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# Sediment and Radionuclide Transport in Rivers

Radionuclide Transport Modeling for Cattaraugus  
and Buttermilk Creeks, New York

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## ABSTRACT

SERATRA, a transient, two-dimensional (laterally-averaged) computer model of sediment-contaminant transport in rivers, satisfactorily resolved the distribution of sediment and radionuclide concentrations in the Cattaraugus Creek stream system in New York. By modeling the physical processes of advection, diffusion, erosion, deposition, and bed armoring, SERATRA routed three sediment size fractions, including cohesive soils, to simulate three dynamic flow events. In conjunction with the sediment transport, SERATRA computed radionuclide levels in dissolved, suspended sediment, and bed sediment forms for four radionuclides ( $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$ , and  $^3\text{H}$ ). By accounting for time-dependent sediment-radionuclide interaction in the water column and bed, SERATRA is a physically explicit model of radionuclide fate and migration. Sediment and radionuclide concentrations calculated by SERATRA in the Cattaraugus Creek stream system are in reasonable agreement with measured values.

SERATRA is in the field performance phase of an extensive testing program designed to establish the utility of the model as a site assessment tool. The model handles not only radionuclides but other contaminants such as pesticides, heavy metals and other toxic chemicals. Now that the model has been applied to four field sites, including the latest study of the Cattaraugus Creek stream system, we recommend a final model validation through comparison of predicted results with field data from a carefully controlled tracer test at a field site. We also recommend a detailed laboratory flume testing to study cohesive sediment transport, deposition and erosion characteristics. The lack of current understanding of these characteristics is one of the weakest areas hindering the accurate assessment of the migration of radionuclides sorbed by fine sediments of silt and clay.

## SUMMARY

The migration and fate of radionuclides in surface waters are controlled by four complex mechanisms. These mechanisms are radionuclide transport due to water and sediment movements; intermedia transfer due to adsorption/desorption, precipitation/dissolution, and volatilization; decay and degradation due to radionuclide decay or chemical and biological degradation (where applicable); and transformation due to the yield of daughter, degradation, or chemical-reaction products (where applicable). SERATRA, a two-dimensional (laterally-averaged) finite element model of sediment-radionuclide transport, was formulated to account for these mechanisms in a physically explicit manner.

SERATRA predicts time-varying longitudinal and vertical distributions of sediments and radionuclides in nontidal rivers and some impoundments. The model consists of three coupled transport submodels, sediment transport, dissolved radionuclide transport, and particulate radionuclide transport, which are capable of time-dependent sediment-radionuclide interaction in the riverbed and water column.

The potential of SERATRA as a site assessment tool has led to a lengthy testing program designed to validate the model over a variety of field conditions. Initially, numerical experiments, i.e., mass balance checks and comparisons with analytical solutions, were performed to confirm the accuracy of the model. Next, SERATRA was taken to the field where it was applied to large rivers with steady flow conditions under several previous projects. SERATRA is currently in the final stage of the testing program where smaller rivers with dynamic flow events are being modeled.

Hence under this study, SERATRA was applied to a system of two small, highly dynamic streams in New York: Cattaraugus and Buttermilk Creeks. Radionuclides found in this system are due in part to a radioactive waste burial site near Franks Creek, a tributary of Buttermilk Creek. An extensive field data collection program provided time- and space-dependent measurements of discharges, sediments, and radionuclides for the modeling of three flow events. Particular attention in the field sampling program was given to the behavior of radionuclides associated with the various size fractions of bed and suspended sediment. Laboratory analyses of collected samples under separate projects yielded data on 30 radionuclides including equilibrium distributions of dissolved and sorbed radionuclide forms. The depths and discharges required as input to SERATRA were obtained by hydrodynamic models with measured and synthesized flow data. Radionuclide information for an application of SERATRA was sufficient in four cases:  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$ , and  $^3\text{H}$ .

Sediment and radionuclide concentrations predicted by SERATRA on the three flow events were in reasonable agreement with values measured in the field. SERATRA performed best where the most field data were available, underscoring the importance of complete and accurate input data when describing a complex modeling system.

SERATRA has now been tested on four field sites of widely varying flow and topographic characteristics. We recommend a comparison of predicted results with field data from a carefully controlled tracer test as the final validation of SERATRA. Since the confidence of radionuclide transport modeling is severely impaired by the general lack of the understanding of cohesive sediment transport characteristics, we strongly recommend that detailed laboratory flume testing be performed to increase the understanding of the basic mechanisms of transport, deposition and erosion of cohesive sediment in fresh and saline waters.

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Most of the measured radionuclide activities used in this study were counted by the University of Washington, Laboratory of Radiation Ecology for radiological analyses under a separate project.

## 1.0 INTRODUCTION

Four complex mechanisms govern the migration and fate of contaminants in surface waters: 1) transport, 2) intermedia transfer, 3) decay and degradation, and 4) transformation.

Transport refers to the mixing and advection of contaminants by the water flow. This includes the transport of sorbed and precipitated contaminants by the movement of solids entrained in the flow. Intermedia transfer involves the exchange of contaminant across the solid-liquid and liquid-gas interfaces. In the bed and water column, particulate-contaminant interaction occurs through precipitation/dissolution and adsorption/desorption. At the water surface, contaminants are volatilized to the atmosphere. Decay and degradation mechanisms attenuate the contaminant severity. Processes included in this category are radionuclide decay, and degradation due to hydrolysis, oxidation, photolysis, and biological activities. Transformation, on the other hand, creates new forms of potentially hazardous substances through the yield of daughter, degradation, or chemical-reaction products.

Historically, contaminant modeling in surface waters has been performed without considering the nonaqueous forms a contaminant may exist in or evolve to. Although a contaminant may be substantially precipitated, volatilized, or sorbed to a solid matrix, the aqueous-only modeling approach remains popular because of the conservative concentrations predicted for dissolved contaminants in most cases. Recent concern for the accumulation of contaminants in the environment in addition to the dissolved contaminant levels has prompted the development of more sophisticated surface water models.

SERATRA, a computer model of sediment-contaminant (e.g., radionuclides, pesticides, heavy metals) transport was developed in response to the need for a site assessment methodology which realistically addresses the governing mechanisms of contaminant migration and fate in surface waters. SERATRA uses the finite element computational approach to predict time-varying longitudinal and vertical distributions of sediments and contaminants in rivers and some impoundments.

The model consists of the following three coupled submodels, which describe sediment-contaminant interactions and migration:

- a sediment transport submodel
- a dissolved contaminant transport submodel
- a particulate contaminant transport submodel.

The sediment transport submodel simulates transport, deposition, scouring and armoring for three size fractions of cohesive and noncohesive sediments. The transport of particulate contaminant (i.e., contaminants adsorbed by sediment) is also simulated for each sediment size. Dissolved contaminants are linked by the adsorption/desorption process to the particulate contaminants. The contaminant submodels account for 1) advection and dispersion of dissolved and particulate contaminants; 2) radionuclide decay and chemical and



biological degradation resulting from hydrolysis, oxidation, photolysis, biological activities where applicable; 3) volatilization; 4) adsorption/desorption; and 5) deposition and scouring of particulate contaminants. SERATRA also computes changes in riverbed conditions for sediment and contaminant distributions.

In an effort to prepare SERATRA for dissemination, a lengthy program of testing has been followed. Initially, numerical experiments were performed to confirm the accuracy of the model. These experiments consisted of simulating problems which have analytical solutions to compare against, and checking the mass balance by isolating the various mechanisms in the model formulation. Upon the successful completion of these experiments, SERATRA was then applied to actual field sites.

Prior to this study, sediment and radionuclide transport in the Columbia River in Washington and the Clinch River in Tennessee, were simulated by SERATRA under steady flow conditions (Onishi and Wise 1979, Onishi et al. 1980). The reasonably good results produced by SERATRA in these two applications paved the way for the final phase of model testing: unsteady flow conditions.

In an ensuing study, contamination in Four Mile and Wolf Creeks in Iowa was simulated over a three year period during which highly dynamic runoff events occurred (Onishi et al. 1979). Although the concentrations of alachlor (a pesticide) predicted by SERATRA were reasonable, no measured data were available for comparison.

SERATRA had now been successfully applied to three diverse stream systems, modeling both radionuclides and pesticides. Despite the satisfactory performance of SERATRA in the field, the time-dependent computation of particulate radionuclide transport remained unverified because of data limitations in these earlier studies.

In an effort to investigate the importance of fluvial sediment in the transport of radionuclides, the U.S. NRC requested PNL to conduct a comprehensive data collection program to provide SERATRA with suitable information for the verification study. The field site selected by the U.S. NRC is located within the watershed of Cattaraugus Creek in rural western New York. Radionuclides found in Cattaraugus Creek and its tributary, Buttermilk Creek, have originated in part from the past operation of a low-level radioactive waste disposal facility at West Valley, New York (Ecker and Onishi 1978, Walters et al. 1982, Ecker et al. 1982).

During each of the years 1977 to 1979, Pacific Northwest Laboratory (PNL) monitored one, week-long flow event on Cattaraugus and Buttermilk Creeks for discharges, sediments, and radionuclides. Hydrodynamics on these three phases of data collection were extremely varied, from a high, unsteady flow in Phase 1 to a low, steady flow in Phase 2 with an intermediate flow in Phase 3. PNL determined the physical characteristics of the water and sediment samples, e.g., temperature, concentrations, sediment size fractions, densities, etc.,

before sending the samples mostly to the University of Washington where the radiochemical analyses were performed. A total of 30 radionuclides were analyzed, of which  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$ , and  $^3\text{H}$  had adequate data bases for a reasonable modeling effort. Fortunately, these four radionuclides have distinctly different geochemical attributes allowing the full breadth of model capability to be tested.

Complex models such as SERATRA have extensive data requirements to be properly applied in a predictive mode. Inadequate data sets have the effect of reducing the analysis to an exercise in curve fitting due to the number of model parameters which can be adjusted. In this study of the Cattaraugus Creek watershed, all parameters were predetermined prior to the model application except for the cohesive sediment transport parameters and vertical dispersion coefficient. To avoid the danger of curve fitting, these latter parameters were calibrated on one flow event and applied unchanged to the other two flow events.

This report discusses the performance testing of SERATRA on three flow events in Cattaraugus and Buttermilk Creeks where four radionuclides are simulated. Included in the report is a model description, summary of previous SERATRA applications, results from the application to Cattaraugus and Buttermilk Creeks, hypothetical case studies and the computer print out of SERATRA code.

## 2.0 CONCLUSIONS AND RECOMMENDATIONS

### CONCLUSIONS

The sediment-radionuclide transport model SERATRA is undergoing a testing program which will lead to its distribution as a site assessment tool. The final phase of this testing program is the field verification of the model. In the latest of a series of field applications, the Cattaraugus Creek stream system in New York was modeled to simulate the transport, deposition and resuspension of sediment and particulate radionuclides; the transport of dissolved radionuclides; and sediment-radionuclide interactions. Radionuclides simulated by SERATRA were  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$ , and  $^3\text{H}$ . Results from this modeling study indicate that SERATRA can reproduce with reasonable accuracy the mechanisms which affect the migration and fate of radionuclides in rivers.

SERATRA generated the best results where known boundary conditions and verification values were both time- and space-dependent. This study emphasizes the importance of providing an adequate data set to model a complex phenomenon.

### RECOMMENDATIONS

1. SERATRA has now been tested at four sites (Columbia River; Clinch River; Four Mile and Wolf Creeks; and Buttermilk and Cattaraugus Creeks) where its ability to handle a wide range of flow, sediment, and contaminant behavior has been demonstrated under current and previous studies. As a final step in the validation of SERATRA, we recommend that SERATRA be applied to a field site where a carefully controlled tracer test (e.g., a neutron activation test) can be performed.
2. Due to the radiochemical nature of the radionuclide transport problem, a critical dependence on laboratory analyses is unavoidable. Radionuclide distribution coefficients are, to a certain extent, affected by factors which cannot always be accounted for in the laboratory. In particular, the dynamics of field phenomena are impossible to duplicate. We recommend additional research into the present method of modeling a dynamic adsorption phenomenon.
3. We also recommend coupling a geochemical model with the transport model, SERATRA, so that adsorption mechanisms and precipitation are more accurately estimated by a geochemical model to obtain more accurate concentrations and forms of radionuclides in surface waters.
4. Basic characteristics of transport, deposition and erosion of cohesive sediment (e.g., silt and clay) should be investigated in a carefully controlled laboratory flume. The current lack of understanding of these characteristics inhibits a reliable prediction of particulate and dissolved radionuclides in surface waters.

### 3.0 FORMULATION OF MODEL, SERATRA

The SERATRA code uses the finite element computation method with the Galerkin weighted residual technique. It consists of three submodels coupled to include the effects of sediment-contaminant interaction. The submodels are: 1) a sediment transport submodel, 2) a dissolved contaminant transport submodel, and 3) a particulate contaminant (contaminants adsorbed by sediment) transport submodel. SERATRA not only calculates distributions of sediment and contaminant concentrations in water, but also predicts river bed conditions, including bed elevation change, sediment size distribution within the bed, and distribution of particulate contaminant concentration in the river bed. The detailed model formulation is discussed below:

#### 3.1 SEDIMENT TRANSPORT SUBMODEL

Since the movements and adsorption capacities of sediments vary significantly with sediment sizes, the sediment transport submodel solves the migration of sediment (transport, deposition and scouring) for three size fractions of cohesive and non-cohesive sediments.

The model includes the mechanisms of:

1. Advection and dispersion of sediments
2. Fall velocity and cohesiveness
3. Deposition on the river bed
4. Resuspension from the river bed (bed erosion and armoring)
5. Sediment contributions from tributaries and point/nonpoint sources into the system and subsequent mixing.

Sediment mineralogy and water quality effects are implicitly included through the above mentioned mechanisms 2, 3, and 4.

Mass conservation of sediment passing through the control volume leads to the following expression for the transport of sediments:

$$\frac{\partial}{\partial t} (C_j B \ell) + (U_o C_j B - U_i C_{ij} B) + \frac{\partial}{\partial z} \{ C_j (W - W_{sj}) B \ell \}$$

rate of accumulation	horizontal advection	vertical advection	
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$$= \frac{\partial}{\partial z} \left( \epsilon_z \frac{\partial C_j}{\partial z} B \ell \right) + \frac{1}{h} (S_{Rj} - S_{Dj}) \quad j = 1, 2, \dots, N \quad (1)$$

vertical diffusion	sediment erosion or deposition		
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where (a)

$B$  = river width

$C_j$  = concentration of sediment of  $j$ th size fraction

$C_{ij}$  = sediment concentration of horizontal inflow for  $j$ th size fraction

$h$  = water depth

$x$  = longitudinal distance

$N$  = number of sediment size fractions considered. Currently,  
 $N = 3$  (i.e., sand, silt and clay)

$S_{Dj}$  = sediment deposition rate per unit area for  $j$ th sediment size fraction

$S_{Rj}$  = sediment erosion rate per unit area for  $j$ th sediment size fraction

$t$  = time

$U_i$  = horizontal inflow velocity

$U_o$  = horizontal outflow velocity

$W$  = vertical flow velocity

$W_{sj}$  = fall velocity of sediment particle of  $j$ th size fraction

$z$  = vertical direction

$\epsilon_z$  = vertical diffusion coefficient

The model neglects longitudinal diffusion and assumes lateral sediment concentrations to be uniform. However, the model does handle vertical variations of longitudinal velocity to cause some longitudinal spread of sediment.

Boundary conditions at the water surface ( $z = h$ ) and river bed ( $z = 0$ ) are:

$$\left( W - W_{sj} \right) C_j - \epsilon_z \frac{\partial C_j}{\partial z} = 0 \quad \text{at } z = h \quad (2)$$

$$- (1 - \gamma) W_{sj} C_j - \epsilon_z \frac{\partial C_j}{\partial z} = 0 \quad \text{at } z = 0 \quad (3)$$

---

(a) The symbols defined above remain the same throughout the report.

where

$\gamma$  = coefficient, i.e., probability that particle settling to the bed is deposited.

Sediment erosion and deposition rates,  $S_{Rj}$  and  $S_{Dj}$ , are also evaluated separately for each sediment size fraction because erosion and deposition characteristics are significantly different for cohesive and noncohesive sediments.

Erosion and deposition of noncohesive sediments are affected by the amount of sediment the flow is capable of carrying. For example, if the amount of sand being transported is less than the flow can carry for given hydrodynamic conditions, the river will scour sediment from the stream bed to increase the sediment transport rate. This occurs until the actual sediment transport rate becomes equal to the carrying capacity of the flow or until the available bed sediments are all scoured, whichever occurs first. Conversely, the river deposits sand if its actual sediment transport rate is above the flow's capacity to carry sediment. Sediment transport capacity of flow,  $Q_T$  in this model, was calculated by either the Toffaleti or the Colby formulas (Vanoni 1975), whichever a user assigns. The computer program of the Colby method used in SERATRA was that developed by Mahmood and Ponce (Mahmood and Ponce 1975). The sediment transport capacity of flow,  $Q_T$ , was then compared with the actual amount of sand,  $Q_{Ta}$ , being transported in a river water. Hence:

$$S_{Rj} = \frac{Q_T - Q_{Ta}}{A} \quad (4)$$

$$S_{Dj} = \frac{Q_{Ta} - Q_T}{A} \quad (5)$$

where

$A$  = the river bed surface area.

The availability of bed sediments to be resuspended was also examined to determine the actual amount of sediment erosion.

For sediment erosion and deposition rates of cohesive sediments (silt and clay), the following Partheniades (1962) and Krone (1962) formulas, respectively, were adopted in this study:

$$S_{Rj} = M_j \left( \frac{\tau_b}{\tau_{cRj}} - 1 \right) \quad (6)$$

$$S_{Dj} = W_{sj} C_j \left( 1 - \frac{\tau_b}{\tau_{cDj}} \right) \quad (7)$$

where

$M_j$  = erodibility coefficient for sediment of  $j$ th size fraction

$\tau_b$  = bed shear stress

$\tau_{cDj}$  = critical shear stress for sediment deposition for  $j$ th sediment size fraction

$\tau_{cRj}$  = critical shear stress for sediment erosion for  $j$ th sediment size fraction.

Values of  $M_j$ ,  $\tau_{cDj}$  and  $\tau_{cRj}$  must be determined by field and/or laboratory tests for a particular river regime. The model examines the availability of cohesive sediments in the river bed to determine the actual amount of sediment erosion.

When the fall velocity,  $W_{sj}$ , depends on sediment concentration and no aggregation occurs, Krone (1962) recommends:

$$W_{sj} = K_j'' C_j^{4/3} \quad (8)$$

where

$K_j''$  = an empirical constant depending on the sediment type.

### 3.2 DISSOLVED CONTAMINANT TRANSPORT SUBMODEL

The dissolved contaminant transport submodel includes the mechanisms of:

1. Advection and dispersion of dissolved contaminants (pesticides, radionuclides, and other toxic substances) within the river
2. Adsorption (uptake) of dissolved contaminants by sediments (suspended and bed sediments) or desorption from sediments into water
3. Radionuclide decay
4. Degradation of dissolved contaminants due to hydrolysis, oxidation, photolysis and biological activities
5. Volatilization
6. Contributions of dissolved contaminants from tributaries and point/nonpoint sources into the system, and subsequent mixing.

Effects of water quality (e.g., pH, water temperature, salinity, etc.) and clay minerals are indirectly taken into account through changes in the distribution coefficients for adsorption and desorption,  $K_{dj}$ ,  $K'_{dj}$ , respectively. In this

model, distribution coefficients for adsorption can be assigned to a value different from that of desorption to be able to handle not-completely-reversible adsorption/desorption processes. Mass conservation of dissolved contaminants may be expressed as:

$$\begin{aligned}
 & \frac{\partial}{\partial t} (G_w B \ell) + (U_w G_w B - U_i G_{wi} B) + \frac{\partial}{\partial z} (W G_w B \ell) \\
 & \quad \text{rate of} \quad \quad \quad \text{horizontal} \quad \quad \quad \text{vertical} \\
 & \quad \text{accumulation} \quad \quad \quad \text{advection} \quad \quad \quad \text{advection} \\
 & = \frac{\partial}{\partial z} \left( \epsilon_z \frac{\partial G_w}{\partial z} B \ell \right) - \lambda G_w B \ell - \sum_{i=1}^5 K_{Ci} G_w B \ell \\
 & \quad \quad \quad \text{vertical} \quad \quad \quad \text{radionuclide} \quad \quad \quad \text{chemical} \\
 & \quad \quad \quad \text{diffusion} \quad \quad \quad \text{decay} \quad \quad \quad \text{and} \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \text{biological} \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \text{degradation} \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \text{and volatilization} \\
 & - \sum_j K_j (K_{dj} C_j G_w - G_j) B \ell - \sum_j K'_j (K'_{dj} C_j G_w - G_j) B \ell \\
 & \quad \text{adsorption to moving} \quad \quad \quad \text{desorption from moving} \\
 & \quad \quad \quad \text{sediment} \quad \quad \quad \quad \quad \quad \text{sediment} \\
 & - \sum_j \gamma_j (1-\text{POR}) D_j K_{bj} (K_{dj} G_w - G_{Bj}) - \sum_j \gamma_j (1-\text{POR}) D_j K'_{bj} (K'_{dj} G_w - G_{Bj}) \\
 & \quad \text{adsorption to sediment in bed} \quad \quad \quad \text{desorption from sediment in bed} \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad j = 1, 2, 3 \quad \quad \quad (9)
 \end{aligned}$$

It was assumed that a contaminant has the same distribution coefficient values  $K_{dj}$  or  $K'_{dj}$ , for the moving (suspended and bed load sediments) and non-moving (bed sediment without any motion)  $j$ th sediment. However, these two types of sediments have two different transfer rates,  $K_j$  or  $K'_j$  and  $K_{bj}$  or  $K'_{bj}$ , as expressed in Equation 9.

In addition to the previously defined symbols:

$D_j$  = diameter of  $j$ th sediment

$G_{Bj}$  = particulate contaminant concentration per unit weight of sediment in  $j$ th sediment size fraction in river bed

$\gamma_j$  = specific weight of  $j$ th sediment

$G_w$  = dissolved contaminant concentration per unit volume of water



$G_{wi}$  = dissolved contaminant concentration in horizontal inflow

$G_j$  = particulate contaminant concentration per unit volume of water

$K_{Ci}$  = the first order reaction rate of contaminant degradation due to hydrolysis, oxidation, photolysis, biological activities, and volatilization

$K_{bj}, K'_{bj}$  = transfer rates of contaminants for adsorption and desorption, respectively, with  $j$ th non-moving sediment in bed

$K_{dj}, K'_{dj}$  = distribution coefficients rate of adsorption and desorption, respectively, between dissolved contaminant and moving sediment (suspended and bed load sediments) of  $j$ th size fraction, respectively

$K_j, K'_j$  = transfer rates of contaminants for adsorption and desorption, respectively, with  $j$ th sediment in motion

$\lambda$  = decay rate of radioactive material.

POR = porosity of bed sediment

The distribution coefficients,  $K_{dj}$  and  $K'_{dj}$ , are defined by:

$$K_{dj} \text{ and } K'_{dj} = \frac{f_{sj} M'_j}{f_w/V_w} = \frac{f_{sj}}{f_w C_j} \quad (10)$$

where

$f_{sj}$  = fraction of contaminant sorbed by  $j$ th sediment

$f_w$  = fraction of contaminant left in solution

$M'_j$  = weight of  $j$ th sediment

$V_w$  = volume of water

$$\frac{f_{sj}}{f_w} = \frac{G_j}{G_w}$$

Hence Equation 10 may be rewritten as:

$$G_j = K_{dj} C_j G_w \quad \text{or} \quad G_j = K'_{dj} C_j G_w \quad (11)$$

The adsorption of contaminant by sediments or desorption from the sediments is assumed to occur toward an equilibrium condition with the transfer rate,  $K_j$  or  $K'_j$  (with the unit of the reciprocal of time), if the particulate contaminant concentration differs from its equilibrium values as expressed in Equation 11. Longitudinal dispersion of dissolved contaminant is considered to be negligible when compared to convection. Longitudinal spread of contaminants due to vertical variation of longitudinal velocity is, however, simulated in this study.

Boundary conditions at the water surface and river bed are:

$$WG_w - \epsilon_z \frac{\partial G_w}{\partial z} = 0 \quad \text{at } z = h \quad (12)$$

$$c_z \frac{\partial G_w}{\partial z} = 0 \quad \text{at } z = 0 \quad (13)$$

One of the important mechanisms of transport and fate of contaminants is the degradation and volatilization of contaminants in an aquatic environment. The contaminant degradation includes both chemical and biological reactions. Major mechanisms of chemical degradation are due to reactions of: 1) hydrolysis, 2) oxidation, and 3) photolysis (Smith et al. 1977). Due to the present lack of knowledge on degradation and volatilization of particulate contaminants (Smith et al. 1977), these degradation mechanisms were considered only for the dissolved contaminants. These degradation and volatilization rates are included in Equation 9 as the first order kinetic reaction rates,  $K_{Ci}$ ;  $i=1, 2, 3, 4$  and  $5$ . Actual formulations of chemical and biological degradation, and volatilization were obtained from pesticide studies conducted by Smith et al. 1977, Zepp and Cline 1977 and Falco et al. 1976. These formulations will be discussed below:

#### Chemical Degradation Due to Hydrolysis:

The fundamental concept of chemical reactivity is based on the quest to improve stability in the configuration of the outer shells. A contaminant in solution will react with other species in solution and form a complex if there is a large increase in stability. Hydrolysis reactions are a specialized type of complex formation in which the  $[OH^-]$  anion acts as the ligand. They are quite sensitive to pH changes. The rate of change of dissolved contaminant concentration due to hydrolysis is expressed by the following equation (Smith et al. 1977):

#### Hydrolysis

$$\begin{aligned} -\frac{dG_w}{dt} &= K_A[H^+]G_w + K_B[OH^-]G_w + K_N G_w \\ &= (K_A[H^+] + \frac{K_B K_w}{[H^+]} + K_N)G_w \\ &= (K_A \cdot 10^{-pH} + K_B \cdot 10^{pH-14} + K_N)G_w \\ &= K_{Cl} G_w \end{aligned} \quad (14)$$

where

$$K_{C1} = K_A \cdot 10^{-\text{pH}} + K_B \cdot 10^{\text{pH}-14} + K_N$$

$$K_w = [H^+] \cdot [OH^-] = 10^{-14}$$

$$\text{pH} = -\log [H^+]$$

$K_A$ ,  $K_B$ ,  $K_N$  = acid, base and neutral hydrolysis rates; respectively.

Rate coefficients,  $K_A$ ,  $K_B$  and  $K_N$  can be determined from laboratory tests (Smith et al. 1977).

#### Chemical Degradation Due to Oxidation

Oxidation of contaminants by free radical processes may become important under some environmental conditions. The rate of oxidation of contaminant may be expressed by the second order reactions depending on the concentration, of free and radical oxygen, and dissolved contaminant as shown below (Smith et al. 1977):

$$-\frac{dG_w}{dt} = K_{ox} [RO_2 \cdot] G_w + K_{AB} [RO \cdot] G_w \quad (15)$$

It is assumed that only a small concentration of dissolved contaminants is oxidized, and that the second term in the right hand side may be deleted (Smith et al. 1977). Hence:

$$-\frac{dG_w}{dt} = K_{ox} [RO_2 \cdot] G_w = K_{C2} G_w \quad (16)$$

where

$K_{ox}$ ,  $K_{AB}$  = oxidation rates of free radical oxygen of  $[RO_2 \cdot]$  and  $[RO \cdot]$ , respectively

$RO_2 \cdot$  = free radical oxygen

$RO \cdot$  = free radical oxygen

The rate constant,  $K_{ox}$  can be obtained from laboratory tests outlined by Smith et al. (1977).

#### Chemical Degradation Due to Photolysis

Some contaminants can be photochemically transformed by absorbing light, especially ultraviolet light. The rate of contaminant concentration change

due to photolysis reactions may be expressed by (Zepp and Cline 1977, Smith et al. 1977, and Stanford Research Institute 1979):

$$-\frac{dG_w}{dt} = \frac{2.303}{J} \phi \sum_{\lambda} \epsilon_{\lambda} I_{\lambda} G_w$$

$$I_{\lambda} = I_{0\lambda} \exp \left\{ -(K_1 + K_2 \bar{C}) (h - z) \right\} \quad (17)$$

where

$\bar{C}$  = average sediment concentration above water depth Z

$I_{0\lambda}$  = incident light intensity of wave length  $\lambda$

$I_{\lambda}$  = light intensity of wave length  $\lambda$  at water depth Z

J = conversion constant

$K_1$  = light attenuation coefficient for water

$K_2$  = light attenuation coefficient due to suspended sediment in water

$\epsilon_{\lambda}$  = molar extinction coefficient of light with the wave length  $\lambda$

$\phi$  = quantum yield.

Since each computational cell has a vertical finite element thickness, the above equation was averaged over the element thickness for each element in this study. Hence:

$$-\frac{dG_w}{dt} = \frac{2.303}{J} \phi \sum_{\lambda} \epsilon_{\lambda} I_{0\lambda} \exp \left[ \left\{ -(K_1 + K_2 \bar{C})(n - i) \Delta z \right\} \right.$$

$$\left. \cdot \left\{ \frac{1 - \exp \left( -(K_1 + K_2 \bar{C}) \Delta z \right)}{(K_1 + K_2 \bar{C}) \Delta z} \right\} G_w \right] \quad (18)$$

$$= K_{C3} G_w$$

where

i = element's number counted from the river bottom

n = total number of elements

$\Delta z$  = element thickness.

Various parameters and coefficients can be measured by conducting laboratory tests and/or field measurements (Zepp and Cline 1977, Smith et al. 1977, and Stanford Research Institute 1979).

### Biodegradation

A contaminant compound may be degraded by microbial activities in an aquatic environment. In this study it is assumed that microbial degradation can be expressed by the second order reaction (Falco et al. 1976, Smith et al. 1977) depending on concentrations of biomass and contaminant in water, as shown below:

$$-\frac{dG_w}{dt} = K_{B1}[B]G_w = K_{C5}G_w \quad (19)$$

where

[B] = biomass per unit volume

$K_{B1}$  = the second order rate constant for biodegradation.

### Volatilization

The volatilization of a contaminant occurs at the air-water interface. The change of contaminant concentration due to volatilization may be expressed by the following first order reaction (Smith et al. 1977):

$$-\frac{dG_w}{dt} = K_{C3}G_w \quad (20)$$

where

$K_{C3}$  = volatilization rate of the contaminant

$K_{C3}$  can be estimated by the following relationship:

$$\begin{aligned} (K_{C3})_{\text{water body}} &= (K_o)_{\text{water body}} \left( \frac{K_{C3}}{K_o} \right)_{\text{laboratory test condition}} \\ &= (K_o)_{\text{water body}} \left( \frac{d_o}{d_s} \right) \end{aligned}$$

where

$d_o, d_s$  = molecular diameters of oxygen and contaminant, respectively

(K<sub>C3</sub>) laboratory test conditions = volatilization rate through any substances measure at a laboratory

(K<sub>0</sub>) water = oxygen reaeration rate through water-air interface

### 3.3 PARTICULATE CONTAMINANT TRANSPORT SUBMODEL

The transport model of contaminants attached to sediment includes the mechanisms of:

1. Advection and dispersion of particulate contaminants
2. Adsorption of dissolved contaminants by sediments or desorption from sediments into water
3. Radionuclide decay
4. Deposition of particulate contaminants to the river bed or resuspension from the river bed
5. Contributions of particulate contaminants from tributaries and point/nonpoint sources into the system, and subsequent mixing.

As in the transport of sediments and dissolved contaminants, the conservation of contaminants adsorbed by each sand, silt and clay sediment may be expressed as:

$$\begin{aligned} & \frac{\partial}{\partial t}(G_j B\ell) + (U_o G_j B - U_i G_{ij} B) + \frac{\partial}{\partial z} \left\{ (W - W_{sj}) G_j B\ell \right\} \quad (21) \\ & \begin{array}{ccc} \text{rate of} & \text{horizontal} & \text{vertical} \\ \text{accumulation} & \text{advection} & \text{advection} \end{array} \\ = & \frac{\partial}{\partial z} \left( \epsilon_z \frac{\partial G_j}{\partial z} B\ell \right) - \lambda G_j B\ell + K_j (K_{dj} C_j G_w - G_j) B\ell + K'_j (K'_{dj} C_j G_w - G_j) B\ell + \frac{1}{h} (G_{Bj} S_R - G_j S_D) \\ & \begin{array}{ccccc} \text{vertical} & \text{radionuclide} & \text{adsorption} & \text{desorption} & \text{contaminated sediment} \\ \text{diffusion} & \text{decay} & & & \text{erosion and deposition} \end{array} \end{aligned}$$

where

$G_{ij}$  = particulate concentration per unit volume of water associated with the  $j$ <sub>th</sub> sediment size fraction in horizontal inflow.

Longitudinal dispersion of particulate contaminant was assumed to be negligible, as compared to longitudinal advection. However, as noted before, the longitudinal spread of particulate contaminant due to nonuniform vertical distribution of longitudinal velocity is simulated in the model. It is also assumed that chemical and biological degradation of particulate contaminants, except radionuclide decay, is not significant. However, if it is necessary to include these mechanisms, the radionuclide decay term may include them.

The boundary conditions at the water surface and bed are:

$$G_j (W - W_{sj}) - \epsilon_z \frac{\partial G_j}{\partial z} = 0 \quad \text{at } z = h \text{ and } 0 \quad (22)$$

The finite element technique with the Galerkin weighted residual method was used to solve the transport equations of sediments, dissolved contaminants and particulate contaminants.

### 3.4 FINITE ELEMENT TECHNIQUE

Because of its increased solution accuracy and ready accommodation to various boundary geometries (Desai and Abel 1972, Norton et al 1973, Onishi and Wise 1978) this method was used for this study. To apply the finite element method to a partial differential equation, an alternate integral equation is developed. The finite element method employing a Galerkin weighted residual was used to solve Equations 1, 9, and 21 with the associated boundary conditions of Equations 2, 3, 12, 13, and 22. Since the governing equations of sediment and contaminant transport have similar forms, the finite element technique is described here for the following advection-diffusion equation of the general form:

$$L[\phi] = \frac{\partial \phi}{\partial t} + \frac{\partial}{\partial z} (v\phi) - \frac{\partial}{\partial z} (\epsilon_z \frac{\partial \phi}{\partial z}) + \alpha\phi - \beta \quad (23)$$

The coefficients  $v$ ,  $\epsilon_z$ ,  $\alpha$ ,  $\beta$  are defined to accommodate the specific forms of the sediment and contaminant transport equations.

#### Galerkin Weighted Residual Method

The governing partial differential equation can be recast in an integral form employing the weighted residual method. This integral is formed by taking the product of  $L[\phi]$  with some arbitrary set of weighting functions,  $W_j$ , which yields:

$$\chi = \int_R L[\phi] W_j dz \quad (24)$$

where

$R$  = a domain of interest.

If  $\phi$  is approximated by some polynomial:

$$\tilde{\phi} = \sum_{i=1}^n \phi_i W_i \quad (25)$$

where

$W_j$  = approximating functions then the quantity  $L[\tilde{\phi}]$  represents the residual error.

For the Galerkin weighted residual method, the approximating function  $W_j$  is chosen to be the same as the weighting function  $W_j$ . The integral term becomes an error distribution principle by which the nodal values  $\phi_i$  can be determined so that the residual error over the domain  $R$  is orthogonal to the polynomial selected for weight and interpolation functions.

By expanding the equation and integrating by parts, the reduced functional results:

$$\chi = \int_R W_j \frac{\partial \phi}{\partial t} + W_j \left[ \frac{\partial}{\partial z} (v\phi) + \frac{\partial W_j}{\partial z} \epsilon \frac{\partial \phi}{\partial z} + W_j \alpha \phi - W_j \beta \right] dz - W_j \epsilon \frac{\partial \phi}{\partial z} \Big|_0^h = 0 \quad (26)$$

$j = 1, 2 \dots n + 1$

Note that Equation 26 was derived by assuming no net flux across the boundary. In cases where the boundary has positive or negative net flux across it, this flux was incorporated as a source or sink term in the governing equation.

The above integral can be partitioned so that:

$$\chi = \chi_e^1 + \chi_e^2 + \chi_e^3 + \dots + \chi_e^n = \sum_{i=1}^n \chi_e^i \quad (27)$$

where

$n$  = the number of subdomains.

This may be expanded to give:

$$\chi = \int_{z_1}^{z_2} [ ] dz + \int_{z_2}^{z_3} [ ] dz + \dots + \int_{z_n}^{z_{n+1}} [ ] dz \quad (28)$$

The contents in brackets in Equation 28 are the same as those in Equation 26. Equation 28 will yield a set of  $n+1$  ordinary differential equations in terms of the  $\phi_{n+1}$ .

### Finite-Element Equations

The contributions from any typical subregion or finite element can be developed by substituting a particular polynomial approximation for  $\phi$  into Equation 26. For simplicity, a linear approximation was chosen: i.e.,



$$\phi = \tilde{\phi} = \frac{z_{i+1} - z}{\Delta z} \tilde{\phi}_i + \frac{z - z_i}{\Delta z} \tilde{\phi}_{i+1} \quad (29)$$

where

$$\Delta z = z_{i+1} - z_i.$$

In vector notation, one has:

$$\tilde{\phi}(z,t) = W_i, W_{i+1} \begin{Bmatrix} \tilde{\phi}_i \\ \tilde{\phi}_{i+1} \end{Bmatrix} \quad (30)$$

where weighting functions are given by:

$$W_i = \frac{1}{\Delta z} (z_{i+1} - z) \quad (31)$$

$$W_{i+1} = \frac{1}{\Delta z} (z - z_i) \quad (32)$$

The individual terms in the functional are approximated by:

$$\frac{\partial}{\partial t} = W_1, W_2 \begin{Bmatrix} \frac{\partial \phi_i}{\partial z} \\ \frac{\partial \phi_{i+1}}{\partial z} \end{Bmatrix} \quad (33)$$

$$\frac{\partial \phi}{\partial z} = \frac{\partial W_i}{\partial z}, \frac{\partial W_{i+1}}{\partial z} \begin{Bmatrix} \tilde{\phi}_i \\ \tilde{\phi}_{i+1} \end{Bmatrix} = - \begin{bmatrix} -\frac{1}{\Delta z}, \frac{1}{\Delta z} \end{bmatrix} \begin{Bmatrix} \phi_i \\ \phi_{i+1} \end{Bmatrix} \quad (34)$$

Substituting these quantities into Equation 26 for a typical subdomain, a set of algebraic equations is obtained.

The results for individual terms are given below.

1. Time Dependent Term:

$$\int_{R_{ei}} W_j \frac{\partial \phi}{\partial t} dz = \int_{z_i}^{z_{i+1}} W_i W_j dz \{ \partial \phi \} \quad dz = \frac{\Delta z}{6} \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \begin{Bmatrix} \frac{d\phi_i}{dt} \\ \frac{d\phi_{i+1}}{dt} \end{Bmatrix} \quad (35)$$

2. Advective Term:

$$\int_{R_{ei}} W_j \frac{\partial v \phi}{\partial z} dz = \int_{R_{ei}} W_j \frac{\partial v}{\partial z} \phi dz + \int_{R_{ei}} W_j v \frac{\partial \phi}{\partial z} dz =$$

$$= \begin{bmatrix} -\frac{2}{3}v_i + \frac{1}{6}v_{i+1} & \frac{1}{6}v_i + \frac{1}{3}v_{i+1} \\ -\frac{1}{3}v_i - \frac{1}{6}v_{i+1} & -\frac{1}{6}v_i + \frac{2}{3}v_{i+1} \end{bmatrix} \begin{Bmatrix} \phi_i \\ \phi_{i+1} \end{Bmatrix} \quad (36)$$

3. Diffusion Term:

$$\int_{R_{ei}} \frac{\partial W_j}{\partial z} \epsilon_z \frac{\partial \phi}{\partial z} dz = \frac{\epsilon_z}{\Delta z^2} \int_{z_i}^{z_{i+1}} \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \begin{Bmatrix} \phi_i \\ \phi_{i+1} \end{Bmatrix} dz = \frac{\epsilon_z}{\Delta z} \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \begin{Bmatrix} \phi_i \\ \phi_{i+1} \end{Bmatrix} \quad (37)$$

4. Decay Term:

$$\int_{R_{ei}} W_j \alpha \phi_i dz = \alpha \int_{z_i}^{z_{i+1}} W_j W_i dz \phi_i = \frac{\alpha \Delta z}{6} \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \begin{Bmatrix} \phi_i \\ \phi_{i+1} \end{Bmatrix} \quad (38)$$

5. Sink/source Term:

$$\int_{R_{ei}} W_j \beta dz = \beta \int_{z_i}^{z_{i+1}} W_j dz = \beta \Delta z \begin{Bmatrix} 1/2 \\ 1/2 \end{Bmatrix} \quad (39)$$

Where  $\beta$  is assumed independent of  $z$ . However, many sink/source terms in Equations 1, 9, and 21 are not independent of  $z$  and these terms are integrated according to their dependency of  $z$ . Summing up and gathering terms, one can write the element contributions to the matrix equation as finite element:

$$\sum_{j=1}^n [P]_{ej} \begin{Bmatrix} \phi_i \\ \phi_{i+1} \end{Bmatrix} + [S]_{ej} \begin{Bmatrix} \phi_i \\ \phi_{i+1} \end{Bmatrix} = \sum_{j=1}^n [R]_{ej} \quad (40)$$

where

$$[P]_{ej} = \Delta z \begin{bmatrix} 1/3 & 1/6 \\ 1/6 & 1/3 \end{bmatrix} \quad (41)$$

$$\{R\}_{ej} = \frac{\beta \Delta Z}{2} \begin{Bmatrix} 1 \\ 1 \end{Bmatrix} \quad (\text{if } \beta \text{ is independent of } z) \quad (42)$$

$$[S]_{ej} = \begin{bmatrix} \left( D - \frac{2}{3} V_i + \frac{1}{6} V_{i+1} + \frac{\alpha \Delta Z}{3} \right) & \left( -D - \frac{1}{6} V_i - \frac{1}{3} V_{i+1} - \frac{\alpha \Delta Z}{6} \right) \\ -\left( D + \frac{1}{3} V_i + \frac{1}{6} V_{i+1} + \frac{\alpha \Delta Z}{6} \right) & \left( +D - \frac{1}{6} V_i + \frac{2}{3} V_{i+1} + \frac{\alpha \Delta Z}{3} \right) \end{bmatrix} \quad (43)$$

$$D = \frac{\epsilon_z}{\Delta Z}, \quad (44)$$

The summation given in Equation 27 gives the rules for construction the matrices for all finite elements; the matrices [P] and [S] become tridiagonal matrices. The final set of equations is a generalization of Equation 40.

#### Time-Dependent Solution

The final set of equations derived above can be expressed by:

$$[\tilde{P}] \left\{ \frac{d\phi}{dt} \right\} + [\tilde{S}] \{\phi\} = \{\tilde{R}\} \quad (45)$$

where

$[\tilde{P}]$  matrix = a symmetric tridiagonal

$[\tilde{S}]$  matrix = an unsymmetric tridiagonal

$\{\tilde{R}\}$  = a load vector.

This final system of equations is approximated by a Crank-Nicholson scheme (Varga 1965):

$$[\tilde{P}] \frac{\{\phi\}^{n+1} - \{\phi\}^n}{\Delta t} = -\frac{1}{2} [\tilde{S}] \left( \{\phi\}^{n+1} + \{\phi\}^n \right) + \frac{1}{2} \left( \{R\}^{n+1} + \{R\}^n \right) \quad (46)$$

Solving the for n+1 value of  $\phi$ , this expression can be rearranged to obtain:

$$[\tilde{P}] \{\phi\}^{n+1} = [\tilde{S}] \{\phi\}^n + \{R\} \quad (47)$$

where the new coefficient matrices are:

$$[\tilde{P}] = [\tilde{P}] + \left( \frac{\Delta t}{2} \right) [\tilde{S}] \quad (48)$$

$$[\tilde{S}] = [\tilde{P}] - \left( \frac{\Delta t}{2} \right) [\tilde{S}] \quad (49)$$

$$\{R\} = \Delta t \{\tilde{R}\} = \frac{\Delta t}{2} (\{R\}^{n+1} + \{R\}^n) \quad (50)$$

This type of approximation is second order correct, unconditionally stable and easily solved by most available tridiagonal solution schemes.

A computer program has been written in the FORTRAN preprocessor language FLECS to implement the model (Onishi and Wise 1979). However, a standard FORTRAN IV version of SERATRA is also available.

### 3.5 LISTS OF INPUT DATA AND SIMULATION OUTPUT

SERATRA, consisting of the three submodels, is applicable to nontidal rivers and impoundments. One of the advantages of SERATRA is that it can be applied to water bodies over large longitudinal distances and shallow depths by using a large aspect ratio of a computational cell. Input data requirements for SERATRA are:

- Common Data Requirements for all the Submodels:
  - Channel geometry
  - Discharges and flow depths of the rivers during the simulation period
  - Discharges of tributaries, overland runoff and other point/nonpoint sources
  - Vertical dispersion coefficient
- Additional Requirements for Sediment Transport Submodel
  - Sediment size fractions
  - Sediment density and fall velocities of sediments (sand, silt, and clay)
  - Critical shear stresses for erosion and deposition of cohesive sediment (silt and clay)
  - Erodibility coefficient of cohesive sediment

#### Initial Conditions

- Sediment concentration for each sediment size fraction
- Bottom sediment size fraction

#### Boundary Conditions

- Sediment concentration at the upstream end of the study reach

- Contributions of sediments from overland, tributaries and other point and nonpoint sources.
- Additional Requirements for Dissolved and Particulate Contaminant Transport Submodels:
  - Distribution coefficients and transfer rates of contaminant with sediment in each sediment size fraction (i.e., sand, silt, and clay). If values of distribution coefficients are not available, it is necessary to know clay mineral and organic sediment content to estimate these values.
  - Degradation, volatilization and decay rates of contaminants

#### Initial Conditions

- Dissolved contaminant concentration
- Particulate contaminant concentration for each sediment size fraction (i.e., those attached to sand, silt, and clay)

#### Boundary Conditions

- Dissolved and particulate contaminant concentrations for each sediment size fraction at the upstream end of the study reach
- Contributions of dissolved and particulate contaminant concentrations from tributaries, overland, and other point/nonpoint sources.

With the input data described above, SERATRA simulates the following:

1. Sediment simulation for any given time
  - longitudinal and vertical distributions of total sediment (sum of suspended and bed load) concentration for each sediment size fraction
  - longitudinal and vertical distributions of sediment size fractions in the river bed
  - change in bed elevation (elevation changes due to sediment deposition and/or scour)
2. Contaminant simulation for any given time
  - longitudinal and vertical distributions of dissolved contaminant concentration
  - longitudinal and vertical distributions of contaminant concentration adsorbed by sediment for each sediment size fraction

- longitudinal and vertical distributions of contaminant concentrations in the bottom sediment within the bed for each sediment size fraction.

## 4.0 MODEL TESTING

This chapter describes the testing program which has led to this application of SERATRA to the Cattaraugus and Buttermilk Creeks in New York. Sensitivity analysis results are also discussed here. SERATRA was developed as a site assessment tool for contaminants in surface waters. To build its credibility as a reliable transport model, a rigorous four point testing program was established:

1. analytical solution confirmation
2. mass balance check
3. steady flow field verification
4. unsteady flow field verification.

SERATRA is now in the final phase of model verification.

### 4.1 ANALYTICAL SOLUTION

First, the model was tested under conditions where analytical solutions were known. These tests examined how accurately the code algorithm portrays the vertical sediment and contaminant distributions. This was accomplished by applying the code to well-posed convection-diffusion boundary value problems having analytical solutions. One of the cases dealt with the following unsteady one-dimensional convection-diffusion equation:

$$\frac{\partial C}{\partial t} + U \frac{\partial C}{\partial y} = \epsilon_y \frac{\partial^2 C}{\partial y^2}$$

with an initial condition of

$$C(y,0) = \exp\left(\frac{Uy}{2\epsilon_y}\right) \sin\left(\frac{\pi y}{\ell}\right)$$

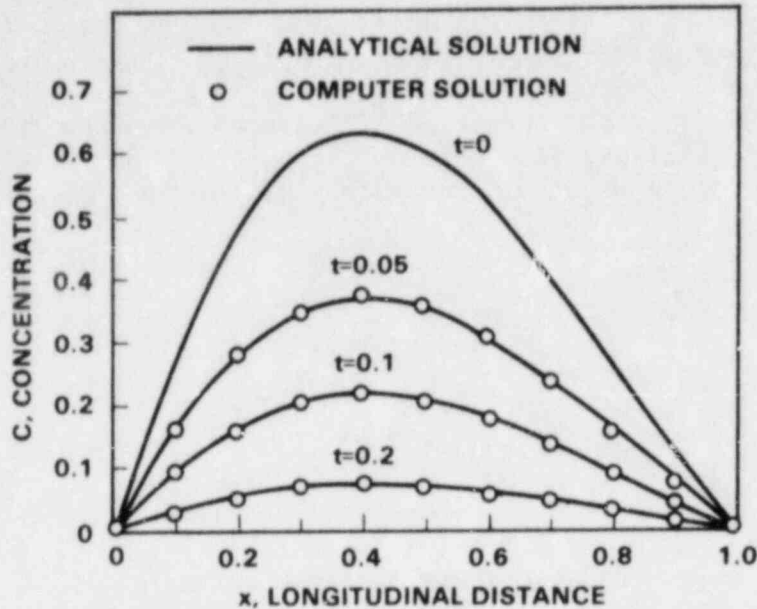
and boundary conditions of

$$C(0,t) = 0 \text{ and } C(\ell,t) = 0.$$

Parameter values employed in the test cases were length ( $\ell$ ) = 1, velocity ( $U$ ) = -2, and vertical dispersivity ( $\epsilon_y$ ) = 1. The computed results and the analytical solution compared favorably (Figure 4.1). Such agreement verified that the finite-element computational scheme of the SERATRA code accurately solves the convection-diffusion equation.

### 4.2 MASS BALANCE

Fundamental to any successful application model is the ability to conserve mass. Errors in mass balance can be due to the model formulation or the truncation error of the computer. Hence, after examining the model against analytical solutions as discussed in Section 4.1, the mass balance of SERATRA



$$\frac{\partial C}{\partial t} + U \frac{\partial C}{\partial x} = K_x \frac{\partial^2 C}{\partial x^2}$$

INITIAL AND BOUNDARY  
CONDITIONS ARE:

$$C(x,0) = \text{EXP} \left( \frac{-Ux}{2K_x} \right) \text{SIN} \left( \frac{\pi x}{l} \right)$$

$$C(0,t) = 0, C(l,t) = 0$$

ASSUME THAT  $U = 2$ ,  $K_x = 1$  AND  $l = 1$

FIGURE 4.1. Comparison of SERATRA Results with the Analytical Solution to the Unsteady Convection-Diffusion Equation

was tested for 18 runs. These numerical experiments were designed to isolate the various physical and chemical processes in SERATRA for mass balance behavior. Table 4.1 summarizes the processes evaluated in this part of the testing program.

The machine accuracy of the computer used to apply SERATRA is seven significant figures. Each segment in this simulation displays mass conservation with an accuracy of at least five significant figures for each of the tested processes.

#### 4.3 SENSITIVITY ANALYSES

As indicated in Chapter 3, only model parameters and coefficients which can be adjusted to fit to measured sediment and radionuclide data are vertical dispersion coefficient, and three parameters for cohesive sediment erosion and deposition (critical shear stresses for erosion and deposition and erodibility coefficient). Sensitivity analyses revealed that dispersion coefficient was rather important not only to the vertical sediment and contaminant distributions but also to the overall stability of the modeling. Three parameters for cohesive sediment erosion and deposition strongly affect the fine sediment distributions in water column and river bed, thus radionuclide transport, deposition and erosion. For example, sediment concentrations almost linearly increase with the erodibility coefficient once the bed shear stress is above the critical shear stress of erosion. Unfortunately, these parameters are



TABLE 4.1. SERATRA Mass Balance Testing Program

	Test																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Scour/Deposition of Sediment							-	-	-	-	-	-						
Radionuclide Adsorption/Desorption in Stream		-		-	-	-		-		-	-	-						
Radionuclide Adsorption/Desorption in Bed				-	-	-				-	-	-	-					
Tributary Boundary Conditions						-					-							
Bed Initial Radionuclide Condition							-					-						
Radionuclide Decay													-					
Biological Decay														-				
Degradation Due to Photolysis															-			
Degradation Due to Hydrolysis																-		
Degradation Due to Oxidation																	-	
Degradation Due to Volatilization																		-

some of the least known parameters due to the lack of general understanding of cohesive sediment erosion and deposition. Further field and laboratory studies on the mechanisms of fine sediment transport, deposition and erosion should be conducted to improve the current understanding of the fine sediment transport characteristics to reduce the uncertainty on the fine sediment, thus also radionuclide transport modeling.

Other model parameters and coefficients should be determined by theoretical, experimental and field studies prior to model calibration rather than to adjust these values as a part of the model calibration to fit predicted distributions to measured data.

The study also reveals that the distribution coefficient is a very important parameter and almost linearly affects the particulate radionuclide concentrations, as shown in a series of cases discussed in the next chapter. Profound effects of flow and sediment diameters on the migration of radionuclides are also revealed as indicated in Chapter 5.

#### 4.4 PREVIOUS FIELD TESTING UNDER STEADY FLOW CONDITIONS

The goal of the field testing program was to demonstrate the effectiveness of the model under a wide range of field conditions.

The Columbia River in Washington between Priest Rapids (River Kilometer 640) and McNary Dams (River Kilometer 470) was modeled under previous studies for the transport of sediments, radioactive  $^{65}\text{Zn}$  (Onishi and Wise 1979), and a heavy metal (Onishi et al. 1982). The Columbia is a large river ( $\sim 1700 \text{ m}^3/\text{s}$ ) which contains both free flowing and backwater regions. Flow conditions were assumed to be steady. A comparison of the SERATRA predicted results with measured  $^{65}\text{Zn}$  concentrations appears in Figure 4.2. Correlation is excellent.

The next site chosen for another previous study was the Clinch River in Tennessee (Onishi et al. 1980). The Clinch is of intermediate proportions ( $\sim 120 \text{ m}^3/\text{s}$ ) also exhibiting steady flow conditions. In this case, the modeled reach was 37.2 km of backwater from the river mouth to Melton Hill Dam (river kilometer 37.2). Results from this modeling of  $^{90}\text{Sr}$  are in excellent agreement with measured concentrations (Figure 4.3).

#### 4.5 PREVIOUS FIELD TESTING UNDER UNSTEADY FLOW CONDITIONS

The success of SERATRA in larger rivers under steady flow conditions paved the way for the first field application with unsteady boundary conditions. Generally, the time scale for events on a large stream are much longer than those on a small stream. Thus, without going to longer simulations, the best way to test the dynamics of the code is to apply it to smaller streams. The baseflow of Wolf Creek in Iowa is  $\sim 7 \text{ m}^3/\text{s}$ . High runoff events on this stream can raise the flow to  $20 \text{ m}^3/\text{s}$  for short periods of time which was the

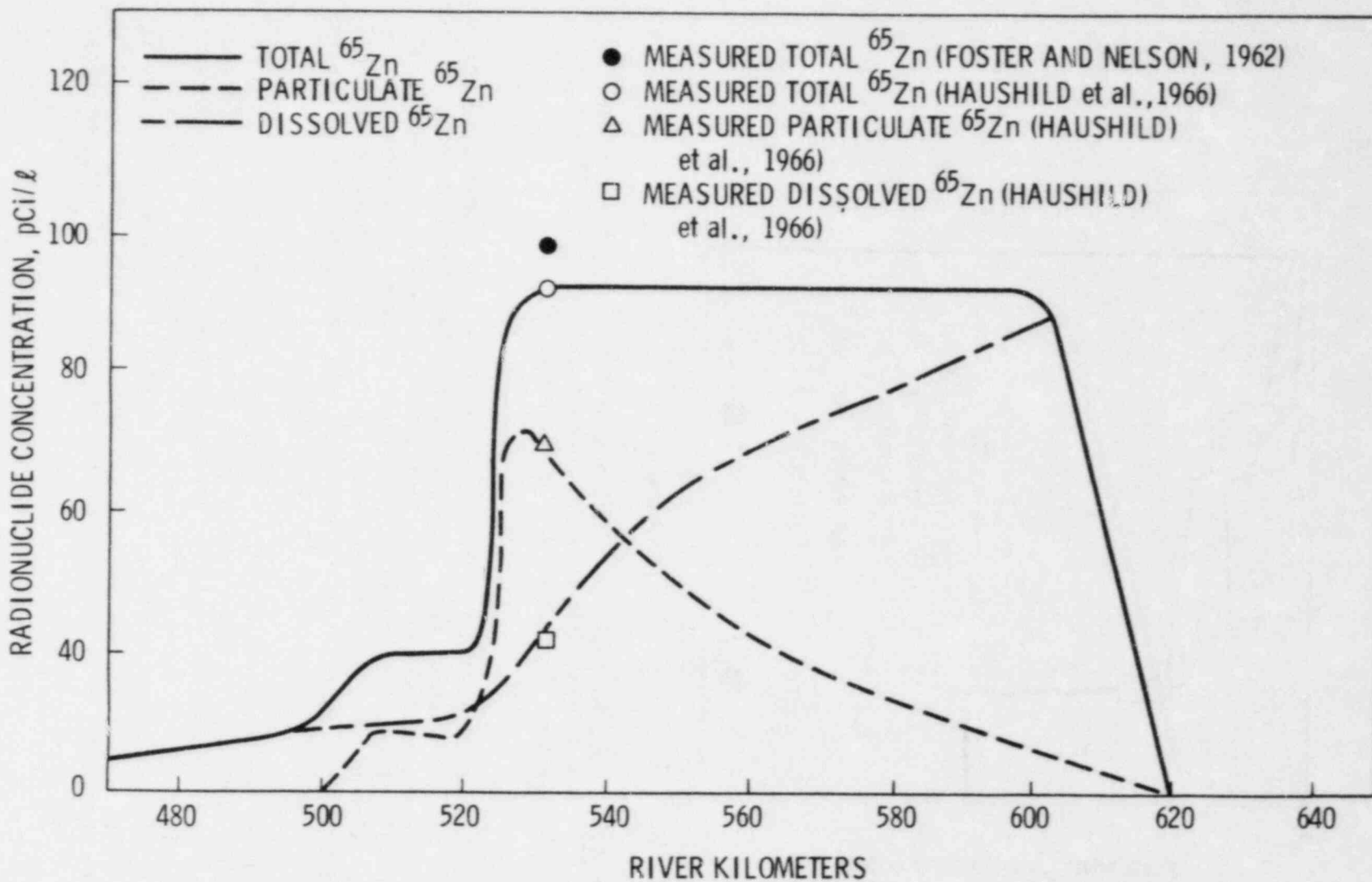
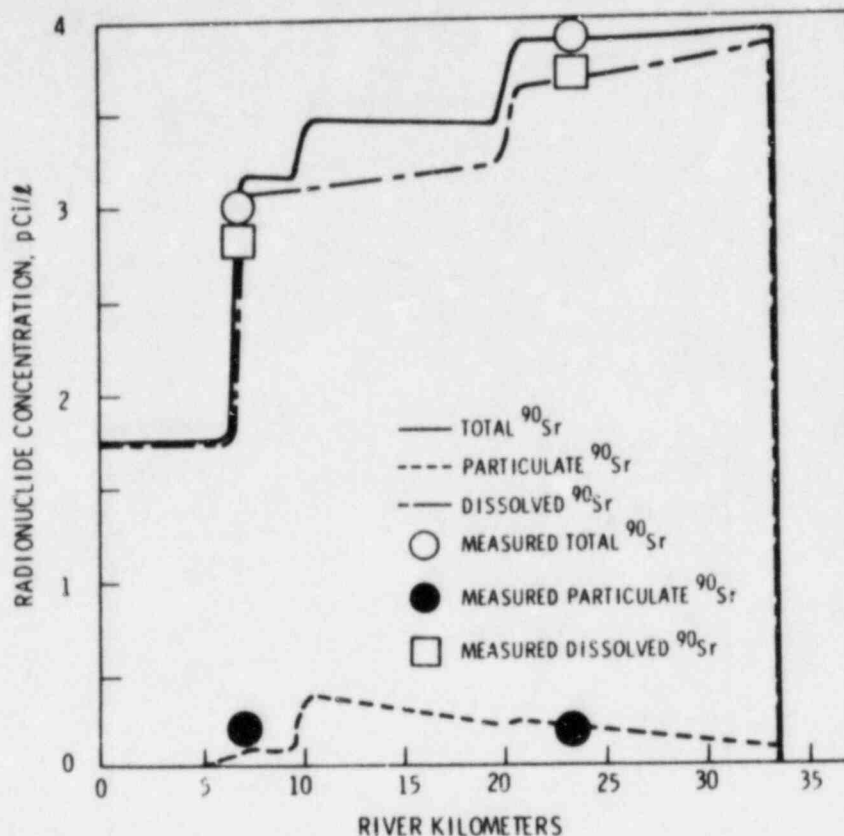


FIGURE 4.2. Comparison of Predicted Results with Measured Zinc-65 Concentrations in the Columbia River, Washington (Onishi et al. 1979)



**FIGURE 4.3.** Longitudinal Distributions of Dissolved, Particulate and Total Strontium-90 Concentrations in the Clinch River, Tennessee (Onishi et al. 1980)

case when SERATRA was applied here (Onishi et al. 1979). A 3 year simulation of a pesticide called Alachlor from June 1971 to May 1974 was performed. Since several runoff events introduced significant amounts of water, sediment, and alachlor into Wolf Creek, the transport processes for these constituents were very dynamic. Although the simulation results under these dynamic flow conditions seem reasonable (Figure 4.4), no measured data were available to examine the accuracy of the model prediction for this case.

The quest for a highly dynamic river with adequate verification data on water, sediment, and radionuclides led to a field sampling program performed on Cattaraugus and Buttermilk Creeks in New York. The information gathered in this watershed is the most extensive collection of radionuclide data ever assembled. In the next chapter, testing of SERATRA will be discussed when it was applied to the Buttermilk and Cattaraugus Creeks in which reasonably good data were collected under a separate project (Ecker and Onishi 1978, Walters et al. 1982, Ecker et al. 1982).

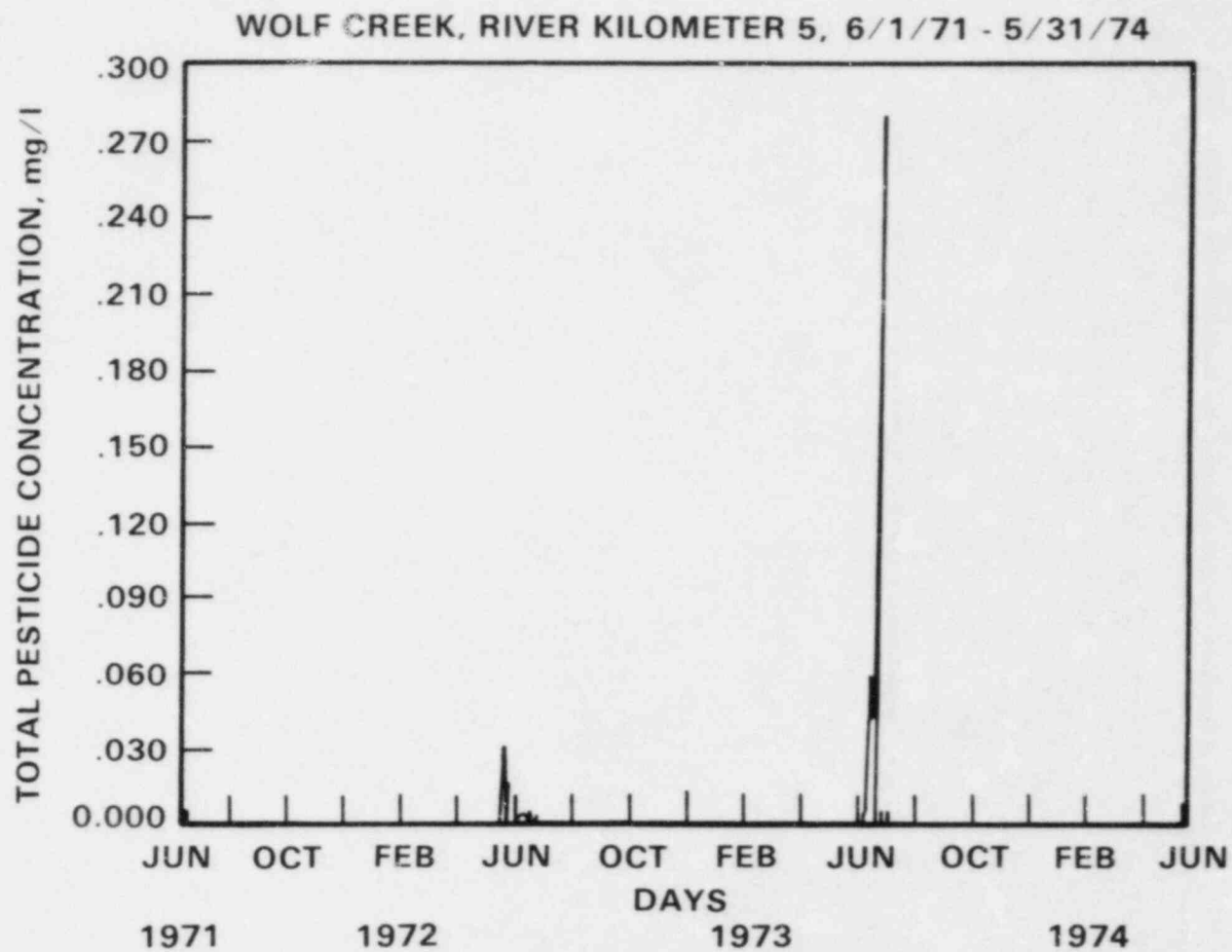


FIGURE 4.4. Time Variation of Total Alachlor Concentration at Wolf Creek River Kilometer 5 During the 3-Year Simulation Period (Onishi et al. 1979)

## 5.0 MODELING APPLICATION

In this chapter, SERATRA, a transient, two-dimensional (laterally-averaged), sediment and radionuclide transport model, is applied to the Cattaraugus/Buttermilk Creeks in New York. Data from an extensive field sampling and analysis program provided the information necessary for the execution of this computer model. Water, sediment, and radionuclides were analyzed for various properties including temperature, concentration and activity levels.

Hydrologic modeling of rainfall, runoff, and instream hydrodynamics were performed to generate data necessary for SERATRA. These data were calibrated against measured streamflow in Cattaraugus Creek. A calibration of the cohesive sediment transport parameters was also done.

Ten simulations were performed on three flow events. The modeled radionuclides were  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$  and  $^3\text{H}$ .

### 5.1 SITE DESCRIPTION

The Western New York Nuclear Service Center, shown in Figure 5.1, is located about 30 miles south of Buffalo, New York. The Center consists of a 3345-acre site in the north central portion of Cattaraugus County. The Center is situated along an elongated rolling plain with glaciated bedrock hills along the eastern, western and southern boundaries, and Buttermilk Valley along the northern boundary. All surface drainage of the Center discharges into Buttermilk Creek. At the northwest end of the property, Buttermilk Creek joins Cattaraugus Creek which flows in a westerly direction into Lake Erie, 39 miles away. Cattaraugus Creek flows in a general westerly direction through Zoar Valley, Gowanda, and Cattaraugus Indian Reservation and empties into Lake Erie, 27 miles southwest of Buffalo. It is 20 stream miles from the confluence of Buttermilk and Cattaraugus Creeks to Gowanda and another 19 miles to the mouth of Cattaraugus Creek at Lake Erie. Franks Creek (Erdmans Brook), a tributary of Buttermilk Creek, serves as a receptor for runoff from the Center's Burial site.

Three water courses, Franks Creek, Buttermilk Creek and Cattaraugus Creek, are the principal water courses of interest in the study of radionuclide transport in surface waters from the Western New York Nuclear Service Center. The following is a brief description of each of these water courses.

Franks Creek, commonly referred to as Erdmans Brook, includes the drainage area for both the low- and high-level nuclear burial sites. The creek flows into Buttermilk Creek about 0.5 miles downstream of the burial sites. The stream flow in the creek is intermittent, varying between 0 and 100 cubic feet per second (cfs). The creek is very narrow, varying in width from 2 to 10 ft. The creek is comprised of chutes and pools, and flows in some places through swampy areas. Stream gradients are moderately steep, and the creek shows active down-cutting through previously undisturbed glacial

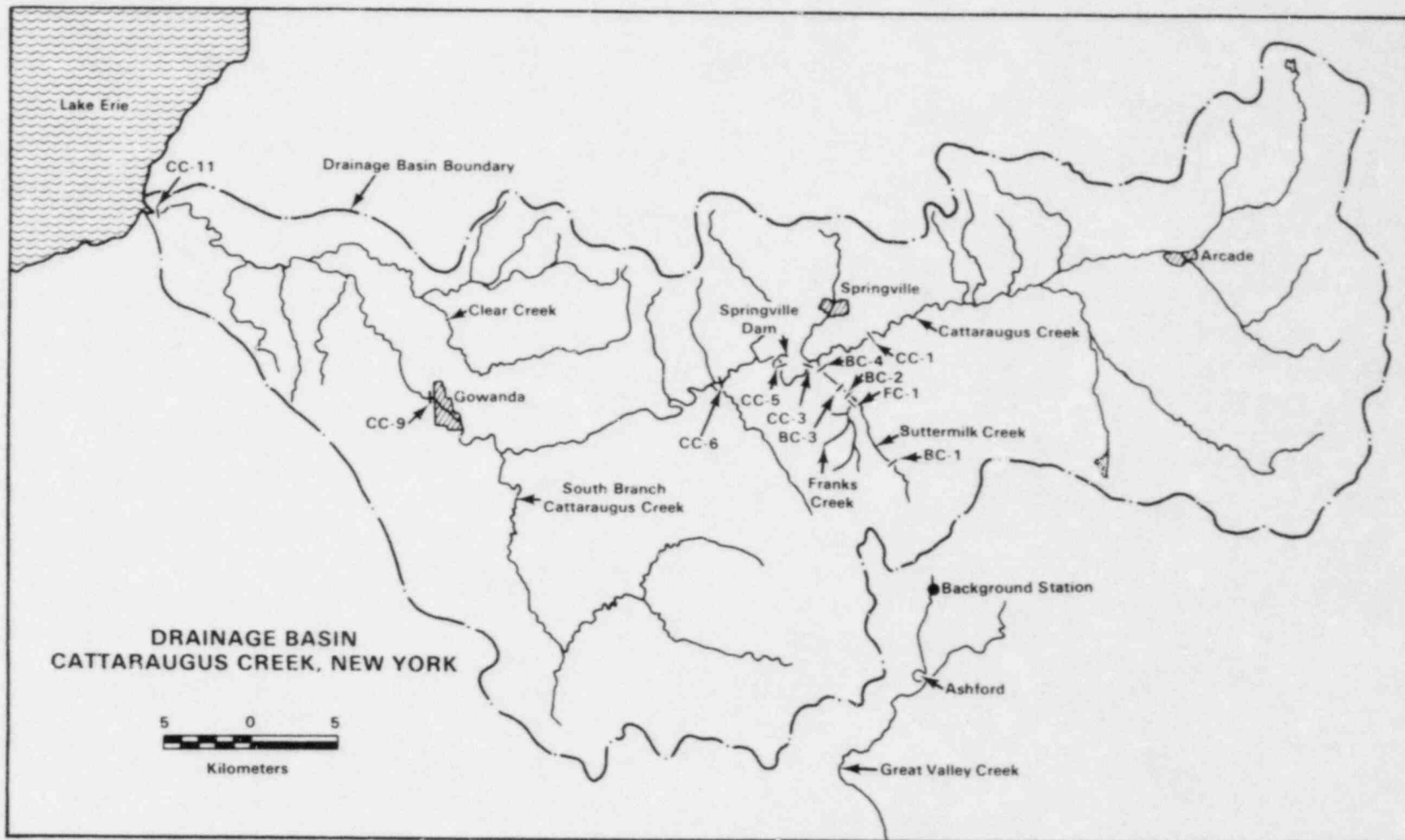


FIGURE 5.1. Map of Cattaraugus, Buttermilk and Franks Creeks

till which is comprised of a very stiff clayey material. This clayey material appears to be fairly resistant to erosion. The creek flows through a narrow and steep, V-shaped valley.

Buttermilk Creek has a drainage area of approximately 29.4 mi<sup>2</sup>. For the period of record from October 1961 to September 1968, the average discharge of Buttermilk Creek was 46.5 cfs. The extreme maximum and minimum discharges during the period of record were 3,910 cfs on 28 September 1967 and 2.1 cfs on 10 October 1963, respectively. Buttermilk Creek flows into Cattaraugus Creek about 2.25 miles downstream of the confluence with Franks Creek. The creek width under normal conditions varies from about 20 ft at the upper end to about 75 ft near the confluence with Cattaraugus Creek. The channel bed is comprised of sand, gravel and cobbles with minor amounts of silt and clay size material. Water frequently overflows the channel banks leaving deposits of fine clayey silt along the flood plain. The flood plain varies from 300 to 500 ft wide with sparse to moderate vegetation.

A reservoir upstream of the Buttermilk Creek study reach collects runoff from a small watershed and periodically releases overflow into Buttermilk Creek. Discharge from the reservoir is regulated by a siphon spillway that maintains reservoir levels below a certain elevation. Once the siphon is primed, large quantities of water are discharged in a short period of time, producing extremely fast rising hydrographs in Buttermilk Creek during periods of relatively low flow.

Cattaraugus Creek has an estimated drainage area of 555 mi<sup>2</sup> at Lake Erie, 432 mi<sup>2</sup> at Gowanda and 218 mi<sup>2</sup> at the confluence with Buttermilk Creek. Based on the United States Geological Survey (USGS) flow data records for Cattaraugus Creek at Gowanda, New York, the average discharge for the period of record, 1940-1976, is 731 cfs. The extreme maximum and minimum daily discharges during the period of record were 34,600 cfs on 7 March 1956, and 6 cfs, respectively, on 21 August 1941.

Peak discharges generally occur on Cattaraugus Creek in October and November, prior to the onset of winter snowfall and again in February and March as a result of snowmelt. Low discharges generally occur during the summer months of July through September when rainfall is less and again during the winter months of December and January when persistent freezing conditions exist. Figure 5.2 is a summary of the 1975 and 1976 water year monthly discharge records of Cattaraugus Creek at Gowanda, New York. Cattaraugus Creek, as well as Buttermilk Creek, can be categorized as "flashy" due to their very rapid changes in discharge. Figure 5.3 is an excerpt from the 1976 water year discharge records showing the September daily discharges of Cattaraugus Creek at Gowanda. Discharges can be seen to vary by >5000 cfs in a period of one day.

Cattaraugus Creek is generally free flowing except for a small impoundment (Springville Dam) near the Village of Springville. Water flow in the creek is confined to a fairly well-defined channel under normal discharge conditions and cuts through a series of bedrock gorges which are connected by shallow valley deposits of sand, silt and gravel. Bed deposits in the gorges appear to be



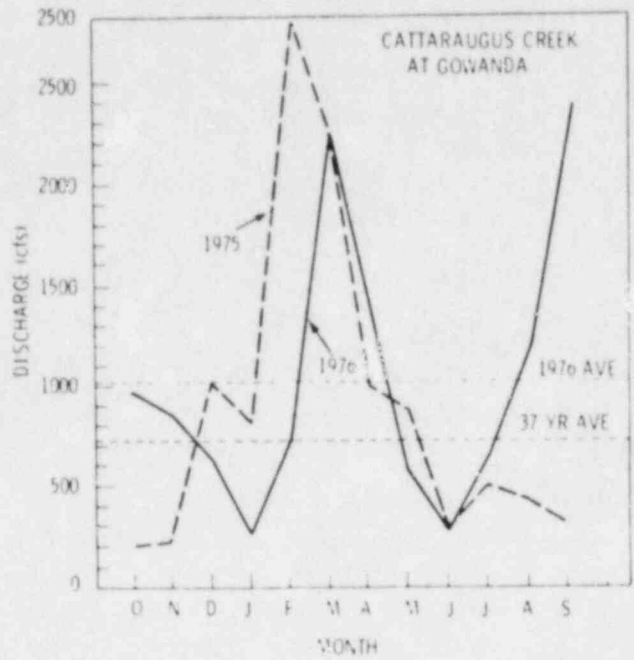


FIGURE 5.2. 1975-76 Monthly Discharges of Cattaraugus Creek at Gowanda

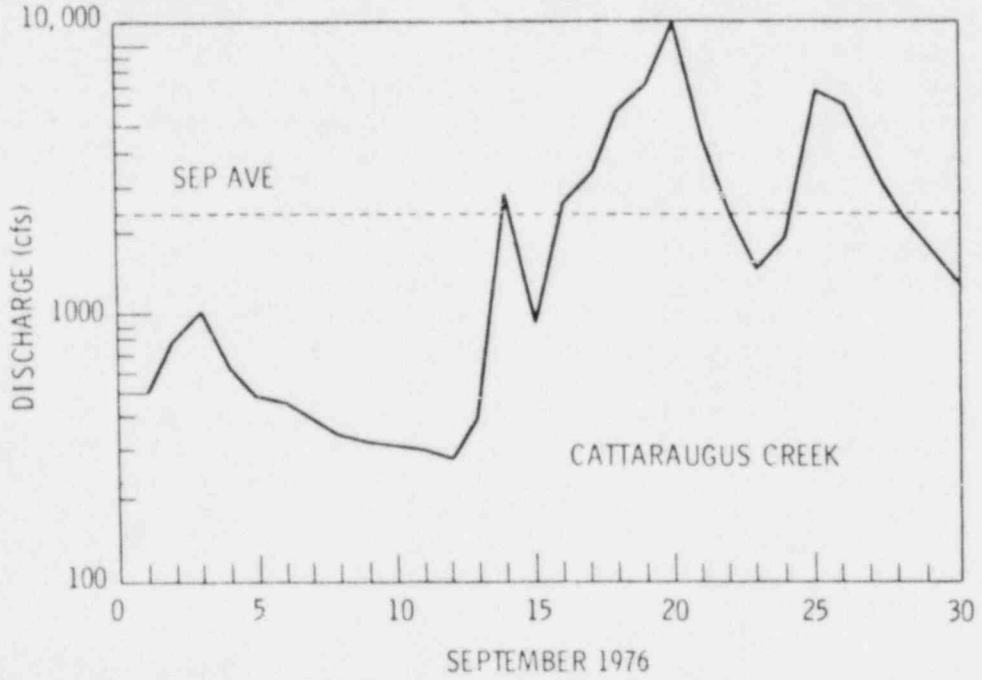


FIGURE 5.3. September Daily Discharges of Cattaraugus Creek at Gowanda

slight and have well defined cross-section profiles. Little bank interaction appears to occur during average- or low-flow conditions.

Springville Dam (Creek Mile 36.5), located about 2.5 miles downstream of the confluence with Buttermilk Creek, is a weir type dam and is 20 ft high. The pool behind the dam is only a few acres in size, is narrow and is surrounded by nearly vertical walls of a deep gorge.

In this study, 41.5 miles of stream length on Buttermilk and Cattaraugus Creeks were modeled. The modeling began on Buttermilk Creek, 2.5 miles above the confluence with Cattaraugus Creek, and continued on Cattaraugus Creek for 39.0 miles to Lake Erie. The only tributary to Buttermilk Creek included in the model was Franks Creek.

Cattaraugus Creek has ten tributaries of varying magnitude, some of which are ephemeral, in addition to numerous transient lateral inflow contributions. The major tributaries on this stretch of Cattaraugus Creek are Spring Brook above Springville Dam, and Spooner, Connoisarauley, South Branch Cattaraugus, and Clear Creeks below the dam. Other than the 0.5 mile long reservoir behind Springville Dam, Cattaraugus Creek is free-flowing. The only permanent stream gaging station on the study reach is operated by the U.S.G.S. at Gowanda Bridge on Cattaraugus Creek 20 creek miles downstream from the Buttermilk Creek confluence.

