ Ceiling 5000 ft		X/5	X	X	5	5	X	X	5
High Ovc Lwr Sctd at 2500 ft⊕/⦶		X/8	2	5	2	8	2	5	2
High Ovc Lwr Brkn⊕/⦷		X/8	X	X	5	8	X	X	5
Overcast ⊕		8	X	X		0	X	X	8
Ovc Sctd at 3000 ft ⊕ 30⦶		8	3	0	2	8	3	0	2
Ovc Brkn at 2500 ft ⊕ 25 ⦷		8	X	X	5	8	X	X	5
Obscured X		0	X	X	X	0	X	X	X
Thin Obscured -X		0	X	X		0	X	X	

SUPPLEMENTARY NOTE C (Continued)

sky was reported only when heavy obstructions to vision and/or heavy precipitation reduced the ceiling to zero and/or the visibility to less than ¼ mile; and when the visibility was ¼ mile or more, a sky symbol was always reported. Effective 1 Jan 47, the symbol "X", for obscured sky, received the same latitude of usage as all other symbols. "X" then represented sky cover of 6/10 or more, obscured by precipitation or obstructions to vision either alone or in combination with lower clouds, and irrespective of higher clouds and ceiling and/or visibility limits. In August 1947, the use of "-X", for thin obscured, was authorized. In 1946 if a layer of scattered clouds above a layer of broken clouds was clearly observable, it was so reported. In 1947 and 1948, symbols corresponding to higher cloud layers indicated the amount of sky covered not only by their respective layers, but by all layers below them. In all years, the presence of few clouds (less than 1/10) was recorded in Remarks.

Jan 49 through May 51: When only one sky symbol was reported it was punched in Col. 20. The use of an "X" overpunch for high (/) layers was discontinued. (/ indicates over 9500 ft). The height of scattered clouds above 9500 ft was punched in Cols. 18-19 as 99.

Effective 1 Jun 51, the reporting of height of low scattered was discontinued, and provision was made to report any number of sky condition symbols, with the height of each. The ceiling layer was not reported separately as before, but was identified by the entry of a ceiling classification letter immediately preceding the height. Sky condition symbols were reported in ascending order of height, and were punched in that order, unless more than four were reported. In that case, the last (highest) symbol was punched in Column 20, and the first three in Columns 17-19, unless the ceiling symbol was thereby excluded. In the latter case, the first two symbols were punched in Columns 17-18, the ceiling symbol in Column 19, and the highest symbol in Column 20. No symbols were reported in Remarks, as was the practice before June 1951.

Sky condition symbols were also re-defined so that obscuring phenomena aloft and clouds were reported in the same manner (i.e., obscuring phenomena aloft were reported by 0, 0, and 0, rather than X and -X). X and -X were used only to indicate the amount of sky hidden by surface-based phenomena. -X was re-defined as partial obscuration (1/10 to less than 10/10 sky hidden). The symbols X and -X unlike 0, 0, and 0, were defined by the amount of the sky hidden by surface-based phenomena, and -X did not indicate the amount of sky covered. The meaning of "thin" was re-defined. If the total opaque cover created by any layer in combination with lower layers was ½ or less of the summation total cover at that level, the layer was classified as thin. Note that the minus sign, when applied to 0, 0, or 0 means "thin"; when applied to X, means "partial".

SUPPLEMENTARY NOTE D: INTENSITY OF DRIZZLE Column 26

In 1946, intensity determined by visibility (as for smoke) only if drizzle occurred alone. When drizzle was accompanied by other forms of precipitation and/or obstructions to vision, its intensity was determined by rate of fall. In 1947, visibility limitations were dropped, and intensity was determined by rate of fall, even though drizzle occurred alone. In June 1951, previous visibility limits were re-instituted. Intensity of freezing drizzle determined in same manner as for drizzle. See page 8 for limits of intensities.

SUPPLEMENTARY NOTE E: OBSTRUCTIONS TO VISION Columns 30-31

Intensity of light, moderate, or heavy were assigned to obstructions to vision, through 1946. Effective Jan 47, the reporting and punching of all intensities of obstructions to vision were discontinued. Prior to 1 Jan 49, the distinction between F and GF was arbitrary, but beginning with that date an objective distinction was established. If the sky was not hidden above an angle of 33° from horizontal (less than 0.6 hidden), the fog was reported as ground fog (GF). Effective 1 Apr 70, Fog (F)-Ground Fog (GF): This hydrometeor is reported as F when it hides more than half (0.5-1.0) of the sky or extends upward into existing cloud layers. Otherwise it is reported as GF.

SUPPLEMENTARY NOTE F: WET BULB TEMP. & RH Columns 50-55

From Aug 60 - Dec 64 at WB stations with a hygrothermometor, wet-bulb temp. was computed and punched at NCC when instrument was operational above -35°F; when non-operational or -35°F and lower, the wet-bulb temp. was punched at the station from values obtained from standby equipment. At stations not equipped with a hygrothermometer, the wet bulb temperature is considered to be the same as the dry bulb temperature whenever the dry bulb temperature is below -35°F. The same value is entered in parenthesis on the WBAN with dew point being computed in

SUPPLEMENTARY NOTE F (Continued)

respect to water and this value punched into WBAN Card. The relative humidity would then be computed by machine, same as for stations equipped with a hygrothermometer.

Prior to Jan 49, relative humidity computed with respect to ice if the dry bulb temperature was less than 32°F. Beginning Jan 49, computed with respect to water, regardless of temperature. Relative humidity machine calculated from 1 Aug 60. RH was not punched for FAA (CAA) stations except in special cases.

SUPPLEMENTARY NOTE G: CLOUD LAYERS Columns 56-79

Provisions are made for punching as many as four layers of clouds and/or obscuring phenomena existing at one time. If more than four layers existed, the data for levels above the fourth were entered in the Remarks portion of WBAN 10B, and were not punched. Their presence is indicated by the entry for total sky cover. Layers were punched in ascending order of elevation. All fields above a layer which prevented observation were left blank. If two or more types of clouds were observed at the same height, only the predominating type was punched, their amounts being combined. For each layer, the amount, type, and height were punched, and for the second and third layer, the summation amount at the level involved was punched, reflecting the total amount of sky covered by that layer and those below it. The summation total is not necessarily the sum of the individual layers.

In addition to the total sky cover, provision was made in Jun 51 for recording and punching the total amount of opaque sky cover, which is the amount of sky hidden by clouds or obscuring phenomena, as distinguished from the total amount of sky cover.

The height of the layers of clouds or obscuring phenomena aloft was recorded in hundreds of feet, and for fully obscuring phenomena based on the ground, the vertical visibility into it was recorded, with no prescribed limit. All heights were recorded to the nearest 100 feet from the surface to 5,000 feet; to the nearest 500 feet between 5,000 and 10,000 feet; and to the nearest 1,000 feet above 10,000 feet. For obscuring phenomena prescribed as "thin", a condition reportable from Aug 47 through May 51, the height of the base was punched, and in the case of thin fog, was always zero. Before Jan 47, obscuration was not reportable as a cloud type.

SUPPLEMENTARY NOTE G (Cont.) Columns 56-79

Some Weather Bureau and Navy cards in this deck were punched from the old type of reporting form (the WBAN 10 with which deck 142 is aligned) and in which five cloud layers were reported with no summation totals. In these cases, the summation total columns were left blank, and the five layers, if reported, were condensed into four.

SUPPLEMENTARY NOTE H: ANTARCTICA STATION NOTES Columns 32-35, 39-40

I. ADMUNDSEN-SCOTT STATION:

1. Wind Direction on all cards was punched according to the following system:

   A. A wind from 0° longitude was punched as N or 360.
   B. A wind from 90° east longitude was punched as E or 090.
   C. A wind from 180° longitude was punched S or 180.
   D. A wind from 90° west longitude was punched W or 270.

2. In place of sea level pressure (Column 32-35) the height of the 700 mb surface in whole meters was punched. This applies to the period 1 Dec 57 through Jan 66. Station pressure in millibars and tenths punched beginning Feb 66.

II. BYRD STATION, ANTARCTICA

1. In place of sea-level pressure (Columns 32-35) the height of the 850 mb surface was punched in whole meters through Jan 66. Station pressure in millibars and tenths punched beginning Feb 66.

III. PLATEAU STATION, ANTARCTICA 12/65-12/68

1. In place of sea-level pressure (Columns 32-35) the height of the 700 mb surface was punched in whole meters through Jan 66. Station pressure in millibars and tenths punched beginning Feb 66.

CODE TABLES

When coding a meteorological report, symbolic letters are replaced by figures, which specify the value or the state of the corresponding element. In some cases, the specification of the symbolic letter (or group of letters) is sufficient to permit a direct transcription into figures (e.g., GG or PPP). In other cases, these figures are obtained by means of a special code table (or code, in short) for each element.

The codes elaborated to this end, as far as they are in world-wide use, are called international meteorological code tables. These same codes are used inversely for decoding observations and thus making available the information contained in them.

Besides the specifications given by the code tables in world-wide use, other sets of code tables are established by the WMO for regional use. Further arbitrary codes have been made necessary by the use of data in card decks which were never encoded into WMO forms.

Only codes pertinent to this card deck are included in the present manual. They appear in the order in which the elements were introduced in the description of the card content. They are numbered consecutively, and if applicable, the corresponding WMO code numbers are shown.

Code 1

(1949 WMO Code 23)
(1960 WMO Code 0877)

dd - True direction, in tens of degrees, from which wind is blowing (or will blow)

Code figure		Code figure	
00	Calm	19	185° - 194°
01	5° - 14°	20	195° - 204°
02	15° - 24°	21	205° - 214°
03	25° - 34°	22	215° - 224°
04	35° - 44°	23	225° - 234°
05	45° - 54°	24	235° - 244°
06	55° - 64°	25	245° - 254°
07	65° - 74°	26	255° - 264°
08	75° - 84°	27	265° - 274°
09	85° - 94°	28	275° - 284°
10	95° - 104°	29	285° - 294°
11	105° - 114°	30	295° - 304°
12	115° - 124°	31	305° - 314°
13	125° - 134°	32	315° - 324°
14	135° - 144°	33	325° - 334°
15	145° - 154°	34	335° - 344°
16	155° - 164°	35	345° - 354°
17	165° - 174°	36	355° - 4°
18	175° - 184°		

Code 2

dd - Wind Direction

Code Figure			
00	C	Calm	
11	↓↓	North	349° - 11°
12	↓↙	North Northeast	12° - 33°
18	↓↘	North Northwest	327° - 348°
22	↙↙	Northeast	34° - 56°
32	←↙	East Northeast	57° - 78°
33	←←	East	79° - 101°
34	←↖	East Southeast	102° - 123°
44	↖↖	Southeast	124° - 146°
54	↑↖	South Southeast	147° - 168°
55	↑↑	South	169° - 191°
56	↑↗	South Southwest	192° - 213°
66	↗↗	Southwest	214° - 236°
76	→↗	West Southwest	237° - 258°
77	→→	West	259° - 281°
78	→↘	West Northwest	282° - 303°
88	↘↘	Northwest	304° - 326°

Code 3

VVV - Visibility (Statute Miles)

Code	Miles	Code	Miles
000	0	012	1-1/8
001	1/16	014	1-1/4
002	1/8	016	1-3/8
003	3/16	017	1-1/2
004	1/4	018	1-5/8
005	5/16	019	1-3/4
006	3/8	020	2
007	1/2	024	2-1/4
008	5/8	027	2-1/2
009	3/4	030-150	3-15 *1 mile
010	1	150-950	15-95 *5 mile
		990	100 or more

*increments

COMPUTATION OF WET BULB

Dry Bulb zero and above

$$TW = T - (.034N - .00072N[N - 1])\ (T + Tdp - 2P + 108)$$

If temperature is less than 100°

TW Rounded = TW + .9 if col. 48 is 0, 1, 2
TW + [.9 - .01 (T + .9)] if col. 48 is 3, 4
TW + .4 if col. 48 is 5 through 9

If temperature is 100° or greater:

TW Rounded = TW + .9.

for Dry Bulb temperatures less than zero:

$$TW = T - (.034N - .006N^2)\ (.6[T + Tdp] - 2P + 108)$$

TW Rounded = TW - .01Tdp

T = dry bulb temperature in °F

TW = wet bulb in °F

Tdp = dew point in °F

$$N = \frac{T - Tdp}{10}$$

P = Station pressure measured in inches of mercury

In all cases TW should be computed to at least two decimal places prior to applying the rounding factor.

COMPUTATION OF RELATIVE HUMIDITY

$$RH \cong \left(\frac{173 - .1T + Tdp}{173 + .9T}\right)^8$$

Where T = Air Temp. in °F
T_{dp} = Dew Point Temp. in °F

Reference to the above formula may be found in "An Approximation Formula to Compute Relative Humidity from Dry Bulb and Dew Point Temperatures" by Julius F. Bosen, Monthly Weather Review, Vol. 86, No. 12, Dec. 1958, page 486.

OTHER CARD DECKS CONTAINING HOURLY OBSERVATIONS

DECK		GENERAL PERIOD
019	London Airport Hourly Surface	1948-1961
021	USAAF in Great Britain Surface	1942-1946
132	Canadian Hourly Surface Obs.	1946-1951
134	Canadian Hourly Surface Obs.	1951-1953
135	Canadian Hourly Surface Obs.	1950-1967
139	Japanese Airway Obs. Hourly Sfc.	1958-1961
141	WBAN Hourly Surface Obs.	1937-1945
142	WBAN Hourly Surface Obs.	1945-1948
156	British Hourly Obs.	1941-1948
157	Turkish Hourly Surface Obs.	1950-1959
158	German Hourly Obs. GZMO	1955-1961
158	German Hourly Obs. GZMO	1962-1964
159	Korean Hourly Obs. ROK	1954-1964
159	Korean Hourly Obs. ROK	1965-1967
160	Azores Hourly Obs.	1951-1955
171	Nanking Hourly Obs.	1928-1937
172	Yungan Hourly Obs.	1938-1942
175	Taichung Hourly Obs.	1952-1956
928	Hourly Marine Sfc OSV's	1965-1970

ELEMENTS (ITEMS) PUNCHED

	Page		Page
CEILING	2	SKY CONDITION	2
CLOUDS (4 layers)	6	STATION NUMBER	2
Amount, Type, Height			
Amount Total	5	TEMPERATURE	
Amount Total Opaque	7	Dew Point	5
		Dry Bulb	5
DATE		Wet Bulb	5
Yr Mo Day Hour	2		
		VISIBILITY	3
HUMIDITY Relative %	5		
		WEATHER AND/OR OBSTRUCTIONS TO VISION	3-4
PRESSURE			
Sea Level	5		
Station	5	WIND	5

CARD DECK 144 ACRONYMS

AF	Air Force
AWS	Air Weather Service
CAA	Civil Aeronautics Administration (same as FAA)
ESSA	Environmental Science Services Administration (NOAA after 3 Oct 1970)
ETAC	Environmental Technical Applications Center
FAA	Federal Aviation Administration (formerly CAA)
GZMO	German Zonal Meteorological Organization
GMT	Greenwich Mean Time
ID	Identification (cards)
METAR	Meteorological Aviation Routine Weather Report
MF	Meteorological Form
NCC	National Climatic Center (formerly National Weather Records Center (NWRC))
NNWS	NOAA National Weather Service (formerly WB)
NOAA	National Oceanic and Atmospheric Administration (eff. 3 Oct 1970)
NWS	Naval Weather Service
OSV	Ocean Station Vessel
ROK	Republic of Korea
USAF	United States Air Force
WB	Weather Bureau (changed to NNWS 3 Oct 1970)
WBAN	Weather Bureau - Air Force - Navy
WMO	World Meteorological Organization

APPENDIX II. Example Input for HEC-5Q Interface

```
TI PROGRAM WEATHER INPUT
TI FOR HEC-5Q OUTPUT OPTION
TI MORGANTOWN WEATHER DATA TEST
C1    85      12       31       86       01       01        0        0
1373685123101---0--0040000000010315005760329060190170540
1373685123104---0--0030000000010308010000029040160150770
1373685123107   0--5060000000010295011540428990160150808
1373685123110---0991060000000010271024760428940380320572
13736851231131800--5150000000000230027760928840480390447
13736851231161400--810000000000021702977032879045038053-
13736851231191000--805000000001019002534032871040034055-
13736851231220700--806000000001016602434062866040034052-
13736860101010650--805001000001012203056082855046039053-
1373686010104018812203000400001009804155042848042041096-
13736860101070080--805000400001009804366102848044044096-
13736860101100088--505000000001010504276102850045044089-
13736860101130120--812000000000010503956102850045042079-
13736860101160168--515000000000012203578092855042039076-
13736860101190230--807000000000014903276092862038035079-
13736860101220180--809000000000015902977082865034032082-
```

APPENDIX III. Example Input for WQRRS Interface

```
TI PROGRAM WEATHER INPUT
TI FOR WQRRS OUTPUT OPTION
TI MORGANTOWN WEATHER DATA TEST
C1    85      12       31       86       01       01        1        0
1373685123101---0--0040000000010315005760329060190170540
1373685123104---0--0030000000010308010000029040160150770
1373685123107   0--5060000000010295011540428990160150808
1373685123110---0991060000000010271024760428940380320572
13736851231131800--5150000000000230027760928840480390447
13736851231161400--810000000000021702977032879045038053-
13736851231191000--805000000001019002534032871040034055-
13736851231220700--806000000001016602434062866040034052-
13736860101010650--805001000001012203056082855046039053-
1373686010104018812203000400001009804155042848042041096-
13736860101070080--805000400001009804366102848044044096-
13736860101100088--505000000001010504276102850045044089-
13736860101130120--812000000000010503956102850045042079-
13736860101160168--515000000000012203578092855042039076-
13736860101190230--807000000000014903276092862038035079-
13736860101220180--809000000000015902977082865034032082-
```

APPENDIX IV. Example Output for HEC-5Q Interface

```
10 61010 9 2 9 9 5 510 9 9 5 510 8 7 5101010 6 7101010 710101010 3 6
 41010 810 3 9 9 410 110101010 4 5 910 6 4 8 9 2 5 4 8 910 8 9 5 4 9
10 8 5 910 3 5101010 8 5 9 3 0 4 8 4 9 210 710 810 310 1 5 3 5 1 2 8
 0 1 2 6 6 0 2 1 6 7 5 3 410101010 5 310 6 8 6 61010 5 0 710 2 71010
 8 910 8 6 6 3 7 4 910 3 81010 91010 5 3 3 9 4 3 2 3 5 6 7 5 810 6 4
 91010 6 81010 7 0 5 8 710 3 7 8 3 61010 610 9 8 6 5 710 5 2 2 61010
 9 9 8 010 8 810 9 7 5 1 1 910101010 8 3 7 7 810 7 4 1 2 0 0 2 5 5 7
 9 8 8 7 2 41010 5 3 8 2 0 0 6 7 2 1 0 81010 9 7 5 9 8 3 510 7101010
 6101010 5 4 1 8101010 7 2 1 4 0 3 7 9 1 910 8 2 81010 9 7 3 01010 4
 4 8 2 9 3 8 9 6 81010 8 4 7 0 3 3 4 3 910 9 9 7 8 910 9 7 6 9 7 7 1
 710 8 6 81010 5 0 7 7 9 0 71010 510 3 810 910 9 9 4
 5 5 812 6 3 4 811 3 8 8 912 810 9 5 6 81111 410 711 6 910 6 61011 4
 8 5 3 910 61111 8 9 612 8 91114 51211 912 9 8 7 7 9 6 7 9 8131011 7
 7 7 6101210 6 810 6111112 7 4 8 7 614 7 7 7 610 8 5 9 7 7 5 8 7 6 9
 7 5 3 7 5 4 4 4 4 710 6 6 810 8 7 5 4 4 911 8 9 8 8 3 5 5 8 5 4 6 5
 6 7 8101110 4 5 6 4 3 4 6 7 3 8 6 5 7 7 5 4 4 3 4 5 7 5 6 7 6 8 4 4
 6 4 3 4 4 4 7 4 4 5 6 9 9 7 7 4 3 3 6 4 3 51010 6 7 6 7 5 4 2 5 6 4
 7 6 4 2 4 3 6 5 4 5 3 2 3 6 4 6 4 3 3 3 5 5 6 3 3 2 3 4 5 3 3 2 4 4
 3 4 6 8 3 3 3 4 3 6 7 3 2 4 5 9 9 5 3 1 3 5 7 7 4 6 6 6 9 3 2 5 7 4
 3 4 5 4 2 5 4 6 6 5 7 6 3 4 9 811 5 5 4 6 611 9 5 8 7 9 4 6 7 3 9 6
 6 8 7 710 9 9 9 9 4 5 7 6 3 4 61110 5 6 8 9 5 911 8 6 9 8 711 2 6 3
 6 7 9 810 4 8 8 6 6 611 6 710111011 6 9 8 9 911 610
 31 39 35 14 11 23 36 15  4 12 31 26 39 31 27 31 14  7 20 33 25 17
 23 47 40 55 27 22 33 29 30 35  7 22 36 27 22 14 24 24 51 43 39 50
 32 54 58 58 57 46 42 57 41 25 46 57 56 51 54 60 58 64 68 68 63 36
 40 36 31 36 39 48 39 35 42 36 20 33 56 64 51 35 40 54 52 58 60 47
 55 63 55 41 35 47 48 39 48 48 41 36 44 40 33 44 53 64 70 71 75 72
 72 73 62 62 67 62 39 36 43 48 52 50 57 45 45 60 67 52 43 48 58 56
 48 60 70 69 65 60 45 44 60 65 56 54 56 50 49 57 64 62 65 68 65 62
 62 64 63 55 65 69 69 71 72 76 75 76 75 73 69 72 72 61 62 71 72 71
 69 70 70 72 74 69 62 66 66 66 67 66 63 67 68 63 75 68 64 68 76 69
 67 66 70 75 74 75 75 74 68 69 70 75 75 75 70 66 63 66 68 71 72 69
 63 65 68 71 74 74 71 68 68 64 68 70 69 70 70 71 76 78 75 73 72 71
 58 61 66 64 65 69 66 58 63 68 70 58 59 67 68 69 65 63 63 65 63 61
 59 53 62 59 59 65 66 55 54 54 57 59 61 61 66 66 55 52 50 49 51 52
 63 53 63 50 46 40 49 51 44 42 43 52 54 43 35 35 43 45 48 41 43 50
 43 35 42 44 30 39 45 39 36 33 34 36 33 40 44 51 38 36 31 30 27 41
 56 57 40 21 14 27 25 13 31 28 38 36 21 25 45 39 44 27 33 41 38 34
 35 45 45 20 23 29 17 37 31 24 36 21 21 15
 27 28 29  5  3  9 20 11 -2  3 27 18 30 18 11 23  5  0  3 28 19  9
 13 31 33 45 25 13 24 22 25 30 -6 11 23 22 17  7 16 15 26 30 19 40
 15 35 50 44 47 31 27 30 34 13 21 25 32 28 24 30 37 43 50 51 46 17
 17 17 19 25 25 31 30 17 22 22  5 18 35 43 40 15 21 26 38 43 43 27
 31 50 46 32 29 32 37 20 29 27 20 15 20 23 12 18 22 38 49 49 45 45
 46 51 44 41 42 47 24 18 24 27 27 36 37 25 19 31 44 47 31 33 38 49
 33 42 56 60 60 54 42 32 43 48 40 41 42 45 45 45 46 52 57 60 61 58
 49 42 42 48 52 54 55 56 59 62 63 63 65 62 60 62 64 61 60 61 61 63
 64 60 60 62 62 59 54 53 57 57 55 58 60 62 58 57 66 59 51 56 66 64
 54 51 54 60 64 65 66 63 53 53 61 65 65 67 64 56 48 50 53 58 64 65
 57 56 58 59 62 65 61 61 54 52 56 56 51 54 56 59 63 65 65 66 65 55
 43 45 54 58 55 57 55 45 43 54 59 48 43 49 51 54 55 59 58 57 54 57
 49 39 40 48 44 58 61 48 45 50 53 55 54 51 52 54 52 48 45 37 38 38
 47 26 38 32 30 24 25 41 28 20 23 45 49 28 21 21 20 31 42 26 22 31
 20 25 22 23 16 15 30 26 24 21 20 21 19 20 23 25 19 23 19 14 20 28
 35 48 35 13  4 11 17  2 20 19 19 32  9 12 24 31 38 10 11 19 26 21
 18 27 35  6  5 13  0 15 23  8 24  7  6  0
```

APPENDIX V. Example Output for WQRRS Interface

WEATH1	75	1	1	0	1.0	52.	50.	28.57	8.
WEATH1	75	1	1	1	1.0	50.	47.	28.57	6.
WEATH1	75	1	1	2	1.0	48.	46.	28.58	5.
WEATH1	75	1	1	3	1.0	47.	44.	28.60	9.
WEATH1	75	1	1	4	1.0	45.	42.	28.60	8.
WEATH1	75	1	1	5	1.0	43.	40.	28.62	9.
WEATH1	75	1	1	6	1.0	42.	40.	28.64	5.
WEATH1	75	1	1	7	1.0	42.	39.	28.65	11.
WEATH1	75	1	1	8	1.0	40.	37.	28.67	8.
WEATH1	75	1	1	9	1.0	40.	37.	28.67	9.
WEATH1	75	1	110		1.0	39.	38.	28.67	13.
WEATH1	75	1	111		1.0	39.	37.	28.66	14.
WEATH1	75	1	112		1.0	39.	36.	28.61	18.
WEATH1	75	1	113		1.0	39.	34.	28.58	11.
WEATH1	75	1	114		1.0	38.	34.	28.60	17.
WEATH1	75	1	115		1.0	37.	31.	28.60	17.
WEATH1	75	1	116		1.0	34.	31.	28.65	14.
WEATH1	75	1	117		0.9	32.	25.	28.69	18.
WEATH1	75	1	118		0.8	32.	24.	28.72	17.
WEATH1	75	1	119		1.0	31.	21.	28.77	17.
WEATH1	75	1	120		1.0	30.	18.	28.82	17.
WEATH1	75	1	121		1.0	29.	18.	28.84	14.
WEATH1	75	1	122		1.0	28.	18.	28.87	13.
WEATH1	75	1	123		1.0	27.	18.	28.91	11.
WEATH1	75	1	2	0	1.0	27.	18.	28.91	13.
WEATH1	75	1	2	1	1.0	27.	17.	28.95	13.
WEATH1	75	1	2	2	1.0	27.	18.	28.98	8.
WEATH1	75	1	2	3	1.0	26.	17.	29.02	10.
WEATH1	75	1	2	4	1.0	27.	17.	29.03	10.
WEATH1	75	1	2	5	1.0	27.	18.	29.04	9.
WEATH1	75	1	2	6	1.0	26.	19.	29.08	5.
WEATH1	75	1	2	7	1.0	27.	20.	29.10	6.
WEATH1	75	1	2	8	1.0	26.	20.	29.13	6.
WEATH1	75	1	2	9	1.0	28.	20.	29.15	4.
WEATH1	75	1	210		1.0	29.	21.	29.17	9.
WEATH1	75	1	211		0.8	30.	23.	29.17	5.
WEATH1	75	1	212		1.0	30.	22.	29.12	5.
WEATH1	75	1	213		0.4	31.	21.	29.08	4.
WEATH1	75	1	214		0.1	32.	21.	29.07	8.
WEATH1	75	1	215		0.2	34.	21.	29.10	9.
WEATH1	75	1	216		0.0	34.	21.	29.10	5.
WEATH1	75	1	217		0.1	32.	20.	29.09	4.
WEATH1	75	1	218		0.0	31.	20.	29.07	0.
WEATH1	75	1	219		0.0	29.	20.	29.06	0.
WEATH1	75	1	220		0.0	27.	21.	29.04	4.
WEATH1	75	1	221		0.0	27.	21.	28.98	5.
WEATH1	75	1	222		0.3	29.	21.	28.92	6.
WEATH1	75	1	223		0.7	29.	21.	28.89	5.
WEATH1	75	1	3	0	1.0	31.	21.	28.84	0.
WEATH1	75	1	3	1	1.0	34.	16.	28.81	9.
WEATH1	75	1	3	2	0.9	33.	21.	28.82	0.
WEATH1	75	1	3	3	1.0	31.	22.	28.79	0.
WEATH1	75	1	3	4	1.0	35.	16.	28.76	5.
WEATH1	75	1	3	5	1.0	30.	27.	28.75	4.

EXHIBIT 5

THERMAL SIMULATION OF LAKES

(HEATX and THERMS)

US Army Corps
of Engineers
Hydrologic Engineering Center

Generalized Computer Program

THERMS
Thermal Simulation of Lakes

User's Manual

July 1970

Approved for Public Release. Distribution Unlimited.

CPD-11

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14. ABSTRACT
This user's manual provides information on the simulation of reservoir temperatures using two computer programs - Heat Exchange Program (HEATX, Appendix A, 722-F5-E1010), and Thermal Simulation Program (THERMS, Appendix B, 722-F5-E1011). HEATX assembles the meteorologic data and performs the necessary calculations to determine the climatologic input to the reservoir heat balance. This output is then used as a portion of the input to THERMS.

HEATX performs all the computations necessary to determine the net rate of heat exchange at the air-water interface. Input to the program consists of measured values of a cloud cover, wet and dry bulb temperatures, and wind speed. See Appendix A for more details about the HEAT programs.

THERMS takes the required hydrologic and meteorologic data, assembles it, and performs the necessary calculations to determine the annual temperature cycle for the reservoir that is being studied. Input requirements may be divided into four categories: site characterization, hydrologic, meteorologic, and water temperature data. See Appendix B for more details about the THERMS program.

15. SUBJECT TERMS
722-F5-E1010, 722-F5-E1011, HEATX, Heat Exchange Program, THERMS, Thermal Simulation Program, annual temperature cycle, impoundment, heat balance, inflow, outflow, heat transfer, water surface, reservoir, meteorological variables, equilibrium temperature, mean daily values, air temperature, wet bulb temperature, wind speed, coefficients of surface heat exchange

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User's Manual

November 1977

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PREFACE

This computer program description as well as the associated source code were developed by Mr. Earl Eiker formerly of the U.S. Army Corps of Engineer District, Baltimore. Since he transferred from the District to the Office of the Chief of Engineers, the Hydrologic Engineering Center has been requested to distribute this program. Several versions of this program presently exist. The version HEC is distributing was obtained from the Ohio River Division. Some recent revisions have been made by HEC.

Extra copies of this publication and/or copies of the source code may be obtained from Ms. Penni Baker by calling (916) 756-1104. Questions regarding its application should be referred to one of the following:

Contact	Office	Commercial
R.G. Willey	HEC	(916) 756-1104
Henry Jackson	ORD	(513) 684-3070

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INTRODUCTION

When a dam is built across a stream, a totally different regime is established which profoundly affects the water quality within and downstream of the impoundment for many miles. The temperature structure within the reservoir is the most important consideration when establishing a management plan for water quality control.

When a study of reservoir temperatures is undertaken, it is important that all of the physical and meteorological heat exchange processes are included, so that consideration of the overall heat balance of the reservoir is assured. A sound theoretical approach will insure this. The analysis should provide a realistic assessment of the inter-relationship between project operations and the thermal variations within the reservoir. The use of input data which cannot be measured "in situ" should be kept to a minimum in order to insure that possible bias in results is eliminated. Finally, application should be straightforward and follow standard accepted procedures in order to provide confidence and guarantee uniformity in results.

CONSERVATION OF HEAT

The simulation of the annual temperature variations within an impoundment begins with the formulation of a mathematical description of the pertinent heat transfer mechanisms. The solution of the mathematical formulation results in an accounting of the external and internal heat balance for the reservoir over the yearly cycle.

The annual temperature cycle of a reservoir is the result of a complex inter-relationship among the many hydrodynamic and thermodynamic processes by which heat enters, is distributed within, and leaves an impoundment. Strictly speaking, the only mathematical descriptions which would be universally applicable would be the three dimensional equations of conservation of heat and mass. However, solution of the three dimensional equations is virtually impossible. There are many instances, though, when the reservoir heat balance can be adequately determined by considering only the vertical distribution of heat and the heat transfer mechanisms associated with movement along the vertical axis. Prototype data are available to support this assumption. The annual temperature cycle for the Beltzville Reservoir in northeastern Pennsylvania is shown on figures 1 through 3. Examination of these figures shows that the assumption of horizontal isotherms (layers of equal temperatures) is indeed valid. Very little variation was measured in either the longitudinal or lateral directions at Beltzville. A large number of Corps reservoirs exhibit this same characteristic and are readily analyzed by considering heat transfer in only the vertical dimension. It should be emphasized, however, that each impoundment is different and before this simplifying assumption is accepted, it should be scrutinized.

Some general guidance is available on the applicability of the one dimensional assumption to a particular reservoir. Orlob (15) has suggested a method of reservoir classification based on a ratio of inflow volume to storage volume in the reservoir.

1) Low flow/volume ratio. - Reservoirs in this class are extremely large and have detention times greater than one year. Little seasonal variation in storage occurs and outflow is generally from surface layers.

2) Medium flow/volume ratio. - Reservoirs in this class are large and detention times are in the range of from four months to one year. These reservoirs show strong patterns of stratification and variations in storage may be large.

3) High flow/volume ratio. - Reservoirs in this class are generally run of river types with detention times of less than four months. Patterns of stratification are difficult to access and longitudinal variations in temperature are common. Along with these longitudinal temperature variations, conditions of underflow may develop.

Reservoirs in the first and second class can be expected to exhibit a strong pattern of thermal stratification. In order to mathematically evaluate the applicability of the one dimensional assumption, Orlob (11) suggests the use of a densimetric Froude number computed as follows:

$$F_D = \frac{LQ}{HV} \sqrt{\frac{1}{g\ e}} \qquad (1)$$

where:

F_D = densimetric Froude number

L = length of the reservoir in ft. @ conservation pool

H = mean reservoir depth in ft.

V = volume of the reservoir in $ft.^3$ @ conservation pool

Q = flow through rate in cfs (check mean annual and spring mean monthly)

g = gravitational constant 32.2 ft/sec^2

e = average normalized density gradient taken as $0.3 \times 10^{-6}/ft.$

According to this theory, if the computed value of F_D is less than $1/\pi$ a strong stratification pattern will exist in the reservoir.

MATHEMATICAL FORMULATION

Several approaches to the simulation of reservoir temperatures have been utilized by various Corps offices (2, 11, 16). These methods have been analyzed by Eiker (6) and each was determined to be lacking in one or more areas. The simulation approach outlined below was developed by the **Baltimore** District and has been applied in several analyses of existing and proposed reservoirs. The basis of the analysis is the simultaneous solution of the time varying, one-dimensional equations for conservation of heat and conservation of mass.

The equations describing conservation of heat and mass for the reservoir are derived in the classical manner. The reservoir is idealized and a control volume is established as shown on figure 4. The control volume is of thickness (ΔZ) and has an average area (A) which is a function of elevation Z. Conservation of mass for the control volume is described by:

$$\frac{\partial Q_v}{\partial Z} = \frac{Q_{in} - Q_{out}}{\Delta Z} \qquad (2)$$

where:

$\frac{\partial Q_v}{\partial Z}$ = change in vertical flow per unit between the bottom and top of the control volume in cfs/ft.

Q_{in} = inflow to the control volume in cfs.

Q_{out} = outflow from the control volume in cfs.

ΔZ = thickness of control volume in ft.

The equation to describe the conservation of heat within the control volume is:

$$\frac{\partial T}{\partial t} + \frac{1}{A}\frac{\partial(Q_v \cdot T)}{\partial Z} = \frac{1}{A}\frac{\partial}{\partial Z}KA\frac{\partial T}{\partial Z} + \frac{T_{in}Q_{in}}{A \cdot \Delta Z} - \frac{T_{out}Q_{out}}{A \cdot \Delta Z} + \frac{1}{\rho C_p A} \cdot \frac{\partial H}{\partial Z} \qquad (3)$$

where:

T = temperature in ^{o}F.

t = time in sec.

A = horizontal area of the control volume in ft^2

Qv = vertical flow in cfs.

Z = elevation in ft.

K = diffusion coefficient (molecular and turbulent) in ft^2/sec.

Tin = temperature of inflow in ^oF.

Qin = inflow to the control volume in cfs.

Tout = temperature of outflow = T in ^oF.

Qout = outflow from the control volume in cfs.

ρ = density of water in LBS/ft^3.

C_p = specific heat of water in $BTU/LBS/^oF$.

$\partial H/\partial Z$ = external heat source in BTU/sec.

An examination of equation (3) confirms that all of the pertinent heat transfer mechanisms are included in the formulation. The first term on the left hand side of the equation represents the change in temperature with respect to time. The second term on the left hand side of the equation accounts for the vertical transfer of head due to advective processes. The first term on the right side of equation (3) is the measure of heat transfer related to diffusion. The remaining three terms account for the external heat balance of the reservoir, that is, inflow, outflow, and interfacial heat transfer. Heat transfer at the solid boundaries, if significant, may be included with an additional term having the same form as the external heat source term.

The next step in the simulation is to incorporate the conservation of mass equation into the conservation of heat equation. This is accomplished by expanding the second term (vertical advection) by the product rule and substituting equation (2) into the result as follows:

$$\frac{1}{A}\frac{\partial(Qv \cdot T)}{\partial Z} = \frac{1}{A}\left[Qv\frac{\partial T}{\partial Z} + \frac{T(Qin - Qout)}{\Delta Z}\right] \qquad (4)$$

Now, when equation (4) is substituted back into equation (3) and simplified the result is:

$$\frac{\partial T}{\partial t} + \frac{Qv}{A} \frac{\partial T}{\partial Z} = \frac{1}{A} \frac{\partial}{\partial Z} KA \frac{\partial T}{\partial Z} + \frac{Qin(Tin - T)}{A \cdot \Delta Z} + \frac{1}{\rho C A} \frac{\partial H}{\partial Z} \qquad (5)$$

ADDITIONAL CONSIDERATIONS

Before proceeding with the solution of equation (5), functional descriptions for the inflow-outflow relationship, diffusion processes and the external heat source term must be developed.

The vertical outflow distribution used in the model is developed, based on methods presented in WES reports (3, 8). These methods enable an accurate prediction of the vertical variation in outflow to be made for either a weir or an orifice type outlet. The velocity distribution is first computed using the WES procedures. The outflow per foot is then developed by multiplying the velocity at each elevation by the reservoir width. A complete explanation of the application is contained in the above references.

When inflow enters a reservoir it tends to seek residence at a depth of similiar temperature (density). Velocity measurements of inflows at Fontana Reservoir, taken by Elder and Wunderlich (7), show that there is a vertical distribution of inflow. This distribution is approximately parabolic and is centered about the elevation where reservoir temperature is equal to inflow temperature. The vertical limits of the inflow distribution are dependent upon the quantity of flow and the degree of thermal stratification existing in the reservoir pool. Orlob (11) has suggested a method for determining the vertical limits of the inflow distribution as a function of densimetric Froude number following Debler's criteria. This relationship is as follows:

$$D = 2.88 \left[\frac{Q}{W \sqrt{gE}} \right]^{\frac{1}{2}} \qquad (6)$$

where:

D = thickness of the inflow distribution in ft.

Q = inflow in cfs.

W = reservoir width in ft.

g = gravitational constant = 32.2 ft/sec^2.

E = stability = $\frac{1}{\rho} \frac{d\rho}{dZ}$

The model uses equation (6) to estimate the thickness of the inflowing layer, fits a parabolic distribution of inflow velocity between the limits and centers this distribution about the point of corresponding density of inflow and reservoir water. If the reservoir surface or bottom restricts the distribution, the center-line is moved up or down as required and the thickness of the inflowing water is kept constant. The inflow quantity distribution is next computed by multiplying the computed velocity distribution by the reservoir width at each elevation. Some mixing of the reservoir inflow occurs as it enters the pool. Based on model studies conducted at WES, this phenomenon is handled by assuming a quantity of water from the top layer of the reservoir is entrained and mixed with the inflow current. A modified volume and volume-weighted temperature for the inflow is computed, based on the assumed quantity of entrainment, prior to placement within the reservoir.

Now, with a knowledge of the inflow and outflow distributions at any point in time, the vertical flows (Q_v) at any elevation are uniquely established. The relationship may be written as:

$$Q_v\ (Z) = \int_{Z_o}^{Z} \left[Q_{in}\ (Z) - Q_{out}\ (Z)\right]\ dZ \qquad (7)$$

where:

Q_v (Z) = vertical flow at elevation Z in cfs.