## 5.2 SAMPLING PROGRAM

The Cattaraugus/Buttermilk Creeks sampling program consisted of field surveys of channel geometry and the monitoring of water, sediment, and radionuclides during three time periods: November 30-December 5, 1977; September 20-24, 1978; and April 26-29, 1979. These monitoring periods are referred to as Phase 1, Phase 2, and Phase 3, respectively. Detailed accounts of these monitoring programs can be found in related publications (Ecker and Onishi 1979, Walters et al. 1982, Ecker et al. 1982).

The modeled streams include 2.5 miles of Buttermilk Creek and 39.0 miles of Cattaraugus-Creek immediately downstream of the Buttermilk confluence. Although the total modeled streamlength is 41.5 miles, six of the eight data verification stations (Table 5.1) are located in the first 8.8 miles of simulated streamlength.

The data collection effort on the three phases of monitoring are similarly unbalanced. More samples were taken during Phase 3 than in Phases 1 and 2 combined. This is because only in Phase 3 were time-varying data for water, sediment, and radionuclides collected.

Therefore, the problem which is best defined is the Phase 3 simulation of the 8.8 miles of streamlength along Buttermilk and Cattaraugus Creeks. This stretch of channel begins just above the Franks Creeks confluence on Buttermilk Creek, continues as Buttermilk Creek enters Cattaraugus Creek and ends at Frye Bridge, 3.8 miles below Springville Dam (Figure 5.1). In this study, the Phase 3 data will be the most heavily relied upon and the Franks Creek to Frye Bridge area will be under closer scrutiny than the downstream areas.

TABLE 5.1. Sampling Station Location

<u>SERATRA Segment</u>	<u>Sampling Station</u>	<u>River Mile</u>	<u>Description</u>	<u>Phase 1</u>	<u>Phase 2</u>	<u>Phase 3</u>
1	BC-2	BCM 2.05	1200 ft downstream of Franks Creek Confluence	X		
3	BC-3	BCM 1.34	Bond Road Bridge	X	X	X
6	BC-4	BCM 0.21	Thomas Corners Bridge	X	X	X
8	CC-3	CCM 38.4	Felton Bridge	X	X	X
14	CC-5	CCM 36.5	Springville Dam	X	X	X
21	CC-6	CCM 32.7	Frye Bridge			X
28	CC-9	CCM 16.4	Gowanda Bridge	X	X	X
34	CC-11	CCM 1.5	Mouth of Cattaraugus Creek	X	X	X

The modeling strategy was to use the Phase 3 data for calibration, attempting to match, as well as possible, the model results to the information from the data stations in the first 8.8 miles of the simulation reach. Once the input data for SERATRA were prepared, the cohesive sediment parameters and the vertical dispersion coefficient remained to be calibrated. Using the Phase 3 flow event, these parameters were calibrated and then applied without recalibration to the Phase 1 and Phase 2 simulations. All other input parameters were specified from the data collection program.

#### Channel Geometry

Surveys of the channel cross-sectional geometry were performed during the Phase 1 field investigation and supplemented by additional surveys in the fall of 1980. More than 50 cross-sections were logged, primarily upstream of Frye Bridge. Long stretches of unsurveyed channel exist between Frye Bridge and Lake Erie due to access problems. U.S. Geological Survey Topographic Maps aided in the synthesis of these missing cross-sections.

#### Sediment Sampling

Grab samples of sediment, both in the channel bed and suspended in the water column, were the source of sediment data input to SERATRA. Samples were taken at each of the collection stations but not in the tributaries. The bulk concentration of the suspended sample was determined before both bed and suspended sediment samples were mechanically separated into sand (>74  $\mu\text{m}$ ), silt (74  $\mu\text{m}$  - 4.0  $\mu\text{m}$ ), and clay (<4.0  $\mu\text{m}$ ) fractions.

#### Radionuclide Sampling

Radionuclides can exist in both aqueous and particulate forms. On the microscopic level there is a constant exchange of radionuclides between

solution and particle surfaces. In either form, radionuclide measurement requires sophisticated laboratory analysis.

After fractioning and weighing the collected bed and suspended sediment samples from Cattaraugus and Buttermilk Creeks, the samples were sent to the University of Washington for laboratory testing. Thirty radionuclides and their respective activity levels were measured for in this testing. Dissolved radionuclides were collected on reactive resin beds as field-sampled water was pumped through the beds. These beds were then sent to the University of Washington and tested in a manner similar to the sediment samples.

In addition to the activity levels detected in the water and sediment, the University of Washington provided distribution coefficients for five radionuclides:  $^{137}\text{Cs}$ ,  $^{85}\text{Sr}$ ,  $^{237}\text{Pu}$ ,  $^{106}\text{Ru}$ , and  $^{241}\text{Am}$  (Schell et al. 1979).

### 5.3 HYDROLOGIC MODELING

As part of its input data set, SERATRA requires depths and discharges at each timestep for every computational segment. The hydrodynamic modeling of Cattaraugus and Buttermilk Creeks which provided these data was performed with two models, DWOPER and MUSK. Boundary conditions for these models were based on measured and synthesized flows.

DWOPER, a one-dimensional dynamic wave model developed by the National Weather Service Hydrologic Research Laboratory (Fread 1978), was intended to be the sole model of instream hydrodynamics in this study. However, the application of DWOPER to Buttermilk Creek resulted in depths and velocities which were unreasonable despite the apparently satisfactory resolution of discharges (Figure 5.4a,b,c). Highly dynamic flow on steep, shallow streams seems to cause the model to underestimate the flow depth (Figure 5.5). This results in a prediction of supercritical flow in areas where it was not observed. Generally, problems of this nature can be alleviated by increasing the Manning roughness coefficient and if necessary, averaging cross-sections so that a smoother transition between computational nodes occurs. Although these techniques produce palatable results, they also have the effect of obscuring the description of the physical phenomena. Since errors in the hydrodynamics are passed on and magnified in the subsequent sediment and radionuclide modeling, they must be kept to a minimum. Cattaraugus Creek was modeled satisfactorily by DWOPER and there was no reason to abandon the model due to difficulties in a relatively short stretch of Buttermilk Creek. The depth calculation problems in Buttermilk Creek were avoided by applying MUSK, a one-dimensional diffusion wave model developed at Colorado State University (Ponce 1980), to this section of the hydrodynamic simulation (Figure 5.6a,b,c).

#### Model Descriptions

##### DWOPER

DWOPER was developed for application to large dendritic river systems such as the Mississippi-Ohio. However, the model is generally applicable to rivers having irregular geometry, variable roughness parameters, and lateral

inflows. In addition, it has certain features to be discussed below which provide the necessary flexibility for its application to the extreme hydraulic conditions found in the Cattaraugus-Buttermilk Creek system.

As described by Fread (1978), DWOPER uses a finite difference solution to the one-dimensional unsteady flow equations consisting of conservation of mass and momentum equations, i.e.,

$$\frac{\partial Q}{\partial x} + \frac{\partial(A+A_0)}{\partial t} - q = 0 \quad (51)$$

$$\frac{\partial Q}{\partial t} + \frac{\partial(Q^2/A)}{\partial x} + gA \left( \frac{\partial h}{\partial x} + S_f + S_e \right) - qv_x + W_f B = 0 \quad (52)$$

in which  $Q$  is discharge,  $A$  is cross-sectional area,  $A_0$  is off-channel cross-sectional area wherein velocity is considered negligible,  $q$  is lateral inflow or outflow,  $x$  is distance along the channel,  $t$  is time,  $g$  is gravitational acceleration,  $v_x$  is the velocity of lateral inflow in the  $x$ -direction,  $W_f$  is the wind term,  $B$  is the channel top width and  $S_f$  is the friction slope defined as:

$$S_f = \frac{n^2 |Q| Q}{2.2 A^2 R^{4/3}} \quad (53)$$

in which  $n$  is the Manning roughness coefficient and  $R$  is the hydraulic radius. The term  $S_e$  is defined as:

$$S_e = \frac{K_e \partial(Q/A)^2}{2g \partial x} \quad (54)$$

in which  $K_e$  is the expansion-contraction coefficient.

Equations (51) and (52) are solved using the weighted four-point finite difference scheme originally developed by Preissmann (1961). In the weighted four-point scheme, the continuous  $x$ - $t$  region in which solutions of  $h$  and  $Q$  are sought is represented by a rectangular net of discrete points. The scheme allows the use of equal or unequal intervals of  $\Delta x$  and  $\Delta t$  along the  $x$  and  $t$  axes, respectively. Each point is identified by a subscript ( $i$ ) which designates the  $x$  position and a superscript ( $j$ ) for time position. The time derivatives are approximated by:

$$\frac{\partial K}{\partial t} = \left( K_i^{j+1} + K_{i+1}^{j+1} - K_i^j - K_{i+1}^j \right) / 2\Delta t \quad (55)$$

in which  $K$  represents any variable. The spatial derivatives are approximated by a finite difference quotient positioned between two adjacent time lines according to weighting factors  $\theta$  and  $1-\theta$ , i.e.,

$$\frac{\partial K}{\partial x} \approx \theta \left( K_{i+1}^{j+1} - K_i^{j+1} \right) / \Delta x + (1-\theta) \left( K_{i+1}^j - K_i^j \right) / \Delta x \quad (56)$$

and variables other than derivatives are approximated in a similar manner, i.e.,

$$K \approx \theta \left( K_i^{j+1} + K_{i+1}^{j+1} \right) / 2 + (1-\theta) \left( K_i^j + K_{i+1}^j \right) / 2 \quad (57)$$

Generally, the ability of a model such as DWOPER to reproduce actual flow events depends on the amount and quality of data available for the stream system under study. These data include: 1) channel geometry, 2) hydraulics, 3) estimate of channel roughness, and 4) initial conditions.

Channel geometry is represented in the model by surface widths as a function of stage at computational points corresponding to actual cross section locations. From the surface widths, wetted area and conveyance are also determined as functions of stage.

Hydraulic data refers to boundary conditions and observed stages and/or discharges. Both upstream and downstream hydrographs are needed on each stream for the operation and calibration of DWOPER. For this study, the upstream boundaries included the inflow hydrographs for each stream as previously discussed. Channel roughness in the model is represented by a single lumped parameter, Manning's "n", which accounts for all the processes that contribute to the loss of energy or momentum, excluding expansion and contraction losses [see Equation (54)]. Initial values for Manning's "n" for the two study streams were computed indirectly from Manning's equation based on velocity measurements at the upstream boundaries. Initial conditions were computed for each computation point using standard step backwater. The use of the computed "n" values resulted in super-critical flow conditions at several locations. This was corrected by increasing the "n" values, within reasonable limits, until the flow became subcritical.

The use of a variable  $\Delta x$  and the ability to change  $\Delta t$  and the weighting factor  $\theta$  are important in the application of DWOPER to Cattaraugus Creek because of the flexibility they provide, when judiciously selected, in controlling the model's numerical stability and convergence. In implicit schemes, such as that used by DWOPER, the finite difference approximations of Equations (51) and (52) converge to the true solutions of the partial differential equations as  $\Delta x$  and  $\Delta t$  approach zero (Abbot and Ionescu 1967, Leendertse 1967). In this sense, convergence is the measure of the error in the numerical scheme due to improper discretization. Stability refers to the ability of a numerical scheme to limit error growth due to round-off. The only necessary condition for stability of implicit schemes is that the weighting factor  $\theta$  be greater than 0.5. Therefore, for a given value of  $\theta$ , a decrease in the values of  $\Delta x$  and  $\Delta t$  increases the accuracy of the model. On the other hand, as  $\theta$  approaches 1.0, the model becomes stable and less convergent, increasing numerical distortion.

Certain channel and hydrograph characteristics can also have an effect on the level of numerical distortion present in the model. Fread (1973) demonstrated that numerical distortion increases with increasing channel length, roughness factor and channel slope or with decreasing initial depth of flow. Also, as the time to peak of the upstream boundary hydrograph decreases, the numerical distortion increases. From this it can be seen that the usual problems encountered in building and running mathematical models are magnified considerably in the face of conditions similar to those in the Cattaraugus Creek system.

### MUSK

MUSK is a simplified flood routing model of the diffusion wave class. In general, it can be applied in steep channels where no downstream controls exist. Unlike DWOPER, MUSK is designed for use on a single primary stream with lateral inflow introduced along the streamlength. Irregular geometries and spatially varying roughness coefficients are normal model input data for MUSK.

The MUSK formulation is based on a manipulated form of the one-dimensional unsteady flow equations. In place of the conservation of momentum equation [Equation (52)], a single-valued resistance equation, i.e., Manning, is substituted. This is known as the kinematic wave approximation. Using this approximation, the one-dimensional convection equation can be derived from the mass conservation equation.

$$\frac{1}{c} \frac{\partial Q}{\partial t} + \frac{\partial Q}{\partial x} = 0 \quad (58)$$

where  $c$  = celerity  
 $Q$  = discharge

A finite difference representation of this equation with weighting in the time dimension yields the following equation

$$\frac{1}{c\Delta t} \left\{ \theta \left( Q_i^{j+1} - Q_i^j \right) + (1-\theta) \left( Q_{i+1}^{j+1} - Q_{i+1}^j \right) \right\} + \frac{1}{2\Delta x} \left\{ \left( Q_{i+1}^{j+1} - Q_i^{j+1} \right) + \left( Q_{i+1}^j - Q_i^j \right) \right\} = 0 \quad (59)$$

An explicit solution scheme is used in MUSK to solve for  $Q$  across the  $x$ - $t$  domain.

The convection equation is inherently nondiffusive, meaning that a flood wave shape is routed downstream without attenuation. This is precisely the behavior of a kinematic wave, the assumption used in the MUSK formulation. However, an analysis of the higher order error terms of the finite difference analogs discloses that numerical deviations in the flood wave will occur. The actual deviation is a function of  $\Delta x$ ,  $\Delta t$ ,  $c$ , and  $\theta$ . It can be shown that if

the diffusion wave approximation is used in place of the conservation of momentum equation, i.e., inertia terms are neglected, the one-dimensional convection-diffusion equation can be derived from the unsteady flow equation set

$$\frac{1}{c} \frac{\partial Q}{\partial t} + \frac{\partial Q}{\partial x} = \frac{Q_0}{2bS_0 c} \frac{\partial^2 Q}{\partial x^2} \quad (60)$$

By matching the truncation error of the convection equation finite difference scheme to the physical diffusion found in the convection-diffusion equation, the weighting value  $\theta$  can be calculated to produce a physically-based diffusion. Thus, although the MUSK formulation is based on a unique stage-discharge relationship, the flood wave attenuation computed by MUSK does not reflect a single-valued rating curve. The behavior described by MUSK is similar to the less simplified parabolic partial differential equation which describes the diffusion wave. Since this is the case, flow depths are calculated by using continuity rather than the resistance equation.

Nonuniform  $\Delta x$  and a constant  $\Delta t$  are user supplied in MUSK while the weighting factor,  $\theta$ , is computed by the model. Because MUSK solves an initial value problem rather than a boundary value problem, a "marching" solution which propagates downstream is used. This precludes any backwater effects from being resolved by the model.

The data requirements by MUSK are very similar to those of DWOPER. The largest difference occurs in the hydraulic data. MUSK needs discharge hydrographs only at the upstream and lateral inflow boundary conditions. Because it solves an initial value problem, internal and downstream boundary conditions are not necessary. MUSK also uses the Manning roughness coefficient in its formulation; however, in this case energy losses from channel expansion and contraction are lumped into this parameter. The Manning resistance coefficient in MUSK is location dependent.

MUSK has been shown to be unconditionally stable and convergent for the types of problems where it is applicable.

#### MODEL APPLICATIONS

The MUSK simulation used 13 nodes to represent the 2.5 miles of Buttermilk Creek at the beginning of the study reach (Figure 5.7). The smallest distance between nodes was 0.20 miles while the longest interval was 0.26 miles. The upstream boundary condition was the hydrograph calculated at the beginning of the simulation reach. Lateral inflow from Franks Creek was brought in as a hydrograph at the second node.

The DWOPER simulation of Cattaraugus Creek was divided into two separate simulations: 12 nodes (4.8 miles) above Springville Dam and 21 nodes below. The upstream boundary condition hydrograph for the upper Cattaraugus Creek simulation was located 2.3 miles above the Buttermilk Creek confluence and based on data collected at Bigelow Bridge. The downstream boundary condition was a single-valued rating curve at Springville Dam (Figure 5.7). The longest



interval between nodes on the upper simulation was 0.63 miles while the shortest interval was 0.15 miles. Major tributaries on this simulation reach were Spring Brook and Buttermilk Creek. The discharge hydrograph calculated by MUSK at the end of the Buttermilk Creek was used by DWOPER as the lateral inflow boundary condition to Cattaraugus Creek.

The DWOPER simulation below the dam use a calculated hydrograph as the upstream boundary condition and observed stage hydrographs at Lake Erie as the downstream boundary condition (Figure 5.8). The longest interval between nodes on the lower Cattaraugus Creek simulation was 3.6 miles while the shortest interval was 0.25 miles. Below Springville Dam, four major tributaries enter Cattaraugus Creek: Spooner, Connoisarauley, South Branch Cattaraugus, and Clear Creeks. These tributaries are treated as lateral inflow boundary conditions requiring discharge hydrographs.

In this study, Snyder's method of hydrograph synthesis was used in conjunction with rainfall information and the SCS (Soil Conservation Service) curve number method for runoff calculation (Viessman et al. 1977). Where boundary conditions were not sufficiently monitored in the field, synthetic unit hydrographs based upon watershed characteristics were computed for individual sub-basins. Rainfall data from NOAA were used to reconstruct precipitation events and determine magnitudes for the individual hydrographs. Runoff reaching the boundary condition site was calculated using the SCS curve number method and superposed upon the estimated baseflows.

#### Hydrodynamic Modeling Results

In the context of the three phases of sampling, the Phase 3 hydrodynamic were moderate in discharge and unsteadiness. Phase 3 was selected for the first modeling effort because boundary conditions and calibration data were available from the field investigation. During Phase 3, all upstream boundary conditions and most major tributaries were gaged for discharge. Hydrograph synthesis was required only at South Branch Cattaraugus Creek which is downstream of the area of primary interest. Calibration of Manning resistance coefficients for the Phase 3 hydrodynamic modeling was available at Frye Bridge (Creek Mile 32.7) and Gowanda Bridge (Creek Mile 16.4). Results of the Phase 3 hydrodynamic modeling are compared with measured values at Gowanda in Figure 5.9. The Phase 3 hydrodynamic modeling began at 8:00 a.m. April 27, 1979 and ended at 8:00 a.m. April 29, 1979. Of the three phases, the Phase 3 hydrodynamics were moderate, as a 48 hr flood wave with a peak discharge of 920 cfs traveled downstream. The modeled discharges are in excellent agreement with the Gowanda stream data.

Phase 2 discharges were the lowest and least dynamic of the three phases. Synthetic inflows were generated for South Branch Cattaraugus, Connoisarauley and Clear Creeks in addition to the Cattaraugus Creek upstream boundary condition at Bigelow Bridge. Measured baseflows were used in Franks and Buttermilk Creek while a 0.4 cfs/sq. mi. runoff distribution was used to determine other lateral inflows. The average basin rainfall during the Phase 2 simulation period was 2.28 in. of which 0.14 in. were calculated to become runoff. For

the most part, Manning resistance coefficients calibrated in the Phase 3 hydrodynamic simulation were used in the Phase 2 simulation although coefficients in the steeper sections of lower Cattaraugus Creek were increased in some cases. Figure 5.10 is a comparison of computed and measured discharges at Gowanda.

Phase 2 radionuclide sampling began at 8:00 a.m. September 20, 1978 and ended at 12:00 noon September 24, 1978. Since the radionuclide sampling began on the falling limb of a flood hydrograph, it was necessary to begin the hydrodynamic modeling 74 hr earlier to simulate the entire flood wave. Only the last 30 hr of the flood wave are included in the radionuclide modeling as the stream returned to baseflow for the concluding 70 hr of simulation. The computed flood wave is a few hours out of phase with the measured wave; however, the representation of the hydrodynamics during the period of radionuclide simulation is good.

Phase 1 hydrodynamics were the most unsteady and had the highest discharges of the three phases of data collection. Flow measurements in this phase were not sufficient to provide the necessary boundary conditions for the hydrodynamic modeling. Thus, all boundary conditions were computed. Hydrograph synthesis was performed at the Cattaraugus and Buttermilk Creeks upstream boundary condition sites in addition to four major tributaries: Spring Brook, Spooner, South Branch Cattaraugus, and Clear Creeks. The remaining lateral inflows were determined on a basin square mile basis. Unfortunately, the U.S.G.S. streamgaging station at Gowanda was not operating during the Phase 1 simulation period and accurate calibration information was unavailable. The uncalibrated model results at Gowanda appear in Figure 5.11.

The Phase 1 hydrodynamic modeling began at 1:00 a.m. November 29, 1977 in Buttermilk Creek and at 3:00 a.m. November 30, 1977 in Cattaraugus Creek. The additional modeling period in Buttermilk Creek was needed to resolve a complete flood wave. The Cattaraugus Creek simulation ended at 3:00 a.m. December 5, 1977. The baseflow in Buttermilk Creek was used to fill out the additional simulation time required by the Cattaraugus Creek modeling. The modeling results reveal two distinct flood waves occurring during the simulation period with peak discharges exceeding 3000 cfs.

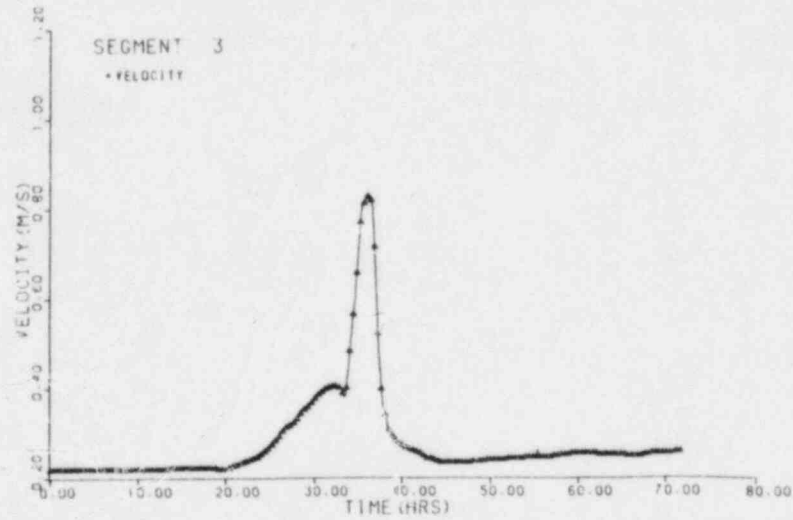
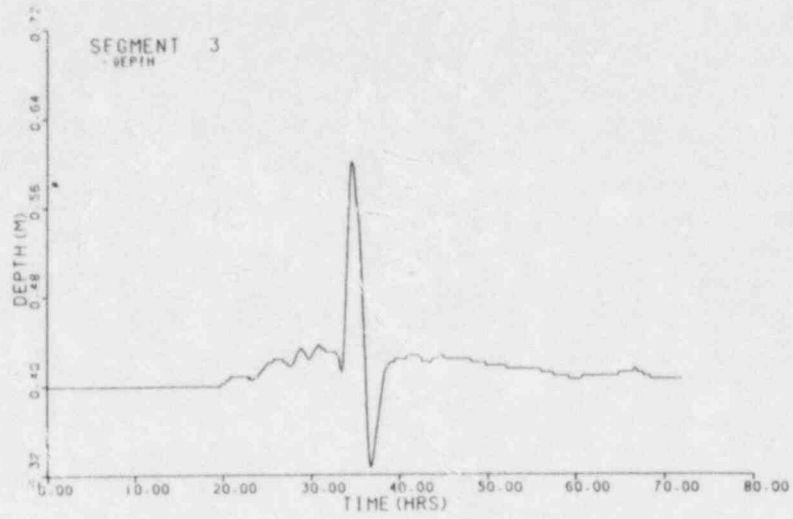
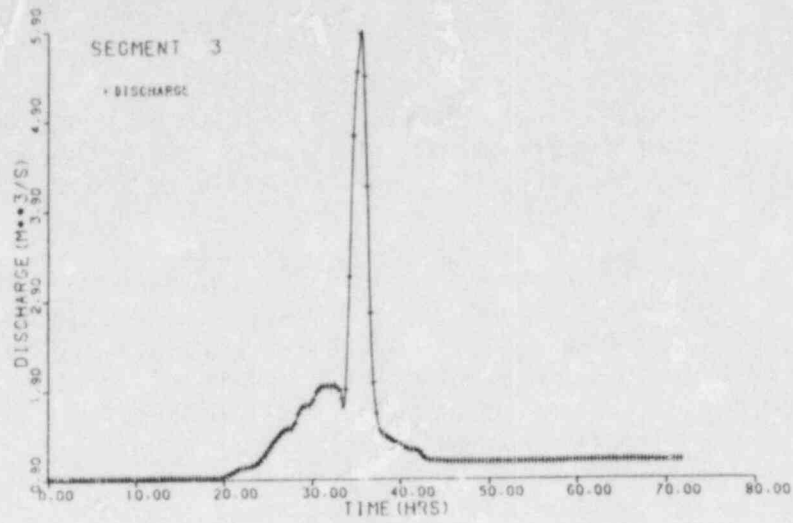
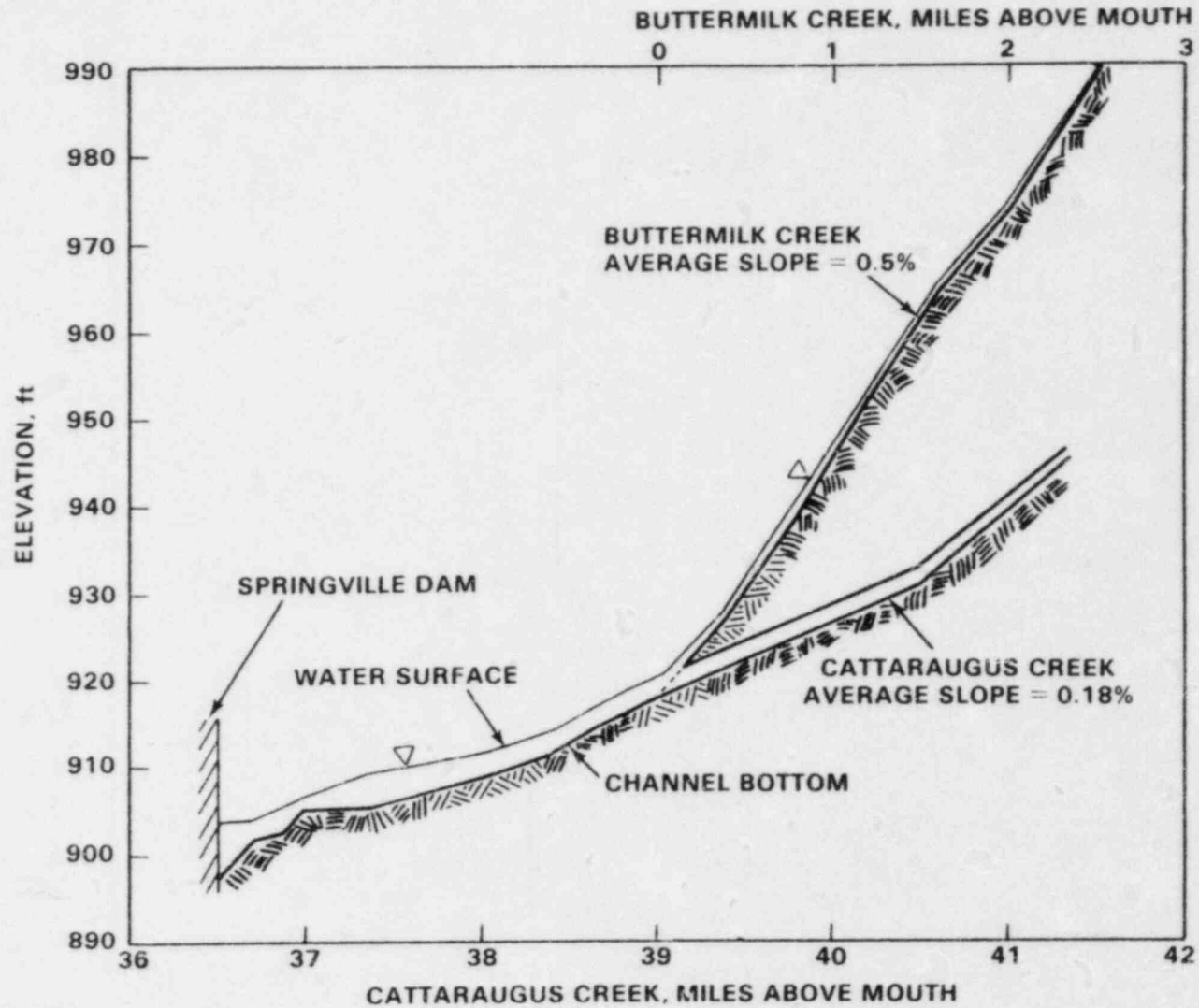
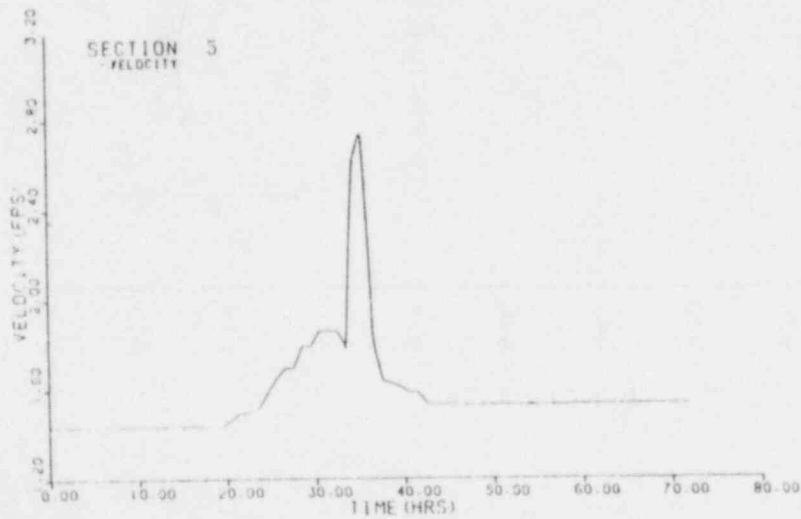
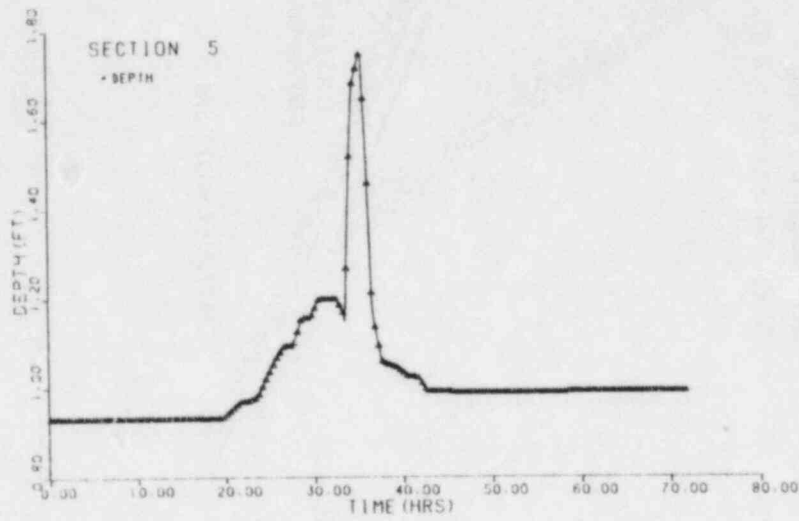
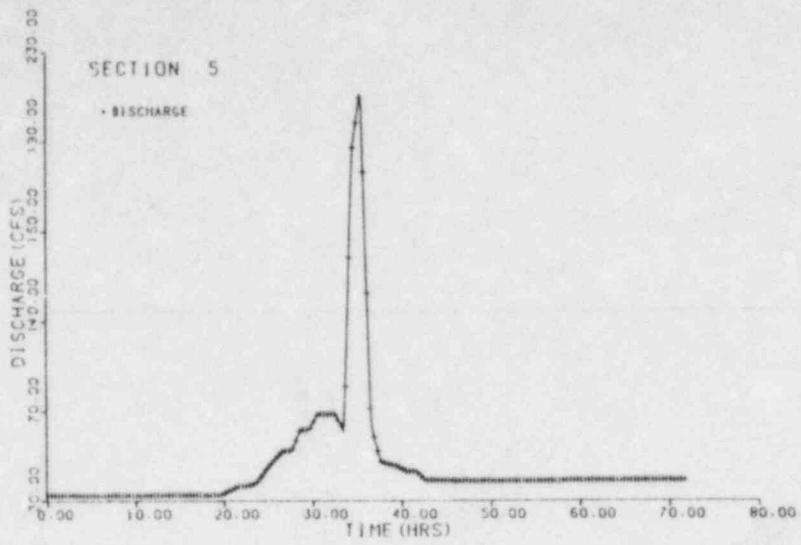


FIGURE 5.4. DWOPER Modeling at Buttermilk Creek Mile 1.6:  
a) Discharge, b) Depth, and c) Velocity



**FIGURE 5.5.** Channel Bottom and Water Surface Profiles of Cattaraugus-Buttermilk Creeks



**FIGURE 5.6.** MUSK Modeling at Buttermilk Creek Mile 1.6:  
a) Discharge, b) Depth, and c) Velocity

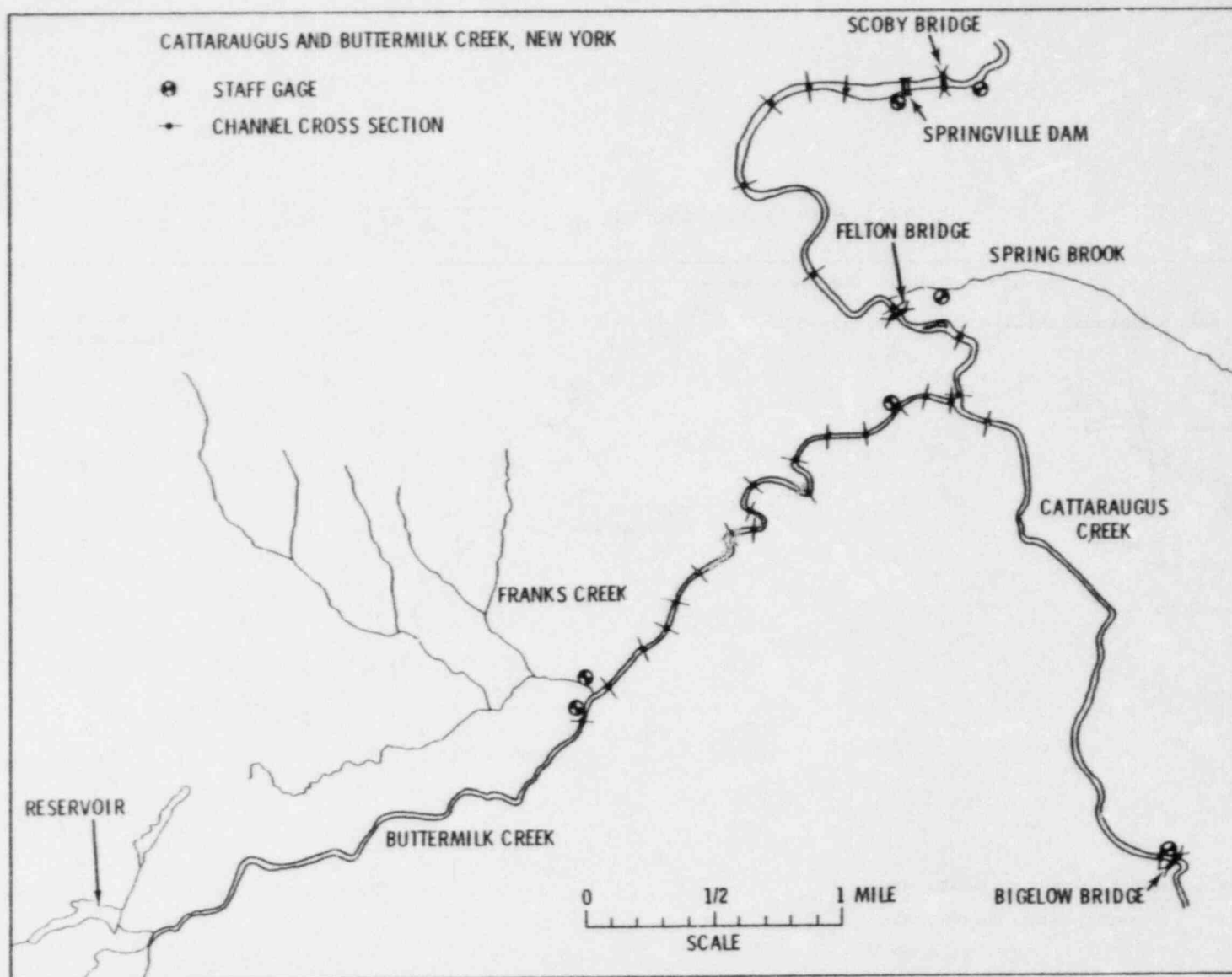


FIGURE 5.7. Map of Cattaraugus-Buttermilk Creeks System, New York

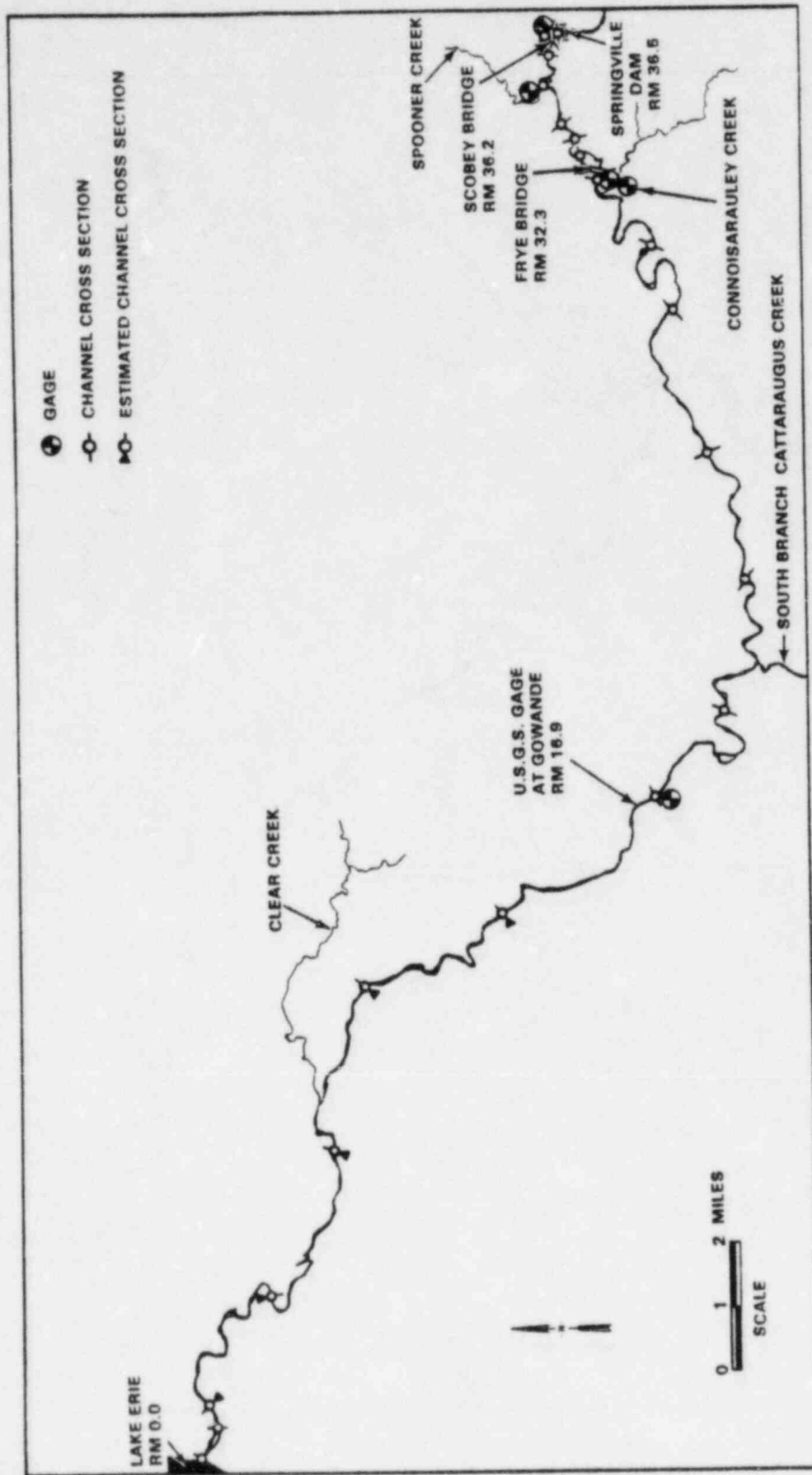


FIGURE 5.8. Cattaraugus Creek, New York

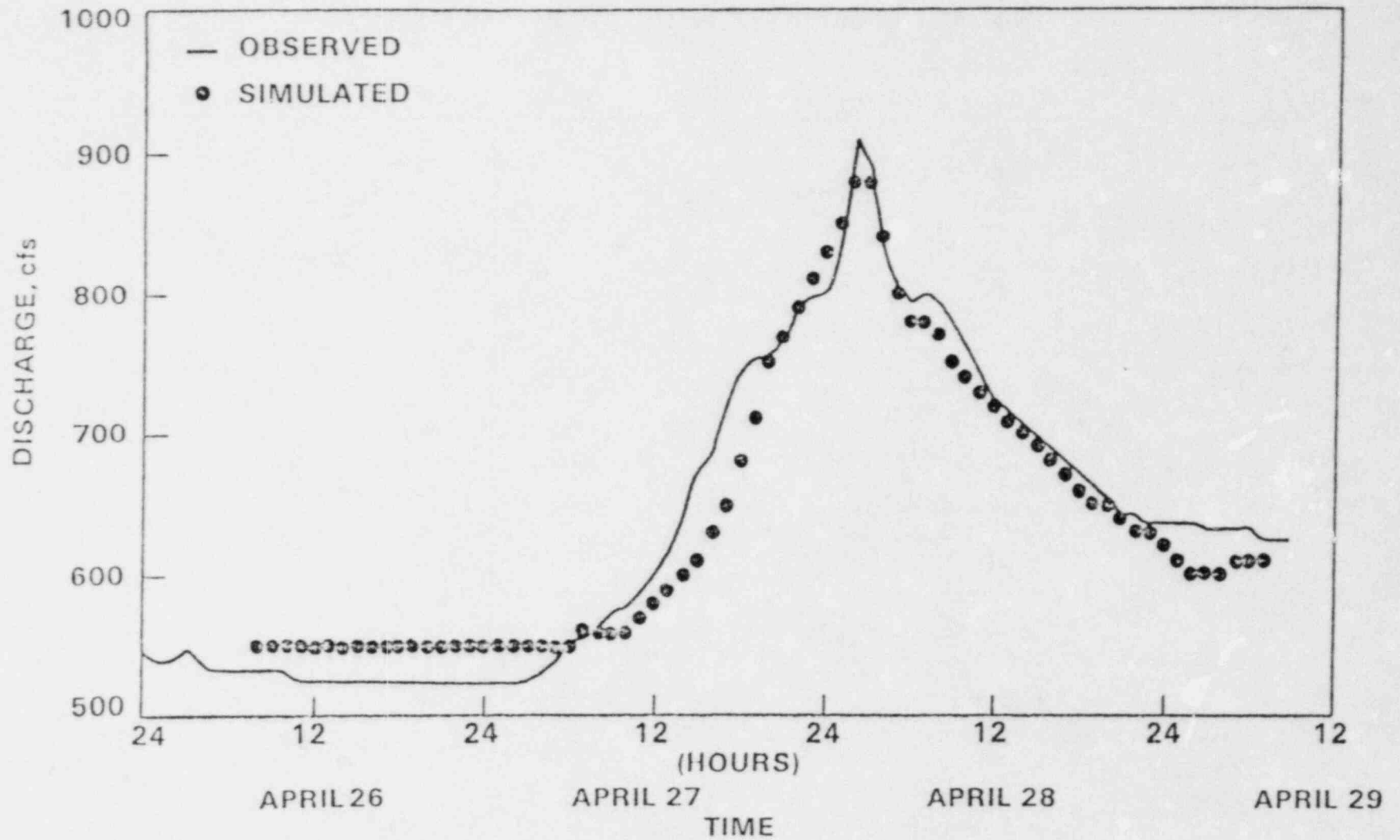


FIGURE 5.9. Phase 3 Discharge Hydrograph at Gowanda



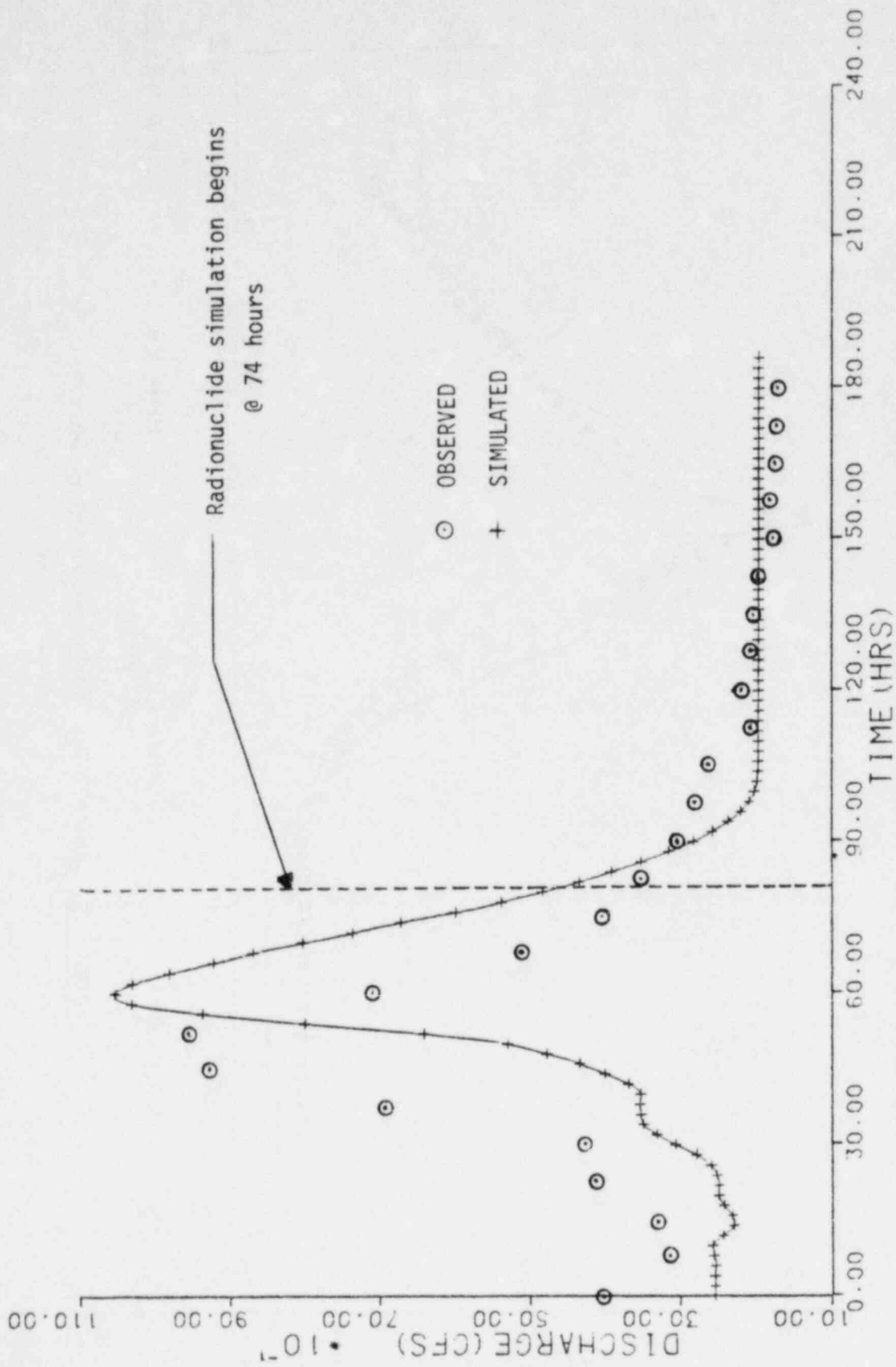


FIGURE 5.10. Phase 2 Discharge Hydrograph at Gowanda

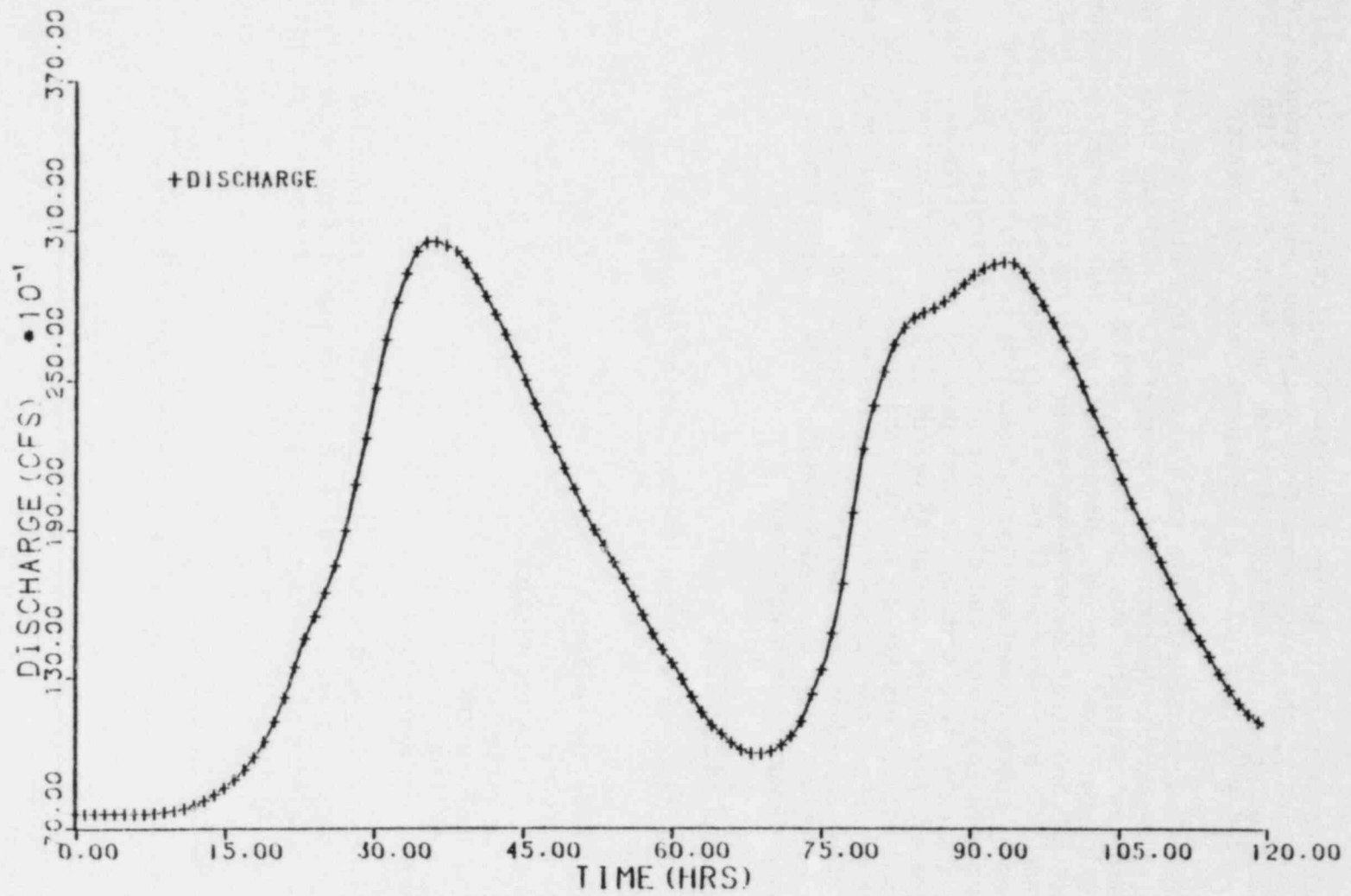


FIGURE 5.11. Phase 1 Discharge Hydrograph at Gowanda

## 5.4 SEDIMENT AND RADIONUCLIDE SIMULATION

This section describes data input to SERATRA and the SERATRA simulation results. Essentially, the Cattaraugus Creek watershed sampling program provided the data set which enabled SERATRA to be applied to four radionuclides ( $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$  and  $^3\text{H}$ ) in the course of three flow events.

The three flow events which are the basis for this study are very different with respect to hydrodynamic characteristics. Of the three phases, Phase 1 hydrodynamics are the most unsteady with the highest discharges occurring during this study period. Unfortunately, time-dependent sediment and radionuclide concentrations were not measured during the Phase 1 field program. Thus, the boundary conditions of a very unsteady flow event are characterized by constant sediment and radionuclide concentrations. The Phase 2 flows were the lowest and steadiest of the three phases. However, as in Phase 1, a single field sampling at each data collection site was relied upon to represent the entire simulation period. Phase 3 hydrodynamics were relatively moderate in discharge magnitude and dynamics. The most extensive data collection effort took place during the Phase 3 field sampling program. In Phase 3, time-dependent sampling was instituted at various data collection sites. The additional data generated provided SERATRA with time-varying sediment and radionuclide boundary conditions.

### 5.4.1 Input Data Description

The SERATRA input data stream is comprised of information which fall into six categories:

1. Numerical Model Parameters
2. Channel Geometry
3. Flow and Fluid Characteristics
4. Sediment Characteristics
5. Radiochemical Parameters
6. Initial Conditions
7. Boundary Conditions

In the Cattaraugus/Buttermilk Creek modeling study, the radionuclide initial and boundary conditions are unique for each of ten applications of SERATRA. However, the remainder of the input parameters are, for the most part, not specific to any of the three flow events being studied.

#### Numerical Model Parameters

The numerical model parameters required by SERATRA are the:

1. number of segments
2. number of timesteps
3. segment length
4. timestep size

5. water column standard element thickness
6. standard channel bed layer thickness
7. number of initial layers in the channel bed.

Basically, the segments and timesteps used in the hydrodynamic modeling of Cattaraugus and Buttermilk Creeks were preserved in the sediment-radionuclide transport simulations. Although segment lengths vary along the study reach, the same channel representation is used for each of the three flow events. Channel bed parameters, i.e., the number of initial bed layers and the bed layer thickness were assigned to be initially constant in this study, regardless of location or flow event.

#### Channel Geometry

At each computational segment, SERATRA requires:

1. segment elevation, and
2. depth-surface area data pairs.

The modeling effort divided the 41.5 mile simulation reach into 34 computational segments. Some of the cross-sections used in the modeling effort were modified/averaged from the original surveys. This is because of model requirements and the existence of more field-surveyed cross-sections than model cross-sections. SERATRA represents channel geometry as depth-width data pairs, i.e., at a given elevation a certain width is associated. This precludes the accurate description of complex or braided channels. For such geometry, an optimized representation of the channel must be developed. Where field information is plentiful, the geometry for a particular cross-section might be the result of averaging two or more field-surveyed cross-sections. In this study, each cross-section at a given location is uniquely characterized but unchanged for all three phases. The channel geometry is taken from the hydrodynamic modeling study performed prior to the execution of the SERATRA code.

#### Flow and Fluid Characteristic

1. the number of water columns based on the flow depth obtained by hydrodynamic models
2. flow discharges obtained by hydrodynamic models
3. water temperature.

#### Sediment Characteristics

The sediment characteristics input to SERATRA are:

1. particle diameter
2. particle density
3. settling velocity
4. critical shear stress for deposition of cohesive sediment
5. critical shear stress for resuspension of cohesive sediment

6. erodability of cohesive sediment, and
7. vertical diffusion coefficient.

In the present application of SERATRA, three particle sizes representing the sand, silt and clay sediment fractions are routed. The selection of the specific size range for each of the three classifications was based on the field measurements in Cattaraugus and Buttermilk Creeks.

The sand fraction can be routed by either the Tofaletti or Colby sediment transport method. The Tofaletti method was used in this study. Silt and clay are treated as cohesive soils whose erosion and deposition rates were estimated by Partheniades (1962) and Krone's Formulas (1962). In the Buttermilk and Cattaraugus Creeks field sampling program, it was not possible to determine the three cohesive sediment parameters (resuspension critical shear stress, deposition critical shear stress, and erodability) required by the SERATRA input stream for the silt and clay size fractions. Therefore, a set of calibration runs were performed prior to the application of the model. The Phase 3 event was chosen for the calibration runs because of the extensive data that was available. To avoid "curve-fitting" the simulation results to the field values, the cohesive sediment transport parameters calibrated with the Phase 3 data were used without recalibration in the Phase 1 and Phase 2 simulations. This is possible because these parameters are theoretically event-independent. The sediment transport parameters are summarized in Table 5.2.

TABLE 5.2. Sediment Characteristics

	<u>Sand</u>	<u>Silt</u>	<u>Clay</u>
Diameter, m	$3.0 \times 10^{-4}$	$1.72 \times 10^{-5}$	$2.0 \times 10^{-6}$
Density, kg/m <sup>3</sup>	2650.0	2650.0	2650.0
Porosity	0.5	0.5	0.5
Vertical Diffusion Coefficient, m <sup>2</sup> /s	0.03	0.03	0.03
Erodability kg/m <sup>2</sup> /s	n.a.	$1.87 \times 10^{-5}$	$1.87 \times 10^{-5}$
Critical Scour Shear Stress kg/m <sup>2</sup>	n.a.	0.9	2.0
Critical Deposition Shear Stress kg/m <sup>2</sup>	n.a.	0.05	0.01

n.a. = not applicable

A reasonable radionuclide modeling requires boundary conditions, distribution coefficients, and verification data to be adequately defined. Of the 30 radionuclides which were detected in the field samples, only four radionuclides generated sufficient information for a reasonable modeling study:  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$ , and  $^3\text{H}$ . Except for the Phase 1 simulation where only  $^{137}\text{Cs}$  and  $^3\text{H}$  were modeled, these four radionuclides were simulated in the Phase 2 and Phase 3 events. Fortunately, these four radionuclides display a wide range of behavior with which SERATRA can be tested. Half lives vary from 12 to 7000 yr while distribution coefficients, i.e.,  $K_d$ s, range over two orders of magnitude.

SERATRA is unique in its treatment of the adsorption/desorption phenomenon. Not only does the model simulate the time-dependent exchange of radionuclide between the dissolved and sorbed forms, but the adsorption and desorption processes are treated as distinctly different mechanisms requiring separate  $K_d$  values. The adsorption  $K_d$  values used in this study are from laboratory measurements of samples taken from the Cattaraugus and Buttermilk Creeks. However, the desorption  $K_d$ s were not measured in the field.

#### Radiochemical Parameters

The radiochemical parameters used in this modeling study are the:

1. adsorption distribution coefficient
2. desorption distribution coefficient
3. adsorption transfer rate
4. desorption transfer rate, and
5. radionuclide decay rate.

The adsorption/desorption parameters were determined through laboratory radionuclide analyses of bulk water-sediment samples in Cattaraugus Creek. Where data were insufficient, desorption parameters were calculated using adsorption/desorption ratios from other studies (Schell et al. 1980). Specific distribution coefficients for each sediment size fraction were created by apportioning the bulk values such that a weighted average of the distribution coefficients would equal the laboratory value. Radionuclide decay rates were based on published physical data. The radiochemical parameters used in this study were unique to the radionuclide being modeled but were kept independent of the flow event being simulated.

Distribution coefficients for adsorption and desorption measured at other freshwater sites (Table 5.3) were used to estimate the desorption  $K_d$ s in this study. For each radionuclide modeled by SERATRA, an average ratio of desorption  $K_d$  was determined from data published in previous studies. This ratio was then applied to the adsorption distribution coefficient measured in Cattaraugus Creek to create the necessary model input (Schell et al. 1980).

TABLE 5.3. Adsorption and Desorption Distribution Coefficients ( $m^3/kg$ )

	$^{137}\text{Cs}$		$^{85}\text{Sr}$		$^{237}\text{Pu}$	
	Adsorption	Desorption	Adsorption	Desorption	Adsorption	Desorption
Lake Michigan	0.509	5.57	0.0822	1.41	141	479
Lake Washington	n.a.	n.a.	n.a.	n.a.	120	300
Clinch River	1.36	n.a.	0.124	0.46	47.1	154
Hudson River	0.401	3.65	0.0737	0.49	9.3	360
Cattaraugus Creek	0.600	n.a.	0.0623	n.a.	20.9	n.a.

n.a. = not available.

The adsorption-desorption process is also a function of sediment size with finer sediment exhibiting a stronger affinity for dissolved radionuclides. SERATRA accounts for this variation by allowing each sediment size fraction to be treated with a separate  $K_d$  value. Since the distribution coefficients measured by the University of Washington were not differentiated by sediment size, an approximate partitioning was employed. It was assumed that a 1:5:10 ratio for sand, silt, and clay distribution coefficients was appropriate. The actual value of each  $K_d$  value was computed such that a weighted average based on sediment fractions yielded the bulk value measured in the laboratory, i.e.,

$$(K_d)_{\text{sand}} (\% \text{ sand}) + (K_d)_{\text{silt}} (\% \text{ silt}) + (K_d)_{\text{clay}} (\% \text{ clay}) = (K_d)_{\text{measured}}$$

where

$$(K_d)_{\text{silt}} = 5 \cdot (K_d)_{\text{sand}}$$

$$(K_d)_{\text{clay}} = 10 \cdot (K_d)_{\text{sand}}$$

Radionuclide input data provided to SERATRA are shown in Table 5.4.

TABLE 5.4. Radionuclide Data Input to SERATRA

	Adsorption			
	$\lambda_s^{-1}$	$Kd_3$ Sand $m^3/kg$	$Kd_3$ Silt $m^3/kg$	$Kd_3$ Clay $m^3/kg$
$^{137}Cs$	$7.27 \times 10^{-10}$	0.1	0.5	1.0
$^{90}Sr$	$7.82 \times 10^{-10}$	0.01	0.05	0.10
$^{239,240}Pu$	$3.34 \times 10^{-12}$	3.5	17.0	35.0
$^3H$	$1.79 \times 10^{-9}$	0.0	0.0	0.0

	Desorption			
	$\lambda_s^{-1}$	$Kd_3$ Sand $m^3/kg$	$Kd_3$ Silt $m^3/kg$	$Kd_3$ Clay $m^3/kg$
$^{137}Cs$	$7.27 \times 10^{-10}$	1.0	5.0	10.0
$^{90}Sr$	$7.82 \times 10^{-10}$	0.1	0.5	1.0
$^{239,240}Pu$	$3.34 \times 10^{-12}$	35.	170.	350.
$^3H$	$1.79 \times 10^{-9}$	0.0	0.0	0.0

#### Initial Conditions

SERATRA requires the following initial conditions to be specified at each segment:

1. bed sediment size fractions
2. bed radionuclide activity
3. suspended sediment size fractions and concentrations
4. suspended radionuclide activity, and
5. dissolved radionuclide activity.

Except for the dissolved radionuclide activity, the initial conditions are defined for each of the three sediment size fractions being modeled. The initial bed conditions for sediment and radionuclide are based on the field sampled values while the water column initial conditions are specified to match boundary conditions at the beginning of the SERATRA simulation.

#### Boundary Conditions

The boundary conditions in SERATRA represent time-varying loadings external to the study reach and include:

1. suspended sediments concentrations
2. particulate radionuclides, and
3. dissolved radionuclides.



Other than the dissolved radionuclides, boundary conditions are specified for each sediment size fraction. Two types of boundary conditions are possible in SERATRA: upstream and lateral inflow. The time-varying boundary conditions in this modeling study were generated by fitting a curve through field-sampled values which were taken over a period of time. If time varying data was sparse, an average value was used.

#### 5.4.2 Sediment Transport Simulation Results

In general, the sediment transport modeling describes a silt-dominated suspended sediment load washing through the creek system. The three flow events modeled are accompanied by relatively high suspended sediment concentrations due in part to the erosion of the channel bed in the study reach. Very little of the fine-grained sediments (silt and clay) are deposited on the channel bottom as the flow carries these particles into Lake Erie. On the other hand, sand displays a net deposition as it passes through the Cattaraugus Creek system. The deposited sediments occur almost exclusively in the Lake Erie and Springville Dam backwaters. Except for these backwater areas, the general tendency is for bed scouring. This scouring of the smaller bed sediment particles leaves a protective surface layer of larger particles which prevents further erosion of the finer sediment. This phenomenon is called bed armoring and was predicted to occur especially during the Phase 1 flow event. The comparison of computed and measured sediment concentrations are shown in this section as well as in Appendix A.

#### Phase 3

From a modeling standpoint, the Phase 3 simulation by SERATRA was well-defined. Time-dependent sampling of water, sediment, and radionuclides at the boundary conditions and verification sites provided a data set which required minimal data generation. Calibration was necessary only for the cohesive sediment transport submodel. All other parameters, including those used in the radionuclide transport submodel were fully specified, thus, no calibration was performed in these cases.

Throughout the simulation silt is a dominant size fraction in the water column accounting for about 85% of the total suspended sediments. Clay accounted for the bulk of the remaining 15% as sand occurred in relatively small concentrations.

The Phase 3 sediment and radionuclide simulation period begins at 8:00 a.m. April 26, 1979 and ends at 8:00 a.m. on April 29, 1979. A summary of the observed and predicted Phase 3 sediment concentrations is found in Table 5.5.

Results from the Phase 3 sediment transport modeling showed a sediment cloud propagating downstream with the 40 hour flood wave. The 'spike' of high discharge in Buttermilk Creek was not reflected in the predicted suspended sediment concentrations, in fact there was a slight decrease in clay concentrations as the spike passed through Buttermilk Creek (Figure 5.12). Although

TABLE 5.5. Phase 3 Observed and Computed Sediment Concentrations

Phase 3 Sediment Comparison (mg/l) (Calibration Run)		
<u>Location</u>	<u>Observed</u>	<u>Computed</u>
BC-3		
Sand	4.46	1.2
Silt	89.01	42.5
Clay	17.82	8.9
BC-4/1		
Sand	0.22	0.3
Silt	15.81	13.1
Clay	4.56	2.0
BC-4/2		
Sand	1.03	1.5
Silt	90.10	62.3
Clay	23.07	7.2
BC-4/3		
Sand	0.26	0.4
Silt	18.27	11.1
Clay	5.27	2.7
CC-3		
Sand	1.06	0.4
Silt	16.31	11.8
Clay	3.74	2.1
CC-5/1		
Sand	0.35	0.3
Silt	19.99	12.0
Clay	4.96	2.9
CC-5/2		
Sand	1.98	0.5
Silt	52.54	34.0
Clay	9.47	6.3
CC-5/3		
Sand	2.18	0.5
Silt	22.68	30.3
Clay	2.84	5.8
CC-6/1		
Sand	0.18	0.5
Silt	15.76	36.9
Clay	4.66	3.3

TABLE 5.5. (contd)

Phase 3 Sediment Comparison (mg/l) (contd)		
<u>Location</u>	<u>Observed</u>	<u>Computed</u>
CC-6/2		
Sand	2.84	0.5
Silt	39.36	53.4
Clay	5.00	5.3
CC-6/3		
Sand	2.42	0.6
Silt	27.88	46.2
Clay	5.91	6.9
CC-9		
Sand	2.25	0.5
Silt	15.12	65.7
Clay	2.92	4.3
CC-11		
Sand	5.33	0.1
Silt	19.22	85.7
Clay	2.65	5.6

the total mass of suspended sediment increased as the spike passed through, dilution by the sudden increase of water volume offset any increases in sediment concentration.

The results of the Phase 3 sediment calibration efforts with SERATRA are in general agreement with measured data. At BC-3, computed silt concentrations are the highest of the three sediment constituents, with clay and sand concentrations considerably below the silt levels. Unlike the sudden high discharges found in Phase 1, a sediment wave gradually changing over 40 hours of simulation characterizes the plots of sediment concentrations. A comparison with the field sampled concentrations at hour 27.5, show predicted concentrations to be 50% lower.

Three field samplings were taken at BC-4 at 3.4, and 36, and 64.5 hr. The gross phenomenon indicated by the field data is a sediment concentration peak occurring near the time of the 37-hour sample. Computed concentrations are in agreement with this trend and compare favorably with the field values (Figure 5.12), especially at the 3.5 and 64.5 hr marks. The predicted sediment concentrations, except for sand, are below the sampled concentrations. As the sediment from Buttermilk Creek enters Cattaraugus Creek, suspended sediment concentrations are reduced by a factor of two (Figure 5.13). A more diffuse sediment wave of a 55 hr duration occurs in this section of Cattaraugus

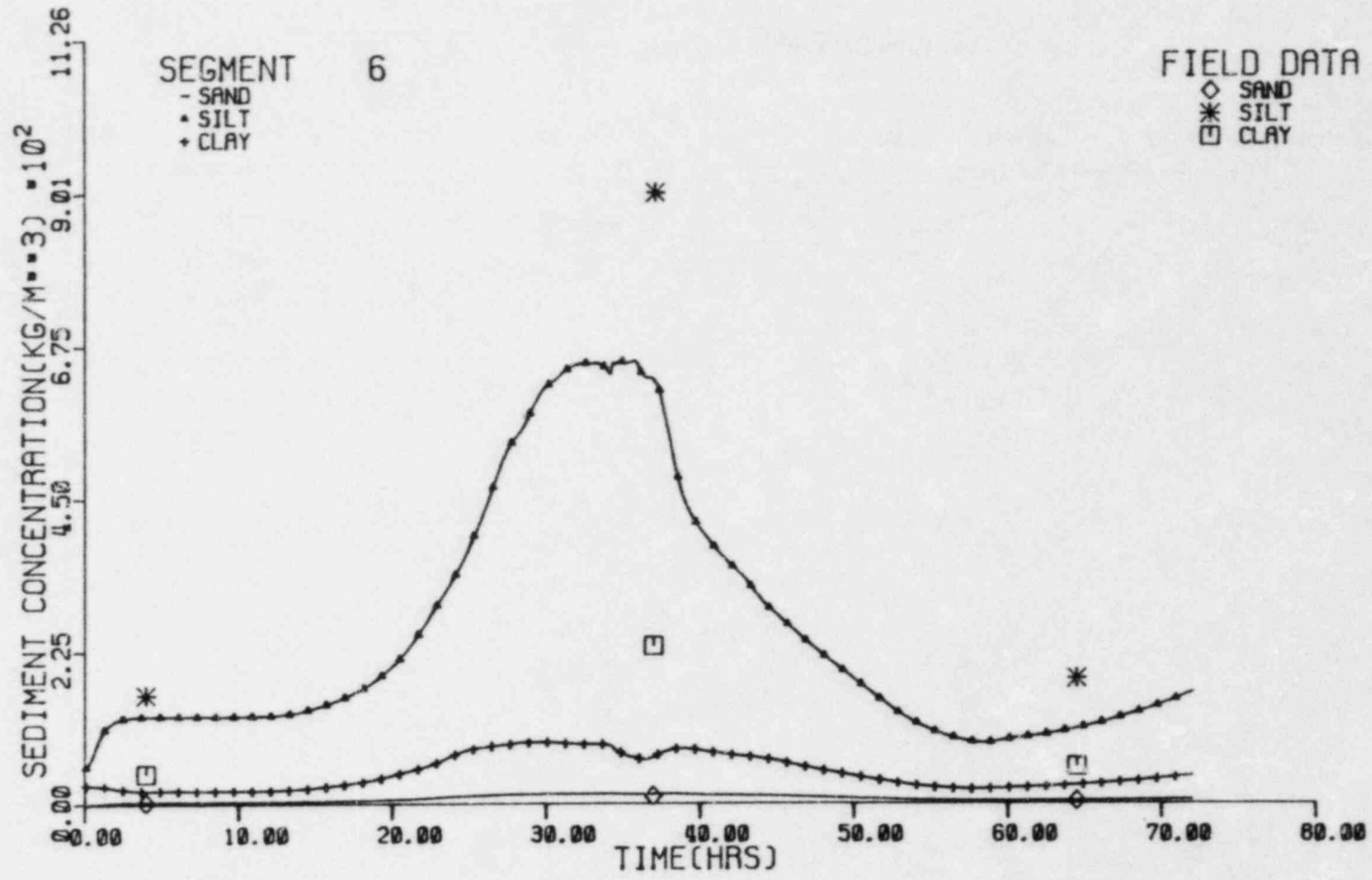


FIGURE 5.12. Phase 3 Sediment Concentrations at BC-4

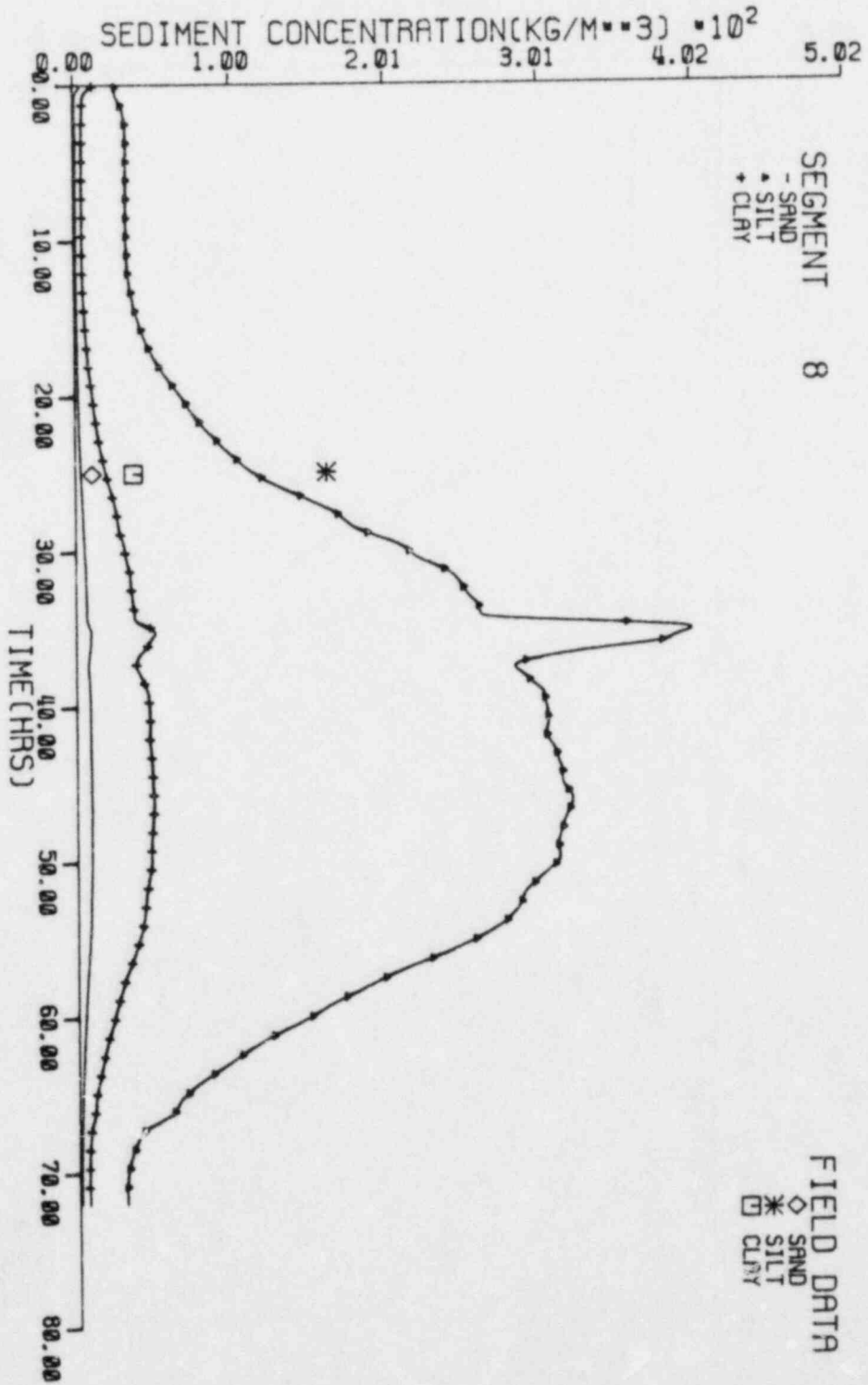


FIGURE 5.13. Phase 3 Sediment Concentrations at CC-3

Creek than in Buttermilk Creek. In this case however, the effect of the Buttermilk Creek discharge is visible. This is due to the sudden increase of sediment mass entering Cattaraugus Creek with the discharge spike.

At CC-3 (Figure 5.13), downstream of the Buttermilk confluence, the predicted sediment wave is broader at the base than that seen on Buttermilk Creek. The "spike" of the Phase 3 hydrodynamics is visible on the sediment wave at CC-3 because the concentrations in Buttermilk Creek are higher than those found in Cattaraugus Creek. Predicted concentrations closely approximate the measured values at 25 hr and are consistently lower.

The field data at CC-5 are samplings at 9, 33, and 59 hr. These data indicate a sediment peak around the 33-hr mark of the event. The modeled peak occurs at 37 hr (Figure 5.14). At 9 and 33 hr, predicted concentrations are consistently 35% below the field concentrations. At 59 hr, predicted silt and clay concentrations are higher than the measured values while the predicted sand is lower than the field concentration.

Downstream of Springville Dam, the wave of predicted sediment becomes more diffuse, taking up the entire simulation period. Although peak sediment concentrations follow the trend of the flood wave, the transported sediment displays the effects of bed scouring and subsequent armoring. Elevated levels of silt concentrations in the first 20 hr of the simulation are the result of bed material suspended by scour. After 50 hr of simulation, the drop in the silt concentration is attributable to the armoring of the silt in the bed by the heavier sand fraction. Clay and sand suspended fractions are not strongly affected by the scouring mechanism and remain in low concentrations with less dynamic effects.

At CC-6 (Figure 5.15) and subsequent segments, the computed silt fraction of the suspended sediment is increasing due to scour. The trend exhibited by the three field samples is in general preserved quite well by the simulation. Clay and sand concentrations computed by SERATRA are within  $0.002 \text{ kg/m}^3$  of the measured concentrations. Predicted silt concentrations are consistently about  $0.015 \text{ kg/m}^3$  higher than the field silt values.

Data Stations CC-9 and CC-11 have very similar results. The sharp wave outline has dissipated, leaving a gentle increase in concentration at hour-50 of the simulation. While the sand and clay concentrations predicted by SERATRA match quite well with sampled data, the silt concentration is about four times higher than the field value. The elevated silt concentrations produced by the model is a result of silt scoured off the channel bottom.

Figure 5.16 is the predicted longitudinal distribution of the total suspended sediment concentration at the end of the 72 hour simulation period. The first four data points represent the modeled concentrations at sites BC-3, BC-4, CC-3, and CC-5. The temporal concentration distributions at these locations indicate these concentrations are at levels near those which existed prior to the flood event. The steady increase in concentration from CC-3 through CC-11 is the spatial description of the falling limb of the sediment wave.

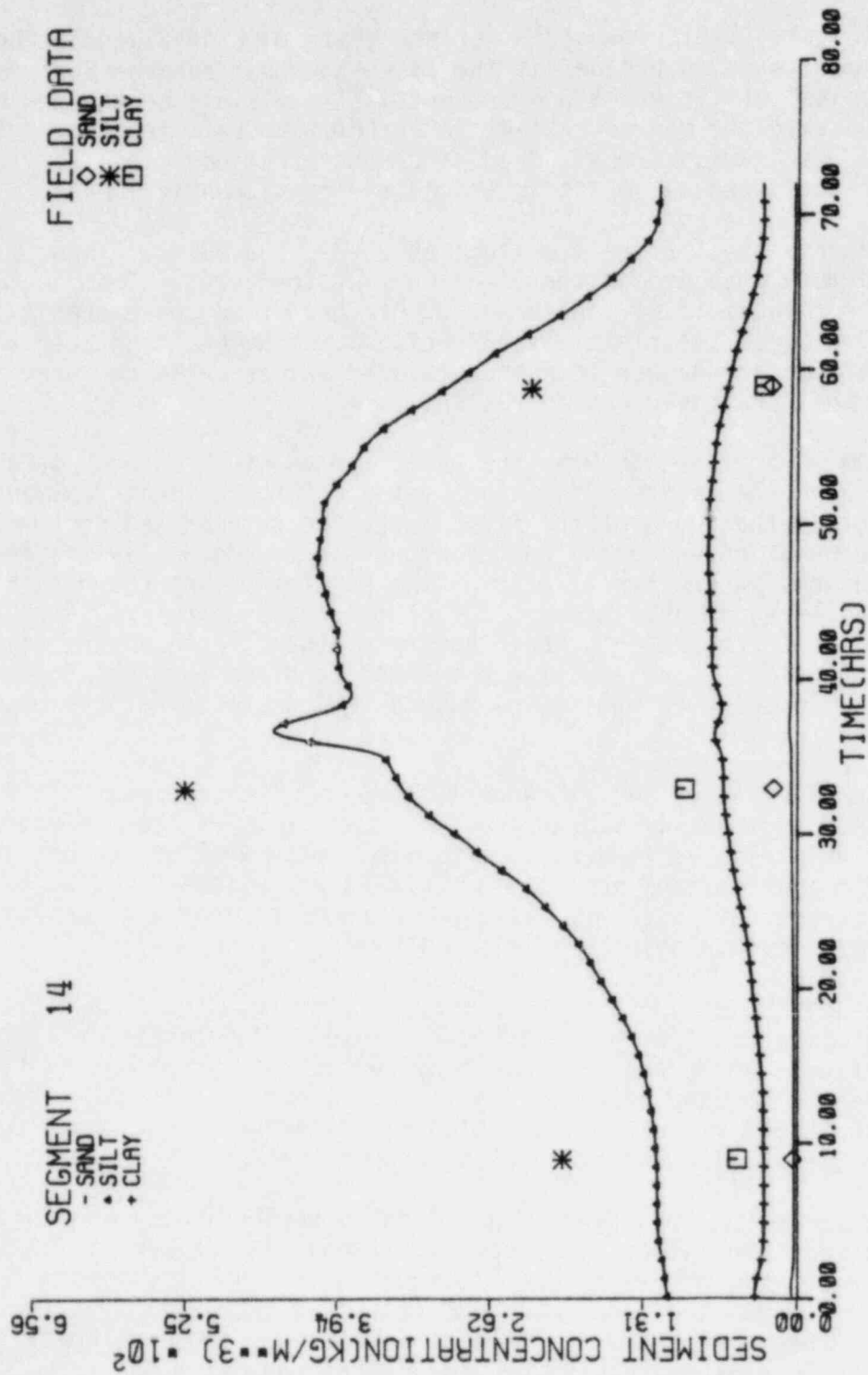


FIGURE 5.14. Phase 3 Sediment Concentrations at CC-5

5.35

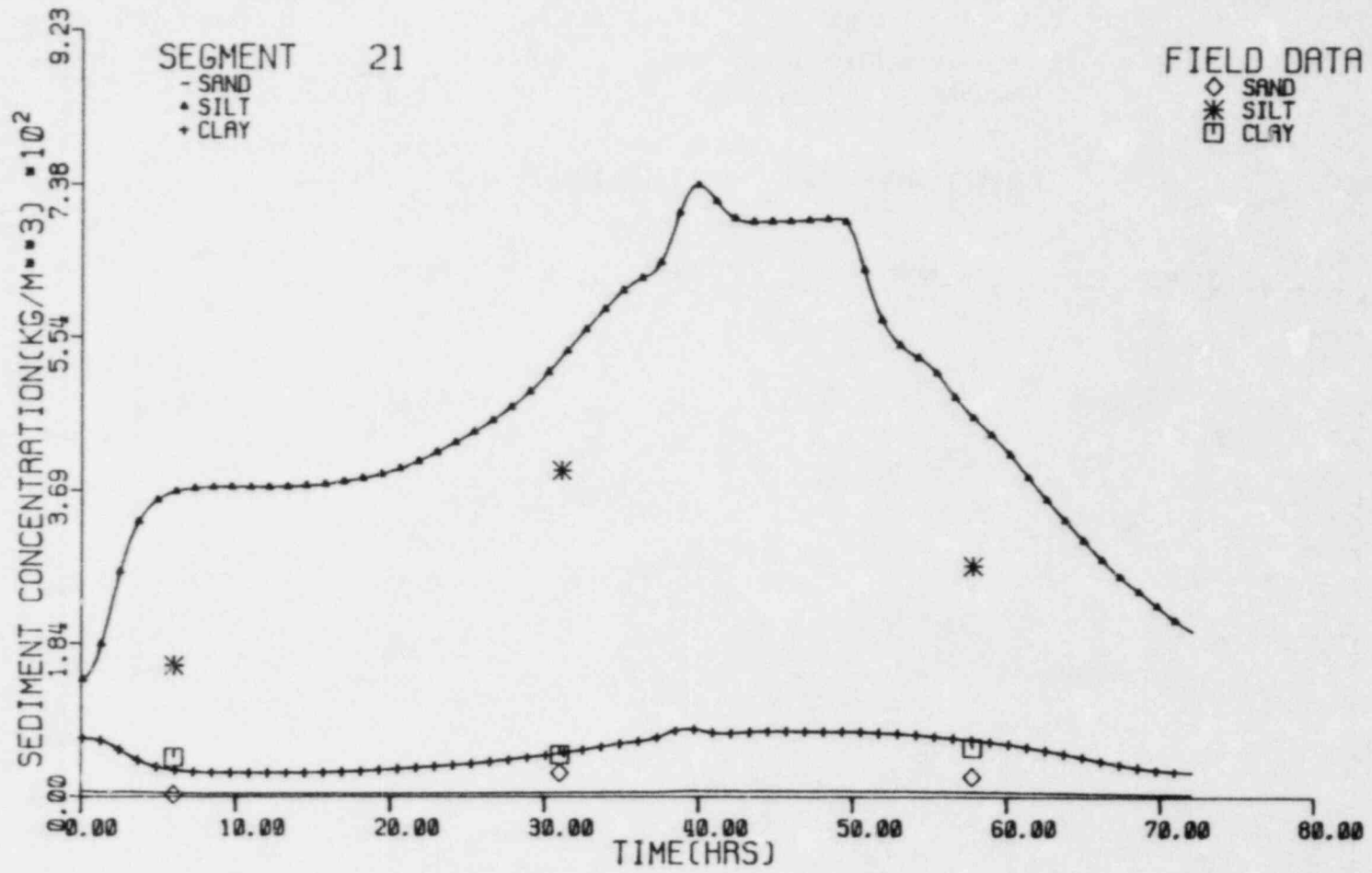
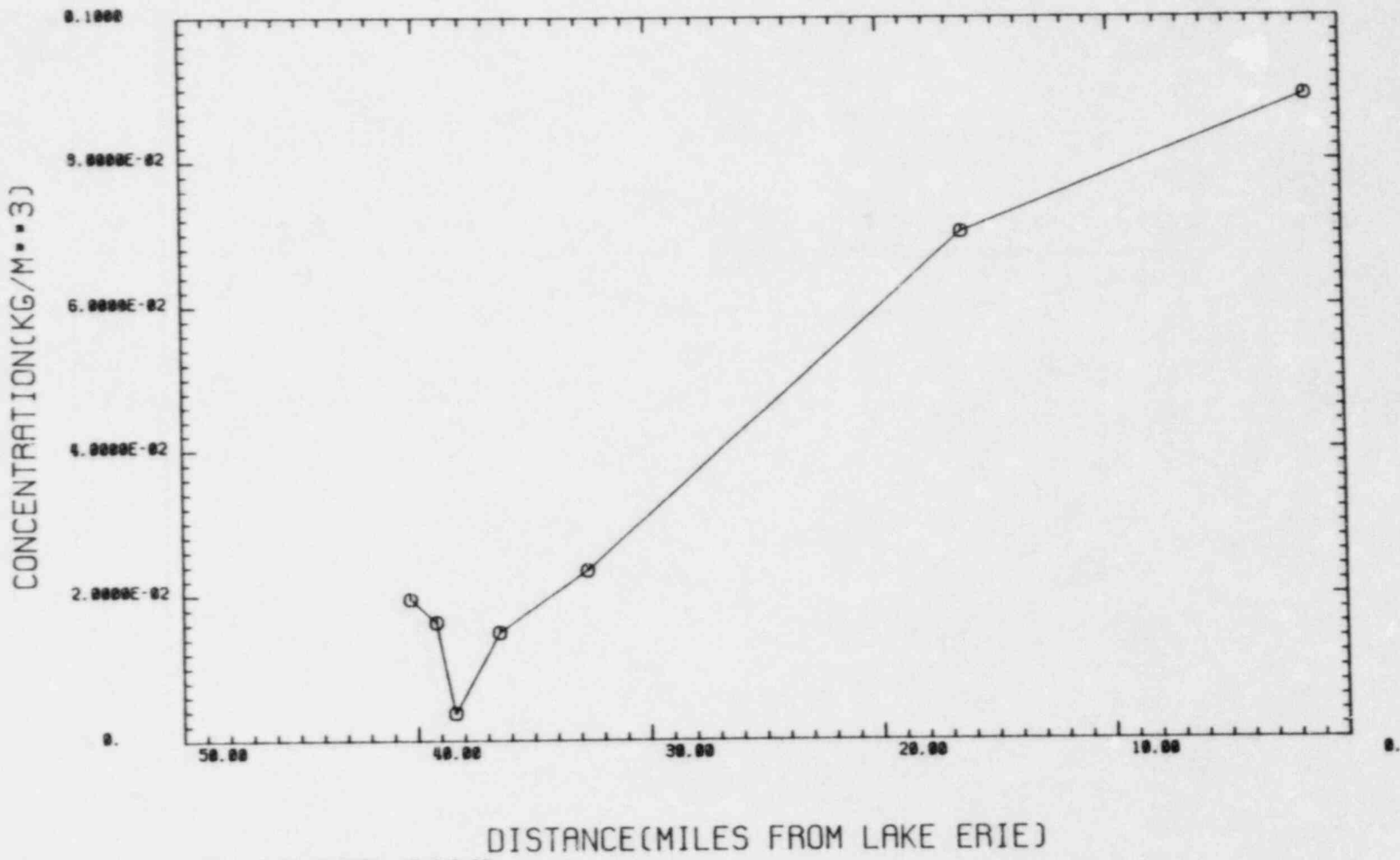


FIGURE 5.15. Phase 3 Sediment Concentrations at CC-6



5.36



TIME\* 13.26.49 DATE\* 19-AUG-82

FIGURE 5.16. Longitudinal Distribution of Suspended Sediment Total Concentration at Hour 72, Phase 3

In Phase 3, deposition was predicted to occur only at Springville Dam (segment 14) and at the mouth of Cattaraugus Creek at Lake Erie (segment 34). These are the two backwater areas on this creek system. Scour was predicted in almost all the other modeled segments. Figure 5.17 is a bar graph of the predicted deposition and scour occurring as a function of distance. The areas of the bars reflects the total mass of sediment scoured or deposited. Large depositions of sand at the Springville Dam and Lake Erie backwaters offset the sand scoured in the other segments. In Phase 3 the net sand deposited amounted to 3400 kg. As Figure 5.17 indicates, the largest volumes of scoured bed material occurred below Springville Dam. Ninety-eight percent of the scoured material was silt amounting to 410,000 kg while scoured clay amounted to 7500 kg. The most intensive erosion took place just below Springville Dam.

A summary of the observed and predicted suspended sediment concentrations is found in Table 5.5. Additional plots of sediment concentration at the data collection stations are in Appendix A. Comparison of these values revealed that SERATRA reproduced reasonably well a dynamic pattern of sediment transport and that most predictions were within 50% of the measured data. Considering the complexity of the stream system and the accuracy of the field data, SERATRA was judged reasonably capable of simulating a dynamic sediment transport process.

## Phase 2

Other than the calibration of the cohesive sediment parameters in Phase 3, no other calibration was performed in this study. In Phase 2 and Phase 1, only a single sample was taken at each data station along the study reach. Thus, no time-dependent sediment or radionuclide information was available. The assumption of constant influence concentrations throughout the flow event was made with the full knowledge that some inaccuracy might result.

The Phase 2 sediment and radionuclide simulation period began at 8:00 a.m. on September 20, 1978 and ended at 12:00 noon on September 24, 1978. A summary of the observed and predicted suspended sediment concentrations is found in Table 5.6.

The modeled flow event begins on the falling limb of a flood wave after which a steady discharge occurs. The effect of the flood wave is significant downstream of the dam. Upstream of the dam, suspended sediment concentrations are virtually constant with silt comprising about 75% of the suspended material while clay accounts for the bulk of the remaining 25%.

TABLE 5.6. Phase 2 Observed and Computed Sediment Concentrations

Phase 2 Sediment Comparison (mg/l)		
Location	Observed	Computed
BC-4		
Sand	0.42	1.1
Silt	45.65	45.7
Clay	13.55	14.7
CC-3		
Sand	0.105/0.15/0.21	0.6
Silt	7.15/8.37/15.90	19.3
Clay	2.42/2.40/2.19	5.4
CC-5		
Sand	0.01/0.01/0.01	0.1
Silt	20.61/15.10/11.45	18.1
Clay	2.48/2.14/1.17	5.2
CC-9		
Sand	0.57	0.1
Silt	20.16	10.5
lay	6.86	3.0
CC-11		
Sand	0.02	0.0
Silt	3.49	20.4
Clay	0.83	2.5

At BC-4 (Figure 5.18), the steady Buttermilk Creek discharge is reflected in unchanging sediment concentrations. Silt is the largest constituent with clay and sand sediment accounting for one-fourth of the total suspended sediment. In comparison with field samples, the predicted concentrations are in excellent agreement.

As sediment enters Cattaraugus Creek from Buttermilk Creek, sediment concentrations are reduced by a factor of three. In Cattaraugus Creek Station CC-3, the predicted concentrations are in general 100% higher than the measured values. At CC-5, good correlation for sand and silt fractions with field data is seen in Figure 5.19. Through CC-5, the concentrations computed by SERATRA were steady. Downstream of Springville Dam, the high discharges from the flood wave are accompanied by high sediment concentrations. The increased suspended sediment load is due to the scour of the channel bed primarily below the dam.

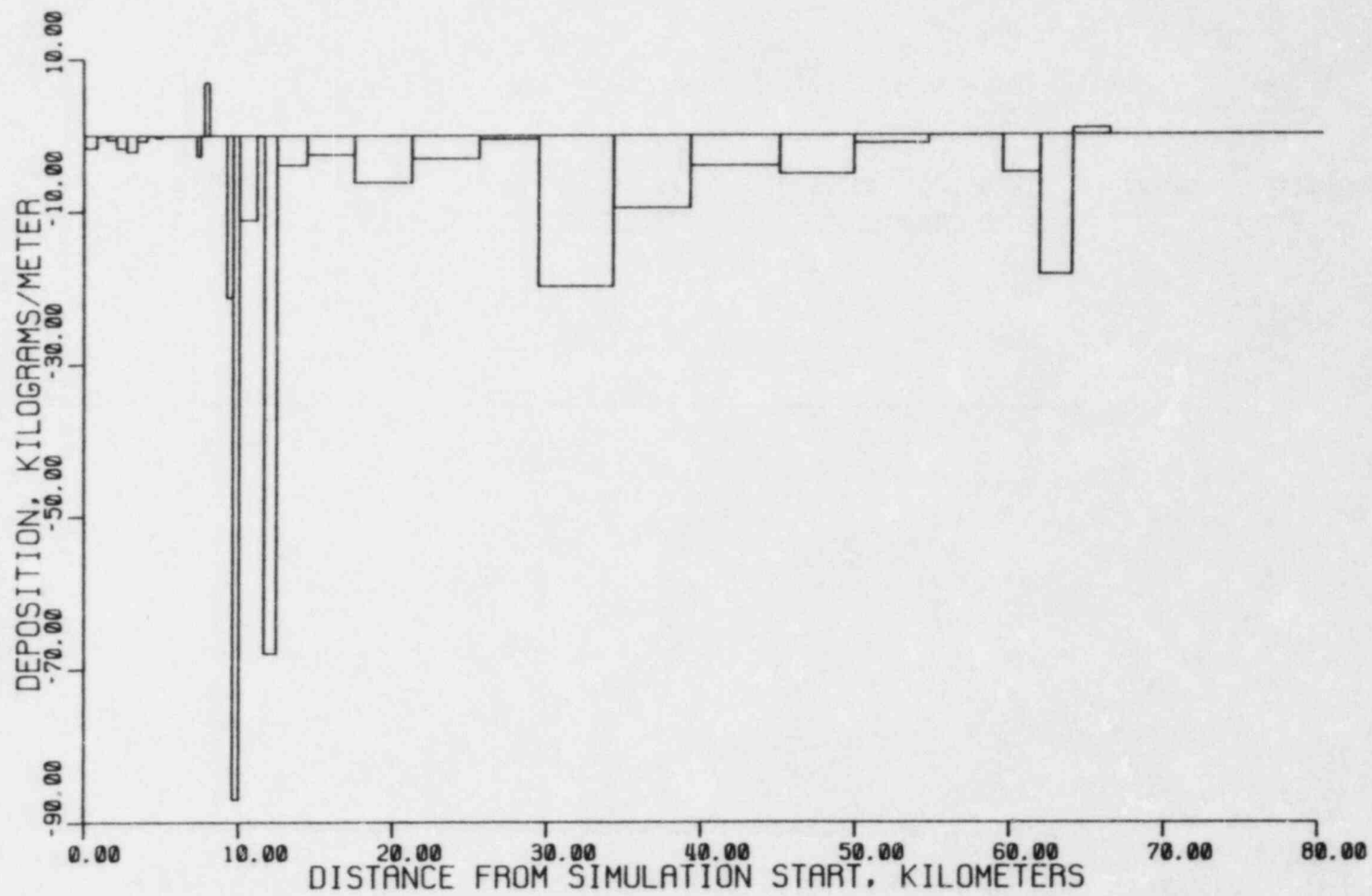


FIGURE 5.17. Predicted Sediment Deposition and Erosion, Phase 3

5.40

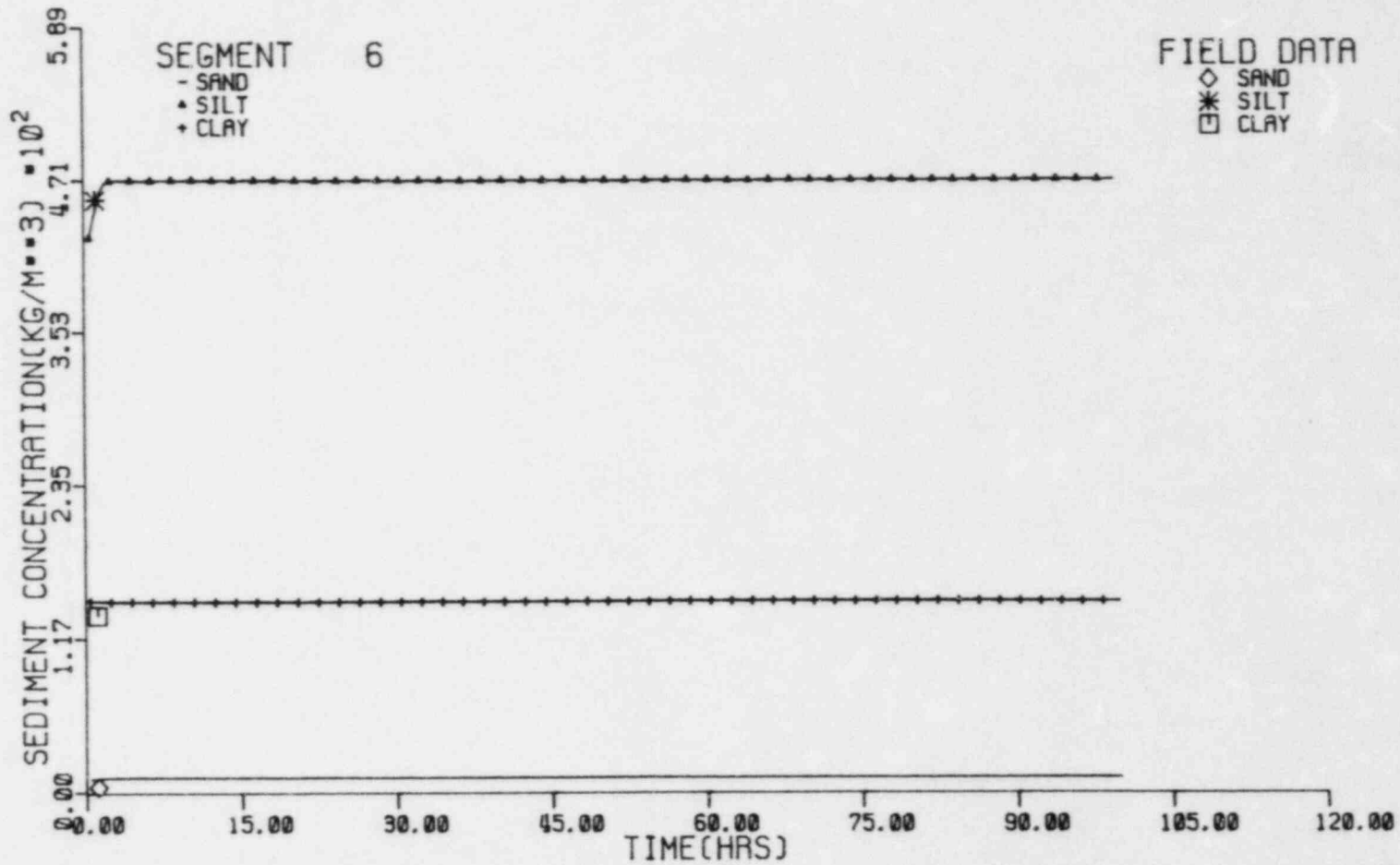


FIGURE 18. Phase 2 Sediment Concentrations at BC-4

5.41

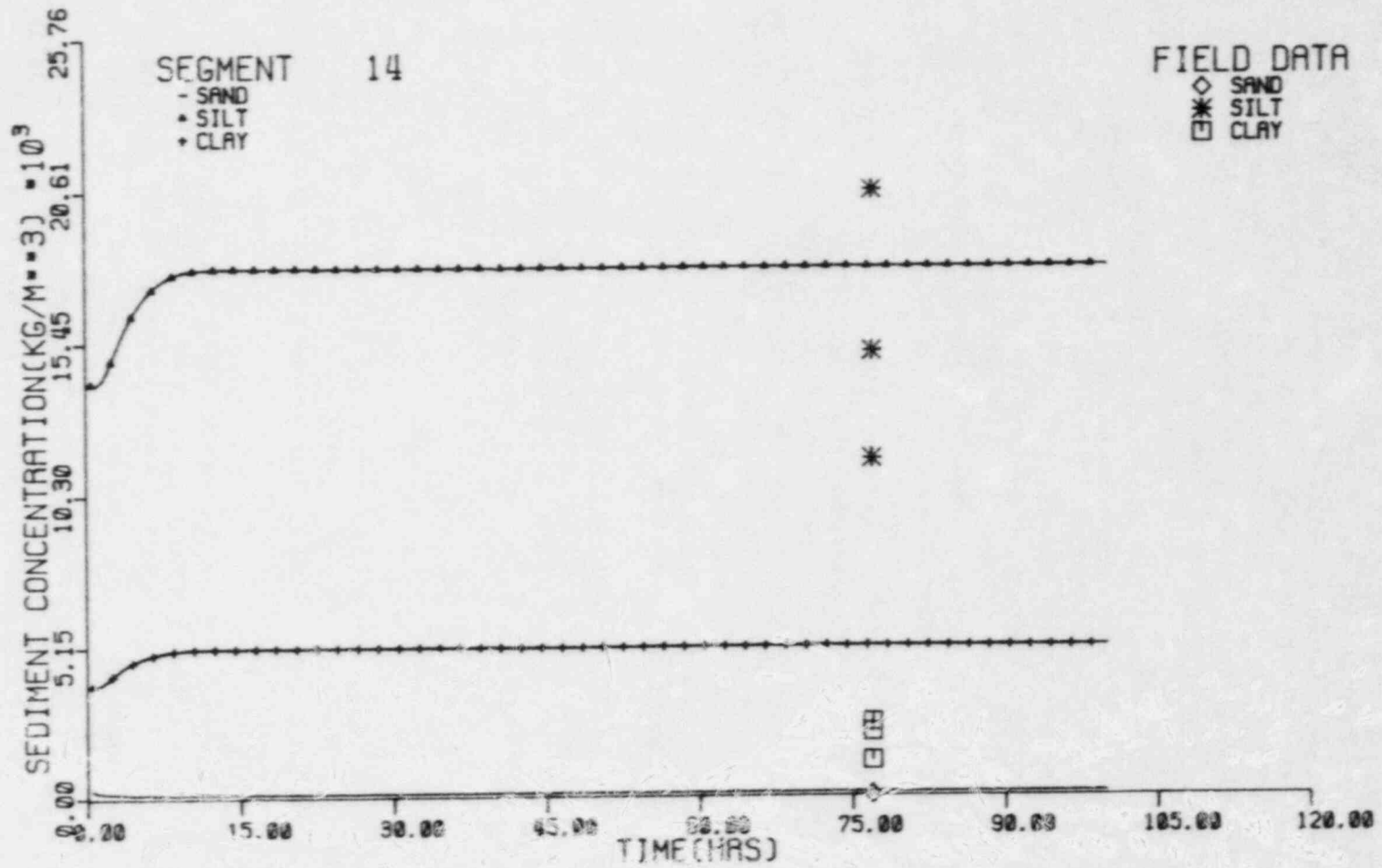


FIGURE 5.19. Phase 2 Sediment Concentrations at CC-5

Figure 5.20 is the plot of sediment concentrations at CC-9. Obviously, the dynamics displayed in CC-9 are due to scouring and eventual armoring of the stream bed downstream of Springville Dam. In this case, predicted concentrations for all constituents are about 50% of the field data. Station CC-11 has a very smooth silt sediment wave that is quite different in character from CC-9. The difference between the CC-9 and CC-11 sediment plots is due primarily to the fact that segments beyond CC-9 are influenced by the recession limb of the hydrograph. These higher discharges are sufficient to resuspend sand and silt from the channel bed. However, on approach to the mouth of Cattaraugus Creek at Lake Erie the sand deposits out.

The longitudinal distribution of suspended sediment concentrations in Phase 2 (Figure 5.21) is a good assessment of the equilibrium conditions that one might find on Cattaraugus and Buttermilk Creeks during normal flow. This spatial distribution is at the end of the 100 hour simulation. Only CC-11 at the mouth of Lake Erie has not reverted completely to the base concentration levels. The highest concentration occurs in Buttermilk Creek and is diluted 2.5 times when it mixes with Cattaraugus Creek. Sediment concentrations decrease slightly as Lake Erie is approached.

Bed armoring of silt was predicted just downstream of Springville Dam (Creek Mile 35.5) and 15 miles upstream from Lake Erie. The scoured bed material is practically all silt, the bulk of which comes from an 18 mile stretch of creek above the Lake Erie backwater (Figure 5.22). The net amount of silt scoured from the channel bed under study was 70,000 kg. The scoured clay amounted to 280 kg. These values are roughly one order of magnitude below the Phase 3 scoured sediment. The largest amount of material scoured in one segment occurred at segment 33, 2.8 miles from Lake Erie.

Deposition is predicted in three locations: 0.5 miles upstream of Springville Dam, at Springville Dam, and at Lake Erie. By far, the greatest deposition of sediment occurs at the Lake Erie backwater. As the suspended sand fraction passes through the study reach, a net deposition of 1000 kg occur.

### Phase 1

The Phase 1 sediment and radionuclide simulation period begins at 3:00 a.m. on November 30, 1977 and ends at 3:00 a.m. on December 5, 1977. A summary of the observed and predicted suspended sediment concentration is found in Table 5.7.

The Phase 1 hydrodynamics were the most unsteady of the three phases. In Buttermilk Creek there were three discharge peaks predicted in the 120 hr SERATRA simulation period. The suspended sediment concentrations tend to follow the trend of the discharge, i.e., increased concentrations at high flows. Two trains of double peaked sediment waves occur in Phase 1. Buttermilk suspended silt accounts for 90% of the sediment in the water column while clay makes up the bulk of the remaining 10%.

5.43

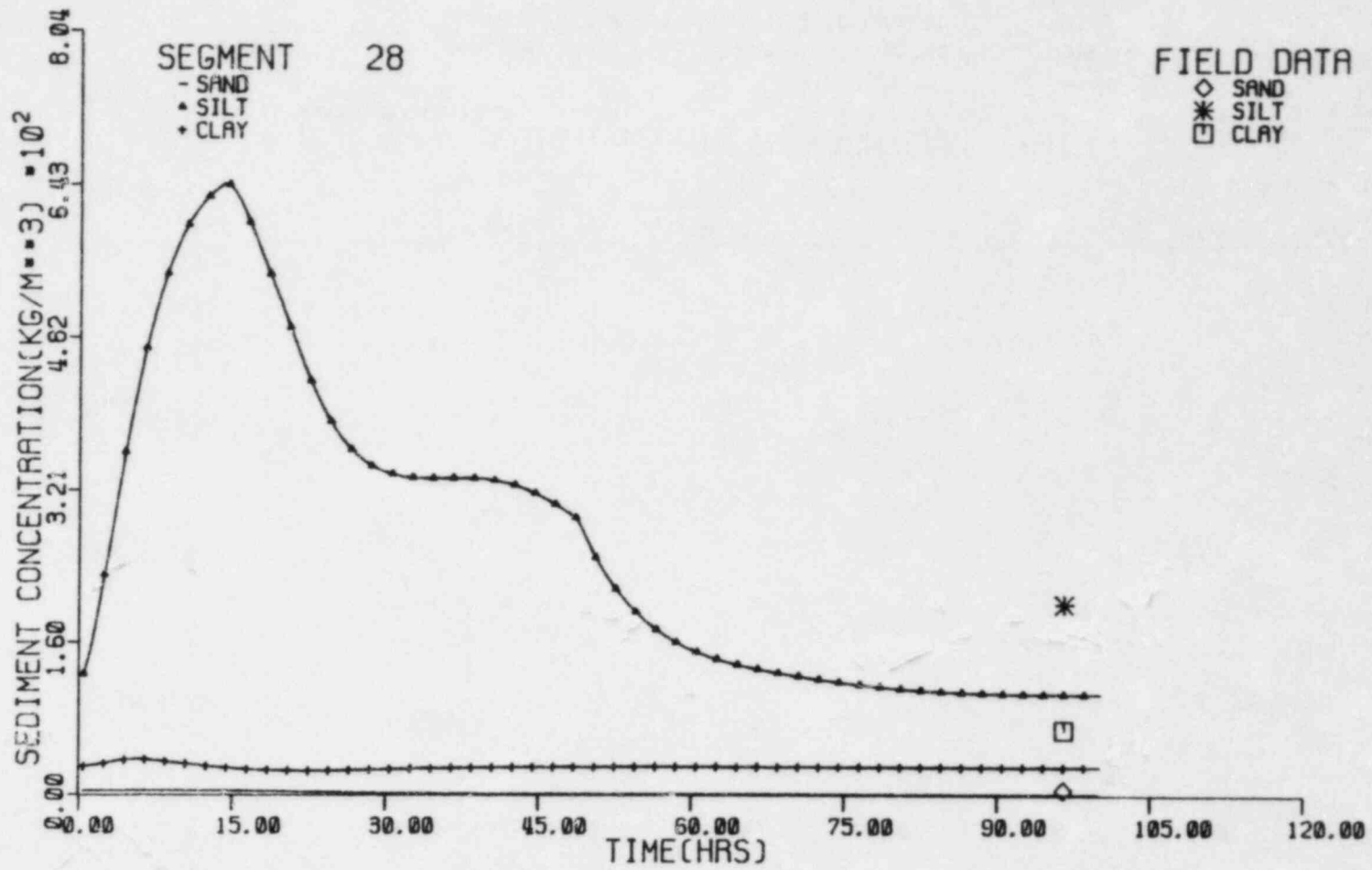
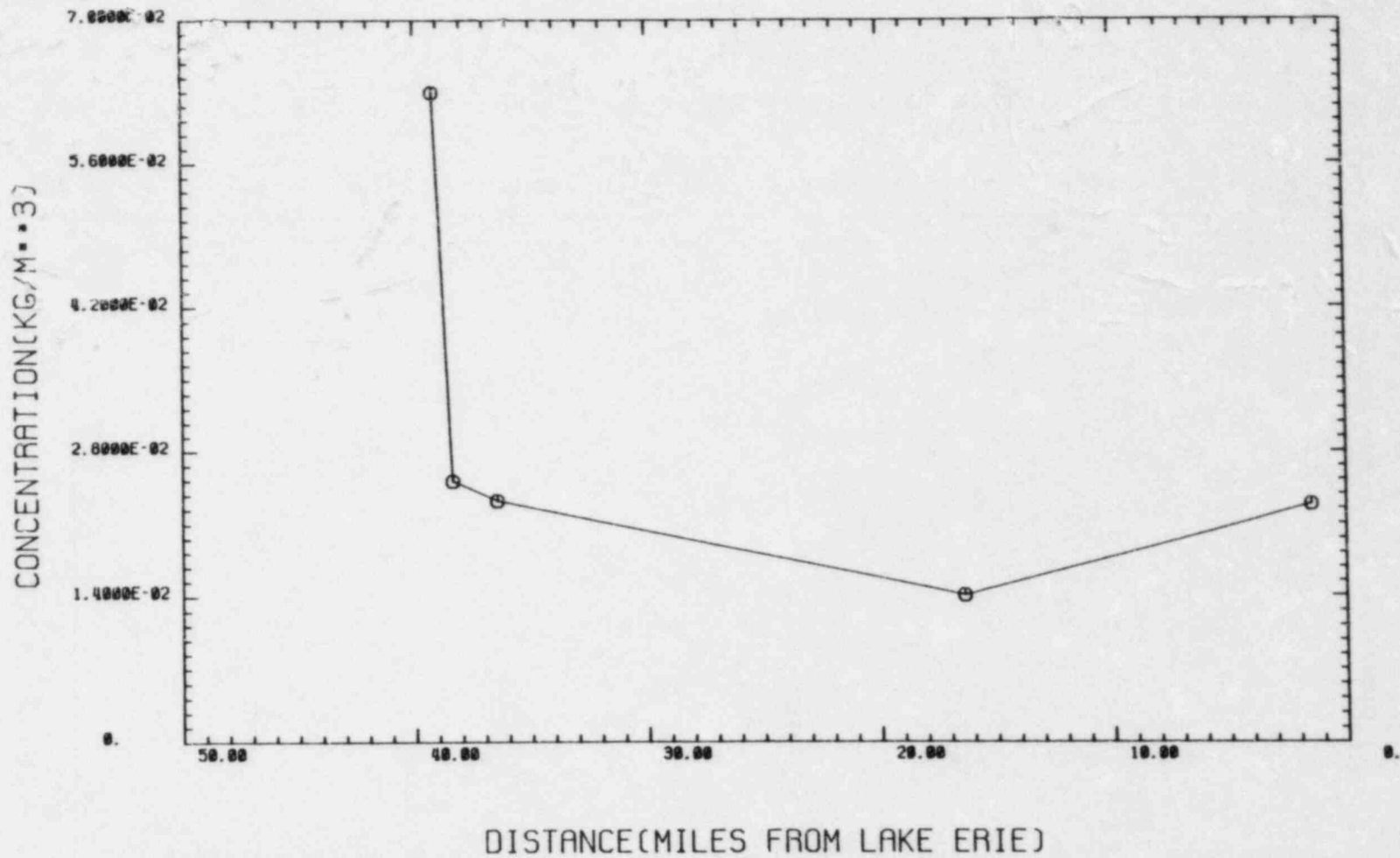


FIGURE 5.20. Phase 2 Sediment Concentrations at CC-9



5.44



TIME: 13:30:04 DATE: 19-AUG-82

FIGURE 5.21. Longitudinal Distribution of Suspended Sediment Total Concentration at Hour 100, Phase 2

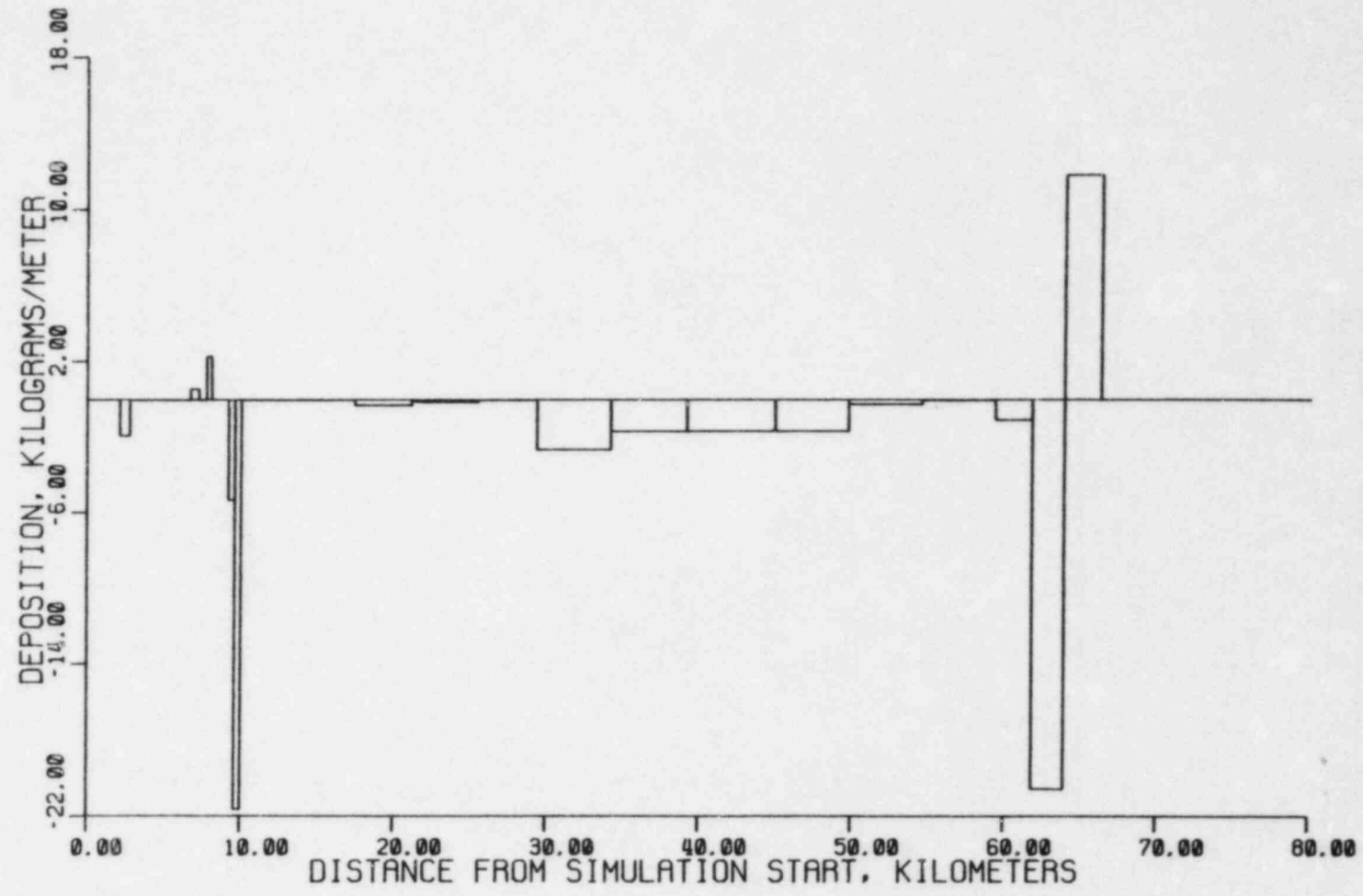


FIGURE 5.22. Predicted Sediment Deposition and Erosion, Phase 2

TABLE 5.7. Phase 1 Observed and Computed Sediment Concentrations

Phase 1 Sediment Comparison (mg/l)		
Location	Observed	Computed
BC-2		
Sand	104.9/51.9	7.9
Silt	445.2/358.5	398.3
Clay	19.4/160.2	43.1
BC-3		
Sand	3.1/10.3	7.8
Silt	110.9/40.3	409.4
Clay	11.0/3.4	43.8
BC-4		
Sand	2.0/0.7	7.4
Silt	43.2/29.0	413.2
Clay	4.9/5.3	44.5
CC-3		
Sand	5.7/0.7/0.9	3.6
Silt	59.4/38.4/39.5	107.5
Clay	2.8/41.9/43.6	8.5
CC-5		
Sand	0.6/0.6	0.8
Silt	71.3/95.3	84.7
Clay	7.1/9.2	6.9
CC-9		
Sand	7.2	1.8
Silt	600.7	44.3
Clay	4.1	2.8
CC-11		
Sand	4.0/7.2	1.6
Silt	79.2/62.2	46.7
Clay	1.8/3.7	3.9

At BC-2 (Figure 23), the comparison of the field sample taken at 31.5 hr with SERATRA predicted values indicates excellent agreement. The silt field value is perfectly correlated with the predicted silt concentration. The predicted sand and clay concentrations both lie below the field values. The character of the various sediment graphs is one of small perturbations about a base value.

At BC-3, the sediment transport behavior is almost identical to that seen at Station BC-2. However, in this case only the predicted sand value is close

5.47

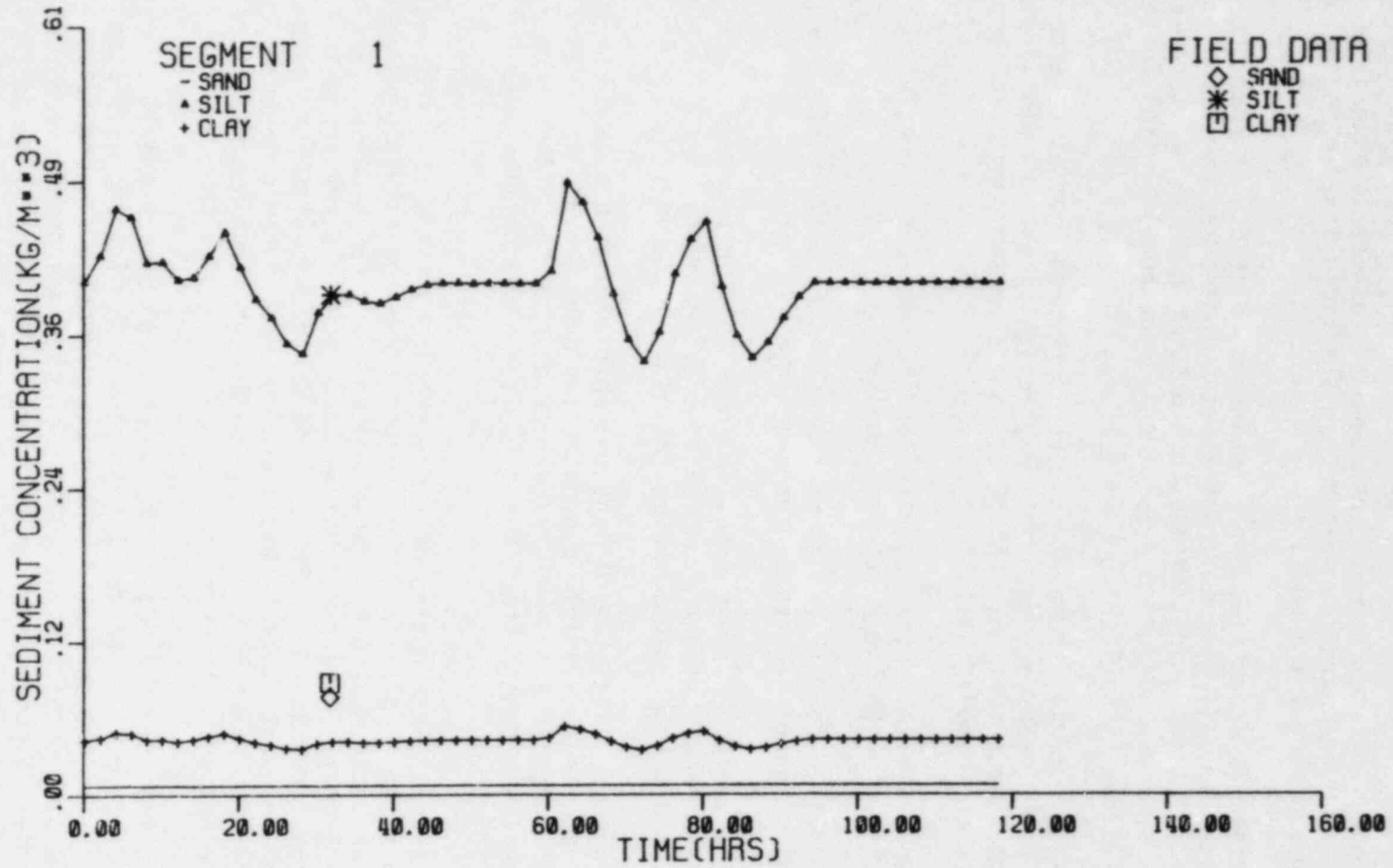


FIGURE 5.23. Phase 1 Sediment Concentrations at BC-2

to the field sand concentration as the field-sampled concentrations exhibit a large deviation from the BC-2 values. Computed silt and clay are four to five times larger than the measured counterparts.

The discrepancy between computed and sampled results is even larger at BC-4 where the silt concentration measured in the field is even below the clay concentration predicted by the model.

As the Buttermilk Creek sediment is transported into Cattaraugus Creek above Springville Dam, all sediment concentration peaks are preserved with the 65 hr peak exhibiting amplification due to a matchup with sediment coming from Upper Cattaraugus Creek. Dilution of sediment concentrations from Buttermilk Creek to Cattaraugus Creek are by a factor of 5.

At CC-3 (Figure 5.24), the peak concentration occurs at 66 hr according to the model. Other peaks are comparatively insignificant and gently dispersing into the base concentrations. At 80 hr, the computed concentrations match quite closely to the sampled data.

At CC-5, very little of the character of the sediment curves has changed from CC-3. Agreement with field data is excellent.

Below Springville Dam, the sediment concentration peaks diffuse and join together so that no sharp or outstanding peaks are visible.

At CC-9, the sediment curves predicted by SERATRA have changed. Highest concentrations now occur between 7 and 23 hr of simulation. Verification at 108 hr is very good with predicted values being slightly low.

At CC-11 (Figure 5.25), the highest concentration occurs at 40 hr with no evidence of the previously visible concentration peaks. Sand and clay computed by the simulation are close to measured values despite the higher sand values indicated in the field data. Predicted silt is running considerably below the field value at 105 hr.

The longitudinal distribution of sediment concentrations at the end of the 120 hr simulation (Figure 26) demonstrates the large dilution which occurs between the three Buttermilk Creek sites and the four Cattaraugus Creek sites. In general, the highest suspended sediment concentrations are found in Phase 1 even at base flow. And as on the Phase 1 and Phase 2 simulations, suspended silt displays the highest concentrations and the most dynamic behavior of the three routed sediment fractions. This is due to the large amounts of silt removed from the bed prior to armoring.

Armoring in Phase 1 is predicted to occur in 30 out of the 34 computational segments. In most of these 30 segments, both silt and clay display armoring. Phase 1 is the only event where clay armoring was predicted. A net erosion of 200,000 kg of silt and 17,000 kg of clay was predicted by SERATRA for the channel bed in the study reach. Sand exhibited a net deposition of 19,000 kg. The deposition of sand occurred strictly in the backwaters of Springville Dam and Lake Erie. Figure 5.27 is a bar graph of scour and

5.49

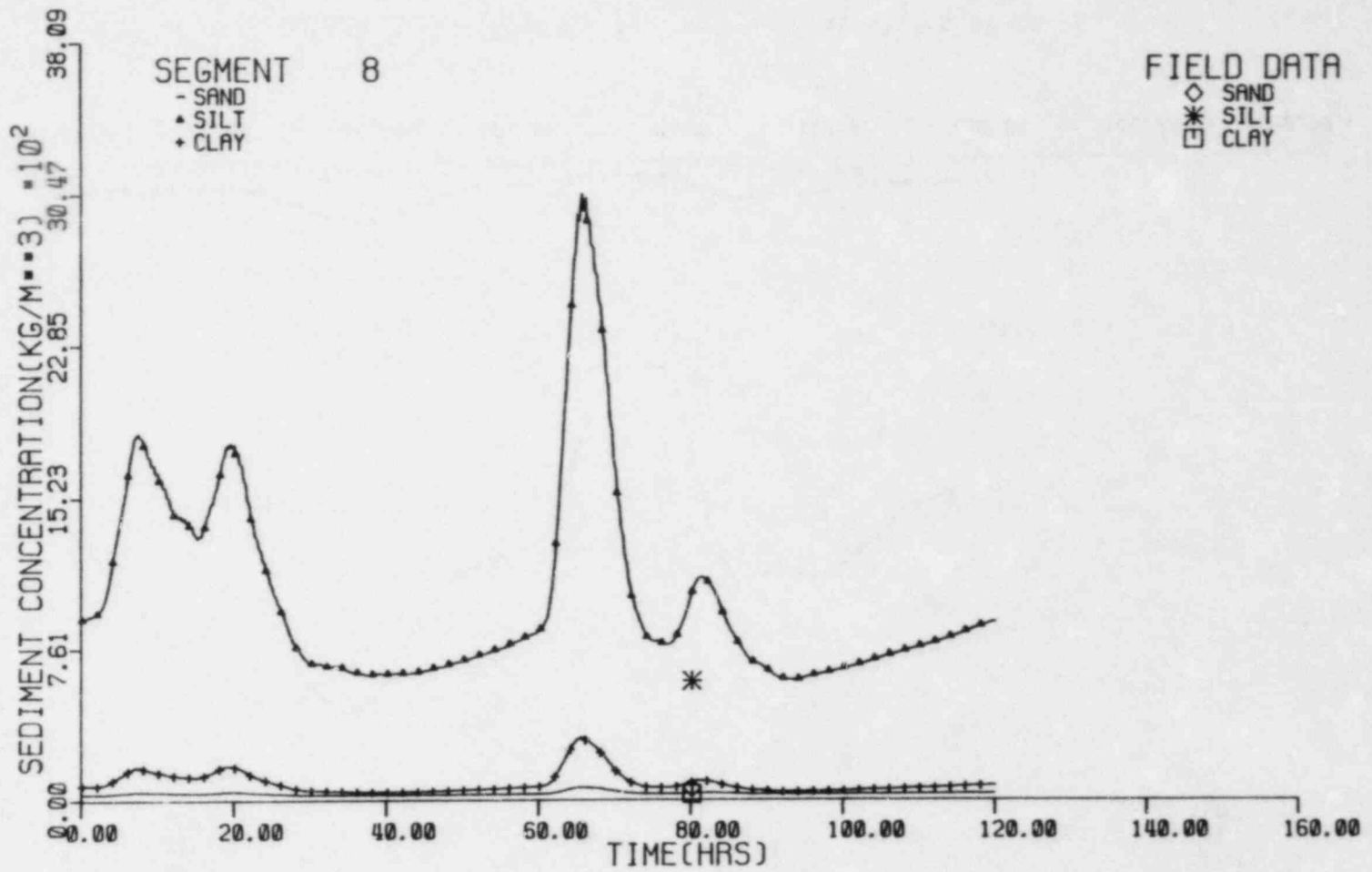


FIGURE 24. Phase 1 Sediment Concentrations at CC-3

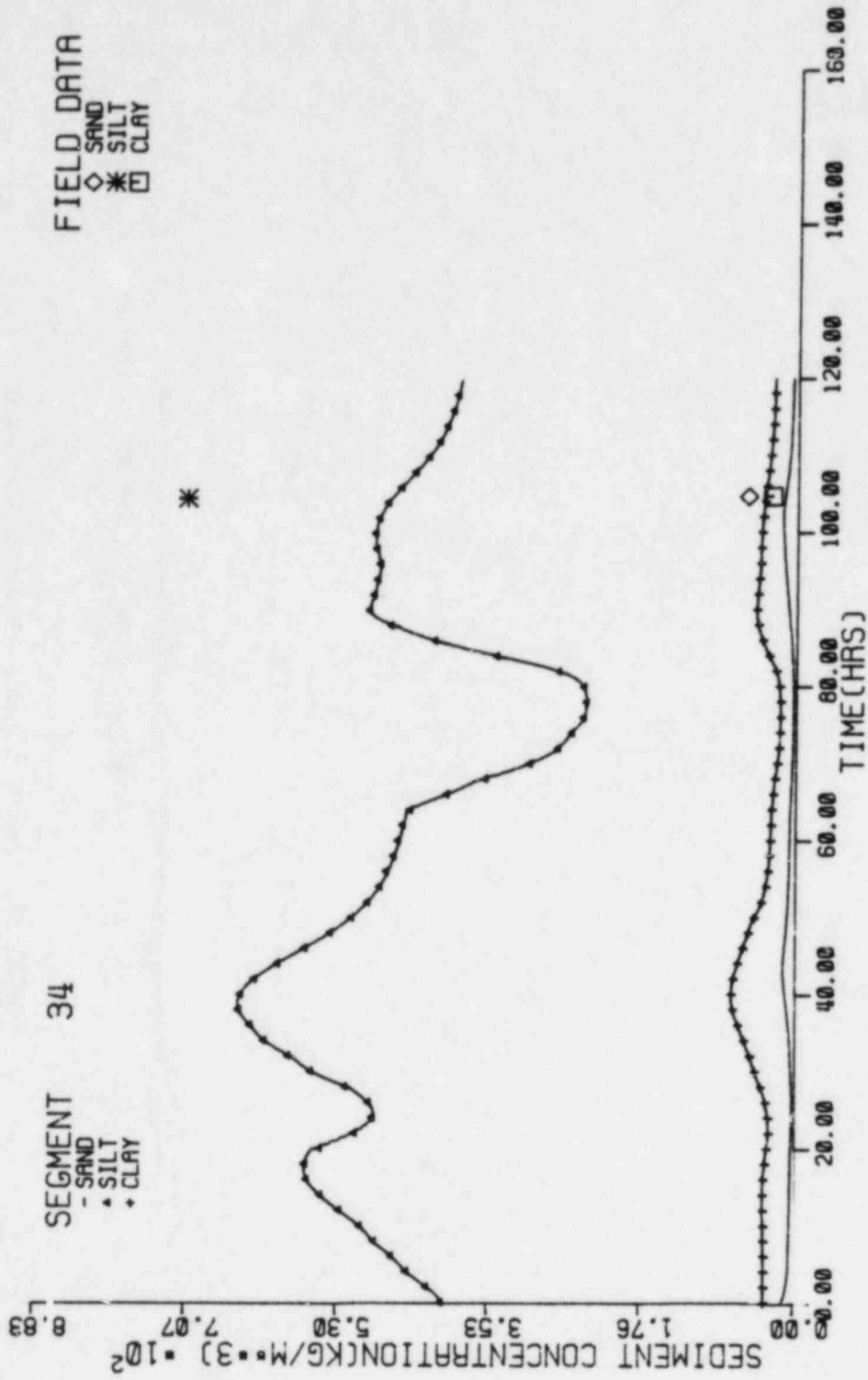
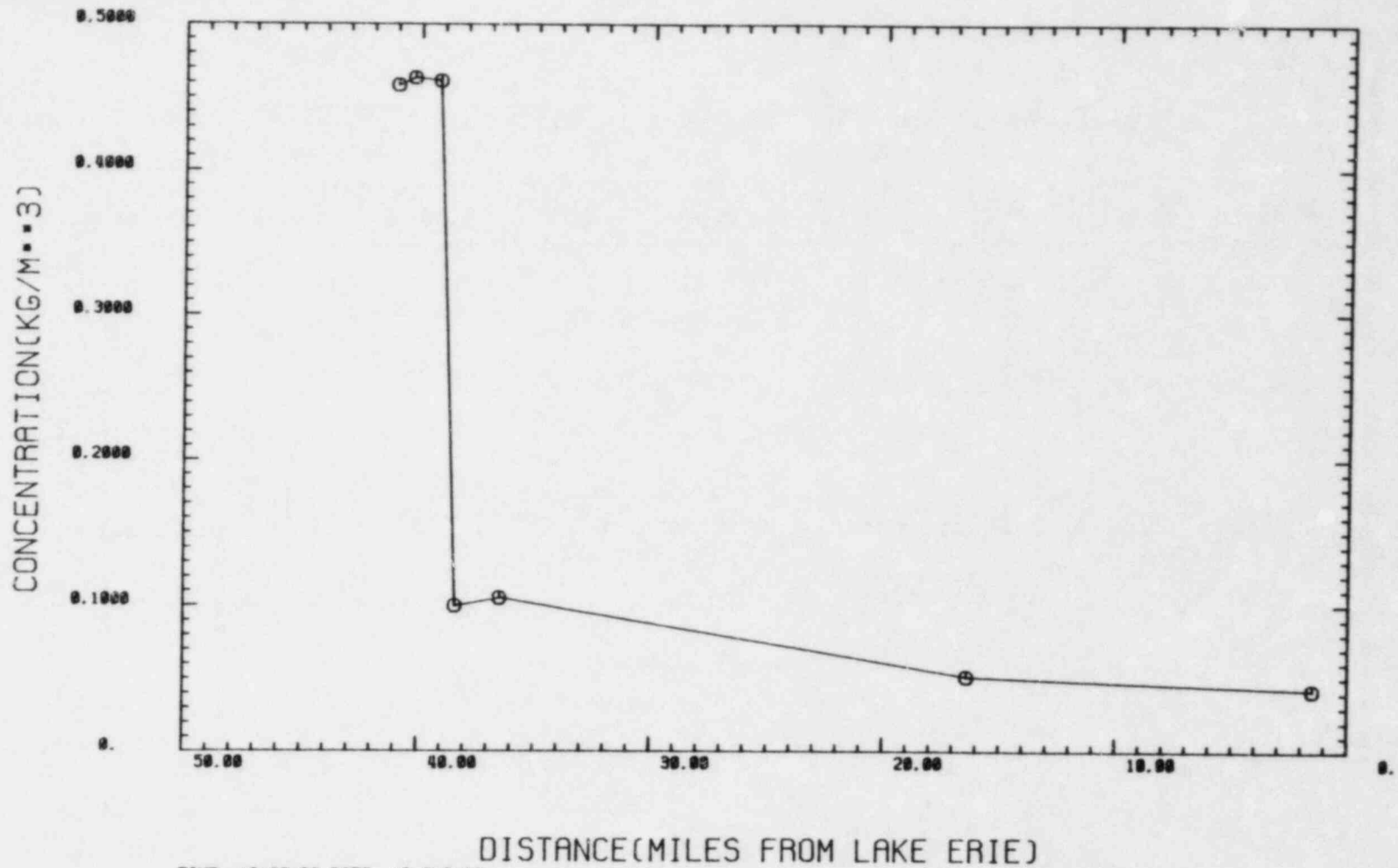


FIGURE 5.25. Phase I Sediment Concentrations at CC-11



TIME\* 13\*28\*36 DATE\* 19\*06\*82

FIGURE 5.26. Longitudinal Distribution of Suspended Sediment Total Concentration at Hour 120, Phase 1



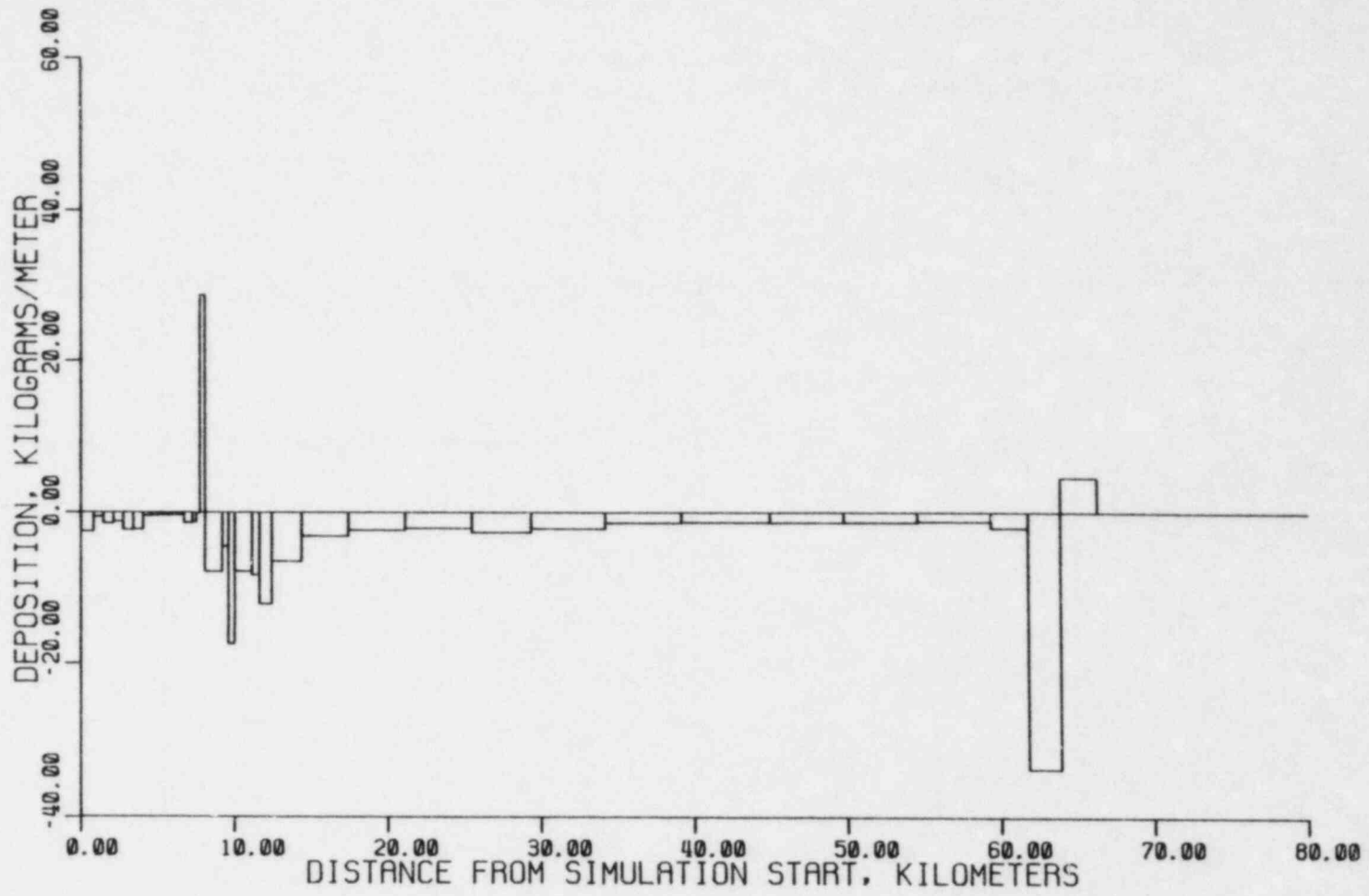


FIGURE 5.27. Predicted Sediment Deposition and Erosion, Phase 1

deposition predicted in each segment during Phase 1. Deposition occurs only in the two backwater areas while scour occurs everywhere else. The most intensive deposition occurs at Springville Dam (Segment 14) whereas the most intensive bed scour is found above the Lake Erie backwater, where slope and depth are quite large. However, the segments immediately below Springville Dam collectively exhibit the area where bed scouring is most active.

#### 5.4.3 Radionuclide Transport Simulation Results

Ten applications of the SERATRA code were performed in the course of this modeling study. Four radionuclides,  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$  and  $^3\text{H}$  were modeled using the Phase 2 and Phase 3 flow events while  $^{137}\text{Cs}$  and  $^3\text{H}$  were modeled with the Phase 1 data.

Although 30 radionuclides were tested for in the laboratory, only these four radionuclides had sufficient information to properly pose the problem for a modeling study. The radionuclides available for modeling were limited largely by the number of distribution coefficients ( $K_d$ s) measured in Cattaraugus Creek. Of the five radionuclides with measured  $K_d$  values,  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ , and  $^{239,240}\text{Pu}$  had adequate data at boundary conditions and verification points. Tritium, which does not sorb to sediment, was sampled separately and thus had the necessary information for a modeling effort. Phase 1 was modeled with  $^{137}\text{Cs}$  and  $^3\text{H}$  because  $^{90}\text{Sr}$  and  $^{239,240}\text{Pu}$  did not have data suitable for modeling.

The purpose of simulating the transport and fate of four radionuclides during three flow events was to test SERATRA under a wide range of hydraulic and radiochemical conditions. Two radionuclides,  $^{137}\text{Cs}$  and  $^3\text{H}$ , were tested under highly dynamic, moderate, and near-steady flows to demonstrate the effect of varying the field conditions while keeping the radionuclide parameters constant. The use of four radionuclides allows the radiochemical effects to be tested, i.e., varying the radionuclide parameters while field conditions are kept constant. This latter analysis pertains to the Phase 2 and Phase 3 SERATRA simulations where all four radionuclides were modeled. The characteristics of the modeled radionuclides are very diverse.  $^{239,240}\text{Pu}$  has a half-life of 6,600 years and a measured adsorption  $K_d$  of  $21 \text{ m}^3/\text{kg}$ .  $^3\text{H}$ , on the other hand, has a half-life of 12 years and no measurable distribution coefficient. The other two radionuclides fall between these extremes.

Radionuclides levels in Franks Creek are the highest in the area with dissolved and sorbed forms exhibiting activity many times greater than that found upstream of the study reach. As Franks Creek enters Buttermilk Creek, activity is reduced by dilution and by the mixing of the relatively 'clean' Buttermilk Creek sediments with the contaminated Franks Creek sediments. Subsequent reductions in radionuclide levels occur as Buttermilk Creek joins Cattaraugus Creek and wherever lateral inflow (such as a tributary) is found. The general trend is for lower activity levels to be found at greater distances from Franks Creek.

For the most part, Springville Dam contains the downstream transport of coarse sediment. This limits the activity levels in the downstream channel beds to values lower than those upstream of Springville Dam.

In general, bed activity levels do not change much unless large amounts of sediment with radionuclide concentrations very different from the bed are deposited. Since significant deposition occurs only at the Springville Dam and Lake Erie backwater areas (near the mouth of Cattaraugus Creek), sorbed levels in the bed in most areas during the simulation periods are largely unchanged even under the most unsteady flow conditions.

Of the four modeled radionuclides,  $^{239,240}\text{Pu}$  consistently has the lowest dissolved and particulate activity levels. Highest dissolved concentrations are found with  $^3\text{H}$  while, the highest sorbed activities are found with  $^{137}\text{Cs}$ .

Partitioning among the three sediment size fractions usually reflects the  $K_d$  values associated with each size fraction, i.e., highest sorbed levels with the clay sediment and lowest with the sand fraction. However, in some instances sand with organic matter or silt exhibit the highest concentrations due to upstream boundary conditions which have such partitioning. For the relatively short reach modeled, these radionuclides do not have enough time to equilibrate. Thus, these uncommon distributions will persist.

The SERATRA radionuclide results presented here are from the same simulations which produced the previously discussed sediment transport results. Thus, the beginning and ending times for the three phases of simulation are the same as those reported earlier and can be directly compared. As in the sediment transport results, time is referenced from the beginning of the SERATRA simulations.

The comparison of computed and measured radionuclides will be shown in this section as well as in Appendix A.

### Phase 3

The general description of the radionuclide concentrations in Phase 3 is a dilution and dispersion of initially dynamic activity levels. The spike of high discharge which occurs on Buttermilk Creek at 35 hours has the effect of causing low radionuclide concentrations in Buttermilk Creek due to dilution and high concentrations in Cattaraugus Creek because of the suddenly large fraction of contaminated water entering from Buttermilk Creek. The dilution of the lateral inflow and the dispersion caused by the vertical velocity shear smooths the upstream changes in radionuclide levels to gentle curves as the radionuclides are transported downstream.

#### $^{137}\text{Cs}$

The total sorbed concentration of  $^{137}\text{Cs}$  was always higher than the dissolved concentration in this simulation. This was merely a reflection of the boundary conditions at Buttermilk and Franks Creeks. Considering the suspended sediment concentrations in this phase and the distribution coefficients used for  $^{137}\text{Cs}$ , the system was not in equilibrium, with desorption from particulate to dissolved forms occurring. For the short reach of creek being simulated, the system did not have sufficient time to equilibrate to the sampled  $K_d$  value.

The partitioning of  $^{137}\text{Cs}$  among the three modeled sediment size fractions was usually highest for clay and lowest for sand. This was to be expected as the finer sediments normally have more capacity to adsorb radionuclides than the coarser sediments.

In Buttermilk Creek,  $^{137}\text{Cs}$  sorbed to the suspended sediment ( $\mu\text{Ci}/\text{kg}$ ) has two peaks during the 72 hr simulation, spaced 50 hr apart. The peaks occurred before and after the suspended sediment concentration peak. This was due to the relatively uncontaminated sediment in the wave which originated upstream of the Franks Creek confluence. As greater amounts of the 'clean' sediment mixed with the influent activity from Franks Creek, a strong dilution occurred. Dissolved  $^{137}\text{Cs}$  entered Buttermilk Creek as a wave of higher concentration in the first 30 hr of simulation. Sorbed concentrations per unit volume of water ( $\mu\text{Ci}/\text{m}^3$ ) tend to increase with the suspended sediment concentration.

Predicted sorbed activities associated with the three types of sediment at BC-3 are very close to the field data values as shown in Appendix A. The predicted clay activity is slightly higher and the sand and silt activities are slightly lower than the sampled values.

Although clay has the highest sorbed activity (activity per unit weight of sediment), the relatively low concentrations of clay sediment prevent the radionuclides associated with clay from being greater than the amount of radionuclides sorbed to silt. "Dips" in the concentration at the 35-hour mark coincide with the passing of the spike of water. The predicted dissolved concentration is below the BC-3 concentration data.

In Segment 6, BC-4, predicted sorbed activities are 2 to 3 times higher than those found in the field (Appendix A). The three field samplings appear to be very consistent while the predicted results are somewhat unsteady. Only the field data taken at 37 hours matches closely with the predicted values. The two dissolved radionuclide field data points agree well with the predicted concentrations.

In Cattaraugus Creek above Springville Dam both sorbed and dissolved  $^{137}\text{Cs}$  have been diluted by a factor of three from the Buttermilk Creek levels. At CC-3, Segment 8, predicted and measured data are highly correlated in both sorbed activity and concentration. This is borne out by Figures 5.28 and 5.29. Interestingly, the plot of silt concentration in Figure 5.29 bears a resemblance to the Buttermilk hydrograph. This would seem to imply that the activity in Buttermilk Creek has a very strong imprint on the subsequent results in Cattaraugus Creek despite the relatively small discharge found in Buttermilk Creek.

At Springville Dam, the field values for sorbed activity are fairly consistent with the predicted concentrations at the 9- and 59-hour data points. At 33 hours predicted silt and clay sorbed activities are  $800 \mu\text{Ci}/\text{kg}$  higher

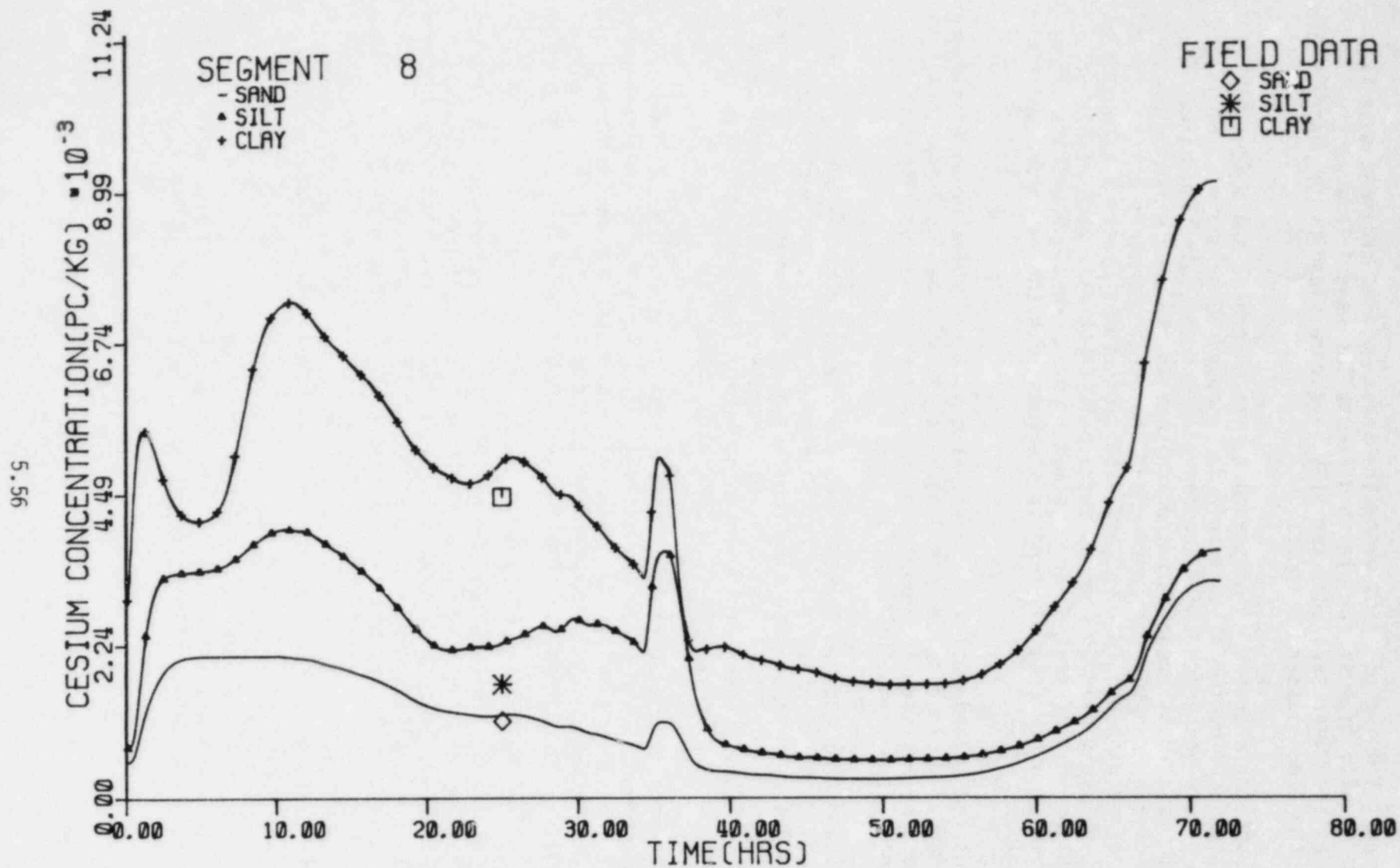


FIGURE 5.28. Phase 3 Particulate Radionuclide Concentrations:  
 $^{137}\text{Cs}$  at CC-3

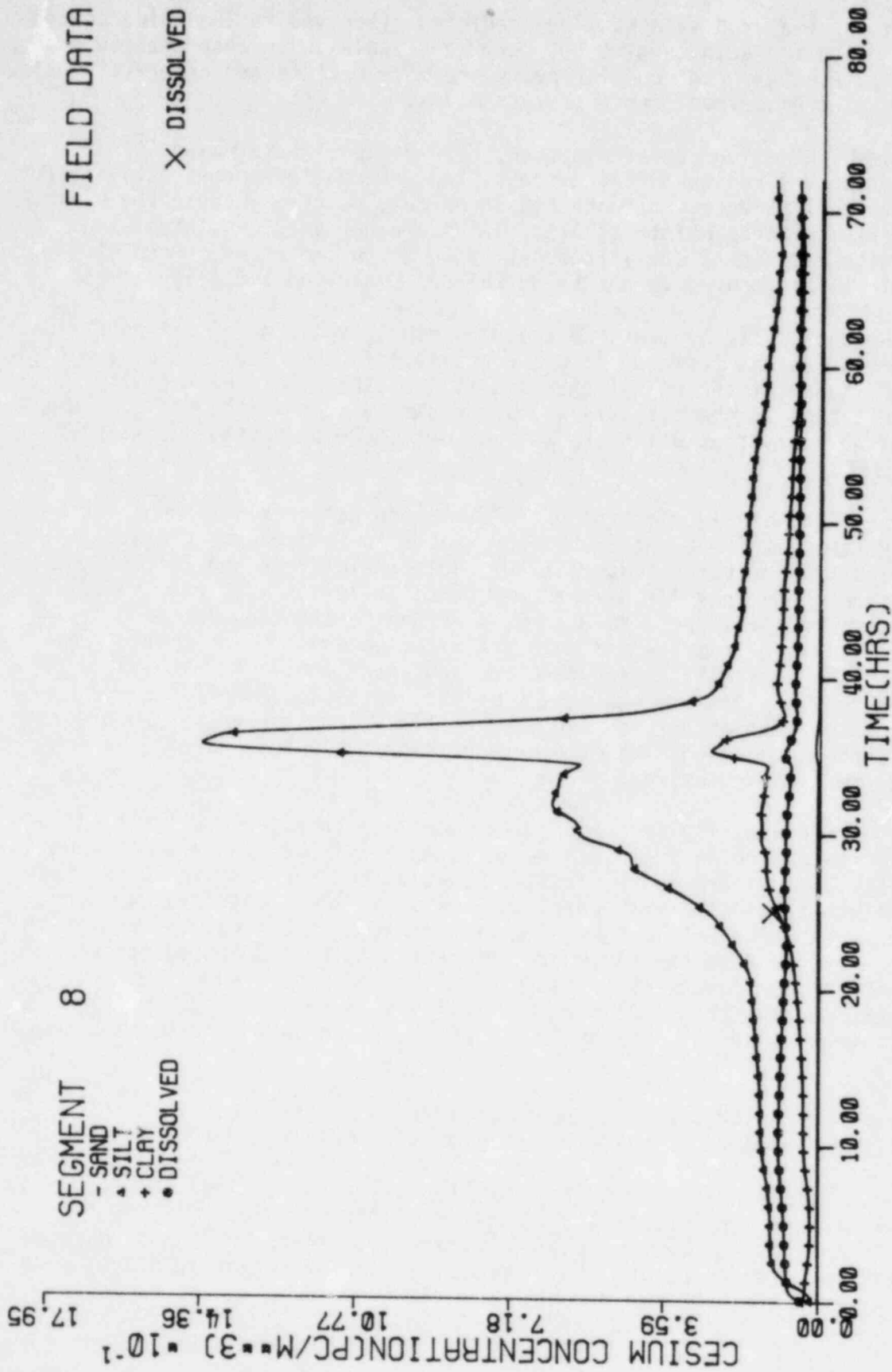


FIGURE 5.29. Phase 3 Particulate and Dissolved Radionuclide Concentrations:  
<sup>137</sup>Cs at CC-3

higher than the measured values. The predicted dissolved radionuclide concentration is below the actual value but very reasonable in an absolute sense. Below Springville Dam, radionuclide peaks are more diffuse and generally follow the pattern of the sediment concentration waves.

At Segment 21 which represents CC-6, Frye Bridge, there was no field value for dissolved radionuclide concentration. Predicted sorbed activity for silt is in excellent agreement with the three data points taken in the field. The clay activity field points at 5 and 31 hr are not very consistent in magnitude with respect to the silt activity found in the field. Predicted clay activity lies both above and below the two field-sampled clay values.

At CC-9 and CC-11, Segments 28 and 34, respectively, no dissolved radionuclide concentrations from sampling are available. The results from the field sampling are taken at the end of the simulation. The predicted activity for each sediment type is consistently below the sampled data. The field values are indicating activities which are as high or higher than previous sampled data.

The longitudinal distribution of  $^{137}\text{Cs}$  in the water column shows high values in Buttermilk Creek and much lower values in Cattaraugus Creek. At the end of the 72 hr simulation (Figure 5.30), Buttermilk Creek and Cattaraugus Creek upstream of Springville Dam had radionuclide levels near base values. The increase in activity from BC-3 to BC-4 is due to the scouring of  $^{137}\text{Cs}$ -laden sediment from the bed into the water column. Lower total (sum of dissolved and particulate) radionuclide concentrations per unit volume of water at Springville Dam are the result of the deposition of  $^{137}\text{Cs}$  carrying sediment. Downstream of Springville Dam, a steady increase in water column activity is the descending limb of a wave of high  $^{137}\text{Cs}$  concentration which was present in these downstream segments.

Bed sediment activity is practically unchanged throughout all simulations. The  $^{137}\text{Cs}$  distribution is presented as an example (Figure 5.31) as all longitudinal distributions are quite similar. Initial bed radionuclide concentrations are highest in Buttermilk Creek and lowest in lower Cattaraugus Creek. The only noticeable change in the bed activity was at the final segment in the Lake Erie backwater near the mouth of the creek. At this point suspended sediment with higher levels of  $^{137}\text{Cs}$  than in the bed deposited out of the water column. During the simulation bed activity increased to 760 pCi/kg; quite small when compared with the 10,000 pCi/kg found in the Buttermilk Creek bed.