Z_o = elevation of reservoir bottom in ft.

Q_{in} (Z)= inflow of distribution function in cfs/ft.

Q_{out}(Z)= outflow distribution function in cfs/ft.

Relating equation (7) to the control volume the net vertical flow through the control volume (Q_v) is evaluated as:

$$Q_v = Q_v\ (Z + \ Z) - Q_v\ (Z) \qquad (8)$$

The external heat sources that are considered in the model are the seven heat exchange processes which operate at the air-water interface and may be written as:

$$H_n = H_s - H_{sr} + H_a - H_{ar} \pm H_c - H_{br} - H_e \qquad (9)$$

where:

H_n = the net heat transfer in BTU/ft^2/DAY

H_s = the short wave solar radiation arriving at the water surface in BTU/ft^2/DAY.

H_{sr}= the reflected short wave radiation in BTU/ft^2/DAY.

H_a = the long wave atmospheric radiation in $BTU/ft^2/DAY$.

H_{ar} = the reflected long wave radiation in $BTU/ft^2/DAY$.

H_c = the heat transfer due to conduction in $BTU/ft^2/DAY$.

H_{br} = the back radiation from the water surface in $BTU/ft^2/DAY$.

H_e = the heat loss due to evaporation in $BTU/ft^2/DAY$.

Complete discussions of the individual terms have been presented by Anderson (1) and in Tennessee Valley Authority report No. 14 (14). All of the heat transfer mechanisms at the water surface, with the exception of short wave solar radiation, affect only the top one or two feet of the reservoir. Short wave radiation, however, penetrates the water surface and may affect water temperatures at great depths. This depth of penetration varies from reservoir to reservoir and is a function of absorption and scattering properties of the water (9).

The method used in the model to evaluate the net rate of heat transfer at the air-water interface has been developed by Edinger and Geyer (5). Their method utilized the concepts of equilibrium temperature and coefficient of surface heat exchange. The equilibrium temperature may be defined as that water temperature at which the net rate of heat exchange between a water surface and the atmosphere will be zero. The coefficient of surface heat exchange is the rate at which the heat transfer process will proceed. The equation to describe this relationship may be written as follows:

$$H_n = K_e \; (T_e - T_s) \qquad (10)$$

where:

H_n = the net rate of heat transfer in $BTU/ft^2/TIME$.

Ke = the coefficient of surface heat exchange in $BTU/ft^2/TIME$.

T_e = the equilibrium temperature in ^oF.

T_s = the surface temperature in ^oF.

Computation of T_e's and K_e's is dependent solely on meteorological variables and is outlined in the literature (5).

The evaluation of the external heat source term is completed by establishing a relationship for the heating effects of short wave solar radiation penetration. Based on laboratory and analytical studies, Dake and Harlemen (4) have developed an equation to describe the distribution of heat input due to solar radiation penetration below the water surface. Their approach is based on a surface absorption of the longer wave lengths of radiation and an exponential decay with depth for the remaining wave lengths of radiation. The equation to describe this exponential decay is:

$$\phi(Z) = (1 - \beta) \ \phi_o \ e^{-\lambda Z} \qquad (11)$$

where:

ϕ (Z) = the quantity of radiation arriving at a horizontal plane (Z feet below the water surface) in BTU.

β = the fraction of radiation absorbed by the top 2 feet of water in the reservoir.

ϕ_o = total incoming radiation in BTU.

λ = the average absorption coefficient of the water in ft^{-1}

Z = depth below the water surface in ft.

Guidance in the selection of β and λ is provided by Dake and Harlemen and also in TVA Report No. 14 (14).

The final and perhaps the most difficult consideration to be made is with regard to the diffusion term. At this time, there is no adequate functional representation by which the variations over time and space in the diffusion coefficient (K) can be computed "a priori". The approach used in the model follows the arguments of Dake and Harleman and Stefan and Ford (13). That is, diffusion of heat in the epilimnion is handled indirectly by a combination of wind induced and convective mixing processes. In the model a coefficient may be used to increase or decrease wind speed effects due to fetch length, sheltering and water surface roughness (see App. B). The result of this procedure is the computation of a uniformly mixed eplimnion. Diffusion in the hypolimnion is considered constant and may be assumed as equal to molecular diffusion in the absence of better data.

SOLUTION TECHNIQUE

Analytical solutions of equation (5) have been accomplished, but their practical application is restricted. Numerical methods are the

the only means by which a workable solution to equation (5) may be obtained. The numerical technique used in the model is of the implicit type. The solution requires the stipulation of an initial condition and two boundary conditions. The initial condition may be taken as isothermal at some time during the spring. The lower boundary condition used in the model assumes no heat is transferred across the bottom boundary. The upper boundary condition assumes the heat exchange at the reservoir surface is equal to the net heat transfer at the air-water interface minus the quantity of heat attributable to the short wave solar radiation that penetrates into the water body. The mechanics of the solution are carried out by beginning from a known or assumed initial condition and stepping forward in time, using constant increments for hydrologic and meteorologic input.

In order to effect the solution, the reservoir is first segmented into a finite number of layers along the vertical axis. These layers may be thought of as a number of control volumes stacked vertically between the reservoir bottom and the surface. Each element has a thickness of ΔZ and an average horizontal area dependent on the reservoir elevation-area relationship. Heat and mass balances are next developed for each layer using central differences to approximate the derivatives in equation (5). The differences are substituted into equation (5) and a difference equation is developed for each layer. The resulting equations have the following general form:

$$\{A_{i+1,\ t+1}\}\ T_{i+1} + \{A_{i,\ t+1}\}\ T_i + \{A_{i-1,\ t+1}\}\ T_{i+1} = T_{i,\ t} + A_v + E_x \tag{12}$$

where:

$A_{i,\ t+1}$ = coefficient describing internal mixing processes

T_i = temperature of each layer at time t+1

$T_{i,\ t}$ = temperature of each layer at time t

A_v = temperature rise in layer i due to inflow

E_x = temperature rise in layer i due to external heat sources.

When equation (12) is written for each layer, there results N equations (one for each layer) in N unknowns. In matrix notation, the equations are written:

$$\left[A_{ij}\right] \quad \left[T_j\right] = \left[C_j\right] \tag{13}$$

where:

$\left[A_{ij}\right]$ = a tri-diagonal matrix of coefficients

$\left[T_j\right]$ = a column matrix of temperatures at time t+1

$\left[C_j\right]$ = a column matrix of terms on the right side of equation (12).

Equation (13) is solved and the result is the temperature profile at time t+1. A more complete discussion of the numerical technique is presented by Keller (10).

COMPUTER PROGRAM

The simulation of reservoir temperatures as described above is accomplished by use of computer programs 722-F5-E1010, Heat Exchange Program and 722-F5-E1011, Thermal Simulation Program. The Heat Exchange Program assembles the meteorologic data needed to describe the interfacial heat exchange mechanism. The program then performs the necessary calculations to determine the climatologic input to the reservoir heat balance. The output from the first program is then used as a portion of the input for actual thermal modeling of the impoundment.

HEAT EXCHANGE

The Heat Exchange Program performs all the computations necessary to determine the net rate of heat exchange at the air-water interface. Computations to determine Equilibrium Temperature and Coefficients of Surface Heat Exchange are carried out using the methods of Edinger and Geyer (5), which have been discussed previously. In addition, if no measured values of short wave solar radiation are available the appropriate computations are made, using methods presented in TVA report No. 14 (14). Input to the program consists of measured values of cloud cover, wet and dry bulb temperatures, and wind speed. Also, physical characteristics such as latitude and longitude, and site elevation are furnished. Details of the program including a flow chart, variable definitions, input description and sample output are contained in Appendix A.

THERMAL SIMULATION

The Thermal Simulation Program takes the required hydrologic and meteorologic data, assembles it, and performs the calculations necessary to determine the annual temperature cycle for the reservoir under study.

The computations are made, based on methods and assumptions discussed previously. Input requirements of the model may be divided into four categories as site characterization, hydrologic, meteorologic, and water temperature data. Site characterization data are composed of reservoir width-elevation and area-elevation tables for the reservoir, project latitude and longitude, and site elevation. The hydrologic input requirements are daily average reservoir inflow and outflow, and daily pool elevation of the impoundment. Meteorologic data consists of mean daily values of Equilibrium Temperature, wind speed, Coefficient of Surface Heat Exchange and short wave solar radiationfrom the Heat Exchange Program. Input data for water temperature consists of daily average values of inflow water temperature and the temperature objective of release water. The geometric configuration of the outlet structure is required with reference to the location of various levels available for withdrawal. Details of the program including a flow chart, variable definitions, input description and sample output are contained in Appendix B.

CONCLUSION

A mathematical model capable of reservoir temperature prediction that is relatively easy to use has been presented. Consideration has been given to maintaining an accurate representation of the physical characteristics of the reservoir under study while adhering to the principles of conservation of heat and mass. Results of model verification studies are included in Appendix C. It is felt that the model presented offers the best combination of approaches to separate phases of the total problem that have been studied by various investigators.

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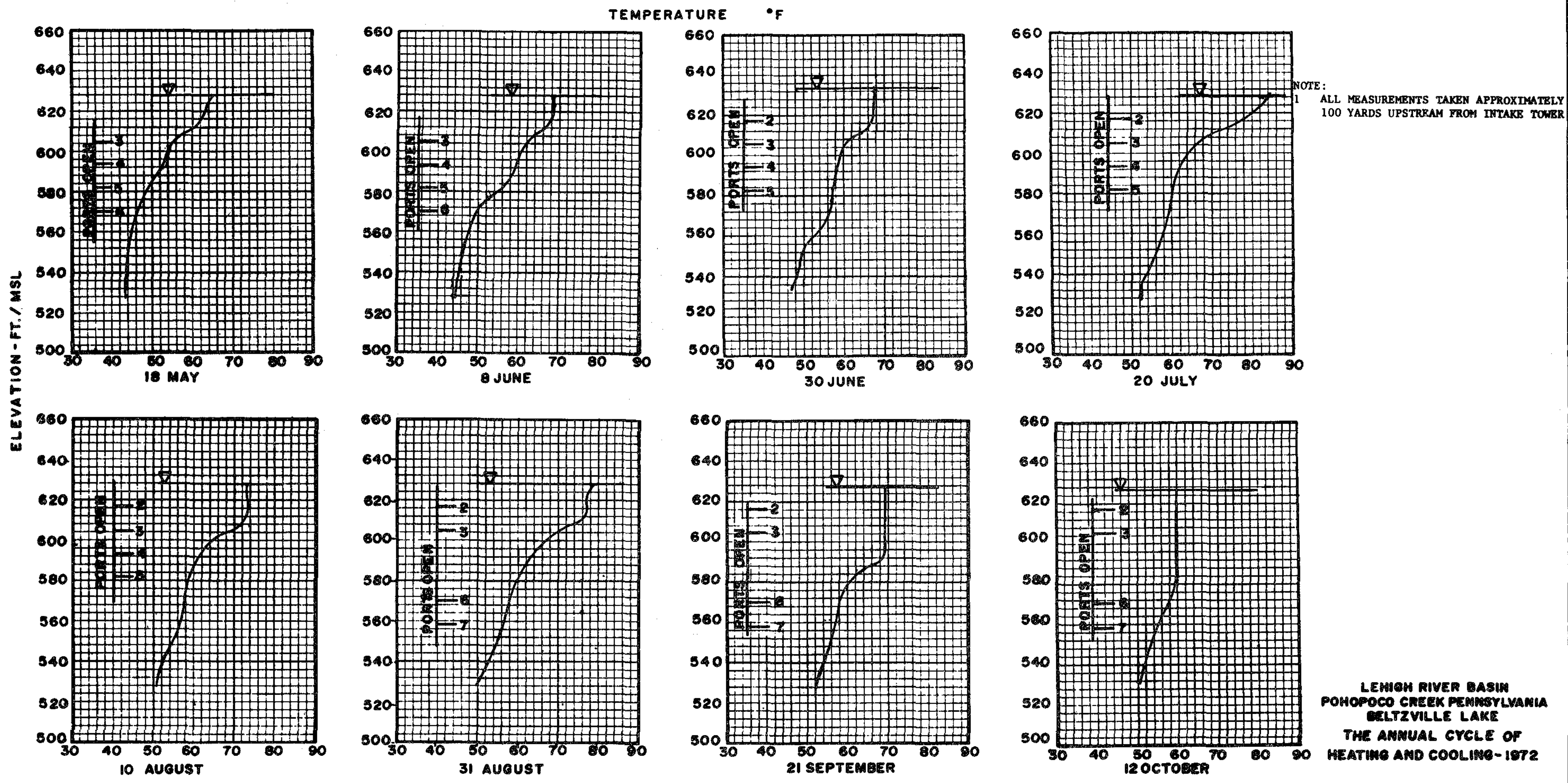
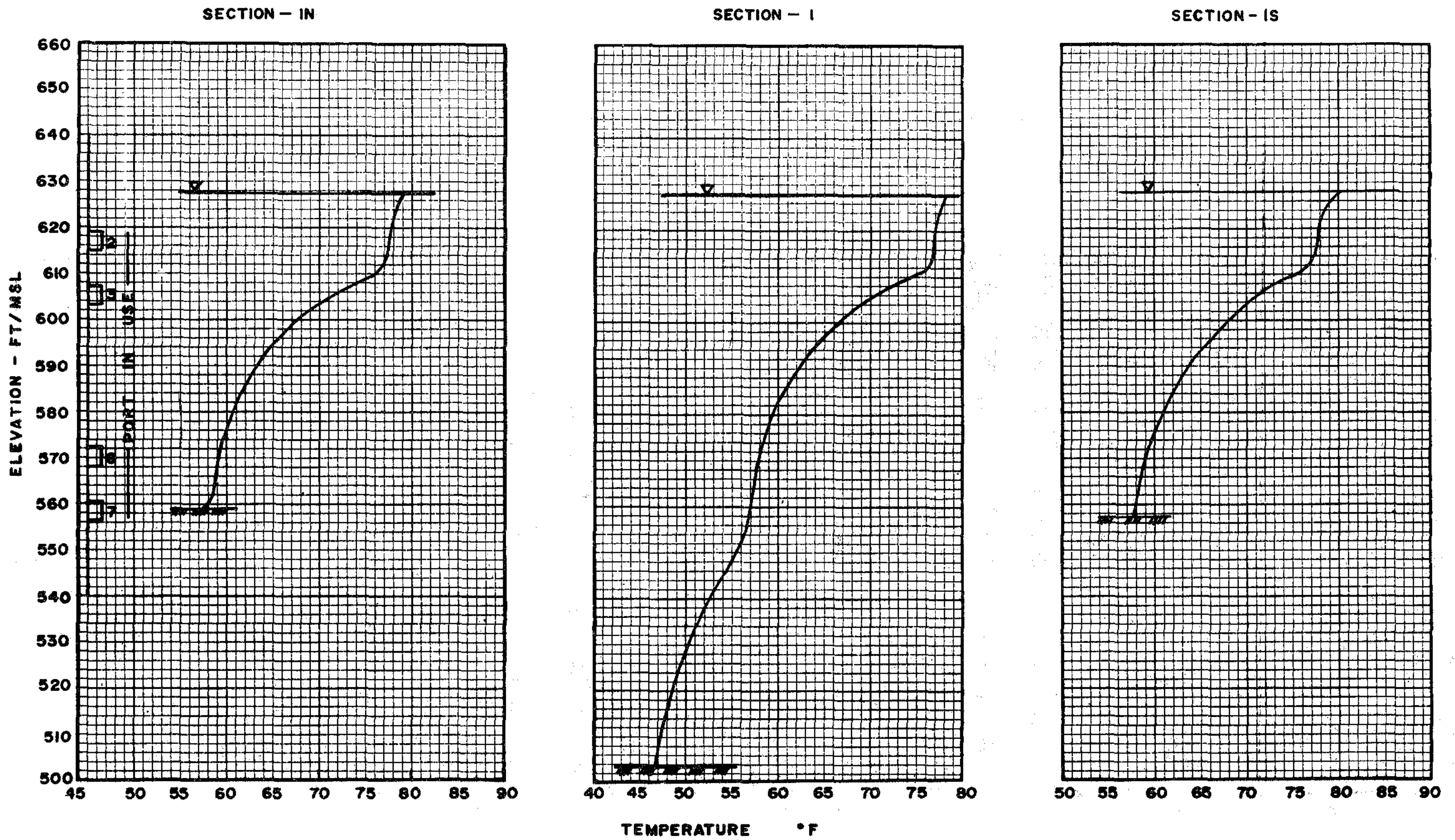


LEHIGH RIVER BASIN
POHOPOCO CREEK PENNSYLVANIA
BELTZVILLE LAKE
THE ANNUAL CYCLE OF
HEATING AND COOLING - 1972

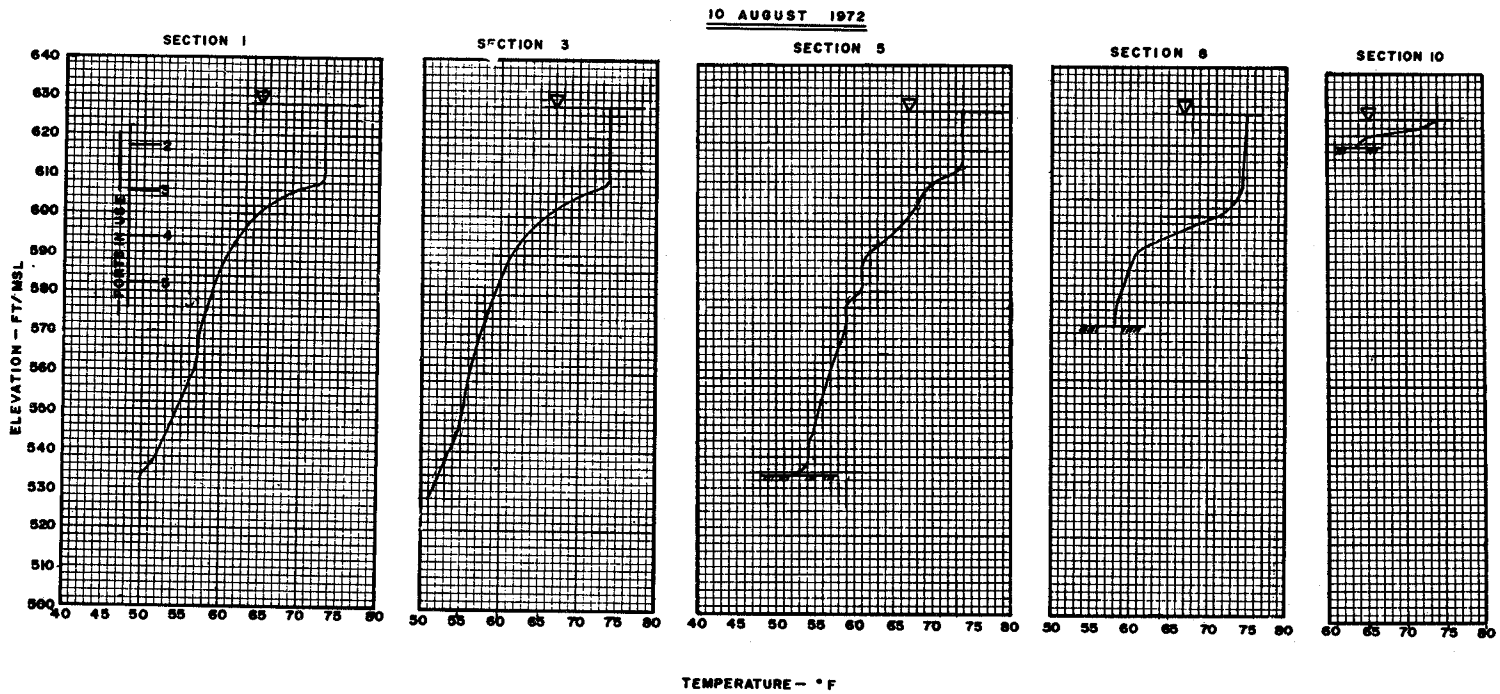
FIGURE I



NOTES.
1. STATION 1 IS LOCATED APPROXIMATELY 100 YARDS UPSTREAM OF INTAKE TOWER ALONG CENTER LINE OF LAKE.
2. STATIONS 1N AND 1S ARE APPROXIMATELY 100 YARDS NORTH AND SOUTH OF STATION 1 ON A LINE PERPENDICULAR TO CENTER-LINE OF LAKE.

LEHIGH RIVER BASIN
POHOPOCO CREEK PENNSYLVANIA
BELTZVILLE LAKE
LATERAL TEMPERATURE VARIATION
31 AUGUST 1972

FIGURE 2

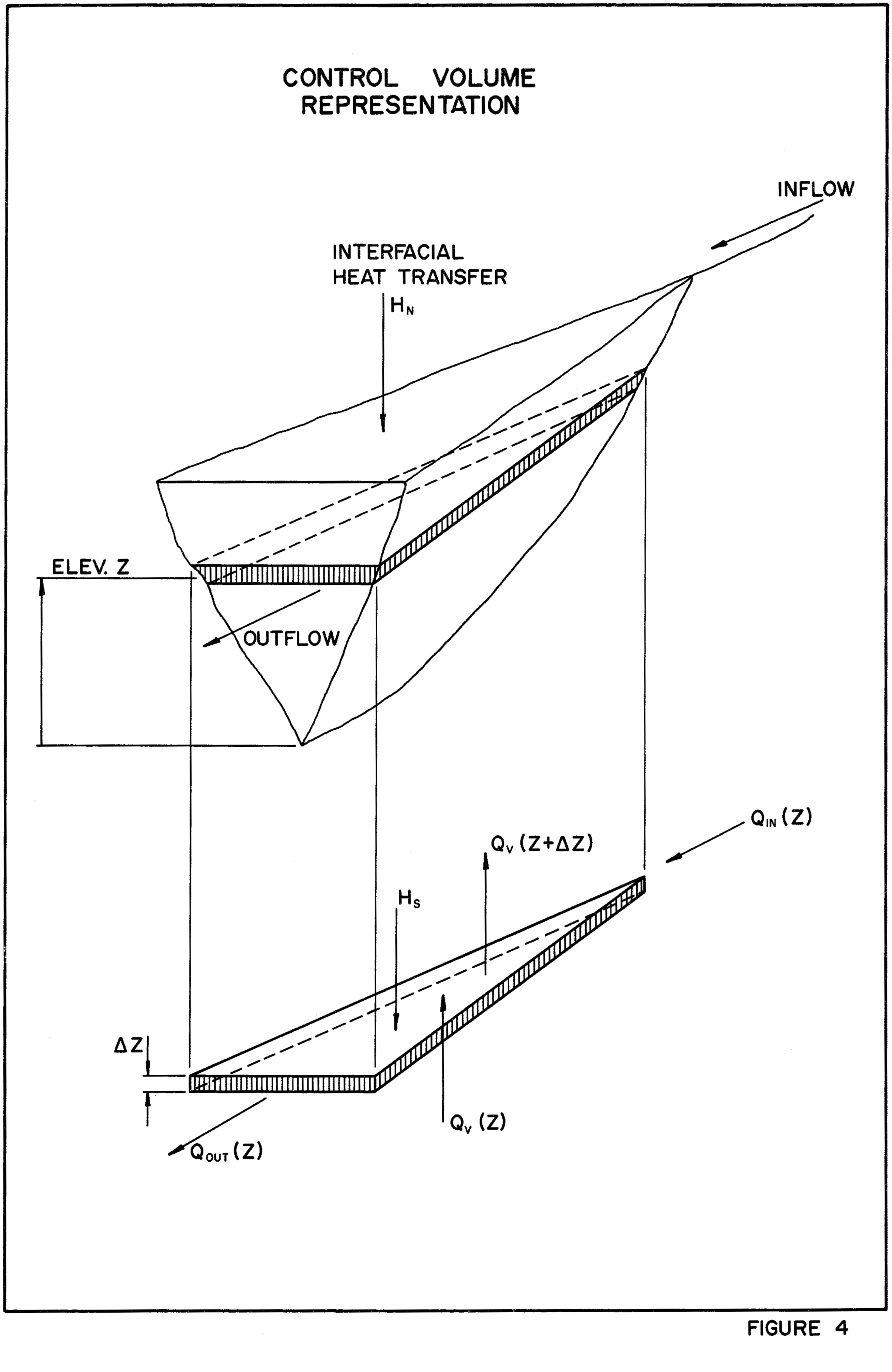


NOTES:
1. ALL STATIONS ALONG CENTER LINE OF LAKE.
2. STATION 1 IS APPROXIMATELY 200 YARDS ABOVE TOWER.
3. STATION 3 IS APPROXIMATELY 1.3 MILES ABOVE TOWER.
4. STATION 5 IS APPROXIMATELY 2.3 MILES ABOVE TOWER.
5. STATION 8 IS APPROXIMATELY 4.2 MILES ABOVE TOWER.
6. STATION 10 IS APPROXIMATELY 6.0 MILES ABOVE TOWER.

LEHIGH RIVER BASIN
POHOPOCO CREEK PENNSYLVANIA
BELTZVILLE LAKE

LONGITUDINAL TEMPERATURE PROFILES

FIGURE 3



CONTROL VOLUME
REPRESENTATION
INFLOW
INTERFACIAL
HEAT TRANSFER
H_N
ELEV. Z
OUTFLOW
$Q_{IN}(Z)$
$Q_V(Z+\Delta Z)$
H_S
ΔZ
$Q_V(Z)$
$Q_{OUT}(Z)$

FIGURE 4

A P P E N D I X A

HEAT EXCHANGE PROGRAM

722-F5-E1010

APPENDIX A

HEAT EXCHANGE PROGRAM

TABLE OF CONTENTS

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM
Heat Exchange Program

PROGRAM NO.
722-F5-E1010

PREPARING AGENCY Water Quality Section, Engineering Division, U.S.A.E.D.
Baltimore District, P.O. Box 1715, Baltimore, Md. 21203

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM: PHASE	STATUS OF PROGRAM: STAGE
Earl E. Eiker	Dec. 1972	Revised	Nov. 1977

A. PURPOSE OF PROGRAM

To analyze the day to day variations in meteorologic variables at a given location and using these variables to compute Equilibrium Temperatures and Coefficients of Surface Heat Exchange for use in estimating net heat exchange between a water surface and the atmosphere.

B. PROGRAM SPECIFICATIONS

1. Language - Fortran IV
2. Input - card only
3. Output- printer and punched card at users option
4. Size of Program - 8500 words
5. External storage - none
6. Restrictions - none

C. METHODS

Reference:

Edinger, J. E. and Geyer, J. C., "Heat Exchange in the Environment" Dept. of Sanitary Engineering, Research Project no. 49, The Johns Hopkins University, Baltimore, Md., June 1965.

D. EQUIPMENT DETAILS

Program is written for the Univac 1108 computer but can be adapted to comparable system. Normal configuration of reader/punch and printer required. Program is written for batch mode of time share operation.

E. INPUT-OUTPUT

Input consists of physical data to describe the site and mean daily values of air temperature, wet bulb temperature, wind speed and cloud cover. Output consists of computed values of Equilibrium Temperature and Coefficients of Surface Heat Exchange for any time period from one hour to one day. Punched card output is compatible with input requirements of program no. 722-F5-E1011, "Thermal Simulation Program."

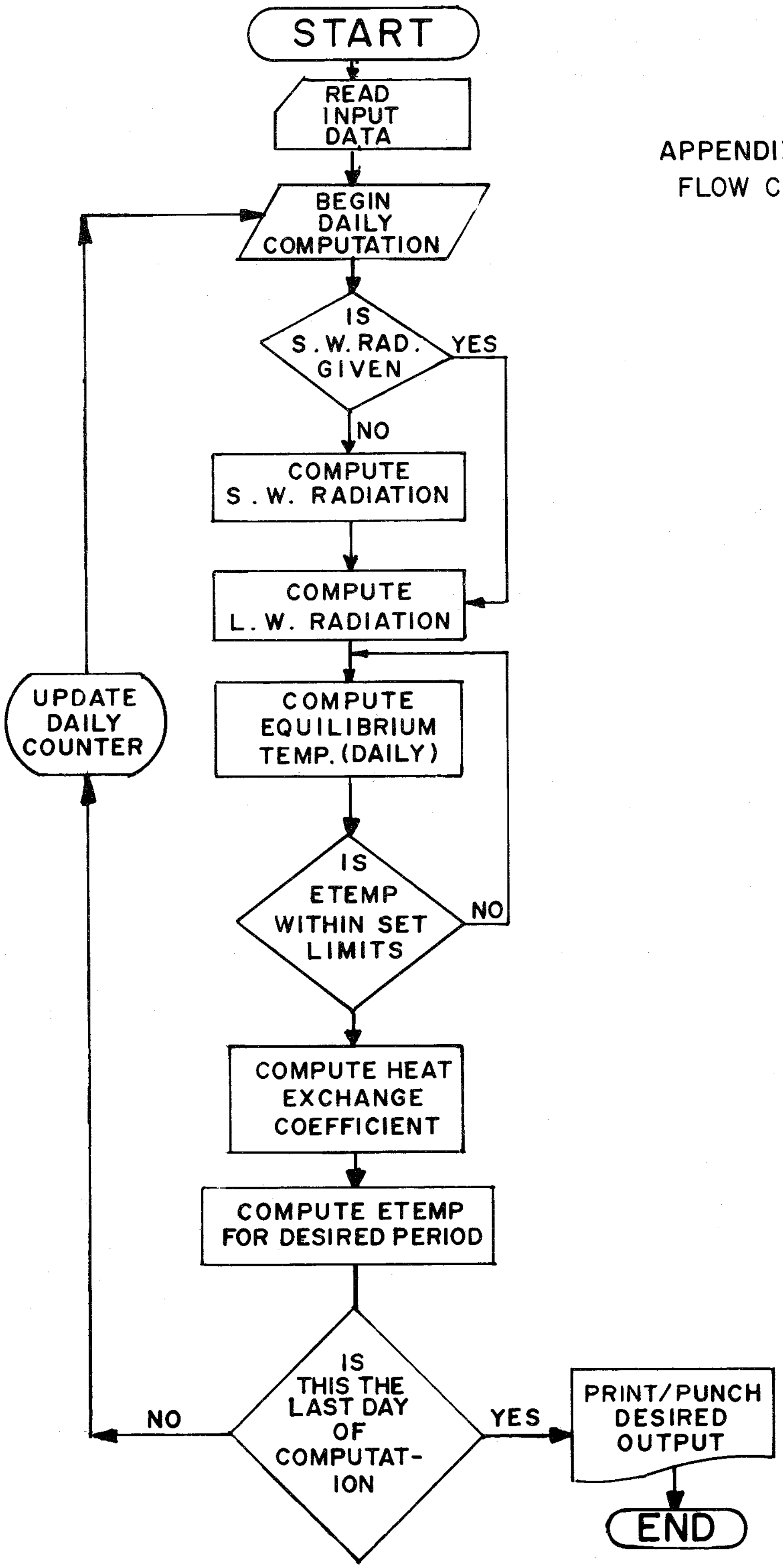
F. ADDITIONAL REMARKS

Complete documentation is available from The Hydrologic Engineering Center. Source deck available upon request.

ENG FORM 2883
1 AUG 60

PREVIOUS EDITIONS ARE OBSOLETE.

APPENDIX A.2
FLOW CHART



HEAT EXCHANGE PROGRAM

APPENDIX A.2

Appexdix A.3
HEAT EXCHANGE PROGRAM
DEFINITION OF VARIABLES

Variables

A1	Constant in S.W. radiation computation.
A11	Constant in S.W. radiation computation.
AEV	Constant in wind speed equation.
AIRT (365)	Average daily air temperature in ^{o}F.
AMASS	Optical air mass, dimensionless.
AMP	Amplitude of Equilibrium Temperature variation.
BEV	Constant in wind speed equation.
BOTEL	Project elevation in ft. above msl.
CBR	Constant in Bowen Ratio.
CL	Cloud cover function.
CLOUD (365)	Average daily cloud cover in tenths.
DEC	Declination of sun in radians.
DEWT (365)	Average daily dew point temperature in ^{o}F.
DSTL	Time difference between local and standard meridians in hrs.
DUST	Constant in S.W. radiation computation.
EA	Atmospheric vapor pressure in inches of Hg.
EK (365)	Coefficient of Surface Heat Exchange in $BTU/FT^2/DAY/^{o}F$.
ES	Saturation vapor pressure in inches of Hg.
ETEMP (365)	Equilibrium Temperature in ^{o}F.
ETEMP1	Initial Equilibrium Temperature (IDAY) in ^{o}F.
FWIND	Wind speed equation.
HA	Atmospheric radiation in $BTU/FT^2/DAY$.
HAB	Hour angle at beginning of time period in radians.
HAE	Hour angle at end of time period in radians.
HAN	Net atmospheric radiation in $BTU/FT^2/DAY$.
HHS (24)	Hourly solar radiation (hemispheric) in $BTU/FT^2/HR$.
HR	Absorbed radiation in $BTU/FT^2/DAY$.
HSD (365)	Daily solar radiation in $BTU/FT^2/DAY$.
HSDAY	Daily solar radiation in $BTU/FT^2/DAY$.
HSN (24)	Hourly solar radiation at site in $BTU/FT^2/HR$.
IDAY	First day of computation (Julian).
IPNCH	Eq. 2 if punched card output desired, Eq. 1 otherwise.
ISW	Eq. 1 if S.W. radiation is furnished, Eq. 2 otherwise.
LDAY	Last day of computation (Julian).
NDAY	Day number for computations.
NLAST	Number of bits of meteorologic data furnished.
NPER	Length of one period in hours.
NSW	Number of bits of S.W. data furnished.
PETEMP (24)	Period Equilibrium Temperature in ^{o}F.
PHI	Latitude of project in radians.

PHHS (24)	Period solar radiation (hemispheric) in $BTU/FT^2/PERIOD$.
PHSN (24)	Period solar radiation (net) in $BTU/FT^2/PERIOD$.
RATIO	Relative distance between earth and sun.
RFA	Water surface reflection of atmospheric radiation in hundredths.
RFG	Reflectivity of ground in hundredths.
RFS	Water surface reflection of S.W. radiation in hundredths.
SGDAY	Mean daily solar radiation (hemispheric) in $BTU/FT^2/DAY$.
SIG	Stefan-Boltzmann constant.
SLOPE	Slope of temperature vs. saturation vapor pressure curve.
STR	Standard time of sunrise in hours.
STS	Standard time of sunset in hours.
SW (365)	Daily solar radiation in $BTU/FT^2/DAY$.
TABS	Absolute temperature - 460 °F.
TIME	Time of day in hours.
WAT	Mean daily precipitable water content in CM.
WIND (365)	Mean daily wind speed in knots.
XDAY	Day number for computations.
XLAT	Latitude of project in degrees.
XLONG	Longitude of project in degrees.
XPER	Length of time period in hours.
XXLONG	Longitude of standard meridian in degrees.

WORKING VARIABLES

AL, ALF, ALT, AN, B, ETRY (3), KE, KNT, LE, M, NEX, SIGN, ST, STT, SUMH, SUMQ, X1, X2, X3, XI, XM, XTEM, XX, Y1, Y2, Y3, YM.

Appendix A.4
HEAT EXCHANGE PROGRAM
Input Description

Card No.

1 FORMAT (2I10)

NDATA - Number of jobs to be run
IHCJ - Output format; 0 for printer, 1 for LARM model input file, -1 for HEC-5Q input file, -2 for WQRRS input file

2 FORMAT (20A4) Job title - one card.

3 FORMAT (8F10.0)

ADDC - constant to be added to cloud cover (default=0)
ADDW - constant to be added to wind speed (default=0)
ADDT - constant to be added to dry bulb temperature (default=0)
ADDD - constant to be added to dew point temperature (default=0)
CMULT - factor to be multiplied times cloud cover (default=1)
WMULT - factor to be multiplied times wind speed (default=1)
TMULT - factor to be multiplied times dry bulb temperature (default=1)
DMULT - factor to be multiplied times dew point temperature (default=1)

4 FORMAT (6I10)

NLAST - Number of bits (e.g., days) of meteorological data furnished. Usually 365.
ISW - Equals 1 if short wave radiation furnished, equals 2 otherwise.
NSW - Number of bits of short wave data furnished.
IDAY - First day of computation. Usually one.
LDAY - Last day of computation. Usually 365.
IPNCH - Equals 2 if punched card output desired, equals 1 otherwise.

5 FORMAT (2F10.2)

ETEMP1 - Estimated initial Equilibrium Temperature in °F. Usually use air temperature.
XPER - Length of computation period and output interval for solar radiation only. Usually 24.

6 FORMAT (4F10.2)

AEV - Evaporation formula constant (0 for daily data).
BEV - Evaporation formula constant (426 for daily data from Lake Colorado City Studies).
RFS - Reflected S.W. radiation in hundredths. Only used if ISW equals 1. (0.05 from Lake Hefner Studies).
RFA - Reflected long wave radiation in hundredths (0.03 from Lake Hefner Studies).

7 FORMAT (4F10.2) - omit this card if card 12 is used.

BOTEL - Elevation of project in feet above sea level.
XLAT - Latitude of project in degrees.
XLONG - Longitude of project in degrees.
RFG - Reflectivity of ground surrounding the lake. This variable effects refluted solar radiation into the lake. See table on Appendix A.6.

8 FORMAT (12X, 34F2.0)

CLOUD (NLAST) - Mean daily cloud cover in tenths.

9 FORMAT (12X, 34F2.0)

WIND (NLAST) - Mean daily wind speed in knots. Can be be used in m.p.h. if WMULT on card 3 is equal to 0.8684.

10 FORMAT (12X, 22F3.0)

AIRT (NLAST) - Mean daily air temperature in °F.

11 FORMAT (12X, 22F3.0)

DEWT (NLAST) - Mean daily dew point temperature in °F.

12 FORMAT (12X, 11F6.1) - OPTIONAL

SW (NLAST) - Total daily short wave solar radiation in Langleys/day.

13 FORMAT (12X, 13F5.0) - OPTIONAL

BP(NLAST) - Barometric pressure needed if output is for WQRRS model. (Card 1.2 is -2)

Note: Skip to card 2 for next job.

APPENDIX A.5

HEAT EXCHANGE PROGRAM

INPUT SET UP

1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
NDATA	IHCJ						
TITLE(20)	(1 CARD)						
ADDC	ADDW	ADDT	ADDD	CMULT	WMULT	TMULT	DMULT
NLAST	ISW	NSW	IDAY	LDAY	IPNCH		
ETEMPI	XPER						
AEV	BEV	RFS	RFA				
BØTEL	XLAT	XLØNG	RFG				
CLØUD(365)							
WIND(365)							
AIRT(365)							
DEWT(365)							
SW(365)							
BP(365)							

Appendix A.6

HEAT EXCHANGE PROGRAM

Table of Values for RFG

Meadows and fields	0.14*
Leave and needle forest	0.07 - 0.09*
Dark, extended mixed forest	0.045*
Heath	0.10*
Flat ground, grass covered	0.25 - 0.33
Flat ground, rock	0.12 - 0.15
Sand	0.18
Vegetation early summer, leaves with high water content	0.19
Vegetation late summer, leaves with low water content	0.29
Fresh Snow	0.83
Old Snow	0.42 - 0.70

*May be too low

<u>Reference:</u>

Tennessee Valley Authority, Division of Water Control Planning, Engineering Laboratory, "Heat and Mass Transfer Between a Water Surface and The Atmosphere," Water Resources Research, Lab. Rept. No. 14, Norris, Tennessee, July 1967, Rev. May 1970.

APPENDIX A.7

HEAT EXCHANGE PROGRAM

SAMPLE INPUT

```
1     1
2     1974 CHARLESTON / SUTTON LAKE, W. VA. AIR % DEW = 2.5 DEG. F
3     0          0          -2.5        -2.5          1          1          1          1
4     365        2           0           1          365          2
5     33.      24.
6     0.      426.          0.          0.03
7     925.     38.661      80.694       0.25
      101  10 41010101010101010 8 810 710 6 610 710 610101010 710 8 3 2 71010
      102  10 6101010 9 9 4 0 910 010 110 7 9 710 3 5 8 11010 51010101010 8 7 9
      103   91010 1 31010 9 910 710 0 7 8 5 71010 8 8 810 3 91010 6 910 8 3 910
      104   9 810 2 8 7 7 01010 6 8 6 2 5 8 5 5 810 9 810 5 510 7 6 7 8 6 0 9 2
8*    105  10 7 8 3 4 9 8 8 710 2 810101010 7 210 8 6 4 8 1 6 5 3 4 4 9 7 7 4 8
      106   8 91010 8 9 8 910 7 6 6 1 1 31010 7 81010 8 9 6 1 9 6 4 710 7 3 610
      107   8 510 6 7 8 8 3 3 810 71010 7 7 9101010 8 1 2 7 710 5 8 4 3 4 5 8 7
      108   6 9 91010101010 5 41010101010 7 9 910 7 9 7 4 11010 7 3 2 8 3 7 710
      109   1 1 7 4 2 0 010 4 2 0 010 9 91010 010 710 0 0 4101010 0 010 9 5 7 6
      110  10 9 9 610 6 3 9 9 9 710 2 6 51010 710 7 0 810 4 5 0 7101010 310 0 2
      111  1010 9 0101010 910 9101010 7 8 3 610 9 51010 910 9
      201   6 6 3 6 3 5 7 5 6 4 8 7 4 61010 8 6 7 6 8 3 6 4 3 412 8 3 210 4 7 5
      202   9 4 6 9 6 6 9 9 8 6 6 5 4 9 3 9 7 716 9 510 7 6 9 5 71010 9 4 5 4 8
      203   8 6 7 7 2 61314 8 6 5 9 4 3 8 5 7 2 4 810 9 8 6 9 910 9 5 7 8 4 5 7
      204   7 911 5 4 5 6 2 61011 8 4 3 2 5 7 9 6 8 9 4 6 7 3 5 8 3 4 6 8 5 7 4
      205   6 5 1 3 4 5 4 6 5 4 3 3 7 5 7 5 3 3 5 6 4 7 5 3 9 7 4 2 3 9 7 5 5 6
9*    206   7 8 6 5 5 4 3 4 4 4 8 6 3 5 5 4 3 3 1 1 6 3 2 3 4 4 2 2 4 7 3 3 3 5
      207   4 3 2 2 2 7 5 3 1 4 6 6 2 3 2 3 3 3 3 4 3 2 3 3 5 2 4 3 4 3 3 2 1 1
      208   4 2 6 8 4 4 4 6 7 4 4 1 2 2 0 3 5 6 4 4 2 3 4 3 3 4 6 4 4 7 3 3 410
      209   9 5 5 3 3 3 1 2 2 1 2 1 1 1 6 6 4 7 4 5 4 1 3 3 2 6 3 0 0 3 3 0 2 3
      210   3 7 9 4 4 1 1 2 6 81110 9 3 6 1 41011 5 3 7 8 3 7 8 4 7 6 8 9 4 2 2
      211   5 7 8 4 2 4 2 3 7 6 6 7 9 1 6 5 8 5 8 3 3 3 2 5 5
      301  30 31 35 30 31 33 33 30 42 44 42 24 23 39 50 56 56 59 60 61 53 52
      302  51 37 39 51 62 49 45 44 50 41 49 34 27 23 41 37 25 22 28 30 43 51
      303  40 35 40 37 40 50 38 45 52 37 34 21 26 37 47 46 59 68 71 58 52 68
      304  67 69 55 43 43 32 34 45 44 37 42 51 48 42 37 51 31 31 46 51 55 59
      305  49 44 67 62 68 68 45 40 49 52 33 41 56 64 68 69 49 52 50 54 54 58
      306  70 66 54 46 48 59 64 71 75 73 63 55 63 55 52 51 45 57 61 59 65 62
      307  59 70 72 73 75 72 72 72 73 71 69 69 60 59 59 60 68 69 72 65 62 66
      308  69 70 72 76 76 77 77 68 64 63 68 69 66 58 66 71 78 77 73 64 61 59
10*   309  62 62 62 62 72 78 76 79 79 76 73 75 76 77 75 73 68 70 74 72 71 72
      310  78 73 72 70 70 70 72 71 73 75 74 74 71 71 71 73 74 72 67 68 72 72
      311  73 73 71 72 75 74 74 73 75 68 72 70 71 71 73 74 75 76 76 73 75 74
      312  73 71 67 63 58 59 59 65 68 67 69 72 72 73 59 58 60 66 66 68 68 59
      313  54 47 50 58 57 61 69 63 54 49 42 37 46 55 57 50 44 48 54 58 62 65
      314  69 57 50 52 48 42 36 34 43 50 58 61 53 47 53 63 63 64 64 66 63 66
      315  55 46 42 39 42 50 58 45 42 40 34 36 39 38 54 53 34 36 44 56 38 28
      316  33 39 34 35 34 32 32 28 26 33 42 42 25 25 34 43 39 38 39 40 32 28
      317  39 30 38 36 50 55 42 29 39 41 44 47 47
      401  27 24 34 28 28 32 29 24 40 43 40 14 14 31 44 44 47 46 55 52 46 41
      402  42 34 37 47 43 42 37 35 31 18 43 32 20 16 33 32 22 15 20 18 20 37
      403  39 26 30 24 24 37 31 30 39 20 26 13 14 17 30 32 48 47 42 47 49 57
      404  54 52 40 35 42 14 15 29 35 27 24 47 38 39 21 29 19 10 29 36 44 47
      405  41 35 40 43 48 56 36 28 26 44 29 28 31 42 52 52 34 30 34 34 40 34
      406  43 51 38 30 28 33 39 46 52 54 47 49 55 40 38 38 30 40 52 47 55 54
      407  40 46 57 60 67 66 65 62 61 65 60 58 46 48 44 48 62 64 66 63 58 56
11*   408  56 54 62 65 65 66 63 55 51 49 54 61 56 49 51 59 67 68 67 62 54 54
      409  54 58 60 58 60 64 67 67 68 67 69 68 69 69 69 66 57 57 60 66 63 64
      410  67 67 64 61 60 65 66 64 68 67 67 67 61 59 59 65 67 62 60 62 65 68
      411  67 67 65 68 68 64 66 68 67 66 64 63 62 63 65 66 68 69 68 69 69 69
      412  68 66 63 60 50 51 57 61 63 65 67 66 66 67 56 54 56 59 60 60 62 57
      413  49 38 41 47 50 56 63 52 41 37 27 27 29 37 42 45 36 36 41 44 49 56
      414  53 50 48 41 37 28 28 24 25 34 47 52 43 31 31 44 55 54 54 55 55 52
      415  47 31 35 32 32 32 31 39 27 29 20 23 32 35 48 44 27 27 27 37 33 17
      416  20 23 20 25 31 30 25 20 19 21 26 37 20 15 23 34 34 34 29 34 26 20
      417  30 25 30 24 28 42 36 18 34 39 39 41 43
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* The first twelve columns of this card have been used for identification. They can be left blank if desired.

APPENDIX A.8

HEAT EXCHANGE PROGRAM

SAMPLE OUTPUT

1974 CHARLESTON / SUTTON LAKE, W. VA. AIR & DEW - 2.5 DEG. F