The vertical distribution of radionuclides is uniform in most cases because of the dominance of silt- and clay-sorbed activity in addition to the dissolved activity. In this creek system, most of silt, clay, and dissolved radionuclides simply wash through to Lake Erie without settling. At CC-3, on Cattaraugus Creek above Springville Dam, this uniform vertical distribution is almost perfect (Figures 5.32 and 5.33). Other simulations in this study produce similar results indicating that a possible simplification in future modeling of this creek could be one dimensional.

65.5

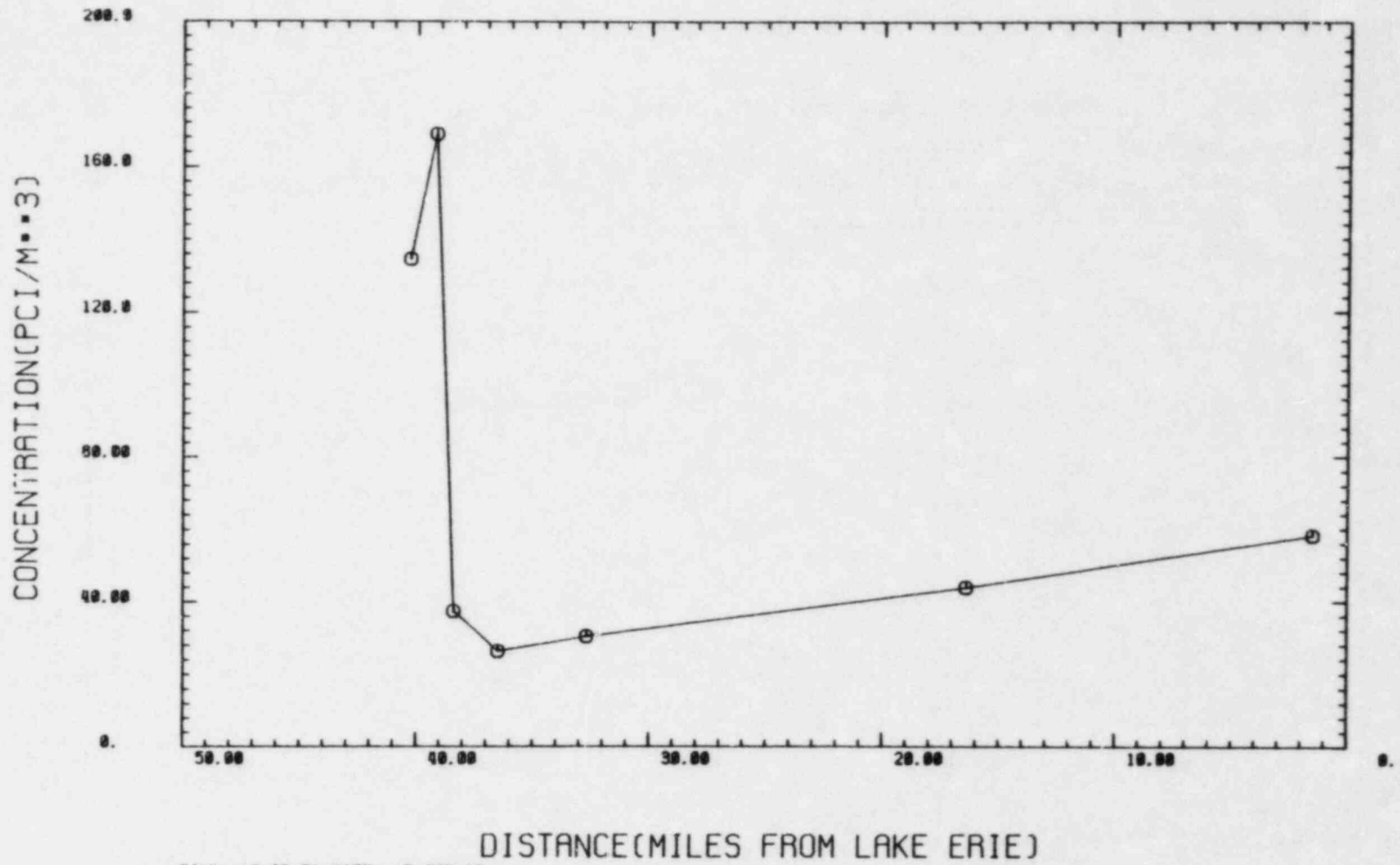


FIGURE 5.30. Phase 3. Longitudinal Distribution of <sup>137</sup>Cs Total Concentration at Hour 72



09.5

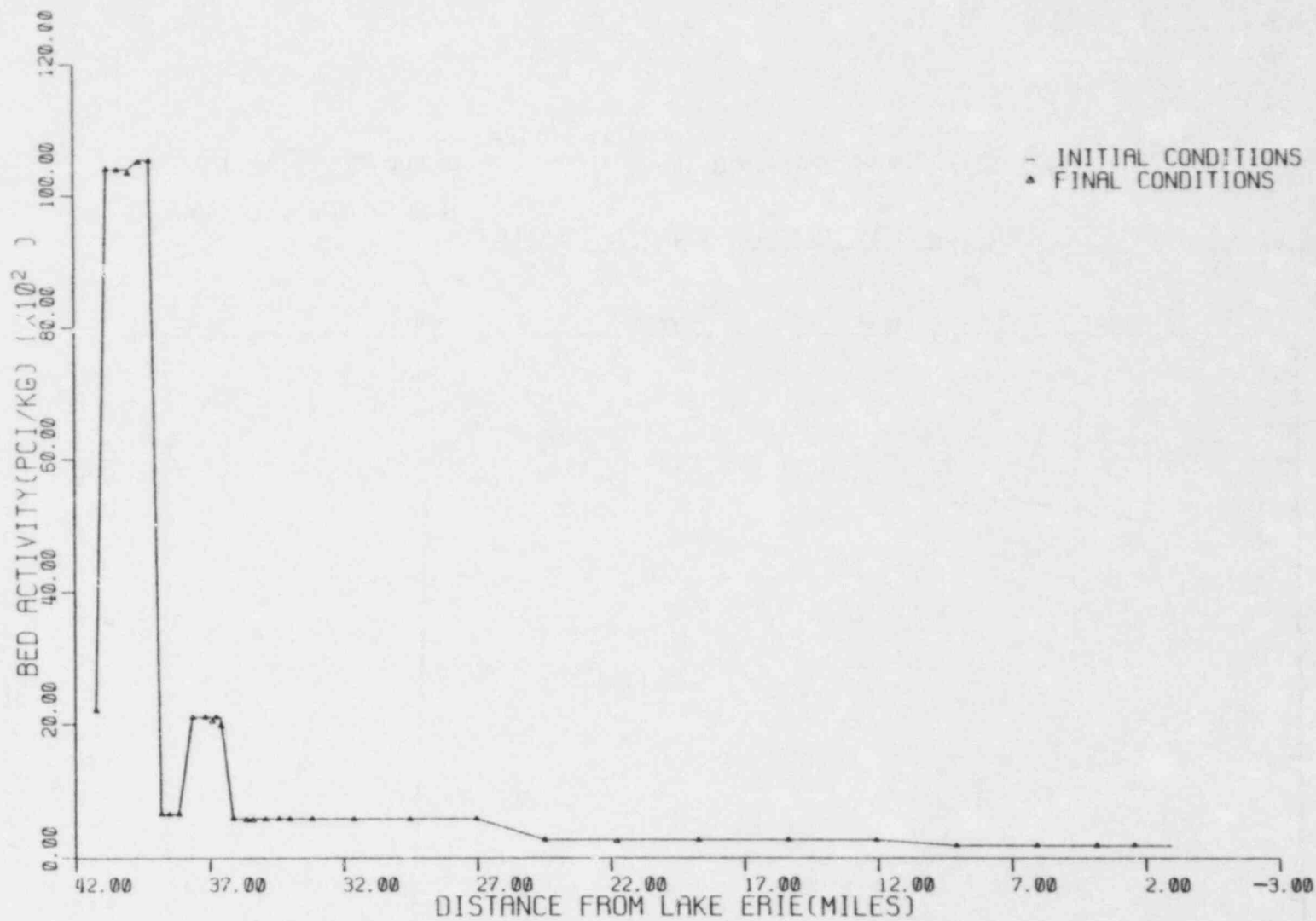


FIGURE 31. Phase 3. Longitudinal Distribution of Bed Activity

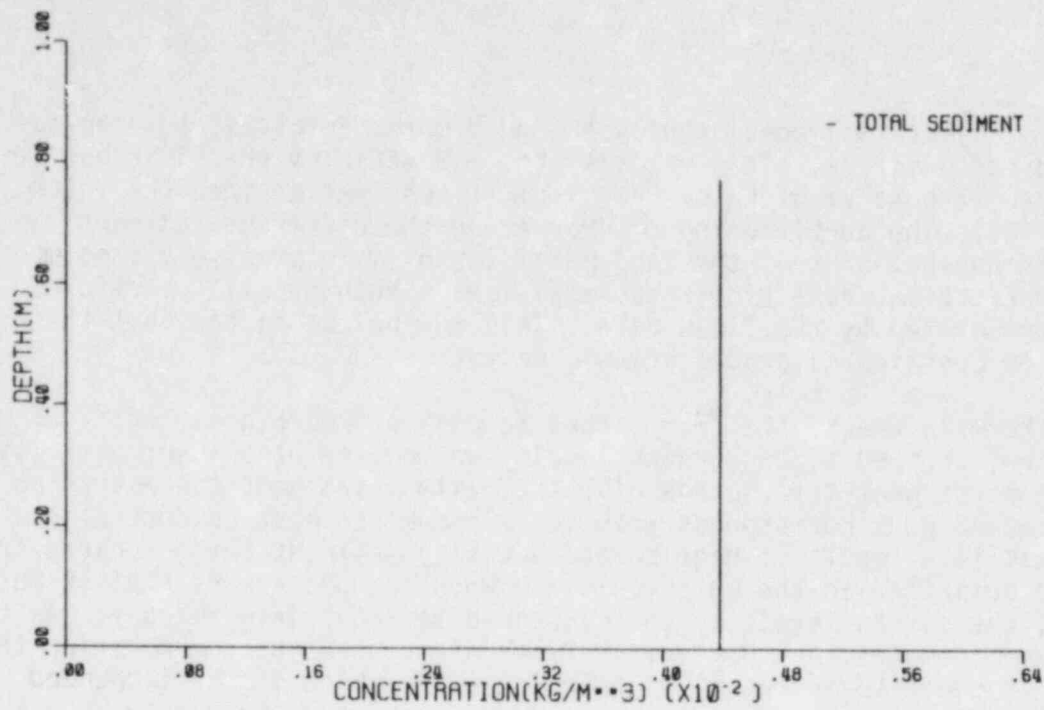


FIGURE 5.32. Phase 3. Vertical Distribution of Total Sediment at CC-3.

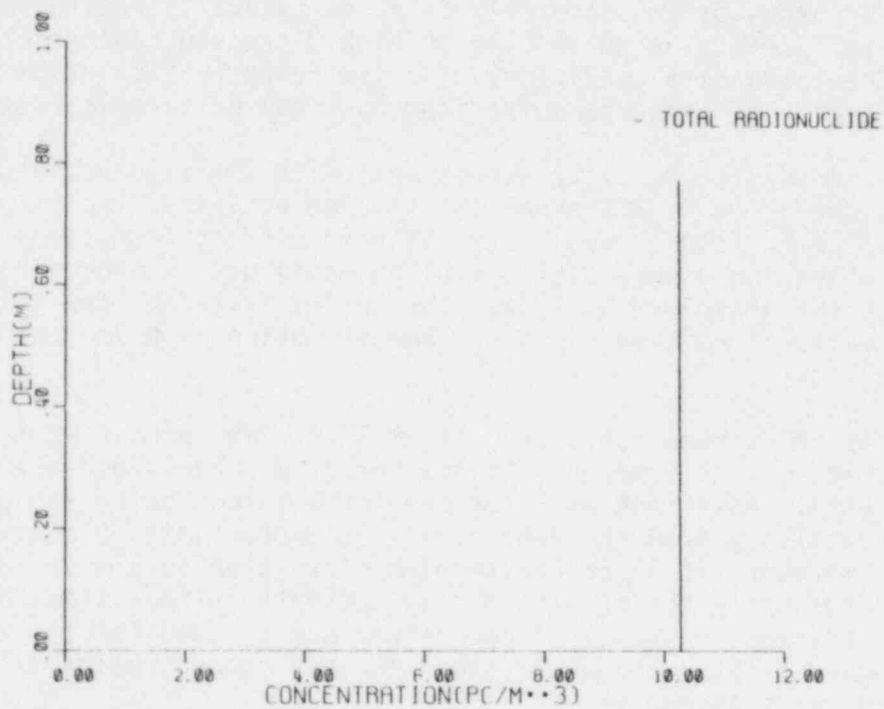


FIGURE 5.33. Phase 3 Vertical Distribution of <sup>137</sup>Cs at CC-3.

## <sup>90</sup>Sr

The <sup>90</sup>Sr simulation consistently has much more dissolved radionuclide than sorbed radionuclide. This reflects the low affinity that <sup>90</sup>Sr has for the sediment. The value of  $K_d$  of <sup>90</sup>Sr is 10 times smaller than the value of  $K_d$  of <sup>137</sup>Cs. The partitioning of <sup>90</sup>Sr among the different sediment fractions is unusual in that the sand particles or more precisely, sediment in a sand size fraction, have higher activity levels than the silt particles. This is corroborated by the field data. This may be due to the fact that sand size fraction contains suspended organic matter.

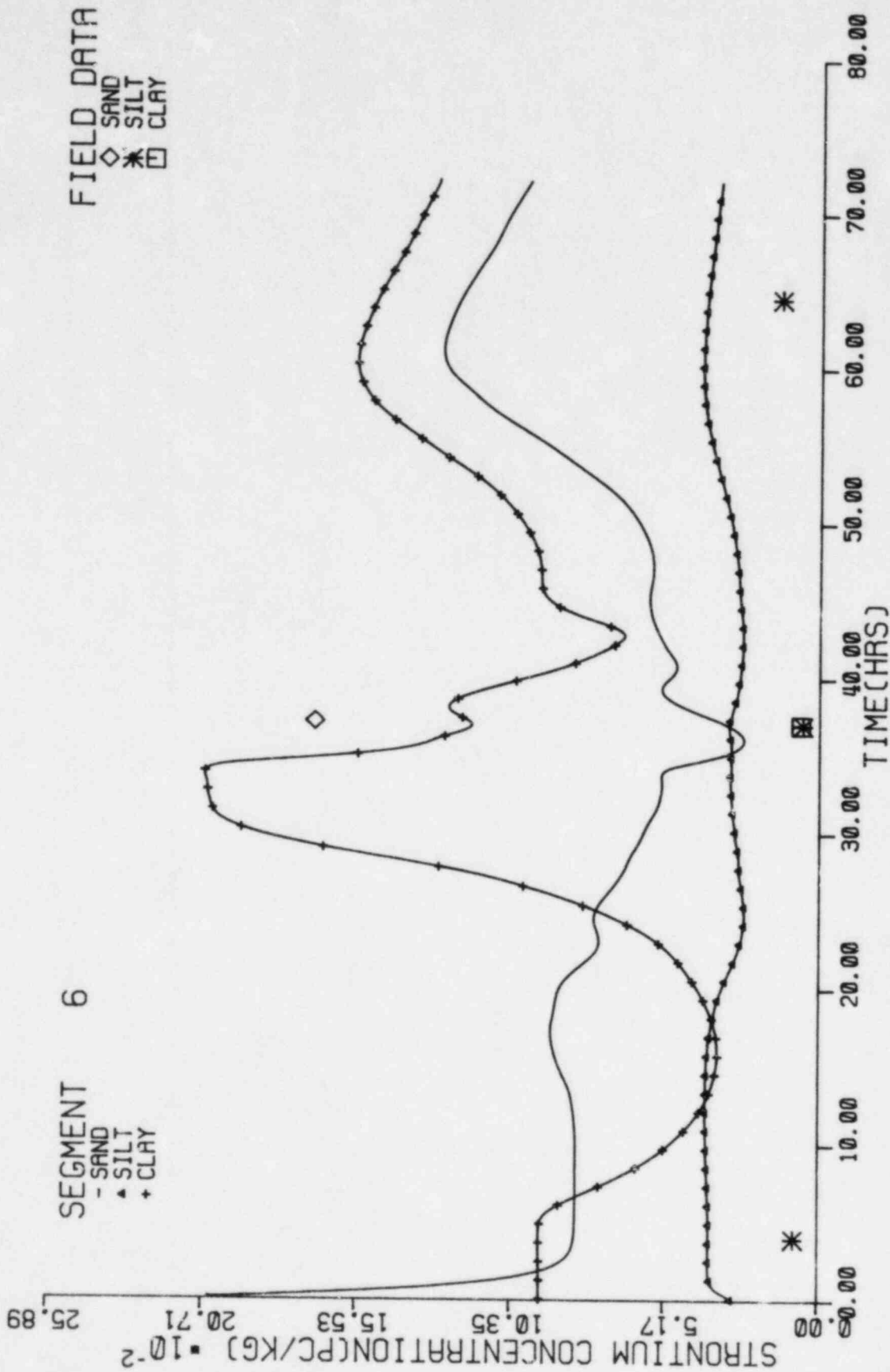
In Buttermilk Creek, the <sup>90</sup>Sr sorbed to clay peaked highest after 35 hr of simulation, dropped to background levels, and peaked at a lower activity at 60 hr. The first peak corresponds with the maximum sediment concentration while the second peak corresponds with the minimum sediment concentration. The high peak is a result of high sorbed activity sediment being scoured from the bed and suspended in the water column. When the bed armors against further clay scour, the sorbed levels in the suspended sediment drop sharply. As the sediment wave from upstream Buttermilk Creek diminishes in concentration the sorbed levels begin to increase, since a larger fraction of the suspended sediments are due to the more contaminated sediments from Franks Creek. Sand- and silt-sorbed <sup>137</sup>Cs display lowest concentration levels during the peak sediment concentrations which indicate that the corresponding upstream clear sediments dilute the sorbed activity.

Dissolved <sup>90</sup>Sr behavior in Buttermilk Creek is basically controlled by the Franks Creek influent. The small wave of high dissolved concentrations is from the Franks Creek boundary condition. The low concentration at 35 hr is due to the passing of the discharge spike from upstream Buttermilk Creek.

At BC-3, predicted silt activity agrees well with the sampled value while the sand activity predicted is 50% below the sampled activity. No clay activity is available for comparison. Strontium-90 differs from the previous <sup>137</sup>Cs result by exhibiting a very high dissolved radionuclide concentration. In comparison with the dissolved activity, the sorbed fractions appear to be insignificantly small. Predicted dissolved concentration is below the measured concentration.

Figure 5.34 is the sorbed activity plot at BC-4. The predicted sand value at 37 hr is one-third of the sampled activity for sand. Field and predicted silt values are fairly consistent with the predicted values being 250 pCi/kg higher. The clay activity from the 4-hr sample is approximated closely by the predicted graph. However, at 37 hr the sampled clay value is almost identical to the low silt value while the predicted clay activity is many times higher. Agreement with field-sampled dissolved concentrations is good for the 37- and 65-hr samples (Figure 5.35). The predicted dissolved concentration at 4 hr is considerably below the measured value.

As Buttermilk Creek enters Cattaraugus Creek sorbed concentrations decrease by a factor of three while dissolved concentrations decrease by a



5.63

FIGURE 5.34. Phase 3 Particulate Radionuclide Concentrations: <sup>90</sup>Sr at BC-4

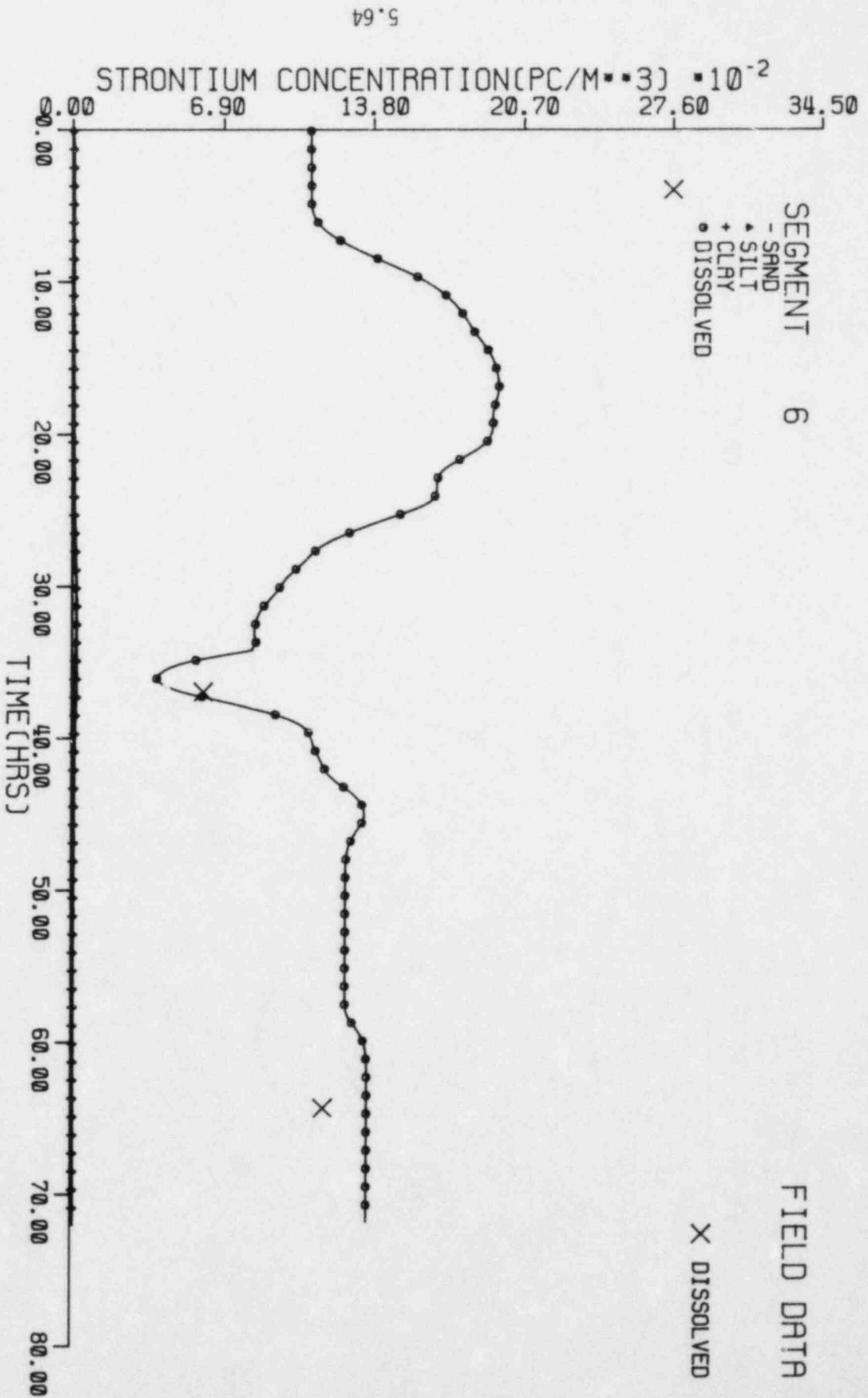


FIGURE 5.35. Phase 3 Particulate and Dissolved Radionuclide Concentrations: <sup>90</sup>Sr at BC-4

factor of 4. The sorbed  $^{90}\text{Sr}$  behaves as it did in Buttermilk Creek. The dissolved  $^{90}\text{Sr}$  in Cattaraugus Creek has a peak at 35 hr where there was a trough in Buttermilk Creek. This is because of the large volume of high activity water accompanying the discharge spike from Buttermilk Creek.

At CC-3, fairly good correlation is achieved with the sorbed activity. Predicted sand is slightly lower and predicted silt slightly higher. The computed dissolved concentration at CC-3 is fairly smooth with a sharp increase and decrease at the time the hydrograph peak passes through the segment. The field concentration of dissolved strontium is about 25% the predicted concentration at 25 hr.

At CC-5, extremely high sand activities found in the field are not duplicated. However, clay and silt activities are matched reasonably. The dissolved concentrations predicted by SERATRA are about the same as in CC-3. However, in this case the field-sampled concentrations are both higher than the predicted.

Downstream of Springville Dam, sorbed and dissolved  $^{90}\text{Sr}$  exhibit no sharp peaks as dispersion and dilution create rather steady effects. At Fryge Bridge, CC-6, sand and clay activities are underestimated by the model. Predicted dissolved concentrations at 6, 32 and 58 hr are 10 to 60% lower than field data.

At CC-9, Segment 28, no dissolved field value is available for comparison. The only sorbed activity collected in the field is for silt. The predicted activity is many times smaller than that field value.

At CC-11, the trend of large field values for sorbed activity downstream of Springville Dam continues. Only the silt activity predicted by SERATRA is fairly close to a field data point; clay and sand field activities simply dwarf those predictions. The predicted dissolved concentration is 60% below the field data. This is fairly consistent with Segments 14 onward.

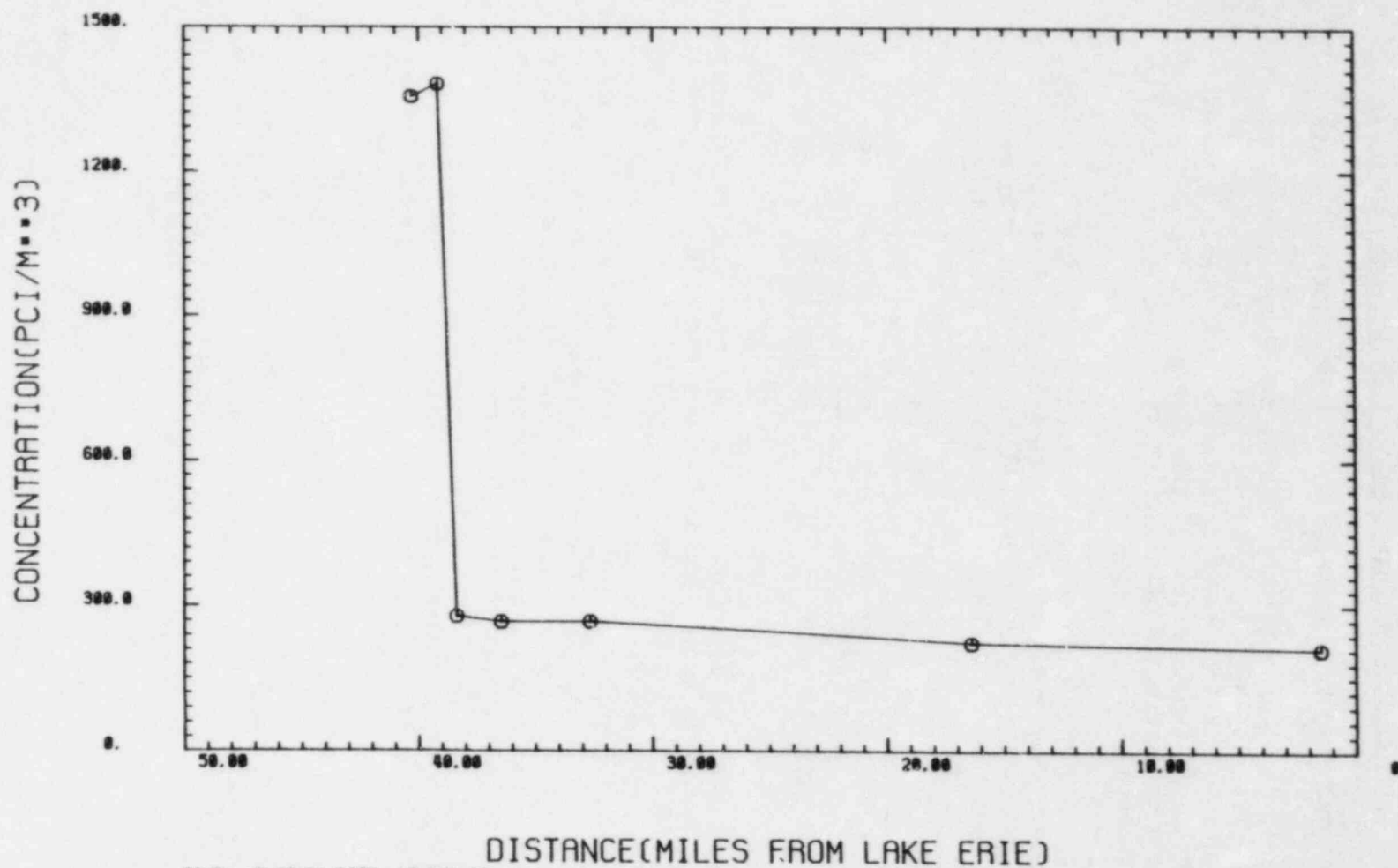
Figure 5.36 is the longitudinal distribution of  $^{90}\text{Sr}$ . This illustrates the strong dilution of radionuclides from Buttermilk Creek to Cattaraugus Creek.

#### $^{239,240}\text{Pu}$

$^{239,240}\text{Pu}$  has a  $K_d$  value 350 times that of  $^{90}\text{Sr}$ . Given the sediment concentrations predicted in the Phase 3 study reach and the  $K_d$  value  $^{239,240}\text{Pu}$  in sorbed form per unit volume of water should be on the same order of magnitude as the dissolved  $^{239,240}\text{Pu}$  if equilibrium exists. As it happens this is the predicted result.

Partitioning of  $^{239,240}\text{Pu}$  is quite dynamic. In Buttermilk Creek silt has the highest sorbed levels; strictly a result of the Franks Creek boundary condition. In Cattaraugus Creek above Springville Dam clay sediment has the highest sorbed levels while below Springville Dam silt retains the most activity. The background condition is for clay to be the most efficient at

99.5



TIME\* 13:45:34 DATE\* 18-AUG-82

FIGURE 5.36. Phase 3, Longitudinal Distribution of  $^{90}\text{Sr}$  Total Concentration of Hour 72

radionuclide uptake which explains the upstream Cattaraugus Creek results. In downstream Cattaraugus Creek, large amounts of high activity silt were suspended from the bed which increased the silt sorbed activity to be above the clay level in the water column.

In Buttermilk Creek, sorbed  $^{239,240}\text{Pu}$  in sand and clay react inversely to the sediment wave from upstream Buttermilk Creek. Silt-sorbed radionuclides are fairly constant. Dissolved  $^{239,240}\text{Pu}$  is virtually constant except for the passing of the discharge spike.

Unlike other radionuclides, predicted silt-sorbed plutonium concentrations are higher than those with clay. The computed silt activity is fairly steady while the computed sand and clay activity display a wider range of values. The relatively sharp peak of computed activity with sand and a valley in the clay activity at 35 hr coincides with the hydrograph spike. A single silt activity data point is available from the field study. The predicted silt activity at that point (28 hr) is about 0.7 pCi/kg greater than the field value. The trend of the  $^{239,240}\text{Pu}$  radionuclide concentration is very similar to the sediment graphs in BC-3 (Segment 3); the dissolved concentration is very steady except for hour 35 in which the hydrograph spike passes through this segment. No field dissolved data points are available for comparison.

At BC-4, Figure 5.37 is the sorbed activity plot. Field data at 37 hr has clay activity higher than silt activity. This is the opposite of the computed results. The predicted clay activity fairly approximates the field data point while the predicted silt activity is two times the sampled data. The radionuclide concentrations in Figure 5.38 are again very similar to the sediment discharges. The predicted dissolved concentration is steady and well above the field-sampled concentration at 65 hr.

In Cattaraugus Creek above Springville Dam clay sorbed  $^{239,240}\text{Pu}$  increase gradually to a peak at 60 hr while sand- and silt-sorbed radionuclides remain steady. At CC-3, the predicted sorbed activity for clay is many times higher than sand and silt activities. The field point for silt activity lies very closely to the predicted silt activity. Radionuclide concentrations are reversed from Buttermilk Creek; radionuclides adsorbed to clay now provide the largest concentrations. No data are available to confirm this with the field.

At CC-5, measured sorbed activities include two silt activity points at 9 and 33 hr. Computed results are similar with one field data point above and one below predicted results. Radionuclide concentrations appear to be very similar to those shown previously at Segment CC-3. No dissolved data from the field is available for comparison. Downstream of Springville Dam, silt-sorbed  $^{239,240}\text{Pu}$  scoured from the bed creates high activity on the water column. Other size fractions exhibit gently changing levels of radionuclide at much lower total concentrations.



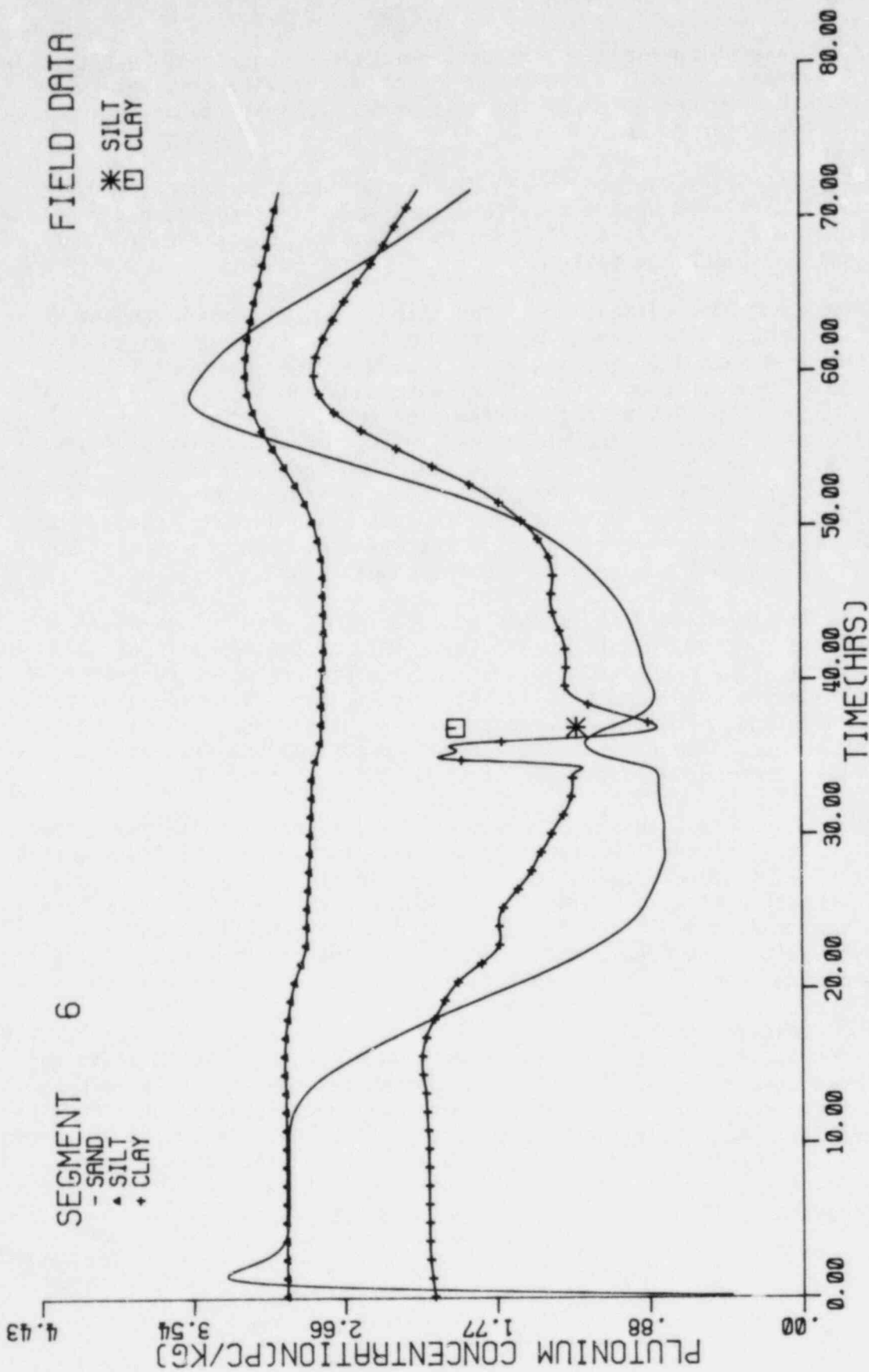


FIGURE 5.37. Phase 3 Particulate Radionuclide Concentrations:  
 $^{239,240}\text{Pu}$  at BC-4

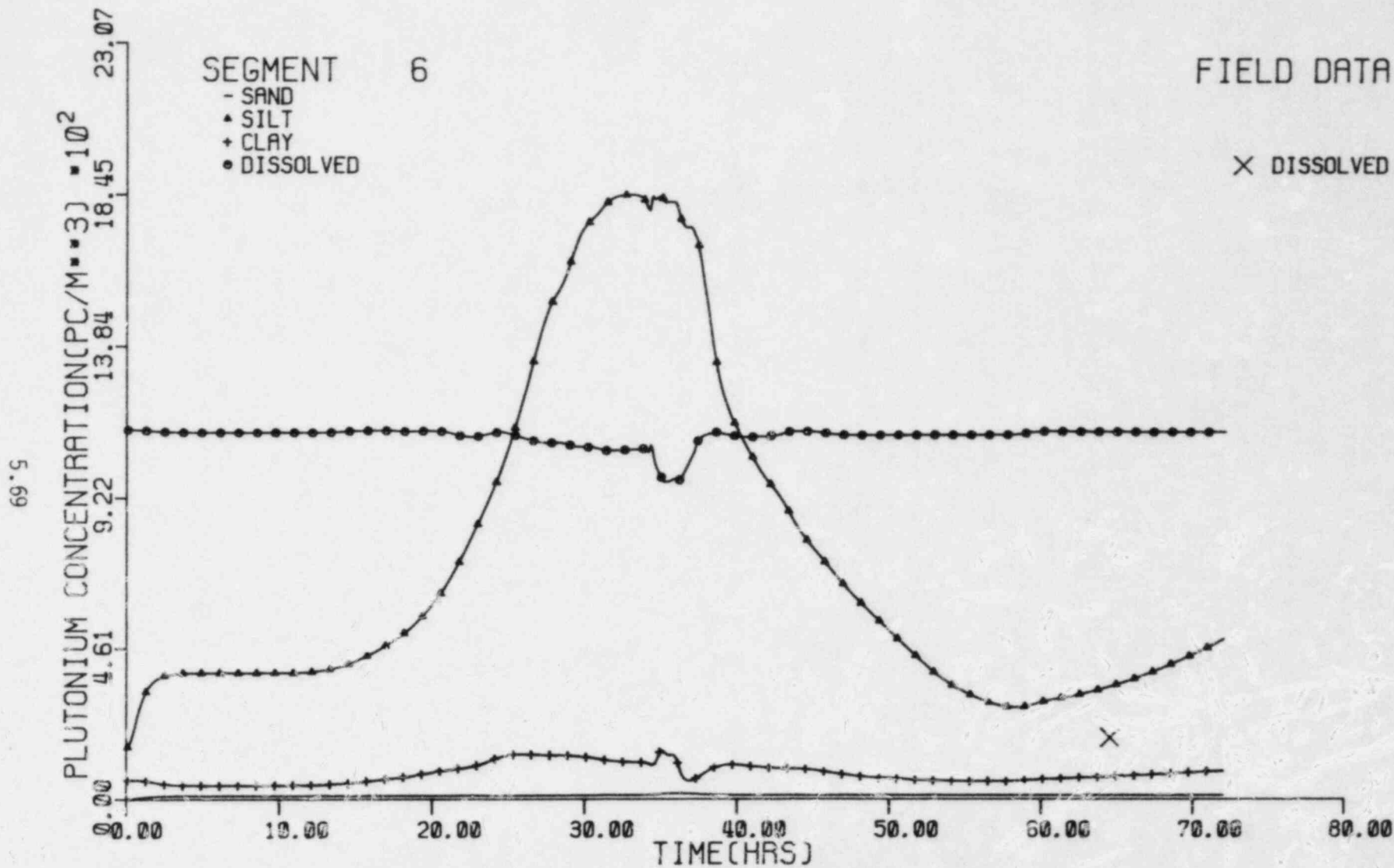


FIGURE 5.38. Phase 3 Particulate and Dissolved Radionuclide Concentrations: <sup>239,240</sup>Pu at BC-4

At CC-6, Fryge Bridge, silt- and clay-sorbed activity, as predicted by SERATRA, alternate having the highest activity. One measured concentration attached to sand is available for verification at 59 hr. The sand activity predicted at that time is about 15 pCi/kg below that data point. Another reversal occurs in the total radionuclide concentration with silt now being the dominant carrier of radionuclides. Predicted dissolved concentrations are almost constant and very near the single field value at 31 hr.

At CC-9, silt is the highest activity carrier of sorbed radionuclide. The predicted clay activity is 50% below the field value. The radionuclide concentrations are relatively low with the exception of silt. This is a direct reflection of the high silt sediment concentration. No field data are available for comparison.

CC-11, the mouth of Cattaraugus Creek, is almost identical to Segment 28 (CC-9) in both concentration and sorbed activity. No field data are available for comparison.

Because of the  $^{239,240}\text{Pu}$ -laden silt scoured from the bed downstream of Springville Dam, total radionuclide concentrations are much higher at downstream locations.. This is shown in the longitudinal distribution of  $^{239,249}\text{Pu}$  at the end of the simulation (Figure 5.39).

### 3H

Tritium on Phase 3 displays very steady concentration levels, changing minutely for the most unsteady field conditions. The reason for this is that the background levels tend to dominate any transport effects. Since tritium exists in dissolved form alone, it is affected greatly by dilution. While high sediment concentrations from Franks Creek tend to preserve the elevated values of sorbed radionuclide in Buttermilk Creek as discussed above, dissolved radionuclides are diluted by a factor of 10.

At BC-3, tritium concentrations are very steady except for hour 35 when the hydrograph spike disrupts the consistency. Predicted concentrations are 40% below the reported value.

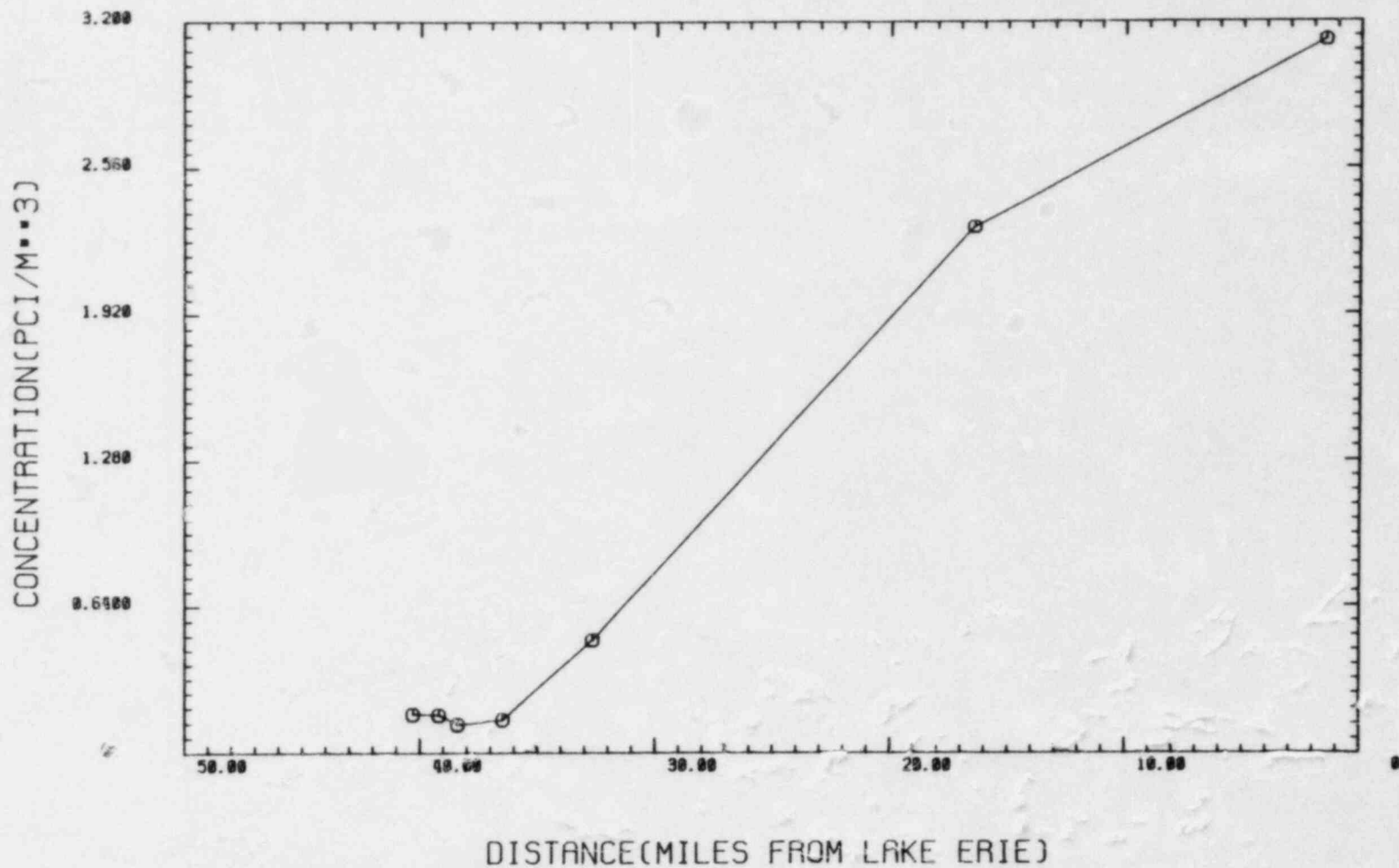
At BC-4, there are field values at hour 37 and hour 65. At hour 37 the computed dissolved concentration is about 20% below the field value while at hour-65 the computed concentration is about 50% of the measured value.

At CC-3, the dissolved concentration graph in Figure 5.40 has slightly more dynamics due to the Cattaraugus Creek inflow. At 25 hours the predicted dissolved concentration is about 20% below the field value.

Figure 5.41 is a plot of the dissolved concentrations at CC-5. There is good agreement between the predicted and field values.

At CC-6, the predicted concentrations are below the measured data by 5 to 25% and very consistent. This is the last segment with field data.

5.71



TIME = 13:50:30 DATE = 18-AUG-82

FIGURE 5.39. Phase 3 Longitudinal Distribution of  $^{239-240}\text{Pu}$  Total Concentration at Hour 72

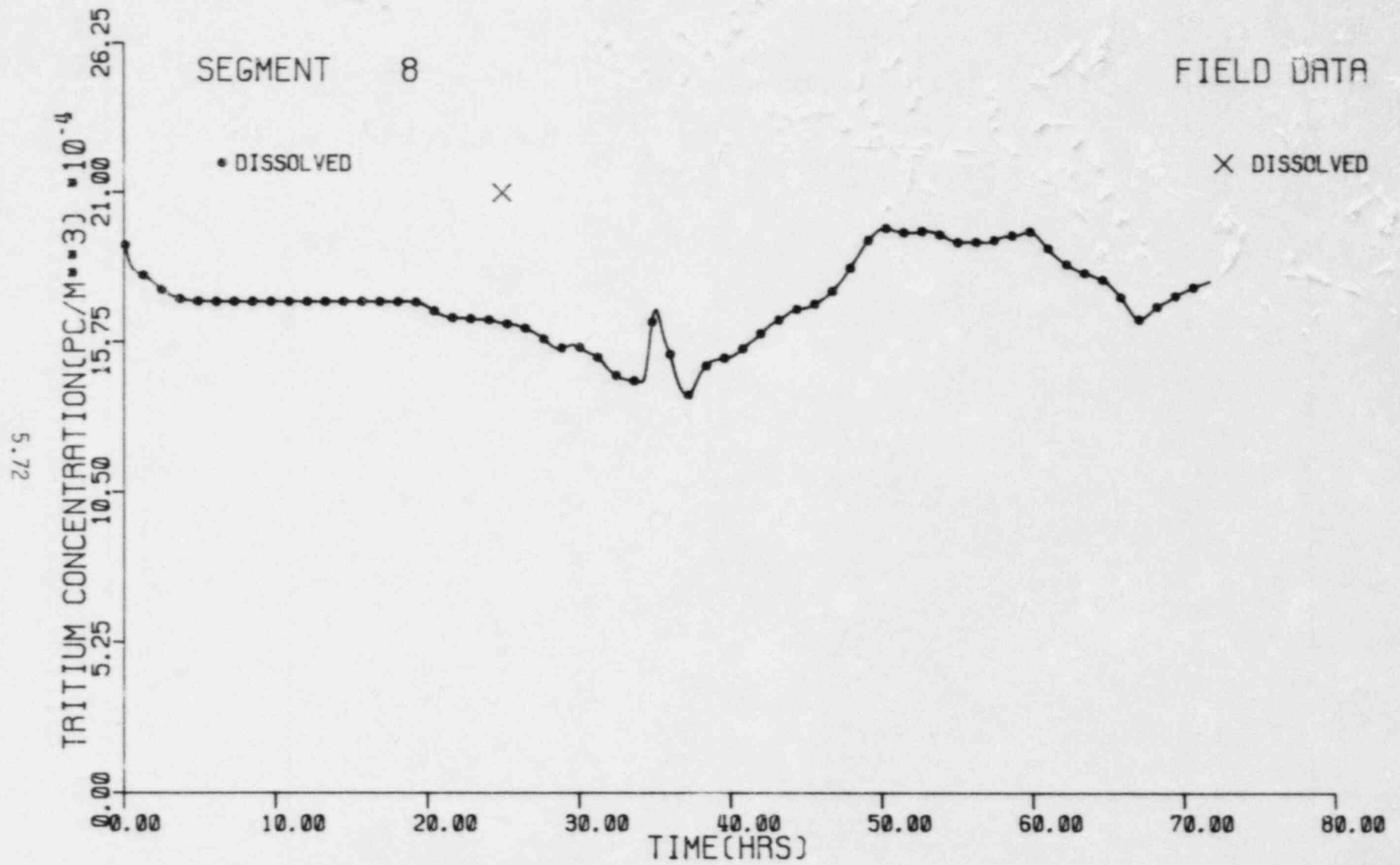


FIGURE 5.40. Phase 3 Dissolved Radionuclide Concentrations: <sup>3</sup>H at CC-3

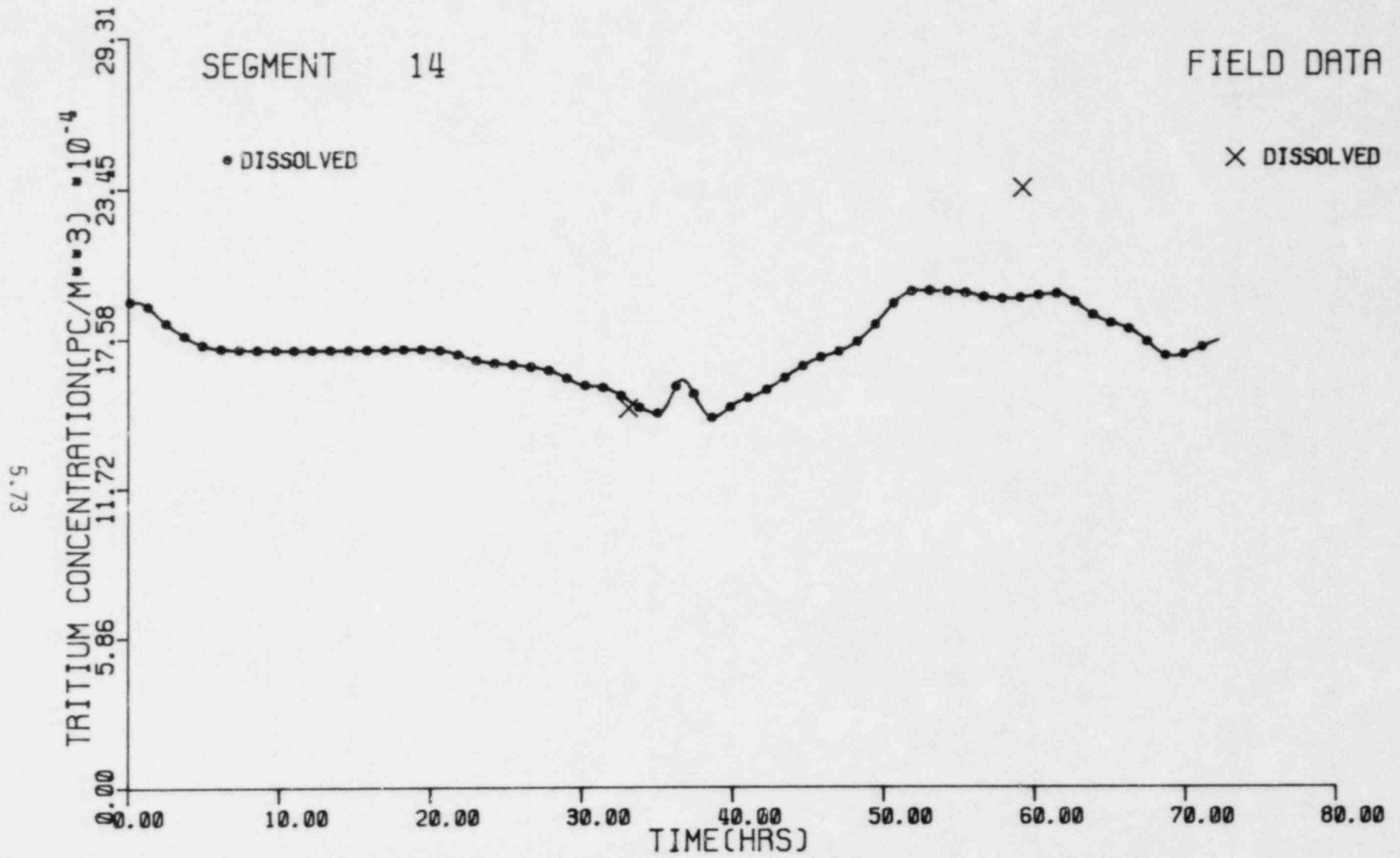


FIGURE 5.41. Phase 3 Dissolved Radionuclide Concentration: <sup>3</sup>H at CC-5

As it happens, the dilution in Buttermilk Creek reduces the tritium levels to below the Cattaraugus Creek background levels. This is borne out by the longitudinal distribution of tritium in Figure 5.42.

A summary of the observed and predicted Phase 3 radionuclides is in Table 5.8. Additional radionuclide plots with field comparison data are in the Appendix A.

## Phase 2

The Phase 2 flow event was mostly steady. Much of the hydrodynamics were synthesized in this phase and single samples of sediment and radionuclides collected at a given sampling location were assumed to be valid to the entire simulation period there. Throughout Phase 2, the radionuclides are partitioned highest to the clay sediment fraction and lowest to the sand fraction.

The results of the Phase 2 radionuclide simulation are very much the same for all four radionuclides. The only area where major change occurs is at the confluence of Buttermilk and Cattaraugus Creeks where all radionuclides are diluted by a factor of four. This can be seen in the four longitudinal distribution plots of  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239,240}\text{Pu}$  and  $^3\text{H}$  in Figures 5.43 through 5.46, respectively.

### $^{137}\text{Cs}$

In general, the predicted  $^{137}\text{Cs}$  radionuclide concentrations in Phase 2 are much higher than the values measured in the field. This discrepancy between predicted and measured data for Phase 2 was mostly due to lack of accurate time varying data as both input data and validation data. At BC-4, the constant boundary condition at FC-1 produces a dissolved concentration three times the field concentration. At CC-3 (Figures 5.47 and 5.48) and CC-5 very steady computed results occur which exceed the field data. At downstream locations CC-9 and CC-11, some dynamics appear in the first 60 hr of simulation before a steady state is approached. Although predicted silt activity appears to be nearing field levels, the particulate  $^{137}\text{Cs}$  is desorbing to the dissolved phase as evidenced by the increasing dissolved concentration of  $^{137}\text{Cs}$  at CC-11.

### $^{90}\text{Sr}$

The Franks Creek boundary condition for dissolved  $^{90}\text{Sr}$  measured in the field was over 100 times larger than any field value found in Cattaraugus Creek. Such a large dilution factor in a steady flow event for these flow conditions seemed impossible. Therefore, a dissolved  $^{90}\text{Sr}$  boundary condition was estimated to produce the BC-4 dissolved field concentration. The steady particulate radionuclide activities are very similar to those found in the  $^{137}\text{Cs}$  modeling. Once again, field particulate levels of radionuclide activity are many times smaller than those predicted. As expected, the BC-4 dissolved concentration predicted is perfectly calibrated to the field concentration.

5.75

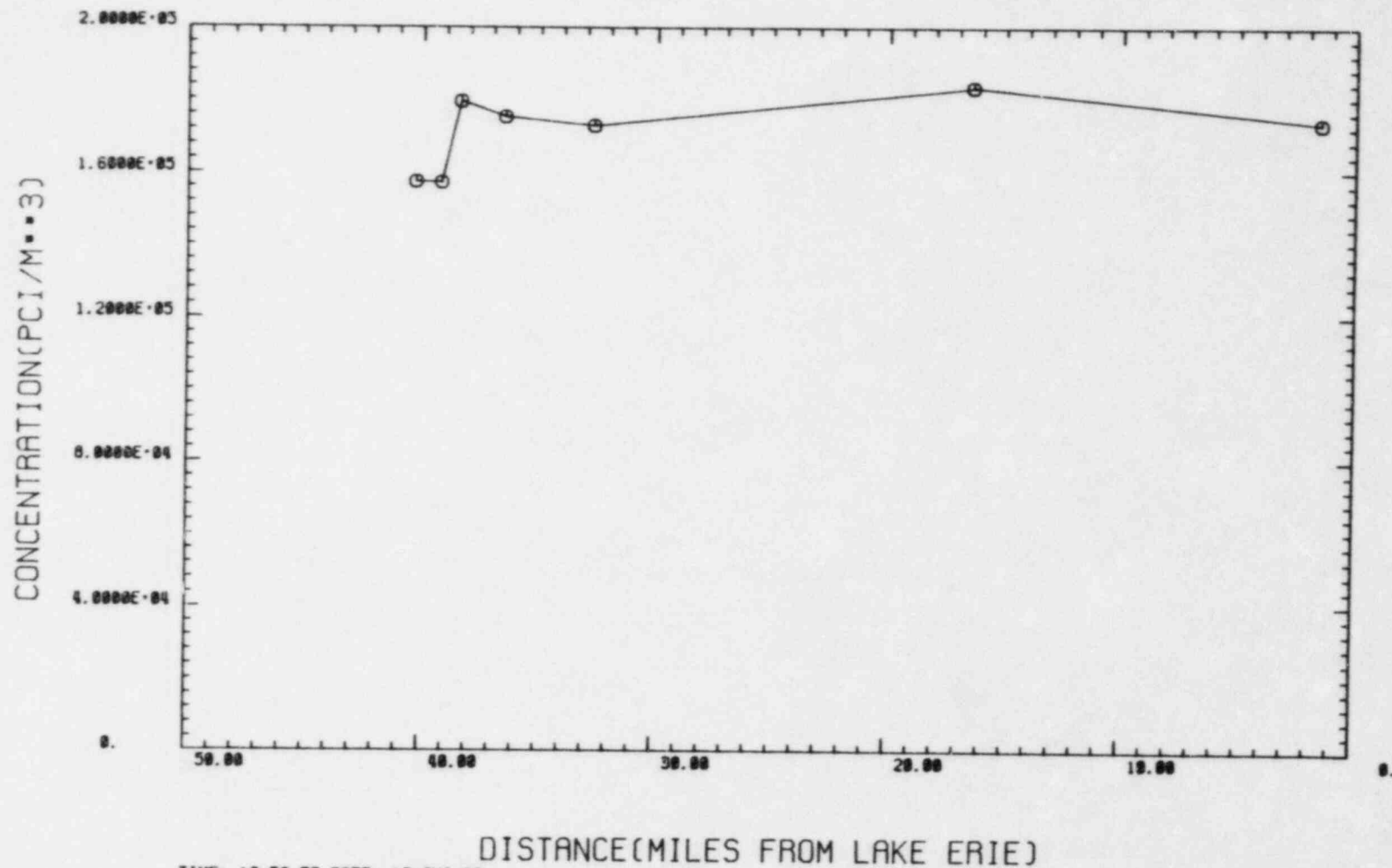


TABLE 5.42. Phase 3 Longitudinal Distribution of <sup>3</sup>H Concentration at Hour 72



TABLE 5.8. Phase 3 Observed and Computed Radionuclide Concentrations

Phase 3 <sup>137</sup> Cs Comparison (pC/g)		
Location	Observed	Computed
3C-3		
Sand	4.99	2.4
Silt	4.79	2.9
Clay	7.86	9.2
Dissolved	45 pC/m <sup>3</sup>	26 pC/m <sup>3</sup>
BC-4 4/26/79		
Sand	-	6.0
Silt	2.51	8.3
Clay	-	9.2
Dissolved	-	45 pC/m <sup>3</sup>
BC-4 4/27/79		
Sand	-	1.9
Silt	2.31	5.0
Clay	4.12	5.5
Dissolved	15 pC/m <sup>3</sup>	12 pC/m <sup>3</sup>
BC-4 4/28/79		
Sand	-	7.3
Silt	2.89	7.7
Clay	3.98	14.8
Dissolved	23.4 pC/m <sup>3</sup>	16 pC/m <sup>3</sup>
CC-3		
Sand	1.13	1.2
Silt	1.67	2.3
Clay	4.44	5.0
Dissolved	11.1 pC/m <sup>3</sup>	8 pC/m <sup>3</sup>
CC-5 4/26/79		
Sand	-	0.3
Silt	0.763	1.2
Clay	1.99	1.9
Dissolved	4500 pC/m <sup>3</sup>	9 pC/m <sup>3</sup>
CC-5 4/27/79		
Sand	-	0.4
Silt	0.877	1.8
Clay	1.65	2.6
Dissolved	16.6 pC/l	8 pC/m <sup>3</sup>

TABLE 5.8. (contd)

Phase 3 <sup>137</sup>Cs Comparison (pC/g)

<u>Location</u>	<u>Observed</u>	<u>Computed</u>
CC-5 4/28/79		
Sand	-	0.2
Silt	0.966	0.5
Clay	-	1.6
Dissolved	-	5 pC/m <sup>3</sup>
CC-6 4/26/79		
Sand	-	0.2
Silt	0.736	0.8
Clay	2.87	1.7
Dissolved	-	7 pC/m <sup>3</sup>
CC-6 4/27/79		
Sand	-	0.4
Silt	1.42	1.0
Clay	1.35	2.6
Dissolved	-	9 pC/m <sup>3</sup>
CC-6 4/28/79		
Sand	-	0.2
Silt	0.580	0.5
Clay	-	1.5
Dissolved	-	6 pC/m <sup>3</sup>
CC-9		
Sand	2.33	0.2
Silt	2.26	0.5
Clay	2.78	1.7
Dissolved	-	7 pC/m <sup>3</sup>
CC-11		
Sand	1.17	0.2
Silt	2.89	0.4
Clay	6.16	1.9
Dissolved	-	11 pC/m <sup>3</sup>

Phase 3 <sup>90</sup>Sr Comparison (pC/g)

<u>Location</u>	<u>Observed</u>	<u>Computed</u>
BC-3		
Sand	1.44	0.7
Silt	0.136	0.2
Clay	-	1.5
Dissolved	1930 pC/m <sup>3</sup>	1060 pC/m <sup>3</sup>

TABLE 5.8. (contd)

Phase 3 <sup>90</sup> Sr Comparison (pC/g)		
<u>Location</u>	<u>Observed</u>	<u>Computed</u>
BC-4 4/26/79		
Sand	-	0.8
Silt	0.081	0.4
Clay	-	0.9
Dissolved	2760 pC/m <sup>3</sup>	1090 pC/m <sup>3</sup>
BC-4 4/27/79		
Sand	1.70	0.3
Silt	0.055	0.3
Clay	0.062	1.2
Dissolved	596 pC/m <sup>3</sup>	500 pC/m <sup>3</sup>
BC-4 4/28/79		
Sand	-	1.2
Silt	0.133	0.4
Clay	-	1.5
Dissolved	1151 pC/m <sup>3</sup>	1350 pC/m <sup>3</sup>
CC-3		
Sand	0.392	0.3
Silt	0.070	0.1
Clay	-	0.5
Dissolved	67.6 pC/m <sup>3</sup>	310 pC/m <sup>3</sup>
CC-5 4/26/79		
Sand	1.41	0.1
Silt	-	0.1
Clay	0.264	0.4
Dissolved	429 pC/m <sup>3</sup>	230 pC/m <sup>3</sup>
CC-5 4/27/79		
Sand	-	0.2
Silt	0.060	0.1
Clay	-	0.7
Dissolved	382 pC/m <sup>3</sup>	260 pC/m <sup>3</sup>
CC-5 4/28/79		
Sand	3.82	0.1
Silt	-	0.1
Clay	-	0.4
Dissolved	-	250 pC/m <sup>3</sup>

TABLE 5.8. (contd)

Phase 3 <sup>90</sup>Sr Comparison (pC/g)

<u>Location</u>	<u>Observed</u>	<u>Computed</u>
CC-5 4/26/79		
Sand	1.54	0.2
Silt	-	0.1
Clay	-	0.5
Dissolved	496 pC/m <sup>3</sup>	220 pC/m <sup>3</sup>
CC-6 4/27/79		
Sand	3.49	0.1
Silt	-	0.1
Clay	1.53	0.4
Dissolved	410 pC/m <sup>3</sup>	270 pC/m <sup>3</sup>
CC-6 4/28/79		
Sand	-	0.1
Silt	-	0.1
Clay	-	0.4
Dissolved	277 pC/m <sup>3</sup>	240 pC/m <sup>3</sup>
CC-9		
Sand	-	0.1
Silt	1.45	0.0
Clay	-	0.3
Dissolved	227 pC/m <sup>3</sup>	220 pC/m <sup>3</sup>
CC-11		
Sand	0.568	0.1
Silt	0.098	0.0
Clay	1.51	0.3
Dissolved	492 pC/m <sup>3</sup>	200 pC/m <sup>3</sup>

Phase 3 <sup>239,240</sup>Pu Comparison (pC/g)

<u>Location</u>	<u>Observed</u>	<u>Computed</u>
BC-3		
Sand	-	0.0004
Silt	0.002	0.0028
Clay	-	0.0015
Dissolved	0.551 pC/m <sup>3</sup>	0.109 pC/m <sup>3</sup>
BC-4/1		
Sand	-	0.0030
Silt	-	0.0030
Clay	-	0.0022
Dissolved	-	0.112 pC/m <sup>3</sup>

TABLE 5.8. (contd)

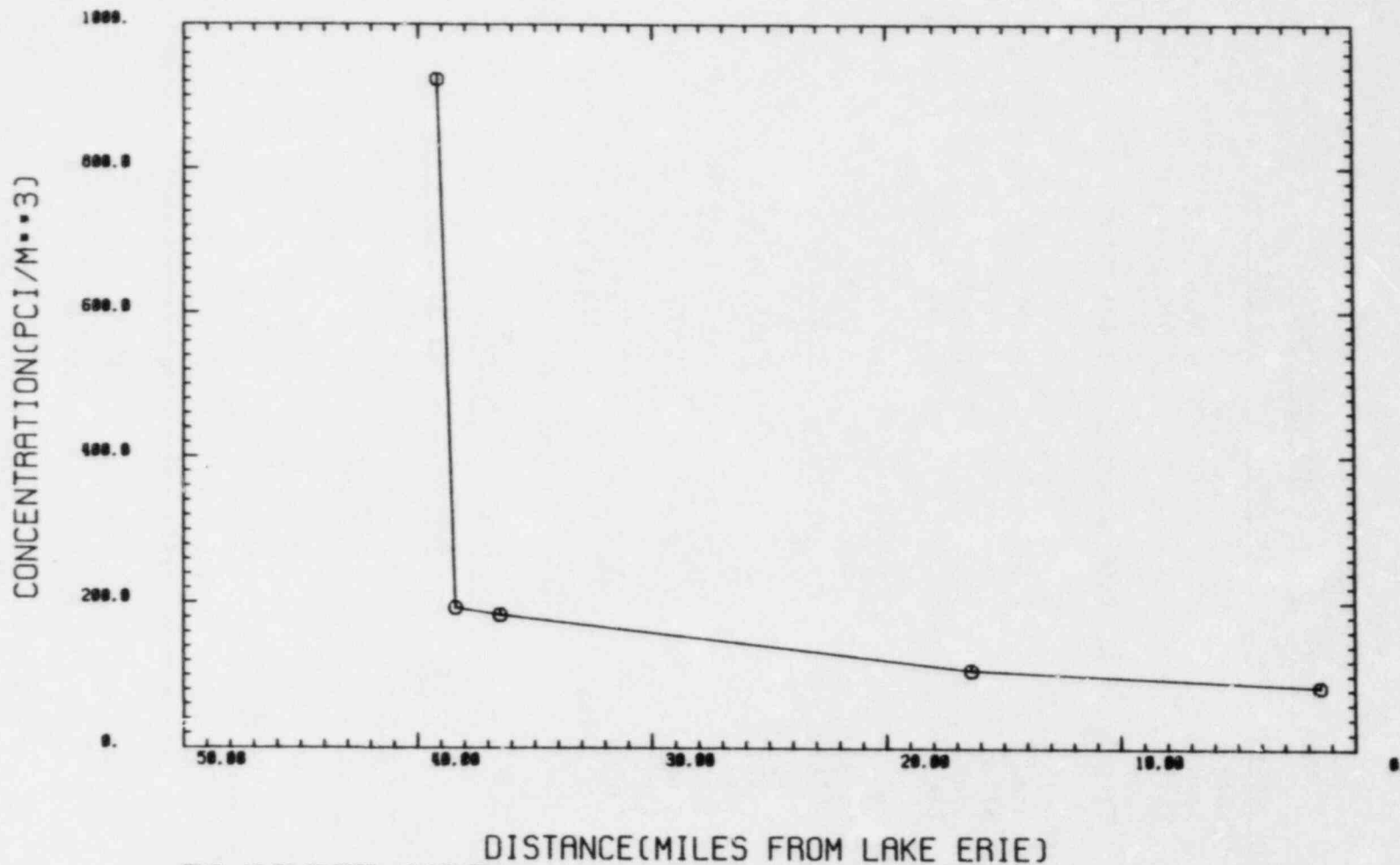
Phase 3 $^{239,240}\text{Pu}$ Comparison (pC/g)		
Location	Observed	Computed
BC-4/2		
Sand	-	0.0011
Silt	0.0013	0.0028
Clay	0.002	0.0009
Dissolved	-	0.104 pC/m <sup>3</sup>
BC-4/3		
Sand	-	0.0030
Silt	-	0.0032
Clay	-	0.0027
Dissolved	0.019 pC/m <sup>3</sup>	0.113 pC/m <sup>3</sup>
CC-3		
Sand	-	0.0005
Silt	0.003	0.0019
Clay	-	0.0280
Dissolved	-	0.104 pC/m <sup>3</sup>
CC-5/1		
Sand	-	0.0002
Silt	0.0007	0.0018
Clay	-	0.0075
Dissolved	-	0.102 pC/m <sup>3</sup>
CC-5/2		
Sand	-	0.0002
Silt	0.0023	0.0019
Clay	-	0.0170
Dissolved	-	0.104 pC/m <sup>3</sup>
CC-5/3		
Sand	-	0.0001
Silt	-	0.0015
Clay	-	0.0232
Dissolved	-	0.100 pC/m <sup>3</sup>
CC-6/1		
Sand	-	0.0006
Silt	-	0.0308
Clay	-	0.0133
Dissolved	-	0.110 pC/m <sup>3</sup>

TABLE 5.8. (contd)

Phase 3 Location	239,240 Pu Comparison (pC/g)	
	Observed	Computed
CC-6/2		
Sand	-	0.0006
Silt	-	0.0251
Clay	-	0.0124
Dissolved	0.06 pC/m <sup>3</sup>	0.103 pC/m <sup>3</sup>
CC-6/3		
Sand	0.016	0.0005
Silt	-	0.0110
Clay	-	0.0264
Dissolved	-	0.099 pC/m <sup>3</sup>
CC-9		
Sand	-	0.0023
Silt	-	0.0322
Clay	0.049	0.0215
Dissolved	-	0.115 pC/m <sup>3</sup>
CC-11		
Sand	-	0.0021
Silt	-	0.0331
Clay	-	0.0219
Dissolved	-	0.174 pC/m <sup>3</sup>

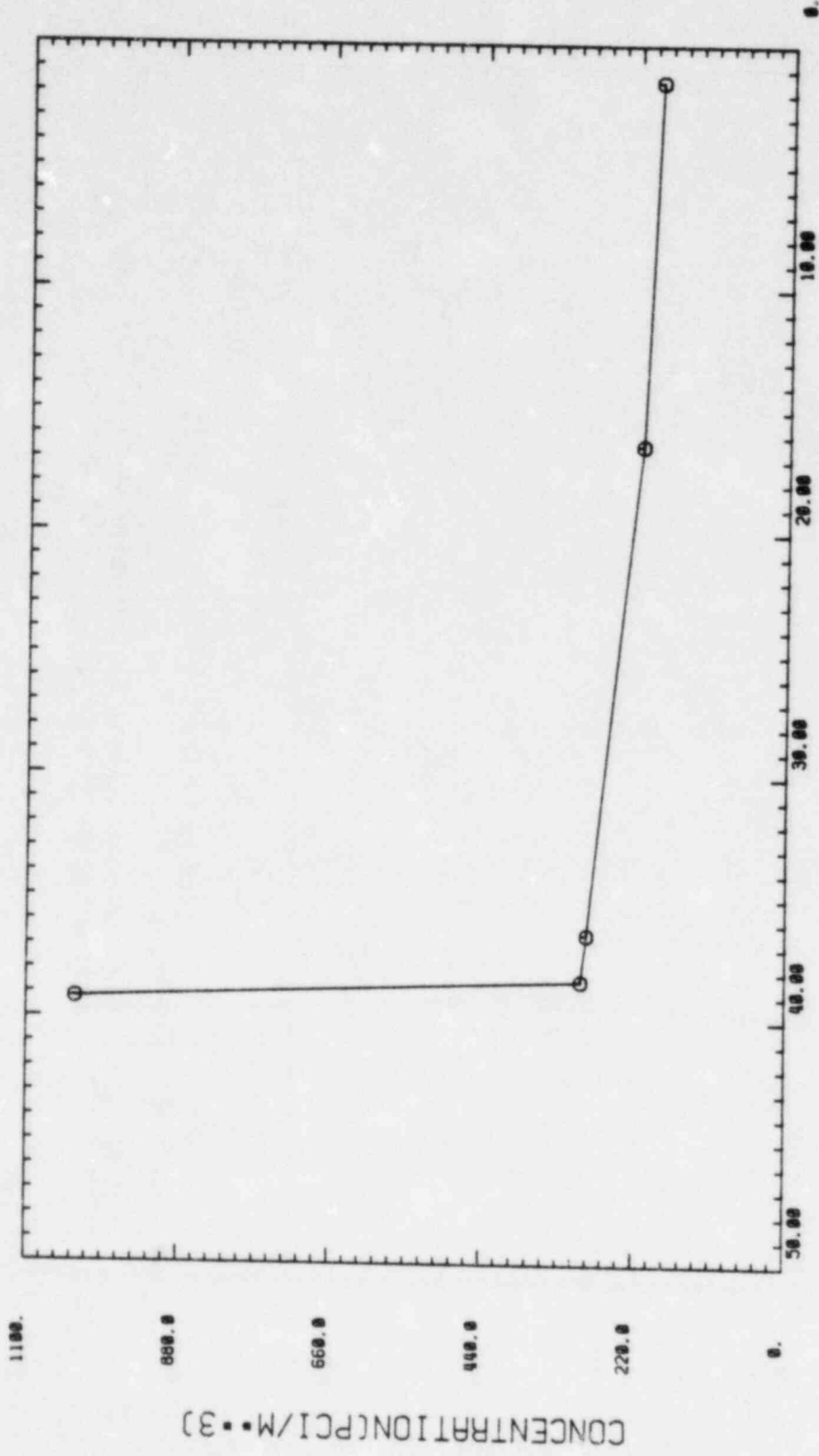
Phase 3 Location	<sup>3</sup> H Comparison (pC/m <sup>3</sup> )	
	Observed	Computed
BC-3	290 x 10 <sup>3</sup>	160 x 10 <sup>3</sup>
BC-4/2	212 x 10 <sup>3</sup>	170 x 10 <sup>3</sup>
BC-4/3	315 x 10 <sup>3</sup>	160 x 10 <sup>3</sup>
CC-3	210 x 10 <sup>3</sup>	250 x 10 <sup>3</sup>
CC-5/2	148 x 10 <sup>3</sup>	150 x 10 <sup>3</sup>
CC-5/3	235 x 10 <sup>3</sup>	190 x 10 <sup>3</sup>
CC-6/1	197 x 10 <sup>3</sup>	180 x 10 <sup>3</sup>
CC-6/2	215 x 10 <sup>3</sup>	160 x 10 <sup>3</sup>
CC-6/3	234 x 10 <sup>3</sup>	190 x 10 <sup>3</sup>

5.82



TIME\* 13\*58\*37 DATE\* 18\*Aug\*82

FIGURE 5.43. Phase 2 Longitudinal Distribution of  $^{137}\text{Cs}$  Total Concentration at Hour 100



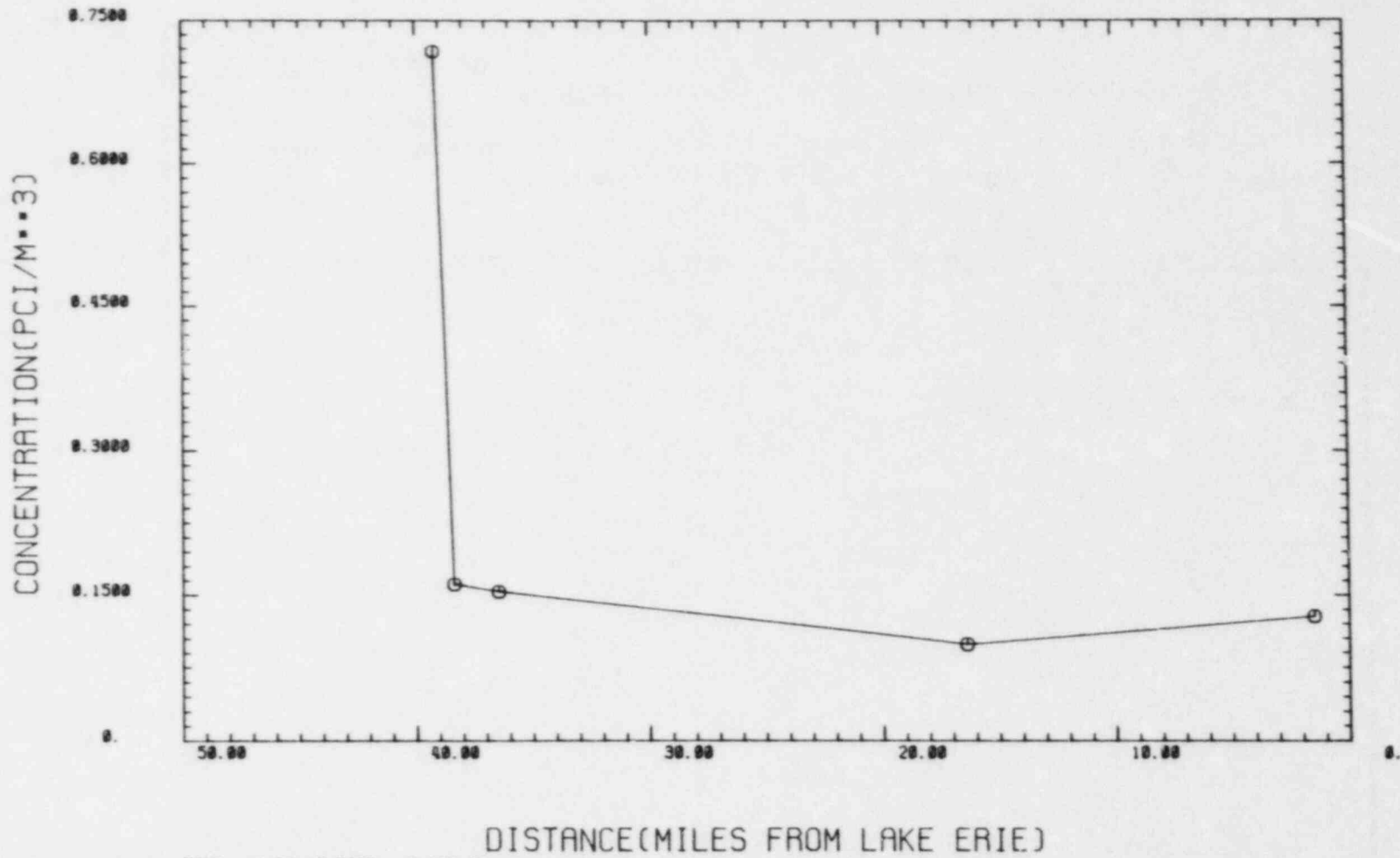
TIME: 14-01-29 DATE: 18-AUG-82

DISTANCE (MILES FROM LAKE ERIE)

FIGURE 5.44. Phase 2 Longitudinal Distribution of <sup>90</sup>Sr Total Concentration at Hour 100



5.84



DISTANCE(MILES FROM LAKE ERIE)  
TIME= 14:04:15 DATE= 18-AUG-82  
FIGURE 5.45. Phase 2 Longitudinal Distribution of  $^{239,240}\text{Pu}$  Total Concentration at Hour 100

5.85

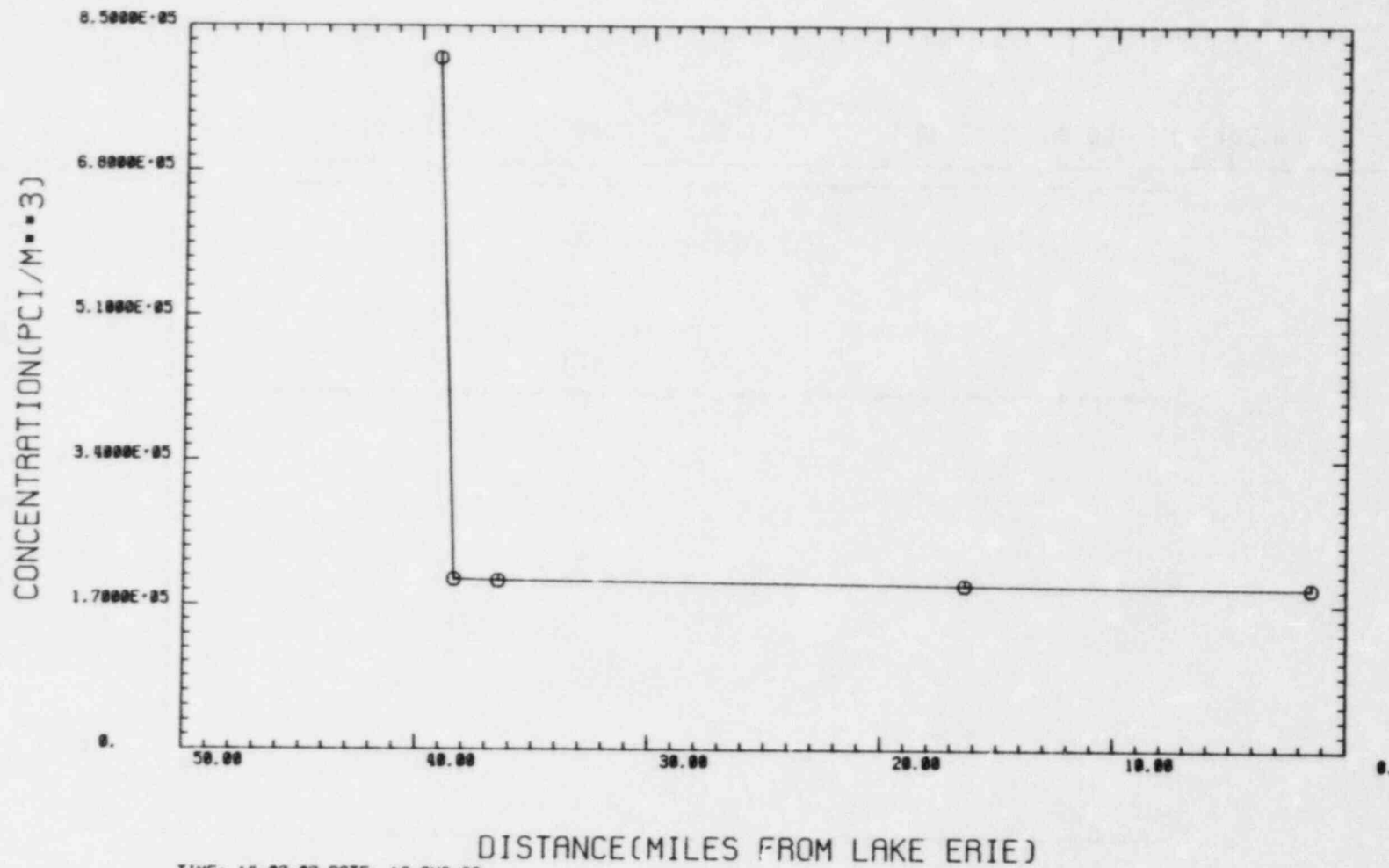


FIGURE 5.46. Phase 2 Longitudinal Distribution of <sup>3</sup>H Total Concentration at Hour 100

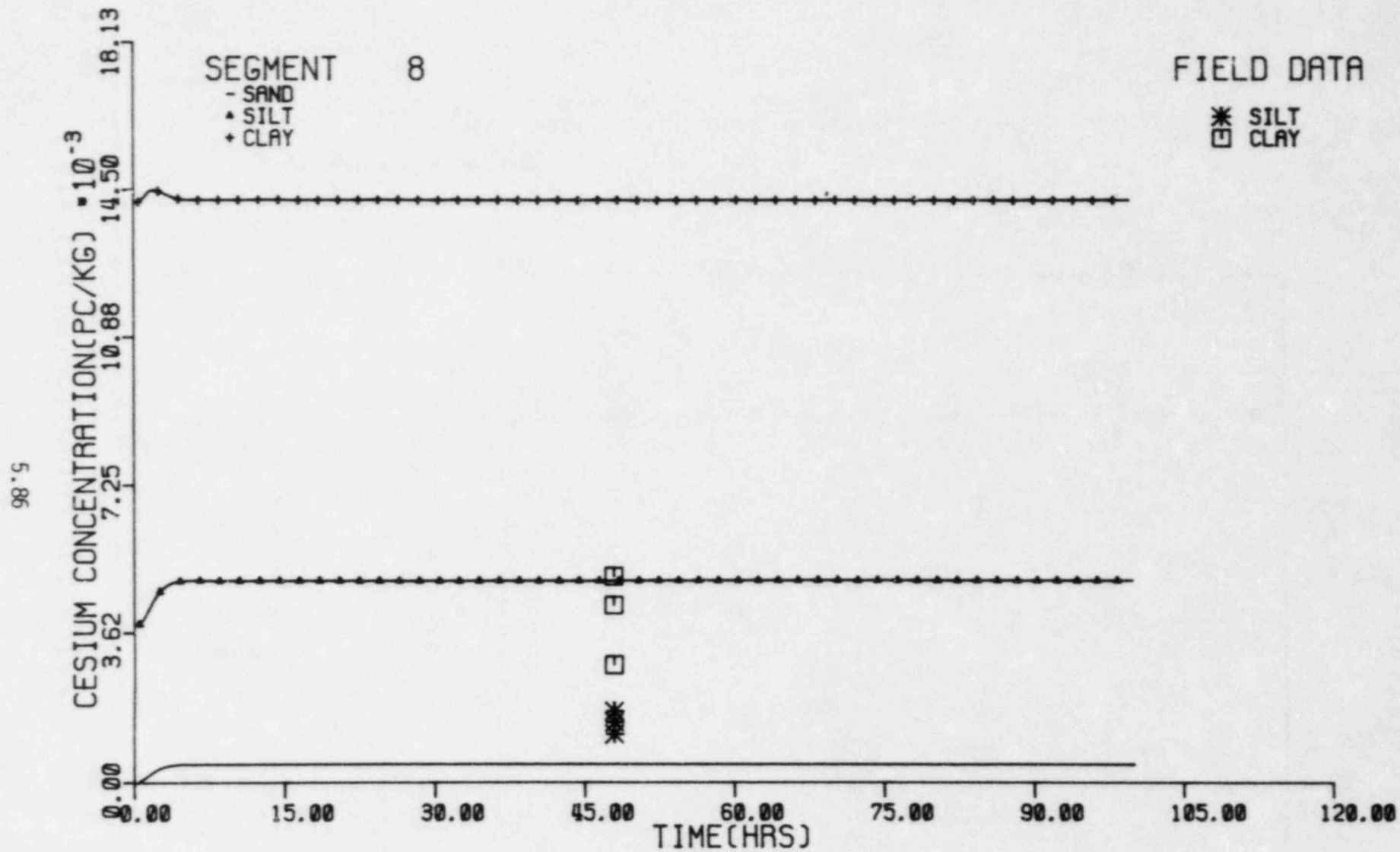


FIGURE 5.47. Phase 2 Particulate Radionuclide Concentrations:  $^{137}\text{Cs}$  at CC-3

78.5

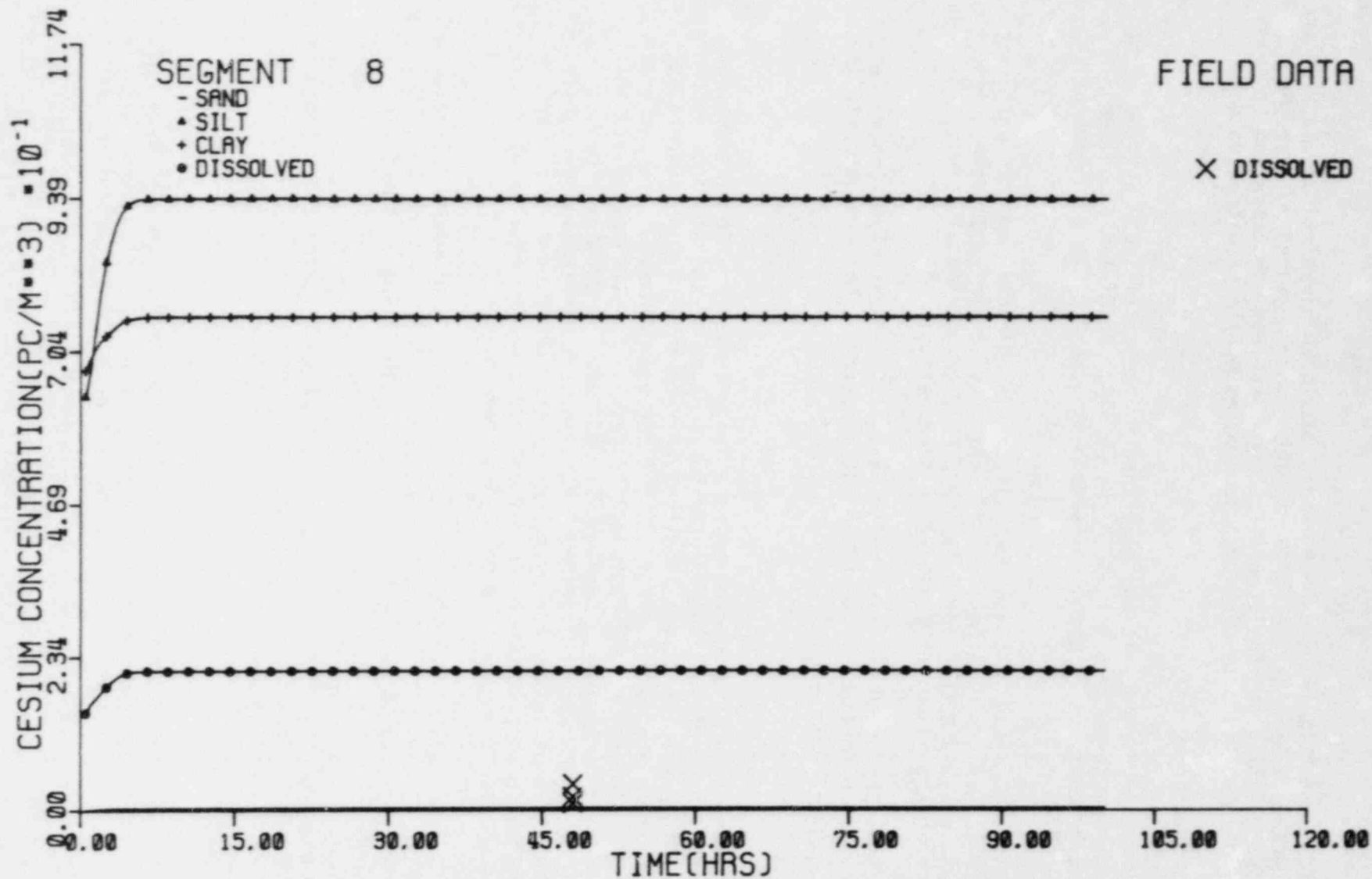


FIGURE 5.48. Phase 2 Particulate and Dissolved Radionuclide Concentrations:  $^{137}\text{Cs}$  at CC-3

At CC-3 and CC-5 (Figures 5.49 and 5.50), both dissolved and particulate  $^{90}\text{Sr}$  predicted by SERATRA are somewhat higher than measured values. At CC-11 (Figure 4.51), the field verification dissolved concentration at 100 hours of simulation is closely approximated by the predicted value.

#### $^{239,240}\text{Pu}$

At BC-4, predicted silt and clay specific activities are two and eight times the respective field values (Figure 5.52). Predicted dissolved  $^{239,240}\text{Pu}$ , however, is in excellent agreement with the field concentration (Figure 5.53).

Plots at CC-3 and CC-5 are very similar in character and concentration levels. Field values for specific silt activity are in excellent agreement with predicted values (Figures 5.54 and 5.55). Predicted dissolved  $^{239,240}\text{Pu}$  at CC-3, however, is 20% of the field concentration.

At CC-11 predicted activities for both silt and dissolved concentration are a fair approximation of the field activity levels but consistently low, as shown in Figures 5.56 and 5.57.

#### $^3\text{H}$

The comparison of predicted tritium concentrations with field values is not so much a test of the SERATRA code but a gauge of the accuracy of the posed problem. Since tritium exists in dissolved form only, the concentrations found downstream are merely the result of the hydrodynamics, i.e., migration, dilution and dispersion, and radionuclide decay. For the relatively short simulation period considered in Phase 2, radionuclide decay is insignificant. Therefore, the sediment and radionuclide transport interaction mechanisms on which SERATRA is based are not being exercised. Discrepancies between predicted and observed tritium concentrations are then the results of an error in the field values or an error in the hydrodynamics.

At BC-4, excellent agreement between predicted and observed tritium is displayed in Figure 5.58. However, subsequent comparisons at CC-3, CC-5 and CC-11 show predicted values to be consistently about 60% of the field concentrations.

A summary of the observed and predicted Phase 2 radionuclide concentrations is found in Table 5.9. Additional plots comparing field data with the predicted radionuclide concentrations are found in Appendix A.

### Phase 1

The Phase 1 hydrodynamics were the most unsteady of the three phases; consequently the radionuclide concentration fluctuated most accordingly. As mentioned earlier, the Phase 1 hydrodynamics were completely synthesized without calibration due mostly to the lack of continuous flow measurement at Gowand (CC-9). Sediment and radionuclide sampling was performed once at each boundary condition which forced a steady concentration to be input for the very unsteady case.

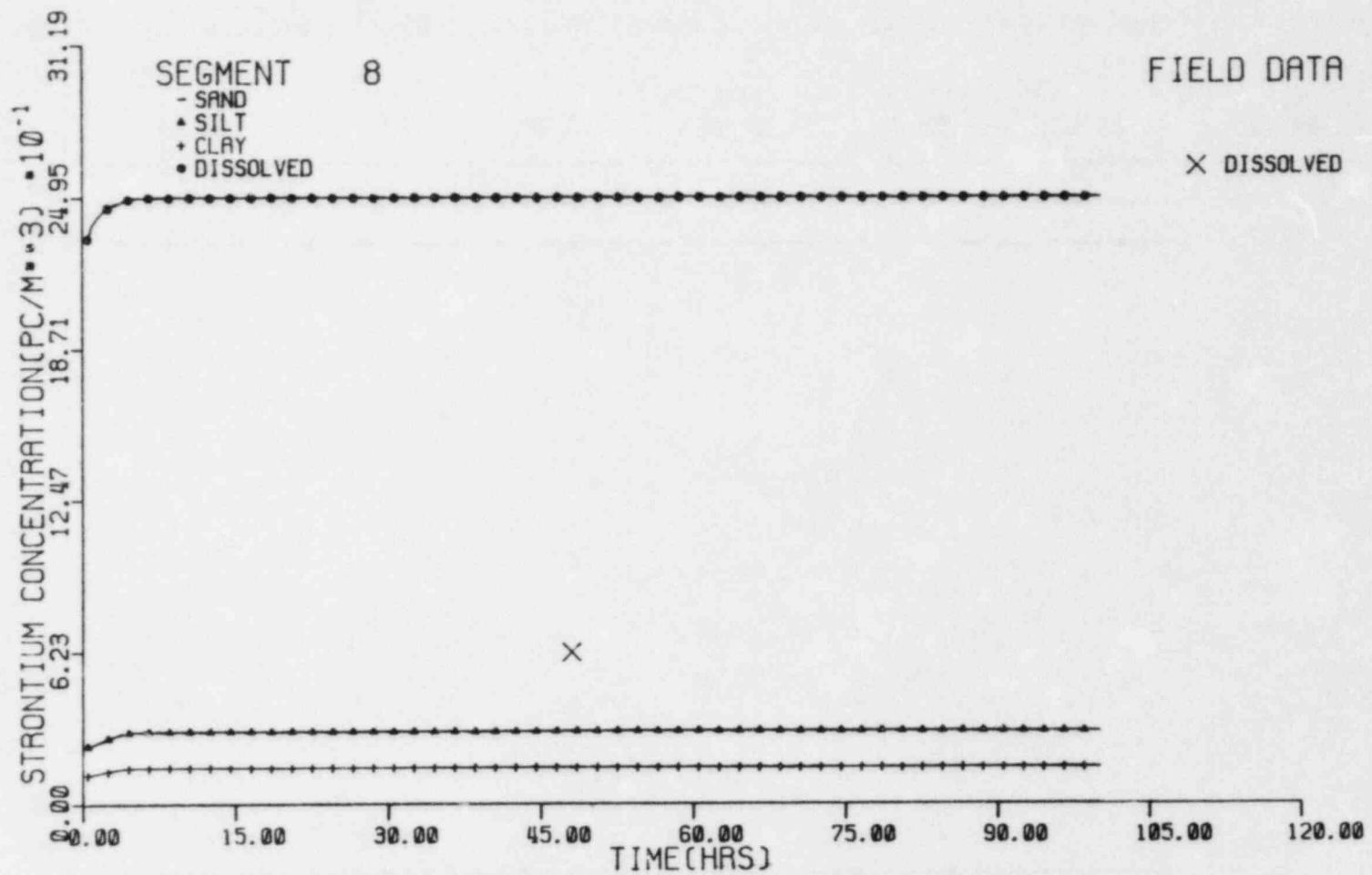


FIGURE 5.49. Phase 2 Particulate and Dissolved Radionuclide Concentrations:  
<sup>90</sup>Sr at CC-3

06.5

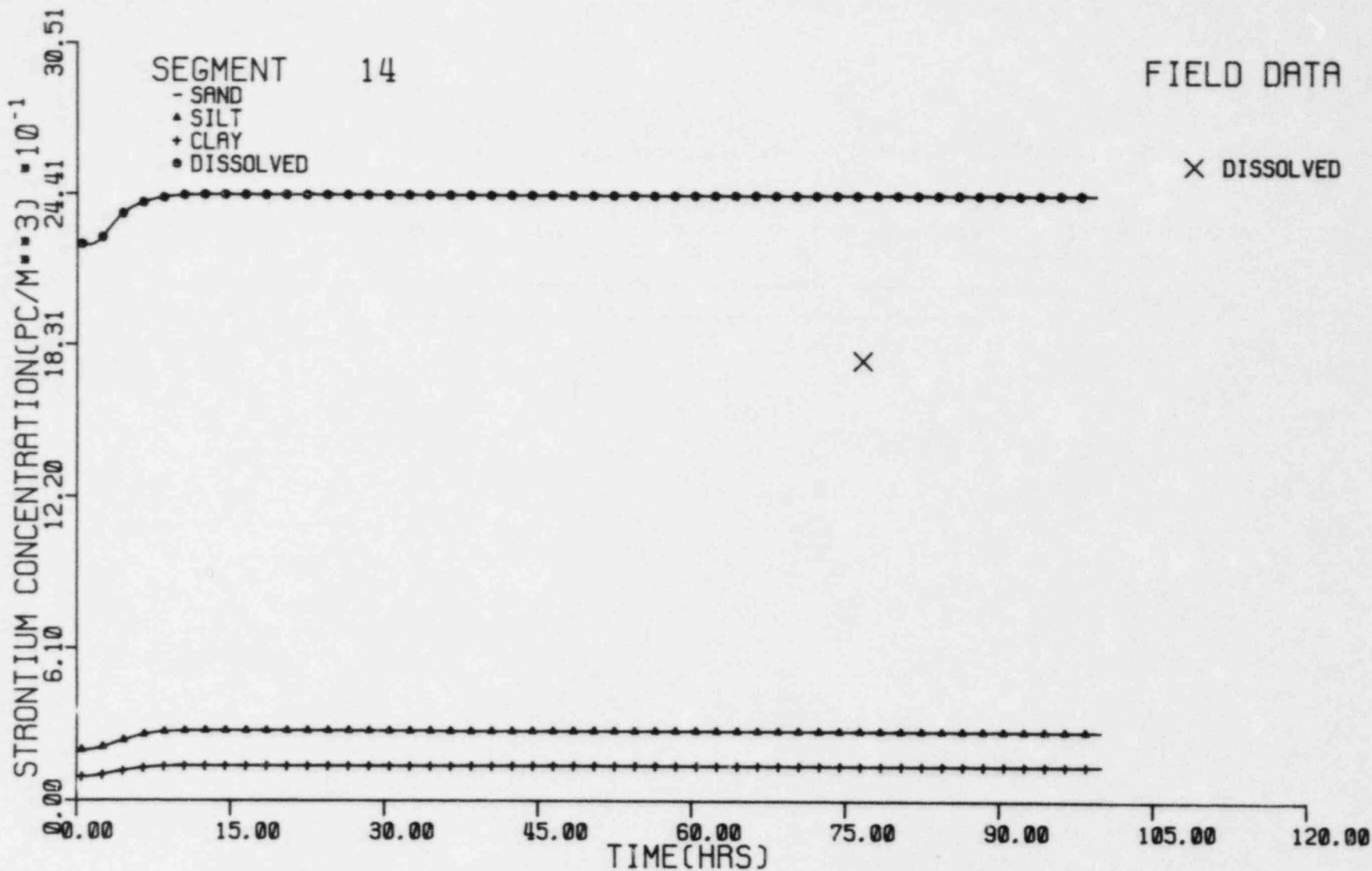


FIGURE 5.50. Phase 2 Particulate and Dissolved Radionuclide Concentrations:  
<sup>90</sup>Sr at CC-5

5.91

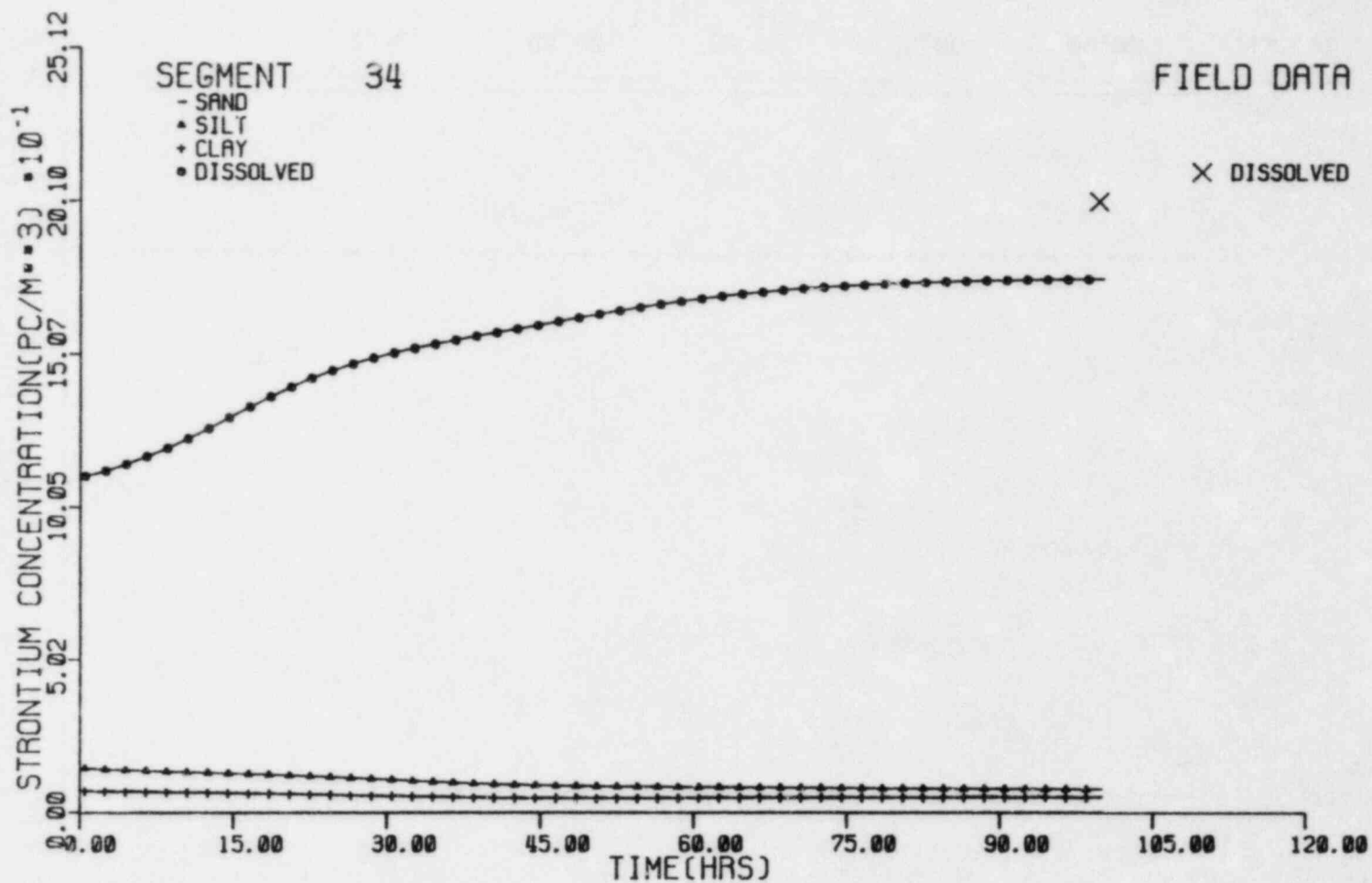


FIGURE 5.51. Phase 2 Particulate and Dissolved Radionuclide Concentration:  
<sup>90</sup>Sr at CC-11



26.5

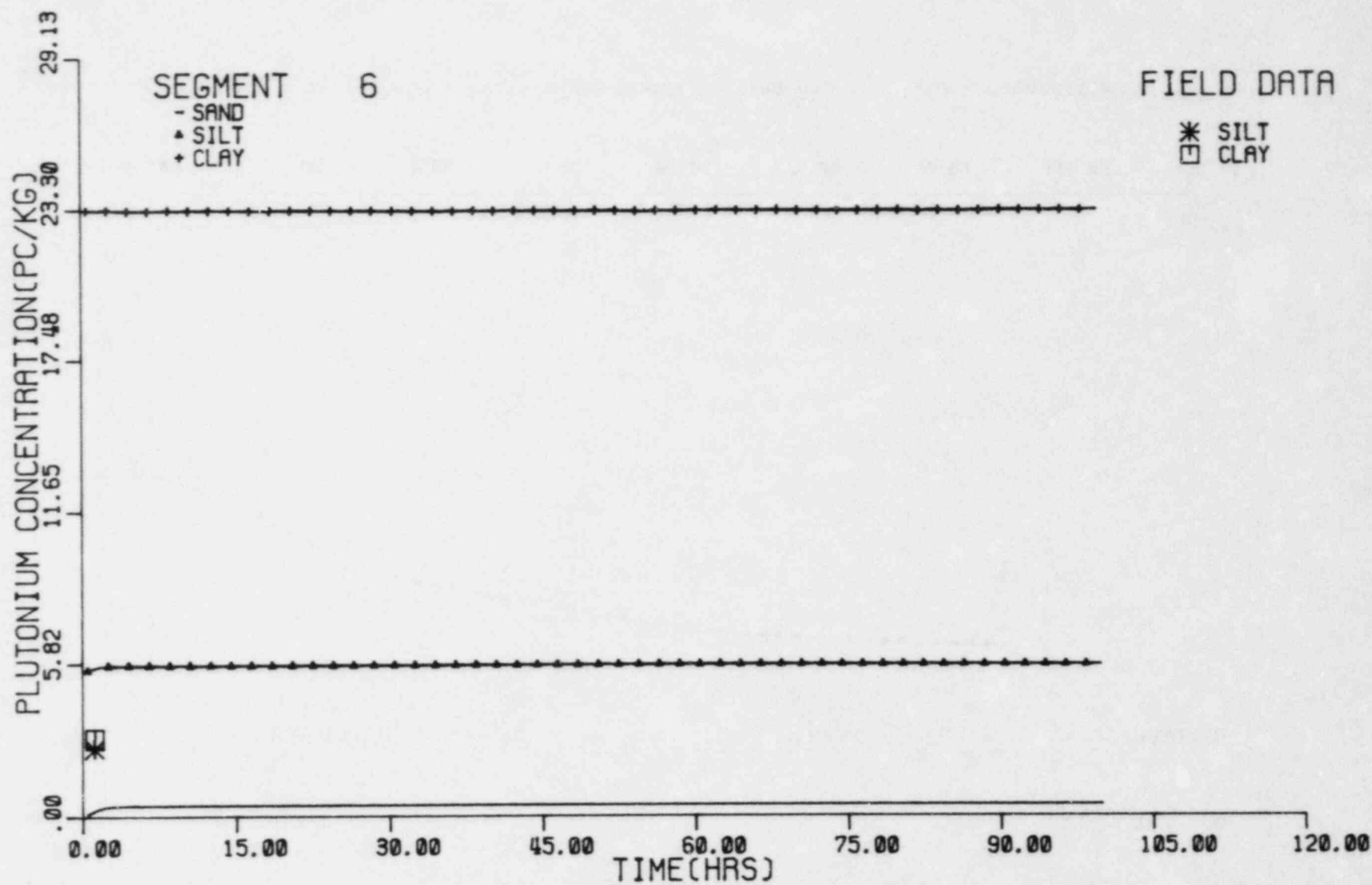


FIGURE 5.52. Phase 2 Particulate Radionuclide Concentrations:  $^{239,240}\text{Pu}$  at BC-4

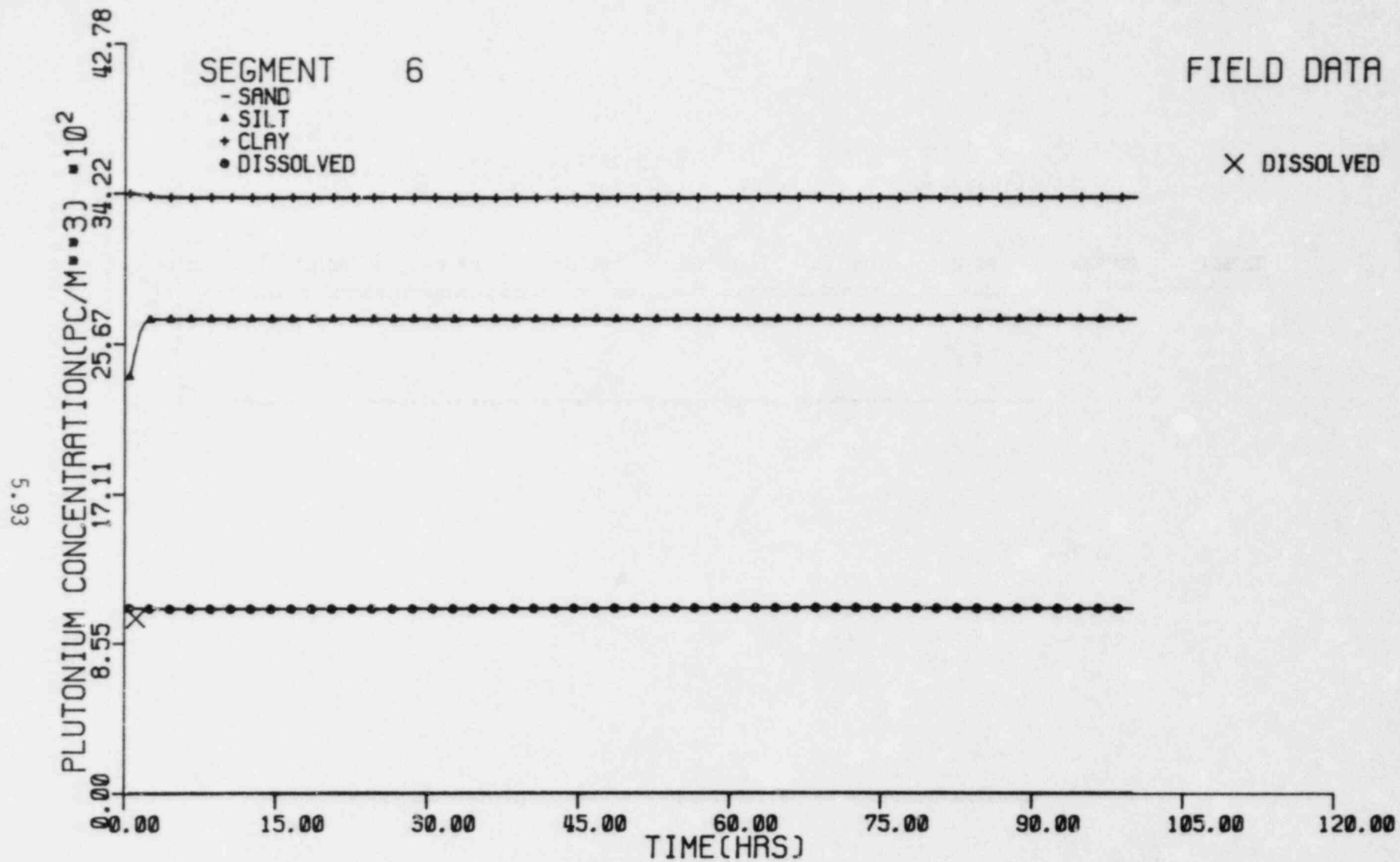


FIGURE 5.53. Phase 2 Particulate and Dissolved Radionuclide Concentrations:  
<sup>239,240</sup>Pu at BC-4

5.94

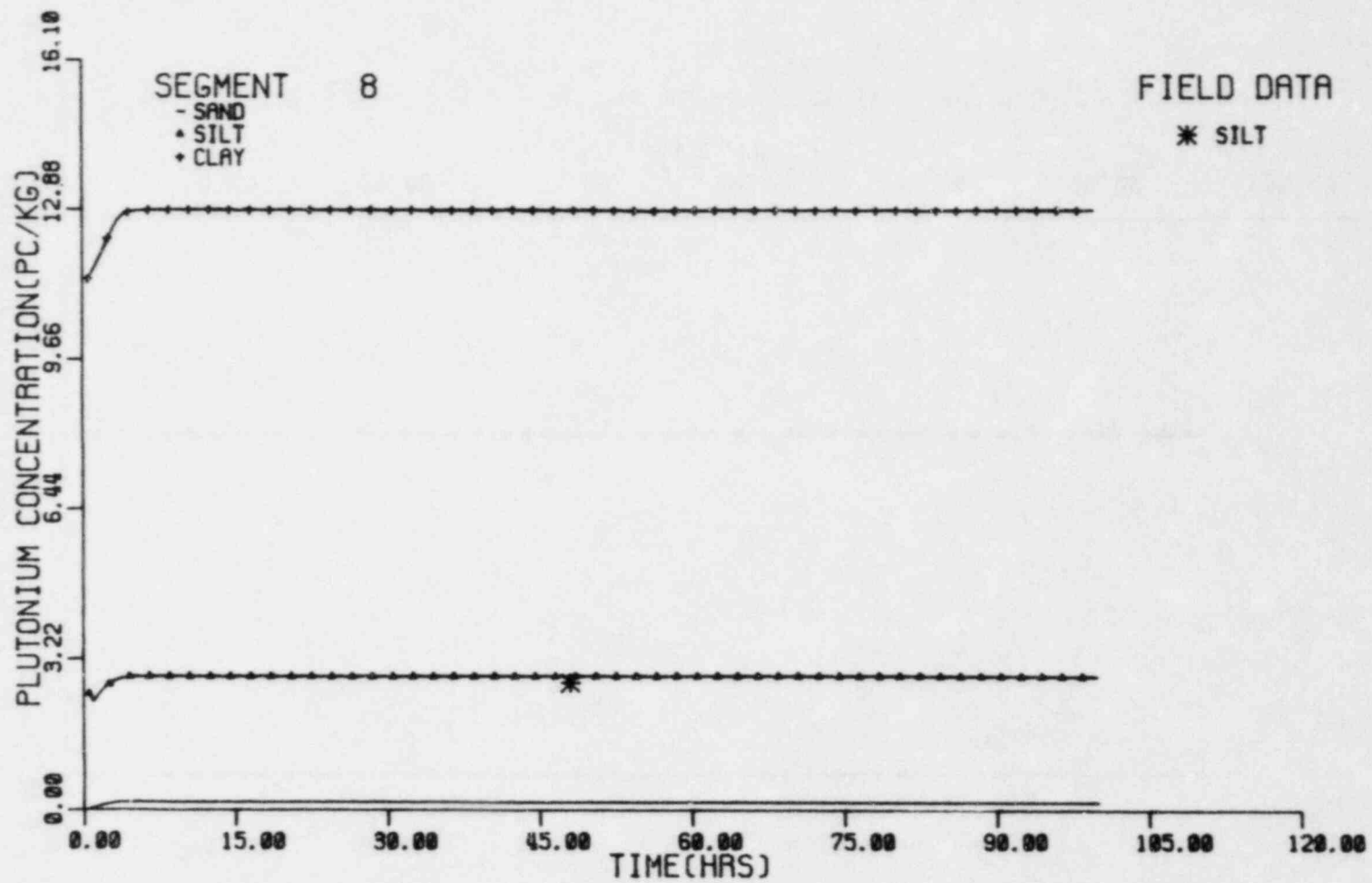


FIGURE 5.54. Phase 2 Particulate Radionuclide Concentrations:  
 $^{239,240}\text{Pu}$  at CC-3

56.5

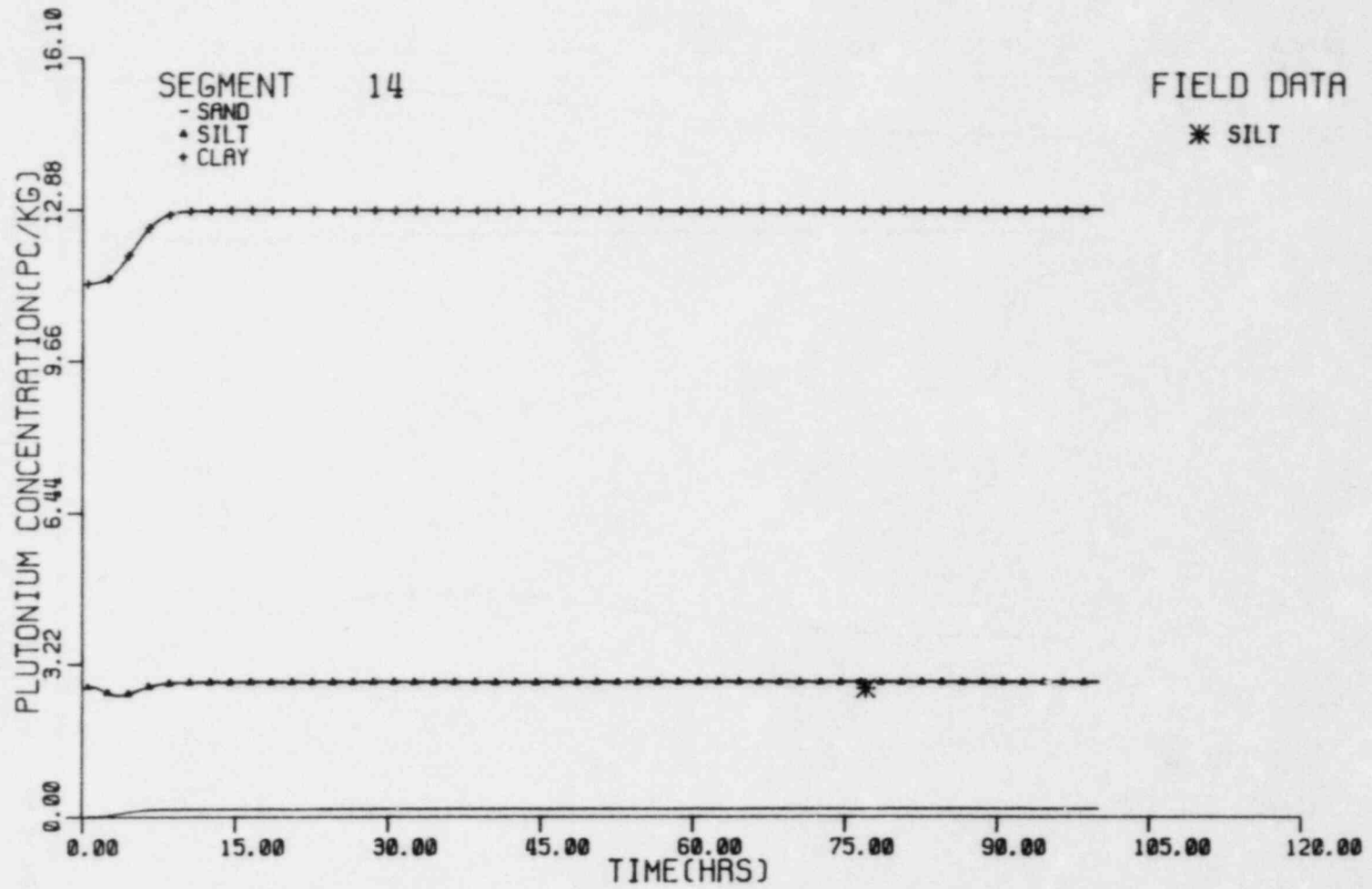


FIGURE 5.55. Phase 2 Particulate Radionuclide Concentrations:  
 $^{239,240}\text{Pu}$  at CC-5

96.9

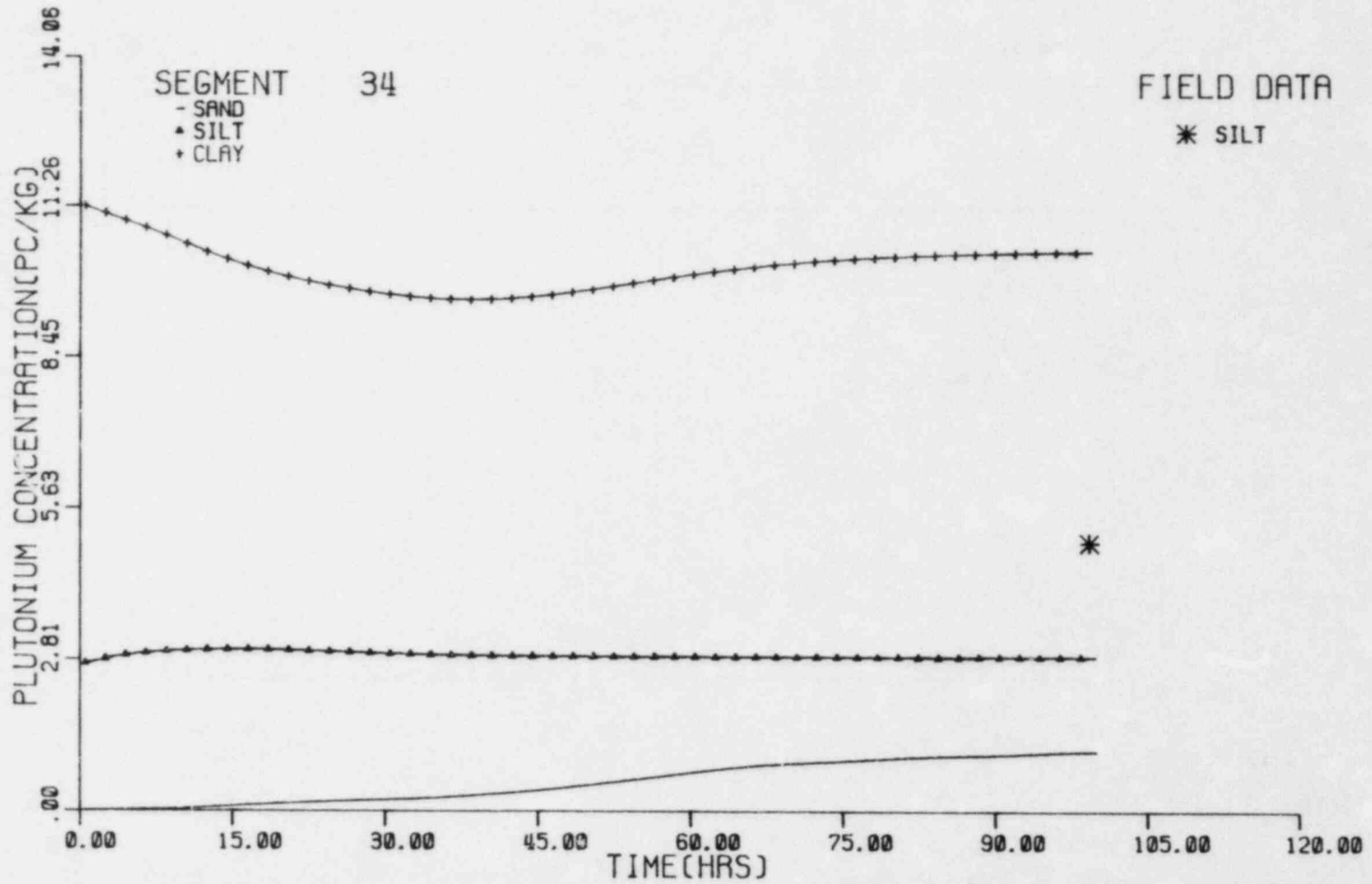


FIGURE 5.56. Phase 2 Particulate Radionuclide Concentrations:  
 $^{239,240}\text{Pu}$  at CC-11

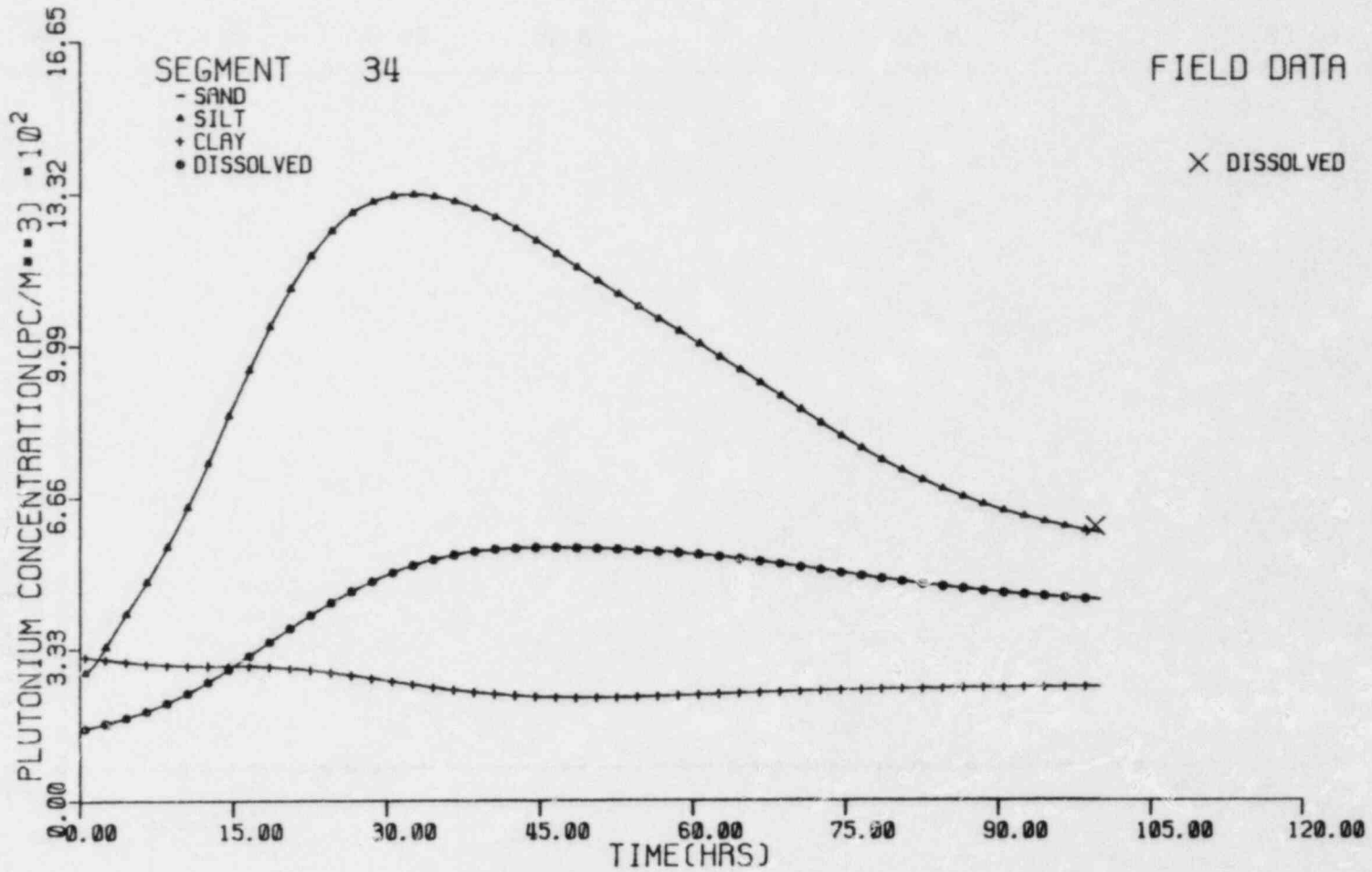


FIGURE 5.57. Phase 2 Particulate and Dissolved Radionuclide Concentrations: <sup>239,240</sup>Pu at CC-11

86.5

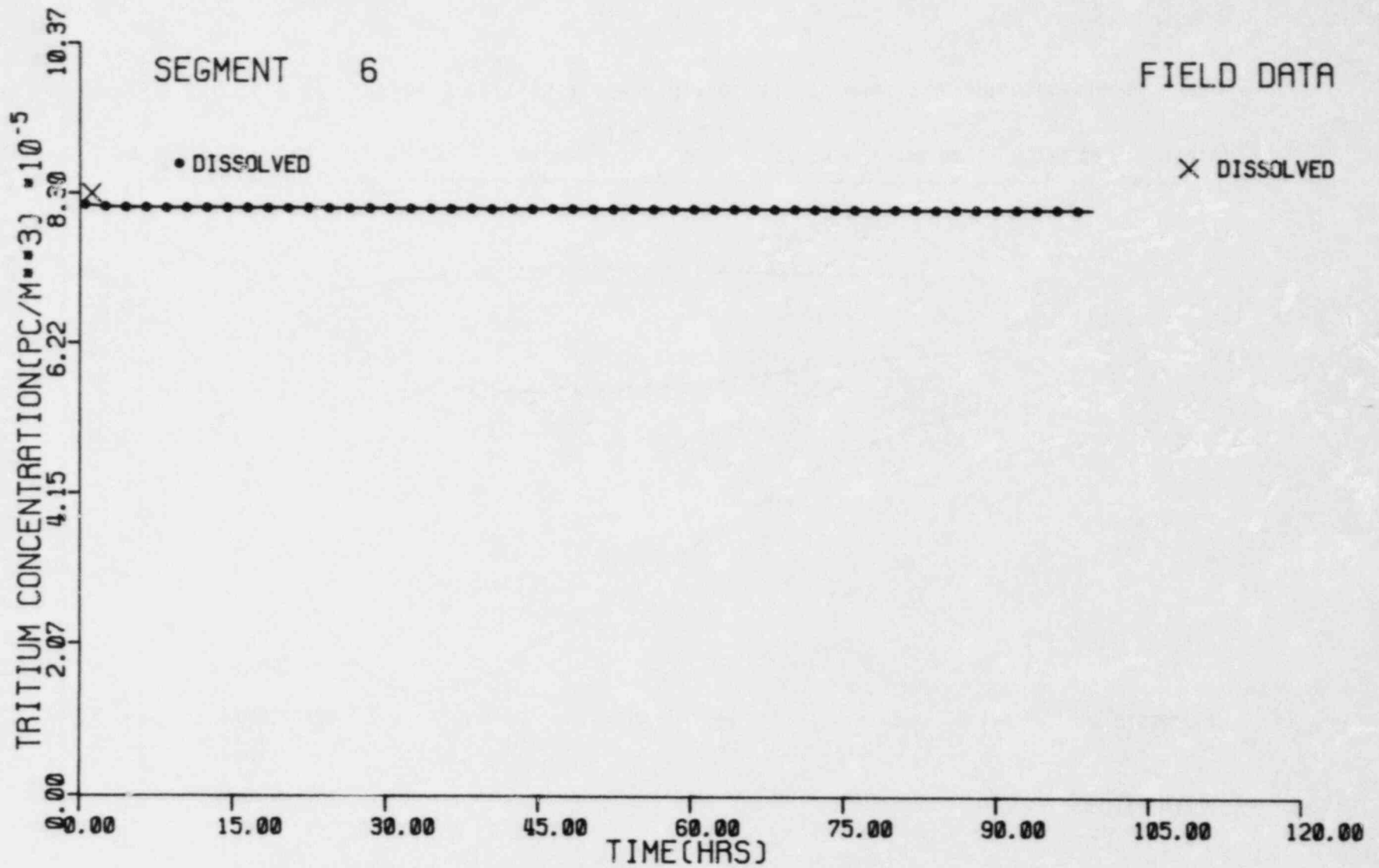


FIGURE 5.58. Phase 2 Dissolved Radionuclide Concentrations: <sup>3</sup>H at BC-4

TABLE 5.9. Phase 2 Observed and Computed Radionuclide Concentrations

Phase 2 Cs <sup>137</sup> Comparison (pC/g)		
Location	Observed	Computed
BC-4		
Sand	---	0.6
Silt	---	9.5
Clay	27.8	
Dissolved	28 pC/m <sup>3</sup>	94 pC/m <sup>3</sup>
CC-3		
Sand	---	0.4
Silt	1.46/1.17/1.72	4.9
Clay	2.84/4.29/5.0	14.3
Dissolved	1.0/2.0/4.0 pC/m <sup>3</sup>	21 pC/m <sup>3</sup>
CC-5		
Sand	---	0.4
Silt	1.17/1.09/1.20	4.8
Clay	1.90/2.10/2.36	14.1
Dissolved	3.0 pC/m <sup>3</sup>	24 pC/m <sup>3</sup>
CC-9		
Sand	---	0.4
Silt	1.85	4.2
Clay	2.74	12.2
Dissolved	---	26 pC/m <sup>3</sup>
CC-11		
Sand	---	0.3
Silt	1.41	1.4
Clay	2.51	10.2
Dissolved	---	32 pC/m <sup>3</sup>

Phase 2 <sup>90</sup> Sr Comparison (pC/g)		
Location	Observed	Computed
BC-4		
Sand	-	0.0
Silt	-	3.3
Clay	0.327	5.1
Dissolved	868 pC/m <sup>3</sup>	880 pC/m <sup>3</sup>
CC-3		
Sand	-	0.0
Silt	-	1.6
Clay	0.359	2.8
Dissolved	62 pC/m <sup>3</sup>	250 pC/m <sup>3</sup>



TABLE 5.9. (contd)

Phase 2 <sup>90</sup> Sr Comparison (pC/g) (contd)		
Location	Observed	Computed
CC-5		
Sand	-	0.0
Silt	0.192	1.5
Clay	-	2.8
Dissolved	177 pC/m <sup>3</sup>	240 pC/m <sup>3</sup>
C-11		
Sand	-	0.1
Silt	0.185	0.4
Clay	-	2.1
Dissolved	201 pC/m <sup>3</sup>	180 pC/m <sup>3</sup>
Phase 2 <sup>239,240</sup> Pu Comparison (pC/g)		
Location	Observed	Computed
BC-4		
Sand	-	0.0
Silt	0.0026	0.0057
Clay	0.003	0.0233
Dissolved	0.1 pC/m <sup>3</sup>	0.11 pC/m <sup>3</sup>
CC-3		
Sand	-	0.0002
Silt	0.0027	0.0028
Clay	-	0.0129
Dissolved	0.2 pC/m <sup>3</sup>	0.04 pC/m <sup>3</sup>
CC-5		
Sand	-	0.0002
Silt	0.0027	0.0028
Clay	-	0.0129
Dissolved	-	0.04 pC/m <sup>3</sup>
CC-11		
Sand	-	0.0011
Silt	0.005	0.0029
Clay	-	0.0104
Dissolved	0.06 pC/m <sup>3</sup>	0.04 pC/m <sup>3</sup>

TABLE 5.9. (contd)

<u>Location</u>	<u>Phase 2 <sup>3</sup>H Comparison (pC/m<sup>3</sup>)</u>	
	<u>Observed</u>	<u>Computed</u>
BC-4	830 x 10 <sup>3</sup>	810 x 10 <sup>3</sup>
CC-3	356 x 10 <sup>3</sup> /383 x 10 <sup>3</sup> /1056 x 10 <sup>3</sup>	200 x 10 <sup>3</sup>
CC-5	312 x 10 <sup>3</sup> /365 x 10 <sup>3</sup>	200 x 10 <sup>3</sup>
CC-11	298 x 10 <sup>3</sup>	190 x 10 <sup>3</sup>

Because of the high flows in this phase, large amounts of sediment were removed from the bed into the water column accompanying the sorbed radionuclides. As most of the channel bed became armored against further silt and clay erosion, the contribution of the suspended radionuclides from the contaminated bed was stopped resulting in falling sediment and radionuclide levels.

### <sup>137</sup>Cs

Because of the constant sediment and radionuclide concentrations used at the Franks Creek boundary condition, the radionuclide levels in Buttermilk Creek are generally proportional to the discharges from Franks Creek. Therefore, as in the hydrodynamic case, two trains of peak concentrations in both sorbed and dissolved forms are visible in Buttermilk Creek. <sup>137</sup>Cs sorbed clay exhibits the highest radionuclide concentrations while sorbed sand has the lowest radionuclide concentrations.

The predicted specific activity levels of particulate <sup>137</sup>Cs at BC-2 are highly dynamic with the clay-sorbed activity being consistently twice as large as those adsorbed by sand and silt. Correlation with measured particulate <sup>137</sup>Cs with silt and clay is good while the field activity with sand is five times the predicted value.

At BC-3 and BC-4, the time-dependent profiles of specific activity levels have changed little from those appearing at BC-2. However, the field values at these locations, despite being taken at times less than three hours apart, are widely divergent. At BC-3, measured <sup>137</sup>Cs adsorbed by suspended sand is the highest particulate activity. Predicted silt and clay activities are 60% of the corresponding field values. At BC-4, the sand field activity lies well below the lowest predicted values. The predicted sand and silt activity levels compare favorably with the field values, activities appearing to be 5 hr out of phase with field data.

The two sets of peaks diffuse and coalesce into two general peaks at the radionuclides are transported to Lake Erie. Dilution from Buttermilk Creek to

Cattaraugus Creek reduces total concentrations of  $^{137}\text{Cs}$  by a factor of four while sorbed activity levels are reduced very slightly. High silt-sorbed  $^{137}\text{Cs}$  concentrations in the water column near the mouth of Cattaraugus Creek are a result of silt-sorbed sediment being scoured from the bed between the mouth of the creek at Gowanda and Lake Erie.

The character of the predicted particulate activity in Buttermilk Creek is preserved in the plots at CC-3 and CC-5 (Figure 5.59). At CC-3, the sand activity field value is much higher than the magnitude of the sampled silt and clay activities. The entire range of predicted results at 80 hours of simulation is between the activity values measured at CC-3. At CC-5, the silt activity correlation between predicted and sampled values is good while the predicted value associated with clay is 40% below the field clay activity. Predicted dissolved  $^{137}\text{Cs}$  levels at the end of the simulation are four times the value in the field (Figure 5.60).

The predicted particulate activity levels at CC-9 display more gradual dynamics than the upstream sites. The silt activity predicted at 108 hours of simulation is twice as high as the field value.

At CC-11, the sudden increase and decrease of the predicted clay specific activity appears due to high activity-bearing clay being scoured from the bed followed by the onset of bed armoring. At 105 hours of simulation, predicted silt activity is fairly close to the field-sampled value while predicted clay activity is 40% of the field value.

The longitudinal distribution of  $^{137}\text{Cs}$  in the water column (Figure 5.61) shows a large dilution effect from Buttermilk Creek to Cattaraugus Creek. Radionuclides in the water column decrease steadily in concentrations as flow moves toward Lake Erie.

### $^3\text{H}$

Tritium does not interact with the sediment and is therefore influenced only by the hydrodynamics with some dispersion and radioactive decay. Since  $^3\text{H}$  concentrations at FC-1, BC-1 and CC-1 were not sampled during the Phase 1 data collection effort, a boundary condition at FC-1 was estimated to match the measured  $^3\text{H}$  concentration at BC-4. Background concentrations were taken from the Phase 3  $^3\text{H}$  field collection data.

The dynamic behavior found in Buttermilk Creek is preserved in form in Cattaraugus Creek above Springville Dam. However, concentrations are reduced by a factor of two. Downstream of Springville Dam, the tritium concentrations tend to slowly oscillate about an average value as the sharply peaked  $^3\text{H}$  concentrations are diffused into two gently curved waves. Predicted values of tritium at BC-4, CC-3 (Figures 5.62 and 5.63) and CC-11 are in excellent agreement with the field values. The longitudinal distribution of  $^3\text{H}$  at hour 120 is shown in Figure 5.64.

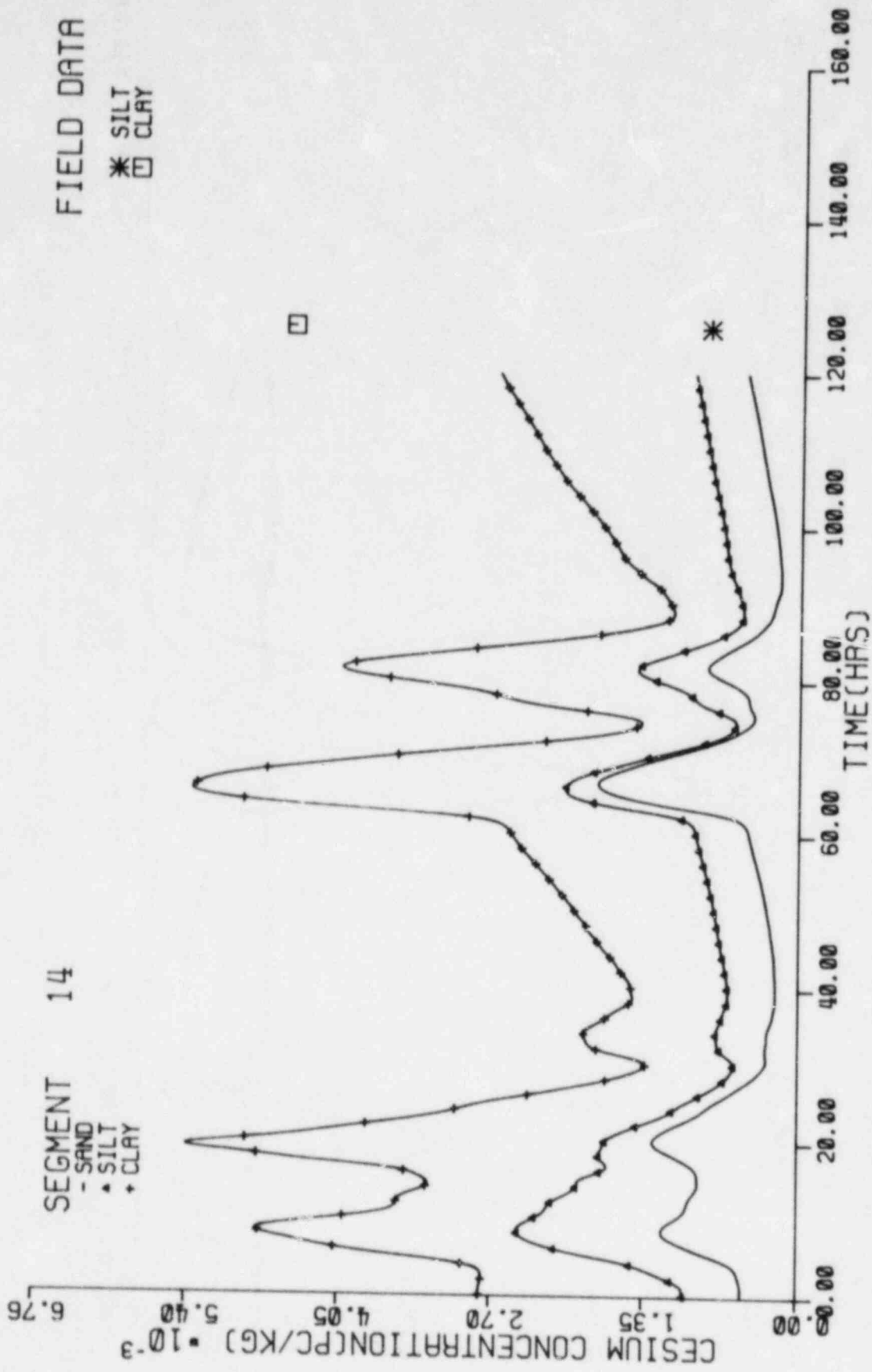


FIGURE 5.59. Phase I Particulate Radionuclide Concentrations:  $^{137}\text{Cs}$  at CC-5

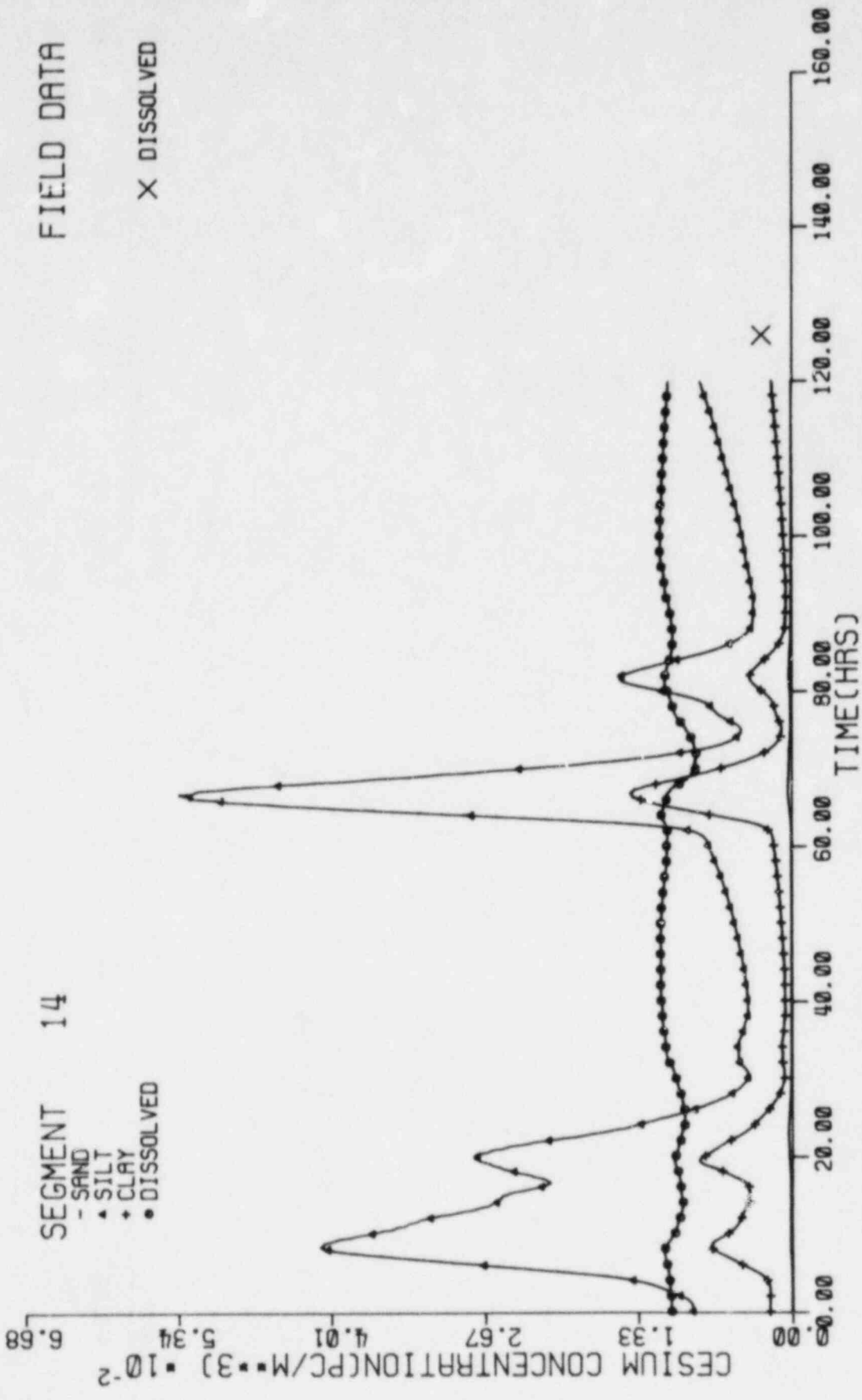
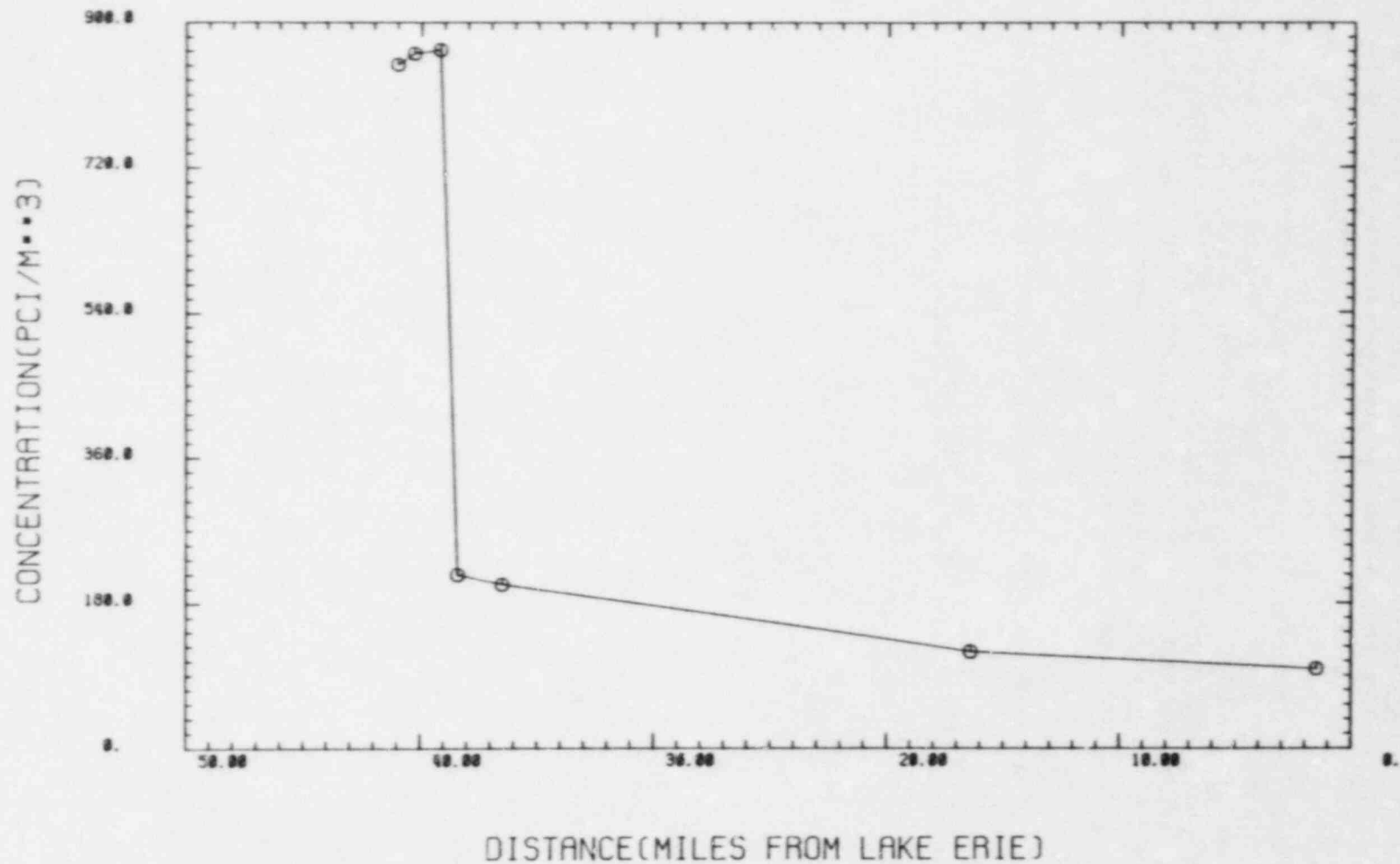


FIGURE 5.60. Phase I Particulate and Dissolved Radionuclide Concentrations: <sup>137</sup>Cs at CC-5

5.105



TIME= 10:11:12 DATE= 18-AUG-82

FIGURE 5.61. Phase 1 Longitudinal Distribution of  $^{137}\text{Cs}$  Total Concentration at Hour 120

A summary of the observed and predicted Phase 1 radionuclide concentrations is found in Table 5.10. Additional plots of predicted radionuclide concentrations with field verification points appears in Appendix A.

The study revealed that SERATRA simulated general patters of radionuclide transport mechanisms fairly well and that most of predicted values with good measured data are within 100% of the observed value. Again, considering that SERATRA does not have adjustable parameters for radionuclide transport calibration, that the Cattaraugus/Buttermilk Creek system is very complex, and that some of the field data were not adequate for its accuracy or quantity, SERATRA performed well for its radionuclide transport simulation.

TABLE 5.10. Phase 1 Observed and Computed Radionuclide Concentrations

Location	Phase 1 <sup>137</sup> Cs Comparison (pC/g)	
	Observed	Computed
BC-2		
Sand	7.64/14.50	1.7
Silt	0.841/1.50	1.5
Clay	3.10/1.65	3.9
Dissolved	---	14 pC/m <sup>3</sup>
BC-3		
Sand	13.6	1.8
Silt	2.55/3.26	1.6
Clay	7.80/7.37	4.1
Dissolved	---	15 pC/m <sup>3</sup>
BC-4		
Sand	0.316	1.9
Silt	2.67/2.41	1.6
Clay	6.55/4.48	4.1
Dissolved	---	21 pC/m <sup>3</sup>
CC-3		
Sand	9.02	0.8
Silt	0.422/0.385/0.326	1.4
Clay	0.198/0.253	4.0
Dissolved	---	116 pC/m <sup>3</sup>
CC-5		
Sand	---	0.5
Silt	0.887/0.740	0.9
Clay	5.46/3.53	2.7
Dissolved	26.0 pC/m <sup>3</sup>	106 pC/m <sup>3</sup>

--- = below detection.