```
CLOUD COVER          = CLOUD COVER X 1.00 +  0.00
WIND SPEED           = WIND SPEED X  1.00 +  0.00
DRY BULB TEMPERATURE = DRY BULB TEMPERATURE X  1.00 + -2.50
DEW POINT TEMPERATURE = DEW POINT TEMPERATURE X 1.00 + -2.50
```

DAY	EG TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
1	24.8	60.7	318.1	1883.6	1827.1	10	7.	28.	25.
2	28.6	61.0	779.8	1674.1	1623.9	4	7.	29.	22.
3	29.9	40.1	318.1	2002.5	1942.4	10	3.	33.	32.
4	25.1	61.1	322.2	1883.6	1827.1	10	7.	28.	26.
5	25.1	38.4	323.9	1906.9	1849.7	10	3.	29.	26.
6	28.4	55.4	324.1	1954.2	1895.6	10	6.	31.	30.
7	28.0	70.0	327.2	1954.2	1895.6	10	8.	31.	27.
8	24.2	52.4	331.0	1883.6	1827.1	10	6.	28.	22.
9	38.0	70.2	326.0	2179.4	2114.1	10	7.	40.	38.
10	40.3	53.8	326.3	2232.3	2165.4	10	5.	42.	41.
11	38.2	88.5	330.3	2179.4	2114.1	10	9.	40.	38.
12	19.6	63.2	557.9	1657.2	1607.5	8	8.	22.	12.
13	19.2	42.8	562.4	1636.7	1587.6	8	5.	21.	12.
14	33.4	64.7	342.1	2102.1	2039.0	10	7.	37.	29.
15	46.1	117.0	642.7	2219.8	2153.2	7	12.	48.	42.
16	48.7	119.7	340.3	2572.6	2495.4	10	12.	54.	42.
17	51.4	103.8	730.6	2333.4	2263.4	6	9.	54.	45.
18	53.7	82.7	738.7	2416.4	2343.9	6	7.	57.	44.
19	55.8	103.6	340.0	2695.2	2614.4	10	8.	58.	53.
20	56.6	89.3	660.3	2524.6	2448.8	7	7.	59.	50.
21	47.9	99.8	353.4	2483.7	2409.2	10	9.	51.	44.
22	50.6	46.6	774.4	2226.4	2159.6	6	3.	50.	39.
23	45.6	75.1	363.1	2425.9	2353.1	10	7.	49.	40.
24	32.9	49.0	371.4	2051.8	1990.2	10	5.	35.	32.
25	35.4	41.7	373.4	2102.1	2039.0	10	3.	37.	35.
26	47.7	58.1	370.4	2425.9	2353.1	10	5.	49.	45.
27	52.7	144.6	723.1	2553.9	2477.3	7	14.	60.	41.
28	44.2	93.9	381.8	2369.2	2298.2	10	9.	47.	40.
29	43.6	43.6	639.8	2141.0	2076.8	8	3.	43.	35.
30	48.5	34.9	1022.0	1937.2	1879.0	3	2.	42.	33.
31	44.4	105.3	1075.5	2063.0	2001.1	2	12.	48.	29.
32	38.2	46.9	788.8	1993.8	1934.0	7	5.	39.	16.
33	44.8	85.2	402.0	2369.2	2298.2	10	8.	47.	41.
34	30.7	56.1	413.5	1978.2	1918.9	10	6.	32.	30.
35	22.5	79.7	423.5	1815.1	1760.6	10	10.	25.	18.
36	25.8	44.1	929.1	1566.4	1519.4	6	5.	21.	14.
37	36.6	66.7	426.8	2153.4	2088.8	10	7.	39.	31.
38	33.1	89.7	432.2	2051.8	1990.2	10	10.	35.	30.
39	21.5	58.6	441.9	1770.6	1717.5	10	7.	23.	20.
40	19.7	56.6	608.0	1658.5	1608.7	9	7.	20.	13.
41	24.9	80.6	612.3	1786.9	1733.3	9	10.	26.	18.
42	30.1	82.0	1142.9	1653.7	1604.1	4	10.	28.	16.
43	40.9	80.2	1289.6	1885.3	1828.7	0	9.	41.	18.
44	46.5	73.1	620.7	2359.0	2288.2	9	7.	49.	35.
45	38.0	69.8	462.5	2127.6	2063.8	10	7.	38.	37.
46	40.2	57.4	1327.5	1711.5	1660.2	0	6.	33.	24.
47	36.5	48.9	478.8	2127.6	2063.8	10	5.	38.	28.
48	37.7	88.3	1353.4	1756.6	1703.9	1	10.	35.	22.

DAY	EQ TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
49	36.4	39.6	492.6	2127.6	2063.8	10	3.	38.	22.
50	46.6	101.9	947.9	2219.8	2153.2	7	10.	48.	35.
51	36.1	74.1	675.9	2019.5	1958.9	9	8.	36.	29.
52	43.1	77.2	978.3	2091.8	2029.0	7	8.	43.	28.
53	45.1	169.3	504.8	2454.7	2381.1	10	18.	50.	37.
54	37.5	86.4	1379.3	1780.5	1727.1	3	10.	35.	18.
55	39.2	57.0	1233.9	1762.6	1709.8	5	6.	32.	24.
56	20.6	83.6	889.3	1596.2	1548.3	8	12.	19.	11.
57	32.2	66.9	1511.9	1534.8	1488.8	1	8.	24.	12.
58	32.0	60.2	545.4	2051.8	1990.2	10	7.	35.	15.
59	40.8	93.2	544.3	2313.7	2244.2	10	10.	45.	28.
60	49.1	62.9	1294.9	2037.1	1976.0	5	6.	44.	30.
61	54.3	96.0	540.0	2664.1	2584.2	10	8.	57.	46.
62	57.9	134.0	546.6	2955.1	2866.4	10	12.	66.	45.
63	58.0	128.7	557.1	3057.7	2966.0	10	12.	69.	40.
64	52.8	116.3	560.5	2633.3	2554.3	10	10.	56.	45.
65	52.0	60.9	565.4	2454.7	2381.1	10	5.	50.	47.
66	66.2	88.7	924.6	2800.5	2716.5	8	6.	66.	55.
67	67.2	72.9	1098.6	2705.0	2623.9	7	5.	65.	52.
68	62.0	120.5	784.7	2906.5	2819.3	9	9.	67.	50.
69	50.7	97.6	810.9	2472.5	2398.3	9	9.	53.	38.
70	41.0	69.4	609.7	2205.8	2139.6	10	7.	41.	33.
71	42.7	83.2	609.4	2205.8	2139.6	10	8.	41.	40.
72	39.3	69.6	1761.7	1652.7	1603.1	1	8.	30.	12.
73	54.3	33.4	1686.5	1716.6	1665.1	3	2.	32.	13.
74	41.4	67.3	638.2	2259.2	2191.4	10	7.	43.	27.
75	40.1	131.2	639.7	2232.3	2165.4	10	15.	42.	33.
76	34.4	128.0	882.1	1995.1	1935.3	9	16.	35.	25.
77	39.4	81.1	893.3	2119.3	2055.7	9	9.	40.	22.
78	50.5	81.1	646.0	2425.9	2353.1	10	7.	49.	45.
79	52.5	67.0	1284.6	2167.8	2102.8	7	6.	46.	36.
80	41.1	99.0	667.2	2179.4	2114.1	10	10.	40.	37.
81	51.9	51.6	1933.6	1753.7	1701.0	0	5.	35.	19.
82	58.1	46.1	1336.4	2246.2	2178.8	7	3.	49.	27.
83	33.3	76.3	1166.3	1807.1	1752.9	8	9.	29.	17.
84	41.7	54.1	1682.6	1699.1	1648.1	5	6.	29.	8.
85	47.7	79.4	1373.0	2116.9	2053.4	7	8.	44.	27.
86	53.8	36.1	706.6	2425.9	2353.1	10	2.	49.	34.
87	54.6	60.0	703.8	2542.7	2466.4	10	5.	53.	42.
88	57.6	110.0	1176.2	2524.8	2449.0	8	9.	57.	45.
89	49.1	117.4	1198.4	2245.3	2177.9	8	12.	47.	39.
90	45.2	99.4	1218.6	2115.6	2052.1	8	10.	42.	33.
91	57.6	104.0	731.6	2921.5	2833.8	10	9.	65.	38.
92	64.9	90.1	1959.4	2393.6	2321.8	3	7.	60.	41.
93	61.0	127.3	991.1	2873.5	2787.3	9	10.	66.	46.
94	62.7	139.9	725.0	2955.1	2866.4	10	10.	66.	54.
95	42.6	107.3	758.0	2259.2	2191.4	10	12.	43.	34.

DAY	EQ TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
96	44.5	94.6	1686.6	1929.8	1871.9	6	10.	38.	26.
97	49.2	60.9	1051.7	2303.8	2234.7	9	6.	47.	24.
98	50.8	90.1	764.7	2454.7	2381.1	10	8.	50.	42.
99	38.3	82.7	1311.7	1852.0	1796.4	8	9.	31.	27.
100	58.0	55.9	2120.1	1868.7	1812.6	3	5.	39.	26.
101	54.9	65.4	1074.3	2501.6	2426.5	9	6.	54.	29.
102	57.6	94.4	787.5	2822.7	2738.0	10	8.	62.	40.
103	64.2	109.9	1052.1	2873.5	2787.3	9	8.	66.	50.
104	64.3	137.0	1307.3	2832.6	2747.6	8	10.	67.	50.
105	44.7	116.7	810.8	2369.2	2298.2	10	13.	47.	32.
106	62.6	69.5	2274.0	2112.3	2048.9	2	6.	50.	28.
107	56.6	57.2	1370.8	2272.0	2203.9	8	5.	48.	32.
108	58.9	68.9	1608.7	2326.9	2257.0	7	6.	52.	32.
109	58.3	82.5	1604.6	2326.9	2257.0	7	7.	52.	38.
110	80.4	44.2	2362.5	2250.7	2183.2	0	2.	56.	32.
111	62.5	87.9	827.7	3023.2	2932.5	10	7.	68.	41.
112	60.0	142.0	822.8	2888.2	2801.6	10	12.	64.	49.
113	54.1	130.5	1846.5	2279.4	2211.0	6	13.	52.	36.
114	47.9	89.2	1428.3	2166.7	2101.7	8	9.	44.	28.
115	60.0	56.8	1886.7	2123.6	2059.9	6	5.	46.	26.
116	75.0	54.7	2389.4	2292.5	2223.7	2	3.	57.	31.
117	80.9	45.7	2048.3	2515.1	2439.6	5	2.	62.	37.
118	69.2	83.2	1428.4	2897.8	2810.9	8	6.	69.	44.
119	72.2	120.7	2020.1	2850.6	2765.1	5	8.	73.	50.
120	69.8	149.0	2019.9	2787.0	2703.4	5	10.	71.	52.
121	63.9	92.1	1446.8	2644.4	2565.0	8	7.	61.	45.
122	54.7	108.8	867.8	2542.7	2466.4	10	9.	53.	47.
123	62.2	137.7	1164.0	2713.3	2631.9	9	10.	61.	53.
124	62.1	62.3	1482.9	2409.7	2337.4	8	5.	53.	38.
125	51.2	76.4	894.7	2454.7	2381.1	10	7.	50.	36.
126	58.7	92.6	2136.5	2161.6	2096.7	5	8.	49.	36.
127	65.8	49.3	2166.3	2013.0	1952.6	5	3.	43.	28.
128	56.1	70.0	902.9	2602.8	2524.7	10	6.	55.	38.
129	63.8	122.8	1729.5	2524.6	2448.8	7	9.	59.	50.
130	73.5	59.2	1970.5	2416.4	2343.9	6	3.	57.	45.
131	72.9	78.3	1730.8	2643.7	2564.4	7	5.	63.	53.
132	65.9	100.0	1491.9	2614.0	2535.6	8	7.	60.	52.
133	61.1	107.7	2014.2	2416.4	2343.9	6	9.	57.	38.
134	75.9	90.0	2587.2	2583.9	2506.4	0	6.	68.	44.
135	68.9	121.7	1211.0	3007.2	2917.0	9	8.	70.	55.
136	82.4	92.2	2471.3	2691.5	2610.8	2	5.	71.	58.
137	73.5	125.1	874.7	3199.3	3103.3	10	7.	73.	65.
138	77.4	110.9	1717.1	2863.5	2777.6	7	6.	70.	64.
139	85.7	52.9	1480.3	2930.9	2842.9	8	2.	70.	63.
140	85.8	77.8	2403.7	2683.7	2603.2	3	3.	70.	60.
141	81.7	92.3	2300.2	2746.1	2663.7	4	5.	71.	59.
142	73.8	104.9	1207.0	2973.3	2884.1	9	6.	69.	63.

DAY	EQ TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
143	74.8	83.9	1517.5	2832.6	2747.6	8	5.	67.	58.
144	70.8	110.0	1529.1	2832.6	2747.6	8	7.	67.	56.
145	66.8	81.2	1834.5	2495.5	2420.6	7	6.	58.	44.
146	61.3	65.5	938.5	2664.1	2584.2	10	5.	57.	46.
147	79.0	61.5	2630.6	2292.5	2223.7	2	3.	57.	42.
148	70.7	57.9	1575.8	2554.2	2477.6	8	3.	58.	46.
149	67.6	126.1	913.4	2955.1	2866.4	10	8.	66.	60.
150	70.6	99.9	909.5	2989.0	2899.3	10	8.	67.	62.
151	71.2	137.6	905.2	3092.6	2999.8	10	6.	70.	64.
152	68.3	96.2	915.1	2855.3	2769.6	10	8.	63.	61.
153	76.2	66.7	1814.0	2553.9	2477.3	7	3.	60.	56.
154	83.7	71.6	2599.3	2485.4	2410.8	2	3.	64.	54.
155	67.9	89.5	936.2	2989.0	2899.3	10	6.	67.	54.
156	70.3	105.2	1575.5	2865.1	2779.1	8	7.	68.	52.
157	80.1	91.3	2027.0	2805.0	2720.9	6	5.	70.	60.
158	78.5	149.5	2343.9	2840.6	2755.4	4	8.	74.	63.
159	77.8	110.4	1534.6	3066.2	2974.2	8	6.	74.	63.
160	90.0	85.6	2595.5	2801.4	2717.3	1	3.	75.	64.
161	74.8	174.7	2028.5	2967.8	2878.7	6	10.	75.	61.
162	71.8	123.5	2258.8	2633.0	2554.1	5	8.	66.	53.
163	77.6	80.0	2563.1	2449.4	2376.0	3	5.	62.	49.
164	86.2	51.8	2450.2	2449.8	2376.3	4	2.	61.	47.
165	82.9	69.8	2426.1	2594.4	2516.6	4	3.	66.	52.
166	68.0	156.7	1260.9	2906.5	2819.3	9	10.	67.	59.
167	69.2	120.9	1844.3	2674.2	2594.0	7	8.	64.	54.
168	66.9	83.3	1872.6	2438.2	2365.0	7	6.	56.	47.
169	74.7	92.6	2444.4	2535.7	2459.6	4	6.	64.	49.
170	72.3	113.1	1569.3	2897.8	2810.9	8	7.	69.	57.
171	76.8	149.6	1532.4	3135.9	3041.8	8	8.	76.	65.
172	74.9	166.4	1234.4	3181.7	3086.3	9	9.	75.	66.
173	72.9	124.1	915.4	3127.8	3034.0	10	7.	71.	65.
174	67.4	94.4	929.5	2822.7	2738.0	10	6.	62.	60.
175	67.7	87.7	1587.1	2584.0	2506.5	8	6.	59.	52.
176	66.2	72.2	1282.5	2590.6	2512.9	9	5.	57.	52.
177	73.3	62.4	1585.6	2614.0	2535.6	8	3.	60.	52.
178	69.0	77.0	1268.9	2682.2	2601.7	9	5.	60.	56.
179	66.8	76.7	932.4	2758.3	2675.6	10	5.	60.	58.
180	73.3	80.8	1829.2	2553.9	2477.3	7	5.	60.	56.
181	72.8	148.2	2043.5	2805.0	2720.9	6	9.	70.	58.
182	78.9	129.8	2018.3	3001.2	2911.2	6	7.	76.	62.
183	89.8	86.2	2581.4	2770.1	2687.0	1	3.	74.	65.
184	84.6	123.5	2578.6	2864.9	2778.9	1	6.	77.	65.
185	84.3	124.4	2432.5	2903.7	2816.6	3	6.	77.	66.
186	76.6	91.9	906.8	3235.5	3138.4	10	5.	74.	65.
187	77.7	75.3	899.4	3127.8	3034.0	10	3.	71.	67.
188	84.5	81.2	1759.9	2962.2	2873.3	7	3.	73.	66.
189	89.0	57.1	1500.7	3066.2	2974.2	8	2.	74.	67.

DAY	EQ TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
190	83.9	53.7	895.5	3272.0	3173.9	10	2.	75.	67.
191	74.6	129.7	894.1	3199.3	3103.3	10	7.	73.	67.
192	81.2	76.3	1508.6	2964.2	2875.3	8	3.	71.	64.
193	78.0	50.2	1249.4	2873.5	2787.3	9	2.	66.	55.
194	81.3	70.2	2022.5	2742.1	2659.8	6	3.	68.	55.
195	83.5	93.6	2587.6	2708.3	2627.1	1	5.	72.	58.
196	76.2	90.6	1210.6	3007.2	2917.0	9	5.	70.	64.
197	87.7	58.9	1977.5	2773.4	2690.2	6	2.	69.	61.
198	90.9	61.9	2291.5	2715.2	2633.7	4	2.	70.	62.
199	82.3	98.9	1729.2	3063.7	2971.8	7	5.	76.	65.
200	72.0	140.5	883.9	3127.8	3034.0	10	8.	71.	65.
201	81.8	75.3	1737.2	2863.5	2777.6	7	3.	70.	62.
202	84.8	76.0	2404.2	2623.5	2544.8	3	3.	68.	59.
203	81.5	72.2	1964.7	2742.1	2659.8	6	3.	68.	58.
204	71.3	101.8	880.3	3023.2	2932.5	10	6.	68.	63.
205	77.8	92.3	1462.9	2930.9	2842.9	8	5.	70.	64.
206	83.7	77.2	2094.9	2724.5	2642.8	5	3.	69.	62.
207	79.7	56.1	863.9	3127.8	3034.0	10	2.	71.	66.
208	89.5	62.5	1894.6	2901.8	2814.7	6	2.	73.	65.
209	87.3	60.8	1679.9	2929.0	2841.1	7	2.	72.	65.
210	74.7	145.5	1434.6	2997.9	2908.0	8	8.	72.	65.
211	73.6	100.5	1456.2	2897.8	2810.9	8	6.	69.	59.
212	84.1	74.0	2338.9	2653.4	2573.8	3	3.	69.	57.
213	91.5	54.0	2329.8	2653.4	2573.8	3	2.	69.	57.
214	77.5	91.1	1422.8	2964.2	2875.3	8	5.	71.	63.
215	72.9	124.0	842.9	3163.4	3068.5	10	7.	72.	65.
216	74.0	119.1	1662.0	2863.5	2777.6	7	7.	70.	60.
217	73.4	49.1	854.1	2921.5	2833.8	10	2.	65.	58.
218	71.7	65.8	845.8	2955.1	2866.4	10	3.	66.	60.
219	85.2	58.2	1625.8	2863.5	2777.6	7	2.	70.	63.
220	81.7	78.3	1602.3	2863.5	2777.6	7	3.	70.	66.
221	78.3	74.3	1111.8	3041.5	2950.2	9	3.	71.	65.
222	76.0	72.4	818.3	3127.8	3034.0	10	3.	71.	65.
223	74.2	69.5	820.0	3057.7	2966.0	10	3.	69.	63.
224	74.1	90.2	808.2	3092.6	2999.8	10	5.	70.	66.
225	81.2	77.8	1340.6	3031.9	2941.0	8	3.	73.	66.
226	90.9	61.9	2283.2	2708.3	2627.1	1	2.	72.	62.
227	85.8	80.8	2213.7	2722.1	2640.5	2	3.	72.	64.
228	81.5	78.1	1538.3	2896.1	2809.2	7	3.	71.	66.
229	77.7	112.6	1533.8	2962.2	2873.3	7	6.	73.	65.
230	74.8	52.4	789.5	2955.1	2866.4	10	2.	66.	64.
231	79.2	92.0	1877.7	2755.6	2672.9	5	5.	70.	62.
232	76.8	70.2	1310.8	2865.1	2779.1	8	3.	68.	61.
233	78.8	89.8	1999.5	2684.5	2604.0	4	5.	69.	60.
234	82.7	75.5	2083.1	2653.4	2573.8	3	3.	69.	61.
235	83.2	77.5	1958.9	2746.1	2663.7	4	3.	71.	63.
236	87.4	60.3	1814.4	2818.7	2734.1	5	2.	72.	64.

DAY	EQ TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
237	85.1	54.0	1254.0	3031.9	2941.0	8	2.	73.	66.
238	87.6	56.0	1449.4	2995.7	2905.8	7	2.	74.	67.
239	80.6	97.7	1625.1	2934.6	2846.6	6	5.	74.	66.
240	80.6	57.2	993.2	3041.5	2950.2	9	2.	71.	67.
241	74.6	129.7	987.0	3110.9	3017.6	9	7.	73.	67.
242	72.0	162.1	725.0	3163.4	3068.5	10	9.	72.	67.
243	73.8	89.9	722.9	3127.8	3034.0	10	5.	71.	66.
244	71.9	86.1	723.1	3057.7	2966.0	10	5.	69.	64.
245	68.6	80.4	725.3	2921.5	2833.8	10	5.	65.	61.
246	63.4	103.2	726.7	2790.3	2706.6	10	7.	61.	58.
247	62.3	105.8	1760.1	2346.4	2276.0	5	8.	56.	48.
248	69.0	72.5	1865.2	2339.0	2268.8	4	5.	57.	49.
249	61.5	70.6	717.2	2664.1	2584.2	10	5.	57.	55.
250	70.7	43.9	704.1	2855.3	2769.6	10	2.	63.	59.
251	72.4	49.8	694.6	2955.1	2866.4	10	2.	66.	61.
252	72.2	50.6	684.9	2921.5	2833.8	10	2.	65.	63.
253	74.8	47.9	674.9	2989.0	2899.3	10	2.	67.	65.
254	78.0	73.4	1307.3	2863.5	2777.6	7	3.	70.	64.
255	72.2	104.0	901.7	3007.2	2917.0	9	6.	70.	64.
256	72.2	123.0	891.2	3041.5	2950.2	9	7.	71.	65.
257	60.6	69.4	675.3	2664.1	2584.2	10	5.	57.	54.
258	64.6	71.0	1308.0	2438.2	2365.0	7	5.	56.	52.
259	67.1	44.9	898.1	2620.8	2542.2	9	2.	58.	54.
260	72.2	64.4	1268.6	2674.2	2594.0	7	3.	64.	57.
261	72.7	81.8	1633.2	2535.7	2459.6	4	5.	64.	58.
262	77.3	68.7	1793.7	2530.0	2454.1	1	3.	66.	58.
263	69.0	63.9	630.0	2955.1	2866.4	10	3.	66.	60.
264	60.4	69.9	633.1	2664.1	2584.2	10	5.	57.	55.
265	57.3	87.6	1240.1	2326.9	2257.0	7	7.	52.	47.
266	57.6	59.1	1710.0	2007.7	1947.5	3	5.	45.	36.
267	60.1	61.6	1742.9	2063.0	2001.1	2	5.	48.	39.
268	56.6	97.3	1035.8	2495.6	2420.7	8	8.	56.	45.
269	67.5	57.0	1622.0	2258.7	2190.9	3	3.	55.	48.
270	67.2	59.5	1160.9	2524.6	2448.8	7	3.	59.	54.
271	71.6	83.1	1126.6	2767.5	2684.5	7	5.	67.	61.
272	57.4	139.6	593.8	2790.3	2706.6	10	12.	61.	50.
273	54.4	112.4	1668.8	2151.6	2087.0	1	10.	52.	39.
274	55.5	68.2	1663.0	2028.4	1967.6	1	6.	47.	35.
275	44.7	59.3	1157.3	2017.9	1957.4	7	6.	40.	25.
276	49.5	43.0	1488.9	1801.4	1747.3	4	3.	35.	25.
277	56.7	45.6	1599.3	1967.4	1908.3	2	3.	44.	27.
278	63.1	50.1	1602.3	2173.2	2108.0	0	3.	53.	35.
279	70.3	38.6	1574.2	2224.6	2157.9	0	2.	55.	40.
280	51.3	37.2	553.9	2397.4	2325.5	10	2.	48.	43.
281	57.5	37.0	1400.6	1959.9	1901.1	4	2.	42.	34.
282	62.8	35.4	1506.8	2014.7	1954.3	2	2.	46.	34.
283	65.8	40.3	1513.7	2147.9	2083.5	0	2.	52.	39.

DAY	EQ TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
284	69.7	38.9	1490.2	2250.7	2183.2	0	2.	56.	42.
285	61.9	37.7	520.0	2758.3	2675.6	10	2.	60.	47.
286	67.6	41.2	684.7	2776.5	2693.2	9	2.	63.	54.
287	62.9	96.0	682.8	2906.5	2819.3	9	7.	67.	51.
288	53.8	85.6	503.0	2602.8	2524.7	10	7.	55.	48.
289	49.3	59.2	499.9	2397.4	2325.5	10	5.	48.	46.
290	52.7	89.6	1404.3	2098.0	2035.1	0	8.	50.	39.
291	44.7	53.3	499.1	2341.3	2271.1	10	5.	46.	35.
292	42.2	58.7	966.5	2017.9	1957.4	7	6.	40.	26.
293	33.1	47.7	494.2	2027.0	1966.2	10	5.	34.	26.
294	48.5	31.1	1373.1	1690.8	1640.1	0	2.	32.	22.
295	49.9	42.8	1356.4	1885.3	1828.7	0	3.	41.	23.
296	53.9	45.9	1190.0	2104.8	2041.7	4	3.	48.	32.
297	56.4	38.9	459.6	2633.3	2554.3	10	2.	56.	45.
298	56.5	89.2	449.6	2726.6	2644.8	10	7.	59.	50.
299	50.0	47.0	453.2	2483.7	2409.2	10	3.	51.	41.
300	56.2	33.2	1272.8	1977.5	1918.2	0	2.	45.	29.
301	60.1	34.0	1258.3	2122.9	2059.2	0	2.	51.	29.
302	57.6	50.1	437.7	2790.3	2706.6	10	3.	61.	42.
303	61.5	56.0	571.2	2713.3	2631.9	9	3.	61.	53.
304	67.7	40.7	974.4	2515.1	2439.6	5	2.	62.	52.
305	65.4	43.6	797.8	2613.5	2535.1	7	2.	62.	52.
306	65.4	58.0	884.2	2619.7	2541.1	6	3.	64.	53.
307	60.1	55.3	404.1	2790.3	2706.6	10	3.	61.	53.
308	59.1	104.2	544.9	2808.5	2724.2	9	8.	64.	50.
309	50.4	113.7	545.2	2472.5	2398.3	9	10.	53.	45.
310	44.8	51.6	884.6	2073.7	2011.5	6	5.	44.	29.
311	37.9	50.6	402.8	2179.4	2114.1	10	5.	40.	33.
312	42.9	31.1	864.1	1906.6	1849.4	6	2.	37.	30.
313	47.4	31.8	1027.2	1891.3	1834.5	3	2.	40.	30.
314	46.9	34.1	530.2	2331.3	2261.3	9	2.	48.	30.
315	48.7	71.6	525.4	2560.6	2483.8	9	7.	56.	29.
316	41.2	89.8	514.0	2196.8	2130.9	9	9.	43.	37.
317	36.5	105.3	733.0	2017.9	1957.4	7	13.	40.	25.
318	33.9	96.6	377.7	2127.6	2063.8	10	12.	38.	27.
319	31.4	83.3	006.1	1702.3	1651.2	2	10.	32.	18.
320	35.6	39.3	402.1	1838.5	1783.4	6	3.	34.	21.
321	37.4	66.7	835.5	1873.0	1816.8	5	7.	37.	30.
322	33.5	30.3	360.5	2076.8	2014.5	10	2.	36.	33.
323	49.9	59.5	349.0	2513.1	2437.7	10	5.	52.	46.
324	48.0	119.0	666.5	2299.7	2230.7	7	12.	51.	42.
325	28.8	100.4	354.9	1978.2	1918.9	10	13.	32.	25.
326	33.1	55.4	671.6	1876.8	1820.5	7	6.	34.	25.
327	43.3	41.5	957.2	1908.0	1850.7	0	3.	42.	25.
328	48.0	83.7	558.3	2438.0	2364.9	8	8.	54.	35.
329	33.2	81.9	341.4	2076.8	2014.5	10	9.	36.	31.
330	27.8	37.4	837.8	1613.4	1565.0	4	3.	26.	15.

DAY	EQ TEMP	EX COEFF	SW DAY	LW	LW NET	SKY	WIND	AIRT	DEWT
331	29.3	67.6	775.5	1741.2	1689.0	5	8.	31.	18.
332	34.8	78.4	921.5	1796.6	1742.7	0	9.	37.	21.
333	30.1	45.5	639.0	1831.6	1776.7	7	5.	32.	18.
334	28.7	68.9	333.0	2002.5	1942.4	10	8.	33.	23.
335	29.2	63.3	328.6	1978.2	1918.9	10	7.	32.	29.
336	27.6	78.0	327.0	1930.4	1872.5	10	9.	30.	28.
337	29.3	84.4	835.5	1675.2	1624.9	3	10.	30.	23.
338	21.4	43.9	326.9	1837.7	1782.5	10	5.	26.	18.
339	27.8	30.3	885.9	1532.2	1486.3	0	2.	24.	17.
340	33.2	31.0	854.6	1681.6	1631.2	2	2.	31.	19.
341	34.4	55.5	320.1	2179.4	2114.1	10	6.	40.	24.
342	37.0	77.3	314.1	2179.4	2114.1	10	8.	40.	35.
343	20.3	71.9	432.0	1721.7	1670.0	9	9.	23.	18.
344	24.2	43.7	870.8	1513.3	1467.9	0	5.	23.	13.
345	26.6	30.5	316.0	1978.2	1918.9	10	2.	32.	21.
346	36.8	50.0	310.8	2205.8	2139.6	10	5.	41.	32.
347	33.0	32.3	309.9	2102.1	2039.0	10	2.	37.	32.
348	33.5	40.8	418.1	2019.5	1958.9	9	3.	36.	32.
349	32.5	71.8	310.4	2102.1	2039.0	10	8.	37.	27.
350	35.2	66.5	416.3	2068.9	2006.8	9	7.	38.	32.
351	26.1	60.8	310.3	1930.4	1872.5	10	7.	30.	24.
352	21.7	65.2	311.8	1837.7	1782.5	10	8.	26.	18.
353	32.7	88.4	308.2	2102.1	2039.0	10	10.	37.	28.
354	27.1	28.7	588.9	1744.0	1691.7	7	2.	28.	23.
355	33.1	64.3	501.7	1968.2	1909.1	8	7.	36.	28.
356	32.7	54.5	796.5	1759.0	1706.2	3	6.	34.	22.
357	41.7	84.1	660.5	2174.5	2109.3	6	9.	48.	26.
358	47.9	66.3	303.4	2542.7	2466.4	10	6.	53.	40.
359	37.2	85.6	415.4	2119.3	2055.7	9	9.	40.	34.
360	26.5	37.3	716.3	1657.8	1608.0	5	3.	27.	16.
361	33.2	40.7	309.4	2102.1	2039.0	10	3.	37.	32.
362	36.2	42.3	307.9	2153.4	2088.8	10	3.	39.	37.
363	40.0	34.0	417.9	2170.7	2105.6	9	2.	42.	37.
364	41.8	63.1	308.9	2313.7	2244.2	10	6.	45.	39.
365	43.1	64.5	417.9	2249.8	2182.3	9	6.	45.	41.

1974 CHARLESTON / SUTTON LAKE, W. VA. AIR & DEW = 2.5 DEG. F

MONTH	EQUILIBRIUM (DEG F)	SURFACE HEAT EXCHANGE (BTU/SQ FT/DAY/DEG F)	SHORT WAVE SOLAR (BTU/SQ FT/DAY)	SHORT WAVE SOLAR (LANGLEYS/DAY)
1	39.0	72.0	496.	135.
2	34.9	74.0	781.	212.
3	49.7	84.5	984.	267.
4	59.5	91.9	1436.	390.
5	69.3	91.9	1581.	429.
6	73.9	102.4	1740.	472.
7	81.5	86.7	1682.	456.
8	79.5	81.3	1395.	378.
9	66.8	76.7	1104.	300.
10	55.9	50.7	1019.	277.
11	41.8	66.5	648.	176.
12	32.3	56.5	460.	125.

A P P E N D I X B

THERMAL SIMULATION PROGRAM

722-F5-E1011

APPENDIX B

THERMAL SIMULATION PROGRAM

TABLE OF CONTENTS

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM	PROGRAM NO.
Thermal Simulation Program	722-F5-E-1011

PREPARING AGENCY Water Quality Section, Engineering Division, U.S.A.E.D. Baltimore District, P.O. Box 1715, Baltimore, Md. 21203

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM: PHASE	STATUS OF PROGRAM: STAGE
Earl E. Eiker Terry Clayton	June 1973	Revised	Nov. 1977

A. PURPOSE OF PROGRAM

To determine the annual temperature cycle of an impoundment by means of a mathematical accounting of the external and internal heat balance of the reservoir due to variations in inflow, outflow and heat transfer between the water surface and the atmosphere.

B. PROGRAM SPECIFICATIONS

1. Language - Fortran IV
2. Input - card only
3. Output - printer and punched card at users option
4. Size of Program - 30,000 words (approximately)
5. External Storage - none
6. Restrictions - none

C. METHODS

The one-dimensional partial differential equations describing the vertical variations in temperature within a reservoir are solved using numerical techniques.

D. EQUIPMENT DETAILS

Program is written for the Univac 1108 computer but can be adapted to any comparable system. Normal configuration of reader/punch and printer are required. Program is written for batch mode operation.

E. INPUT-OUTPUT

Input consists of the hydrologic, meteorologic and physical parameters unique to the site and year under study. Meteorologic input is developed by program no. 722-F5-E1010, "Heat Exchange Program."
Output consists of a daily summary of pertinent hydrologic, meteorologic and thermal data and vertical temperature structure of the reservoir at selected time intervals.

F. ADDITIONAL REMARKS

Complete documentation of this program is available from The Hydrologic Engineering Center. Source deck available upon request.

ENG FORM 2883 1 AUG 60 PREVIOUS EDITIONS ARE OBSOLETE.

APPENDIX B.2

THERMAL SIMULATION PROGRAM

DISCUSSION

The Thermal Simulation is divided into a main program and five subroutines as follows.

1. Main Program - The main program is used for assimilation of input and set up of the hydrologic, meteorologic and physical data required for the simulation. The main program acts as a control for the entire simulation. Computations are performed to establish the elevation-area and elevation-width relationships for the reservoir. Also, the short wave solar radiation distribution is calculated for each time step. All subroutines are called from the main program with the exception of subroutine WEIR.

2. Subroutine REG - This subroutine performs the day by day regulations of the reservoir in order to meet a specified downstream release temperature. Regulation is accomplished by an algorithm which scans existing temperature witin the lake and makes the selection of outlets to regulate. Regulation is made by using either one outlet, two adjacent outlets or an outlet and the flood control conduit. Maximum and minumum release capability of the selective withdrawal system and maximum capacity of each outlet are considered for regulation.

3. Subroutine EJM - This subroutine computes the inflow distribution, the outflow distribution and quantity of vertical flow generated by the inflow-outflow relationship. Outflow velocities for orifice type outlets are computed. If outflow from the reservoir is over a weir the actual velocities are computed by subroutine WEIR which is called from EJM.

4. Subroutine WEIR - This subroutine computes the outflow velocity distribution due to outflow over a weir. Weir flows are considered if ungated spillway flow occurs, if a skimmer weir is utilized as the top outlet or if the outlet being regulated is not completely submerged.

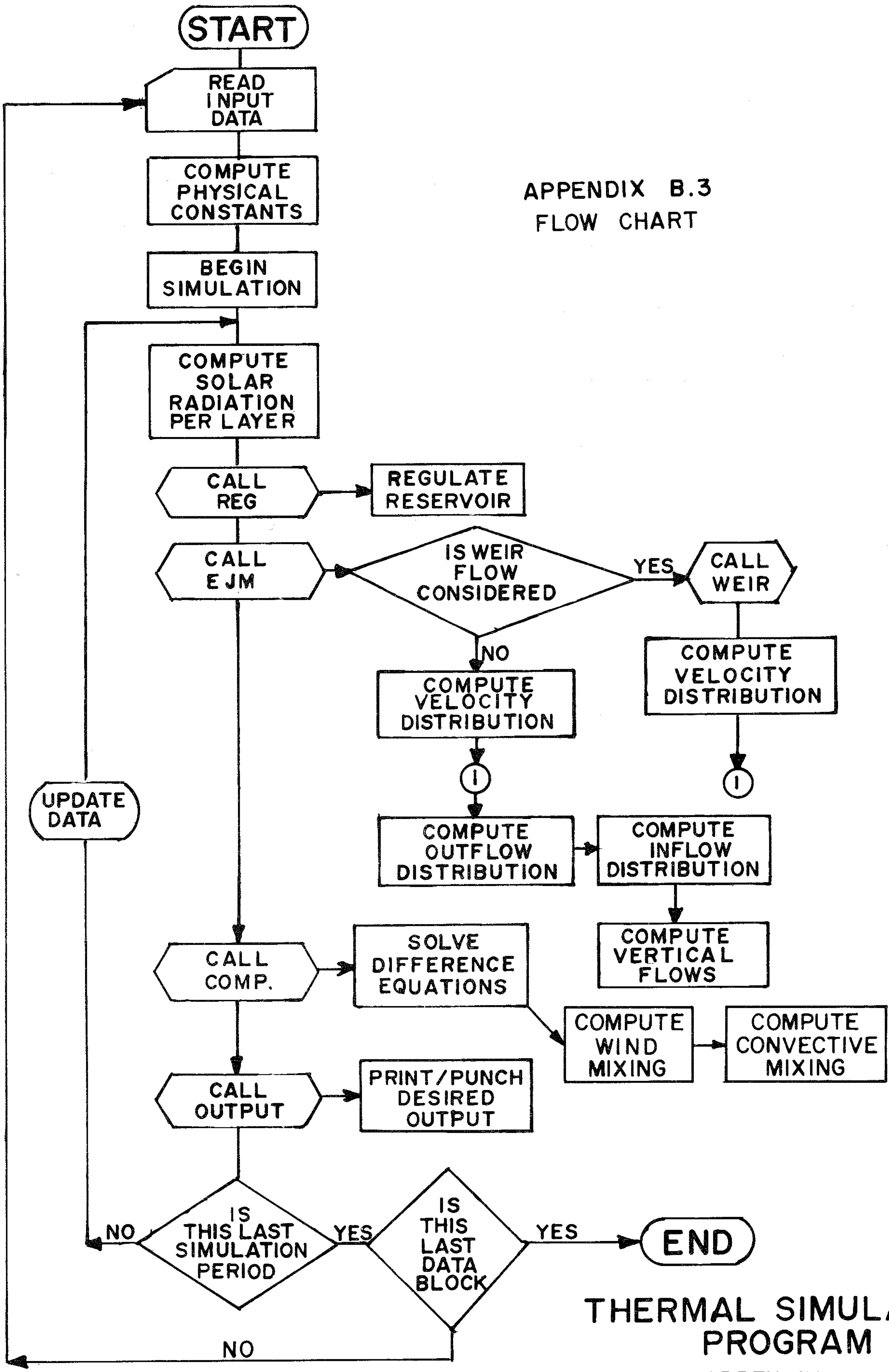
5. Subroutine COMP - This subroutine sets up and solves the simultaneous equations for each layer within the reservoir. After the temperature profile has been calculated wind stress is applied to the surface and mixing due to wind is computed. If an unstable profile exists at this point a convective mixing routine is performed to eliminate the unstable conditions.

6. Subroutine OUTPUT - This subroutine prints the daily summary table, the selected amplified output and the plot of the reservoir temperature profile. The frequency of the amplified and profile output are selected by the program user.

The major input parameters selected by the user are CDIFF, BETA, XNU, UPMIXand WCOEF. Final selection should be based on the model verification runs presented in Appendix C of this manual and comparisons of the simulation output with measured data available in the area under study. If enough data is available at a nearby impoundment a verification study should be made. The effect of every parameter change has a definite effect on the shape of the computed profiles. An increase in CDIFF will result in a smoother profile with a less clearly defined thermocline. An increase in BETA will result in a cooler epilimnium. An increase in XNU will result in a thinner epilimnion. An increase in UPMIX will result in a warmer metalimnion. An increase in WCOEF will result in a deeper epilimnion. Note that only one of the studies in Appendix C utilizes WCOEF. At present very little information is available to estimate this coefficient. It has been included in the model in anticipation of the completion of ongoing work at WES. In the meantime if the user desires to consider wind in the analysis a value of 1.0 should be used (0.0 will eliminate wind from the computations however wind data is still required as input).

If output is desired for use in graphical post-processor routines, tape 11 and tape 12 are formatted output tapes which can be saved for later processing.

APPENDIX B.3
FLOW CHART



THERMAL SIMULATION PROGRAM

APPENDIX B.3

Appendix B.4
THERMAL SIMULATION PROGRAM
DEFINITION OF VARIABLES

MAIN PROGRAM

Variables

A (100)	Planar areas at center of layer in ft^2.
AE (J)	Outlet area in S.F. (J-NOUTS).
AMP	Amplitude of daily variation in equilibrium temperature.
AR (100)	Planar areas at top of layers in ft^2.
AREA (K)	Area points, maximum K=100 (K=NAREA).
BETA	Amount of short wave radiation retained in top layer in percent/100.
BOTEL	Bottom elevation of reservoir in ft/sld.
CDIFF	Constant diffusion coefficient in ft^2/day.
CP	Specific heat of water - 1.0 BTU/ft^3/^oF.
CRSTEL	Spillway crest elevation in ft/sld.
CTEMP	Constant initial temperature of reservoir in ^oF.
DELZ	Thickness of top layer in ft.
DEL1	Thickness of top layer in ft.
DEPTH	Depth of water in ft.
DIFF (100)	Diffusion in ft^2/hr.
EKK (365)	Mean daily coefficient of surface heat exchange in BTU/ft^2/day.
EK (24)	Coefficient of surface heat exchange in BTU/ft^2/period.
EL (K)	Elevation Points, maximum K=100 (K=NAREA).
ELEV (100)	Average elevation of layers in ft/sld.
ETEM (365)	Mean daily equilibrium temperature in ^oF.
ETEMP (365)	Equilibrium temperature for simulation period in ^oF.
FLIN (3,365)	Mean daily inflows in cfs.
FLOT (365)	Mean daily inflows in cfs.
GAT (365)	Gate opening in ft. (controlled spillway) For an uncontrolled spillway - 0 = No spillway flow 1 = Spillway flow
GATOP (N)	Gate operation in ft. or whether or not spillway flow occurs.
GHT (J)	Port height in ft. (J=NOUTS).
GWT (J)	Port width in ft. (J=NOUTS).
HSN	Net short wave radiation in BTU/ft^2/period.
IDATA	Number of jobs to be run.
INPER	Counter for daily print cycle.
IPNCH	Set equal to 1 if punched card output. Set equal to 0 if no punched card output.
ITYPE	Set equal to 1 for uniform temperature conditions (initial). Set equal to 2 for variable initial temperature conditions.
JECHO	Set equal to 0 for no input data listing. Set equal to 1 if input data listing desired.
JJFMT	Set equal to 1 for hydrologic data in 8 F 10.2 format. Set equal to 2 for hydrologic data in USGS format.

JJGAT	Set equal to 0 if no GAT data furnished. Set equal to 1 if GAT data furnished.
JWEIR	Set equal to 0 if weir coef. claculated. Set equal to 1 if submerged weir flow coefficient to be used. Set equal to 2 if free weir flow coefficient to be used.
KDATA	Count of job being executed for multiple job runs.
KWEIR	Print control for type of weir flow.
LOL (J)	Layer number at center line of each outlet (J=NOUTS).
N	Counter of periods per day (24 maximum).
NAREA	Number of points on area - elevation table. (maximum - 100).
NDATA	Number of hydrologic data bits furnished.
NDAY	Counter of day number (365 - maximum).
NDDD	Counter of days between specified selected printout.
NDPN	Counter of days between selected printout.
NDPT	Frequency of selected printout in days, equals 0 if day numbers are specified.
NIFLO	Number of tributary inflows.
NL	Present period number of layers.
NLAST	Last day of simulation.
NLAY1	Number of layers on first day of simulation.
NLPNT	Frequency of vertical printout.
NNL	Previous period number of layers.
NOUTS	Number of outlets (Maximum = 16)
NPER	Number of periods - periods per day (Maximum = 24)
NPRE	Eq. 1 if multiple jobs change CDIFF, XNU, BETA, WCOEF and UPMIX Eq. 0 for complete data sets.
NSTRT	First day of simulation.
NDSEL (48)	Specified days for selected printout.
NSP	Equals 1 for controlled spillway, equals 2 for uncontrolled.
NWR	Equals 0 for orifice at top outlet, equals 1 for weir.
NVER	Equals 0 for simulation, 1 for verification.
OCAP	Maximum outlet capacity in cfs.
OMIN	Minumum flood control conduit outflow in cfs.
OTEMP (19)	Temperature at center line of each outlet in ^oF.
PCAP (J)	Maximum port capacity in cfs. (J-NOUTS)
PER	Number of periods per day (PER = NPER)
PFLOW(J)	Peak flow for hydropower generation in cfs.
PLEL (N)	Pool elevation in ft/sld per period.
QIN (N)	Inflow per period in cfs.
QOUT (N)	Outflow per period in cfs.
REW (K)	Reservoir width points, maximum K = 100 (K = NAREA).
RO	Specific weight of water 62.4 lb/ft^3.
ROW (I)	Reservoir widths at delz increments in ft.
SCAP	Selective withdrawal system capacity in cfs.
SFCE (365)	Mean daily pool elevation in ft/sld.
SMIN	Minimum selective withdrawal system release in cfs.
SPWTH	Effective spillway width in ft.
SRT (100)	Temperature rise due to S.W. radiation in each layer in ^oF.
SSW (365)	Daily total short wave radiation in $BTU/ft^2/day$.
SW (24)	Period total short wave radiation in $BTU/ft^2/period$.
TAR (365)	Mean daily target temperature in ^oF.

TARGET (N)	Target temperature per period in °F.
TEMP (100)	Present period temperature profile in °F.
TEMP1 (I)	Initial Temperature if variable in °F (I = NLAY1)
TFLI (3,365)	Mean daily inflow temperature in °F.
TIN (N)	Inflow temperature per period in °F.
TITLE (100)	Array of job titles (5 Cards).
TW	Reservoir width at spillway elevation in ft.
UPMIX	Inflow mixing coefficient
WCOEF	Wind speed coefficient - direct multiple of wind speed to account for effects of sheltering, fetch, water surface roughness, etc.
WIND (365)	Mean daily wind speed in mph.
WR (J)	Reservoir width at each outlet in ft. (J=NOUTS)
XNU	Light extinction coefficient in ft^{-1}.
XPER	Length of simulation period in hours.
XWIND	Average wind speed per period in mph.
YTEMP (100)	Previous period temperature profile in °F.
Z (100)	Distance from surface to bottom of layer in ft.
ZCLE (J)	Outlet centerline elevation in ft/sld (J=NOUTS).

WORKING VARIABLES

AFL, ARF, ATRY, HOLDB, HQ(200), IDON, IJJ, IKK, IKE, J, JCNT, JSTR, KA, KAR, KNL, KOEL, LN, LNL, LOC, LPER, M, MOO, NA, NAP, NAPT, NDDD, NDEL, NHL, NIFL, NIFP, NLR, NPSAV, NRISE, NSLC, SAAV, SLL, SUM, TOT, U(200), W, X, SDAY, XPSAV, XNL, ZAP, ZSOL

Subroutines called:

1. REG — Determines outlets to regulate temperature to meet downstream objectives.

2. EJM — Computes withdrawal zone thickness for an orifice outflow.

3. COMP — Solves simultaneous equations.

4. OUTPUT — Prints output.

5. WEIR — Computes withdrawal zone for outflow over a weir; called from EJM.

SUBROUTINE REG

Variables

DELT	Difference between TMIX and TARGET.
KOUT (2)	Number of outlets being regulated.
NNN	Number of outlets open.
NOO	Number of outlets open.
NOS	Number of outlets open.
NOUTS1	(NOUTS + 1) Outlet number assigned to spillway.
OFLOW	Outflow, conduit only, in cfs.
OTEM (19)	Temperature at center line of each outlet in ^{o}F.
QMIX (2)	Flow from each outlet in cfs.
QZZ (2)	Specified flow from each outlet in cfs.
SPILL	Spillway flow in cfs.
TMIX	Estimate of mixed temperature due to regulation of outlets in ^{o}F.

WORKING VARIABLES - REG

CHECK, KLAY, LO, LOO1, NLOO, NV, NVER, QT, QX1, QX2, XI, XX, YY.

SUBROUTINE EJM

Variables

AO	Area of orifice opening in s.f.
AV	Average velocity through orifice in ft/sec.
CREST	Elevation of top of weir in ft/sld.
CD	Coefficient of discharge for weir.
DOC	Vertical shift of the withdrawal limit in ft.
DRHOS1, DRHOS2	Density difference of fluid between the layers of the original withdrawal limit and the shifted withdrawal limit.
DRHOB	Density difference between orifice center line and bottom boundary of withdrawal zone.
DRHOS	Density difference between orifice center line and free surface.
DRHO1	Density difference between maximum velocity and local velocity in withdrawal layer.
DRHO1M	Density difference between max. velocity and lower limit of withdrawal zone.
DRHO2M	Density difference between max. velocity elevation and upper limit of withdrawal zone.
DRHO1P	Density difference between orifice center line and lower limit.
DRHO2P	Density difference between orifice center line and upper limit.
G	Acceleration due to gravity (32.2 ft/sec^2)
GBT	50% of the height of an orifice gate in ft.
H	Total thickness of withdrawal zone in ft.
HLIM	Vertical distance of overlap of velocity profiles in layers.
HOR	Vertical distance between orifice centerlines in layers.
HRATIO	Extent of overlap of the two withdrawal zones.
HTEST	Densimetric froude number.
HTRY	Densimetric froude number.
IADD	Number of layers inflow distribution is shifted.
LAYER	Layer with density corresponding to density of inflow.
LIL	Layer of lower limit of inflow distribution.
LIU	Layer of upper limit of inflow distribution.
NCLD	No. of layers from water surface to center line of orifice.
NHLIM	Vertical distance of overlap of velocity profiles in layers.
NHOR	Vertical distance between orifice centerlines in layers.
NOVER	Number of layers where outflow exceeds layer volume.
NWAT	Vertical shift of the withdrawal limit in layers.
NWHO	Vertical shift of the withdrawal limit in layers.
NZLL	Elevation of lower limit of withdrawal zone in ft/sld.
NZUL	Elevation of upper limit of withdrawal zone in ft/sld.
OVER	Quantity of outflow in excess of layer volumes.
PARAM (100)	Density array of the reservoir by layers.
PLA	Vertical distance from pool elevation to top of the orifice in ft.
POOL	Elevation of water surface in ft/sld.
Q	Total discharge through orifice in cfs.

QLAY	Layer inflow in ft^3/period.
QOUTL (365)	Array of discharge per layer in cfs.
QOT (2, 100)	Array of discharges for 2 outlets in cfs.
QVERT (100)	Array of discharges along vertical axis in cfs.
RHOO	Density at orifice center line elevation.
RHOS1 / RHOS2	Density of fluid at the layer of the original withdrawal limit.
RHOVM	Density at maximum elevation in the withdrawal zone.
RW	Width of reservoir in ft.
SQ	Total discharge for all ports open in cfs.
STAB	Stability of reservoir.
THD	Vertical dimension of inflow in layers.
THICK	Vertical dimension of inflow in ft.
VAVG	Average Velocity in any layer in ft/sec.
V (100)	Array of velocities in entire layer system in ft/sec.
V1 (100)	Array of velocities at any layer below max. velocity in ft/sec.
V2 (100)	Array of velocities at any layer above max. velocity in ft/sec.
VH1	Average velocity in the zone of overlap of the lower withdrawal zone in ft/sec.
VH2	Average velocity in the zone of overlap of the upper withdrawal zone in ft/sec.
VLAY	Layer volume in ft^3.
VRA1	The ratio of a local velocity to the max. velocity below the maximum velocity elev.
VRA2	The ratio of a local velocity to the max. velocity above the maximum velocity elev.
VV (2, 100)	Array of outflow velocity for two outlets in ft/sec.
WHAT	Vertical shift of the withdrawal limit in layers.
WHERE	Vertical shift of the withdrawal limit in layers.
WHO	Vertical shift of the withdrawal limit in ft.
WTEMP (100)	Previous period temperature plus solar radiation in ^oF.
XLW	Width of spillway or width of gate used as weir in ft.
XPL	Vertical distance from pool elev. to a point above the top of a gate.
ZB	Vertical distance from orifice center line to bottom boundary in ft.
ZCLO	Elevation of orifice center line in ft/sld.
ZDEL	The elev. of the max. velocity in withdrawal zone in layers.
ZMV	Elevation of max. velocity in withdrawal zone in ft.
ZS	Vertical distance from orifice center line to free surface in ft.
Z1H	Z1/H
Z1	Vertical distance from orifice to lower limit in ft.
Z2	Vertical distance from orifice to upper limit in ft.
ZONE	Vertical distance of overlap of velocity profiles in ft.

WORKING VARIABLES - EJM

ASQ, B, BIGED, BSQ, BTEST, BTRY, C, DELIN, DELQ, DISTR, DZ, FIFJ, ID, INEX, IS, JJ, K, KK, KR, K1, LIP, LL, L1, MEAN, ML,MLL, MUL, MMM, MMN, MN, NASQ, NBSQ, NH, NLL, NLL2, NNN, NOX, NUL, NULZ, NY1, NY1M, NYI, NZD, NZD1, NZMV, STEST, STRY, SUM, SUM1, SUM2, SUMIN, SUMIQ, SUMQ, TEST, TRY, VLAY, XD, XI, XLEFT, XML, XR, XRAT, XNH, XHY, Y1, Y2, Y1M, Y1MH, Y2M, YD1M, YD2M, YI, Z1LL, Z1LU, ZZLL, ZZLU.

SUBROUTINE WEIR

Variables

AW	Cross sectional area of flow over weir in ft^2.
DELD	Density difference between the crest of the weir and the lower limit of the withdrawal zone.
DEPL	The distance from the free surface to the lower limit of the withdrawal zone in layers.
DRHO	Density difference between the layer of maximum velocity and the corresponding layer of local velocity.
HW	The head on the weir or the depth of flow over the weir.
KWEIR	Equals 1 if submerged weir flow considered, equals 2 if free weir flow considered.
LVM	The layer number that contains the maximum velocity.
ML	The distance in layers from the weir crest to the lower limit of the withdrawal zone.
QW	Discharge over the weir.
RHOW	Density at the weir crest.
SUM1 (100)	The dimensionless velocity distribution for the portion below the maximum velocity.
SUM2 (100)	The dimensionless velocity distribution for the portion above the maximum velocity.
VM	The maximum velocity in the zone of withdrawal in ft/sec.
VW	The average velocity over the weir in ft/sec.
Y1F	The vertical distance in feet from the maximum velocity to the lower limit of the withdrawal zone.
Y2F	The vertical distance in feet from the maximum velocity to the upper limit in the withdrawal zone.
Y1L	The vertical distance in layers from the maximum velocity to the lower limit of the withdrawal zone.
ZO	The distance from the elevation of the weir crest to the lower limit of the withdrawal zone in feet.

WORKING VARIABLES - WEIR

BDFR, DEN, DENZ, DEPF, DEF, EXZ, LDEP, LL, LVM1, LY1F, NY1L, SAM, SAM1, SAM2, Y1, Y2, YS1

SUBROUTINE COMP

Variables

ALG 1 (100)	Computed coefficient for solution algorithm.
ALG 2 (100)	Computed coefficient for solution algorithm.
AVT	Average reservoir temperature in ^oF.
COEF (100, 3)	Matrix coefficients.
EKIN	Kinetic energy in wind mixing computation.
EPOT	Potential energy in wind mixing computation.
FORCE (100)	Computed values for right side of difference equations.
MIX1	Mixing depth for epilimnion in layers.
MIX2	Mixing depth for hypolimion in layers.
MIX3	No. layers to be mixed internally to produce stable profile.
QHEAT	Temperature rise of reservoir due to advection in ^oF.
SHEAR	Shear stress on surface due to wind.
SHEAT	Temperature rise of reservoir due to surface heating in ^oF.
SHVEL	Shear velocity on surface due to wind.
SUMV	Reservoir volume in ft^3.
TOUT	Outflow temperature in ^oF.
TSURF	Surface temperature in ^oF.
YAVT	Average reservoir temperature for previous time period in ^oF.

WORKING VARIABLES - COMP

CNTR, D, DEN1, DEN2, DIST, ETE, HOLDL, HOLDU, K, KFLAG, KL, KLOOP, KN, KNL, LM, LN, LNM, M, QVBOT, QVL, QVTOP, QVU, SMT, SUMVT, T1, T2, TEMPL, TEMPU, TFN, TMPMX, V2, VLA, VLEFT, VO, VO1, VOLL, VOLU, W1, XI, ZD

SUBROUTINE OUTPUT

Variables

PLOT (71)	Variable in plot routine.
SAVE (71)	Variable in plot routine.
B(100)	Layer areas in AC-FT.

WORKING VARIABLES - OUTPUT

ITP, KPLOT, KXX, LINES, LN, LNP, NN, NOU, NTO, SCALE

APPENDIX B.5
THERMAL SIMULATION PROGRAM
Input Description

Card No.

1 FORMAT (I10) No. jobs to be run.

2 FORMAT (20A4) Job title - five cards.

CODE INPUT

3 FORMAT (8I10)

1. NSTRT - 1st day of simulation. Usually in the spring; about 90.
2. NLAST - Last day of simulation. Usually in the fall; about 300.
3. NOUTS - Number of outlets for selective withdrawal (max. 16)
4. NAREA - Number pts. furnished for elev., area, width curves.
5. NDPT - Number days between profile output (0 if day numbers specified by card no. 16)
6. NLPNT - Vertical frequency of profile output. Usually one.
7. IPNCH - Equals 1 for punched card output, equals zero otherwise. Usually zero.
8. NPRE - Equals 1 for data change of CDIFF, XNU, BETA, UPMIX and WCOEF for additional job runs, equals 0 if additional data is read in complete sets. If 1 is used, on the next job following cards 22 read 5 title cards and 1 card with CDIFF, XNU, BETA, UPMIX, WCOEFF (5F10.2)

4 FORMAT (8I10)

1. NLAY1 - Number layers 1st day of simulation. The top layer will always be greater than or equal to 2 feet.
2. ITYPE - Equals 2 for variable initial temperature condition, equals 1 otherwise.
3. NPER - Number periods per day. Usually one.
4. NDATA - Number hydrologic & meteorologic data points. furnished. Usually 365.
5. NSP - Code to describe spillway, 1 for controlled, 2 for uncontrolled. Defines type of flow; tainter gate is treated like an orfice flow.

6. NWR - Code to describe top outlet, 1 for weir, 0 for orifice. (Spillway is not defined as an outlet).
7. NVER - Equals 1 for verification, equals 0 for simulation. This value controls the input of card 22.
8. NIFLO - Number of tributary inflows. At least one is is required. (maximum of 3 tributaries)

5 FORMAT (4I10)

1. JJGAT - Equals 1 if card 12 included, equals 0 otherwise.
2. JJFMT - Equals 1 for 8F10.2 format, equals 2 for USGS format on cards 8-13
3. JECHO - Equals 1 if input data listing desired, equals 0 otherwise.
4. JWEIR - Code to describe weir coefficient, equals 0 for computed, 1 for submerged, 2 for free weir flow.

PHYSICAL INPUT

6 FORMAT (8F10.5)

1. XPER - Length of one time period in hrs. Usually 24.
2. DELZ - Depth of one layer in ft.
3. BOTEL - Bottom elevation of reservoir in feet above sea level.
4. XNU* - Light extinction coefficient in $ft.^{-1}$
5. BETA* - Fraction of SW RAD placed in top layer. BETA at 2 feet.
6. TW - Effective reservoir width at spillway crest in ft.
7. CDIFF* - Diffusion coefficient in ft^2/day.
8. CTEMP - Initial reservoir temperature if constant in °F. Only used if ITYPE=1.

7 FORMAT (8F10.2)

1. CRSTEL - Spillway crest elevation in feet above sea level.
2. SPWTH - Effective spillway width in ft. Subtract for pier width.
3. OCAP - Outlet works capacity (max) for flood control in cfs. This is the bottom outlet.
4. SCAP - Selective withdrawal system capacity (max.) in cfs.
5. OMIN - Minimum flood control conduit release in cfs.
6. SMIN - Minimum selective withdrawal system release in cfs.

7. UPMIX*+ - Inflow mixing coefficient indicating quantity of top layer water to be entrained (e.g. if UPMIX equals 0.5 a quantity of water equal to 1/2 the inflow volume will be withdrawn from the top layer and mixed with the inflow)

8. WCOEF*+ - Coefficient to modify wind speed to account for fetch, sheltering, over water effects, etc.

* Several values derived in field office application are shown in Appendix C.8.

\+ Use zero if this value is not to be considered in the calculation.

HYDROLOGIC INPUT

8-13	FORMAT (8F10.2) or (15X, 8F7.0, 9X) - Defined on Card 5; JJFMT	
8	FLIN (NIFLO, NDATA)	- inflows beginning Jan. 1 (daily) in cfs.
9	TFLI (NIFLO, NDATA)	- inflow temperature in °F.
10	FLOT (NDATA)	- outflows in cfs.
11	TAR (NDATA)	- outflow temperatures in °F.
12	GAT (NDATA) (Optional)	- spillway operations, a positive value indicates spillway flow, a 0.0 indicates no spillway flow for day, if spillway is gated, positive value should be gate opening in ft. (include only if JJGAT equals 1 on card 5)
13	SFCE (NDATA)	- pool elevations in ft. above sea level.

Note: Cards 8-13 are read in complete sets.
Cards 8-9 are repeated for each tributary inflow.

RESERVOIR GEOMETRY - Not necessarily at the top of each layer. These cards are input from the ground elevation to the highest water surface expected.

14 FORMAT (3F10.2) Note: 1 card for each point

EL (NAREA) - Elevation of area with width pts. in feet feet above sea level.
AREA (NAREA) - Surface area at EL in acres Should not be zero.
REW (NAREA) - Effective reservoir width at EL in ft.

OUTLET DESCRIPTION - These cards are input from the lowest outlet first to the highest outlet.

15 FORMAT (6F10.2) Note: 1 card for each outlet (max. 16)

ZCLE (NOUTS) - Elevation center line of outlet in ft. above sea level or invert of weir if top oulet is an overflow weir.
AE (NOUTS) - Area of outlet in ft^2.
GHT (NOUTS) - Height of outlet in ft.

GWT (NOUTS) - Width of outlet in ft.
WR (NOUTS) - Reservoir width at center line of outlet in ft.
PCAP (NOUTS) - Maximum Port capacity in cfs.
PFLOW(NOUTS) - Peak flow in cfs occuring during hydropower generation. If this value is positive, it will define the reservoir withdrawal zone. If this value is blank or zero, the withdrawal zone is defined by the flow data on either card 10 or 22.

SPECIFIED DAYS FOR SELECTED PRINTOUT (OPTIONAL)

16 FORMAT (16I5)

NDSEL (48) - Julian day numbers for selected output.

Note: 3 cards always needed with last specified day always equal to day number 365. Set NDPT=0 on card 3 if card 16 is used.

INITIAL TEMPERATURE

17 FORMAT (8F10.2)

TEMP1 (NLAY 1)- Initial temperature values for each layer in °F. (Read from bottom to top)

Note: Card 17 to be deleted for isothermal initial condition (i.e., ITYPE=1)

METEOROLOGICAL INPUT

18	FORMAT (16F5.1)	
	ETEMP (NDATA)	- Equilibrium Temperatures in °F.
19	FORMAT (16F5.1)	
	EKK (NDATA)	- Surface heat exchange coefficients in BTU/ ft^2/day.
20	FORMAT (16F5.1)	
	XWIND (NDATA)	- mean daily wind speed in mph.
21	FORMAT (10F8.1)	
	SSW (NDATA)	- Short wave solar radiation in BTU/ft^2/period.

Note: Cards 18, 19, 20 and 21 are output from HEAT EXCHANGE PROGRAM.

STIPULATED OUTFLOWS - Omit these cards if NVER=0.

22	FORMAT (16F5.0)	
	QZZ (NOUTS)	- Outflow for each outlet (one card per day) in cfs. First card is for first day of verification (i.e., NSTRT).

Note: Card 22 for verification runs for daily time periods only. Outlets are numbered from bottom to top with discharge from outlet no. 1 placed in first 5 column field. If less than 16 outlets are specified only that number (NOUTS) of columns are used.

APPENDIX B.6

THERMAL SIMULATION PROGRAM INPUT SET UP

1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
IDATA							
TITLE(100)		(5 CARDS)					
NSTRT	NLAST	NØUTS	NAREA	NDPT	NLPNT	IPNCH	NPRE
NLAYI	ITYPE	NPER	NDATA	NSP	NWR	NVER	NIFLØ
JJ6AT	JJFMT	JECHO	JWEIR				
XPER	DELZ	BØTEL	XNU	BETA	TW	CDIFF	CTEMP
CRSTEL	SPWTH	ØCAP	SCAP	ØMIN	SMIN	UPMIX	WCOEF
FLIN(3,365)							
TFLI(3,365)							
FLØT(365)							
TAR(365)							
GAT(365)							
SFCE(365)							
EL(100)	AREA(100)	REW(100)					
ZCLE(16)	AE(16)	GHT(16)	GWT(16)	WR(16)	PCAP(16)		
NDSEL(48)							
TEMPI(100)							
ETEMP(365)							
EKK(365)							
XWIND(365)							
SSW(365)							
QZZ(16)							

APPENDIX B.7

THERMAL SIMULATION PROGRAM

SAMPLE INPUT

Card	Line								
1	1	1							
2	2	POMMEI DE TERREI							
	3	VERIFICATION STUDY							
	4	CALENDAR YEAR 1970							
	5	K.C.							
	6	AEV # 0.0 BEV # 289.0							
3	7	151	334	1	59	0	1	0	0
4	8	29	2	1	365	2	0	0	1
5	9	1	1						
6	10	24.	3.0	750.	0.15	0.8	10965.	.13	0.0
7	11	874.	180.	999999.	999999.	0.0	0.0	1.0	1.75
8	12	150.	150.	150.	150.	150.	150.	150.	100.
	13	100.	100.	100.	100.	100.	100.	100.	100.
	14	200.	300.	200.	300.	200.	150.	150.	150.
	15	250.	450.	400.	350.	350.	350.	250.	200.
	16	250.	200.	200.	200.	200.	200.	200.	150.
	17	150.	150.	100.	100.	100.	100.	100.	110.
	18	110.	115.	115.	115.	115.	155.	115.	115.
	19	150.	150.	125.	210.	760.	1160.	710.	510.
	20	450.	385.	360.	235.	235.	260.	410.	310.
	21	310.	335.	335.	710.	560.	910.	3160.	2290.
	22	1710.	1250.	1060.	840.	840.	720.	570.	560.
	23	535.	535.	510.	1010.	810.	600.	570.	510.
	24	430.	430.	370.	350.	350.	290.	260.	240.
	25	235.	215.	300.	260.	2380.	1340.	640.	470.
	26	365.	4400.	885.	530.	410.	1115.	610.	5550.
	27	35450.	10900.	2000.	1200.	500.	460.	240.	320.
	28	200.	200.	500.	330.	180.	320.	1400.	1000.
	29	550.	400.	300.	270.	270.	170.	120.	170.
	30	170.	130.	110.	90.	90.	240.	150.	110.
	31	350.	410.	170.	150.	135.	120.	80.	80.
	32	75.	75.	250.	200.	190.	150.	190.	100.
	33	100.	560.	550.	300.	200.	170.	70.	60.
	34	60.	60.	60.	60.	60.	50.	40.	30.
	35	20.	20.	20.	20.	15.	15.	15.	15.
	36	155.	80.	70.	60.	50.	20.	15.	10.
	37	10.	10.	10.	10.	10.	10.	10.	10.
	38	20.	40.	40.	40.	160.	100.	40.	20.
	39	20.	15.	260.	25.	15.	10.	10.	10.
	40	10.	10.	10.	10.	10.	10.	10.	10.
	41	10.	10.	10.	10.	10.	10.	10.	10.
	42	10.	10.	10.	20.	30.	330.	260.	315.
	43	870.	220.	390.	2320.	800.	250.	200.	80.
	44	700.	250.	270.	200.	860.	760.	310.	280.
	45	150.	4050.	7670.	2670.	760.	700.	550.	480.
	46	440.	430.	400.	280.	150.	130.	230.	200.
	47	110.	5125.	5900.	1100.	750.	350.	460.	1470.
	48	680.	580.	400.	330.	370.	330.	240.	220.
	49	325.	320.	270.	2650.	4320.	1850.	890.	660.
	50	570.	550.	420.	380.	320.	350.	250.	240.
	51	1400.	950.	650.	550.	500.	500.	500.	400.
	52	400.	380.	370.	560.	300.	300.	300.	300.
	53	250.	200.	200.	190.	190.	190.	190.	190.

54	190.	190.	150.	140.	130.	130.	130.	130.
55	130.	120.	120.	120.	110.	350.	310.	260.
56	210.	210.	410.	560.	510.	510.	300.	300.
57	250.	240.	230.	230.	400.			
58	45.95	41.41	37.92	38.07	38.89	37.43	33.40	32.00
59	32.00	32.00	38.29	40.36	43.61	43.68	45.63	48.97
60	47.13	41.62	33.89	32.00	32.00	34.42	37.60	44.94
61								
62	51.05	53.53	55.78	56.41	52.94	52.09	47.54	49.31
63	47.34	41.59	40.40	42.40	48.08	51.98	49.76	49.29
64	47.47	44.72	46.56	43.60	43.11	41.32	41.55	46.32
65	48.87	49.59	45.45	45.49	49.17	53.23	53.82	50.09
66	49.28	49.44	52.89	57.86	58.96	61.06	59.48	56.04
67	53.94	53.59	53.99	55.47	53.67	50.51	45.17	41.65
68	41.61	41.01	42.83	43.52	45.44	45.01	44.96	43.44
69	42.84	44.18	48.06	49.89	50.86	49.94	48.22	48.25
70	55.66	61.05	60.53	62.45	60.81	63.19	60.06	58.66
71	57.03	60.11	63.85	64.70	62.61	60.49	58.45	62.28
72	61.02	61.32	60.56	62.69	66.07	67.49	70.71	67.39
73	60.96	56.18	53.71	56.30	60.27	62.54	65.20	65.72
74	65.87	66.73	68.29	69.66	71.61	71.35	67.13	62.37
75	60.22	62.76	64.53	68.18	69.49	70.87	71.81	72.03
76	70.27	67.86	66.79	69.21	71.36	72.63	72.43	70.70
77	68.96	65.72	65.20	65.63	67.10	67.74	69.08	70.14
78	78.00	75.41	73.44	71.40	70.95	70.07	72.49	74.30
79	72.18	72.85	73.17	75.31	76.49	78.59	78.11	78.51
80	75.14	72.74	72.95	73.91	76.22	79.11	79.55	79.10
81	75.50	72.77	69.71	72.17	75.06	76.05	75.99	74.13
82	74.72	75.98	76.68	76.25	74.89	75.12	75.37	78.33
83	73.03	71.22	65.96	68.55	70.83	73.54	75.11	76.64
84	76.40	78.18	77.81	79.87	78.96	80.12	79.99	80.74
85	80.62	79.96	79.29	80.01	78.65	78.34	74.17	73.23
86	71.98	74.14	76.14	78.14	79.25	79.96	79.95	79.29
87	77.73	73.22	73.88	71.52	70.81	70.73	72.45	74.22
88	75.83	77.40	78.18	78.63	76.73	75.71	73.29	75.43
89	75.64	78.67	76.26	77.16	72.56	70.97	69.26	70.50
90	73.73	74.31	76.86	76.80	74.28	73.42	74.57	76.19
91	76.08	72.06	68.64	67.79	64.90	64.86	61.19	63.79
92	65.64	67.46	69.33	67.29	66.49	65.25	65.18	68.40
93	65.24	58.93	52.68	51.91	56.80	59.63	59.21	57.47
94	55.00	53.66	53.69	55.81	57.17	59.69	61.14	61.73
95	62.56	62.83	64.09	60.31	56.91	53.52	54.15	53.55
96	54.31	50.15	47.82	47.08	48.62	51.26	54.56	58.10
97	57.18	56.28	53.78	52.13	51.31	49.16	47.05	46.31
98	46.79	50.67	53.30	53.03	54.79	51.67	47.03	40.90
99	40.57	48.47	54.91	57.72	58.00	60.56	62.18	62.50
100	59.86	57.54	55.47	50.10	49.63	50.83	54.99	59.03
101	56.29	52.13	45.53	46.47	49.69	49.30	51.08	52.88
102	52.07	51.12	47.66	51.75	51.83	49.91	42.68	41.77
103	42.81	46.26	47.96	48.75	47.96			
104	100.	100.	100.	100.	100.	100.	100.	100.
105	100.	100.	100.	100.	100.	100.	100.	100.
106	100.	100.	100.	100.	100.	100.	100.	100.
107	100.	100.	300.	400.	400.	400.	400.	400.

9

Group									
10	108	400.	400.	400.	400.	400.	400.	400.	400.
	109	150.	100.	100.	100.	100.	100.	100.	100.
	110	100.	100.	100.	100.	100.	100.	100.	100.
	111	100.	100.	100.	100.	100.	100.	100.	100.
	112	100.	625.	700.	700.	700.	700.	700.	700.
	113	500.	400.	400.	400.	400.	400.	400.	1180.
	114	1500.	1500.	1500.	1500.	1310.	1500.	1170.	1000.
	115	1000.	1000.	1000.	1000.	1000.	554.	500.	500.
	116	500.	500.	310.	250.	150.	100.	100.	100.
	117	100.	100.	100.	100.	100.	100.	100.	100.
	118	100.	475.	600.	600.	600.	600.	600.	600.
	119	600.	600.	600.	600.	600.	5525.	5800.	5800.
	120	4800.	4800.	4800.	4600.	4800.	4700.	4700.	4600.
	121	4500.	4400.	1483.	500.	500.	500.	250.	200.
	122	200.	200.	200.	138.	100.	100.	100.	100.
	123	100.	100.	100.	100.	100.	100.	100.	100.
	124	100.	100.	100.	100.	100.	100.	100.	100.
	125	100.	100.	100.	100.	100.	100.	100.	170.
	126	200.	200.	200.	200.	60.	25.	25.	25.
	127	25.	25.	25.	25.	25.	25.	25.	25.
	128	25.	25.	25.	25.	25.	25.	25.	25.
	129	25.	25.	25.	25.	25.	25.	25.	25.
	130	25.	25.	25.	25.	25.	25.	25.	25.
	131	25.	25.	25.	25.	25.	25.	25.	25.
	132	25.	25.	25.	25.	25.	25.	25.	25.
	133	25.	25.	25.	25.	25.	25.	25.	25.
	134	25.	25.	25.	25.	25.	25.	25.	25.
	135	25.	25.	25.	25.	25.	25.	25.	25.
	136	25.	25.	25.	25.	25.	342.	500.	500.
	137	500.	500.	500.	500.	833.	2830.	3000.	3000.
	138	3000.	3000.	2330.	580.	500.	500.	140.	25.
	139	25.	25.	25.	25.	25.	1500.	3500.	3500.
	140	3500.	2500.	1000.	1000.	1000.	656.	100.	100.
	141	100.	100.	100.	233.	300.	1490.	2000.	2000.
	142	2000.	2000.	2000.	783.	100.	100.	260.	300.
	143	300.	766.	1000.	1000.	1000.	580.	500.	500.
	144	500.	500.	300.	260.	260.	250.	260.	260.
	145	260.	260.	260.	186.	150.	150.	150.	150.
	146	150.	150.	150.	150.	150.	150.	105.	100.
	147	100.	100.	100.	100.	100.	100.	100.	100.
	148	100.	100.	100.	100.	100.	100.	275.	300.
	149	300.	300.	300.	300.	300.			
11	150	40.	40.	40.	40.	40.	40.	40.	40.
	151	40.	40.	40.	40.	40.	40.	40.	40.
	152	40.	40.	40.	40.	40.	40.	40.	40.
	153	40.	40.	40.	40.	40.	40.	40.	40.
	154	40.	40.	40.	40.	40.	40.	40.	40.
	155	40.	40.	40.	40.	40.	40.	40.	40.
	156	40.	40.	40.	40.	40.	40.	40.	40.
	157	40.2	40.4	40.5	40.7	40.9	41.1	41.3	41.4
	158	41.6	41.9	42.2	42.5	42.8	43.1	43.4	43.7
	159	44.0	44.3	44.7	45.0	45.3	45.6	46.0	46.3
	160	46.6	46.9	47.3	47.6	48.0	48.3	49.6	49.9
	161	49.3	49.6	50.0	50.3	50.6	50.9	51.3	51.6

11	152	51.9	52.2	52.6	52.9	53.2	53.5	53.9	54.2
	163	54.5	54.8	55.0	55.3	55.6	55.8	56.1	56.3
	164	56.6	57.0	57.3	57.7	58.0	58.4	58.7	59.1
	165	59.4	59.7	60.0	60.3	60.7	61.0	61.3	61.6
	166	61.9	62.2	62.4	62.7	62.9	63.2	63.4	63.7
	167	63.9	64.2	64.5	64.7	65.0	65.3	65.5	65.8
	168	66.1	66.3	66.6	66.8	67.1	67.3	67.5	67.8
	169	68.0	68.2	68.5	68.7	68.9	69.1	69.4	69.6
	170	69.9	70.1	70.3	70.5	70.8	71.0	71.2	71.4
	171	71.6	71.8	72.0	72.2	72.4	72.6	72.8	73.0
	172	73.2	73.4	73.7	73.9	74.1	74.3	74.6	74.8
	173	74.7	74.9	75.0	75.2	75.3	75.5	75.6	75.8
	174	75.9	76.0	76.1	76.2	76.4	76.5	76.6	76.7
	175	76.8	76.9	77.0	77.1	77.2	77.3	77.4	77.4
	176	77.5	77.5	77.4	77.4	77.4	77.3	77.3	77.3
	177	77.3	77.2	77.1	76.9	76.8	76.7	76.6	76.4
	178	76.3	76.1	75.8	75.6	75.3	75.1	74.8	74.6
	179	74.3	73.9	73.6	73.2	72.8	72.4	72.1	71.7
	180	71.3	70.9	70.6	70.2	69.9	69.5	69.1	68.8
	181	68.2	67.8	67.5	67.2	66.9	66.5	66.2	65.8
	182	65.5	65.1	64.8	64.4	64.0	63.6	63.3	62.9
	183	62.5	62.2	61.8	61.5	61.2	60.8	60.5	60.1
	184	59.8	59.5	59.2	58.9	58.6	58.2	57.9	57.6
	185	57.3	57.0	56.7	56.4	56.2	55.9	55.6	55.8
	186	55.0	54.7	54.4	54.1	53.8	53.4	53.1	52.8
	187	52.5	52.2	51.8	51.5	51.2	50.8	50.5	50.1
	188	49.8	49.5	49.2	48.8	48.5	48.2	47.9	47.5
	189	47.2	46.8	46.5	46.1	45.8	45.4	45.0	44.7
	190	44.3	44.0	43.6	43.3	43.0	42.6	42.3	41.9
	191	41.6	41.4	41.3	41.1	41.0	40.8	40.6	40.5
	192	40.3	40.3	40.2	40.2	40.2	40.1	40.1	40.0
	193	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	194	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	195	40.0	40.0	40.0	40.0	40.0	40.0		
12	196								
	197								
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	237								
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	239								
	240								
	241								
13	242	839.07	839.09	839.10	839.11	839.12	839.14	839.14	839.15
	243	839.14	839.13	839.13	839.13	839.14	839.14	839.14	839.15
	244	839.17	839.23	839.25	839.29	839.31	839.33	839.35	839.36
	245	839.40	839.48	839.51	839.50	839.50	839.47	839.43	839.38
	246	839.34	839.29	839.24	839.18	839.13	839.07	839.03	838.95
	247	838.95	838.96	838.98	838.97	838.98	838.98	838.99	838.99
	248	838.99	838.98	838.99	838.99	838.99	839.01	839.02	839.01
	249	839.04	839.02	839.03	839.05	839.23	839.49	839.63	839.74
	250	839.82	839.76	839.67	839.55	839.43	839.32	839.24	839.15
	251	839.09	839.06	839.06	839.13	839.17	839.29	839.98	840.26
	252	840.30	840.24	840.13	839.96	839.84	839.65	839.50	839.38
	253	839.26	839.15	839.02	839.02	838.97	838.97	838.98	838.97
	254	838.93	838.90	838.90	838.92	838.95	838.97	839.02	839.02
	255	839.05	839.07	839.11	839.13	839.70	839.99	840.12	840.20
	256	840.25	841.21	841.27	841.26	841.20	841.31	841.30	842.48
	257	850.02	852.02	852.28	852.39	852.44	851.37	850.26	849.23
	258	848.15	847.21	846.29	845.33	844.28	843.27	842.50	841.66
	259	840.66	839.57	839.35	839.27	839.19	839.09	839.05	839.03
	260	839.01	838.98	838.94	838.91	838.89	838.92	838.91	838.90
	261	838.96	839.04	839.05	839.06	839.06	839.05	839.03	839.00
	262	838.99	838.96	838.98	838.99	839.00	839.01	838.99	839.00
	263	838.97	839.09	839.19	839.23	839.25	839.25	839.23	839.20
	264	839.15	839.09	839.04	838.98	838.96	838.95	838.94	838.93
	265	838.91	838.88	838.85	838.83	838.81	838.79	838.77	838.75
	266	838.77	838.77	838.76	838.73	838.73	838.71	838.69	838.67
	267	838.63	838.61	838.58	838.55	838.53	838.51	838.49	838.47
	268	838.46	838.44	838.42	838.40	838.41	838.41	838.39	838.37
	269	838.35	838.32	838.36	838.35	838.34	838.32	838.30	838.28

13	270	838.27	838.24	838.22	838.20	838.18	838.19	838.14	838.11
	271	838.09	838.07	838.05	838.02	838.00	837.98	837.95	837.93
	272	837.91	837.89	837.87	837.86	837.85	837.92	837.97	838.04
	273	838.25	838.27	838.35	838.93	839.09	839.14	839.17	839.17
	274	839.34	839.39	839.44	839.48	839.68	839.78	839.73	839.66
	275	839.56	840.44	842.16	842.66	842.64	842.13	841.53	840.92
	276	840.28	839.62	839.15	839.06	838.96	838.83	838.86	838.90
	277	838.91	840.19	841.88	842.11	842.27	842.00	841.27	840.77
	278	840.05	839.58	839.43	839.26	839.09	839.00	839.03	839.05
	279	839.10	839.16	839.20	839.79	840.78	840.86	840.59	840.26
	280	839.90	839.52	839.11	839.03	839.08	839.14	839.13	839.11
	281	839.39	839.43	839.34	839.22	839.08	839.02	839.01	839.03
	282	839.00	838.97	838.98	839.05	839.06	839.05	839.07	839.05
	283	839.05	839.02	839.00	838.98	838.99	839.01	839.02	839.03
	284	839.07	839.04	839.03	839.02	839.02	839.00	838.99	839.00
	285	839.03	839.02	839.03	839.04	839.04	839.11	839.16	839.19
	286	839.22	839.23	839.32	839.43	839.54	839.63	839.63	839.63
	287	839.61	839.60	839.58	839.36	839.38			
14	288	750.	0.0	0.0					
	289	750.5	6.	10.					
	290	751.	12.	25.					
	291	752.	24.	75.					
	292	753.	36.	125.					
	293	754.	48.	126.					
	294	755.	60.	130.					
	295	756.	72.	135.					
	296	757.	84.	140.					
	297	758.	96.	152.					
	298	759.	108.	158.					
	299	760.	120.	165.					
	300	761.	130.	210.					
	301	762.	180.	225.					
	302	763.	210.	230.					
	303	764.	240.	235.					
	304	766.	300.	415.					
	305	768.	360.	925.					
	306	770.	420.	1700.					
	307	772.	506.	1705.					
	308	774.	592.	1890.					
	309	776.	678.	2050.					
	310	778.	764.	2063.					
	311	780.	850.	2080.					
	312	782.	975.	2090.					
	313	784.	1134.	2145.					
	314	786.	1323.	2215.					
	315	788.	1512.	2465.					
	316	790.	1700.	2590.					
	317	792.	1922.	2680.					
	318	794.	2144.0	2890.					
	319	796.	2366.	2975.					
	320	798.	2588.	3055.					
	321	800.	2810.	3115.					
	322	803.	3092.	3245.					
	323	805.	3374.	3440.					

14	*24	309.		3656.		3550.											
	*25	312.		3998.		3770.											
	*26	315.		4345.		4155.											
	*27	318.		4702.		4885.											
	*28	321.		5092.		5625.											
	*29	324.		5520.		6400.											
	*30	327.		5955.		8370.											
	*31	330.		6390.		8670											
	*32	333.		6867.		8925.											
	*33	336.		7344.		9135.											
	*34	339.		7820.		9265.											
	*35	342.		8420.		9425.											
	*36	345.		9050.		9570.											
	*37	348.		9680.		9700.											
	*38	351.		10321.		9810.											
	*39	354.		10984.		9970.											
	*40	357.		11647.		10245.											
	*41	360.		12310.		10460.											
	*42	364.		13354.		10650.											
	*43	368.		14398.		10770.											
	*44	372.		15510.		10860.											
	*45	376.		16667.		11070.											
	*46	378.5		17374.		11130.											
15	*47	758.2		214.		16.		13,375		153.							
16	*48	161	199	201	221	241	260	273	281	301	334	365					
	*49																
	*50																
17	*50.2		52.0		52.0		52.0		52.0		52.2		52.5		52.8		53.1
	*50.3		53.4		53.8		54.3		54.9		55.6		56.5		57.4		58.2
	*50.4		59.1		60.0		61.3		63.3		66.0		69.8		74.3		75.0
	*50.5		75.3		75.7		75.9		76.2		76.5						
18	*55	25.7	16.9	19.9	27.4	21.0	10.3	7.8	3.7	15.8	13.8	28.8	25.1	28.6	32.1	38.7	42.4
	*56	24.7	7.0	2.2	10.2	3.9	19.9	30.0	41.6	49.6	44.4	45.1	52.2	32.7	35.2	37.9	37.6
	*57	21.2	18.6	30.2	44.8	36.0	47.0	35.6	28.2	43.0	28.2	36.1	27.2	26.2	22.1	39.0	48.3
	*58	41.0	31.3	39.2	46.8	42.8	44.3	46.7	34.0	41.0	52.8	46.7	52.8	58.5	56.5	46.8	47.8
	*59	48.7	44.4	55.7	53.1	35.4	30.9	28.4	35.7	39.7	34.5	31.6	33.1	36.9	37.7	33.6	35.1
	*60	39.6	42.7	48.8	44.6	42.0	50.2	38.5	38.4	43.3	45.5	44.5	49.2	57.6	40.7	54.0	61.6
	*61	59.8	60.3	55.8	64.4	65.0	60.4	44.3	55.4	56.1	64.9	62.9	64.4	54.9	59.0	64.3	64.7
	*62	54.6	65.5	61.9	72.4	73.6	74.0	72.1	65.4	55.4	69.6	69.6	72.3	73.7	73.6	68.8	68.6
	*63	64.9	74.3	76.0	75.6	75.5	73.7	61.1	69.0	73.7	76.3	77.2	77.7	78.4	75.5	78.7	79.8
	*64	72.3	80.2	67.9	75.9	72.4	75.6	76.8	70.4	67.9	71.6	67.2	66.9	79.4	81.0	78.3	72.9
	*65	74.0	71.8	77.0	84.7	83.0	83.5	82.4	81.0	84.3	75.0	84.0	73.5	81.5	77.2	80.5	83.1
	*66	80.5	84.9	78.1	82.9	85.4	88.6	89.5	82.4	74.8	82.5	77.1	79.3	83.9	88.0	82.4	78.0
	*67	86.4	86.2	85.3	80.7	90.2	87.2	78.9	82.6	62.0	73.7	76.2	74.2	81.9	81.0	80.2	83.7
	*68	81.7	84.5	83.7	86.8	86.6	91.9	91.0	85.1	83.0	81.2	81.5	82.7	77.9	78.8	75.6	82.7
	*69	83.9	81.4	82.3	84.2	82.3	81.9	82.6	79.4	79.7	76.8	79.9	77.7	85.4	81.8	81.5	81.6
	*70	81.2	83.2	81.1	81.1	74.3	74.8	75.5	79.9	81.0	82.0	79.8	74.2	68.0	73.5	76.5	76.0
	*71	80.9	81.9	80.8	78.0	75.8	83.3	79.5	77.6	71.5	66.0	74.4	68.9	52.4	68.2	70.3	69.9
	*72	75.2	69.3	71.4	64.3	64.9	67.2	67.5	65.6	49.1	38.5	54.5	56.2	58.9	54.5	49.2	48.6
	*73	60.4	48.2	48.3	55.6	59.7	59.8	58.1	56.5	60.0	64.7	60.0	47.5	49.2	50.3	52.5	43.0
	*74	37.8	35.4	35.0	33.9	45.5	49.4	55.3	51.5	43.0	51.3	42.2	39.7	39.0	31.4	30.4	39.4
	*75	39.6	48.8	41.5	42.5	44.8	32.2	18.5	20.7	43.3	52.4	45.0	47.4	57.3	56.9	50.7	50.5
	*76	46.6	43.1	35.1	36.0	39.6	46.7	54.6	48.1	31.2	23.6	35.1	40.0	37.3	34.1	44.7	42.7
	*77	51.2	32.9	41.8	46.5	32.6	25.9	22.7	30.5	30.4	35.5	40.8	34.9	26.8			

19	378	54.4	59.4	47.4	54.2	69.8	67.0	51.3	60.5	56.5	73.4	75.7	50.4	59.8	51.8	60.7	64.8
	379	55.8	59.6	40.5	60.1	47.1	72.2	62.2	84.4	75.1	58.7	76.2	121.9	83.7	65.3	76.2	85.6
	380	93.0	60.7	76.7	58.2	82.8	77.4	79.2	73.9	66.5	65.3	62.5	73.5	69.4	66.8	49.4	97.5
	381	103.7	66.7	47.7	62.1	75.9	62.0	64.4	86.1	67.9	69.5	92.0	105.3	132.2	125.8	92.1	73.3
	382	70.0	53.6	71.3	90.3	88.3	85.5	82.2	56.4	67.3	51.8	66.4	68.0	70.7	66.8	67.5	54.3
	383	55.6	77.8	72.7	107.0	87.8	59.2	81.6	71.4	70.2	79.0	101.3	97.6	72.0	72.1	63.8	81.9
	384	97.7	125.6	57.9	71.0	103.2	129.9	117.0	94.4	121.4	71.4	115.6	164.6	122.7	102.8	78.3	165.0
	385	95.1	83.7	117.6	119.3	182.5	163.1	155.2	115.6	108.3	60.1	78.2	83.9	96.5	107.4	134.3	145.3
	386	163.7	137.4	170.6	182.9	149.2	165.6	86.3	86.9	97.5	104.4	107.7	121.1	124.9	101.5	128.1	117.2
	387	114.3	74.5	108.8	137.5	140.1	136.7	114.0	95.3	78.4	95.9	102.4	108.5	99.3	91.5	120.5	156.6
	388	181.4	178.3	184.2	154.3	137.2	150.0	167.9	185.0	118.9	132.6	117.1	102.8	81.2	138.1	188.1	103.1
	389	142.8	85.6	160.6	183.9	154.1	132.4	130.6	167.9	119.4	78.7	116.6	150.1	139.2	76.5	87.1	111.8
	390	109.1	123.5	123.4	113.2	66.1	105.8	135.8	166.5	103.8	93.2	87.9	85.8	106.8	130.7	123.1	130.7
	391	128.6	163.6	132.2	124.6	113.2	91.8	105.6	153.4	162.3	158.2	173.9	174.7	175.8	145.9	103.7	86.5
	392	86.2	135.7	153.2	117.5	142.3	196.5	159.2	136.8	137.4	99.3	92.1	87.0	61.7	82.3	94.9	109.7
	393	138.6	132.8	92.3	117.7	137.6	146.2	134.6	140.9	185.8	157.9	89.7	127.9	101.4	133.1	164.3	87.5
	394	116.1	131.9	115.9	111.8	106.3	80.9	150.7	168.8	138.7	116.9	102.2	97.1	86.8	47.9	58.9	76.6
	395	65.9	69.2	71.8	67.2	99.8	123.5	159.4	172.5	109.4	83.7	75.2	89.6	63.6	76.4	73.4	77.2
	396	35.3	46.6	53.5	42.7	51.9	100.6	124.0	121.9	71.0	102.6	92.2	73.4	67.2	69.1	63.0	53.5
	397	51.2	55.9	61.4	63.6	64.6	74.5	51.1	103.6	80.4	52.0	82.7	66.1	63.0	82.7	61.5	61.7
	398	63.2	52.0	93.7	73.8	88.5	77.5	73.5	44.8	113.8	140.9	72.5	62.7	93.1	98.1	84.9	72.7
	399	97.4	46.6	60.0	38.8	72.0	102.7	66.5	91.3	83.9	50.3	43.9	62.3	97.3	63.0	86.1	92.3
	400	62.3	62.1	61.8	61.9	63.4	44.8	60.6	55.4	38.3	48.5	31.0	80.2	51.3			
20	401	10.4	12.7	9.2	10.4	15.0	16.1	11.5	15.0	12.7	17.3	15.0	9.2	11.5	9.2	10.4	10.4
	402	12.7	13.8	8.1	13.8	10.4	16.1	11.5	15.0	11.5	9.2	12.7	18.4	17.3	12.7	15.0	16.1
	403	21.9	13.8	16.1	9.2	15.0	11.5	15.0	15.0	11.5	12.7	11.5	15.0	13.8	13.8	8.1	17.3
	404	19.6	13.8	8.1	10.4	12.7	9.2	9.2	18.4	12.7	10.4	15.0	15.0	17.3	17.3	16.1	12.7
	405	11.5	8.1	10.4	13.8	17.3	17.3	17.3	10.4	12.7	9.2	12.7	12.7	12.7	11.5	12.7	9.2
	406	9.2	13.8	11.5	18.4	16.1	9.2	15.0	12.7	11.5	12.7	17.3	17.3	10.4	12.7	9.2	11.5
	407	15.0	18.4	8.1	9.2	13.8	18.4	21.9	15.0	18.4	8.1	15.0	19.6	17.3	15.0	10.4	20.7
	408	13.8	10.4	15.0	12.7	18.4	16.1	15.0	12.7	16.1	6.9	9.2	9.2	10.4	11.5	16.1	17.3
	409	19.6	13.8	16.1	17.3	13.8	16.1	10.4	10.4	10.4	10.4	10.4	11.5	11.5	9.2	11.5	10.4
	410	11.5	6.9	12.7	13.8	13.8	12.7	10.4	9.2	8.1	10.4	11.5	12.7	9.2	8.1	11.5	16.1
	411	18.4	18.4	17.3	11.5	10.4	11.5	13.8	16.1	9.2	12.7	9.2	10.4	6.9	12.7	16.1	8.1
	412	12.7	6.9	13.0	15.0	11.5	9.2	9.2	13.8	12.7	6.9	11.5	13.8	11.5	5.7	6.9	9.2
	413	8.1	9.2	9.2	9.2	4.6	8.1	11.5	13.8	12.7	10.4	9.2	8.1	9.2	11.5	10.4	10.4
	414	10.4	12.7	10.4	9.2	8.1	5.7	6.9	11.5	12.7	12.7	13.8	13.8	15.0	12.7	9.2	6.9
	415	6.9	11.5	12.7	9.2	11.5	16.1	12.7	11.5	11.5	8.1	8.1	8.1	4.6	6.9	8.1	9.2
	416	11.5	10.4	6.9	9.2	12.7	13.8	11.5	11.5	15.0	12.7	6.9	13.8	11.5	12.7	15.0	6.9
	417	9.2	10.4	9.2	9.2	9.2	5.7	12.7	15.0	13.8	13.8	9.2	11.5	12.7	4.6	5.7	8.1
	418	5.7	6.9	8.1	8.1	11.5	13.8	17.3	19.6	18.4	15.0	10.4	11.5	6.9	10.4	11.5	12.7
	419	3.5	5.7	6.9	4.6	5.7	12.7	16.1	16.1	8.1	11.5	11.5	11.5	10.4	10.4	9.2	8.1
	420	8.1	9.2	10.4	11.5	10.4	11.5	5.7	16.1	13.8	6.9	13.8	10.4	10.4	17.3	11.5	10.4
	421	10.4	6.9	17.3	12.7	16.1	17.3	17.3	8.1	18.4	21.9	11.5	8.1	11.5	13.8	12.7	10.4
	422	18.4	6.9	11.5	5.7	12.7	16.1	8.1	16.1	17.3	9.2	6.9	10.4	18.4	11.5	13.8	17.3
	423	11.5	10.4	9.2	10.4	12.7	8.1	12.7	10.4	5.7	8.1	3.5	15.0	10.4			

21	424	758.8	636.0	923.4	824.7	334.1	942.3	891.9	958.2	960.2	349.9
	425	346.6	463.7	868.3	761.6	975.9	759.9	362.3	609.7	377.9	504.0
	426	385.8	384.8	393.0	877.3	878.8	843.7	350.0	518.4	1005.9	1147.1
	427	902.4	417.4	428.6	1212.8	583.5	1196.7	436.0	433.5	742.6	612.3
	428	1274.0	456.6	1240.7	477.1	481.2	498.4	1369.1	1383.5	1169.7	1437.9
	429	1450.5	1305.9	516.5	517.5	519.9	1530.0	1541.2	1186.0	545.3	539.7
	430	538.2	738.7	1453.8	1508.9	977.9	589.3	1670.9	1410.8	609.6	619.7
	431	629.9	1504.2	1799.8	1078.0	653.5	657.6	561.4	665.8	677.4	682.0

432	924.2	1152.9	594.9	595.6	1183.5	1397.4	720.9	726.6	728.5	729.8
433	735.3	2121.8	1909.7	760.7	1669.1	2166.2	2189.9	1499.4	1062.3	1720.7
434	2217.3	1530.5	1090.6	2061.2	1086.4	1075.9	1337.3	784.6	805.0	1611.9