TABLE 5.10. (contd)

Phase 1 <sup>137</sup> Cs Comparison (pC/g)		
<u>Location</u>	<u>Observed</u>	<u>Computed</u>
CC-9		
Sand	---	0.2
Silt	0.290	0.6
Clay	---	1.5
Dissolved	---	80 pC/m <sup>3</sup>
CC-11		
Sand	---	0.4
Silt	0.454/0.571	0.8
Clay	5.50	2.2
Dissolved	---	63 pC/m <sup>3</sup>

Phase 1 <sup>3</sup> H Comparison (pC/g)		
<u>Location</u>	<u>Observed</u>	<u>Computed</u>
BC-4	461 x 10 <sup>3</sup>	460 x 10 <sup>10</sup>
CC-3	305 x 10 <sup>3</sup>	290 x 10 <sup>3</sup>
CC-11	206 x 10 <sup>3</sup>	210 x 10 <sup>3</sup>



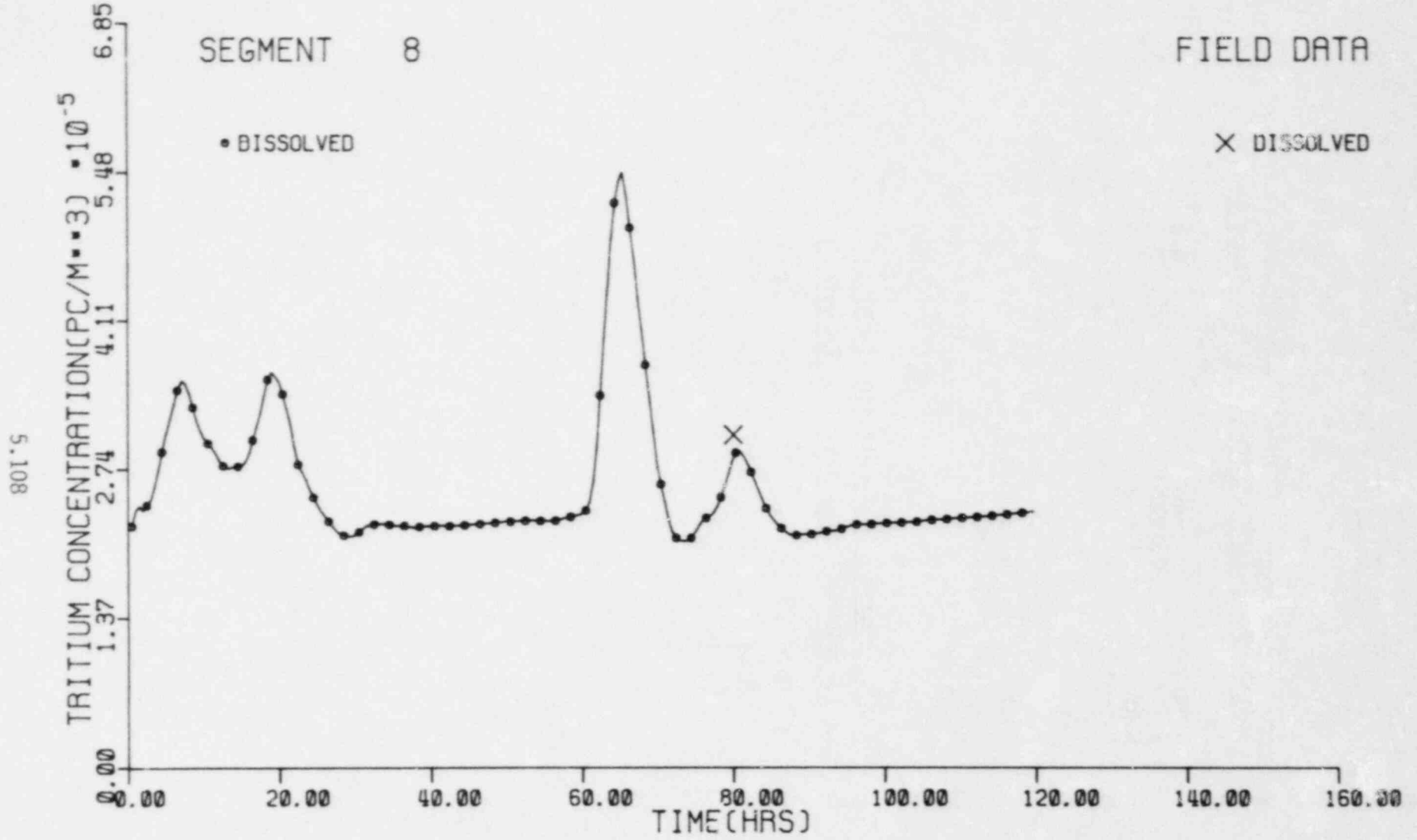


FIGURE 5.62 Phase 1 Dissolved Radionuclide Concentration: <sup>3</sup>H at CC-3

601.5

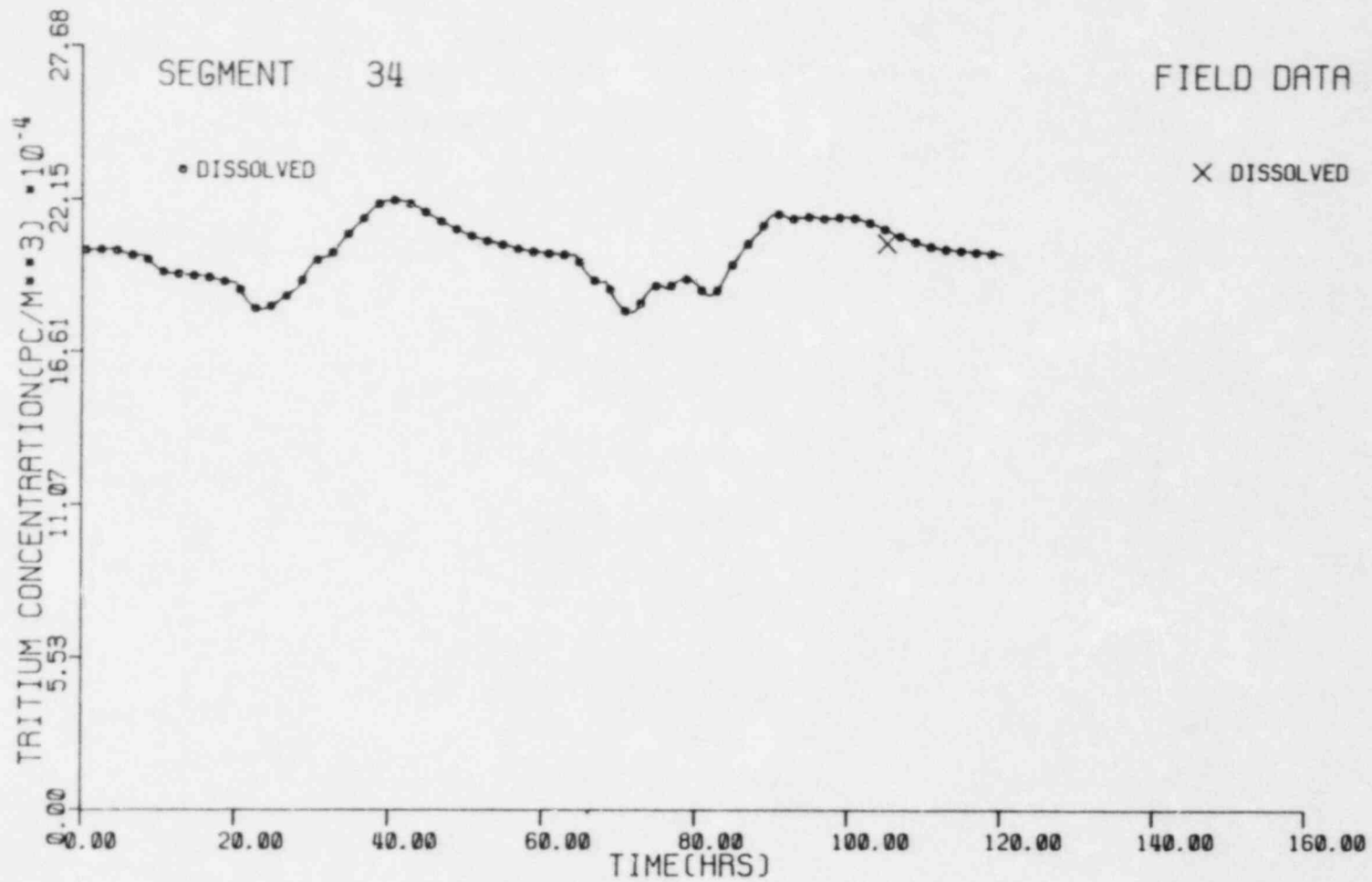
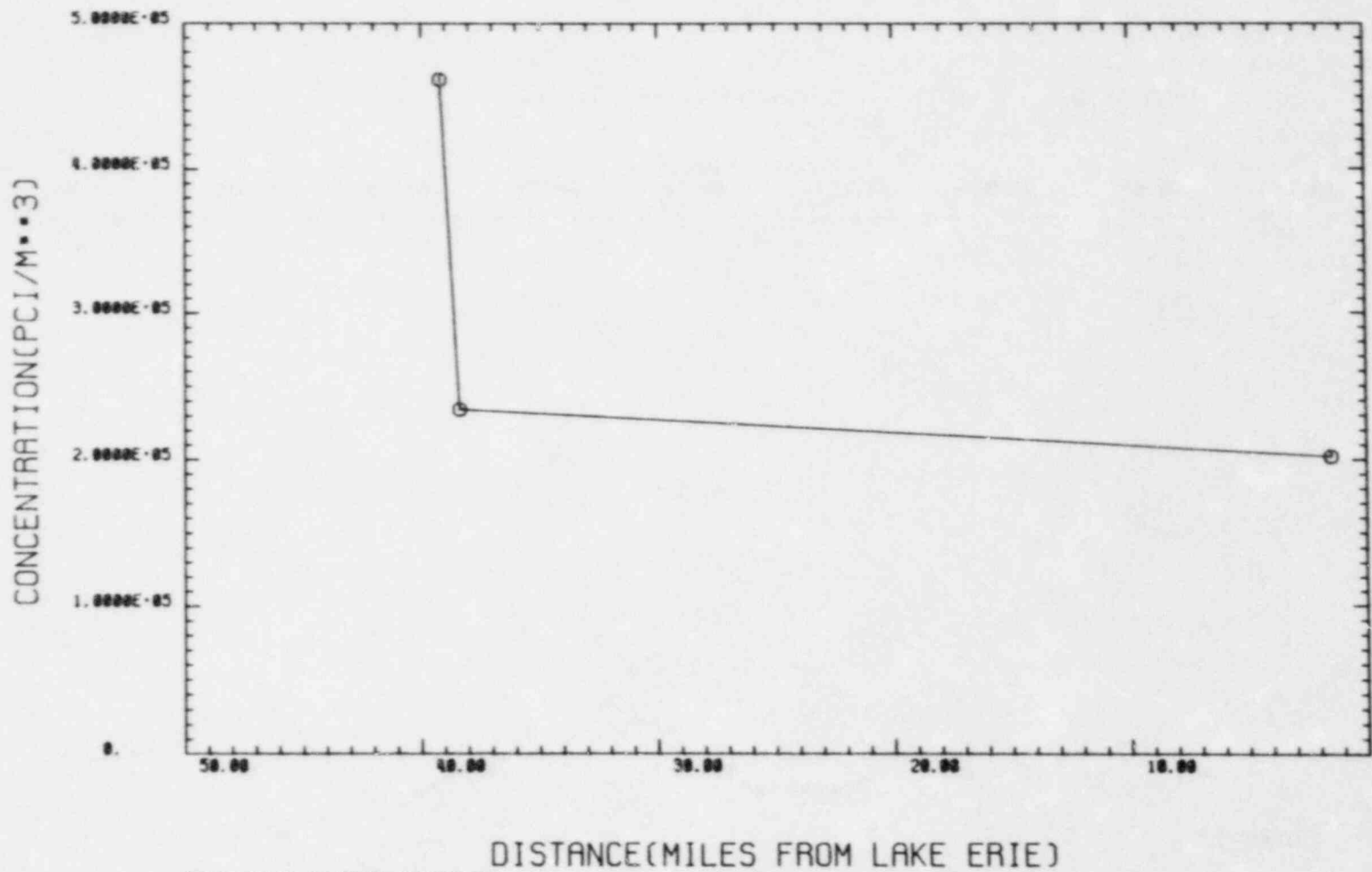


FIGURE 5.63. Phase 1 Dissolved Radionuclide Concentration: <sup>3</sup>H at CC-11

5.110



TIME\* 14\*14\*42 DATE\* 18-AUG-82

FIGURE 5.64. Phase 1 Longitudinal Distribution of  $^3\text{H}$  Total Concentration at Hour 120

## 6.0 HYPOTHETICAL TEST CASES

After SERATRA was tested in the Cattaraugus Creek system as discussed in Chapter 5, SERATRA was then applied to the same site for two hypothetical cases. These cases of instantaneous radionuclide releases were conducted to illustrate how SERATRA can be used as a site assessment tool.

### Case 1. Instantaneous Release of X Dissolved Radionuclide

An instantaneous release of X (highly sorptive but short-lived) radionuclide to Buttermilk Creek at the confluence of Franks Creek was simulated as an example. The assumed conditions for this case are shown in Table 6.1.

TABLE 6.1. Assumed Conditions for Case 1

Half Life	=	6 hrs
Release Amount	=	333 pCi
$K_d$ for Sand	=	2000 ml/g
$K_d$ for Silt	=	10000 ml/g
$K_d$ for Clay	=	20000 ml/g

Computed results at BC-2 and the mouth of Buttermilk (BC-4) Creek for this case are presented in Figures 6.1 through 6.4. The instantaneous release dispersed longitudinally to form a bell-shaped wave with a 10-hour duration. The three particulate radionuclide waves are each slightly out of phase, with the smaller diameter particles arriving before the heavier sediment. Clay is the most efficient in concentrating radionuclide on particle surfaces while the sand particles are the least efficient.

### Case 2. Instantaneous Release of Y Dissolved Radionuclide

The second hypothetical case was instantaneous release of Y (less sorptive but long lived) dissolved radionuclide at FC-1. The conditions used for this case are shown in Table 6.2.

At BC-2 and BC-4 in Buttermilk Creek, predicted results are shown in Figures 6.5 through 6.8. Comparison of Cases 1 and 2 reveals that sorbed Y radionuclide concentrations are 100 times higher than those of Case 1 and that the total Y radionuclides (sum of dissolved and sorbed radionuclide concentrations) after 10 hr are approximately twice as much as those of Case 1. These are reflections of half-lives and distribution coefficients selected for Cases 1 and 2. These two hypothetical cases demonstrate the usefulness of SERATRA as a site assessment tool.

TABLE 6.2. Assumed Conditions for  $^{129}\text{I}$  (Case 2)

Half Life		$1.7 \times 10^7$ years
Release Amounts	=	333 pCi
$K_d$ for Sand	=	20 ml/g
$K_d$ for Silt	=	100 ml/g
$K_d$ for Clay	=	200 ml/g

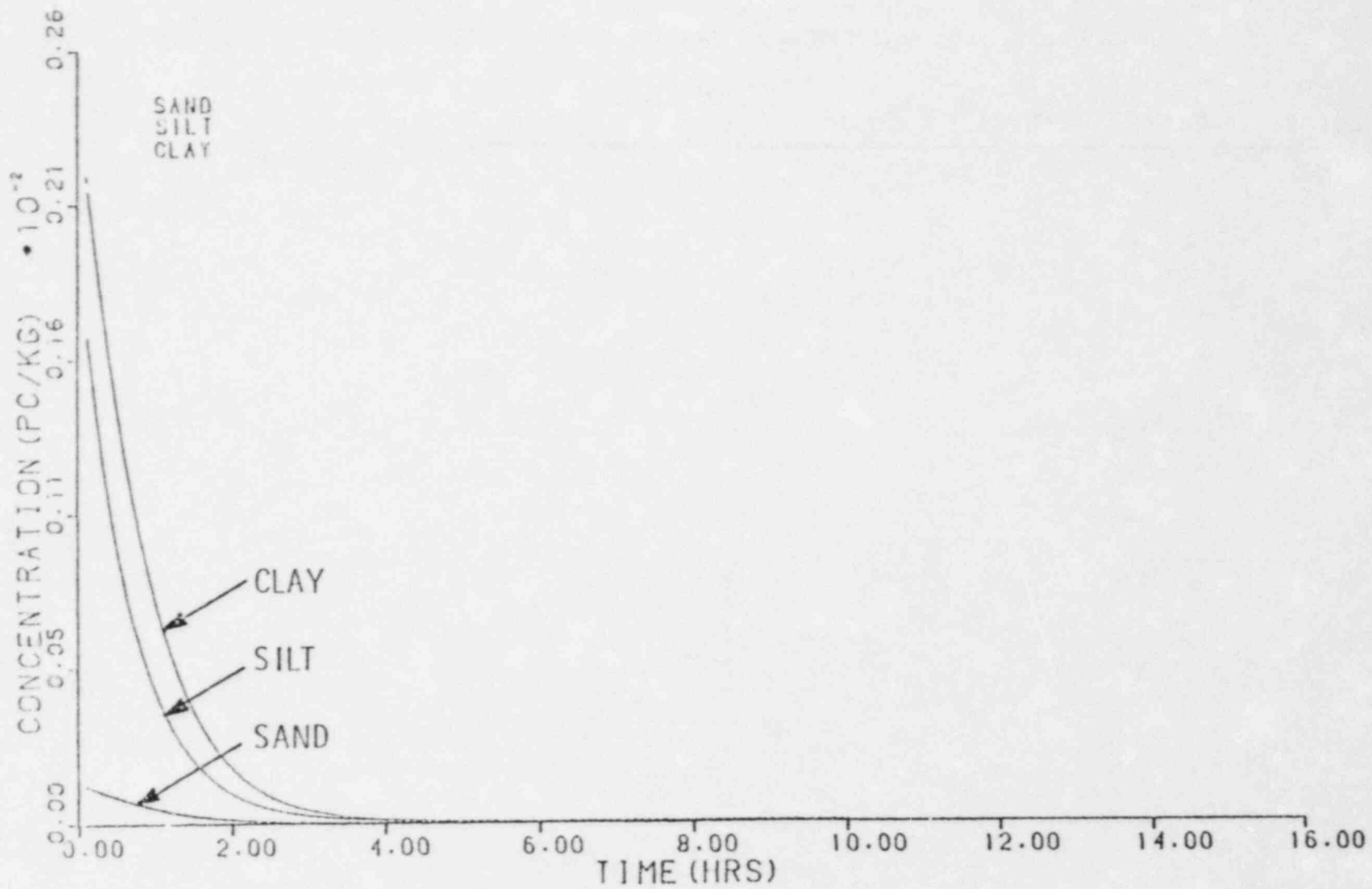


FIGURE 6.1. Computed Sorbed X Radionuclide Concentrations at Buttermilk Creek RM 2.26 for Case 1

6.4

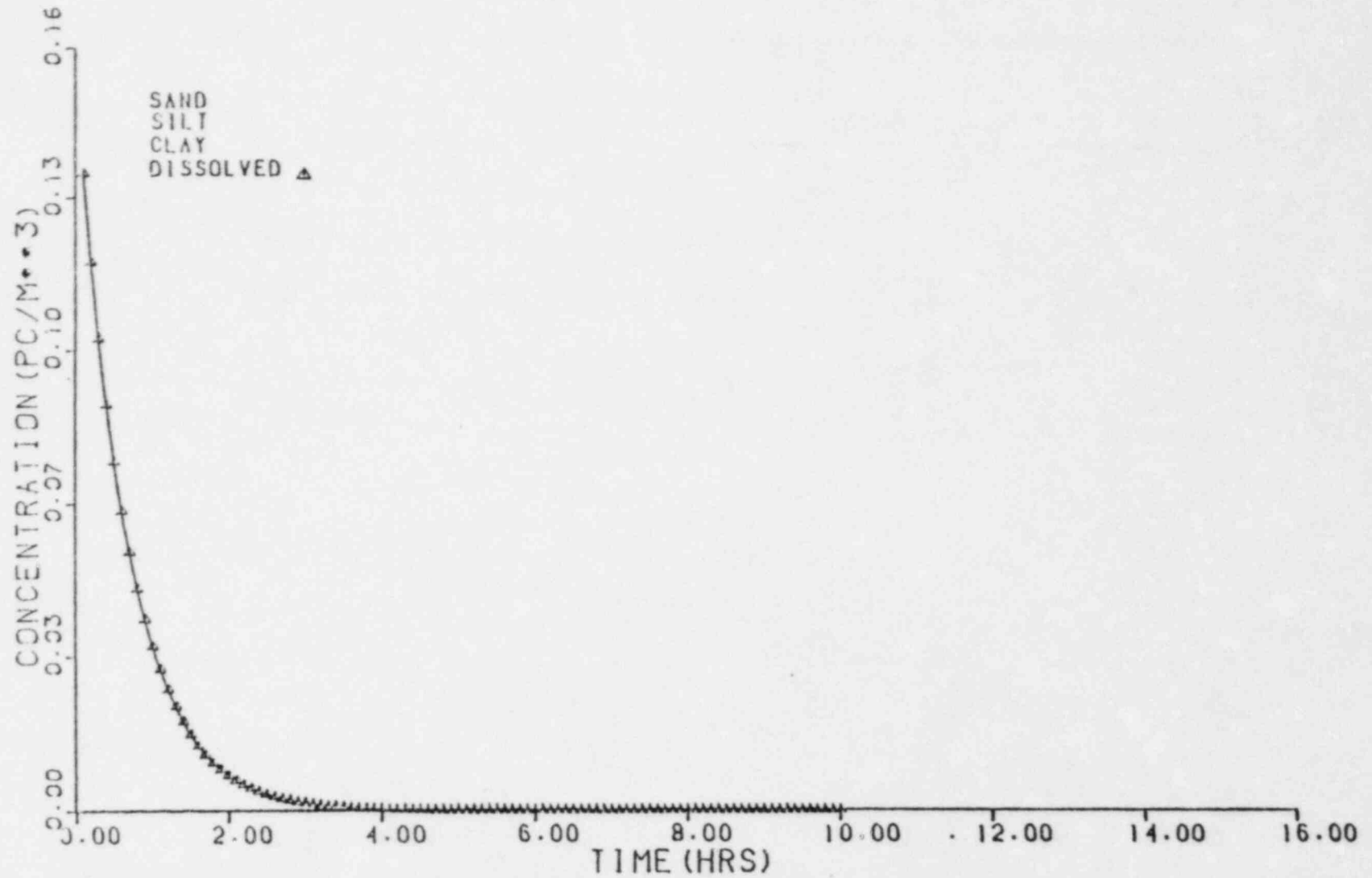


FIGURE 6.2. Computed Sorbed and Dissolved X Radionuclide Concentrations at Buttermilk Creek RM 2.26 for Case 1

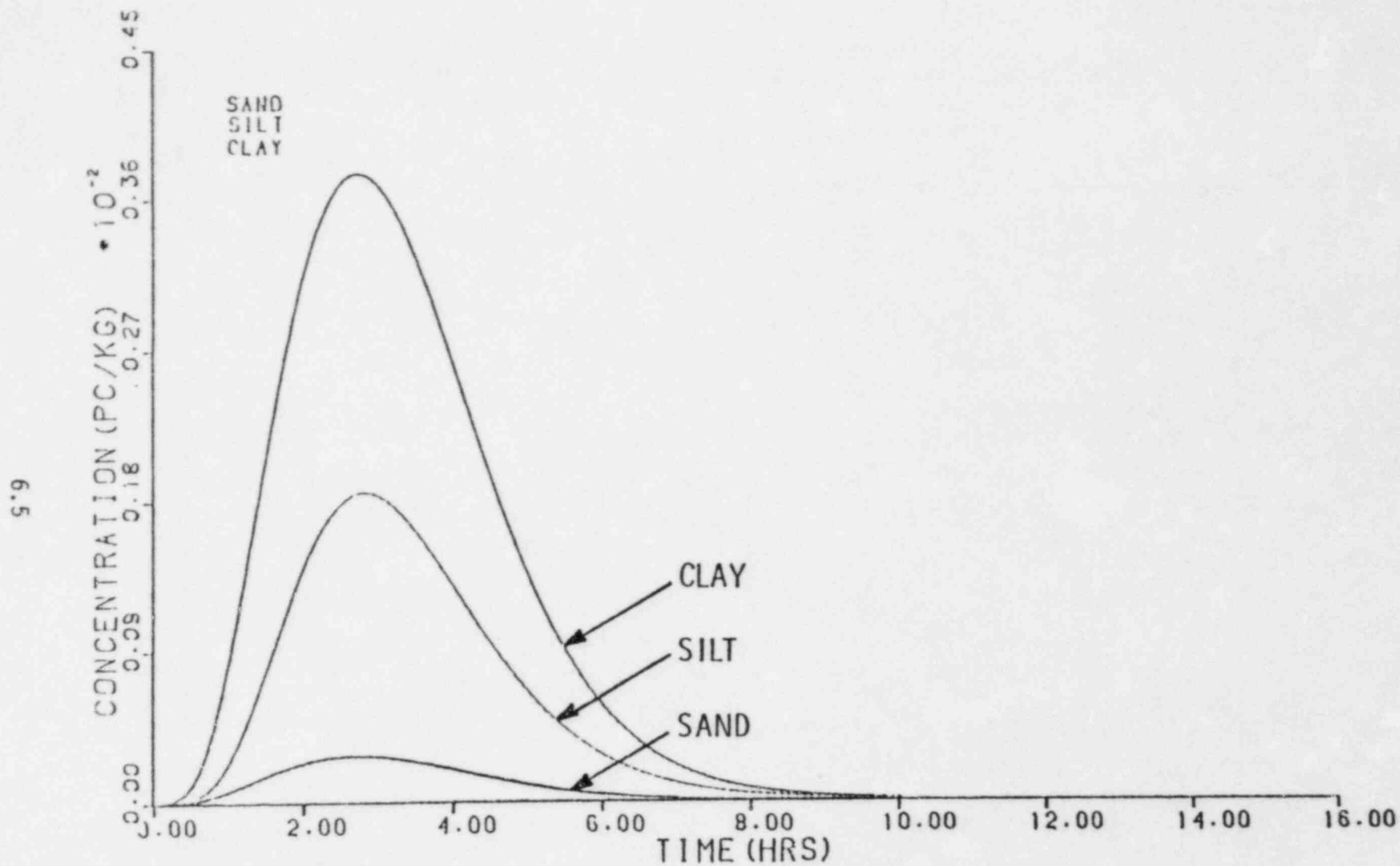


FIGURE 6.3. Computed Sorbed X Radionuclide Concentrations at the Mouth of Buttermilk Creek (BC-4) for Case 1



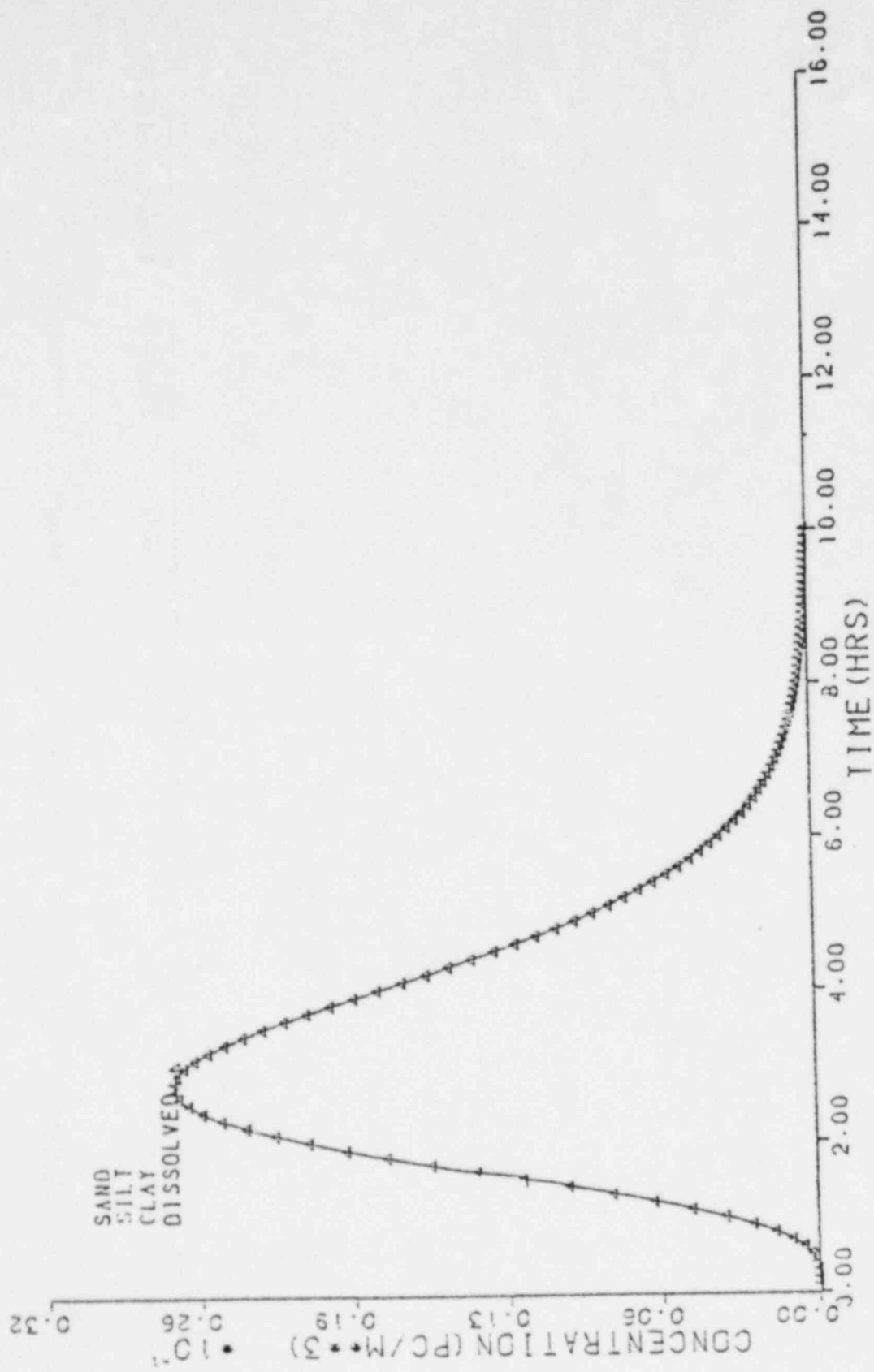


FIGURE 6.4. Computed Sorbed and Dissolved X Radionuclide Concentrations at the Mouth of Buttermilk Creek (BC-4) for Case 1

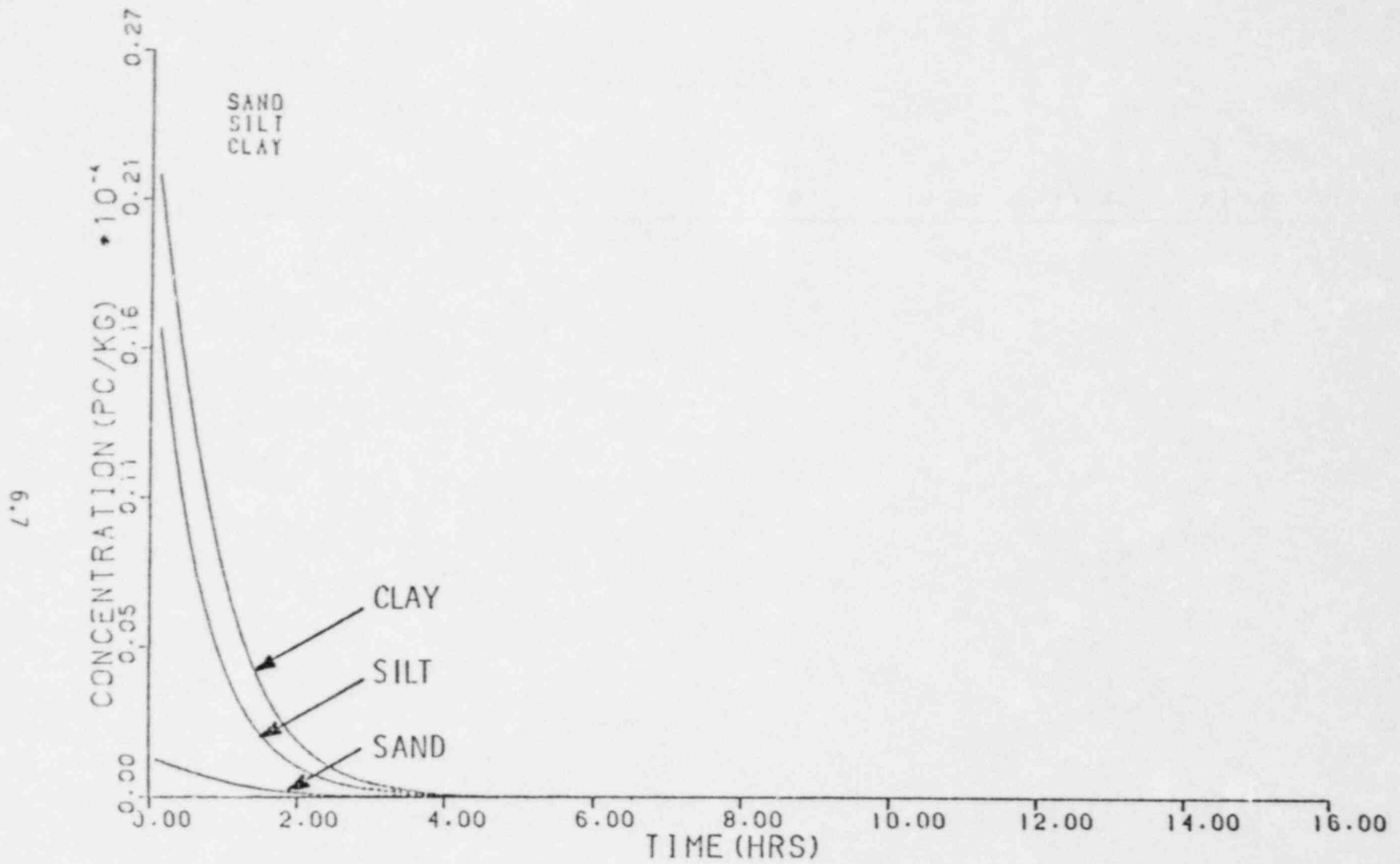


FIGURE 6.5. Computed Sorbed Y Radionuclide Concentrations at Buttermilk Creek RM 2.26 for Case 2

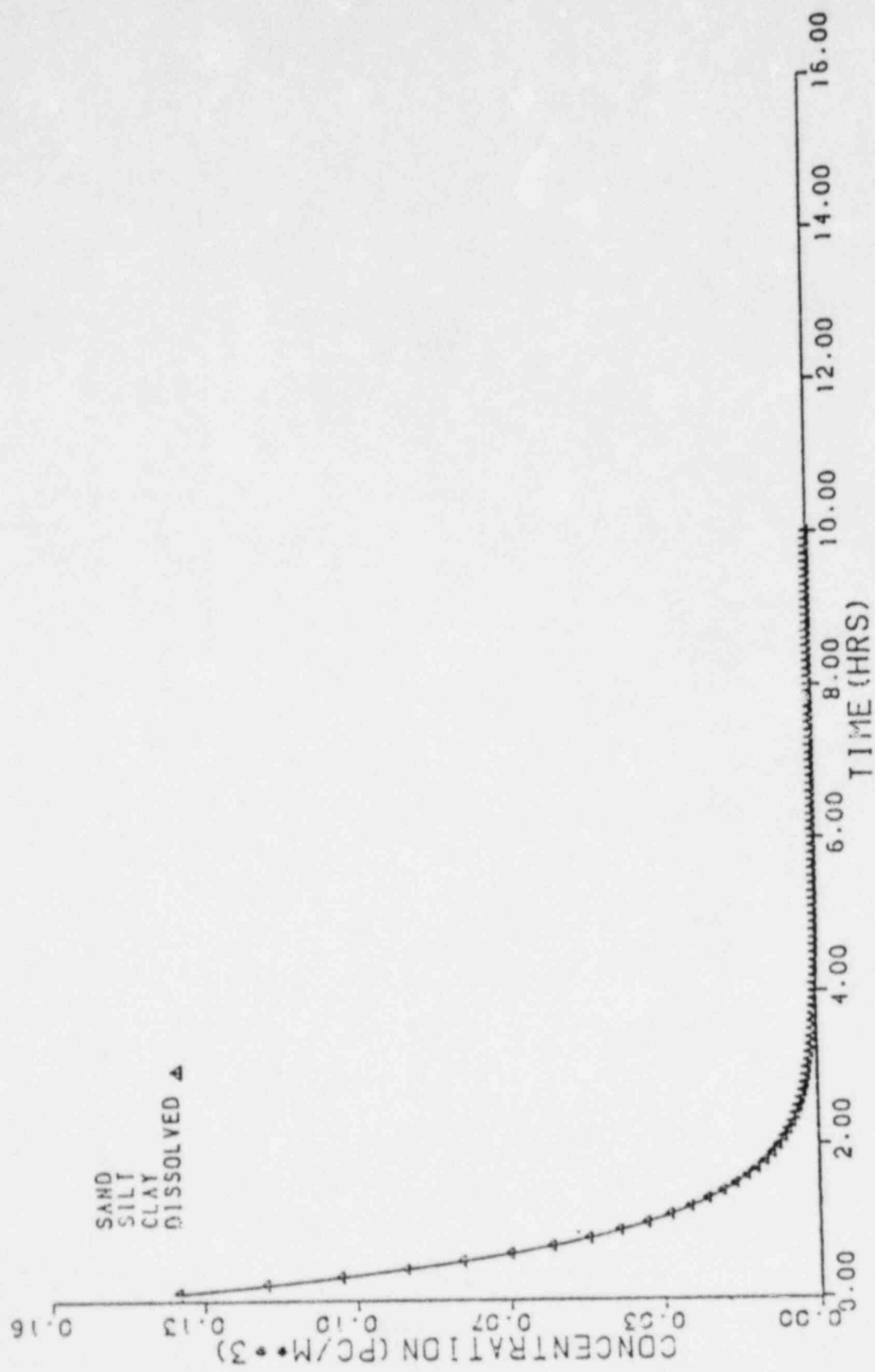


FIGURE 6.6. Computed Sorbed and Dissolved Y Radionuclide Concentrations at Buttermilk Creek RM 2.26 for Case 2

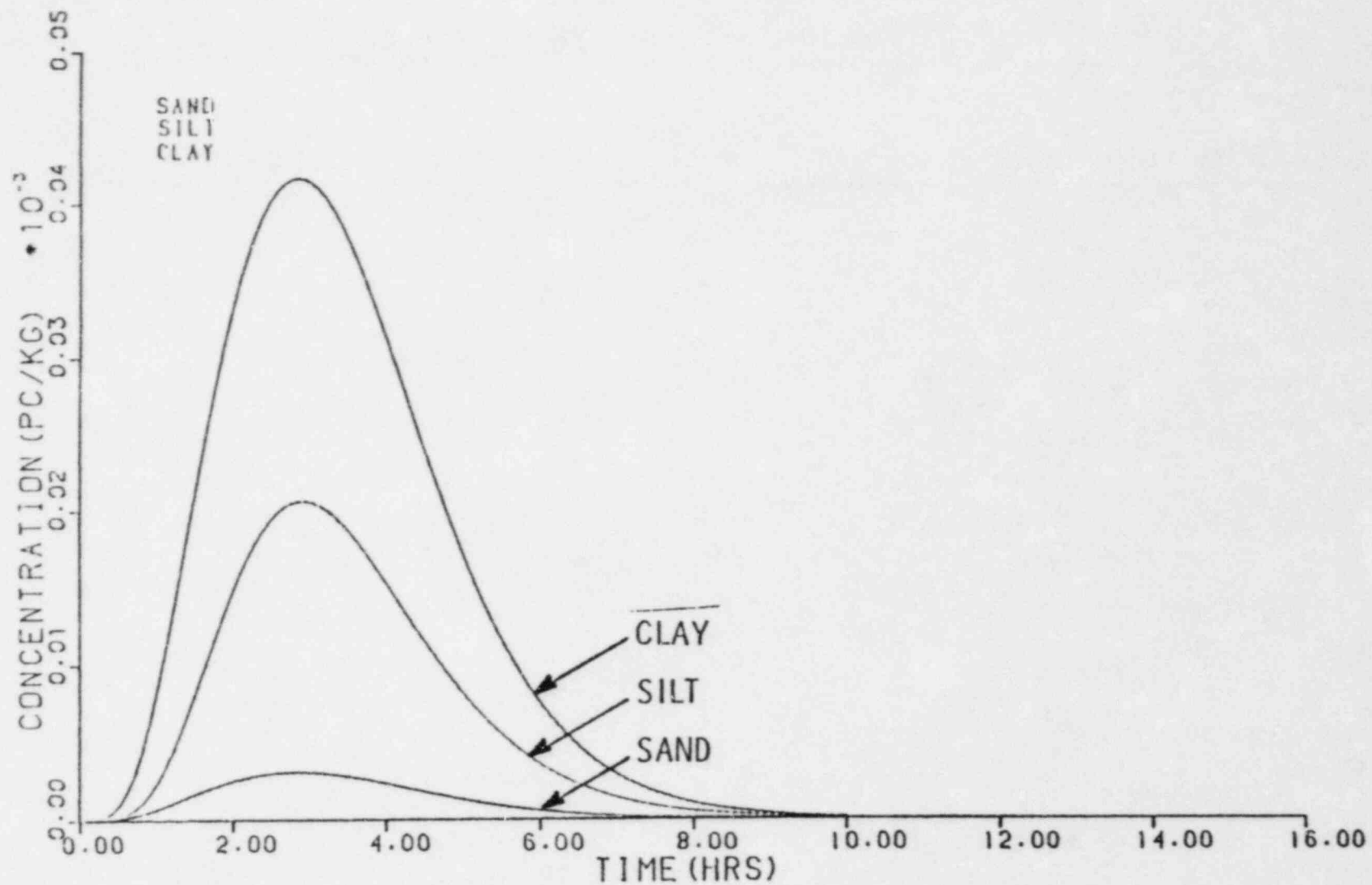


FIGURE 6.7. Computed Sorbed Y Radionuclide Concentrations at the Mouth of Buttermilk Creek (BC-4) for Case 2

6.10

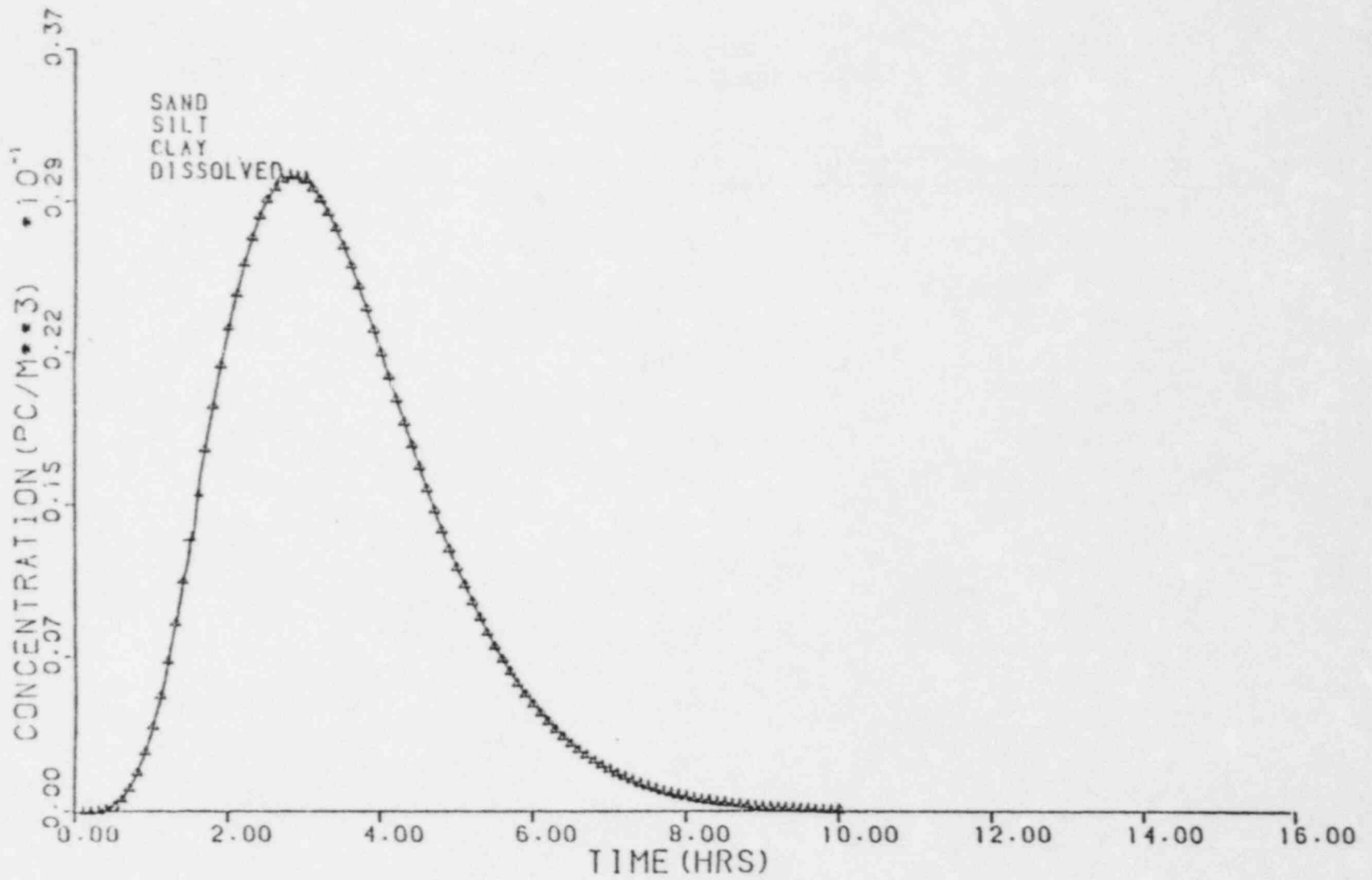


FIGURE 6.8. Computed Sorbed and Dissolved Y Radionuclide Concentration at the Mouth of Buttermilk Creek (BC-4) for Case 2

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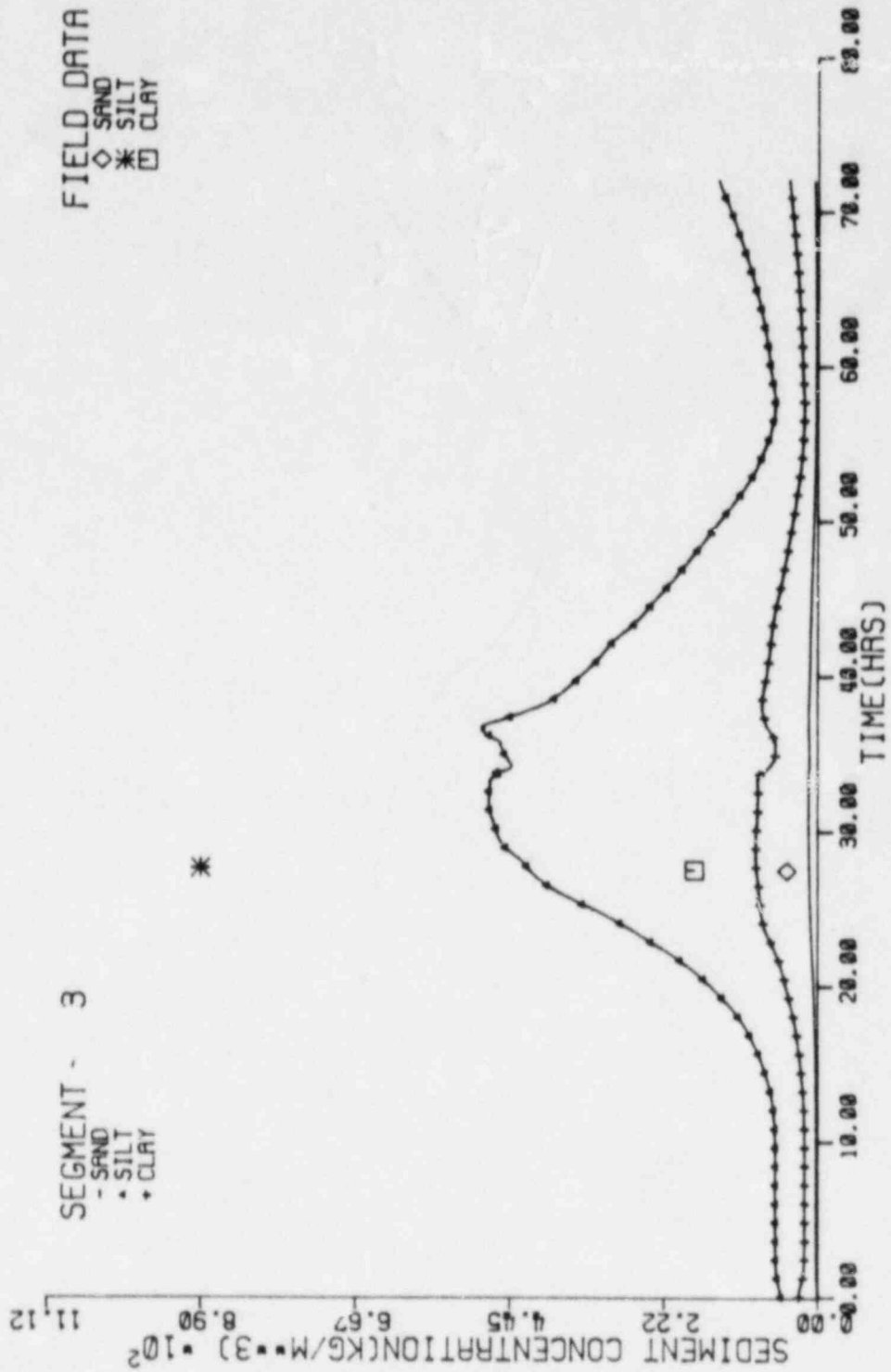
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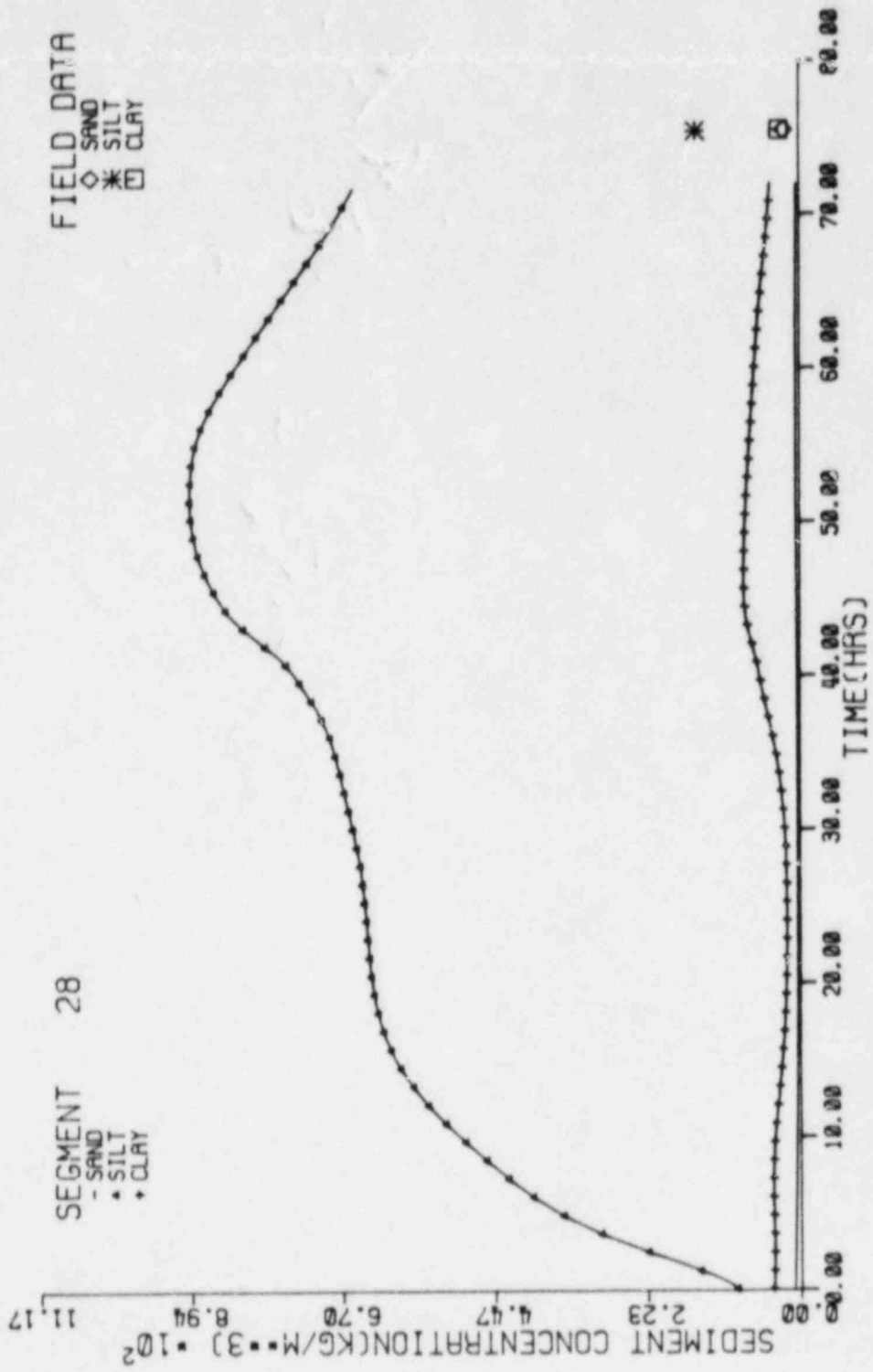
APPENDIX A

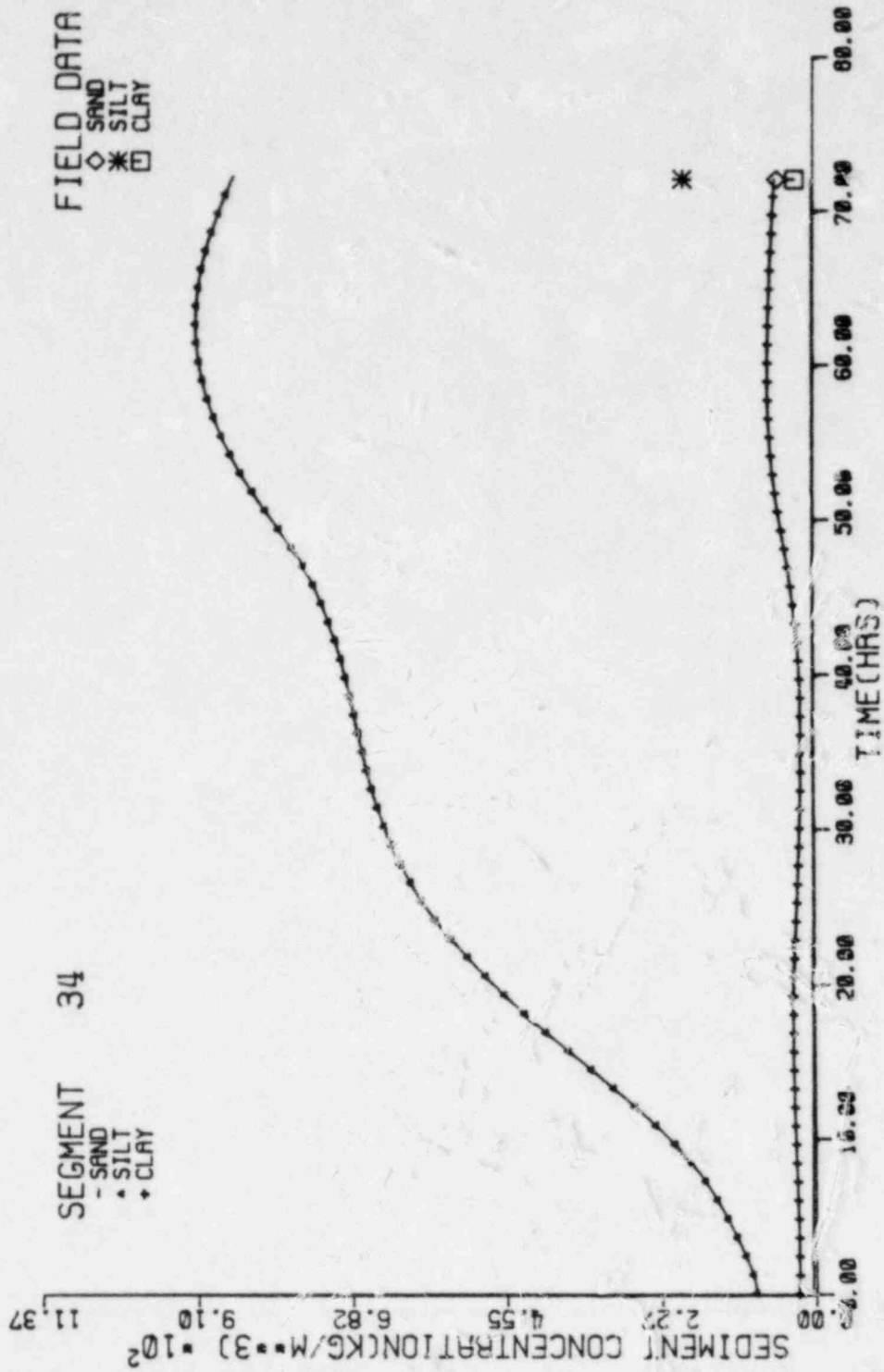
COMPARISONS OF COMPUTED AND MEASURED CONCENTRATIONS  
OF SEDIMENT AND RADIONUCLIDES



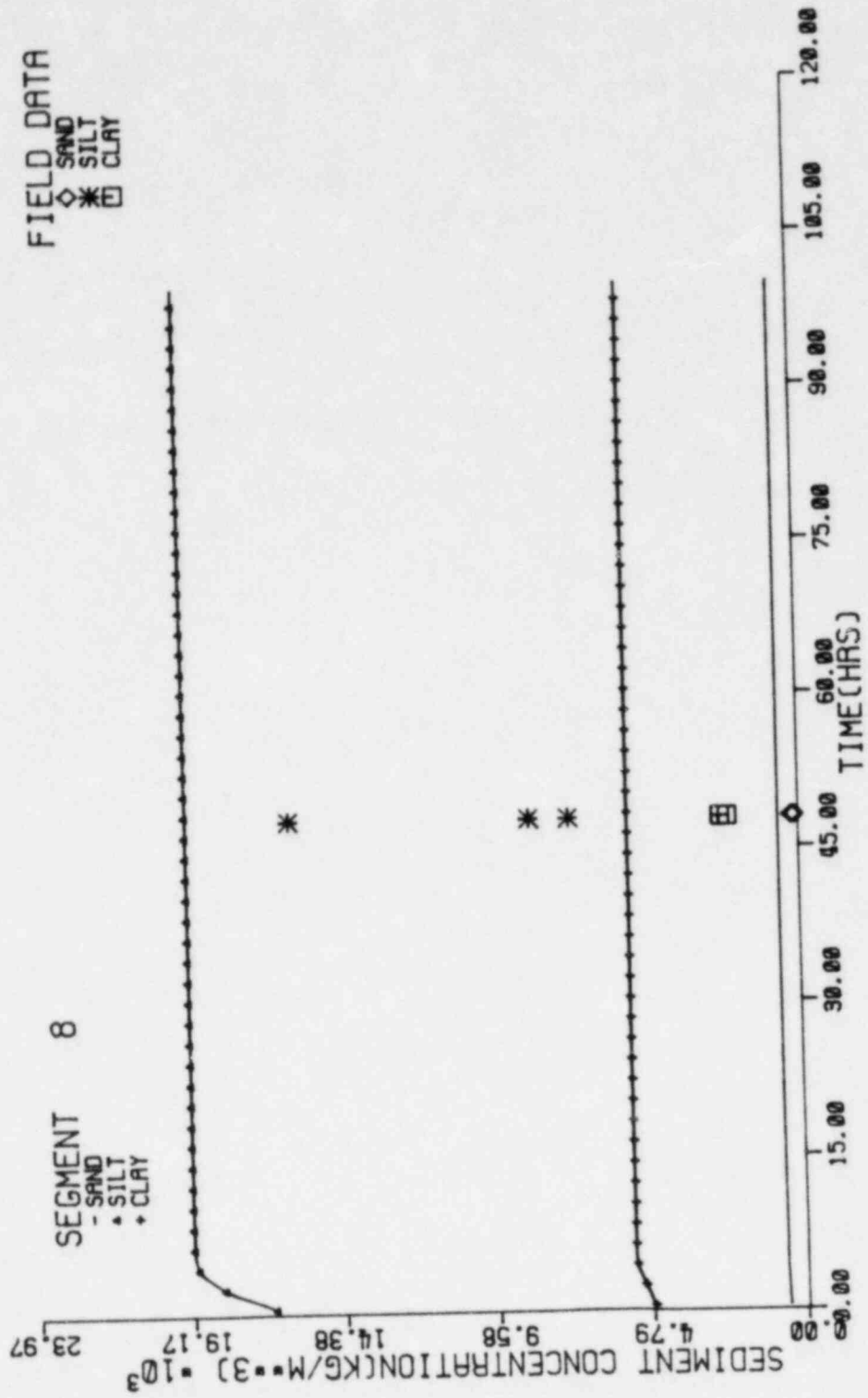
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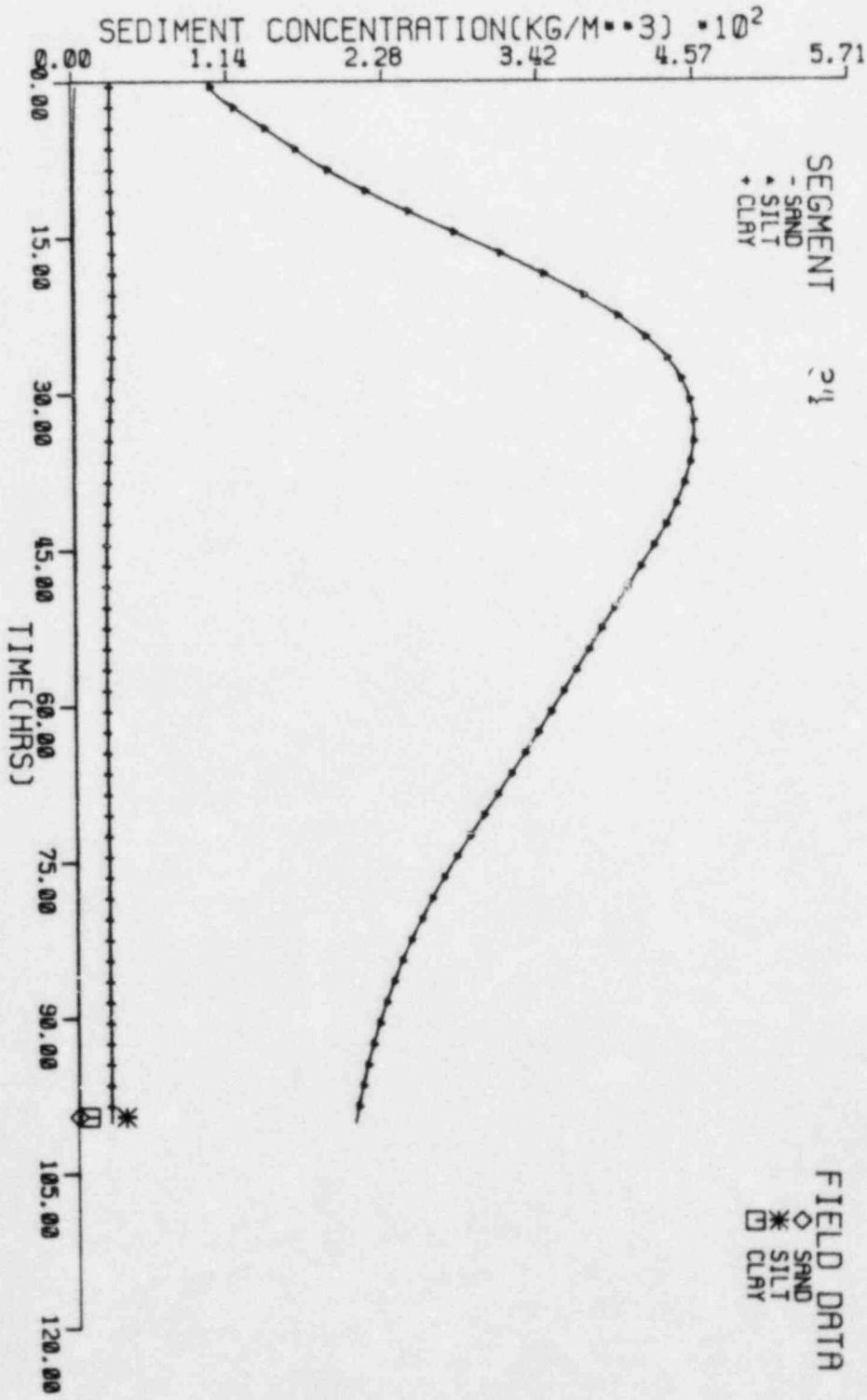






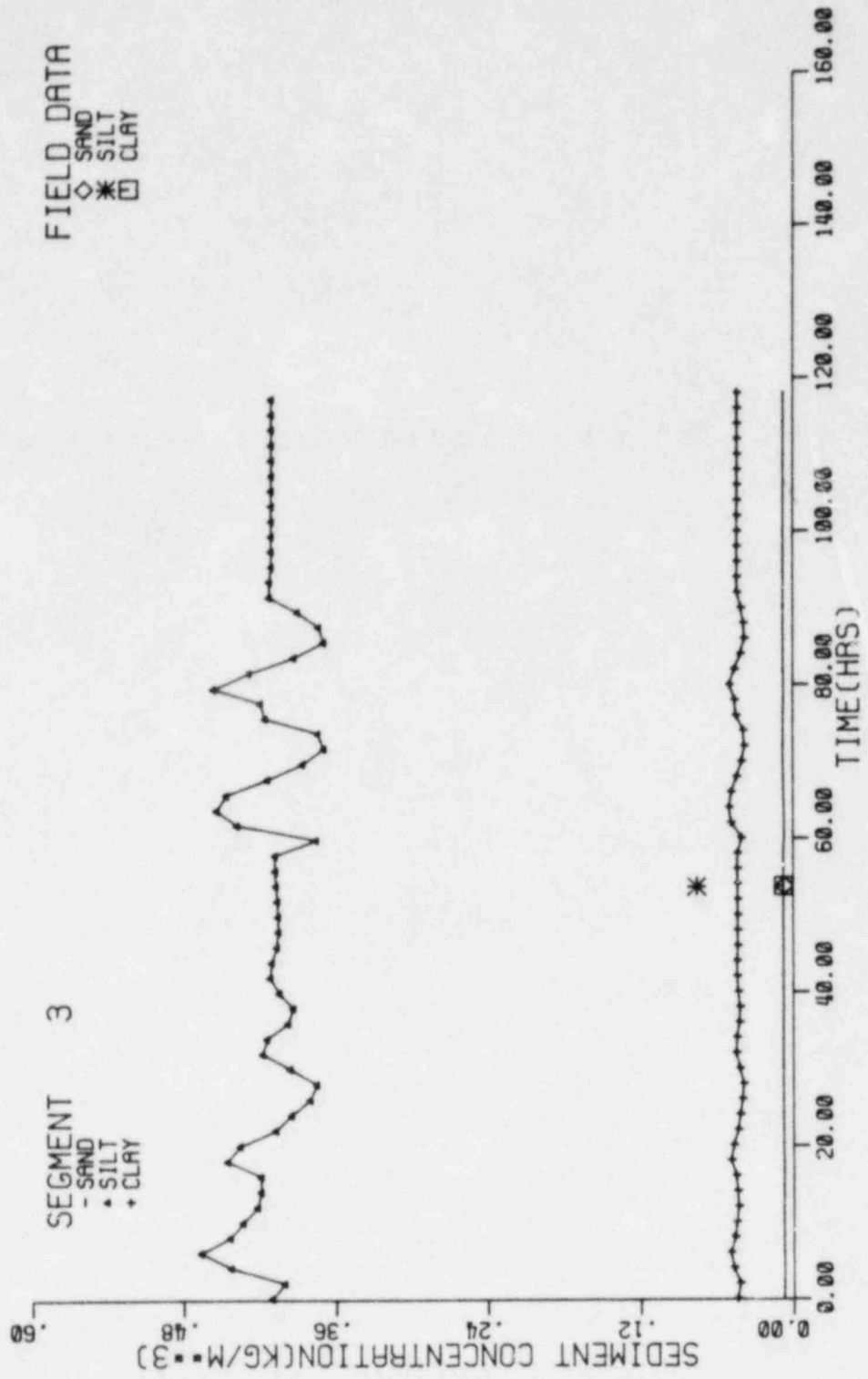
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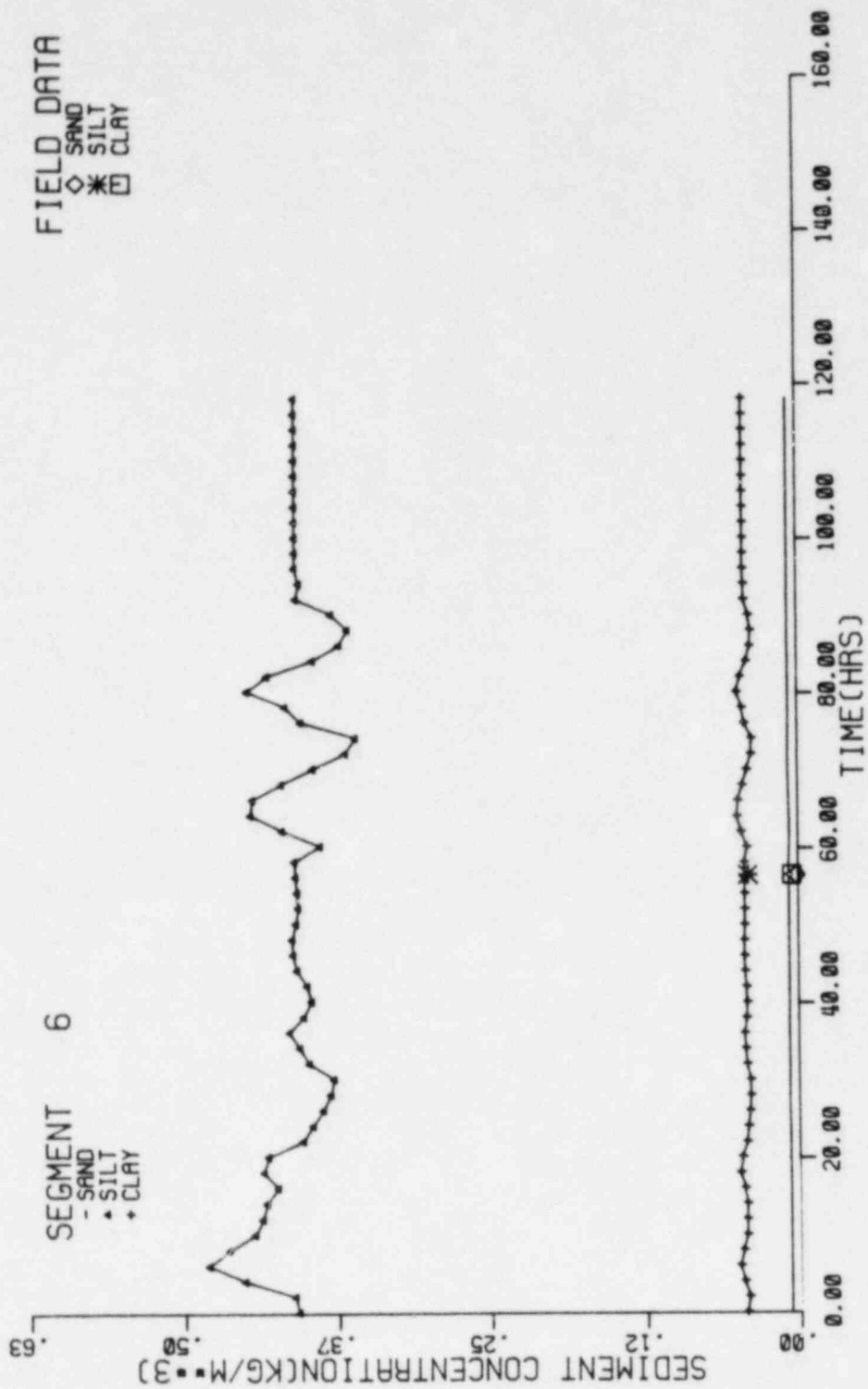


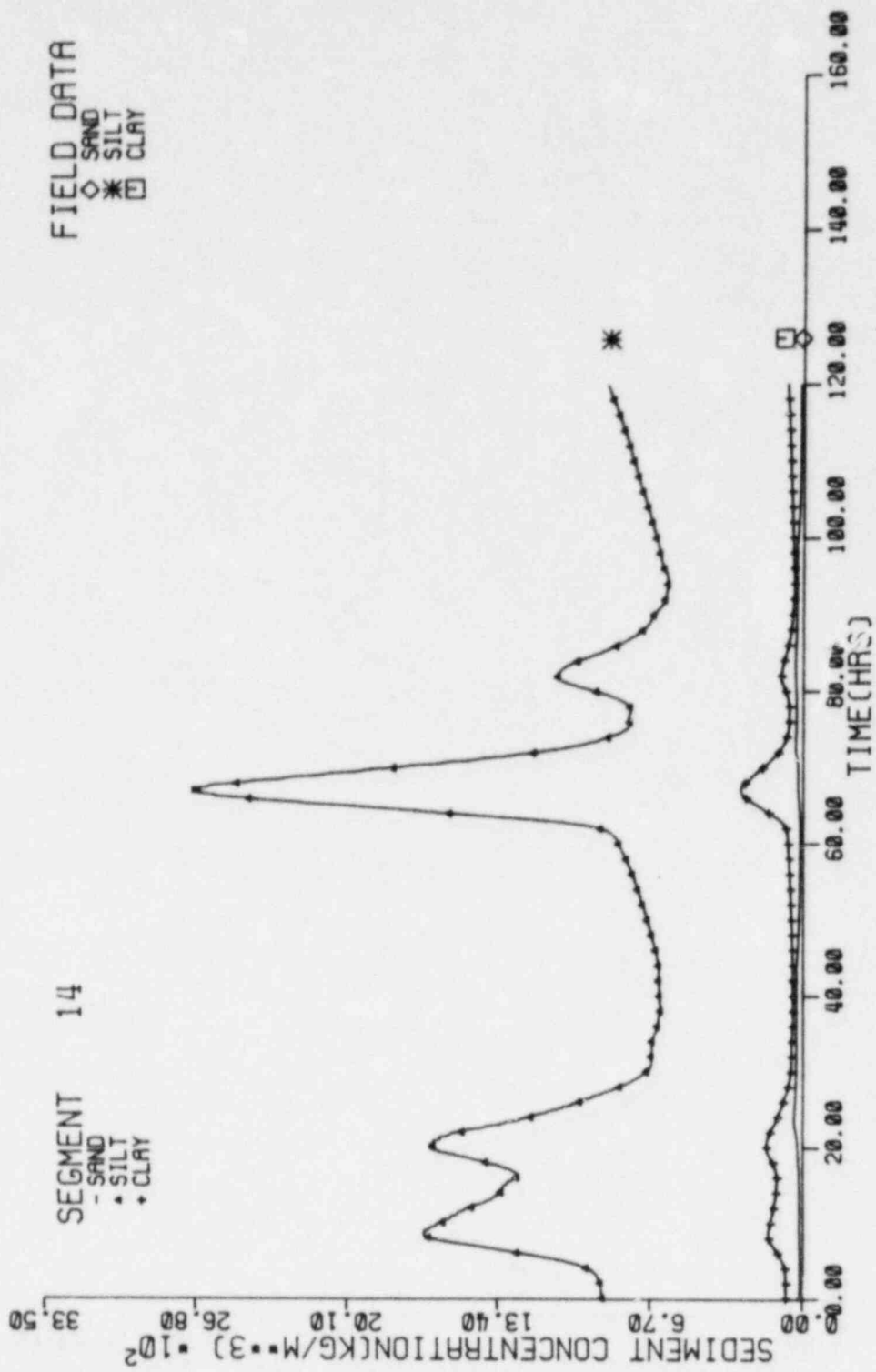


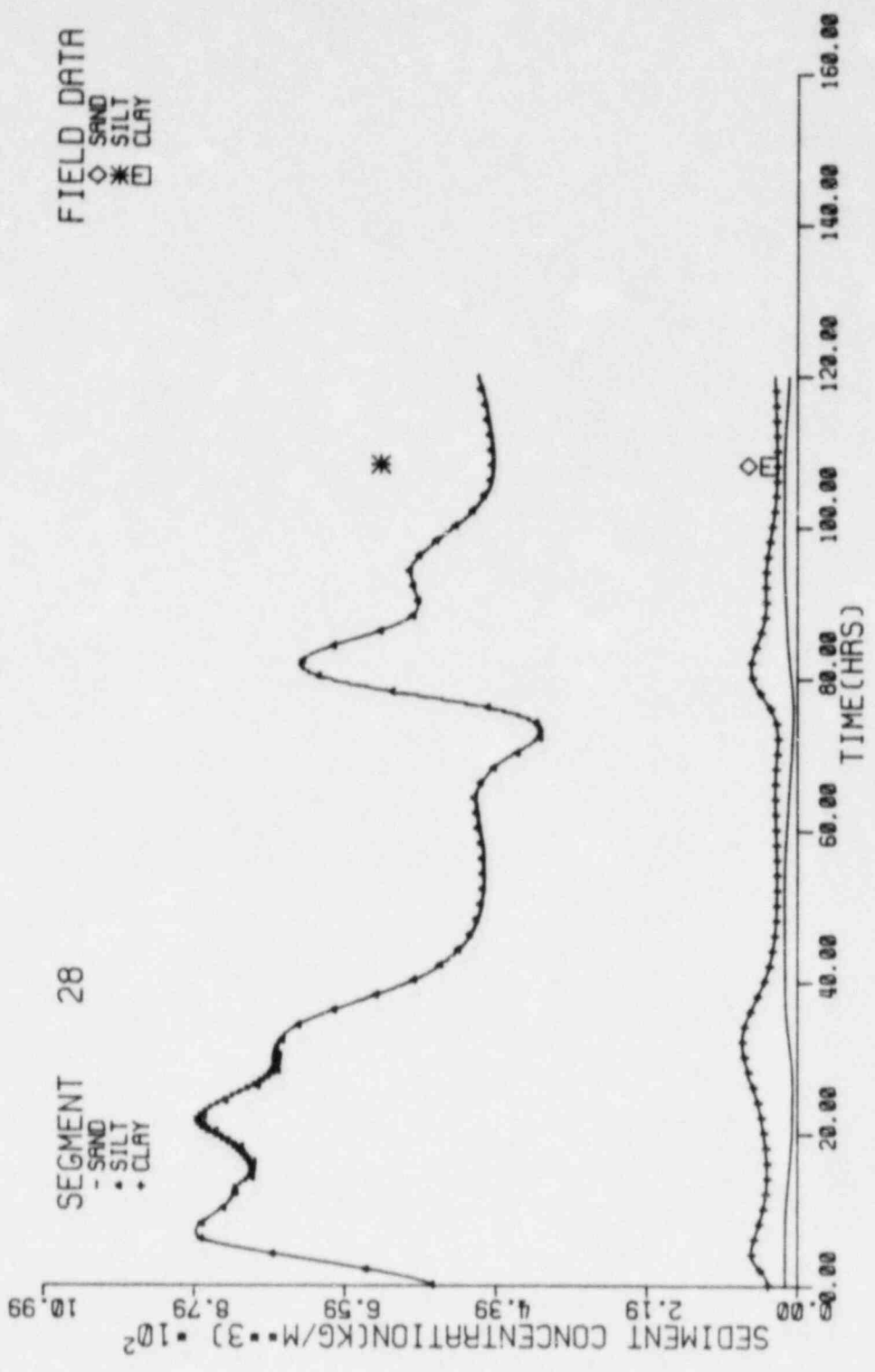
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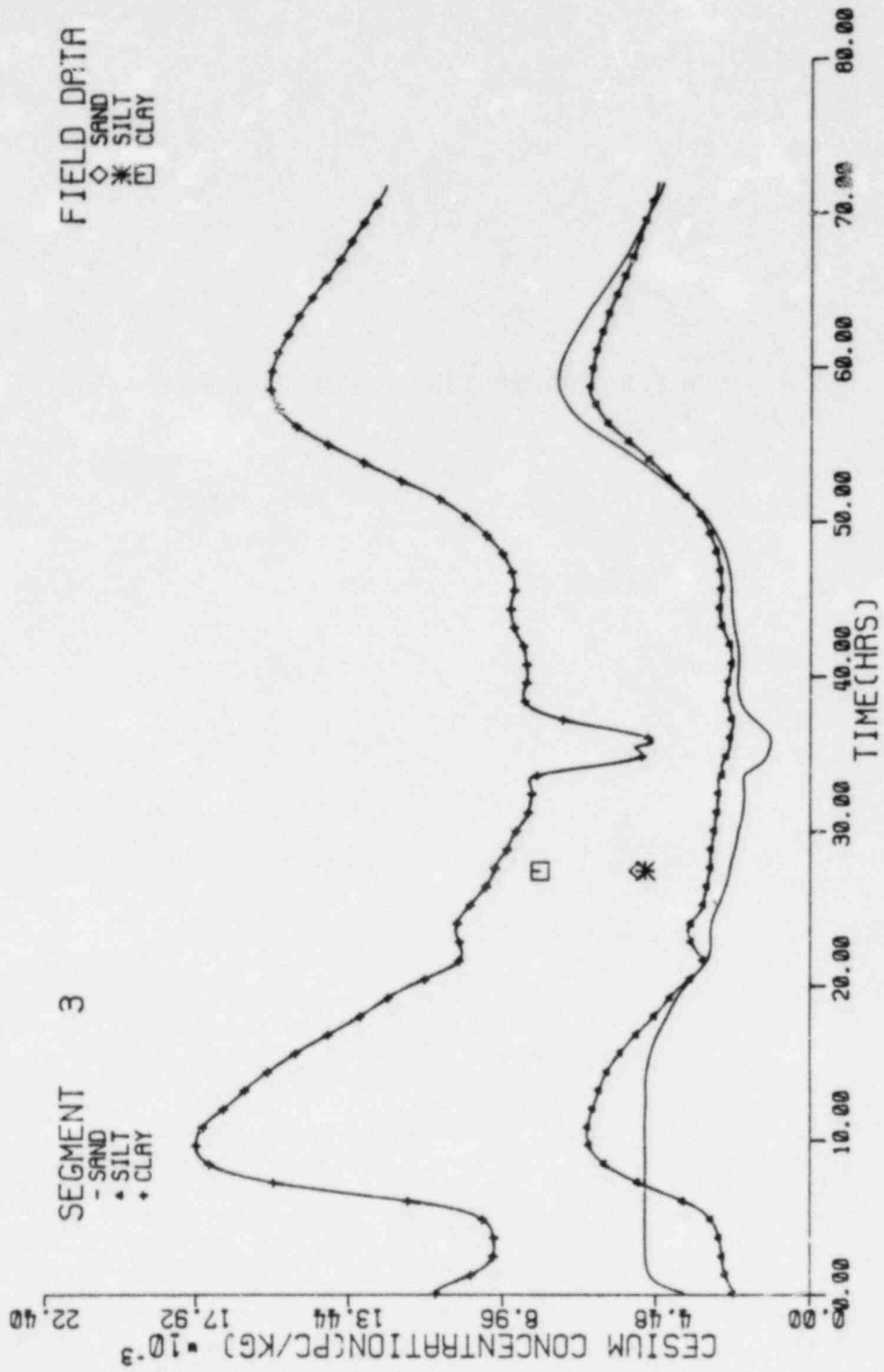