435	2239.9	1357.0	832.5	1999.7	1121.2	2287.2	2176.2	1091.3	804.9	827.5
436	1895.3	2488.0	2475.0	2462.5	2409.2	2455.8	2227.7	2080.1	967.6	2199.8
437	1872.1	1872.3	1432.2	1441.8	1213.1	2590.6	2556.1	2546.3	2540.3	2527.6
438	2387.8	1203.0	2121.6	2282.2	1758.9	2626.5	1252.3	2176.0	997.1	1497.7
439	1509.9	904.2	921.3	2048.4	1258.9	1266.4	2629.6	2625.5	2621.0	1535.1
440	1787.3	1239.8	2169.6	1941.8	1481.1	1736.0	2300.7	2519.4	1982.3	1531.8
441	2318.1	1918.6	2381.4	1780.9	2299.6	1986.8	2591.3	2628.1	2590.7	2533.1
442	2265.0	2459.9	2519.2	2400.5	2644.7	2647.5	2567.5	2319.3	2554.8	2600.6
443	1758.0	880.8	2459.5	2445.9	2091.1	1718.6	2570.2	2516.2	1182.0	2422.1
444	905.2	2602.7	2595.3	1201.4	2443.0	2420.9	1676.9	2175.9	1859.4	2322.2
445	2004.3	2244.3	1973.3	2103.8	2278.9	2080.5	1782.6	1352.8	1364.5	1562.7
446	1080.7	1768.0	1351.6	2079.2	2308.9	2262.1	2191.9	2014.2	1860.1	1965.1
447	1827.5	1496.2	1673.0	752.9	2159.9	2210.1	2197.6	2173.1	2147.8	2115.0
448	2030.3	1841.7	714.8	1186.1	713.8	1192.4	938.3	1153.9	1732.1	1884.3
449	918.8	1997.7	1670.6	1860.2	1831.5	648.6	1417.3	1799.2	1393.5	853.9
450	1052.0	1467.6	1690.2	1444.5	617.1	1045.9	1692.5	1476.4	626.2	1338.3
451	1522.8	1581.2	1628.7	951.3	1657.8	1638.7	1577.2	1070.6	1043.6	720.5
452	560.9	557.2	1494.0	711.2	516.7	525.8	714.8	1330.0	1458.9	507.2
453	500.0	666.9	1062.9	1196.9	469.3	464.4	617.0	1250.9	608.6	462.9
454	1283.0	1263.1	968.8	445.9	442.5	437.3	431.5	431.1	1178.2	1121.9
455	772.8	405.0	406.4	1106.2	395.2	389.3	390.2	393.6	834.5	1034.0
456	375.9	979.9	371.4	1008.0	1004.6	848.7	1005.0	685.4	649.4	555.0
457	344.5	331.0	325.8	332.6	910.0	536.5	829.9	891.2	721.5	908.2
458	900.6	519.2	714.2	431.2	324.2	323.3	392.4	872.2	317.3	317.4
459	853.5	318.9	424.9	312.9	310.5	739.3	394.4	800.3	870.5	893.4
460	322.4	697.0	889.6	321.1	331.3					

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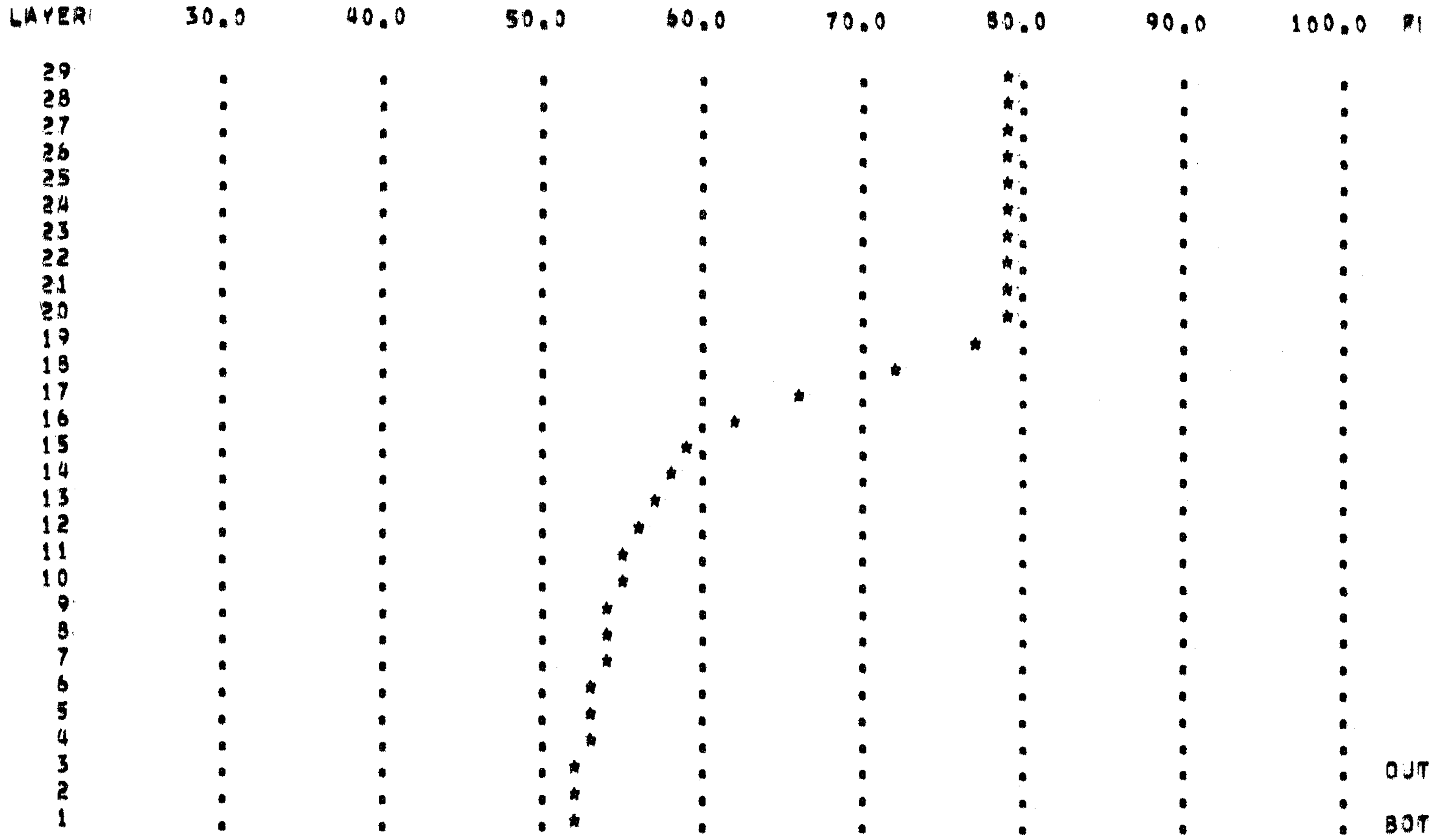
WATER QUALITY SECTION

DAY NUMBER 189 PERIOD NUMBER 1

LAYER	ELEV	TEMP	INFLOW	OUTFLOW	VEL 1	VEL 2	RES WDTH	RES AREA	SW DEG	SW PCT
29	836.41	79.24	0.00	0.00	0.000000	0.000000	9090.00	7166.8	7.34	13.75
28	832.50	79.24	0.00	0.00	0.000000	0.000000	8865.00	6640.5	.79	11.08
27	829.50	79.24	0.00	0.00	0.000000	0.000000	8595.00	6184.5	.50	7.06
26	826.50	79.24	0.00	0.00	0.000000	0.000000	7738.33	5749.5	.32	4.50
25	823.50	79.24	0.00	0.00	0.000000	0.000000	6166.67	5313.0	.21	2.87
24	820.50	79.24	0.00	0.00	0.000000	0.000000	5403.33	4904.0	.13	1.83
23	817.50	79.24	0.00	0.00	0.000000	0.000000	4666.67	4535.5	.08	1.17
22	814.50	79.24	0.00	0.00	0.000000	0.000000	4051.67	4178.5	.05	.74
21	811.50	79.24	0.00	0.00	0.000000	0.000000	3721.67	3834.0	.03	.47
20	808.50	79.24	0.00	0.00	0.000000	0.000000	3538.33	3527.0	.02	.30
19	805.50	77.00	30.00	0.00	0.000000	0.000000	3400.00	3245.0	.01	.19
18	802.50	72.43	0.00	0.00	0.000000	0.000000	3226.67	2963.0	.01	.12
17	799.50	66.22	0.00	0.00	0.000000	0.000000	3110.00	2655.5	.01	.08
16	796.50	61.62	0.00	0.00	0.000000	0.000000	3000.00	2322.5	.00	.05
15	793.50	59.07	0.00	0.00	0.000000	0.000000	2810.00	1989.5	.00	.03
14	790.50	57.66	0.00	0.00	0.000000	0.000000	2615.00	1673.5	.00	.02
13	787.50	56.72	0.00	0.00	0.000000	0.000000	2365.00	1382.3	.00	.01
12	784.50	55.99	0.00	0.00	0.000000	0.000000	2170.00	1114.3	.00	.01
11	781.50	55.40	0.00	0.00	0.000000	0.000000	2110.00	903.5	.00	.01
10	778.50	54.90	0.00	0.00	0.000000	0.000000	2090.00	754.5	.00	.00
9	775.50	54.47	0.00	0.00	0.000000	0.000000	1995.00	625.5	.00	.00
8	772.50	54.11	0.00	0.00	0.000000	0.000000	1730.00	496.5	.00	.00
7	769.50	53.77	0.00	3.51	0.000000	.001321	1337.50	387.0	.00	.00
6	766.50	53.42	0.00	4.52	0.000000	.005176	440.00	297.0	.00	.00
5	763.50	53.06	0.00	4.90	0.000000	.009672	255.00	207.0	.00	.00
4	760.50	52.72	0.00	4.64	0.000000	.012283	190.00	135.0	.00	.00
3	757.50	52.43	0.00	4.14	0.000000	.012648	165.00	90.0	.00	.00
2	754.50	52.21	0.00	2.93	0.000000	.009774	151.00	54.0	.00	.00
1	751.50	52.08	0.00	.36	0.000000	.003592	50.00	18.0	.00	.00

WATER QUALITY SECTION

TEMPERATURE PROFILE FOR DAY 189   PERIOD NUMBER 1

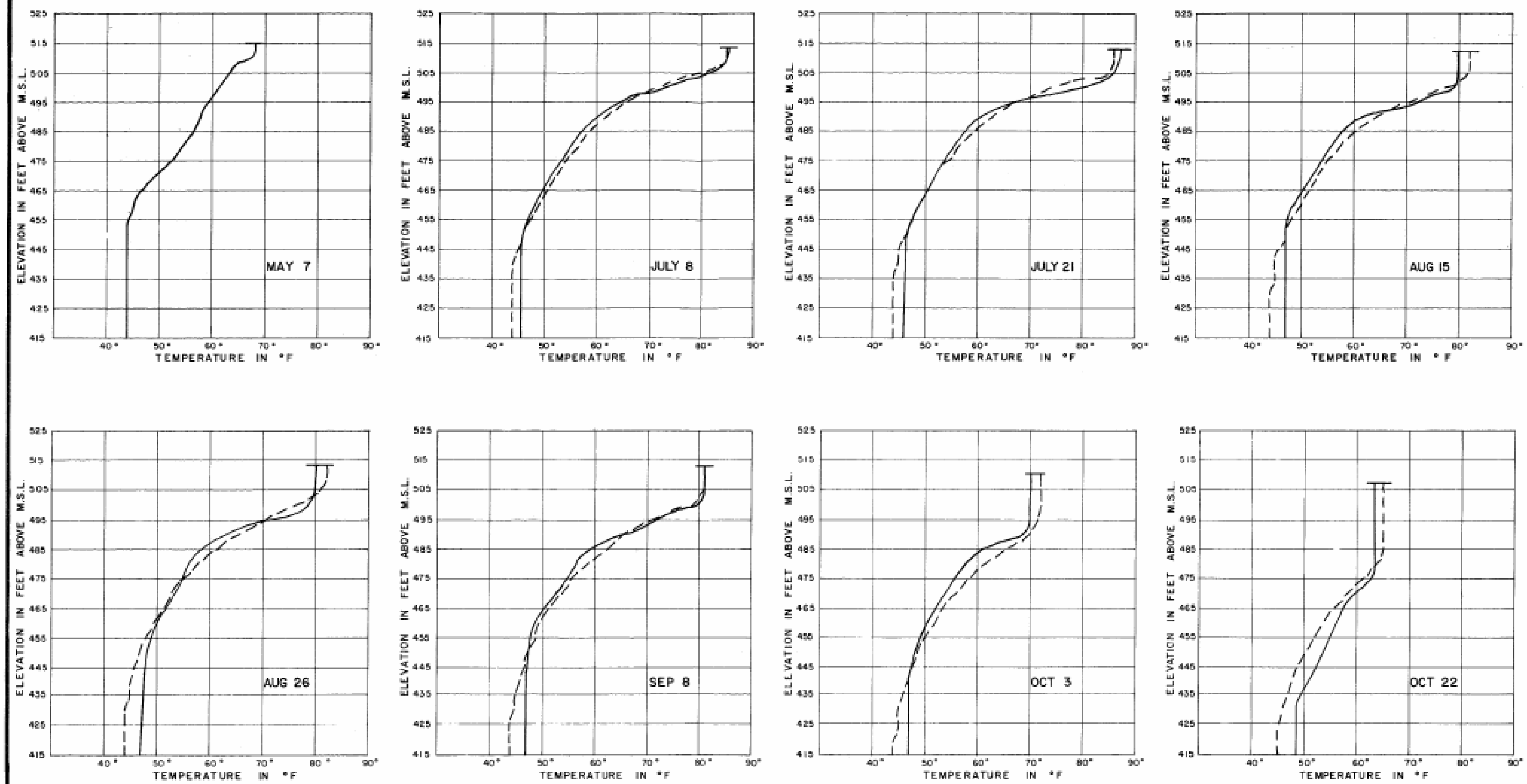


OUTLET NUMBER 1

BOTTOM ELEV = 750.0

WATER QUALITY SECTION

DAY	PER	POOL	INFLOW	ITEMP	OUTFLOW	OUTLET	NO	OUTLET	NO	OTEMP	TARGET	EQTEMP	EXCOEF	TSURF	AVTEMP	BETA
190	1	838.8	15.0	76.0	25.0	0.	0	25.0	1	53.0	75.5	88.0	76.5	79.8	75.2	.86
191	1	838.8	15.0	76.0	25.0	0.	0	25.0	1	53.0	75.6	82.4	87.1	79.8	75.3	.86
192	1	838.8	15.0	74.1	25.0	0.	0	25.0	1	53.0	75.8	78.0	111.8	79.6	75.2	.86
193	1	838.8	155.0	74.7	25.0	0.	0	25.0	1	53.0	75.9	86.4	109.1	80.1	75.5	.86
194	1	838.8	80.0	76.0	25.0	0.	0	25.0	1	53.0	76.0	86.2	123.5	80.5	75.8	.86
195	1	838.8	70.0	76.7	25.0	0.	0	25.0	1	53.1	76.1	85.3	123.4	80.8	76.0	.86
196	1	838.8	60.0	76.3	25.0	0.	0	25.0	1	53.1	76.2	80.7	113.2	80.7	76.0	.86
197	1	838.7	50.0	74.9	25.0	0.	0	25.0	1	53.1	76.4	90.2	66.1	81.3	76.2	.86
198	1	838.7	20.0	75.1	25.0	0.	0	25.0	1	53.1	76.5	87.2	105.8	81.5	76.4	.86
199	1	838.7	15.0	75.4	25.0	0.	0	25.0	1	53.1	76.6	78.9	135.8	81.1	76.3	.86
200	1	838.7	10.0	78.5	25.0	0.	0	25.0	1	53.1	76.7	82.6	166.5	80.9	76.3	.86
201	1	838.6	10.0	73.0	25.0	0.	0	25.0	1	53.2	76.8	62.0	103.8	79.7	75.5	.86



NOTES :

COMPUTED — — —
MEASURED ———
FIRST DAY OF SIMULATION — MAY 7

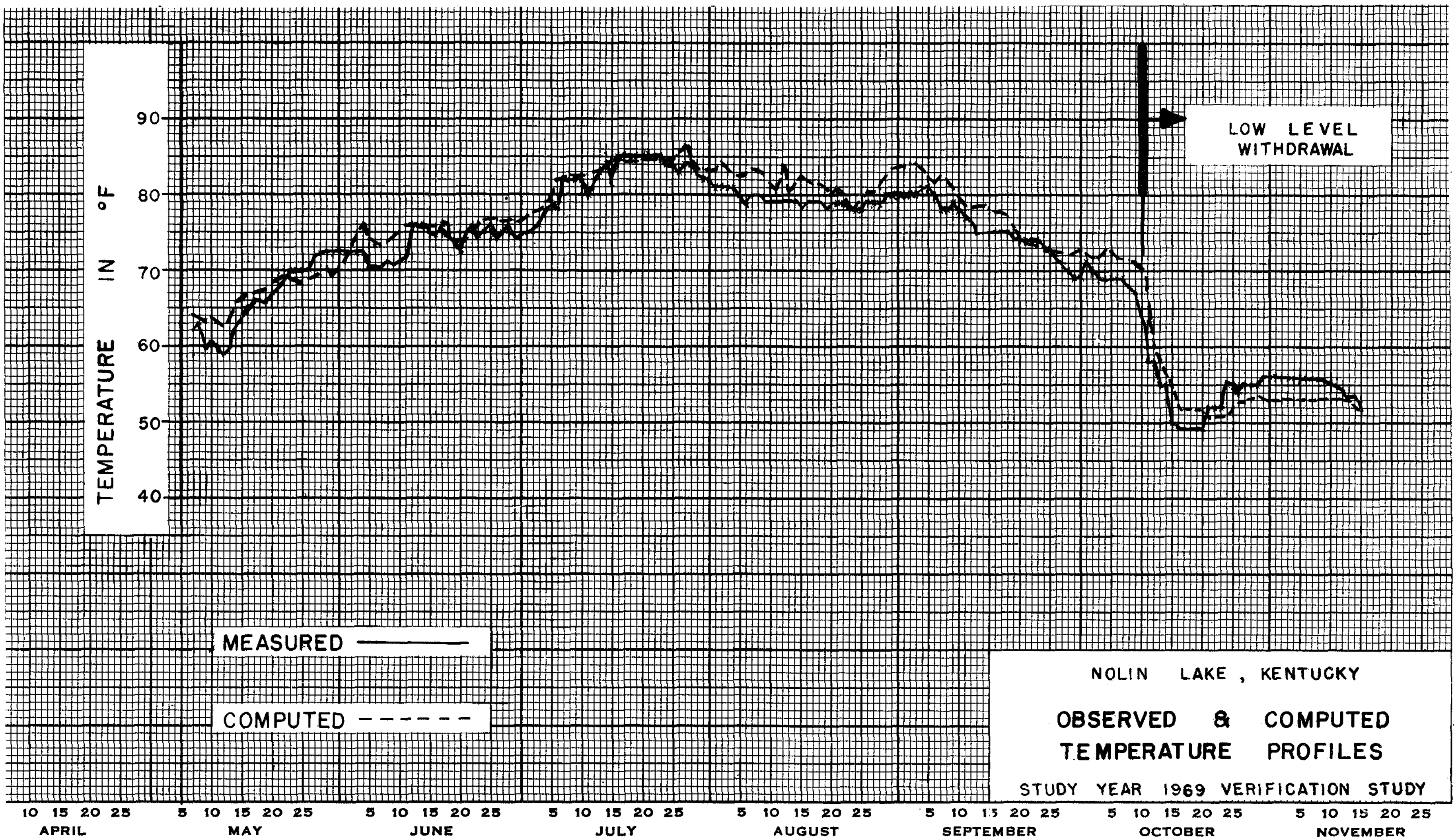
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

NOLIN LAKE, KENTUCKY

OBSERVED & COMPUTED
TEMPERATURE PROFILES

STUDY YEAR 1969 VERIFICATION STUDY

EXHIBIT I

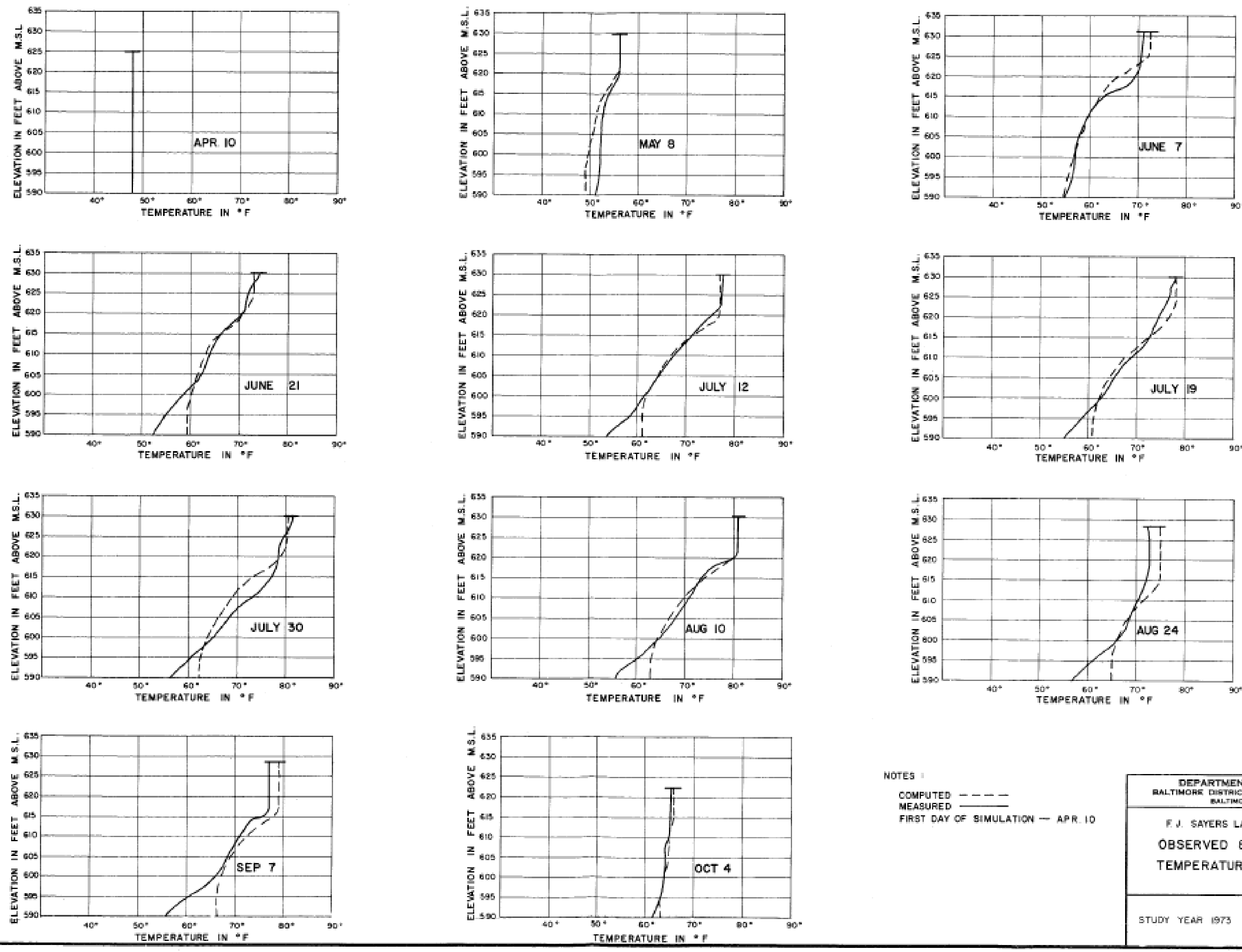


NOLIN LAKE, KENTUCKY

OBSERVED & COMPUTED TEMPERATURE PROFILES

STUDY YEAR 1969 VERIFICATION STUDY

EXHIBIT 2



NOTES :

COMPUTED — — — —
MEASURED ————
FIRST DAY OF SIMULATION — APR. 10

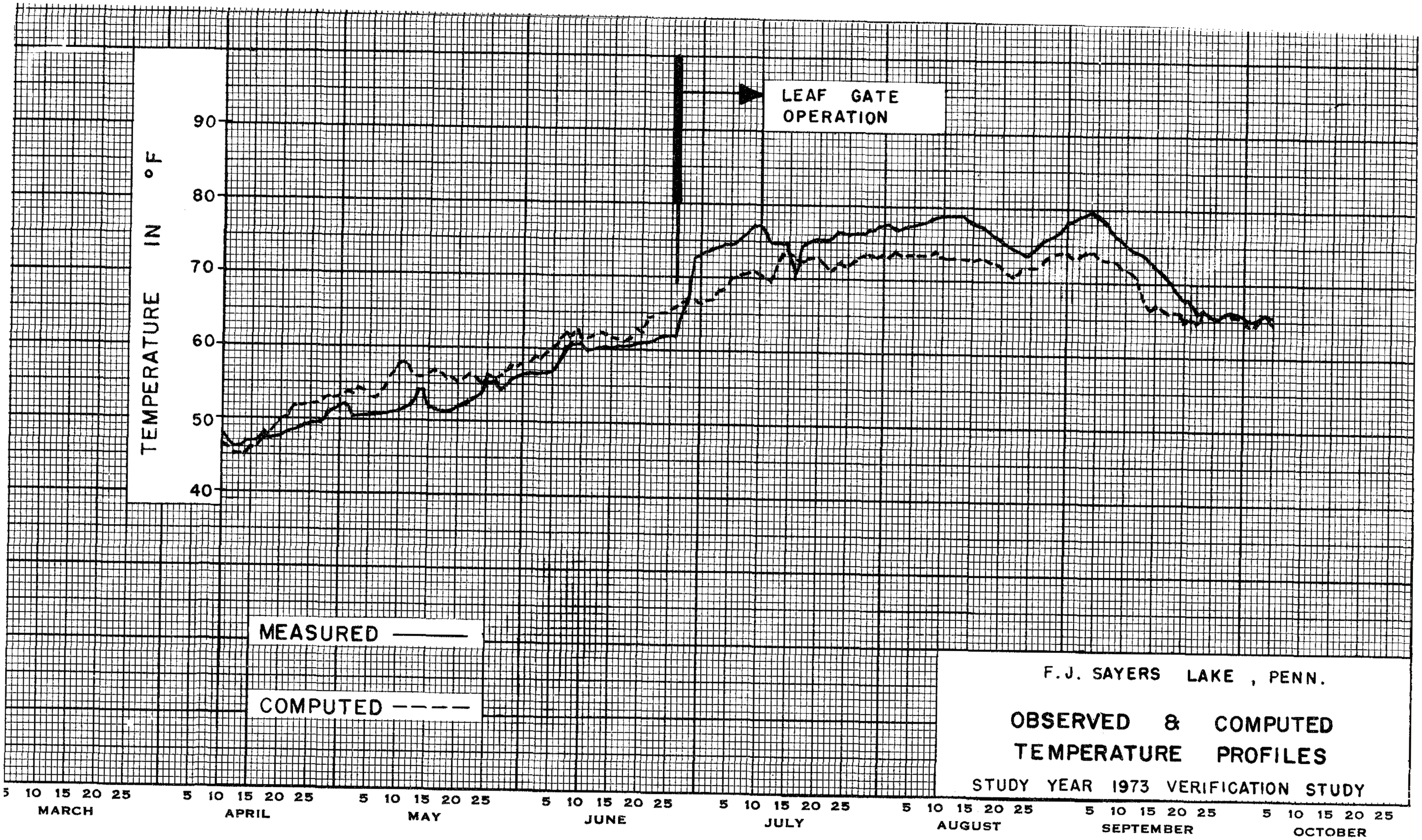
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

F. J. SAYERS LAKE, PENNSYLVANIA

OBSERVED & COMPUTED
TEMPERATURE PROFILES

STUDY YEAR 1973 VERIFICATION STUDY

EXHIBIT 3


LEAF GATE OPERATION
TEMPERATURE IN °F
90
80
70
60
50
40
MEASURED ——
COMPUTED ----
F.J. SAYERS LAKE, PENN.
OBSERVED & COMPUTED TEMPERATURE PROFILES
STUDY YEAR 1973 VERIFICATION STUDY
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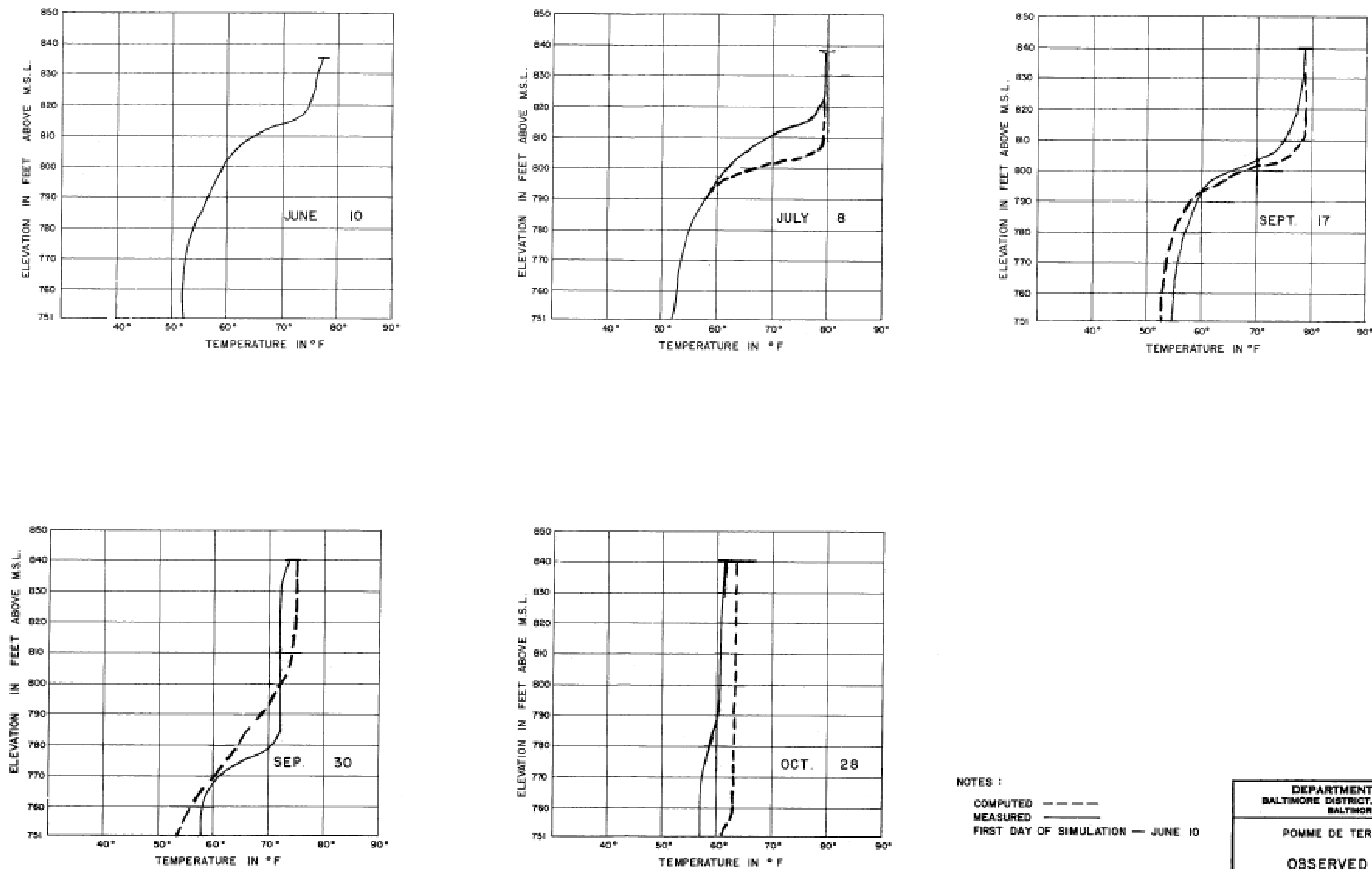
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER

EXHIBIT 4



NOTES :

COMPUTED – – – –
MEASURED ————
FIRST DAY OF SIMULATION — JUNE 10

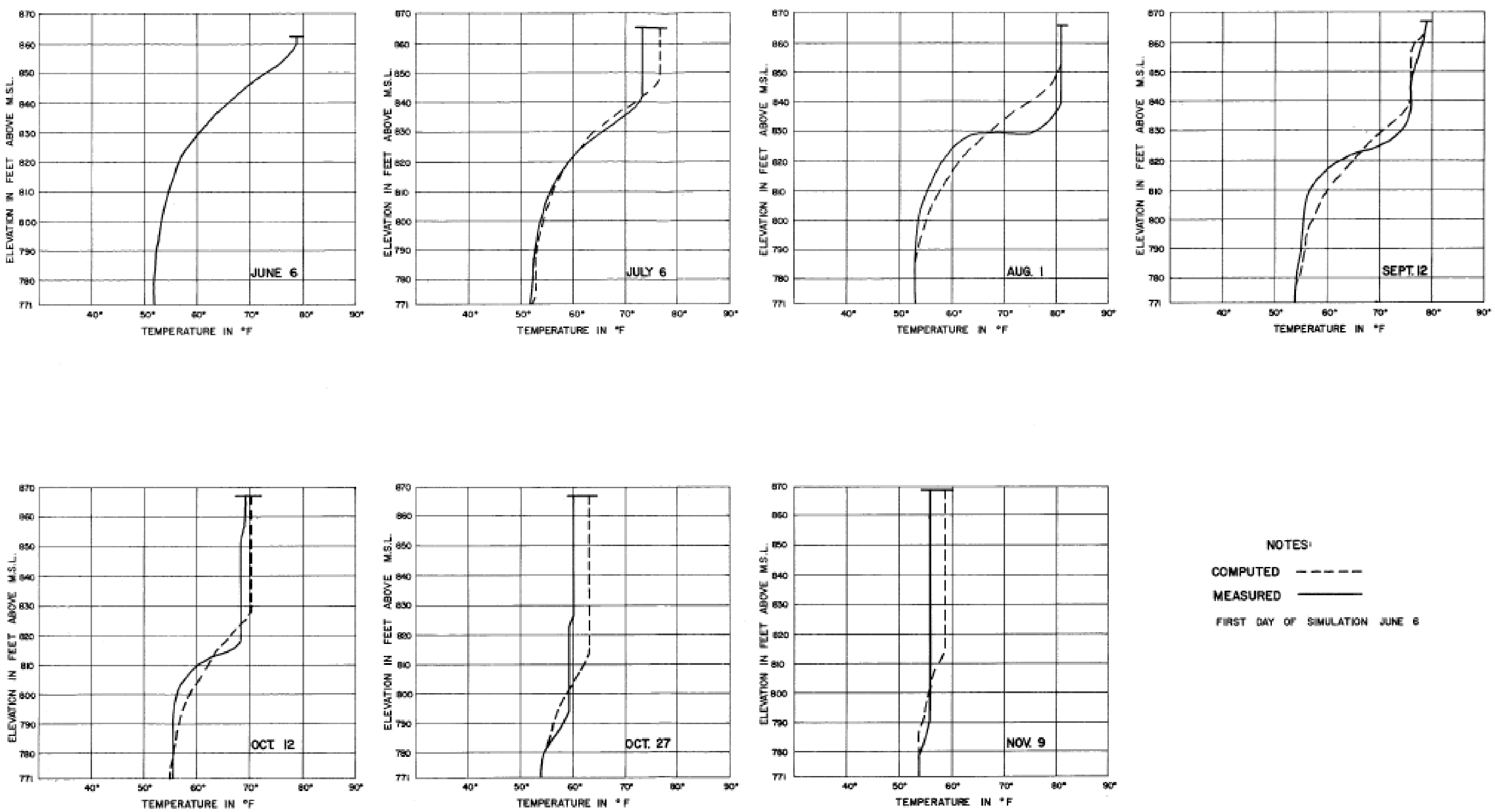
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

POMME DE TERRE LAKE, MISSOURI

OBSERVED & COMPUTED TEMPERATURE PROFILES

STUDY YEAR 1970 VERIFICATION STUDY

EXHIBIT 5



NOTES:

COMPUTED - - - - -

MEASURED ————

FIRST DAY OF SIMULATION JUNE 6

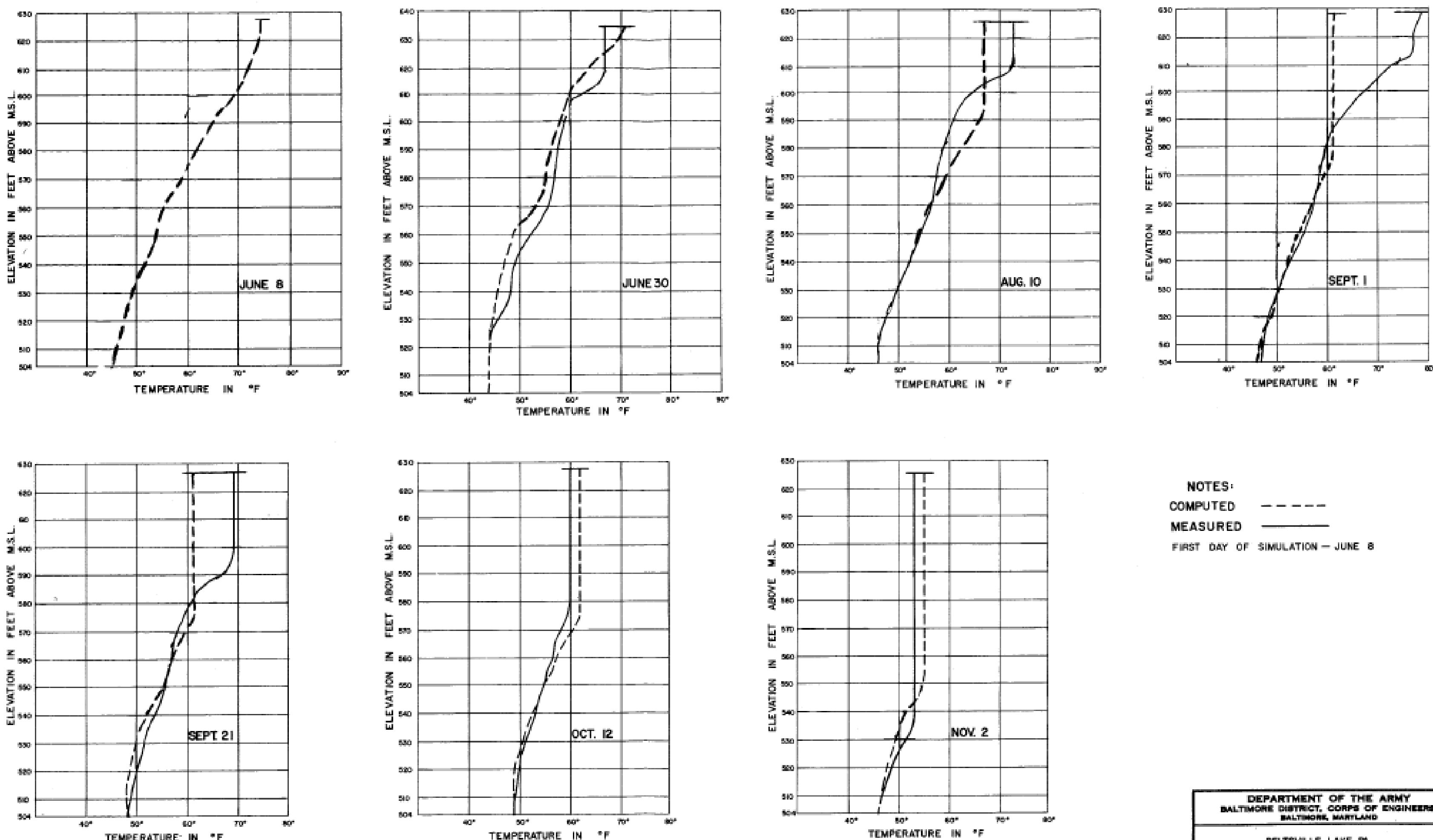
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

STOCKTON LAKE, MISSOURI

OBSERVED & COMPUTED TEMPERATURE PROFILES

STUDY YEAR 1972 VERIFICATION STUDY

EXHIBIT 6



NOTES:
COMPUTED - - - - -
MEASURED ———
FIRST DAY OF SIMULATION — JUNE 8

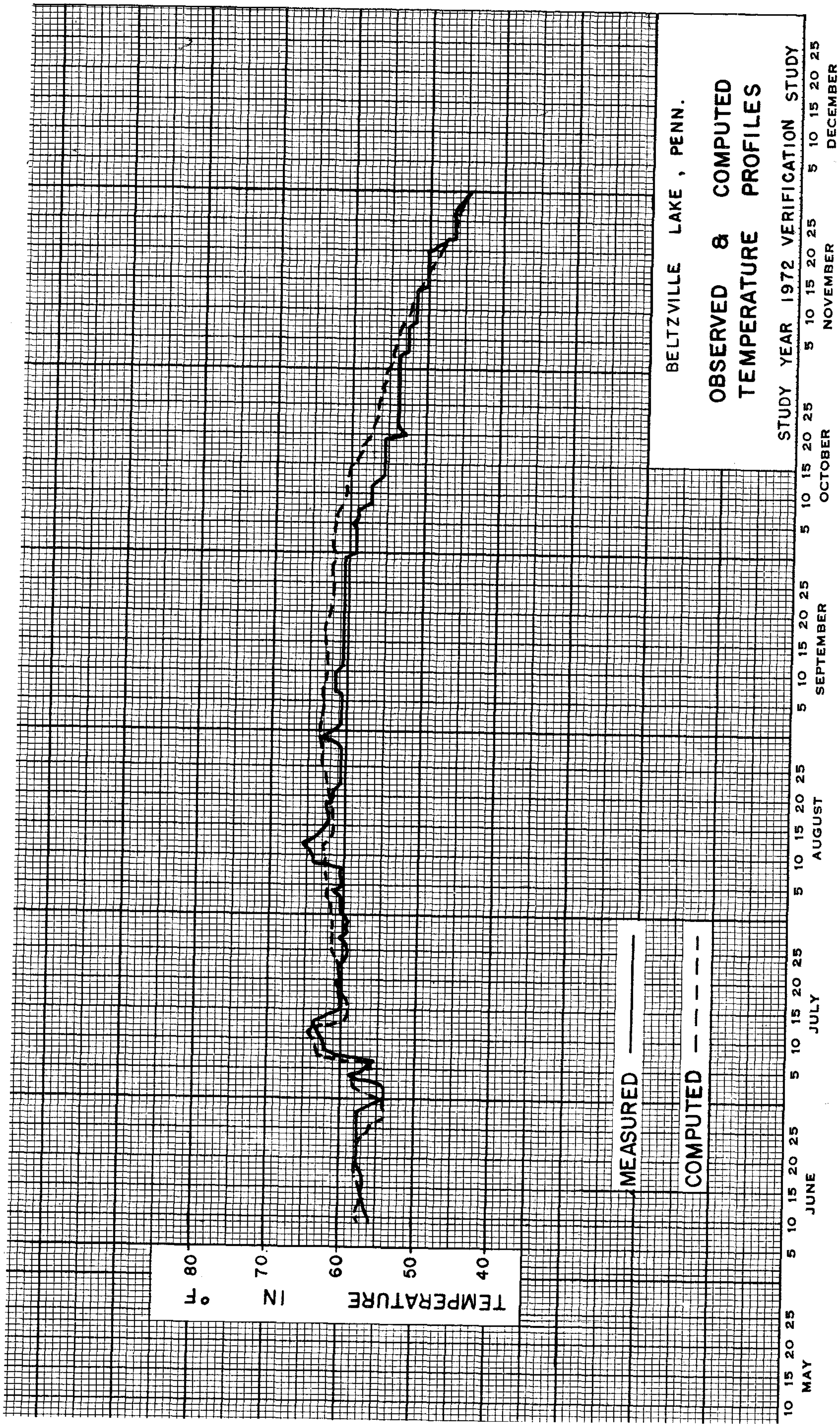
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BELTSVILLE LAKE, PA

OBSERVED & COMPUTED TEMPERATURE PROFILES

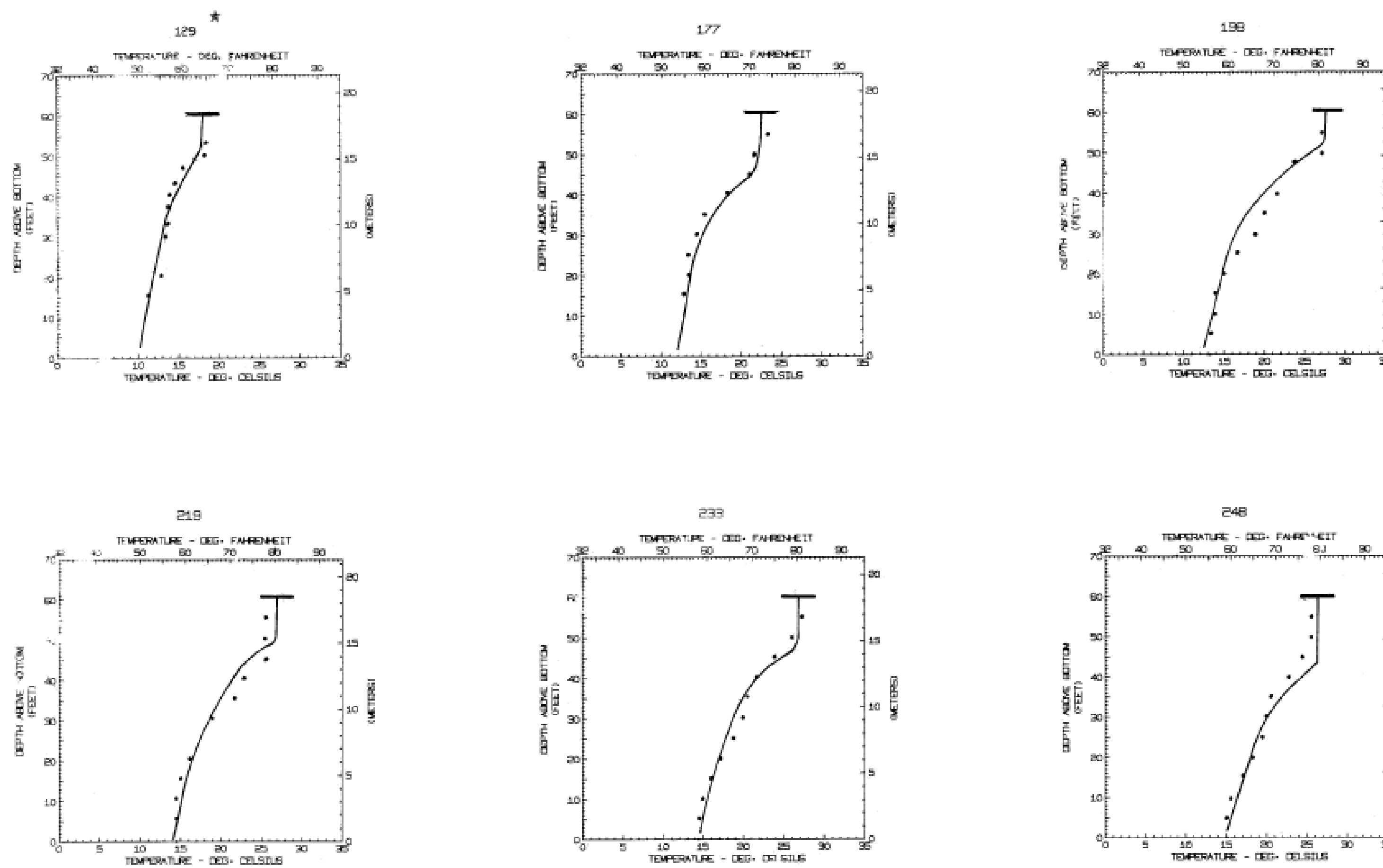
STUDY YEAR 1972 VERIFICATION STUDY

EXHIBIT 7



BELTZVILLE LAKE, PENN.
OBSERVED & COMPUTED TEMPERATURE PROFILES
STUDY YEAR 1972 VERIFICATION STUDY
MEASURED
COMPUTED
TEMPERATURE IN °F
80
70
60
50
40
10 15 20 25
MAY
5 10 15 20 25
JUNE
5 10 15 20 25
JULY
5 10 15 20 25
AUGUST
5 10 15 20 25
SEPTEMBER
5 10 15 20 25
OCTOBER
5 10 15 20 25
NOVEMBER
5 10 15 20 25
DECEMBER

CORPS OF ENGINEERS U.S. ARMY



★ JULIAN DAY
—— COMPUTED
• • • MEASURED

U.S. ARMY ENGINEER DIVISION, OHIO RIVER
RESERVOIR CONTROL CENTER
CINCINNATI, OHIO

GRAYSON LAKE, KENTUCKY

OBSERVED & COMPUTED TEMPERATURE PROFILES

STUDY YEAR 1972 | VERIFICATION STUDY

EXHIBIT 9

EXHIBIT 6

GEDA PROGRAM MANUAL

US Army Corps
of Engineers
Hydrologic Engineering Center

Generalized Computer Program

GEDA
Geometric Elements From Cross Section Coordinates

User's Manual

October 1981

CPD-15

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

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October 1981	Computer Program Documentation	

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GEDA
Geometric Elements From Cross Section Coordinates

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5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
CEIWR-HEC

5d. PROJECT NUMBER

5e. TASK NUMBER

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US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center (HEC)
609 Second Street
Davis, CA 95616-4687

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12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The purpose of this program is to prepare tables of hydraulic elements for use by the computer program "Gradually Varied Unsteady Flow Profiles". The program read data and produces tables of hydraulic elements for nodal points spaced a constant distance apart. The following hydraulic elements are calculated for each water surface elevation specified: cross sectional area, hydraulic radius to the 2/3 power, top width, average n-value, and velocity distribution factor.

15. SUBJECT TERMS
cross section, GEDA, coordinates, geometric elements, hydraulic, water surface elevation, cross sectional area, hydraulic radius, top width, average n-value, velocity distribution factor, conveyance, flow boundary, storage, reach

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER**
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Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39-18

GEDA
Geometric Elements From Cross Section Coordinates

User's Manual

October 1981

US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
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CPD-15

10 December 1984

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GEOMETRIC ELEMENTS FROM CROSS SECTION COORDINATES

INTRODUCTION

1. ORIGIN OF PROGRAM

This program was developed at the Hydrologic Engineering Center by William A. Thomas.

2. PURPOSE OF PROGRAM

The purpose of this program is to prepare tables of hydraulic elements for use by the computer program "Gradually Varied Unsteady Flow Profiles." It reads data coded in the standard format for "Water Surface Profiles, HEC-2" and produces tables of hydraulic elements for nodal points spaced a constant distance apart. The following hydraulic elements are calculated for each water surface elevation specified in the table: Cross sectional area, hydraulic radius to the 2/3 power, top width, average n-value, and velocity distribution factor. In addition to printing the hydraulic elements as each cross section is processed, the tables of hydraulic elements interpolated for each node are printed and the user may elect to have these tables also punched on cards.

PROGRAM DESIGN

1. CAPABILITY OF COMPUTER PROGRAM

In water surface profile calculations it is important to model conveyance. This sometimes results in cross sections which end at a flow boundary rather than extending all the way to the high ground, as illustrated in figure No. 1. In unsteady flow profile calculations it is necessary to also model the conveyance. However, there is the additional requirement that storage in the reach must be modeled also. This dual requirement is fulfilled by assigning limits of flow to any cross section which might not convey flow over its entire cross sectional area. The entire area is available for storage, however.

The elevations in the hydraulic elements table are specified at the downstream end of the study area. These may be projected section by section to the upstream end on a horizontal line, or a sloping line may be used. Oftentimes the number of elevations required to specify the geometric model can be reduced if a sloping computation grid is utilized. The slope may be changed at any cross section in the study area or may be based on the stream's channel bed slope.

Normally, the interpolation to establish computation nodes is done based on the main channel length. However, if another length would be more appropriate, these values may be specified for each cross section. This does not change the reach lengths used in computation of volume or accumulated surface area. Rather, the so-called "weighted" lengths are designed to be more along the center of the flow and are only used in locating nodes.

Ineffective area may be specified just as it is in the data for water surface profile calculations. This area is considered to be ineffective both for conveying and storing water until the water surface rises to a certain minimum elevation. Above this elevation the area is no longer considered to be ineffective. It is utilized both in conveyance and storage calculations.

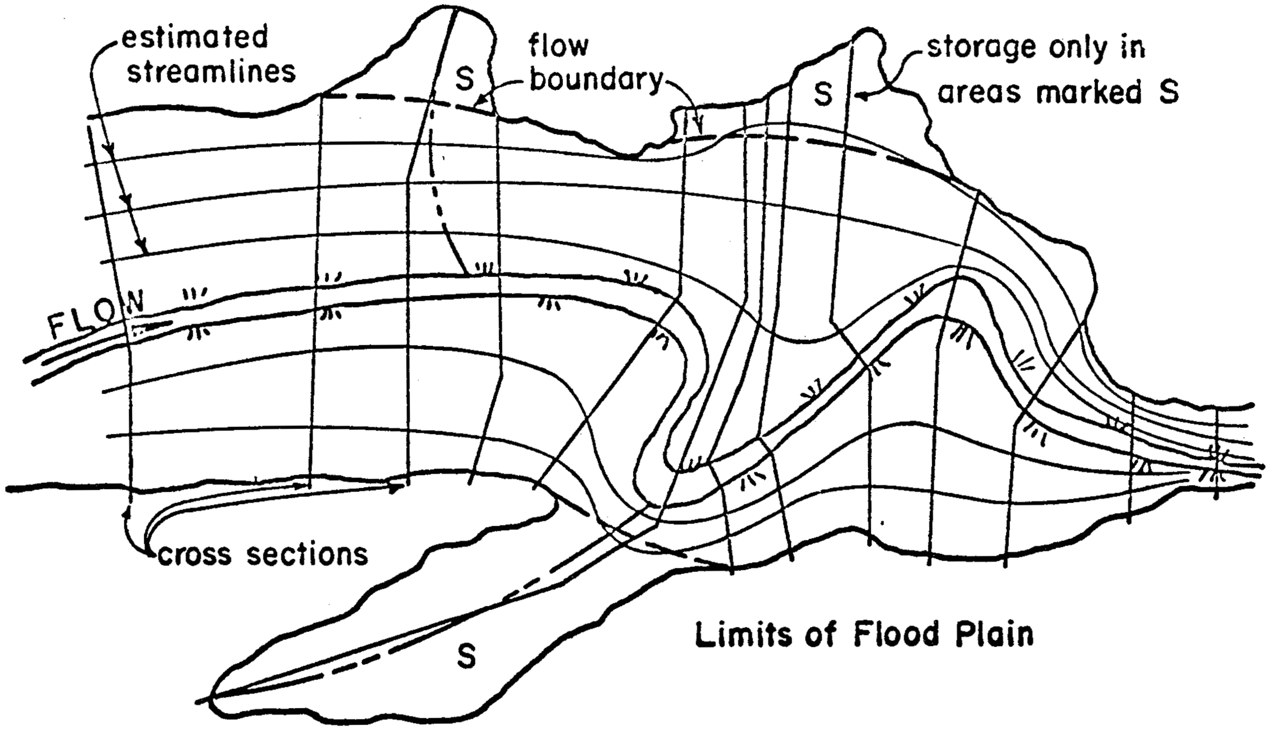


Fig. 1 Plan View of River and Flood Plain

The unsteady flow routing model permits n to vary with elevation but only one value may be specified for the entire cross section at each elevation. However, in most steady flow calculations for water surface profiles, different n-values may be used in the overbanks and main channel. This program accepts n-values specified in the normal way and calculates a composite n for each elevation based on conveyance.

The interpolated values for top width are calculated from accumulated volume in the study reach rather than the cross section width at the water surface. This insures that the correct volume is preserved in the geometric model.

2. PROGRAM ORGANIZATION

The functional and organizational flow chart is shown in figure 2. A two pass computation procedure is used. During the first pass, input data is read section by section, and hydraulic element tables of area, hydraulic radius to the 2/3 power, water surface width, composite n-value, the velocity distribution factor, surface area, and volume are calculated, stored and printed out for each cross section. The position of each cross section is located in terms of distance to the downstream boundary using either the channel length or weighted length - if those values are specified. After the final cross section has been processed, the second pass is made through the hydraulic element tables at which time the position of each nodal point is located and the interpolated values for the hydraulic element tables are calculated. All of the second pass calculations are performed in subroutine INTPL.

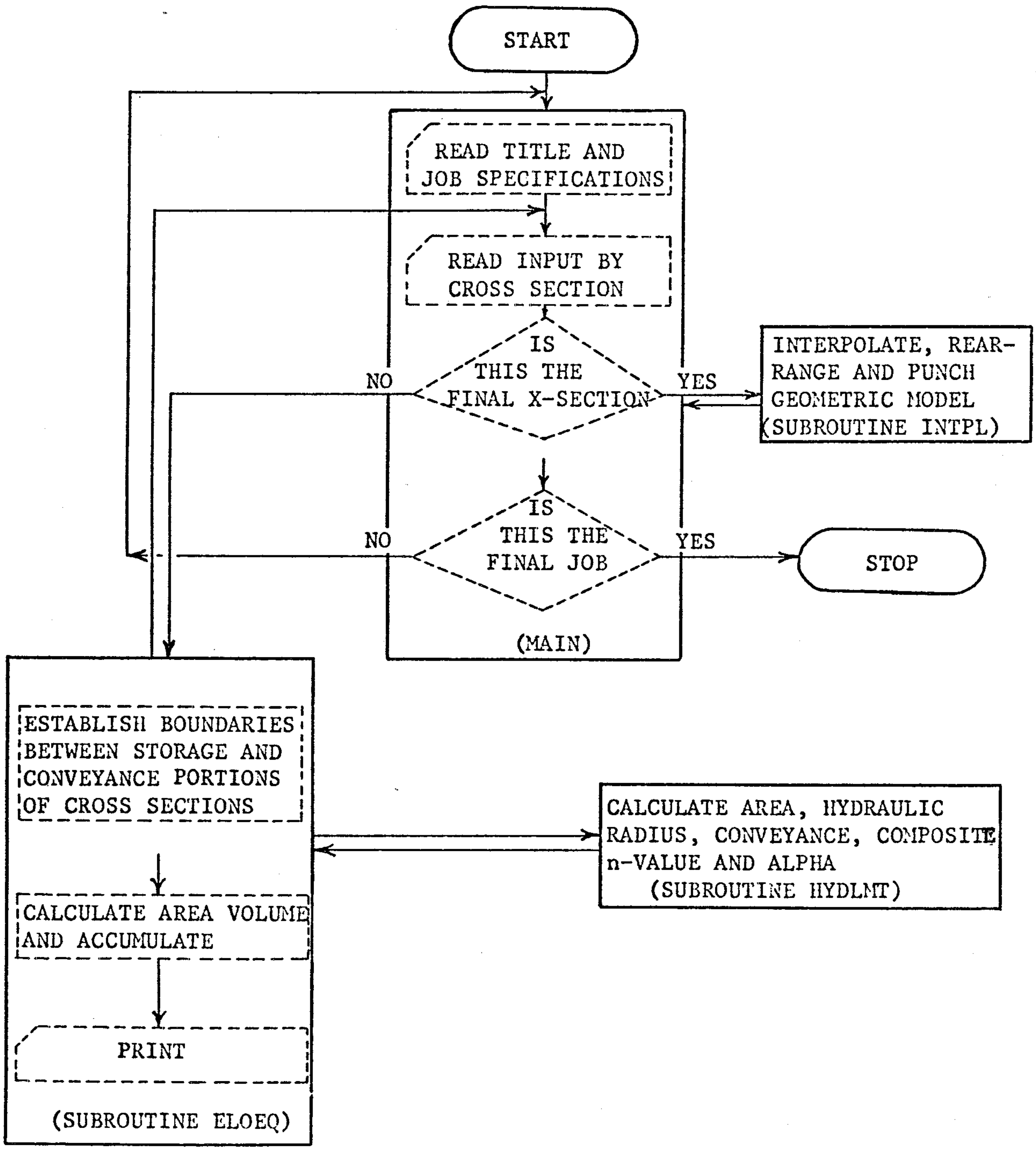
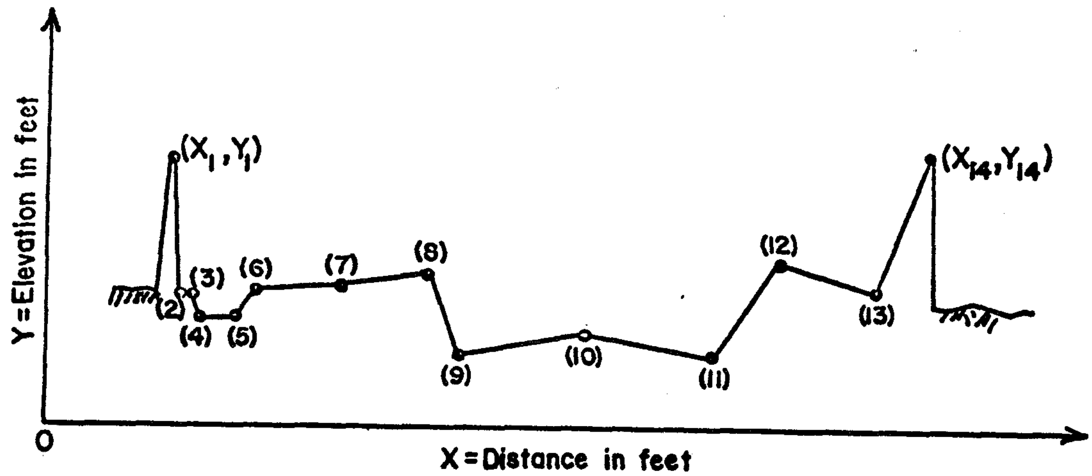


Figure 2. Functional and Organizational Flow Chart

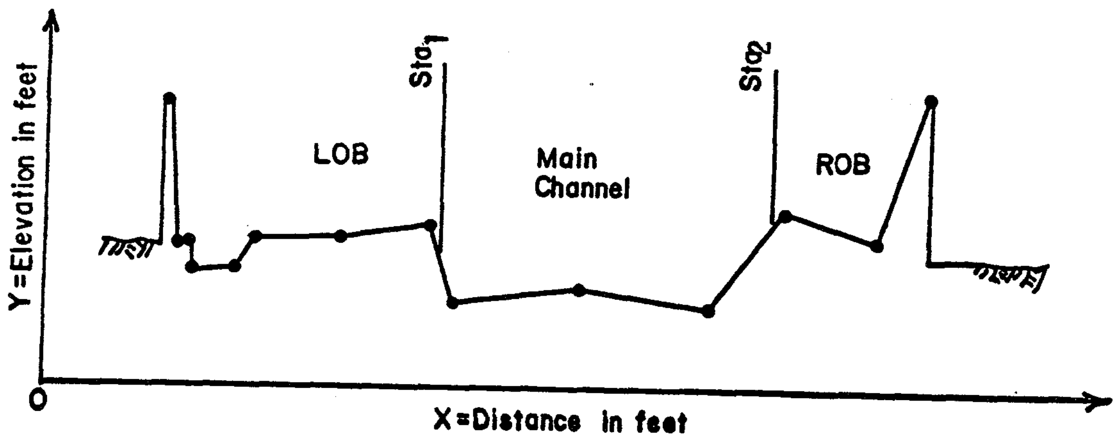
THEORETICAL BASIS

1. COMPUTATION OF GEOMETRIC ELEMENTS

Each cross section is defined by coordinate points, and for convenience of assigning n-values, reach lengths, etc., each cross section is divided into subsections.



a. Typical cross section



b. Subdivisions of typical cross section

Fig. 3. Typical Cross Section

The cross section is subdivided into left overbank, main channel, and right overbank, and hydraulic elements are computed for each of these subsections, as shown below.

a. Subsection area. The subsection area is computed by summing incremental areas between consecutive coordinates of the cross section. Fig. 4 illustrates the technique by using the Main Channel subsection (3) of the previous figure as an example.

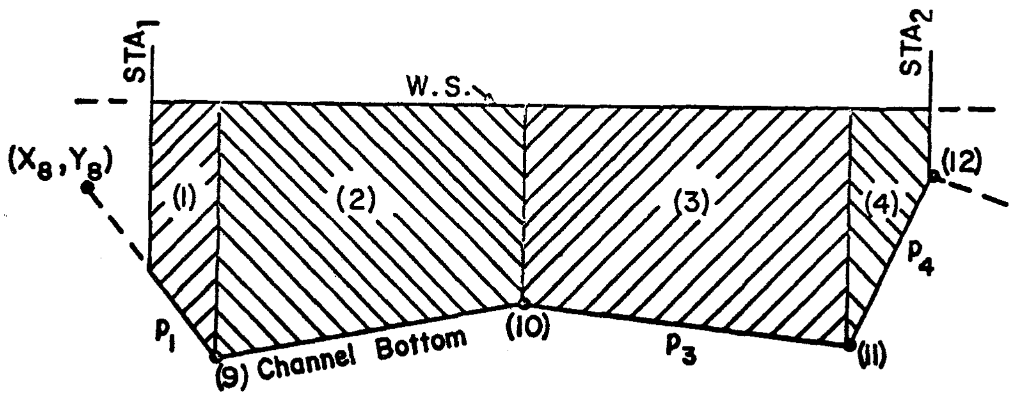


Fig. 4. Incremental Areas in Subsection

$$A_3 = a_1 + a_2 + a_3 + a_4$$

The equation for an incremental area is:

$$a = \frac{(A_1 + B_1)\, W_{avg}}{2}$$

Normally, where A_1, B_1 and W_{avg} are defined as shown in fig. 5, an incremental area is defined by two consecutive cross section coordinates. However, at the first and last increments in each subsection, a subsection station defines one side of the incremental area. If the subsection station does not coincide with an X coordinate, as below, straight line interpolation is used to compute the length of either A_1, B_1, or both.

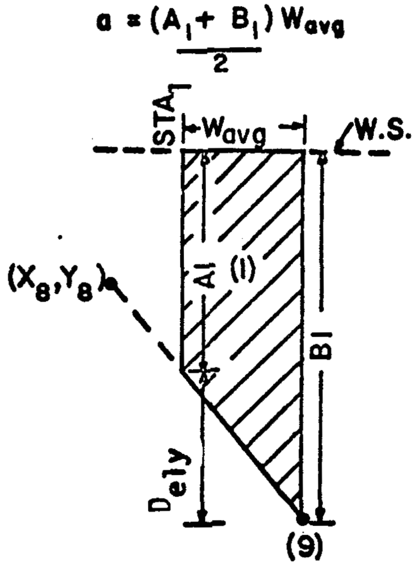


Fig. 5. An Incremental Area

b. Wetted perimeter. The wetted perimeter is computed as the length of cross section below the water surface. In the case of Fig. 4 this is:

$$P_3 = P_1 + P_2 + P_3 + P_4$$

The equation for wetted perimeter of each incremental area is:

$$p = \sqrt{\overline{D_{ely}}^2 + \overline{W_{avg}}^2}$$

where D_{ely} and W_{avg} are defined in fig. 5. Note that only the line between coordinate points and neither A_1 nor B_1 is considered in p. No energy is transferred between adjacent subsections.

c. Hydraulic radius. The hydraulic radius is calculated for each subsection:

$$R_j = \frac{A_j}{P_j}$$

2. CONVEYANCE

The conveyance is computed for each subsection by:

$$K_j = \frac{1.49}{n_j} A_j R_j^{2/3}$$

The total conveyance in the cross section is

$$K_t = \Sigma_{j=1}^{NSS} K_j$$

where NSS is total number of subsections.

3. ALPHA, THE VELOCITY DISTRIBUTION FACTOR

Alpha is a factor to account for the distribution of flow across the flood plain and not the vertical shape of the velocity profile. Large values (≥2) of Alpha may occur if the depth of flow on the overbanks is shallow, the conveyance small, and the area large. Alpha is computed as follows:

$$\alpha = \frac{\left(\frac{K_1}{A_1}\right)^2 K_1 + \left(\frac{K_2}{A_2}\right)^2 K_2 + \ldots + \left(\frac{K_j}{A_j}\right)^2 K_j + \ldots \left(\frac{K_{NSS}}{A_{NSS}}\right)^2 K_{NSS}}{\left(\frac{K_t}{A_t}\right)^2 K_t}$$

where A_t is the sum of the subsection areas and K_t is sum of conveyances.

4. COMPOSITE N-VALUE

The composite n-value is calculated as follows:

$$n = \frac{1.49 \times SUMA \times COMR^{2/3}}{SUMK}$$

SUMA = Total area of cross section (conveying flow)

COMR = Composite hydraulic radius = SUMA/SUMP

SUMK = Total conveyance of cross section (conveying flow)

SUMP = Total wetted perimeter of cross section (conveying flow)

5. VOLUME AND TOP WIDTH

Volume beneath the specified elevation is calculated by averaging each subsection end area and multiplying by the subsection reach length. These results are accumulated for each reach and with distance from the downstream end of the study area.

TOP WIDTH (not SUMW) is calculated for each nodal point using the interpolated values of accumulated volume.

$$V_{2DX} = V_o + B_w \times DH \times 2 \times DX$$

where

V_{2DX} = Volume of water that could be stored between nodal points located a distance of 2 x DX apart

V_o = Volume corresponding to the elevation 1DH below that elevation for V_{2DX}

B_w = TOP WIDTH at elevation DH/2 below that elevation for V_{2DX}

DH = Vertical distance between values in the elevation table

DX = Horizontal distance between nodal points

PROGRAM USAGE

1. COMPUTER EQUIPMENT REQUIREMENTS

This program requires 46000 decimal words of central processor memory on a CDC 7600. Punch file output, when requested, is written on Tape 7. A tape 95 is always generated for plotting results.

2. INPUT PREPARATION

The bulk of input data is required for pass I. Only the DX value (or the number of nodes) is utilized in subroutine INTPL.

a. Modeling the study reach. With the study reach located on a topographic map, mark the left (upstream) and right (downstream) boundaries and the lateral limits for the geometric model. Mark the location of each cross section in the study reach. Subdivide the flood plain into channel and overbank strips. Determine the reach length for each strip. This will be the distance between cross sections unless a strip ends before reaching the next cross section. Assign n-values to each strip.

It is important to correctly model both volume and conveyance. Therefore, delineate portions of a cross section conveying flow from that portion which just stores water. Special cross section controls are provided for this purpose (see subparagraph 2b (3) below). A sketch of the flow lines is usually sufficient to adequately separate conveyance of water from storage of water in the geometric model.

b. Coding input data. Code the data by starting at the downstream boundary and proceeding to the upstream boundary. A sample listing of the data cards for the problem presented in fig. 6 is shown on page 1, exhibit 1. A detailed description of input variables is given in exhibit 3 and a summary of required cards is shown in exhibit 4.

(1) Cross section coordinates. The station points which define the cross section geometry must be positive values in units of feet (actually, any consistent set of units may be used with this program if n-values are appropriately chosen) and must be entered in increasing order of magnitude. These are coded on GR-cards.

(2) Subsection stations. The left and right sides of the main channel subdivide the cross section into subsections. These do not have to coincide with a coordinate point, but they can.

(3) Conveyance limits. Computations for conveyance can be restricted to any portion of a cross section by specifying limits with either STS, ENST or both on the CL-card. None of these controls have to coincide with a subsection station, but they can. Volume computations are not restricted by these controls. The entire cross section is utilized to compute volume.

(4) Reach lengths. The reach length should be measured in feet and entered on the X1 card for the upstream end of each reach. A value is required for each strip in the reach. This length does not have to extend from one cross section to the next.

(5) n-values. Manning's n-values can either be a constant in each strip or they can vary vertically with either elevation or discharge in the main channel. They should be defined at the first cross section and be redefined only as necessary to change their value.

(6) Elevation table. This program will accept up to 30 different elevation values spaced at random. However, the "Gradually Varied Unsteady Flow Profiles" program will accept only 21 values of elevation and these may not be spaced at random intervals. Only three different intervals may be specified and these intervals must be integer numbers. The elevations may be real numbers but the interval between elevations must be integers.

It is recommended that larger increments be used at the top and bottom of the elevation table so that solutions generated by the unsteady flow program will always remain within the table.

(7) Section no. A cross section identification number is always assigned on the X1-card. River mile is recommended. However, this value is used for identification only -- not for distance between cross sections. Likewise, node numbers, which are interpolated from Section Numbers, are for identification only.

c. Computation grid. It is often desirable to project the values in the elevation table on a slope rather than horizontally. This is permitted by input variable ASEL (JP-card). It is also necessary to establish the distance between interpolated nodes. The routing program requires an odd number of nodes equal to or greater than 5. This can be produced by specifying NODE (JP-4) or DX (JP-3). The computation grid is different from the computation net in the unsteady flow program. This grid is in the (X,Y) plane whereas the computation net is in the (X,T) plane.

PROGRAM OUTPUT

1. PRINTED OUTPUT

Printed output is shown in exhibit 1. As each cross section is processed, Average Section Number, Reach Length (channel strip), Elevation, Area, R2/3, top width of conveyance portion of section, weighted n-value, Coriolis coefficient (alpha) for velocity distribution, accumulated surface area and accumulated volume beneath the water surface are printed.

After the final cross section has been processed, the geometric model being developed for the unsteady flow program is printed. Finally, a table of elevation versus volume is printed. These values are for comparison with the volumes printed at Section No. 3 of page 2, exhibit 1, as a check on the ability of the interpolated geometric data tables to reproduce the actual volume of the study reach.

2. PUNCHED CARD OUTPUT

The geometric elements will be punched on cards if that option is exercised (Card JP-10). The default option suppresses the punch. It is always advisable to review the printed results before punching the data.

EXAMPLE PROBLEM

The following figure shows boundary geometry for a prismatic channel on a slope of .0002.

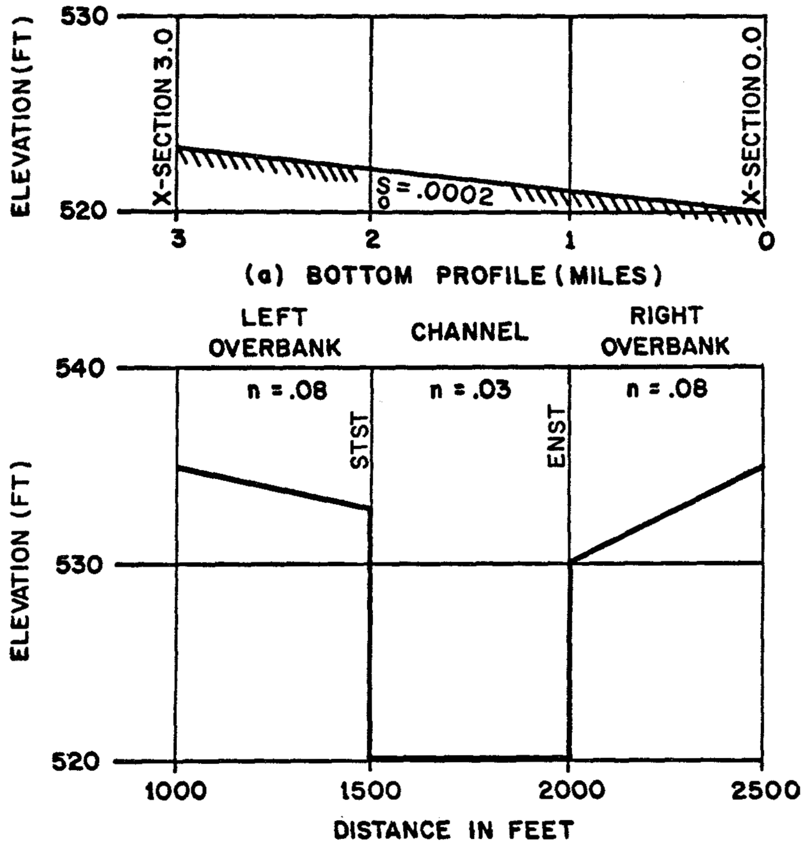


Figure 6 Annotated Boundary Geometry

The left overbank extends from cross section station 1000 to 1500. The channel extends from station 1500 to 2000, and the right overbank from 2000 to 2500. The n-values and reach lengths are shown on the figure. This example assumes that only the channel portion of the section conveys flow. The locations for STST and ENST are shown. These do not have to coincide with STA values.

The elevations specified for geometric data extend above elevation 535, the highest elevation of the cross section. The program assumes a vertical boundary at each end of the cross section, and it disregards any influence on wetted perimeter. Volume is important in the unsteady flow program; and it may be in error if the cross section coordinates do not extend above the elevation table range.

A listing of the input data is shown in exhibit 1. Only two cross sections are required, since the channel is prismatic, and the interpolation subroutine provides tables for seven nodal points equally spaced at 2640 feet apart.

3. TAPE 95 OUTPUT

The GEDA program produced a tape or file which contains 65 different output variables. The 65 variables are temporarily stored in an array called QVAR and written out to tape 95 as each section is processed. Tape 95 can then be used by HEC's Hydraulics Program to plot the variables interactively on a Tektronix 4014 computer display terminal or batch on a Calcomp drum plotter. A list and description of the 65 variables on tape 95 are given in Appendix I and II.

INSERT

MODIFICATIONS TO GEDA

(Version 4.2, Dec. 1987)

1. The computer program "Geometric Elements from Cross Section Coordinates" (GEDA) has been modified to operate interactively; that is, the user merely enters the name of the executable program file and responds to prompts from the program for various file names. GEDA also can now produce data files for direct input to the NWS DAMBRK computer program. The data that GEDA develop are input records 20-25 (distances, elevations, and top widths), and 28-30 (Manning's n-values). The former are written to default file name R2025 and the latter to R2830. The rest of the DAMBRK input data set will have to be prepared by the user and merged with the GEDA - produced data using either an editor or system commands.

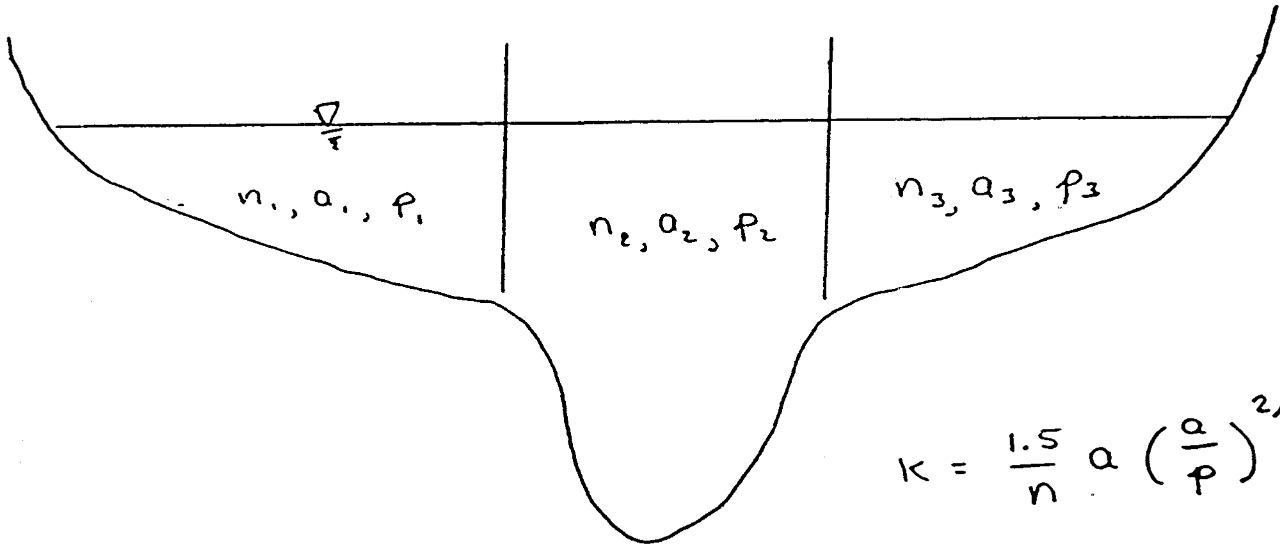
2. DAMBRK has two options for routing; the "standard" option and the special "flood plain" option. The cross section data are different for these two options. GEDA will prepare data for either option at the users request. For the standard option, DAMBRK top-width and n-value vs. elevation functions are computed using the same compositing approach as is used for preparation of input to DWOPER (please refer to "Documentation for the GEDA/DWOPER Interface", dated 17 April 85). For the flood plain option, the HEC-2 cross section is used directly; that is, the left overbank n-value and top width are transferred into the DAMBRK data for the left flood plain, and likewise for the other two subdivisions. Note, since DAMBRK uses n-values on a reach basis rather than on a section basis, the subdivision n-values are averaged for two successive sections to obtain a reach value.

3. At this time (Dec. 1987), these changes to GEDA have received minimal testing, particularly the flood plain option calculation. A potential problem area is that of one section having an overbank, followed or preceded by a section that does not. Users are advised to check BOTH the GEDA output AND the files developed for DAMBRK for errors or discrepancies. Please notify Michael Gee at HEC (FTS 460-1748 or (916) 551-1748) of any problems.

Documentation for the GEDA/DWOPER Interface

Background: Increasing use of the National Weather Service's dynamic routing model, "Dynamic Wave-Operational" (DWOPER), for unsteady flow analyses has highlighted the need for an improved means for describing hydraulic geometry for that program. Geometric input to DWOPER consists of tables of cross-section widths and composite Manning n values as functions of elevation. Development of these data has proven difficult for two reasons: (1) many users are familiar with the x-y coordinate method of describing cross sections and many data sets exist in that format (i.e., for the program HEC-2); and (2) composite n values for complex cross sections cannot be estimated directly from field observations. Experience has shown that use of estimated n values directly in DWOPER data can result in conveyance functions that decrease with elevation, which, in turn, leads to computational instabilities. Consequently the HEC has modified an existing program, "Geometric Elements from Cross Section Coordinates" (GEDA), to develop input geometric data for DWOPER which are consistent with HEC-2 data in both conveyance and volume (storage). It is emphasized that correct dynamic routing will be achieved only if the HEC-2 cross sections accurately describe both storage and conveyance of the river channel. The GEDA-produced data are in the appropriate sequence and format for DWOPER versions dated 2/22/80 to 7/18/84.

Theory: HEC-2 cross sections are subdivided to allow for transverse distribution of roughness. Given an HEC-2 cross section, GEDA computes the total conveyance and top width of that section for a sequence of elevations. The composite n vs. elevation function that provides the same conveyance at each elevation is then calculated. An example is shown below.



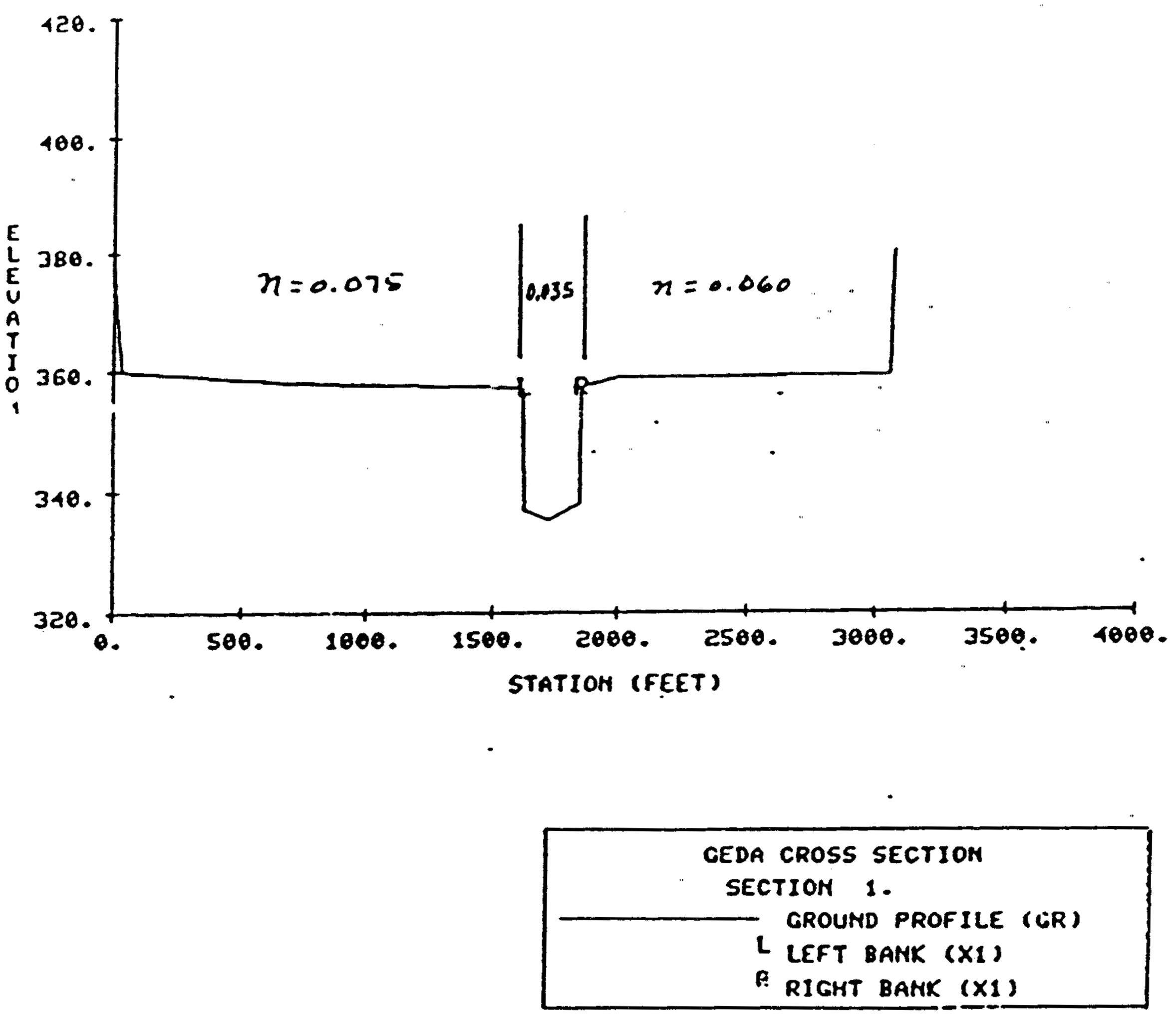
$$K = \frac{1.5}{n} a \left(\frac{a}{p}\right)^{2/3}$$

$$K_T = K_1 + K_2 + K_3$$

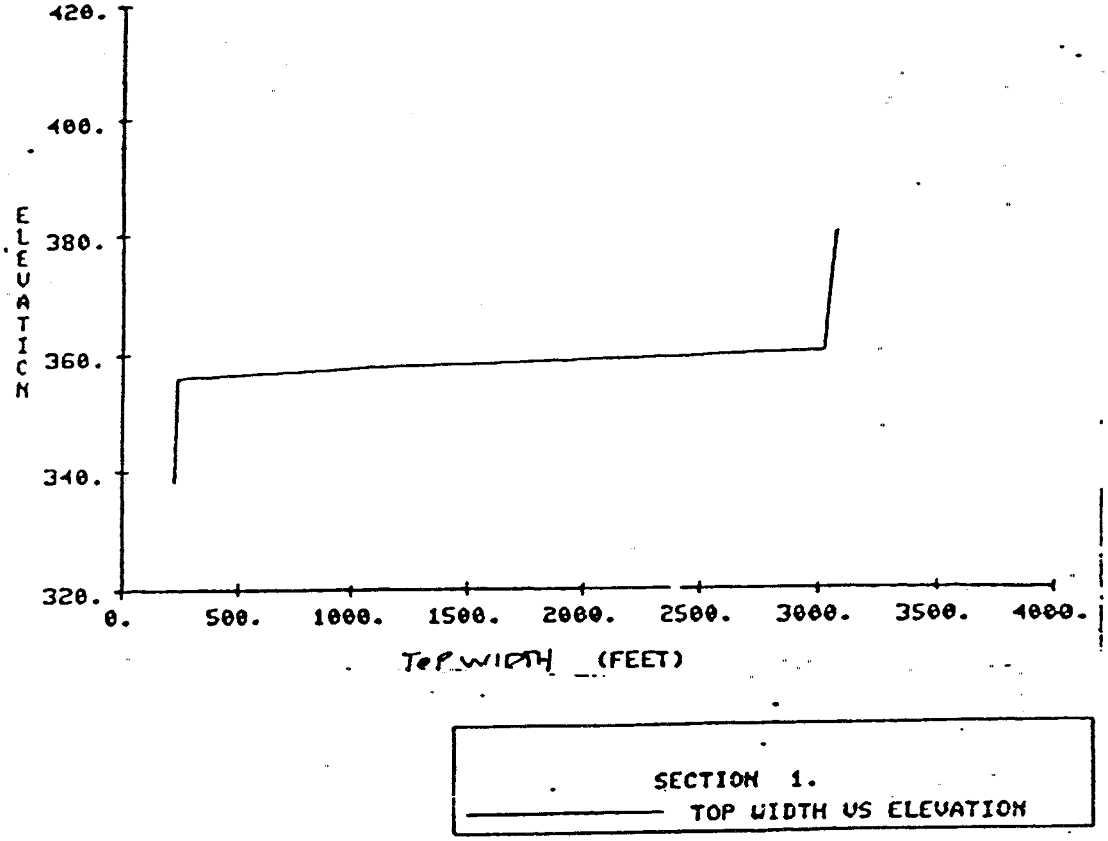
$$A_T = A_1 + A_2 + A_3$$

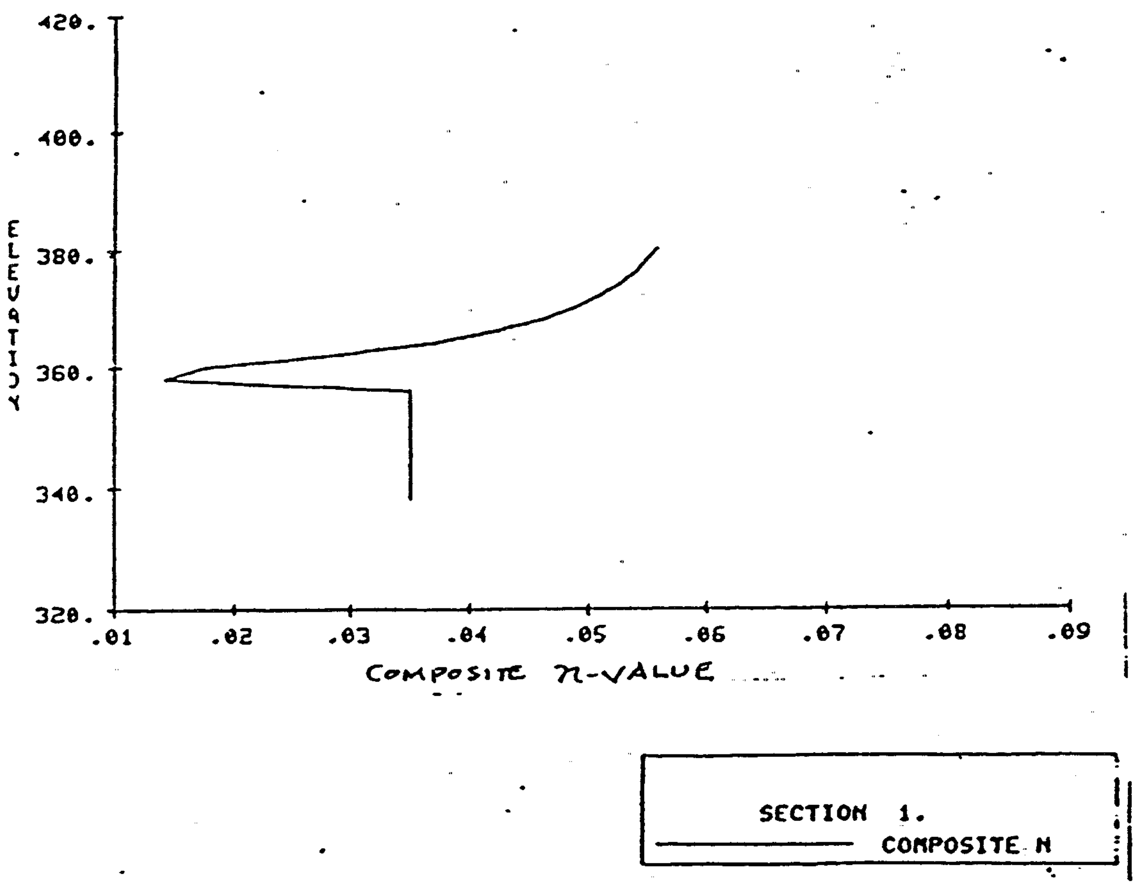
$$P_T \approx B_1 + B_2 + B_3$$

$$n_{\text{COMPOSITE}} = \frac{1.5\, A_T \left(\frac{A_T}{P_T}\right)^{2/3}}{K_T}$$



420.
400.
380.
360.
340.
320.
ELEVATION
n=0.075
0.035
n=0.060
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
STATION (FEET)
GEDA CROSS SECTION
SECTION 1.
GROUND PROFILE (GR)
L LEFT BANK (X1)
R RIGHT BANK (X1)


420.
400.
380.
360.
340.
320.
ELEVATION
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
TOP WIDTH (FEET)
SECTION 1.
TOP WIDTH VS ELEVATION


420.
400.
380.
360.
340.
320.
ELEVATION
.01
.02
.03
.04
.05
.06
.07
.08
.09
COMPOSITE n-VALUE
SECTION 1.
COMPOSITE N

Also, as DWOPER allows only a single distance between sections, the GEDA program calculates that distance to preserve the volume between each two successive sections using the HEC-2 channel and overbank distances. This computation is only performed for the highest elevation for which information is requested.

Operation: Upon execution of GEDA all geometric data are written to disk files* in the correct sequence (upstream to downstream) and format for DWOPER input if the variables NODE and DX (refer to the JP card description in the GEDA Users Manual) are set to zero. The data are computed for each HEC-2 section input. The interpolation feature of GEDA plays no role in the process and should not be used. Consequently, DWOPER computational points coincide with the HEC-2 sections.

The elevations for which widths and n values are calculated are controlled by the ET cards. Separation of sections into active and inactive widths is governed by KL cards. Refer to the GEDA Users Manual for descriptions of these cards.

The specific DWOPER input card images and the units to which they are written are shown in Table 1.

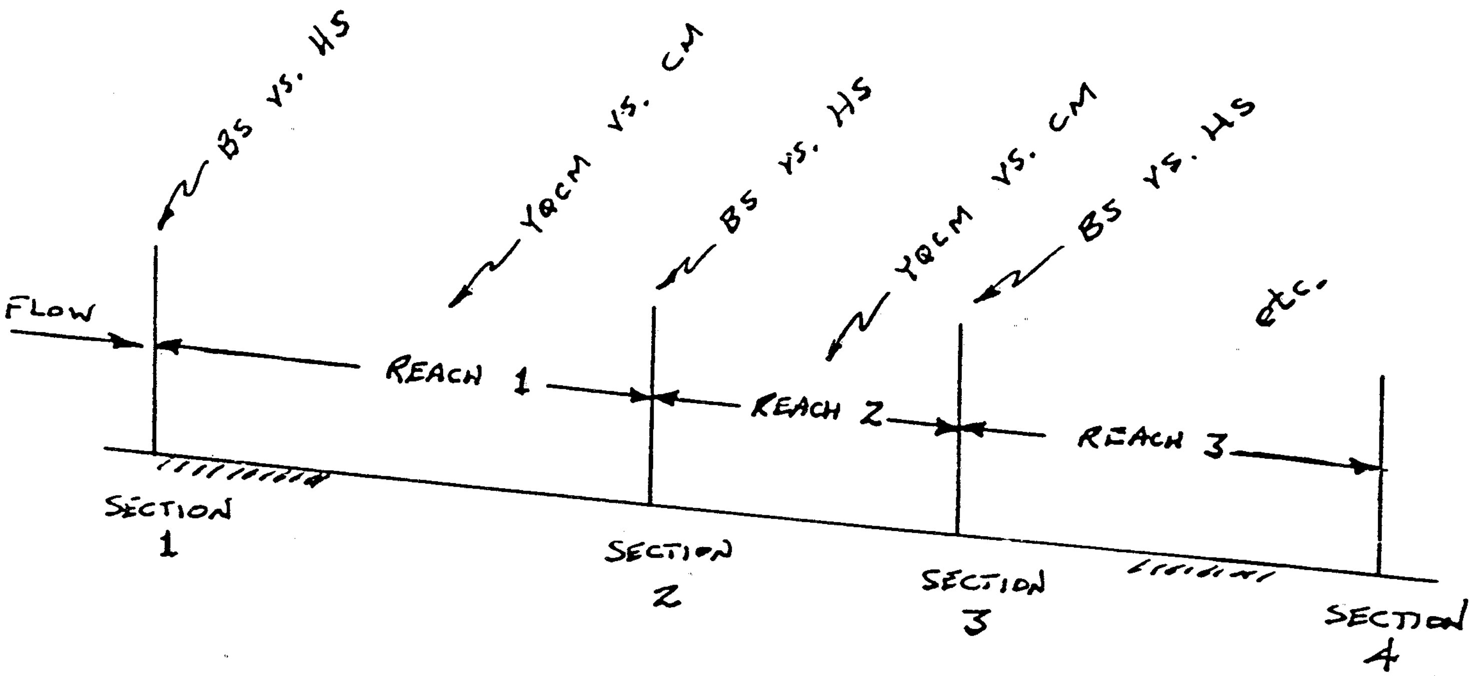
*Because geometric data appear at several locations in the DWOPER input stream, several files must be merged upon DWOPER execution.

TABLE 1 DWOPER VARIABLES WRITTEN BY GEDA

DWOPER Variable Name	DWOPER Card Group No.	Description	Unit No.
BS	28	Table of top widths for all sections, upstream to downstream	11
HS	29	Table of elevations corresponding to the above	11
AS	30	Cross-sectional area below lowest elevation at each section	11
BSS	31	Table of storage widths	15*
HSS	32	Elevations corresponding to above (same as HS)	15
ASS	33	Storage area below lowest elevation (these are always zero)	15
X	36	Location of each computational section, units are feet from upstream boundary	14
YQCM	55	Table of elevations for which n values are provided, by reach** from upstream to downstream	12
CM	56	Manning n values corresponding to above	13

* The information on unit 15 is only written for those sections that have off-channel storage. This can be ascertained from GEDA output.

**NOTE: n values are associated with reaches rather than sections in the DWOPER computational scheme. Therefore, when using GEDA, an n value vs. elevation function is determined for every "reach" between two cross sections by averaging the n vs. elevation functions at the two cross sections bounding the reach. Hence, for DWOPER input the number of Manning n reaches (NRCM1, card 15) is one less than the number of cross sections and the station numbers defining those reaches (NCM, card 16) starts with 2 and goes to NB (the number of sections).



EXAMPLE STREAM PROFILE
SHOWING RELATIONSHIP BETWEEN
CROSS SECTIONS AND REACHES

Input Data

```
T1        TEST 1 PREPARED IN AUG74 ** DATA DECK IN HEC-2 FORMAT **
T2        GEOMETRIC ELEMENTS FROM CROSS SECTION COORDINATES, AUXILARY PROGRAM TO
T3        GRADUALLY VARIED UNSTEADY FLOW PROFILES.    W A THOMAS, HEC, DAVIS, CA.
JP           .0002            2640.
ET   521.     522.     523.     524.     525.     526.                              1
NC    .08      .08      .03
X1     0.       6.    1500.    2000.
GR   535.    1000.     533.    1500.     520.    1500.     520.    2000.     530.    2000.
GR   535.    2500.
X1    3.0       0.    1500.    2000.   15840.   15840.   15840.            3.168
EJ
```

```
VERSION 2.2 19SEPT1974
T1      TEST 1 PREPARED IN AUG74 ** DATA DECK IN HEC-2 FORMAT **
T2      GEOMETRIC ELEMENTS FROM CROSS SECTION COORDINATES, AUXILARY PROGRAM TO
T3      GRADUALLY VARIED UNSTEADY FLOW PROFILES.    W A THOMAS, HEC, DAVIS, CA.

HEADING DATA IN HEC-2 FORMAT.
ONLY CARDS NC,NV,X1,X3 AND GR CARDS ARE PERMITTED.