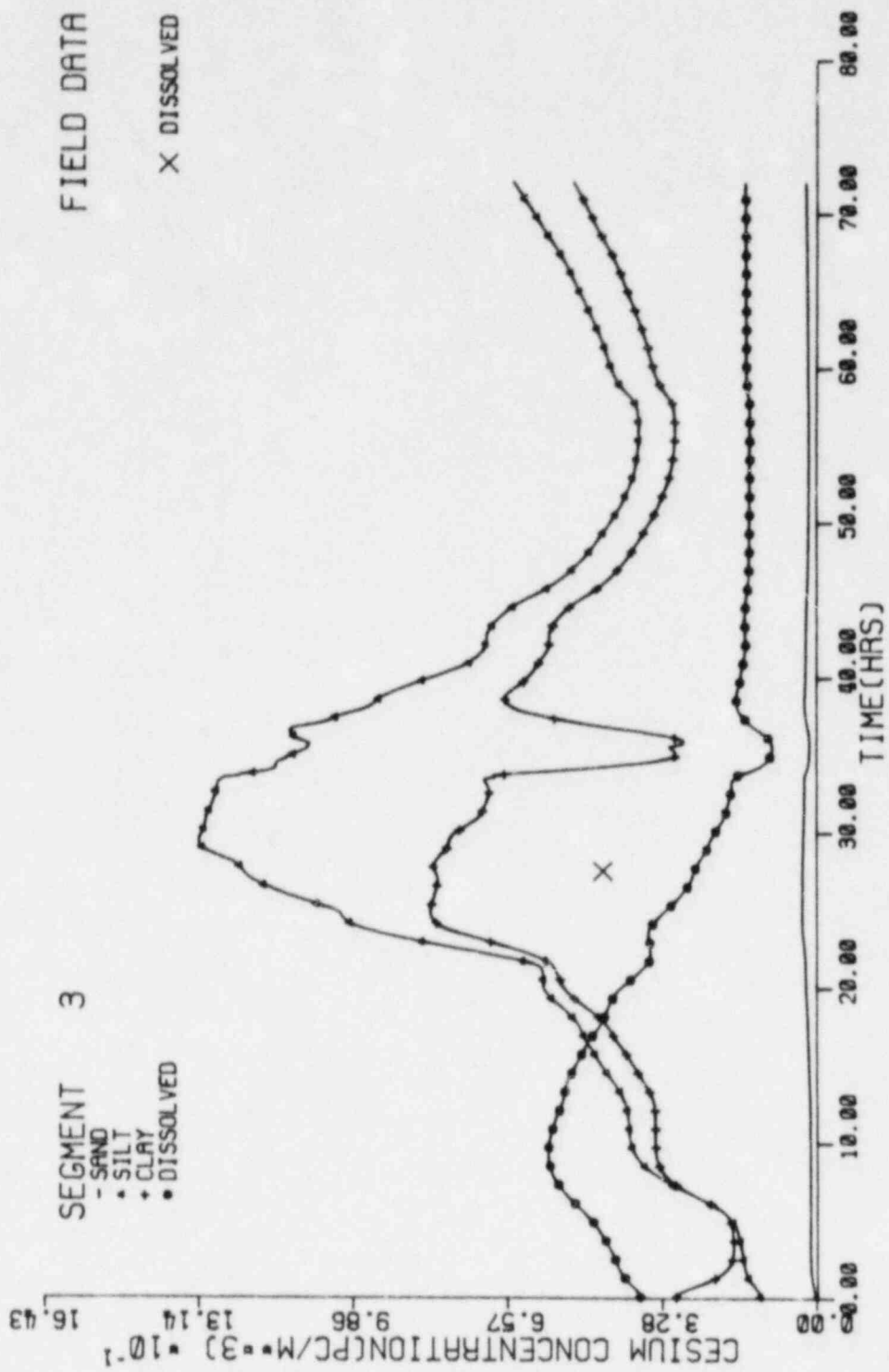


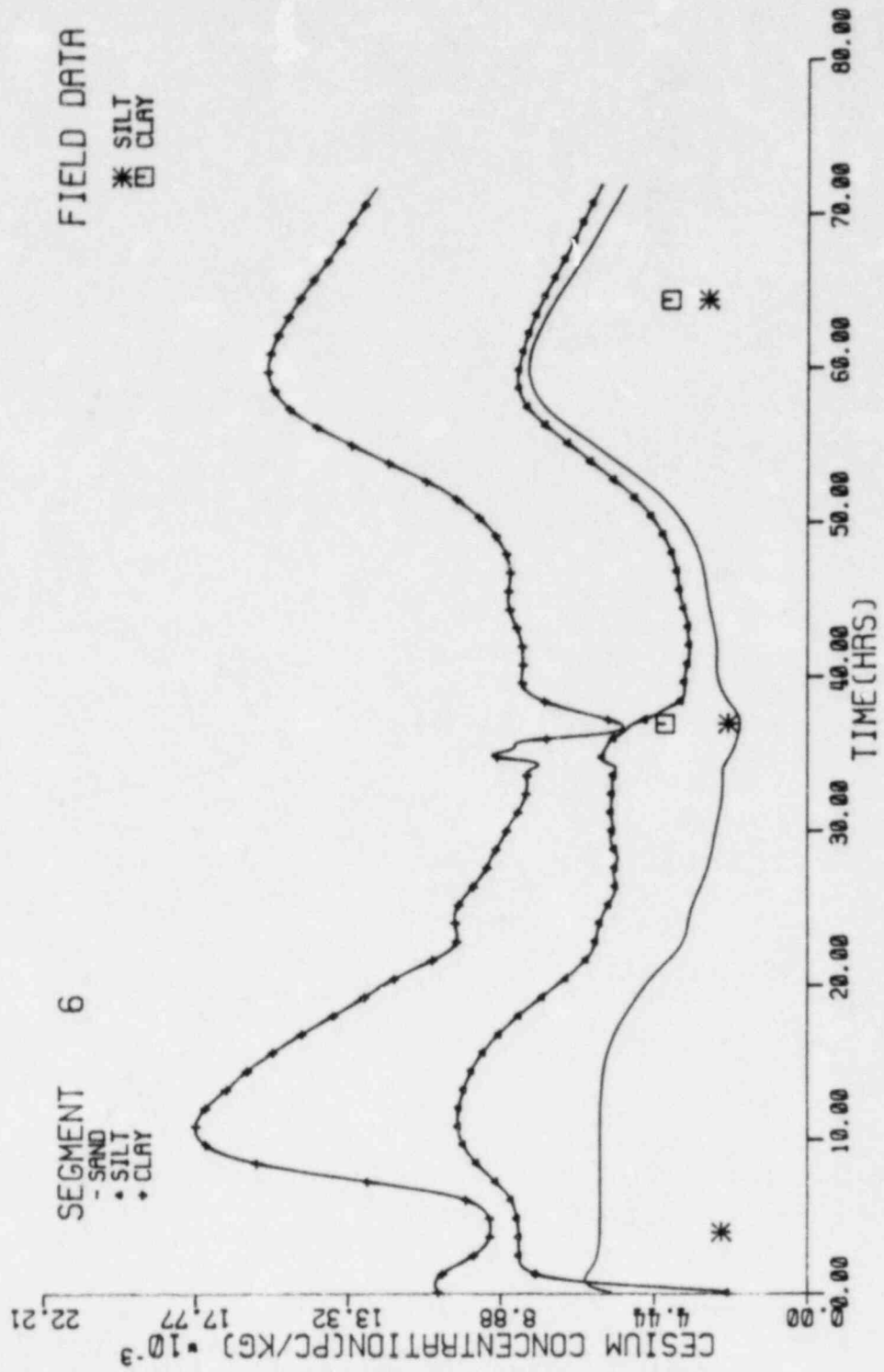




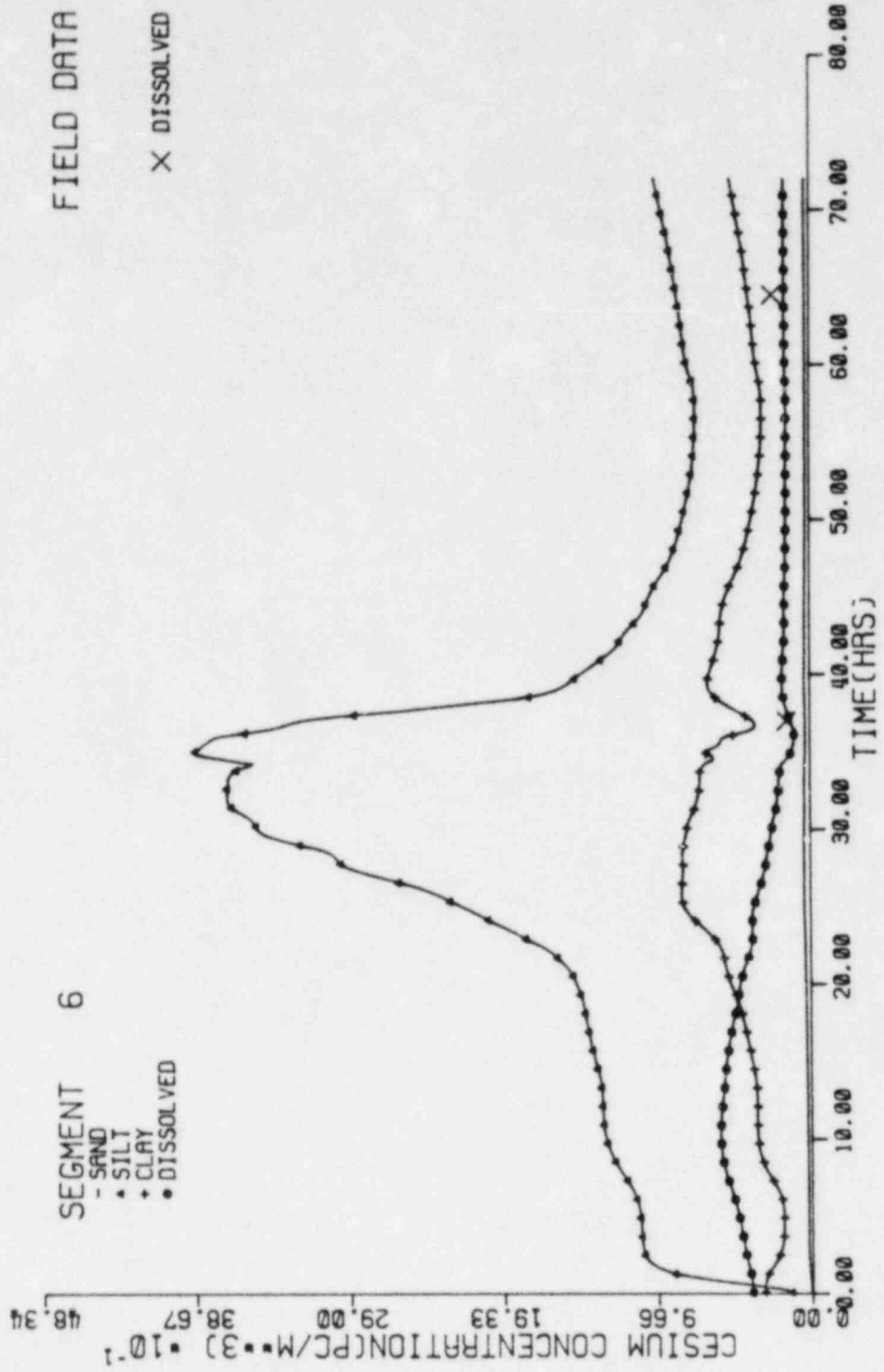
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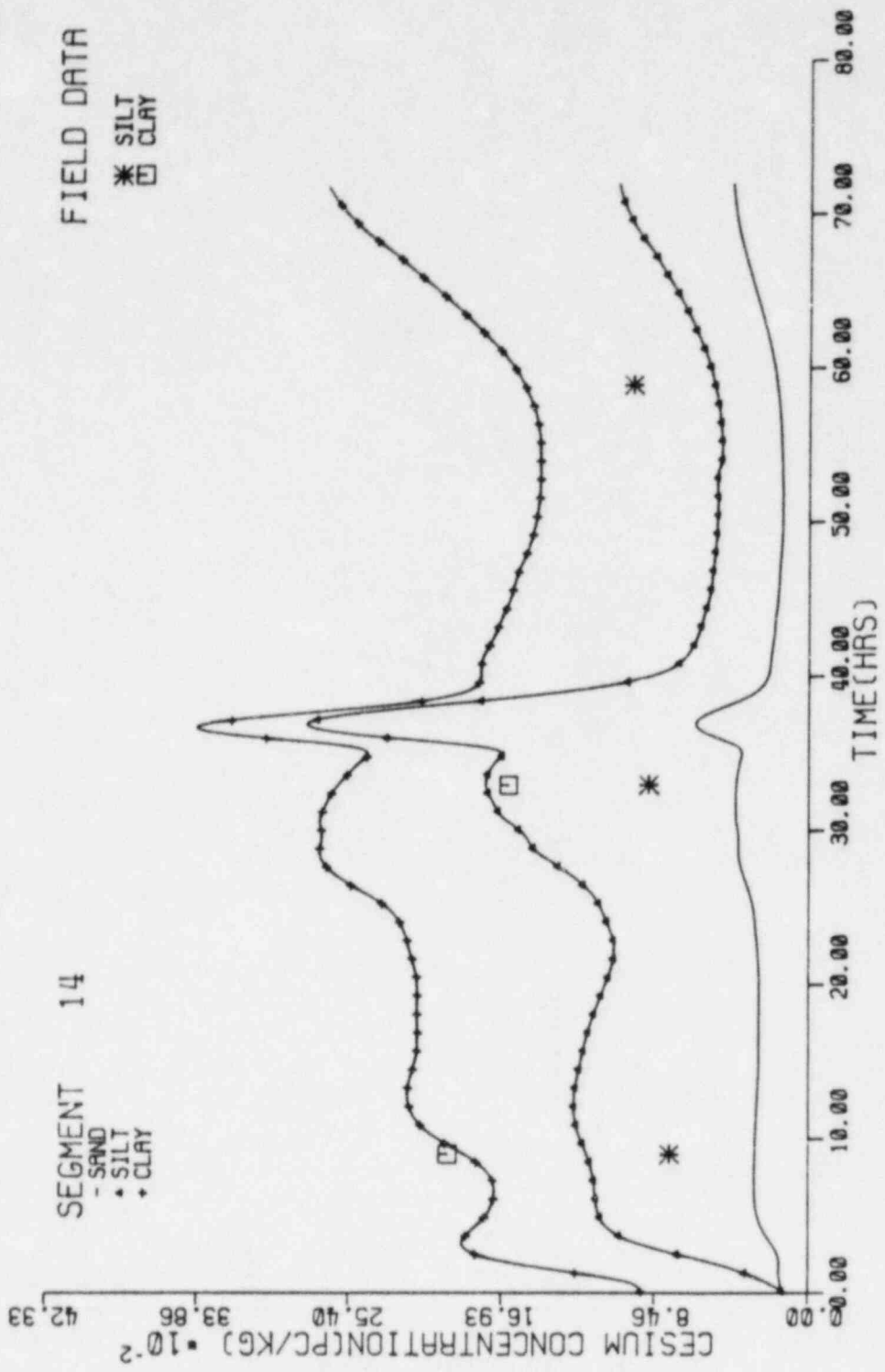




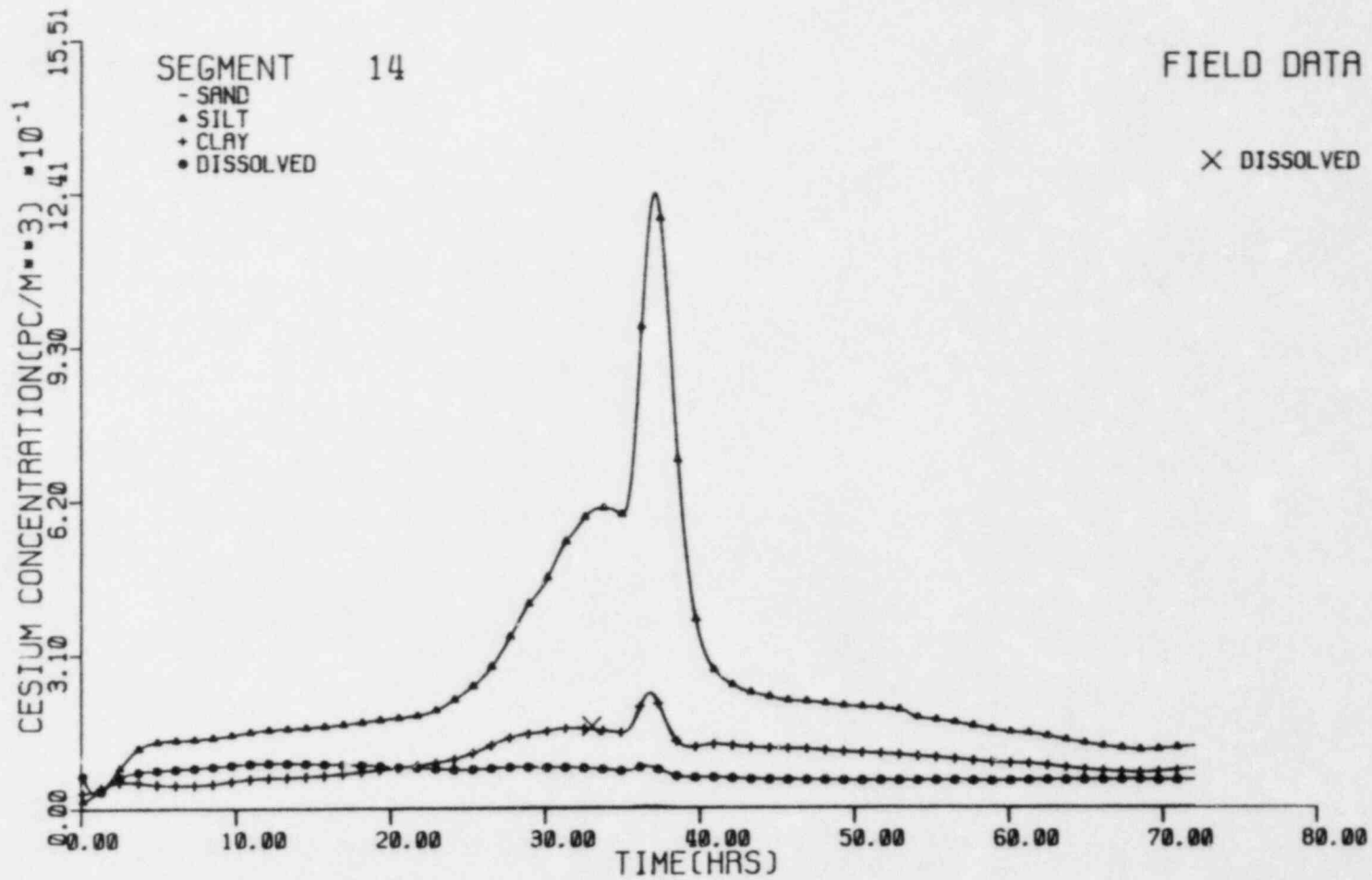


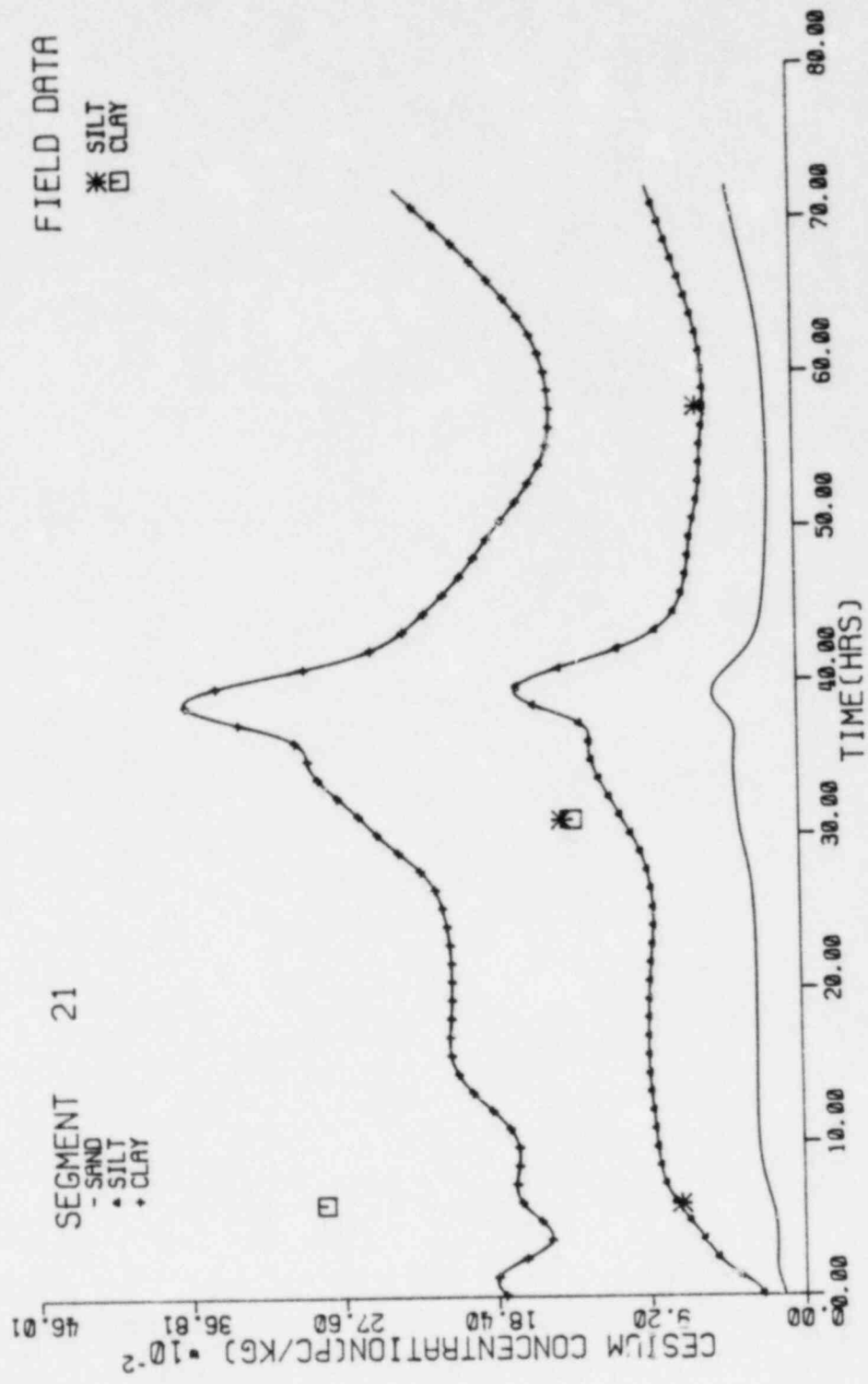


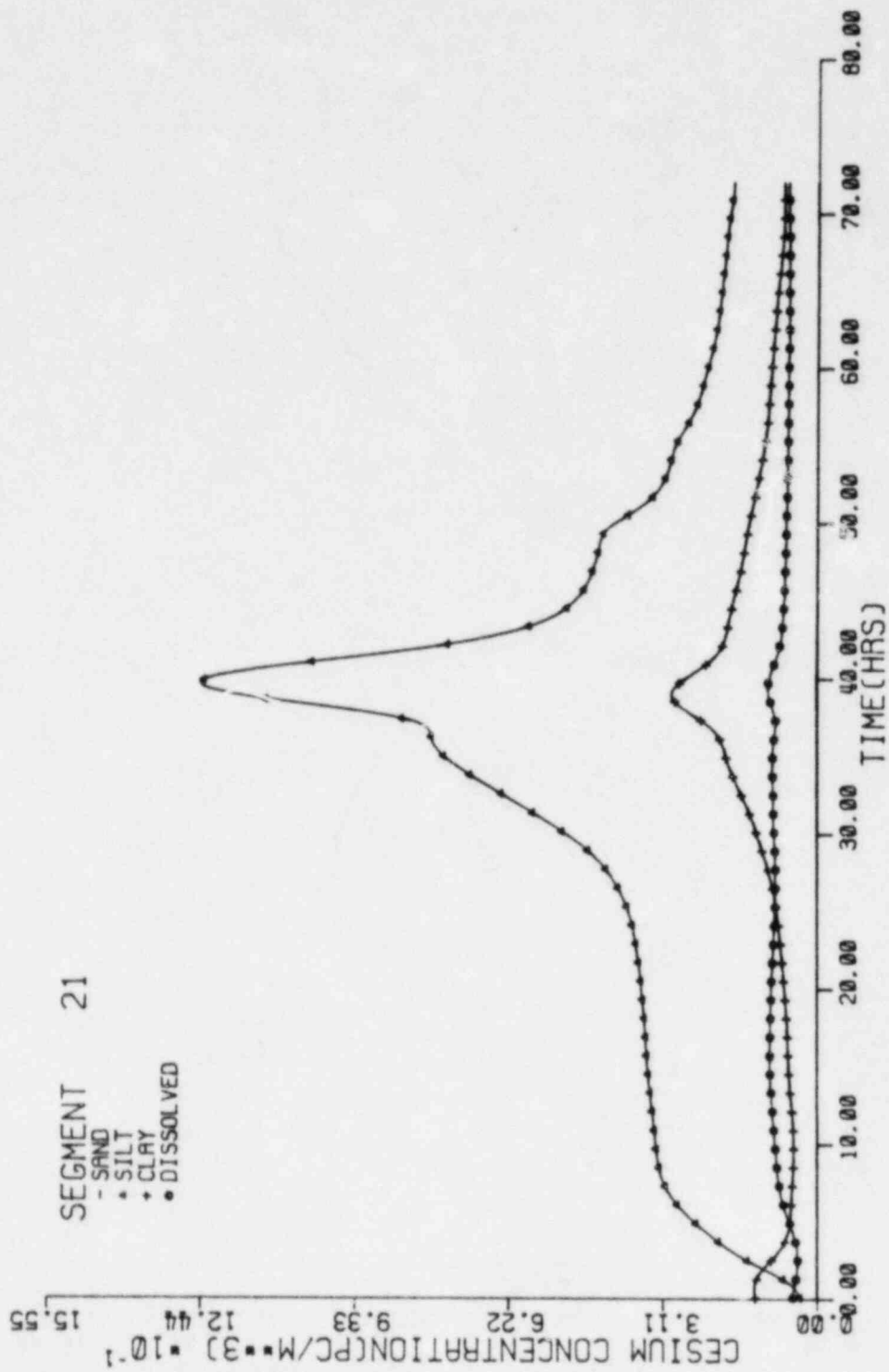




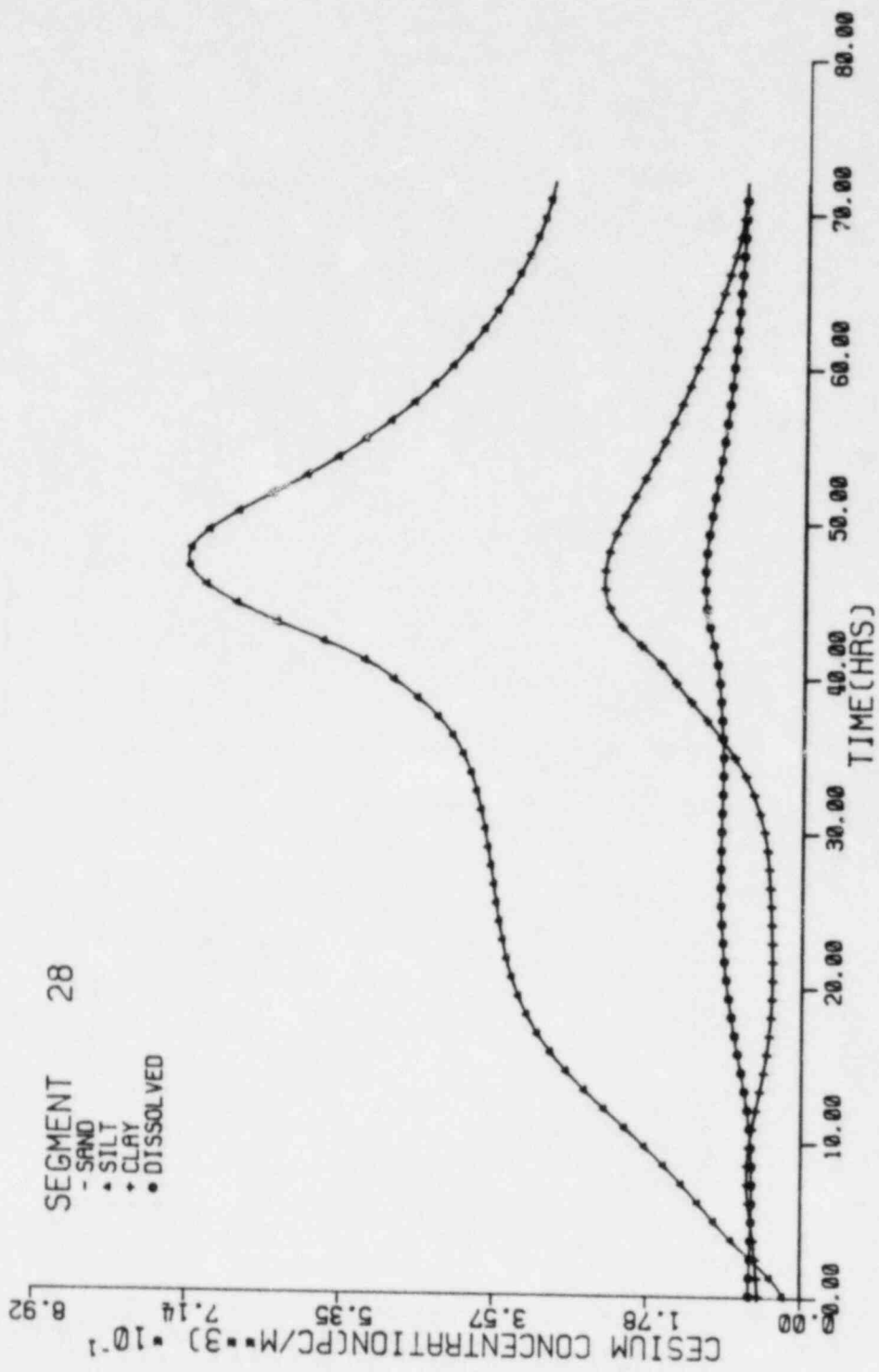
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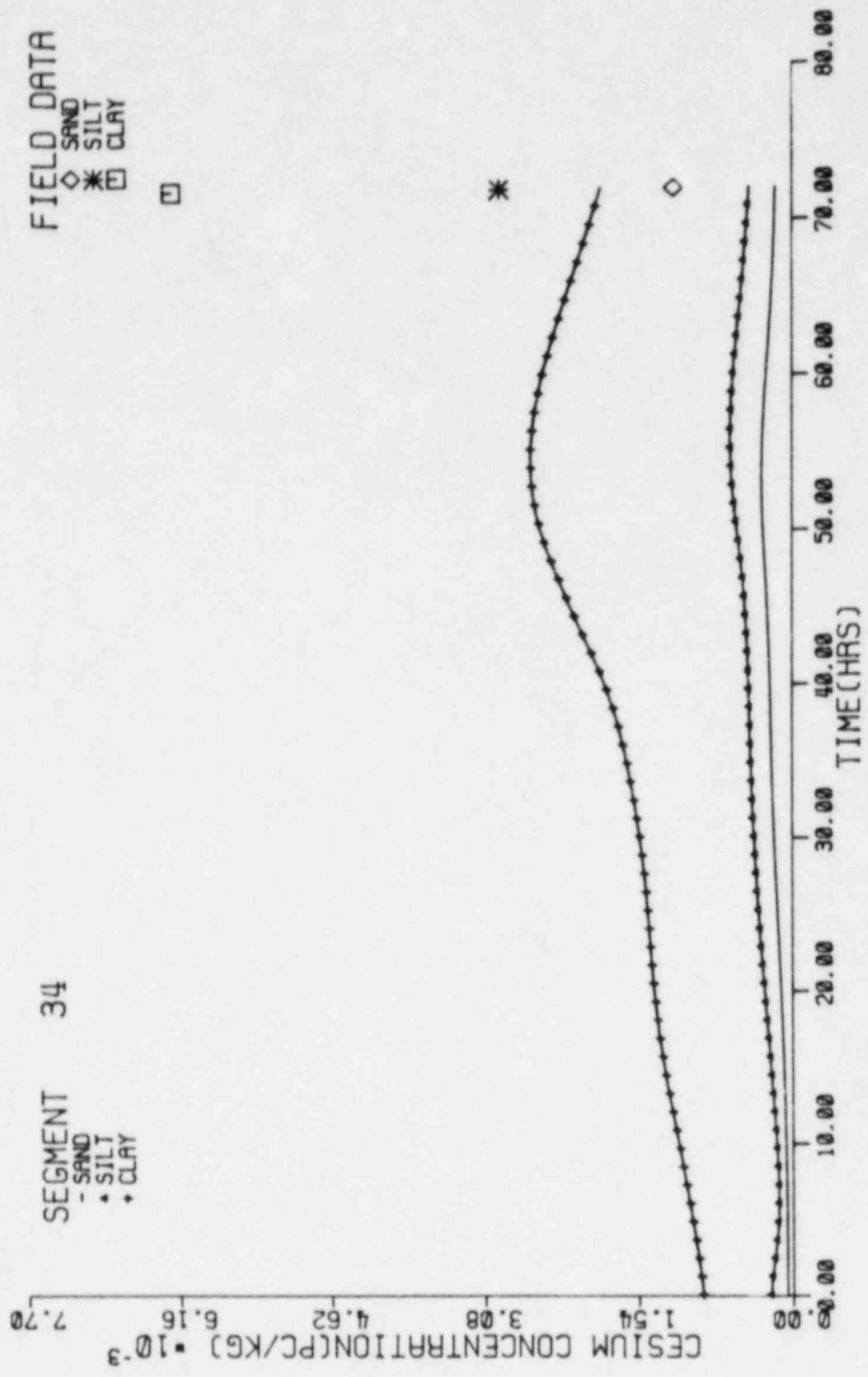




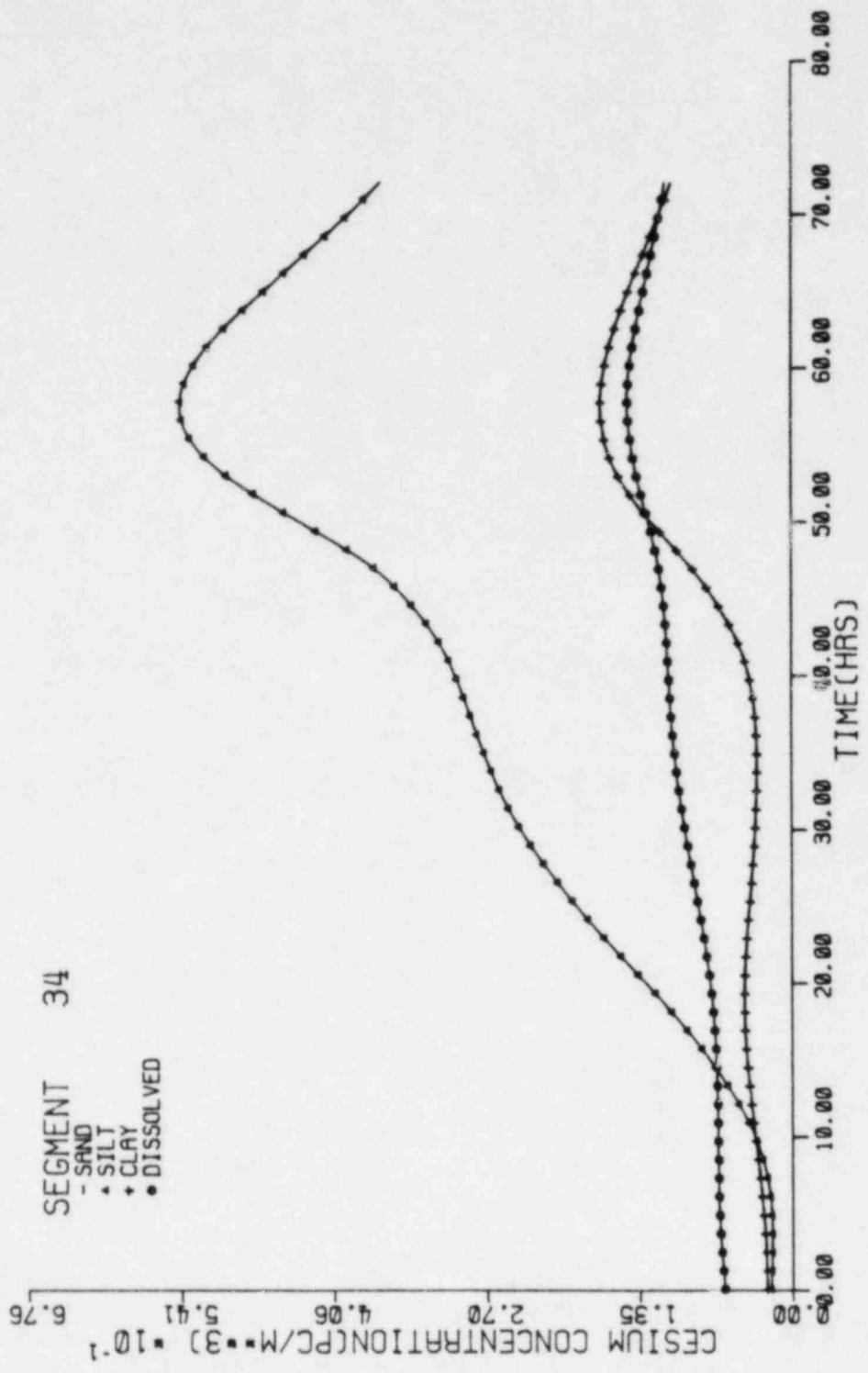


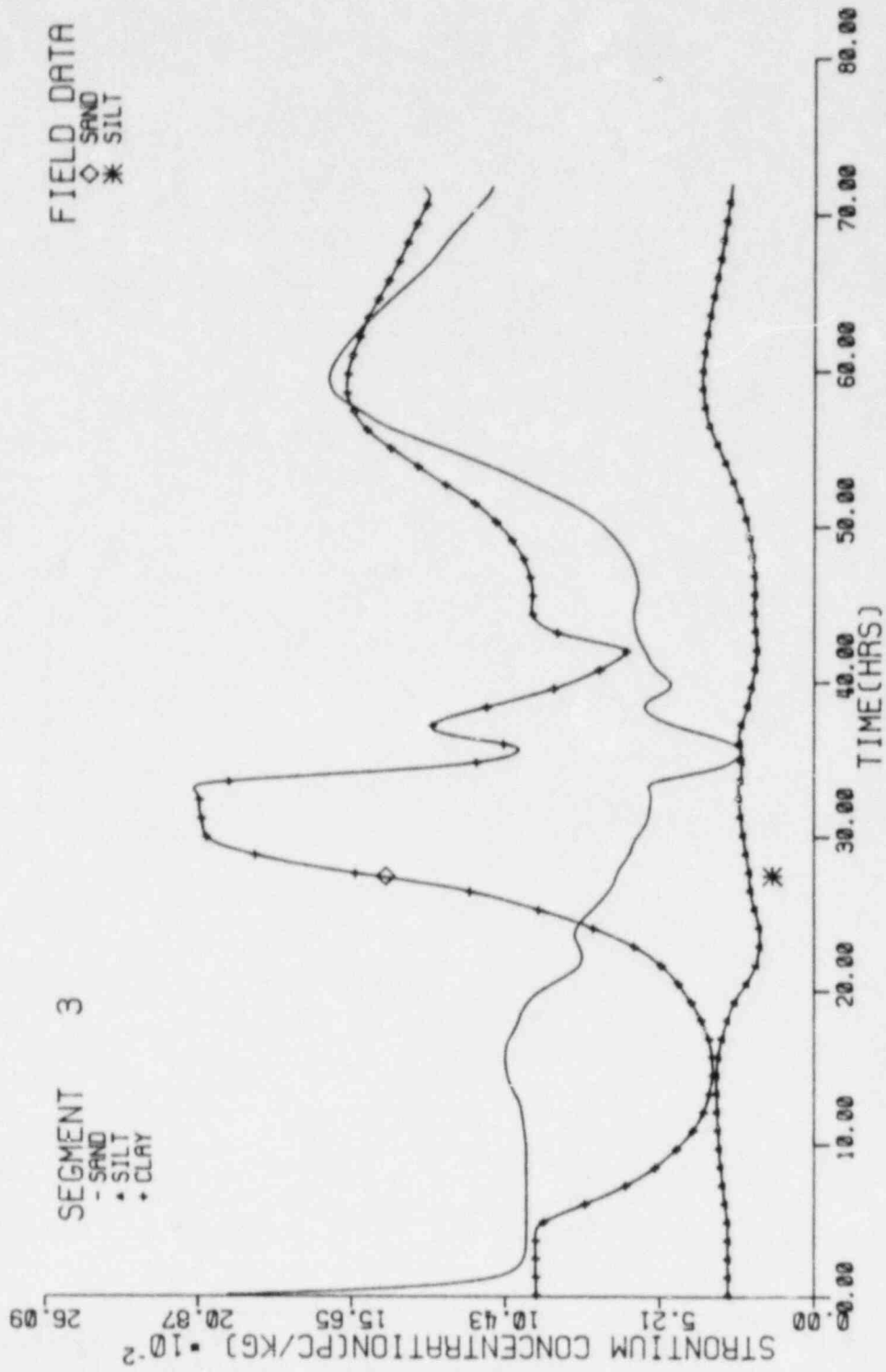




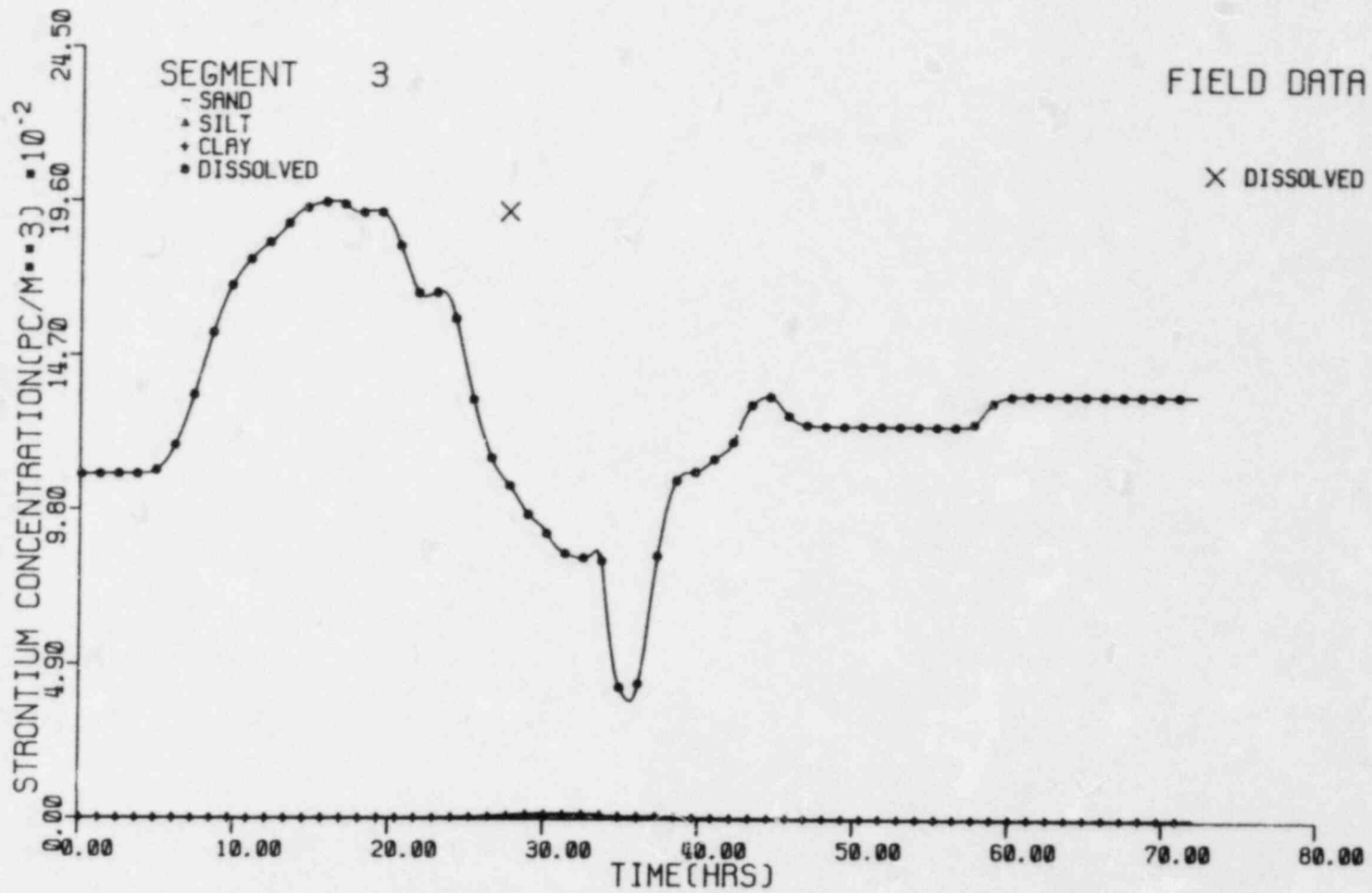


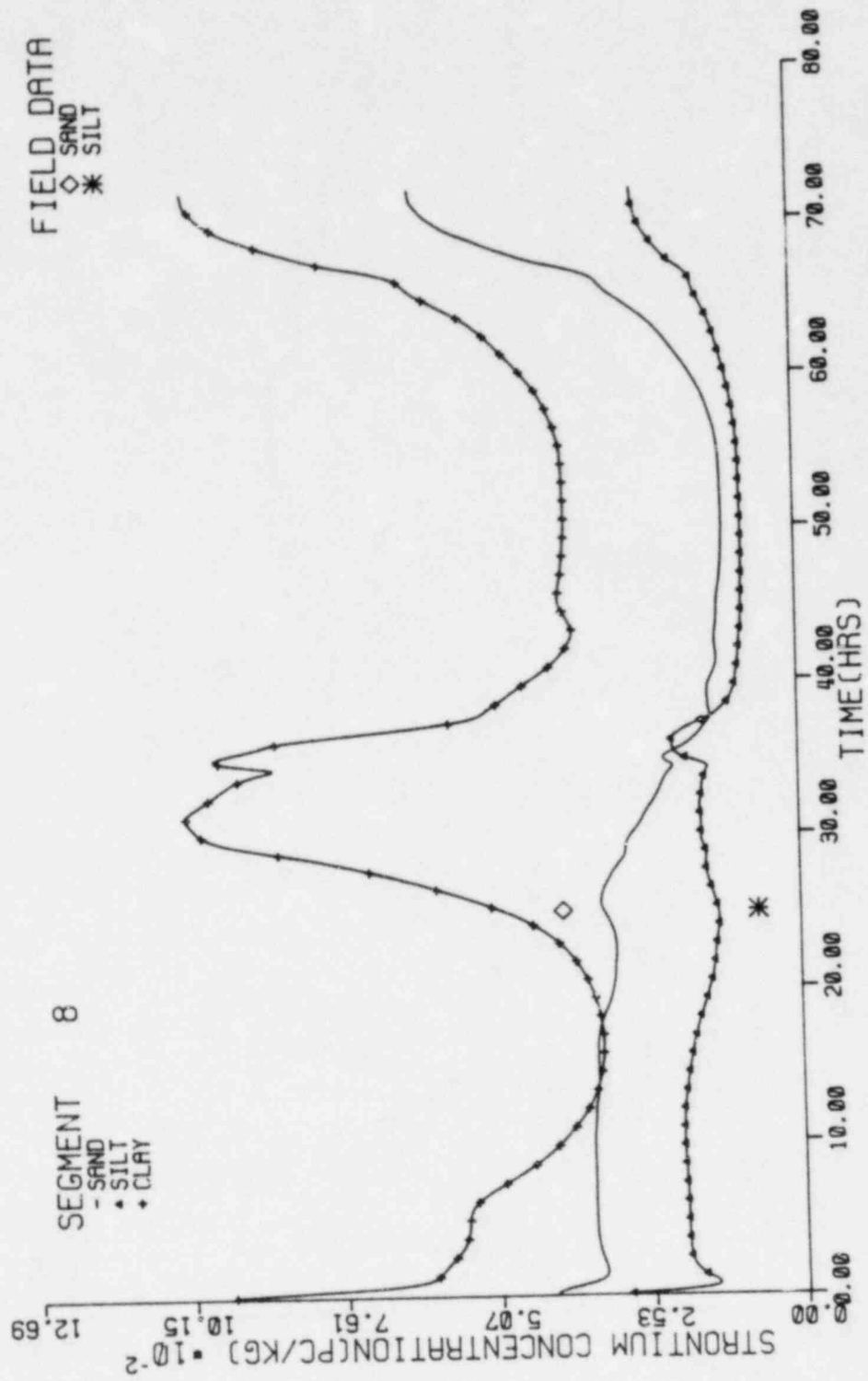




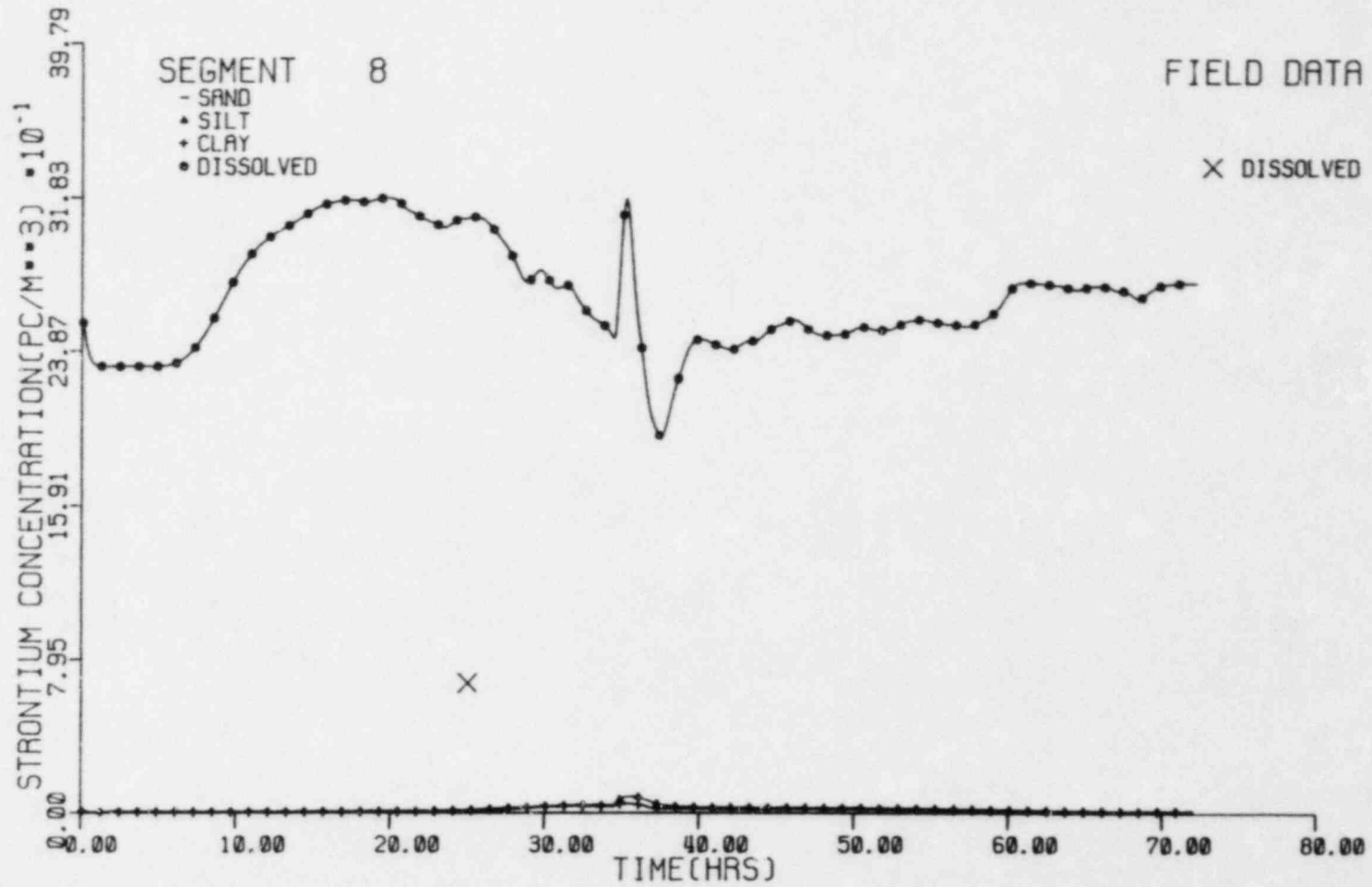


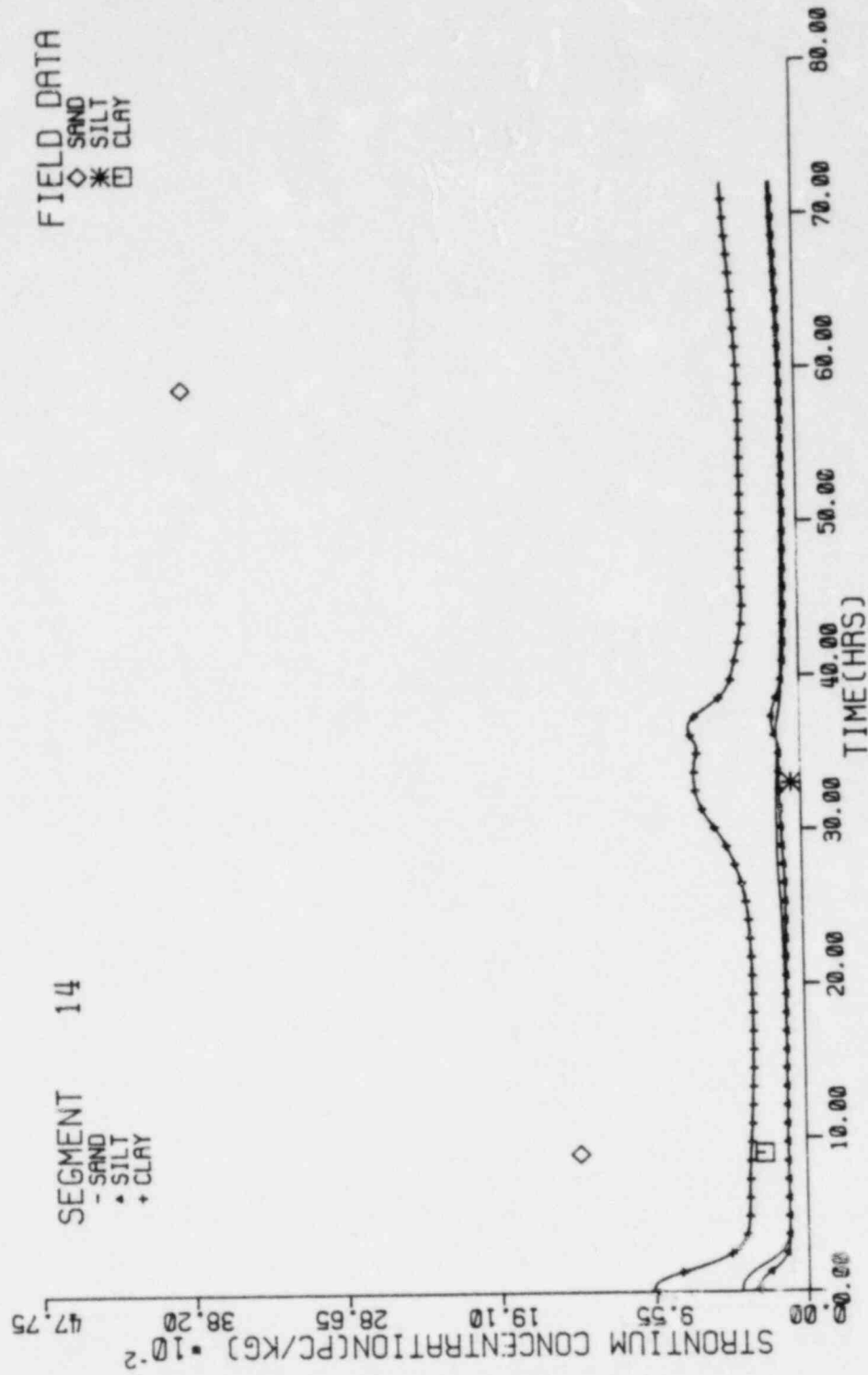
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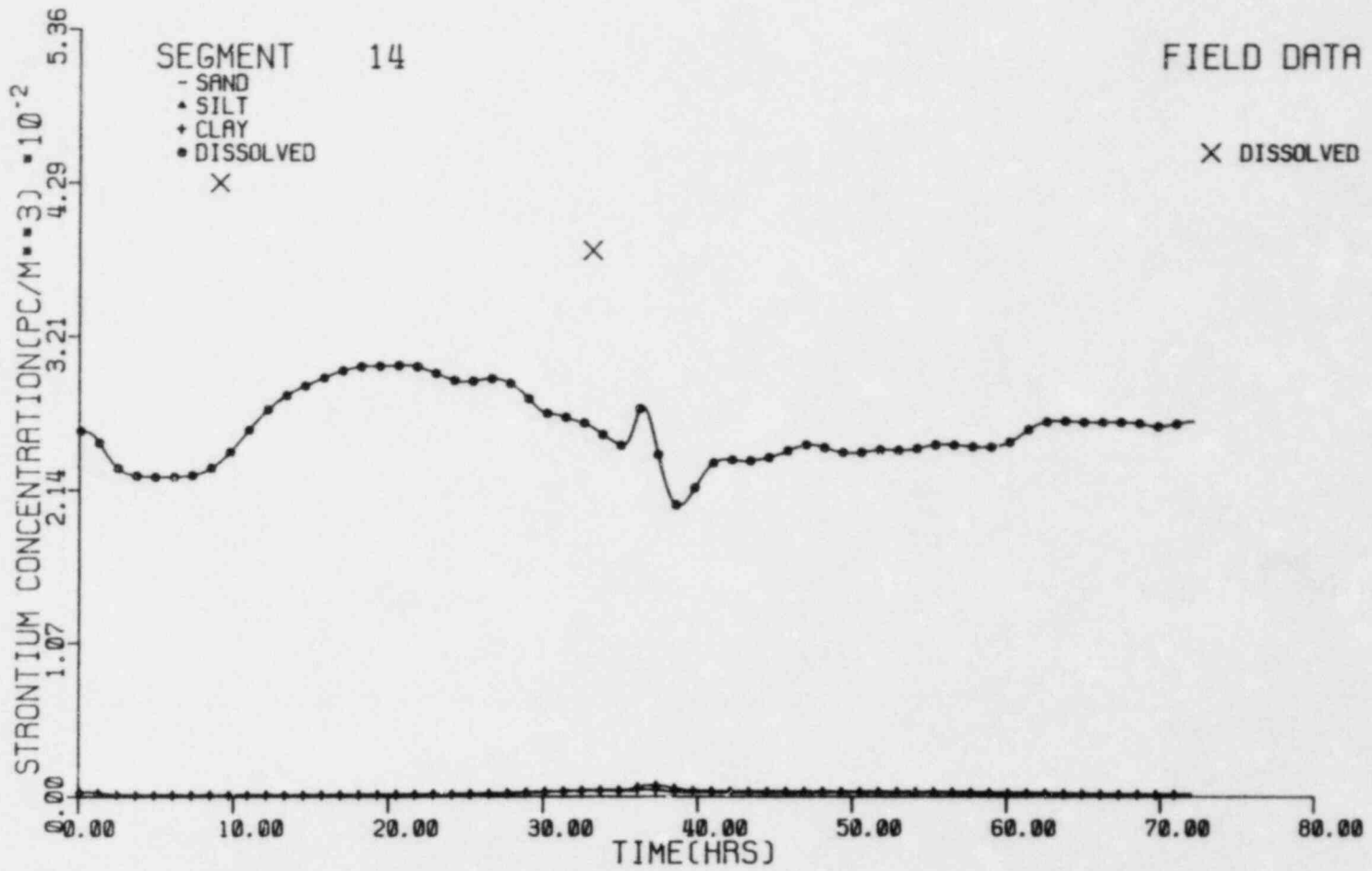


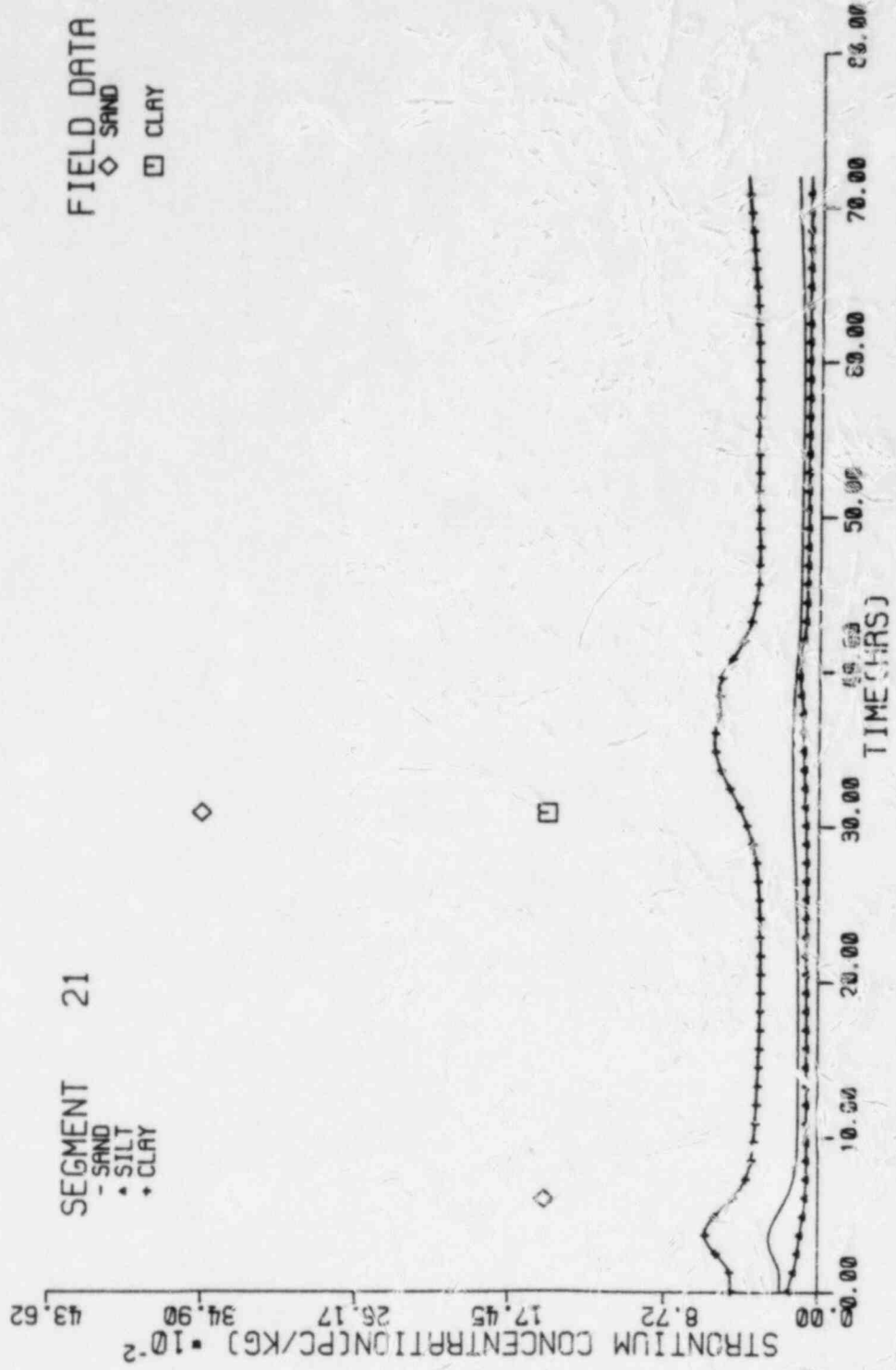
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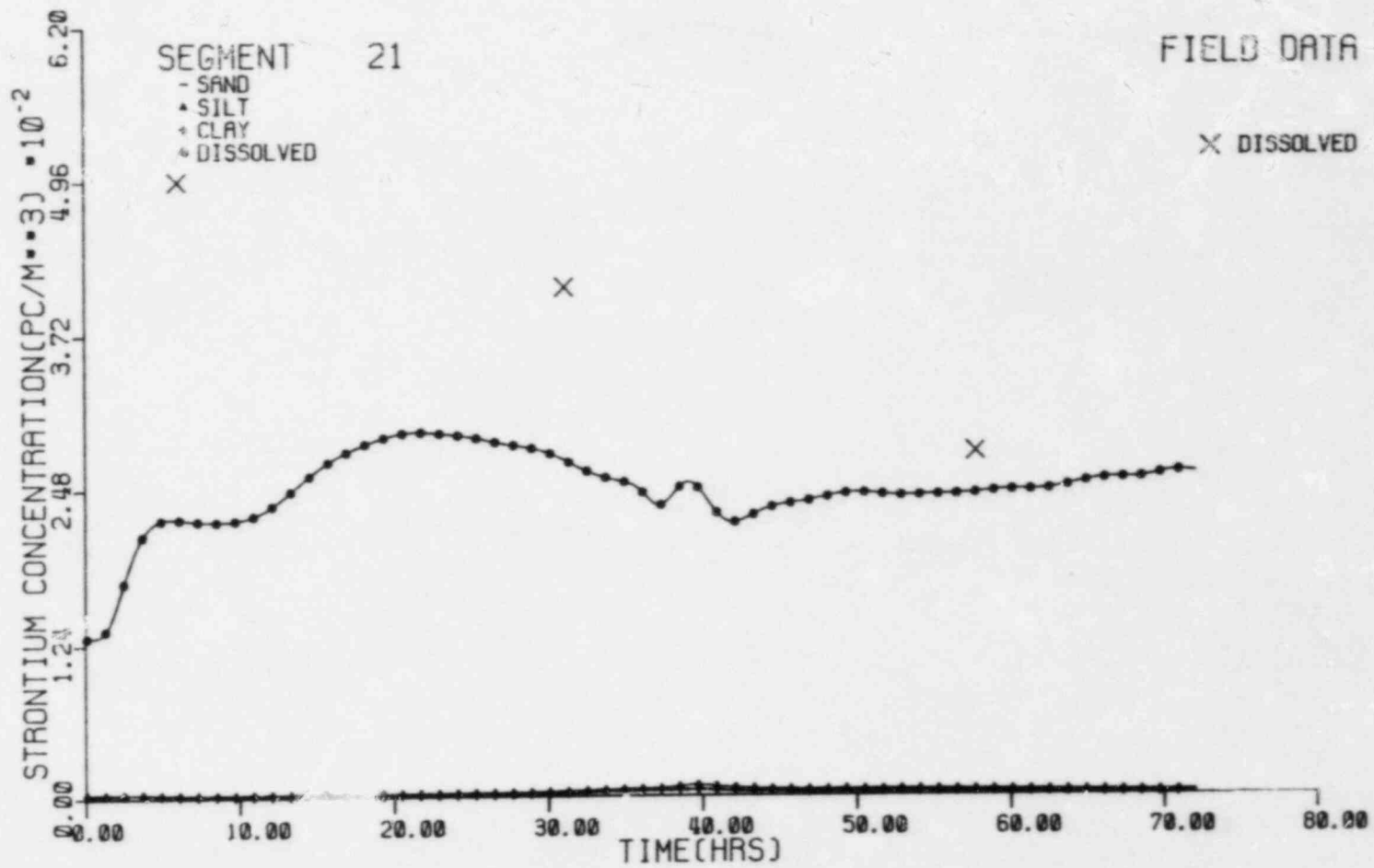
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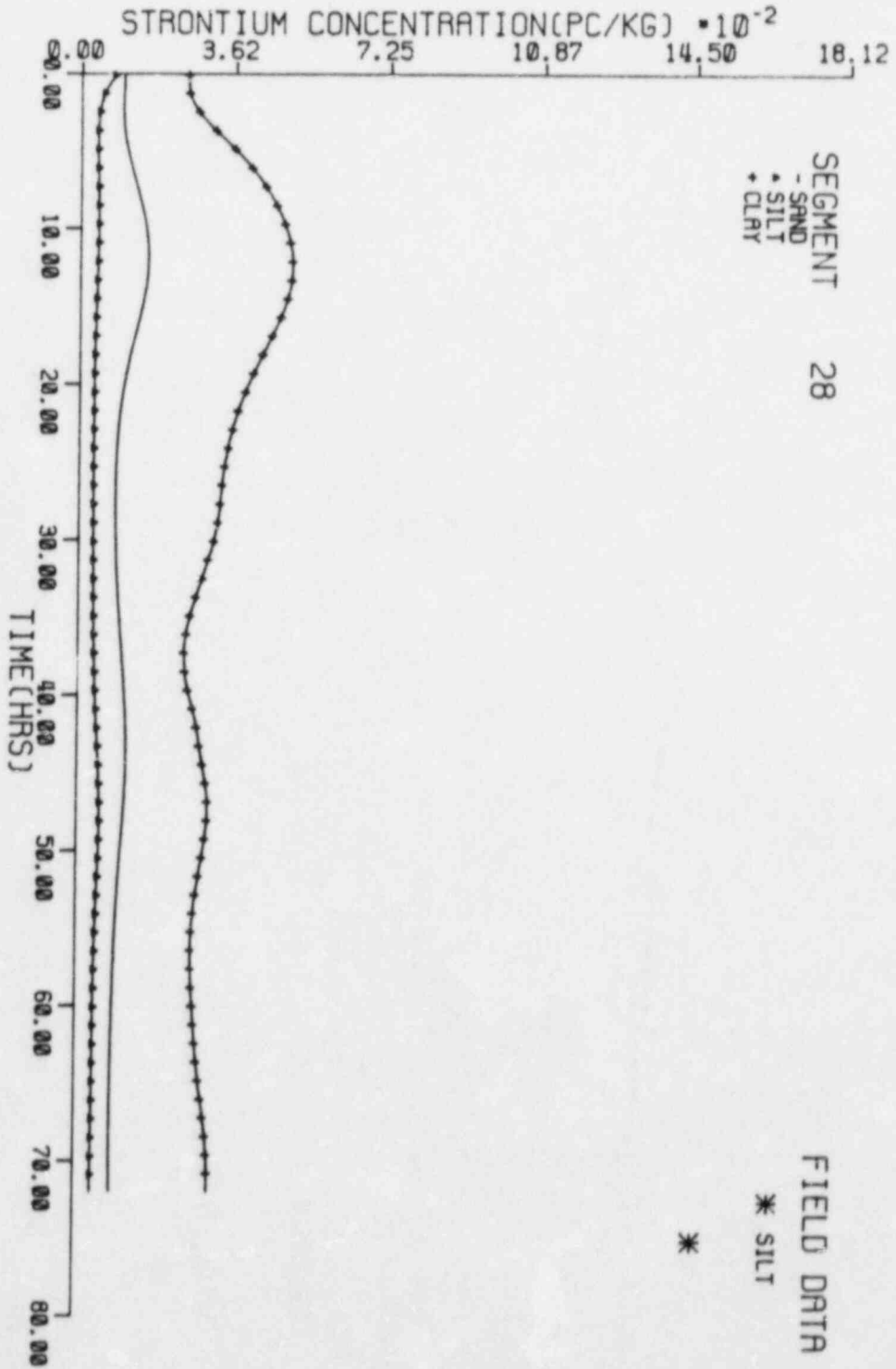


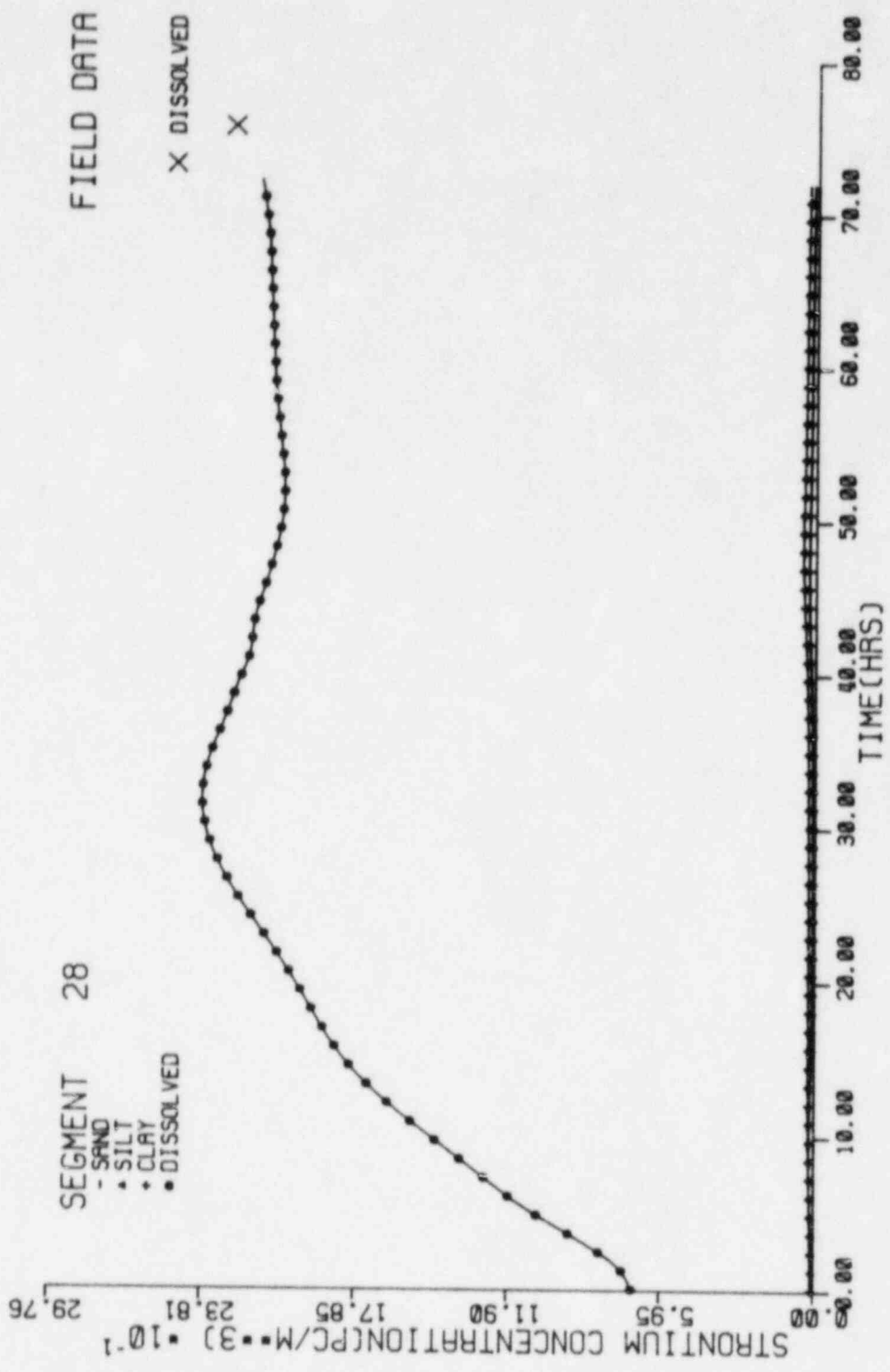


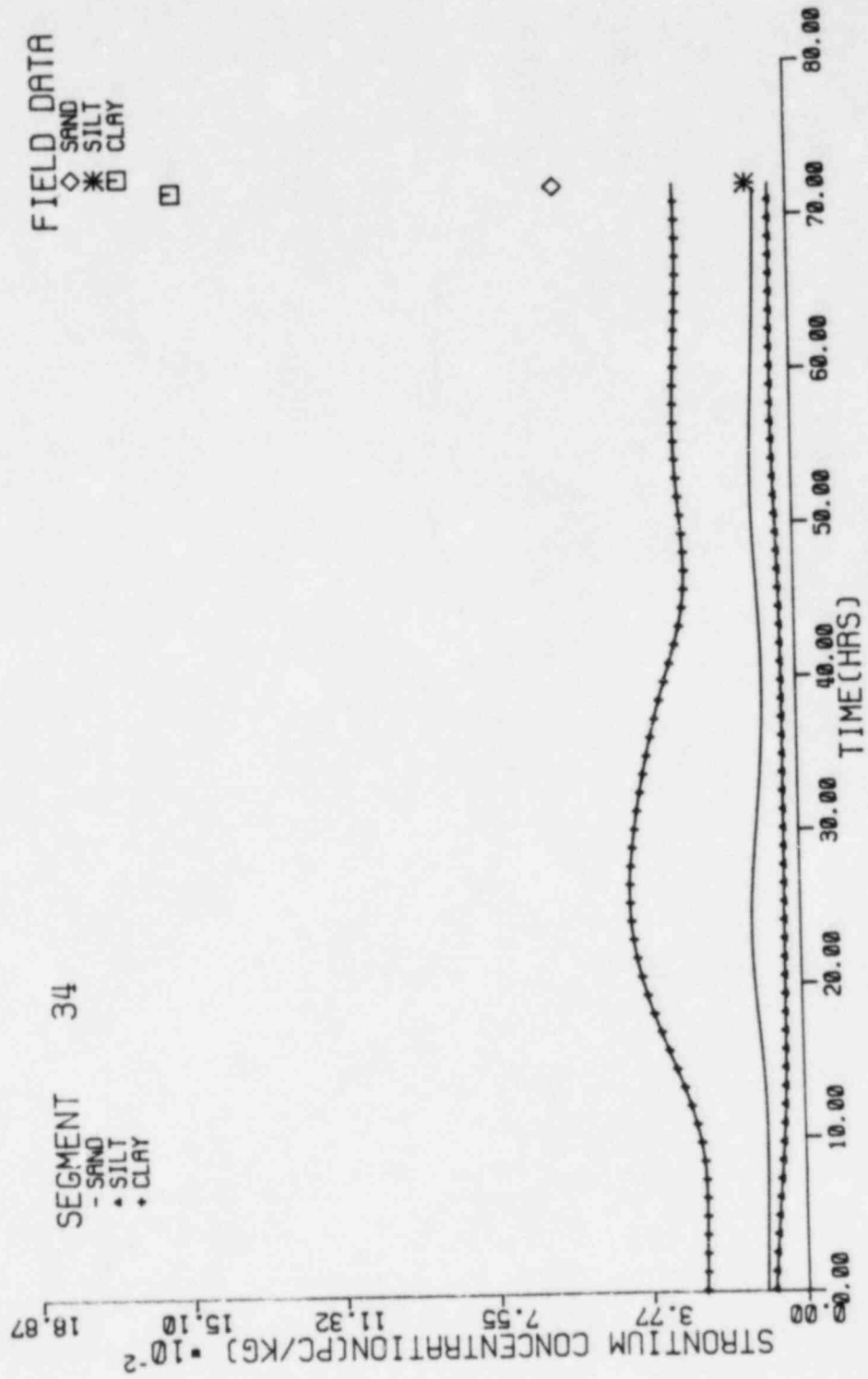


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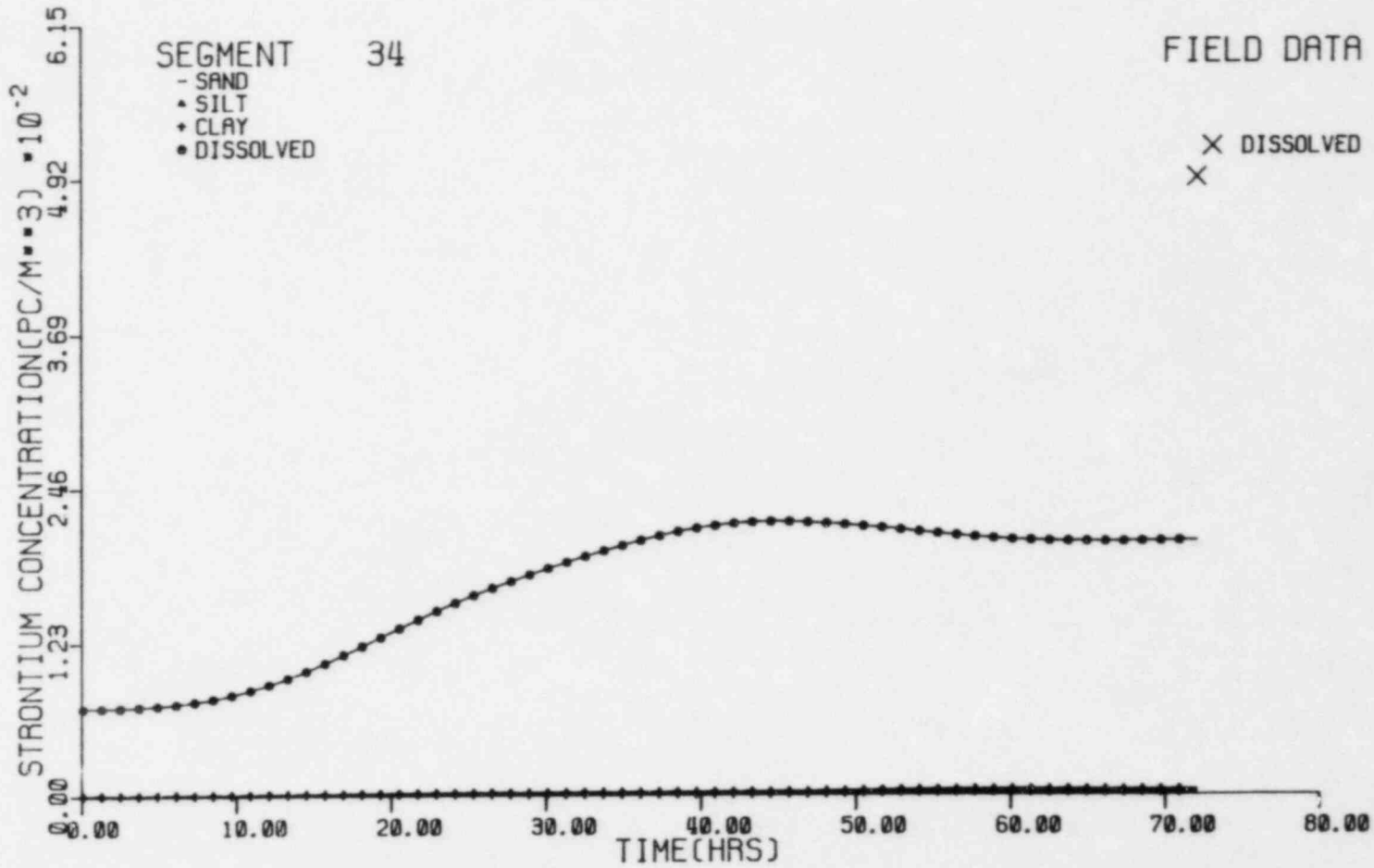