P-CARD         ASEL          JM      DX        KSW(1)   KSW(11)   KSW(12)
             .0002000         6   2640.00         1        -0         1

                                       ELEVATION TABLE
   521.000   522.000   523.000   524.000   525.000   526.000

              ELEV       AREA        R2/3      SUMW        ANV        ALFA  SURFACE   VOLUME

SEC NO.       0.000
INCREMENTAL AND ACCUMULATED CHANNEL LENGTHS =          0          0
INCREMENTAL AND ACCUMULATED WEIGHTED LENGTHS=          0          0 RATIO OF ACCUMULATED WEIGHT/CHANNEL=     0.0000
              521.00     500.00       1.00    500.00      .0300    1.0000        0        0
              522.00    1000.00       1.58    500.00      .0300    1.0000        0        0
              523.00    1500.00       2.06    500.00      .0300    1.0000        0        0
              524.00    2000.00       2.49    500.00      .0300    1.0000        0        0.
              525.00    2500.00       2.89    500.00      .0300    1.0000        0        0
              526.00    3000.00       3.25    500.00      .0300    1.0000        0        0

SEC NO.       3.000
INCREMENTAL AND ACCUMULATED CHANNEL LENGTHS =      15840      15840
INCREMENTAL AND ACCUMULATED WEIGHTED LENGTHS=      15840      15840 RATIO OF ACCUMULATED WEIGHT/CHANNEL=     1.0000
              524.17     500.00       1.00    500.00      .0300    1.0000      182      182
              525.17    1000.00       1.58    500.00      .0300    1.0000      182      364
              526.17    1500.00       2.06    500.00      .0300    1.0000      182      545
              527.17    2000.00       2.49    500.00      .0300    1.0000      182      727
              528.17    2500.00       2.89    500.00      .0300    1.0000      182      909
              529.17    3000.00       3.25    500.00      .0300    1.0000      182     1091
```

GEOMETRIC MODEL FOR UNSTEADY FLOW PROGRAM 8

SDM	ITM	JM	ASEL	DX	FORMAT
3.00	7	6	.00020	2640.0	8X,F8.0,8X,5F8.0,/(24X,5F8.0)

X-SEC NO	X	ELEV	AREA	R2/3	TOP WIDTH	AVG N-VALUE	ALPHA
3.000	0.000	524.17	500	1.00	500	.0300	1.0000
3.000	0.000	525.17	1000	1.58	500	.0300	1.0000
3.000	0.000	526.17	1500	2.06	500	.0300	1.0000
3.000	0.000	527.17	2000	2.49	500	.0300	1.0000
3.000	0.000	528.17	2500	2.89	500	.0300	1.0000
3.000	0.000	529.17	3000	3.25	500	.0300	1.0000
2.500	.500	523.64	500	1.00	500	.0300	1.0000
2.500	.500	524.64	1000	1.58	500	.0300	1.0000
2.500	.500	525.64	1500	2.06	500	.0300	1.0000
2.500	.500	526.64	2000	2.49	500	.0300	1.0000
2.500	.500	527.64	2500	2.89	500	.0300	1.0000
2.500	.500	528.64	3000	3.25	500	.0300	1.0000
2.000	1.000	523.11	500	1.00	500	.0300	1.0000
2.000	1.000	524.11	1000	1.58	500	.0300	1.0000
2.000	1.000	525.11	1500	2.06	500	.0300	1.0000
2.000	1.000	526.11	2000	2.49	500	.0300	1.0000
2.000	1.000	527.11	2500	2.89	500	.0300	1.0000
2.000	1.000	528.11	3000	3.25	500	.0300	1.0000
1.500	1.500	522.58	500	1.00	500	.0300	1.0000
1.500	1.500	523.58	1000	1.58	500	.0300	1.0000
1.500	1.500	524.58	1500	2.06	500	.0300	1.0000
1.500	1.500	525.58	2000	2.49	500	.0300	1.0000
1.500	1.500	526.58	2500	2.89	500	.0300	1.0000
1.500	1.500	527.58	3000	3.25	500	.0300	1.0000
1.000	2.000	522.06	500	1.00	500	.0300	1.0000
1.000	2.000	523.06	1000	1.58	500	.0300	1.0000
1.000	2.000	524.06	1500	2.06	500	.0300	1.0000
1.000	2.000	525.06	2000	2.49	500	.0300	1.0000
1.000	2.000	526.06	2500	2.89	500	.0300	1.0000
1.000	2.000	527.06	3000	3.25	500	.0300	1.0000
.500	2.500	521.53	500	1.00	500	.0300	1.0000
.500	2.500	522.53	1000	1.58	500	.0300	1.0000
.500	2.500	523.53	1500	2.06	500	.0300	1.0000
.500	2.500	524.53	2000	2.49	500	.0300	1.0000
.500	2.500	525.53	2500	2.89	500	.0300	1.0000
.500	2.500	526.53	3000	3.25	500	.0300	1.0000
.000	3.000	521.00	500	1.00	500	.0300	1.0000
.000	3.000	522.00	1000	1.58	500	.0300	1.0000
.000	3.000	523.00	1500	2.06	500	.0300	1.0000
.000	3.000	524.00	2000	2.49	500	.0300	1.0000
.000	3.000	525.00	2500	2.89	500	.0300	1.0000
.000	3.000	526.00	3000	3.25	500	.0300	1.0000

ELEVATION	AREA	VOLUME, *
524		182
525		364
526		545
527		727
528		909
529		1091

END OF RUN

*NOTE: The units of volume are acre-feet.

Input Data *

```
* TEST 2 PREPARED IN OCT69, MODIFIED MAR71, AUG74
* GEOMETRIC ELEMENTS FROM CROSS SECTION COORDINATES, AUXILARY PROGRAM TO
* GRADUALLY VARIED UNSTEADY FLOW PROFILES.      W A THOMAS, HEC, DAVIS, CALIF.
P       .0002                           6.      2640.                           1
R521.   522.    523.    524.    525.    526.
A0.     1.      6.              1.
B1500.  2000.   2500.                                   1500.   2000.   2000.
C1.     1.      1.
E0.08   .03     .08
G1000.  535.    1500.   533.    1500.   520.    2000.   520.    2000.   530.
G2500.   535.
A3.0    1.      6.
B1500.  2000.   2500.                                   1500.   2000.   2000.
C15840. 15840.  15840.
G1000.  538.168 1500.   536.168 1500.   523.168 2000.   523.168 2000.   533.168
G2500.  538.168
A       -1.
```

*NOTE: Test 2 is coded in an alternate input format which is not described in this manual.

```
VERSION 2.2 19SEPT1974
* TEST 2 PREPARED IN OCT69, MODIFIED MAR71, AUG74
* GEOMETRIC ELEMENTS FROM CROSS SECTION COORDINATES, AUXILARY PROGRAM TO
* GRADUALLY VARIED UNSTEADY FLOW PROFILES.        W A THOMAS, HEC, DAVIS, CALIF.


PROGRAM READING DATA IN ALTERNATE FORMAT.
ONLY CARDS R,W,A,B,C,D,E AND G OR GR ARE PERMITTED.

P-CARD         ASEL          JM        DX        KSW(1)    KSW(11)   KSW(12)
             .0002000         6     2640.00        -0        -0         1

R-CARD                                                     ELEVATIONS
  521.000    522.000    523.000    524.000    525.000    526.000

T-CARD                                    INITIAL WATER SURFACE AREA IN ACRES
      0          0          0          0          0          0
U-CARD                                      INITIAL VOLUME IN ACRE-FEET
    0.0        0.0        0.0        0.0        0.0        0.0


             ELEV       AREA       R2/3      SUMW        ANV       ALFA  SURFACE   VOLUME


SEC NO.      0.000
INCREMENTAL AND ACCUMULATED CHANNEL LENGTHS =            0          0
INCREMENTAL AND ACCUMULATED WEIGHTED LENGTHS=            0          0 RATIO OF ACCUMULATED WEIGHT/CHANNEL=     0.0000
              521.00     500.00       1.00     500.00      .0300     1.0000         0         0
              522.00    1000.00       1.58     500.00      .0300     1.0000         0         0
              523.00    1500.00       2.06     500.00      .0300     1.0000         0         0
              524.00    2000.00       2.49     500.00      .0300     1.0000         0         0
              525.00    2500.00       2.89     500.00      .0300     1.0000         0         0
              526.00    3000.00       3.25     500.00      .0300     1.0000         0         0

SEC NO.      3.000
INCREMENTAL AND ACCUMULATED CHANNEL LENGTHS =        15840      15840
INCREMENTAL AND ACCUMULATED WEIGHTED LENGTHS=        15840      15840 RATIO OF ACCUMULATED WEIGHT/CHANNEL=     1.0000
              524.17     500.00       1.00     500.00      .0300     1.0000       182       182
              525.17    1000.00       1.58     500.00      .0300     1.0000       182       364
              526.17    1500.00       2.06     500.00      .0300     1.0000       182       545
              527.17    2000.00       2.49     500.00      .0300     1.0000       182       727
              528.17    2500.00       2.89     500.00      .0300     1.0000       182       909
              529.17    3000.00       3.25     500.00      .0300     1.0000       182      1091
```

GEOMETRIC MODEL FOR UNSTEADY FLOW PROGRAMS

SDM	ITM	JM	ASEL	DX	FORMAT
3.00	7	6	.00020	2640.0	8X,F8.0,8X,5F8.0,/(24X,5F8.0)

X-SEC NO	X	ELEV	AREA	R2/3	TOP WIDTH	AVG N-VALUE	ALPHA
3.000	0.000	524.17	500	1.00	500	.0300	1.0000
3.000	0.000	525.17	1000	1.58	500	.0300	1.0000
3.000	0.000	526.17	1500	2.06	500	.0300	1.0000
3.000	0.000	527.17	2000	2.49	500	.0300	1.0000
3.000	0.000	528.17	2500	2.89	500	.0300	1.0000
3.000	0.000	529.17	3000	3.25	500	.0300	1.0000
2.500	.500	523.64	500	1.00	500	.0300	1.0000
2.500	.500	524.64	1000	1.58	500	.0300	1.0000
2.500	.500	525.64	1500	2.06	500	.0300	1.0000
2.500	.500	526.64	2000	2.49	500	.0300	1.0000
2.500	.500	527.64	2500	2.89	500	.0300	1.0000
2.500	.500	528.64	3000	3.25	500	.0300	1.0000
2.000	1.000	523.11	500	1.00	500	.0300	1.0000
2.000	1.000	524.11	1000	1.58	500	.0300	1.0000
2.000	1.000	525.11	1500	2.06	500	.0300	1.0000
2.000	1.000	526.11	2000	2.49	500	.0300	1.0000
2.000	1.000	527.11	2500	2.89	500	.0300	1.0000
2.000	1.000	528.11	3000	3.25	500	.0300	1.0000
1.500	1.500	522.58	500	1.00	500	.0300	1.0000
1.500	1.500	523.58	1000	1.58	500	.0300	1.0000
1.500	1.500	524.58	1500	2.06	500	.0300	1.0000
1.500	1.500	525.58	2000	2.49	500	.0300	1.0000
1.500	1.500	526.58	2500	2.89	500	.0300	1.0000
1.500	1.500	527.58	3000	3.25	500	.0300	1.0000
1.000	2.000	522.06	500	1.00	500	.0300	1.0000
1.000	2.000	523.06	1000	1.58	500	.0300	1.0000
1.000	2.000	524.06	1500	2.06	500	.0300	1.0000
1.000	2.000	525.06	2000	2.49	500	.0300	1.0000
1.000	2.000	526.06	2500	2.89	500	.0300	1.0000
1.000	2.000	527.06	3000	3.25	500	.0300	1.0000
.500	2.500	521.53	500	1.00	500	.0300	1.0000
.500	2.500	522.53	1000	1.58	500	.0300	1.0000
.500	2.500	523.53	1500	2.06	500	.0300	1.0000
.500	2.500	524.53	2000	2.49	500	.0300	1.0000
.500	2.500	525.53	2500	2.89	500	.0300	1.0000
.500	2.500	526.53	3000	3.25	500	.0300	1.0000
.000	3.000	521.00	500	1.00	500	.0300	1.0000
.000	3.000	522.00	1000	1.58	500	.0300	1.0000
.000	3.000	523.00	1500	2.06	500	.0300	1.0000
.000	3.000	524.00	2000	2.49	500	.0300	1.0000
.000	3.000	525.00	2500	2.89	500	.0300	1.0000
.000	3.000	526.00	3000	3.25	500	.0300	1.0000

ELEVATION	AREA	VOLUME, *
524		182
525		364
526		545
527		727
528		909
529		1091

END OF JOB

*NOTE: The units of volume are acre-feet.

DESCRIPTION OF PAUSES

Pause No.	Cause	Action
0	End of job	
1	Negative value in input data.	Check Q(N), IDF, MEID, NCH, KXY, KQCH, n-values, NMD, ISXY.
2	one or more reach lengths either zero or blank. One or more STA(I) values are negative.	
3	Negative value in the n-value table.	
4	Logical error in program code.	Requires program debugging.
5	STA(I) is larger than the largest X coordinate on the GR cards.	
6	Sill length or sill elevation is negative.	Positive values required.
10	STST is negative	Positive value is required.
11	STST is larger than the largest X coordinate on the GR cards.	
12	STST is larger than the largest STA(I) value.	Change the data so at least 1 STA(I) value is greater than STST.
13	Logical error in subroutine HYDLMT.	Requires program debugging.
14	Either STST or the first STA(I) value is larger than the largest X coordinate on the GR card.	
15	An X coordinate is smaller than the previous one coded on the GR card.	

Pause No.	Cause	Action
16	Logical error in subroutine HYDLMT.	Requires program debugging.
17	Logical error in subroutine HYDLMT. Variable LOST is one and should not be.	Same as 16.
18	Similar to 17 except LOST = 2.	Same as 16.
19	Similar to 17 except LOST = 3.	Same as 16.
20	A bridge section has been entered, but there are not enough discharge coefficients.	Check data and eliminate bridge sections.
21	Starting water surface elevation is below critical depth.	This pause should be eliminated. Check the program logic.
22	Submerged flow exists at a weir and no submergence coefficients were provided.	Eliminate weir sections.
23	Submerged flow exists and 2 submergence coefficients are the same.	Same as 22.

GEOMETRIC ELEMENTS PROGRAM

INPUT DATA DESCRIPTION

Version 3.0 January 1976

This input description presents a "value" or "range of values" for each variable. The code "+" under the "Value" column means any positive number. Zeroes are not recommended except where indicated in the "Value" column. Avoid negative numbers unless that option is specifically stated as a value. Blanks are read as zero except where otherwise noted. Parentheses denote footnotes. All numeric variables are read as floating point numbers and integer variables are converted immediately after being read. Numbers may be coded either left or right justified.

HEC-2 Data Cards T1, T2, T3, NC, NV, X1, X3, X4 and GR are permitted. However, only a portion of the data on cards NC, X1, and X3 are utilized in this program (see pages for each card type).

INPUT DATA DESCRIPTION

TITLE CARDS - REQUIRED CARDS

CARDS T1, T2, T3

a. CARD T1

Title card for output title. This card is required for each job.

Field	Variable	Value	Description
0		T1	Card identification characters.
1-10	None		Numbers and alphabetical characters for title.

b. CARD T2

Title card for output title. This card is required for each job.

Field	Variable	Value	Description
0		T2	Card identification characters.
1-10	None		Numbers and alphabetical characters for title.

c. CARD T3

Title card for output title. This card is required for each job.

Field	Variable	Value	Description
0		T3	Card identification characters.
1-10	None		Numbers and alphabetical characters for title.

Note: Columns 9-32 on card T3 are not saved for subsequent use on plots, and this differs from the T3 card in HEC-2.

JOB PARAMETERS - REQUIRED CARD

CARD JP

The geometric elements may be calculated for the same elevation at each cross section or they may be calculated on a sloping grid. The latter usually results in fewer elevation points for jobs covering long distances of the river. In any case, using a sloping grid is only a matter of convenience and the slope does not impact on routing calculations in the unsteady flow model.

FIELD	VARIABLE	VALUE	DESCRIPTION
0	ICG	JP	Card identification characters.
1	AVGS	0,+,-	The downstream cross section identification (i"e., if cross section locations are identified by River Mile (X1-i), use the mile for the first sections here).
2	ASEL	+,-	The change in elevation between cross sections is calculated by multiplying the slope ASEL times the channel reach length.
		1000	ASEL will be based on the downstream channel slope.
		2000	ASEL will be based on the downstream minimum channel bank elevation slope.
3	NODE	0	The program will calculate the number of nodes from DX and the total model length.
		+	The program will calculate the distance between nodes from total model length and interpolate tables of geometric elements at those points.
4	DX	0	The value for NODE should be positive so the program will calculate DX and the resulting tables of geometric elements.

FIELD	VARIABLE	VALUE	DESCRIPTION
		+	Tables of geometric elements will be interpolated on the constant interval, DX, however, if both NODE and DX have been specified the value for NODE will override the value for DX.
5	LFA	0	Program calculates the velocity distribution factor ALPHA.
		1	The program assigns 1 to the velocity distribution factor.
6	NOSC	0	The largest identification number that can be printed or punched out by this program is 9999.999. The largest cross section area is 9,999,999. The program will test the size of section identification numbers and cross section areas and calculate a factor to scale down numbers which are too large. An appropriate note is printed giving the resulting scale factor.
		+	A scale factor of 1.0 is assigned.
7-8			Not used.
9	KSW(11)	0	Suppresses printout of subsection areas, wetted perimeters, conveyances, etc.
		1	Print the intermediate values of conveyance, area, hydraulic radius, n-value and reach length for each subsection in each cross section.
10	KSW(12)	0	The geometric elements are interpolated from adjacent input cross-sections and printed.
		1	Punch cards of the above geometric elements for subsequent use in the routing calculation.
		2	The geometric elements are interpolated by weighting the values at all input cross-sections within $\pm\frac{1}{2}$DX of the node and printed.
		3	Punch cards of the above geometric elements for subsequent use in the routing calculation.

ELEVATION TABLE - REQUIRED CARDS

CARD ET

The table of geometric elements may contain from 3 up to 21 values of elevation. The difference between two successive elevation values on this card, called the elevation interval, must be an integer amount for the routing program. Up to three different intervals may be utilized. Values must be entered from lowest to highest elevation for the routing program.

Field	Variable	Value	Description
0	ICG	ET	Card identification characters.
1 - 10	WS	0,+	Elevations may be zero or positive. Enter 10 values across the card and use as many cards as are required. The program will count the number of values internally using a zero or blank field to signify the end of elevations.

WEIGHTED REACH LENGTH - OPTIONAL CARDS

CARD WL

Frequently, the channel distance is not representative of the length of flow when extremely large flood events are to be analyzed. This card permits the user to enter a length between cross sections that reflects the flow length for the floods that he plans to analyze. The weighted reach length is not used in calculating area and volume, only in establishing the location of cross sections for subsequent calculations as the geometric elements are interpolated for each Node.

Field	Variable	Value	Description
0	ICG	WL	Card identification characters.
1-10	XRL	0	At the first cross section only.
		+	The weighted distance from the second to the first cross section is entered in field 2. Field 3 goes with the third cross section, ETC. Enter one value of weighted reach length for each cross section. The program will count the number of values entered using 0 or blank to identify the end.

REQUIRED CARD FOR FIRST CROSS SECTION

CARD NC

Manning's n-values are entered for starting each job, or for changing values previously specified. Manning's n-values apply at a cross section and halfway to the cross section on either side. The values on this NC card apply to the cross section described on the following X1 card and apply until changed by a future NC card.

Field	Variable	Value	Description
0	IA	NC	Card identification characters.
1	XNL	0	No change in Manning's "n" value for the left overbank.
		+	Manning's "n" value for the left overbank.
2	XNR	0	No change in Manning's "n" value for the right overbank.
		+	Manning's "n" value for the right overbank.
3	XNCH	0	No change in Manning's "n" value for the channel.
		+	Manning's "n" value for the channel.

Note: Other HEC-2 variables on NC-card are not used in this program.

OPTIONAL CARD FOR ROUGHNESS DESCRIPTION

CARD NV

Used to vary the channel n-values in the vertical based on water surface elevations. Straight line interpolation is used between points.

Field	Variable	Value	Description
0	IA	NV	Card identification characters.
1	NUMNV	+	Total number of Manning's "n" values entered on NV cards (maximum five). If more than one NV card is used, field 1 on the other cards would contain an ELN(N) value.
2,4,6..	VALN(N)	+	Manning's "n" coefficient for area below ELN(N). The overbank "n" values specified on CARD NC will be used for the overbank roughness regardless of the values in this table.
3,5,7..	ELN(N)	+	Elevation of the water surface corresponding to VALN(N) in increasing order.

Note: HEC-2 permits 20 n-value points. This program permits only 5.

SLOPE CHANGE - OPTIONAL CARD

CARD SC

The slope ASEL (JP-2) is changed at any cross section with this card. The slope will remain at this new slope until it is changed again. The specified set of closely spaced elevations follow approximately along the top bank elevation of the channel.

Field	Variable	Value	Description
0	ICG	SC	Card identification characters.
1	AVGS	0,+	The cross section identification number for the first cross section where the new slope was used.
2	ASEL	+,-	The change in elevation between cross sections is calculated by multiplying the slope ASEL times the channel reach length.
		1000	ASEL will be based on the downstream channel slope.
		2000	ASEL will be based on the downstream minimum channel bank elevation slope.

REQUIRED CARD FOR EACH CROSS SECTION

CARD X1

This card is required for each cross section, and is used to specify the cross section geometry and program options applicable to that cross section. This program differs from HEC-2 in that it does not read Field 10 and only 100 cross sections may be specified.

Field	Variable	Value	Description
0	IA	X1	Card identification characters.
1	SECNO	+	Cross section identification number
		-	(Tributaries in HEC-2). Not used in this program.
2	NUMST	0	Previous cross section is used for current section. Next GR cards are omitted.
		+	Total number of stations on the next GR cards.
3	STCHL	0	May be omitted if NUMST (X1.2) is 0.
		+	The station of the left bank of the channel.
4	STCHR	0	May be omitted if NUMST (X1.2) is 0.
		+	The station of the right bank of the channel. Must be equal to or greater than STCHL.
5	XLOBL	+	Length of reach between current cross section and next downstream cross section of the left overbank.
6	XLOBR	+	Length of reach between current cross section and next downstream cross section for the right overbank.
7	XLCH	+	Length of reach between current cross section and next downstream cross section for the channel.

CARD X1 (cont.)

Field	Variable	Value	Description
8	PXSECR	0	Cross section stations will not be changed by the factor PXSECR.
		+	A ratio which will be multiplied times all cross section stations, except the first station, to increase or decrease cross section width. The ratio can apply to a repeated cross section or a current one. A 1.1 would increase the width by 10 percent.
9	PXSECE	0	Cross section elevations will not be changed.
		+ -	Constant to be added (+) or subtracted (-) from all cross section elevations. A repeated cross section is handled in the same manner as one just entered. Elevation changes are permanent; therefore, changes accumulate with successive, repeated sections.

OPTIONAL PLOTS OF CROSS SECTION

Field	Variable	Value	Description
10	IPLOT	0	Not recognized by this program

SPECIFICATION OF INEFFECTIVE FLOW AREAS

CARD X3 - OPTIONAL CARD

Field	Variable	Value	Description
0	IA	X3	Card identification characters.
1	IEARA	0	Total area of cross section described on GR cards below the water surface elevation is used in the computations.
		10	Only the cross sectional area confined by levees below the water surface elevation is used in the computations, unless the water surface elevation is above the top of levee (elevations corresponding to STCH(X1.3) and STCHR (X1.4), in which case flow areas outside the levee will be included.
2	ELSED	0	NA
		+	NA
3	ENCFP	0	Width between encroachments is not changed or is not specified.
		+	Width between encroachments is centered in the channel, midway between the left and right overbanks. Flow areas outside this width are not included in the computations. This width will be used for all cross sections unless changed by a positive ENCFP on Card X3 of another cross section or unless overridden by the use of STENCL(X3.4).
4	STENCL	0	Encroachments by specifying station and/or elevation will not be used on the left overbank.
		+	Station of the left encroachment. Flow areas to the left of (less than) this station and below ELENCL are not included in the computations. This option will override the option using ENCFP when both are used.

CARD X3 (cont)

Field	Variable	Value	Description
5	ELENCL	0	An encroachment elevation on the left side is not applicable and is therefore assumed very high.
		+	Elevation of the left encroachment. Flow areas below this elevation and less than STENCL are not included in the computations.
6	STENCR	0	An encroachment station on the right is not used.
		+	Station of the right encroachment. Flow areas to the right of (greater than) this station and below ELENCR are not included in the computations.
7	ELENCR	0	An encroachment elevation on the right side is not applicable and is therefore assumed very high.
		+	Elevation of the right encroachment. Flow areas below this elevation and greater than STENCR are not included in the computations.
8	ELLEA	0	NA
		+	NA
9	ELREA	0	NA
		+	NA
10			NA

ADDITIONAL GROUND POINTS

CARD X4 - OPTIONAL CARD

An additional input card X4 may be inserted following cards X1, X2, or X3 in order to add additional points to describe the ground profile of the cross section. Stations of X4 data points must fall within the range of GR stations. The X4 data point is an added point and cannot be used to replace any GR data point. This option is useful when modifying data cards for a proposed obstruction as it allows points to be added anywhere in the cross section.

Field	Variable	Value	Description
0	IA	X4	Card identification characters.
1	NELT	+	Number of additional points to supplement the current set of GR cards read in describing the ground profile of the cross section. A maximum of 20 points may be used.
2	ELT(1)	+	Elevation of first additional ground point.
3	STAT(1)	+	Station of first additional ground point. All stations must be less than the maximum station on the GR cards. The pairs of elevations and stations do not have to be in any particular order.
4,5, etc.			Additional pairs of elevation and station values.

CONVEYANCE LIMITS - OPTIONAL CARD

CARD KL

The geometric model for unsteady flow calculations must describe both volume and conveyance. Satisfying the volume requirement often causes cross sections to extend up tributaries. This is an area that does not contribute to conveyance of the mainstem discharge, however, and conveyance limits can be established for affected cross sections.

Field	Variable	Value	Description
0	ICG	KL	Card identification characters.
1	AVGS	0,+	Cross section identification number.
2	STST	0	The entire cross section is used for both volume and conveyance on the left overbank.
		+	The cross section station separating storage from conveyance on the left overbank. This value does not have to coincide with a coordinate point.
3	ENST	0	The entire right overbank of the cross section is used to convey flow.
		+	The cross section station beyond which only volume is calculated.

GROUND PROFILE

CARD GR

This card specifies the elevation and station of each point in a cross section used to describe the ground profile, and is required for each X1 card unless NUMST (X1.2) is zero. The points outside of the channel determine the subdivision of the cross section which corrects for the nonuniform velocity distribution.

Field	Variable	Value	Description
0	IA	GR	Card identification characters.
1	EL(1)	+ -	Elevation of cross section point 1 at station STA(1). May be positive or negative.
2	STA(1)	+	Station of cross section point 1.
3	EL(2)	+ -	Elevation of cross section point 2 at STA(2).
4	STA(2)	+	Station of cross section point 2.

Continue with additional GR cards using up to 100 points to describe the cross section. Stations should be in increasing order and positive.

END OF JOB CARD

CARD EJ - REQUIRED

Required following the last cross section for each job. Each group of cards beginning with Card T1 is considered a job.

Field	Variable	Value	Description
0		EJ	Card identification characters.
1-10			Not used.

END OF RUN

CARD ER - REQUIRED CARD

Required at the end of a run consisting of one or more jobs in order to end computation on stop command. Three blank cards after the EJ card of the last job are optional.

Field	Variable	Value	Description
0	IA	ER	Card identification characters
1 - 10			Not used

APPENDIX I

Tape 95 Variable Description

TAPE95 VARIABLES

HEC2 Variable Name	HEC2 Description	Code Number	GEDA Variable Name	GEDA Description
CWSEL	Computed water surface elevation.	1	ECOM	Water surface elevation.
CRIWS	Critical water surface elevation.	2	SCHL	Accumulated channel length.
EG	Energy gradient elevation for a cross section which is equal to the computed water surface elevation CWSEL plus the discharge-weighted velocity head HV.	3	XRL(NST)	Incremented weighted length.
TOPWID	Cross section width at the calculated water surface elevation.	4	SUMW	Total top width.
SLOPE (10K*S)	Slope of the energy grade line for the current section (times 10,000).	5	ASEL	Projection slope.
TIME	Travel time from the first cross section to the present cross section in hours.	6	SDM	Accumulated weighted length.
VOL	Cumulative volume of water in the stream from the first cross section (in acre-feet for English units or 1000 cubic meters in Metric units).	7	AV	Cumulative volume of water in the stream from the first cross section (in acre-feet).
DEPTH	Depth of flow.	8	QVAR	Depth of flow in the channel.
WSELK	Known water surface elevation.	9	RWC	Ratio of accumulated weight/channel.
HV	Mean velocity head across the entire cross section.	10	STST	Left overbank station separating storage from conveyance.
HL	Energy loss due to friction.	11	ENST	Right overbank station separating storage from conveyance.

TAPE95 VARIABLES

HEC2			GEDA	
Variable Name	Description	Code Number	Variable Name	Description
OLOSS	Energy loss due to expansion or contraction.	12	SUMP	Total wetted perimeter
QLOB	Amount of flow in the left overbank.	13	RTS	Hydraulic radius to the 2/3 power.
QCH	Amount of flow in the channel.	14	QVAR	Profile number.
QROB	Amount of flow in the right overbank.	15	QVAR	Cross section counter.
XNL (K*XNL)	Manning's 'n' for the left overbank area (times 1,000).	16	SUBK(1)*.01	Sub-conveyance value.
XNCH (K*XNCH)	Manning's 'n' for the channel area (times 1,000).	17	SUBK(2)*.01	Sub-conveyance value.
XNR (K*XNR)	Manning's 'n' for the right overbank area (times 1,000).	18	SUBK(3)*.01	Sub-conveyance value.
WTN (K*WTN)	Weighted value of Manning's 'n' for the channel based on the distance between cross sections and channel flow from the first cross section. Used when computing Manning's 'n' from high water marks (times 1,000).	19	ANV	Average 'n' value.
CASE	A variable indicating how the water surface elevation was computed. Values of -1, -2, -3, and 0 indicate assumptions of critical depth, minimum difference a fixed change (X5 card) or a balance between the computed and assumed water surface elevations.	20	SUBK(4)*.01	Sub-conveyance value.

TAPE95 VARIABLES

HEC2		Code Number	GEDA	
Variable Name	Description		Variable Name	Description
STCHL	Station of the left bank	21	QVAR	Left bank station.
STCHR	Station of the right bank.	22	QVAR	Right bank station.
XLBEL	Left bank elevation.	23	QVAR	Left bank elevation.
RBEL	Right bank elevation.	24	QVAR	Right bank elevation.
AREA	Cross section area.	25	SUMA	Cross section area.
VCH	Mean velocity in the channel	26	SUBK(5)*.01	Sub-conveyance value.
STENCL	The station of the left encroachment.	27	STENCL	The station of the left encroachment.
STENCR	The station of the right encroachment.	28	STENCR	The station of the right encroachment
CLSTA	The centerline station of the trapezoidal excavation.	29	SUBK(6)*.01	Sub-conveyance value.
BW	The bottom width of the trapezoidal excavation.	30	SUBK(7)*.01	Sub-conveyance value.
ELENCL	Elevation of left encroachment.	31	ELENCL	Elevation of left encroachment.
ELENCR	Elevation of right encroachment.	32	ELENCR	Elevation of right encroachment.
CHSLOP (K*CHSL)	Channel slope (times 1,000).	33	QVAR	Channel slope.
.01K	The total discharge (index Q) carried with $S^{1/2}$ = .01 (equivalent to .01 times conveyance).	34	SUMK*.01	Total conveyance.
QLOB%	Percent of flow in the left overbank.	35	SA(1)	Sub-area value.

TAPE95 VARIABLES

HEC2			GEDA	
Variable Name	Description	Code Number	Variable Name	Description
PERENC	The target of encroachment requested	36	SA(2)	Sub-area value.
TWA	The cumulative topwidth area (acres or 1000 square meters).	37	ASA	Cumulative topwidth area (in acres).
SECNO	The cross section identification number.	38	AVGS	The cross section identification number.
XLCH	Channel reach length.	39	CHL	Incremented channel length.
ELTRD	Minimum elevation for top of road profile.	40	SA(3)	Sub-area value.
ELLC	Maximum low chord elevation.	41	SA(4)	Sub-area value.
ELMIN	Minimum elevation in cross section.	42	QVAR	Minimum elevation in the channel strip.
Q	Discharge.	43	SA(5)	Sub-area value.
EGPRS	Energy elevation assuming pressure flow.	44	SA(6)	Sub-area value.
EGLWC	Energy elevation assuming low flow.	45	SA(7)	Sub-area value.
QWEIR	Total weir flow at the bridge.	46	R(1)	Sub-hydraulic radius value.
QPR	Total pressure or low flow at the bridge.	47	R(2)	Sub-hydraulic radius value.
H3	Change in water surface elevation from Yarnell's equation.	48	R(3)	Sub-hydraulic radius value.

TAPE95 VARIABLES

HEC2 Variable Name	HEC2 Description	Code Number	GEDA Variable Name	GEDA Description
CLASS	Controlling flow type for bridge solution.	49	R(4)	Sub-hydraulic radius value.
DIFWSP	Difference in water surface elevation for each profile.	50	R(5)	Sub-hydraulic radius value.
DIFWSX	Difference in water surface elevation between sections.	51	R(6)	Sub-hydraulic radius value.
DIFKWS	Difference between known and computed water surface elevations.	52	R(7)	Sub-hydraulic radius value.
SSTA	Starting station where the water-surface intersects the ground (on the left side of the cross section).	53	QVAR	Starting station where the water surface intersects the ground (on the left side of the cross section).
ENDST	Ending station where the water surface intersects the ground on the right side.	54	QVAR	Ending station where the water surface intersects the ground on the right side.
VLOB	Average velocity in the left overbank area.	55	XNV(1)	Sub-n value.
VROB	Average velocity in the right overbank area.	56	XNV(2)	Sub-n value.
ALPHA	Velocity head coefficient.	57	ALFA	Velocity head coefficient.
KRATIO	Ratio of the upstream to downstream conveyance.	58	XNV(3)	Sub-n value.
QROB%	Percent of flow in the right overbank.	59	XNV(4)	Sub-n value.
QCH%	Percent of flow in the channel.	60	XNV(5)	Sub-n value.

TAPE95 VARIABLES

HEC2			GEDA	
Variable Name	Description	Code Number	Variable Name	Description
DIFEG	Difference in energy elevation for each profile.	61	XNV(6)	Sub-n value.
INLEQ	Friction loss equation index.	62	XNV(7)	Sub-n value.
TELMX	Elevation of the lower of the two end points of the cross section.	63	QVAR	Elevation of the lower of the two end points of the cross section.
NA		64	QVAR	Minimum channel bank slope.
NA		65	QVAR	Minimum channel bank elevation.

APPENDIX II

GEDA --Tape 95

TAPE 95

First record on tape 95:

Z ITAPE JM Z Z KVAR Z Z Z

Z - a zero value is used

ITAPE - This is set to 94 to identify it as a GEDA tape 95

JM - is set equal to the total number of profiles

KVAR - is set to 65, which is the number of variables written out to tape 95

Second record on tape 95:

TITLE(1) - TITLE (6)

TITLE - Title on title card based on A4 format

Third record on tape 95:

X(1) - X(100), Z, Z

X and Z - are set to zero

Fourth record on tape 95:

X(1) - X(100)

X - is set to zero

Fifth and all other records on tape 95:

QVAR(1) - QVAR(65)

Last record on tape 95:

QVAR(1) is set equal to -1.E + 0 5

QVAR(1) - QVAR(65)

Total records = 4 + total number sections X total number of profiles + 1