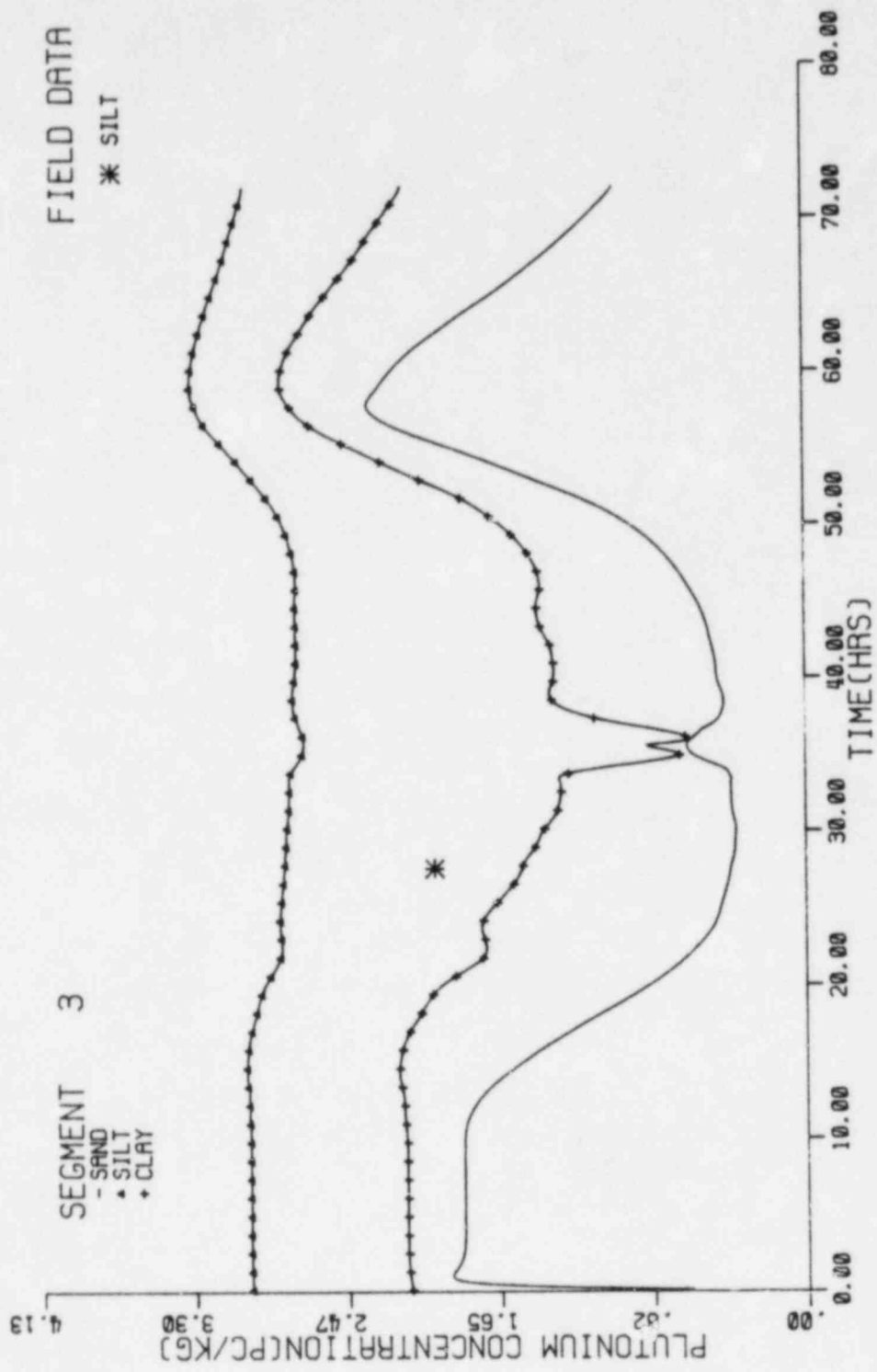


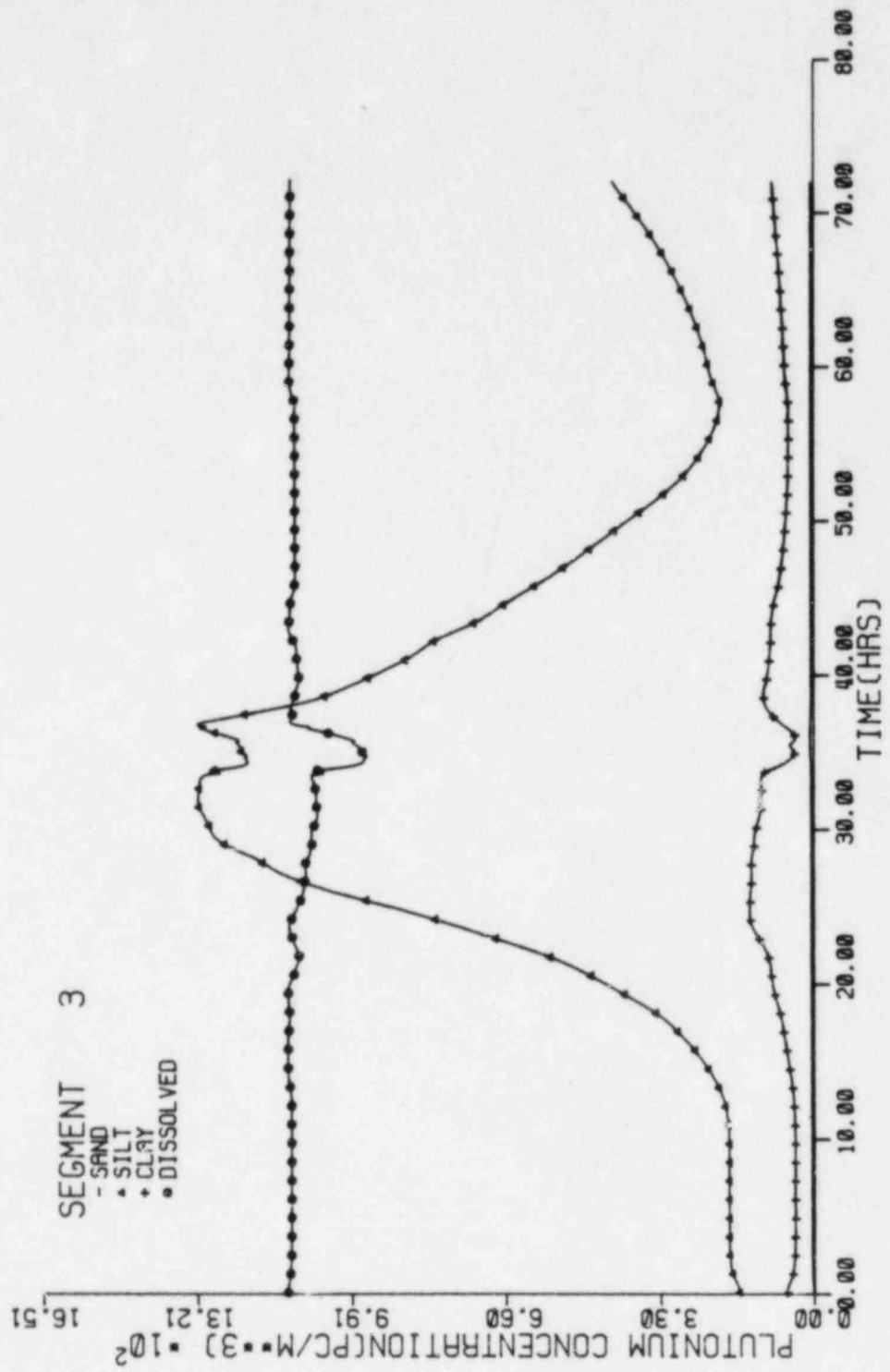


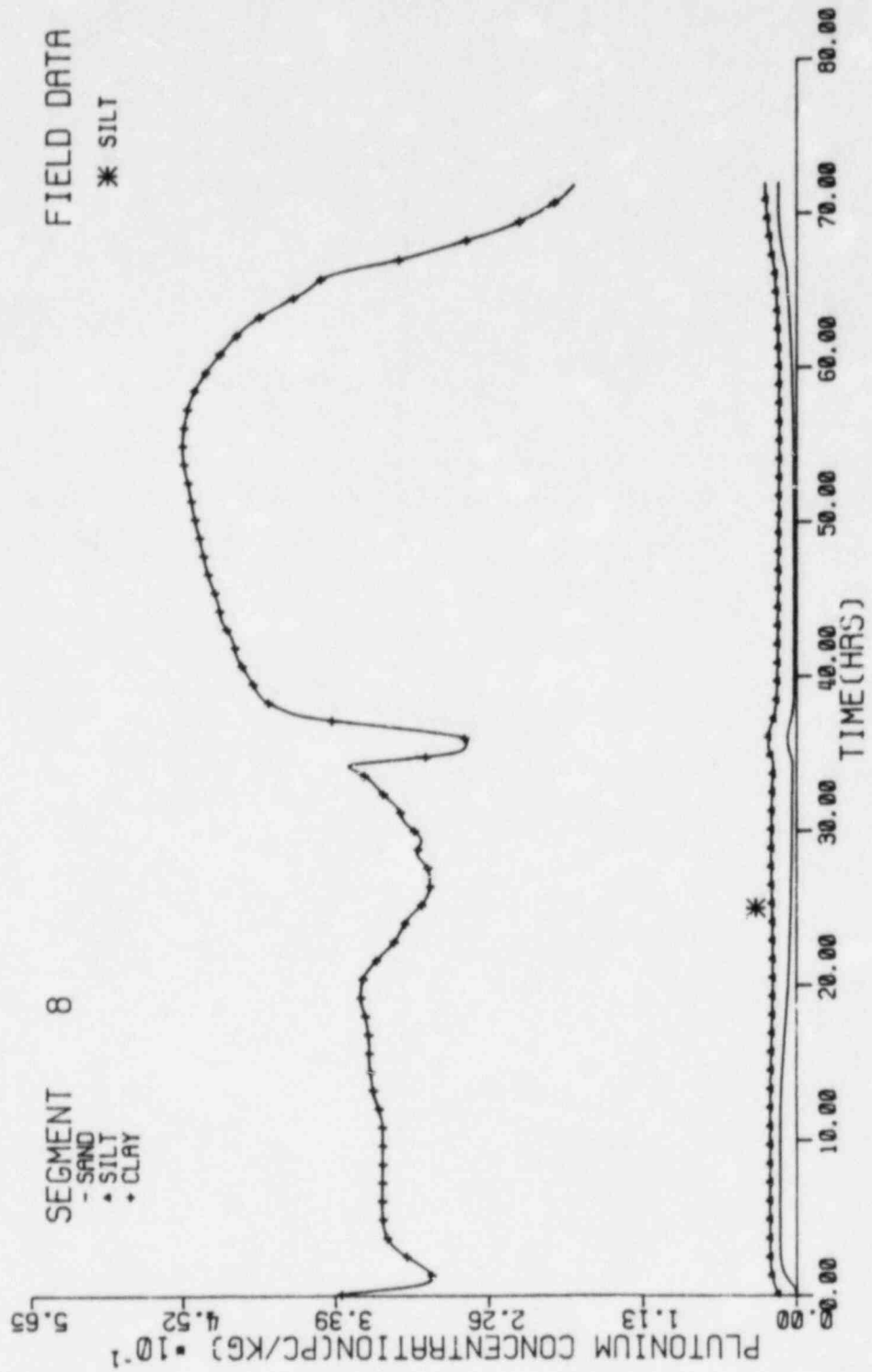


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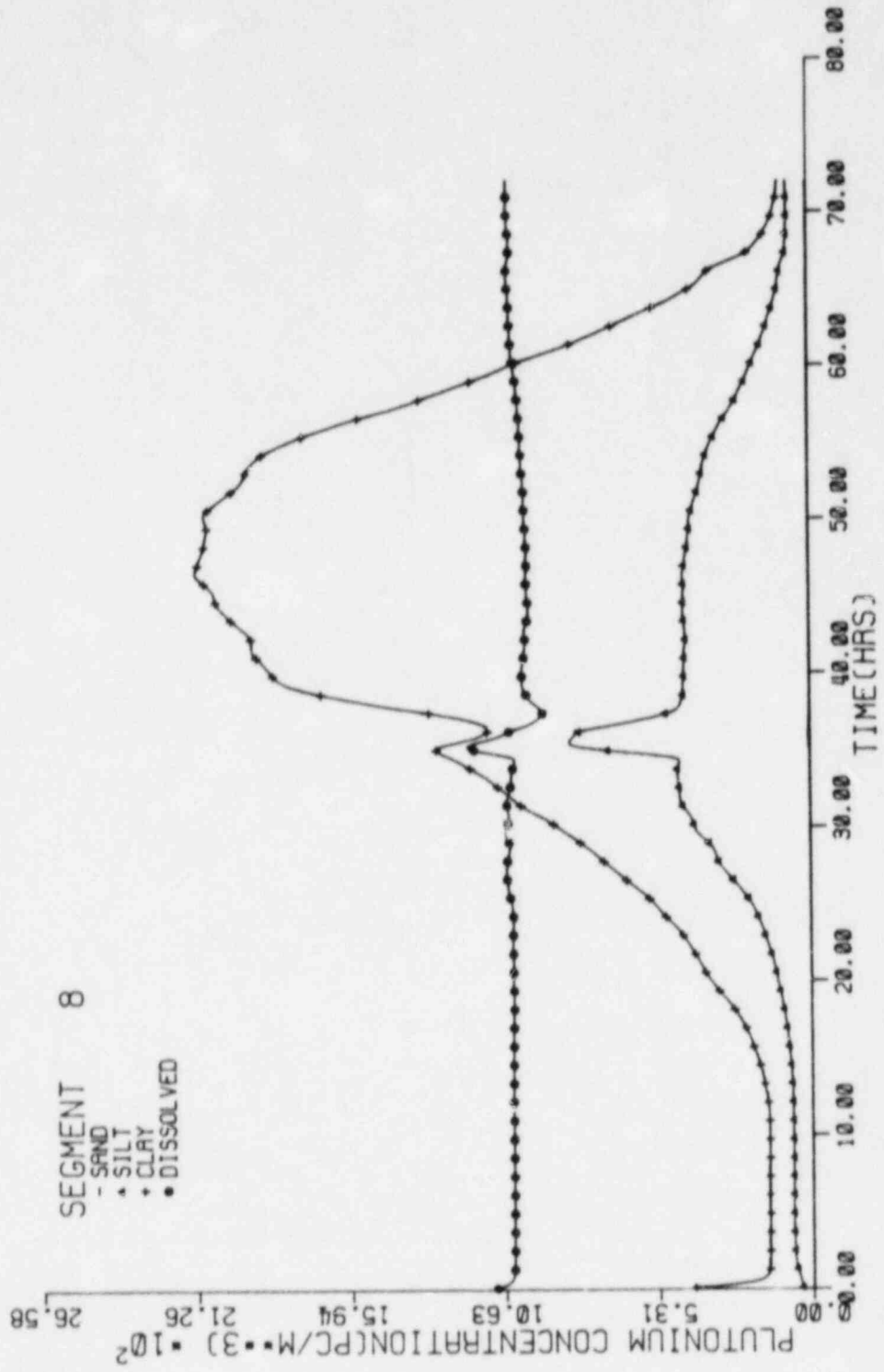


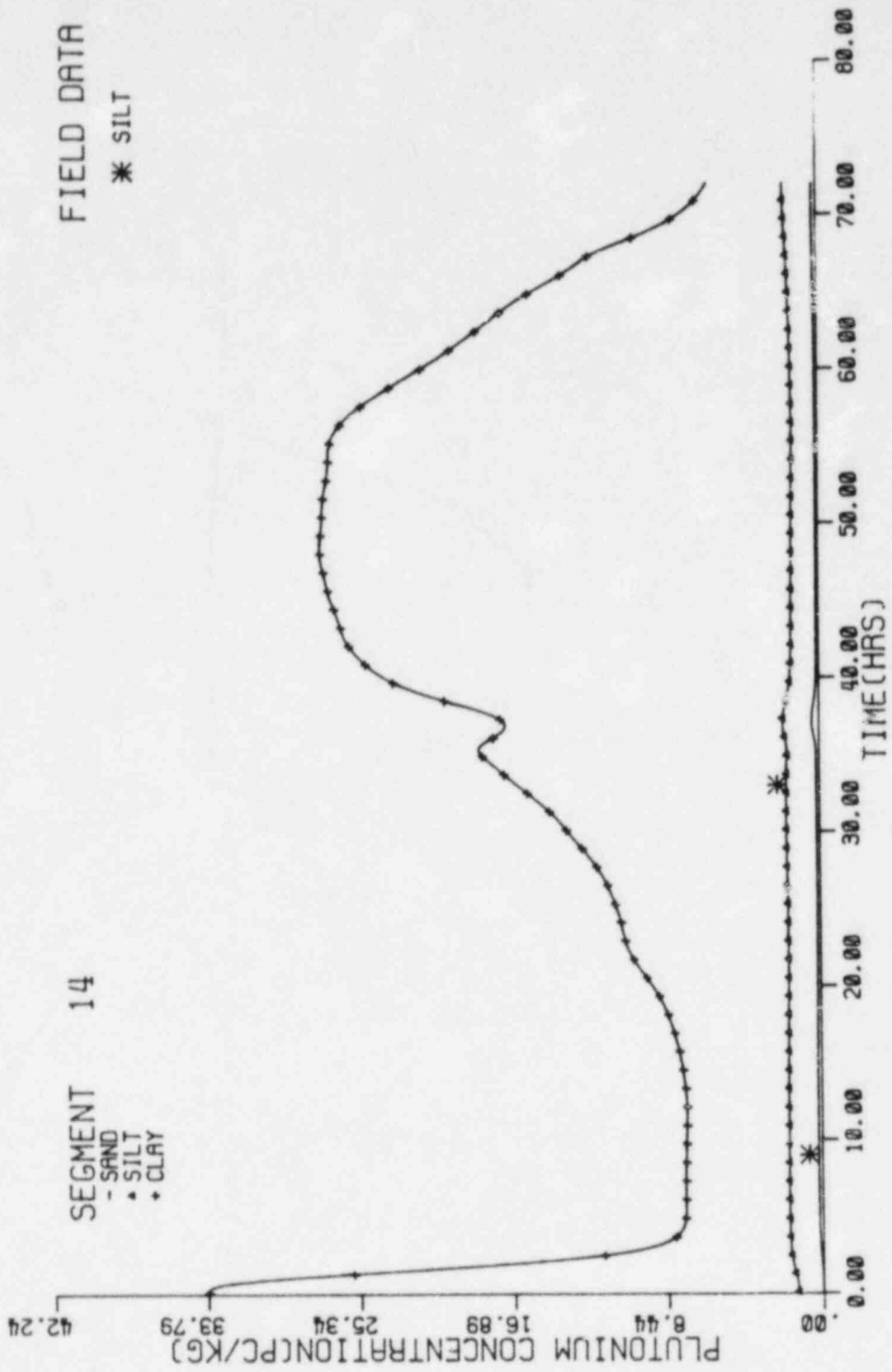


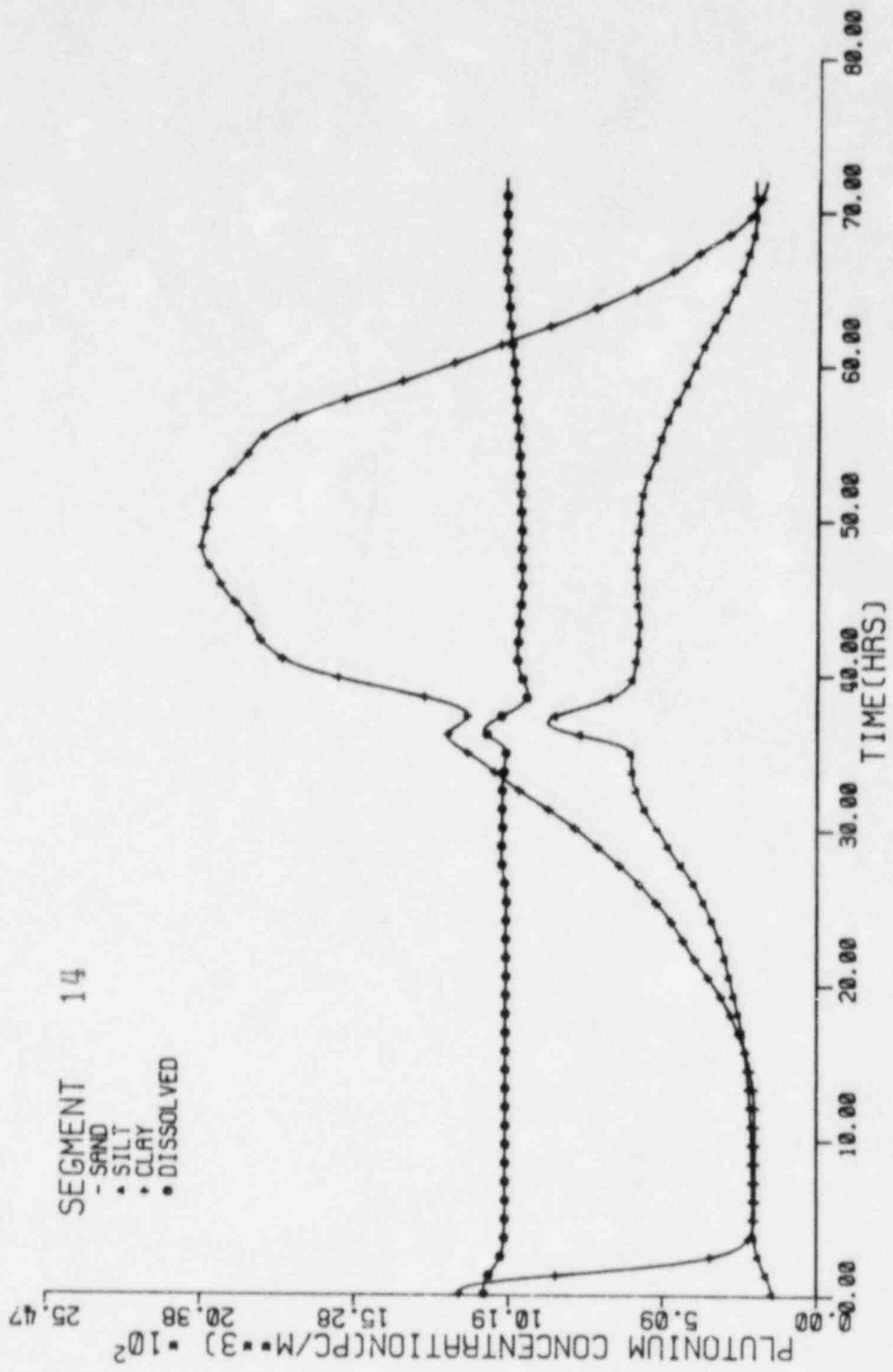


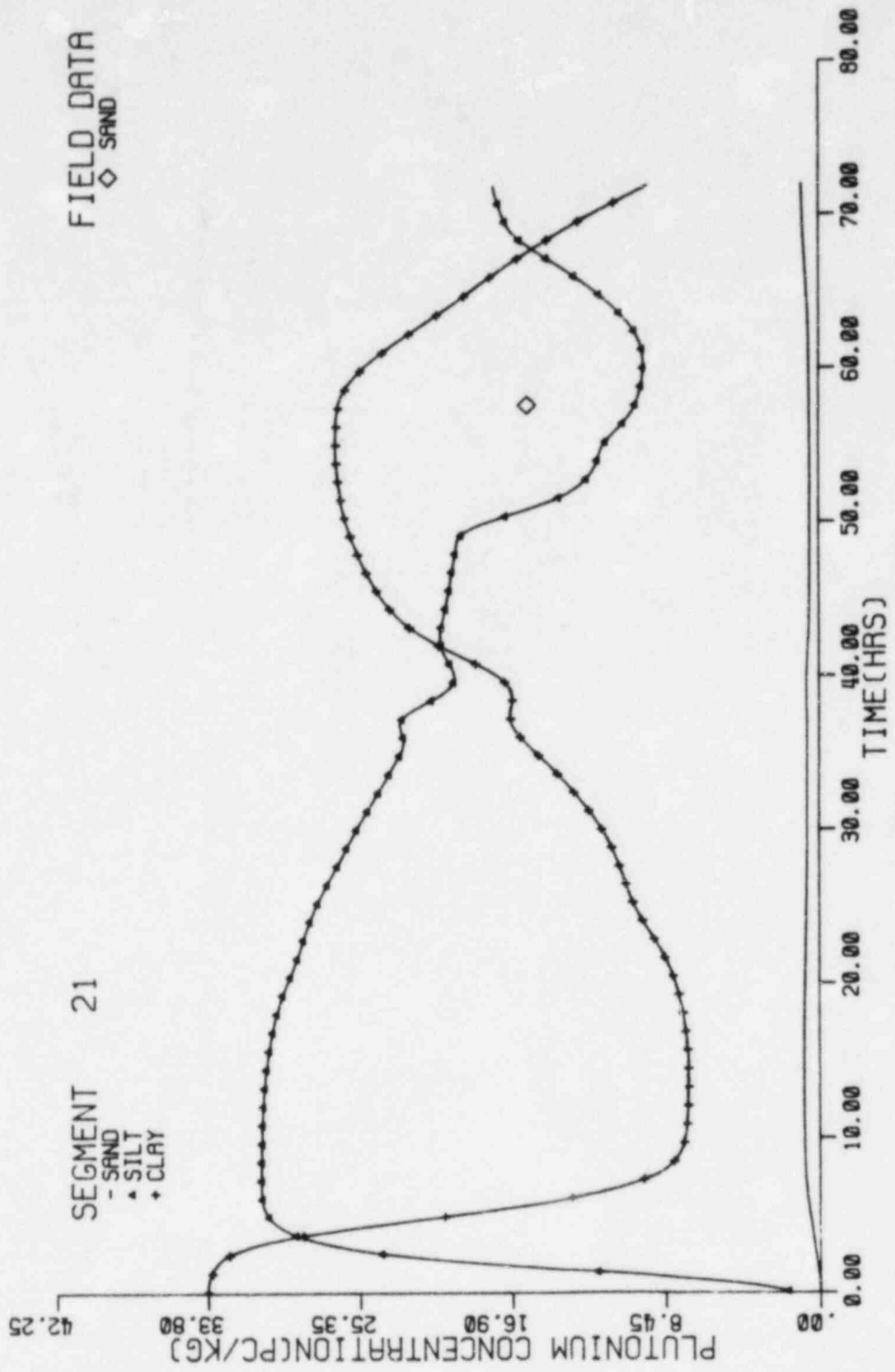


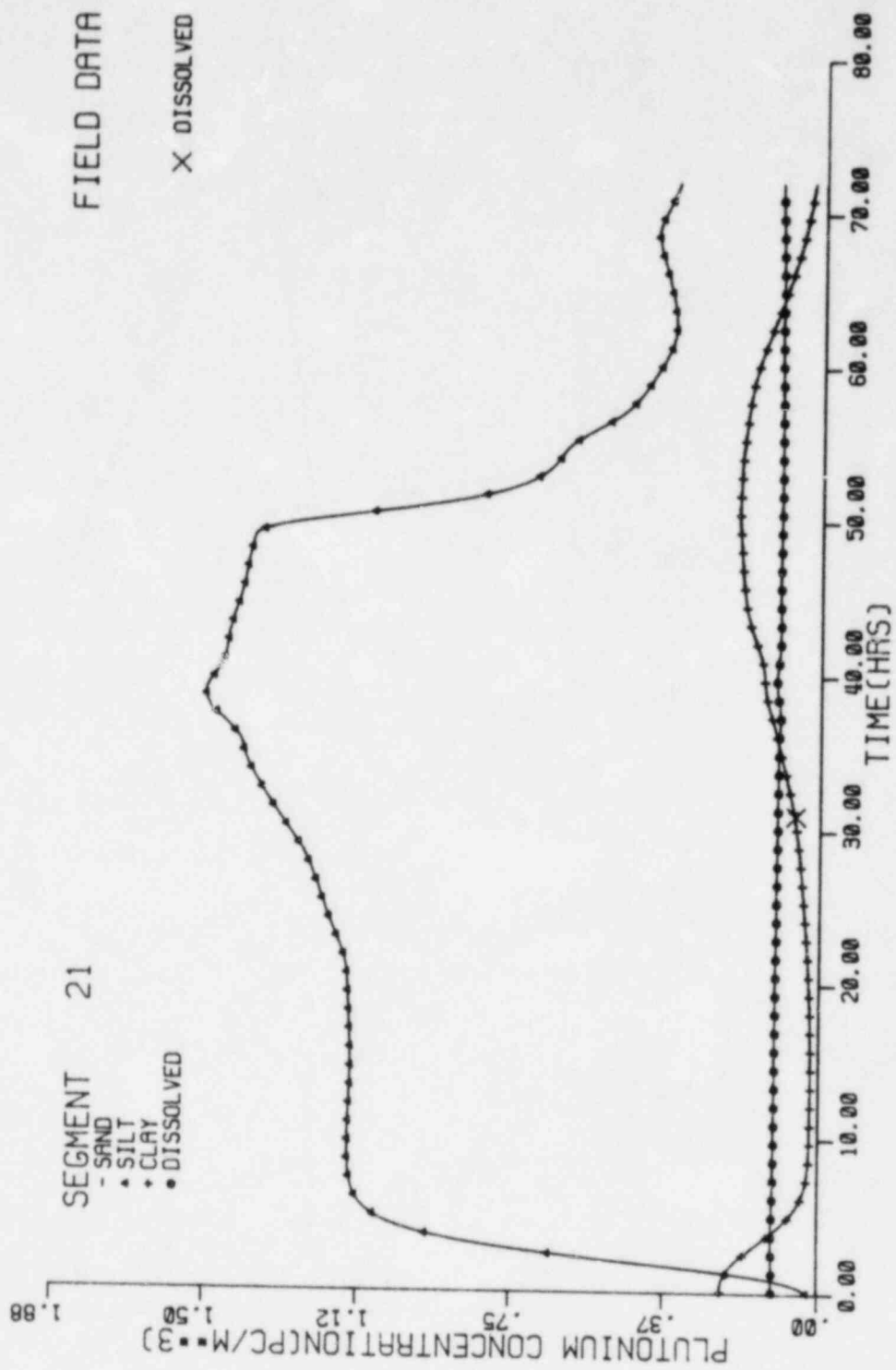


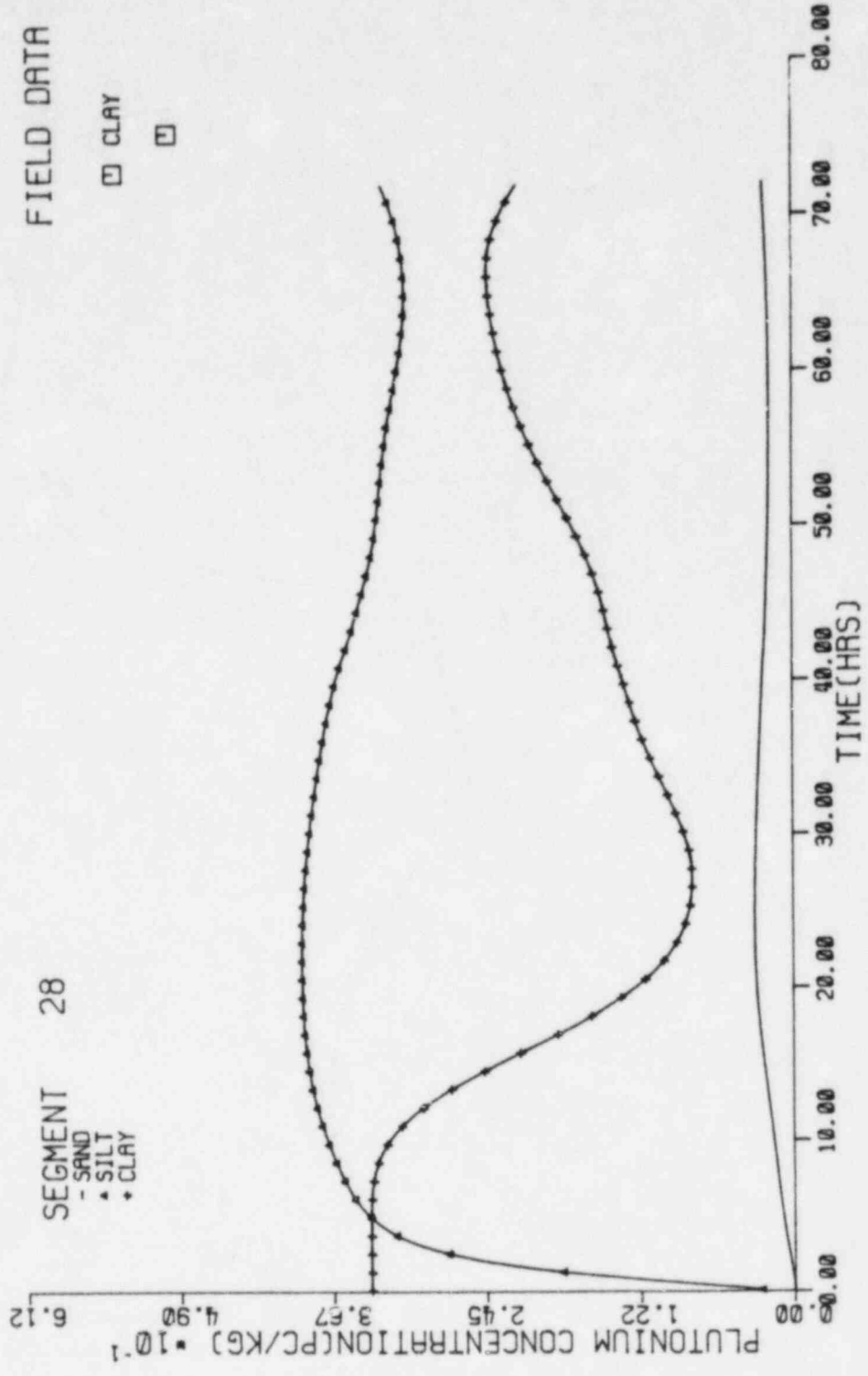




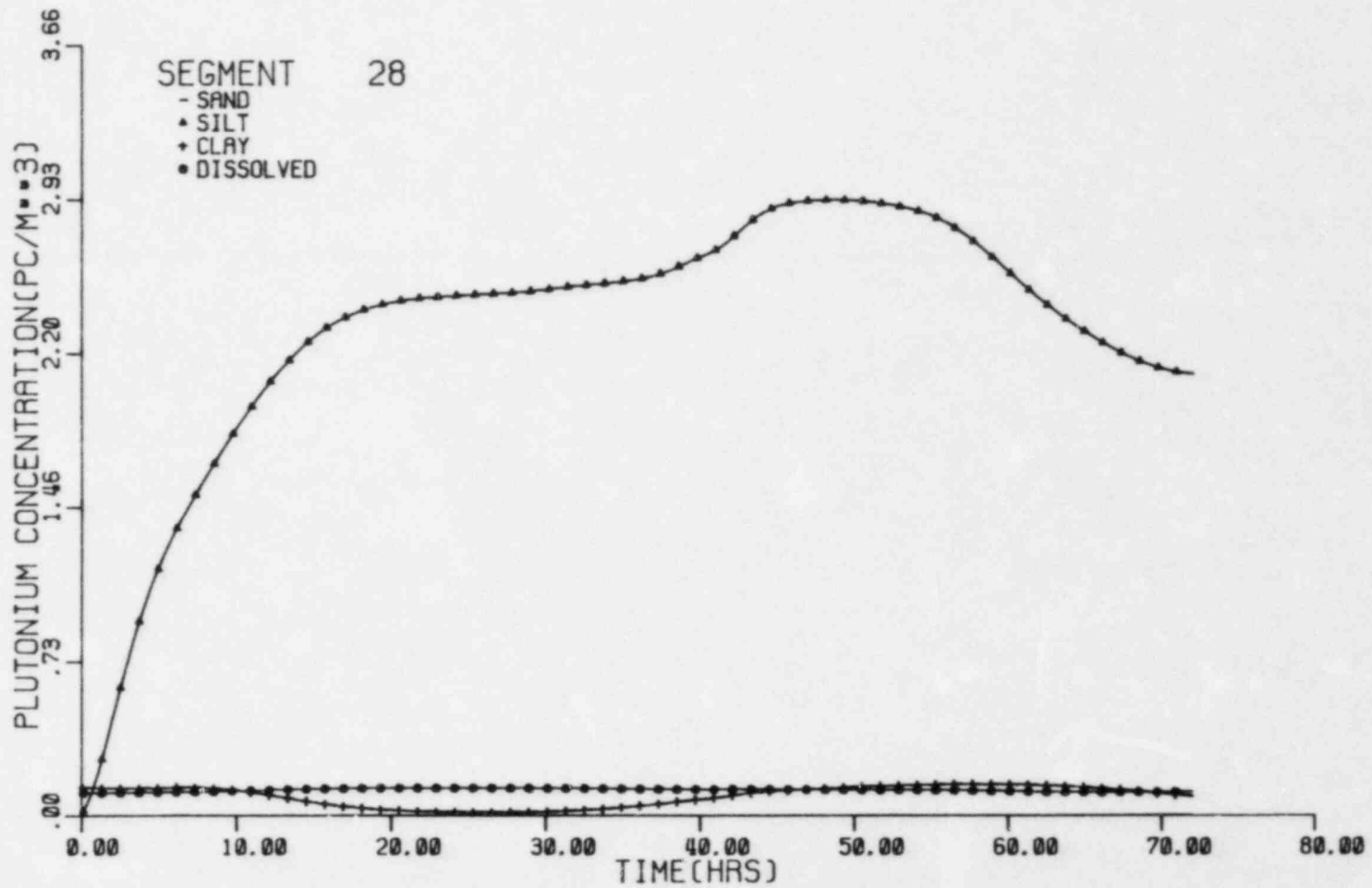


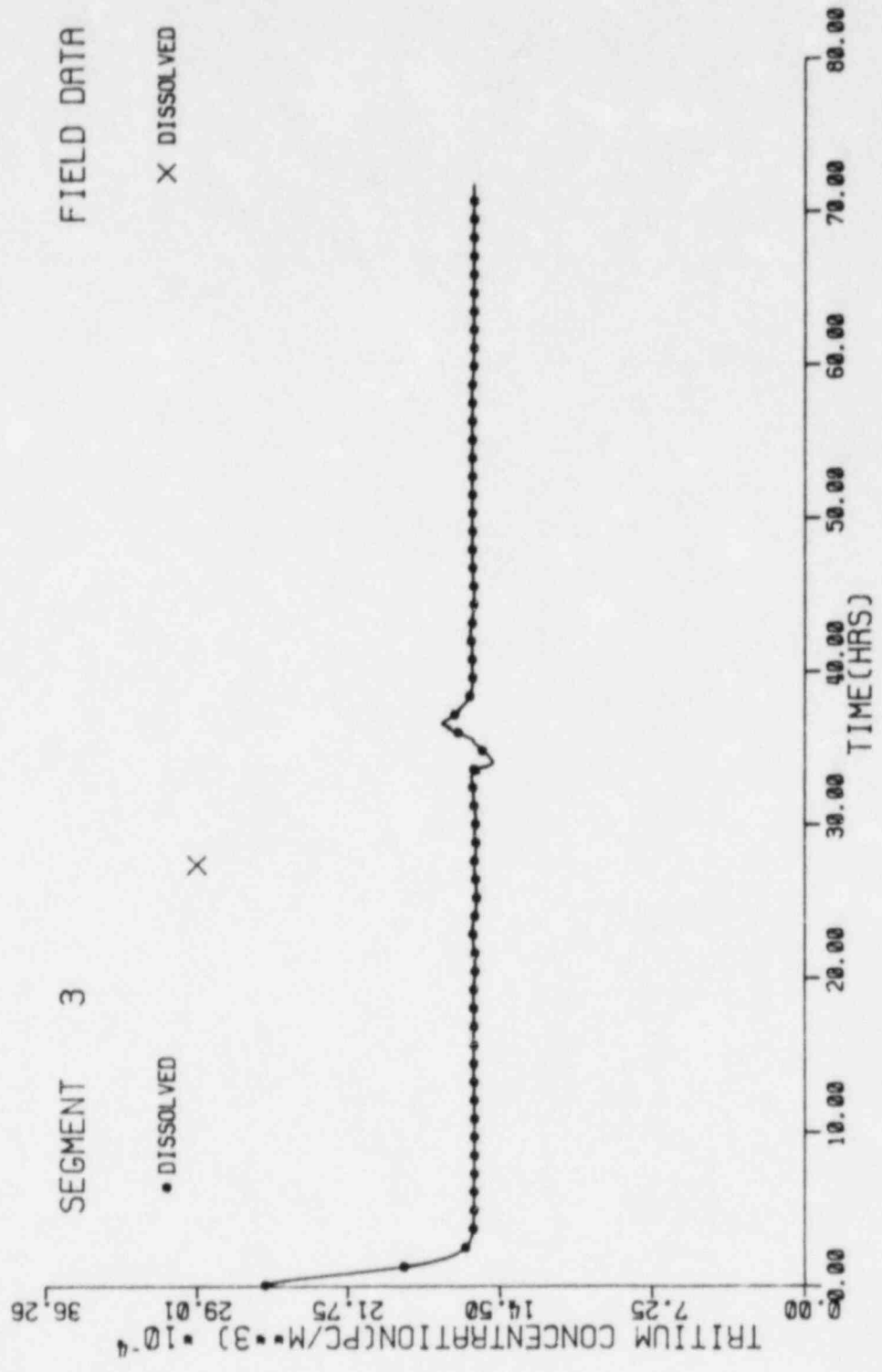




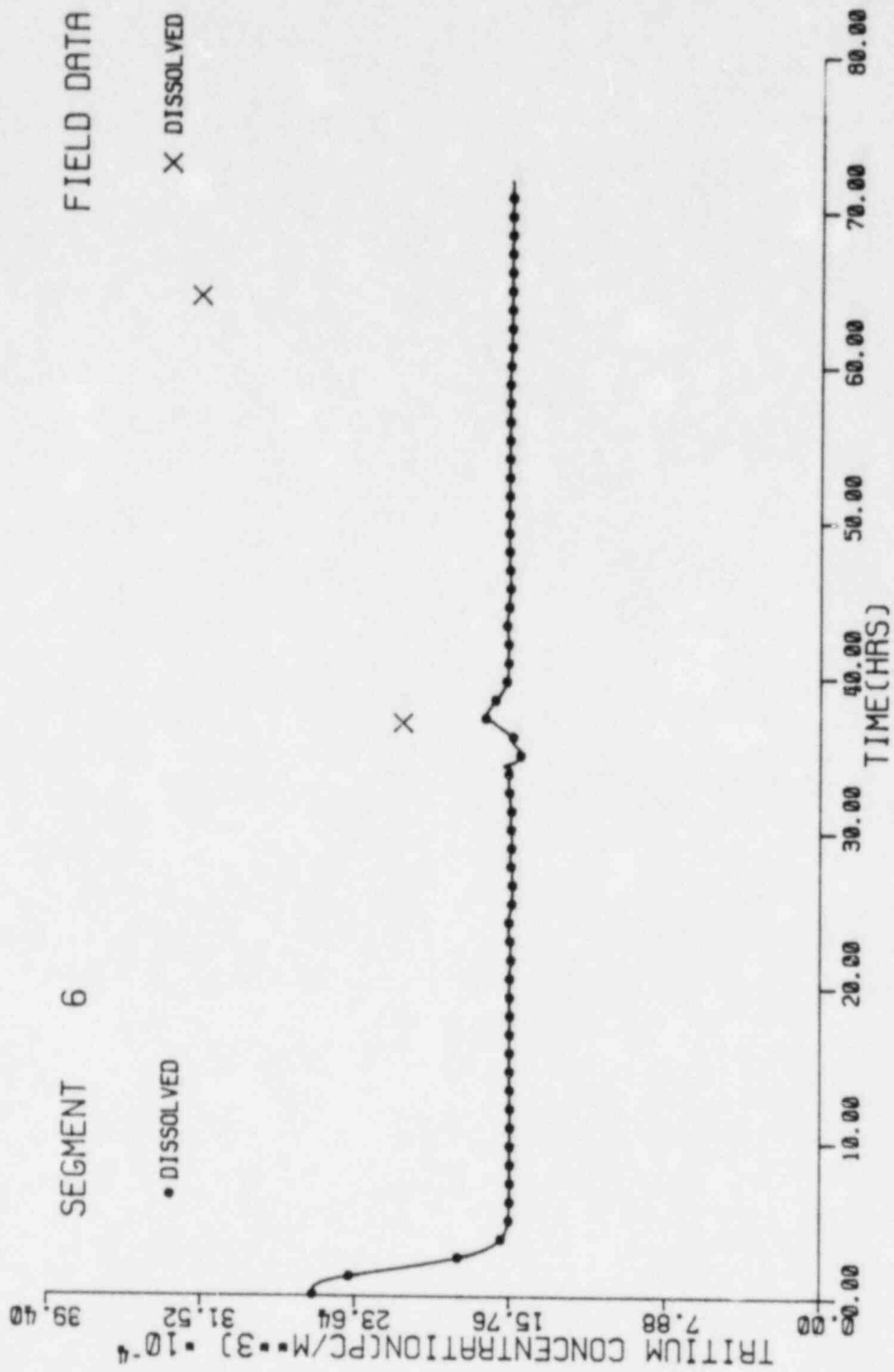


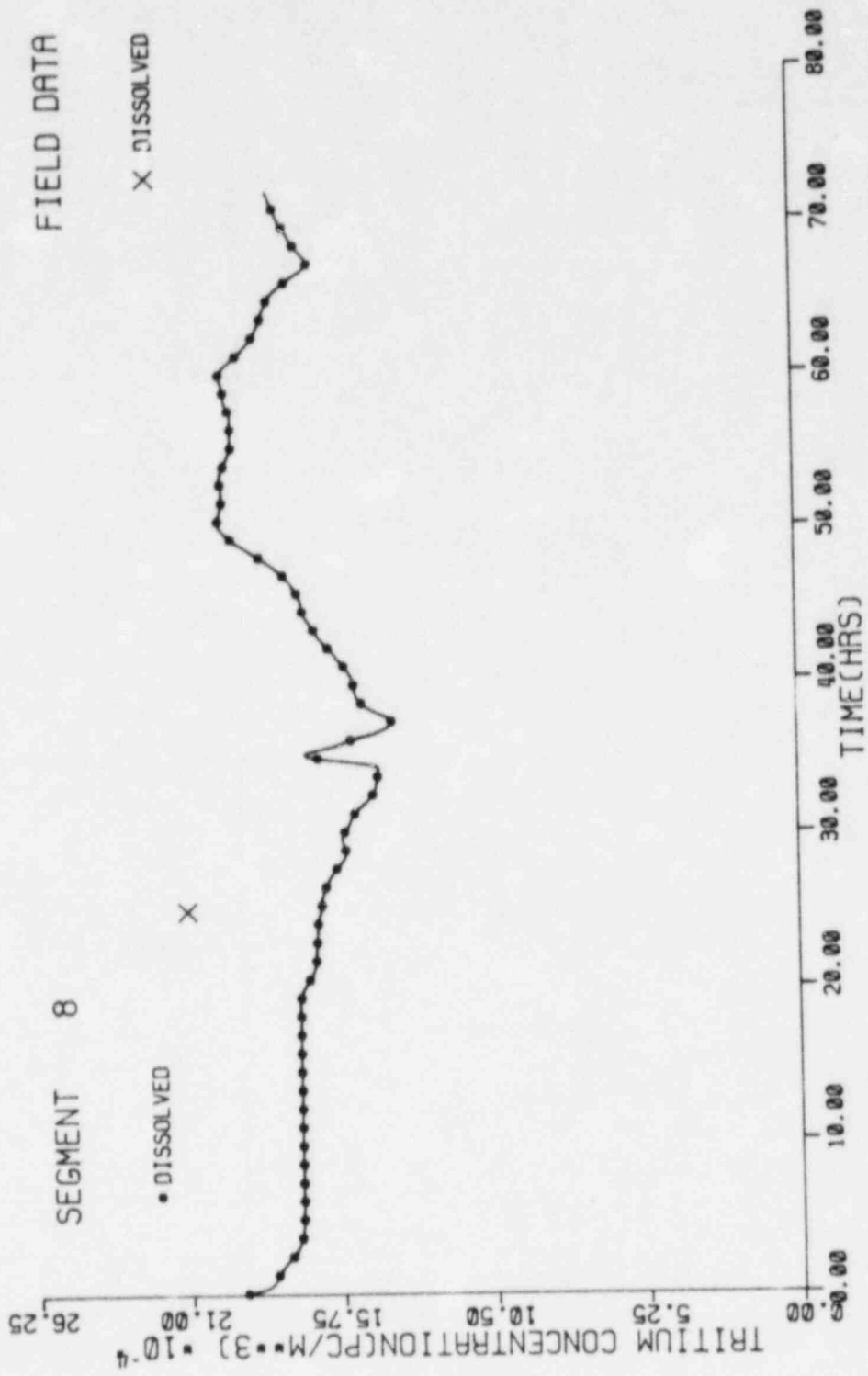
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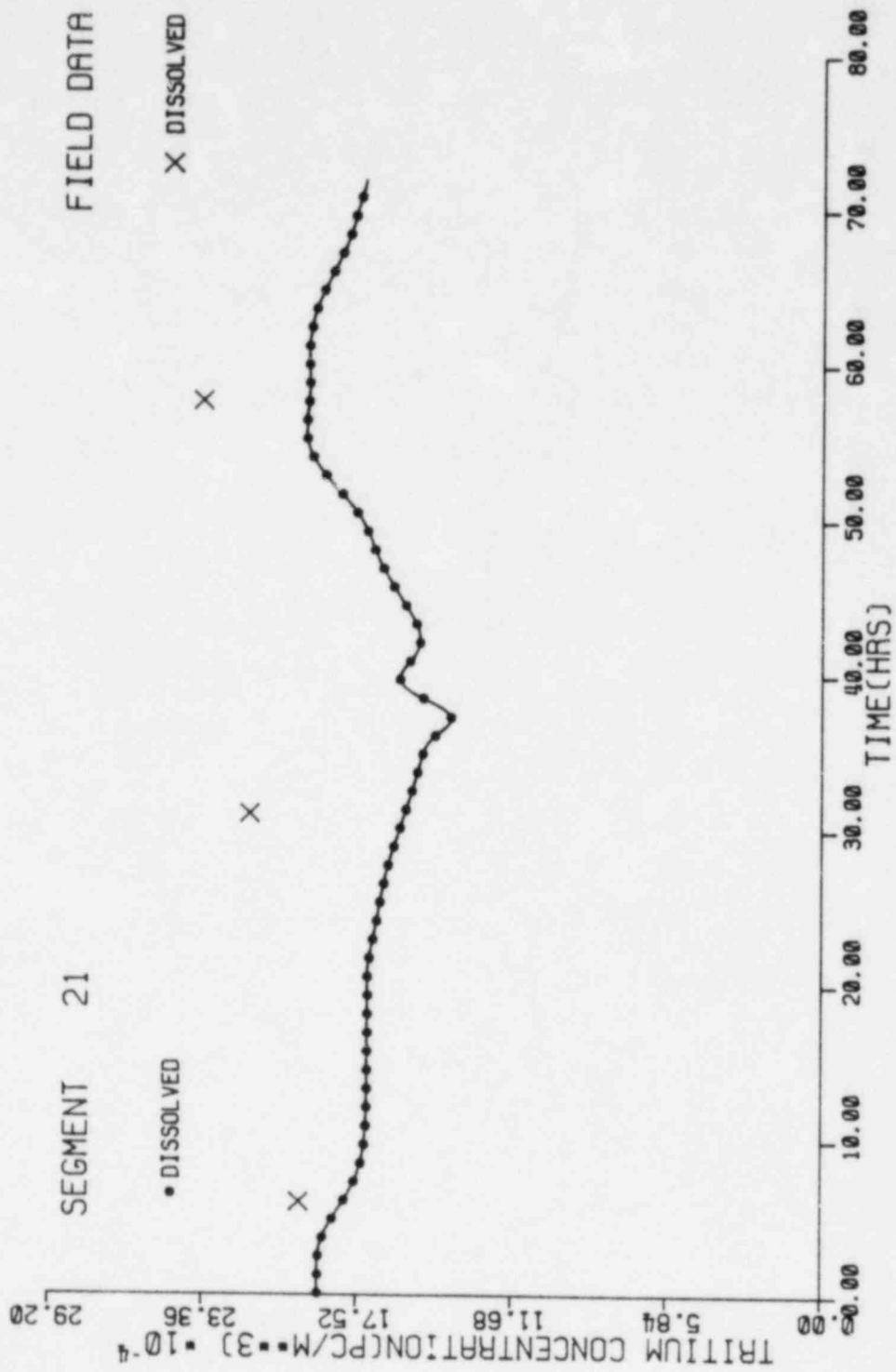


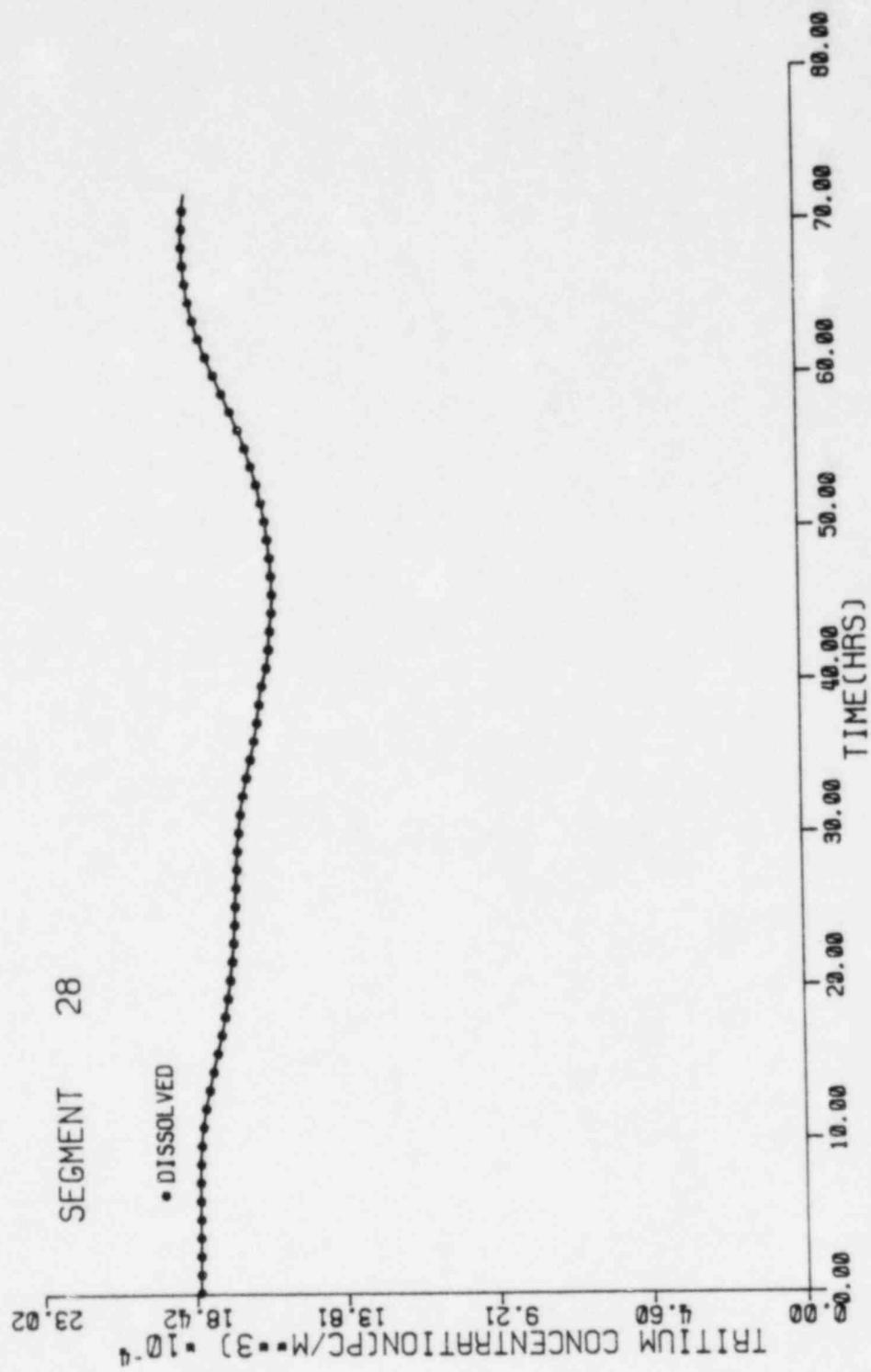


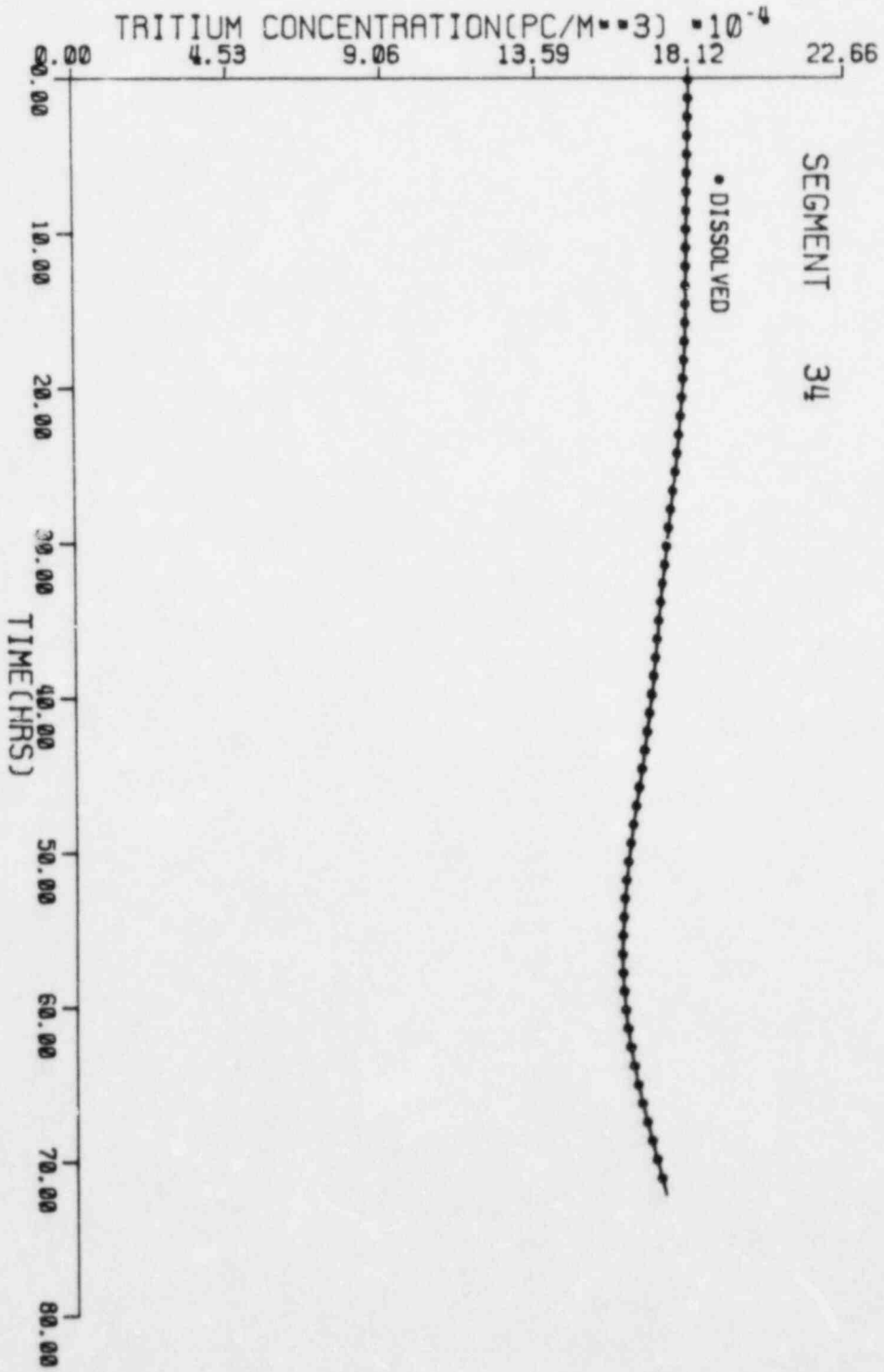




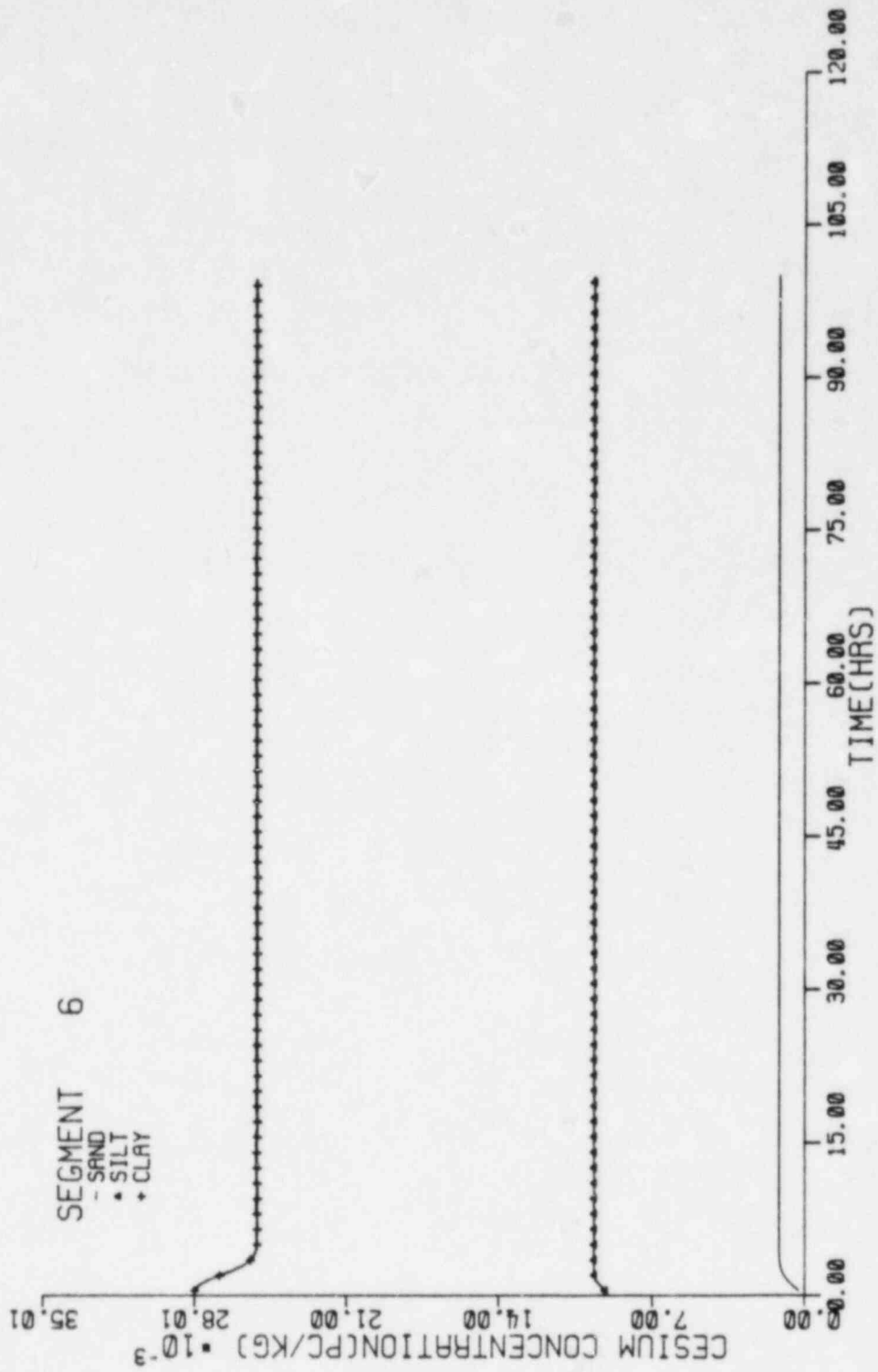


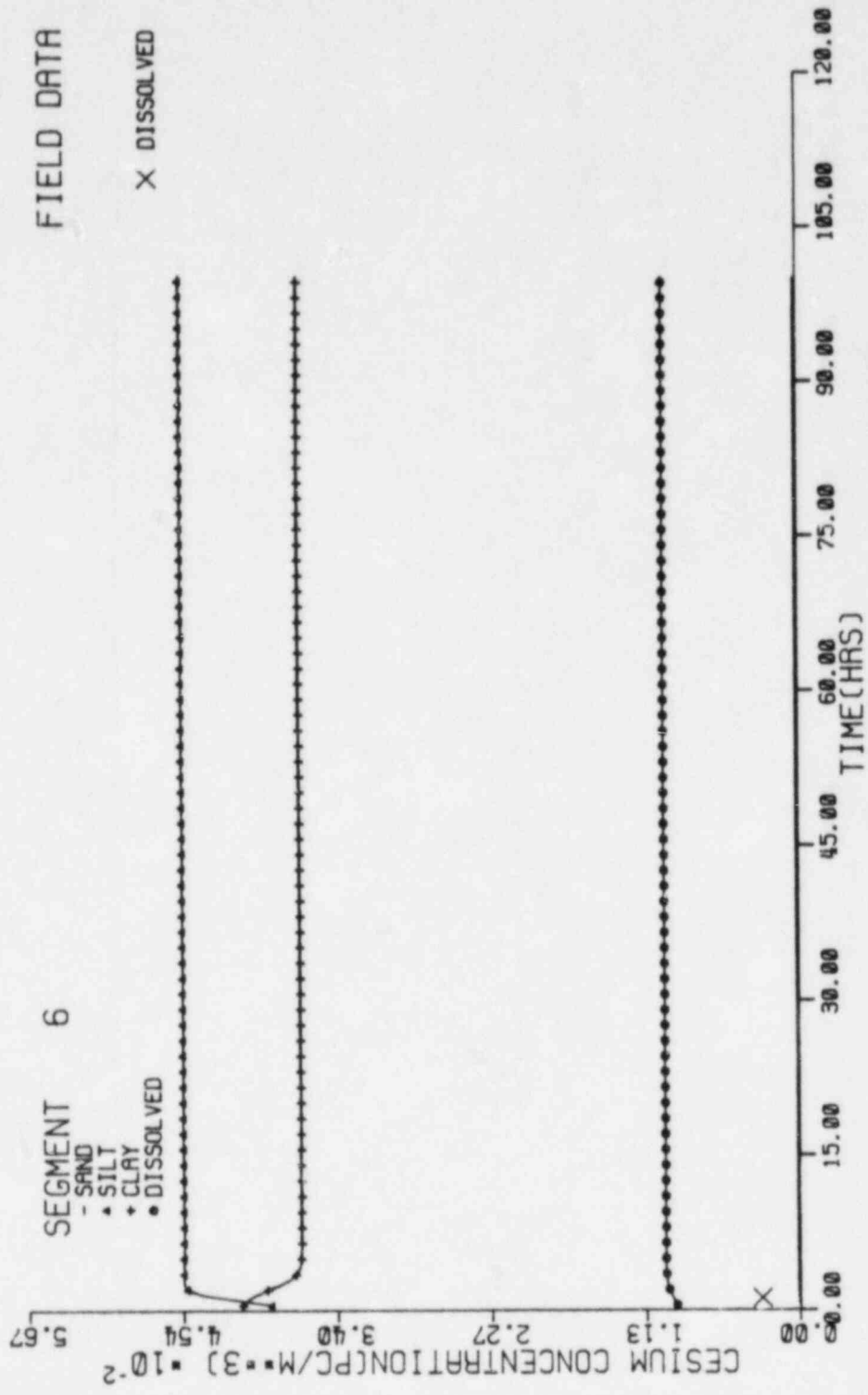




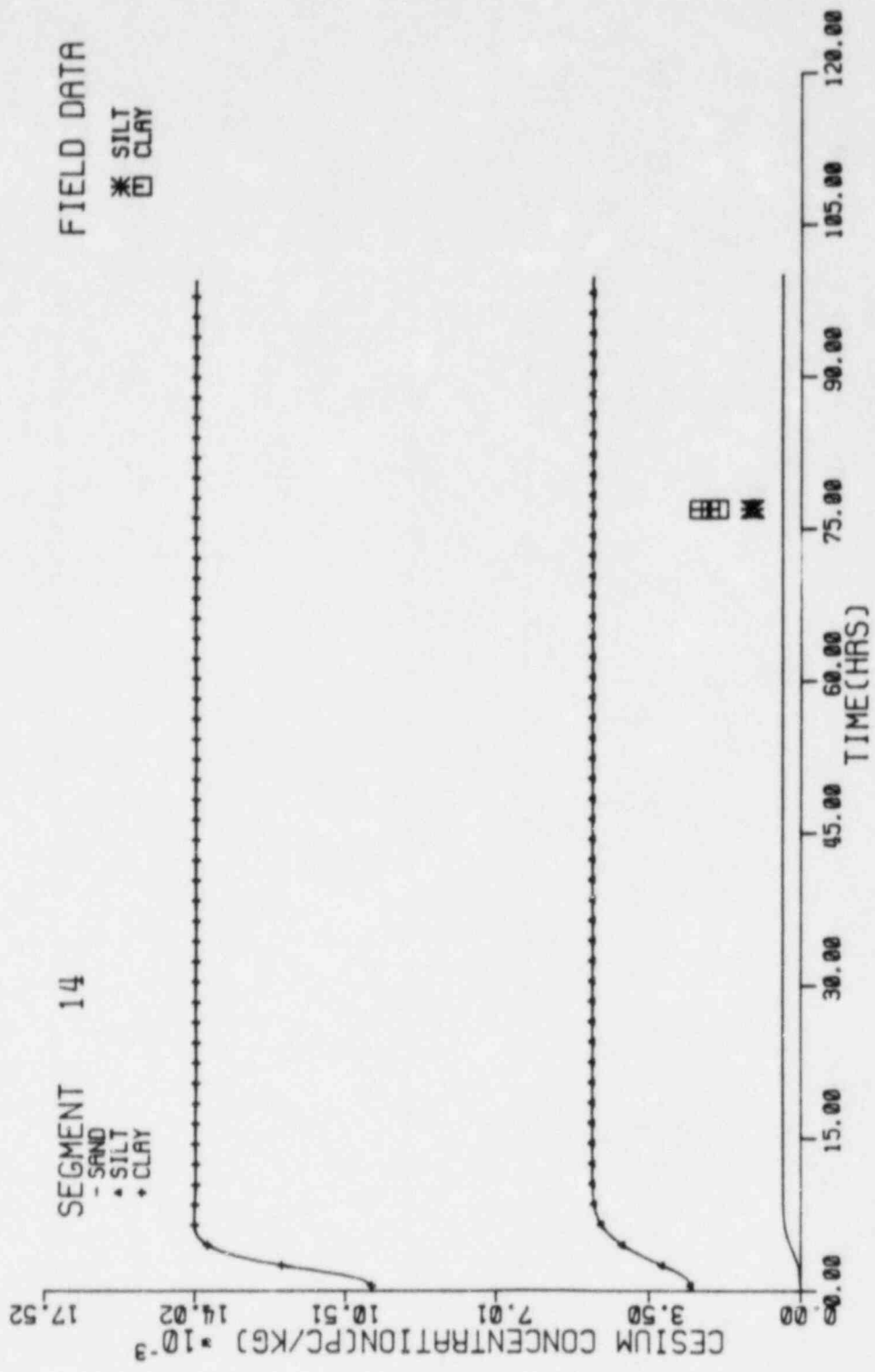


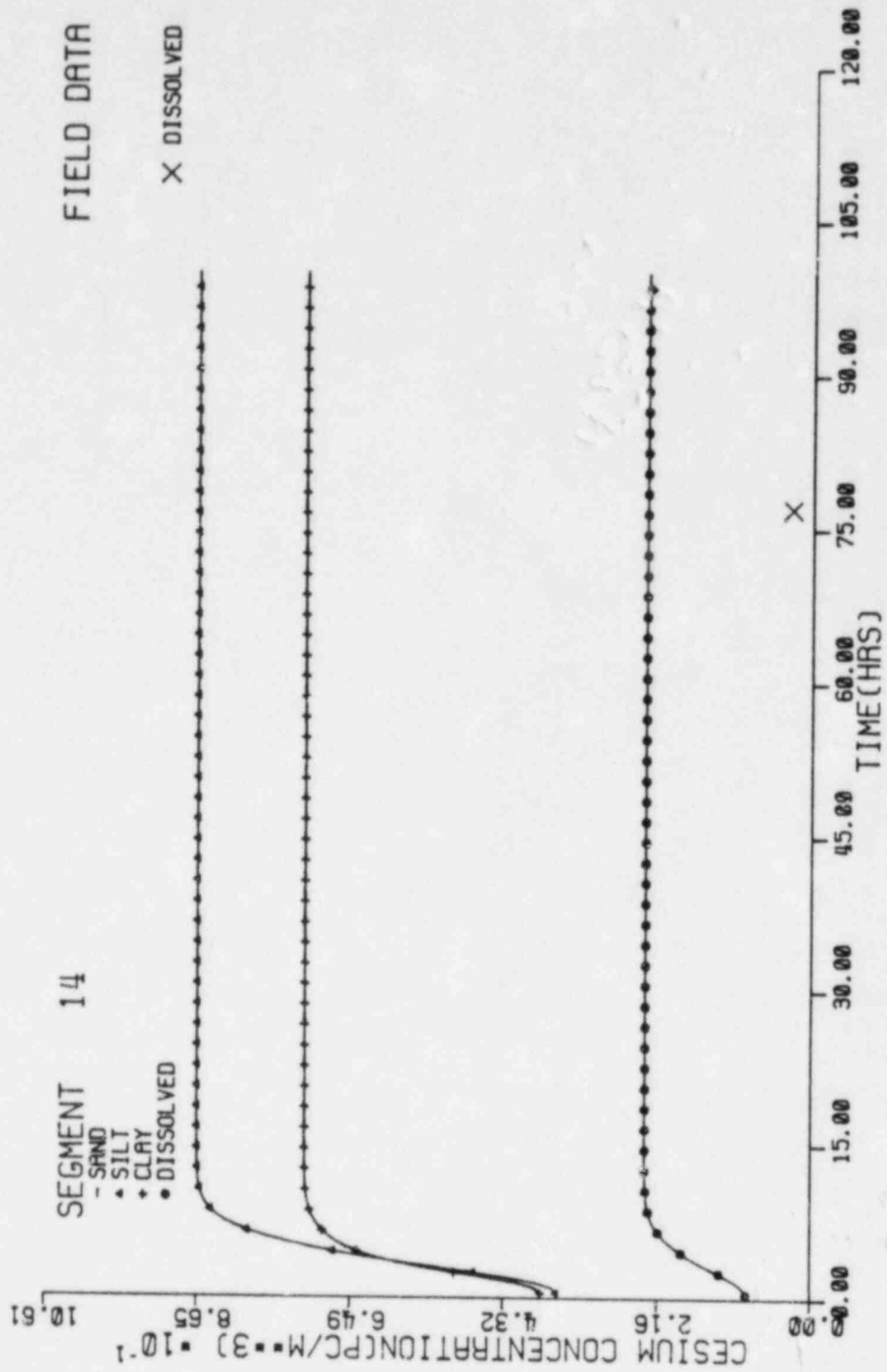
A.2.2. RADIONUCLIDE CONCENTRATIONS FOR PHASE 2

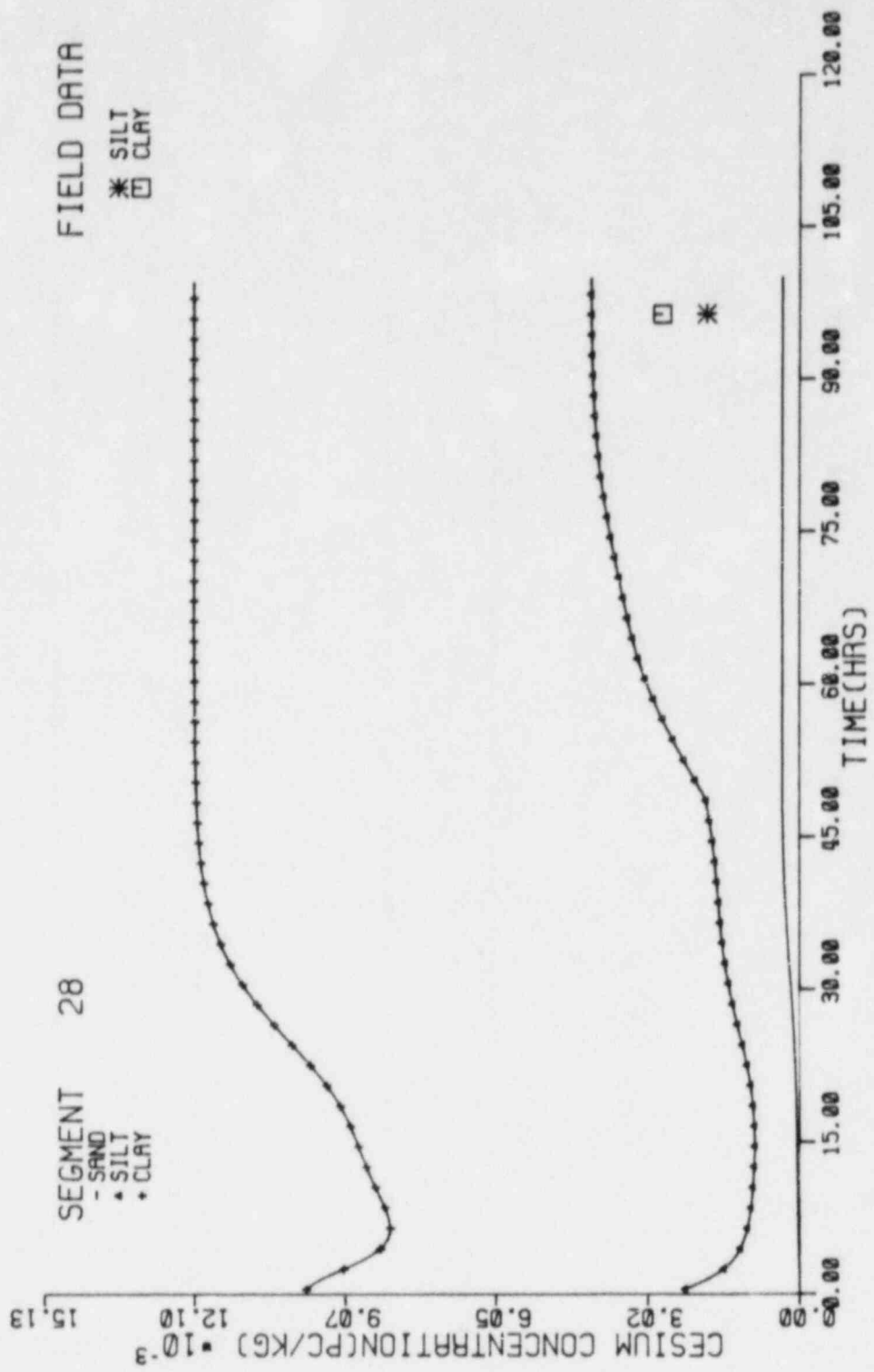


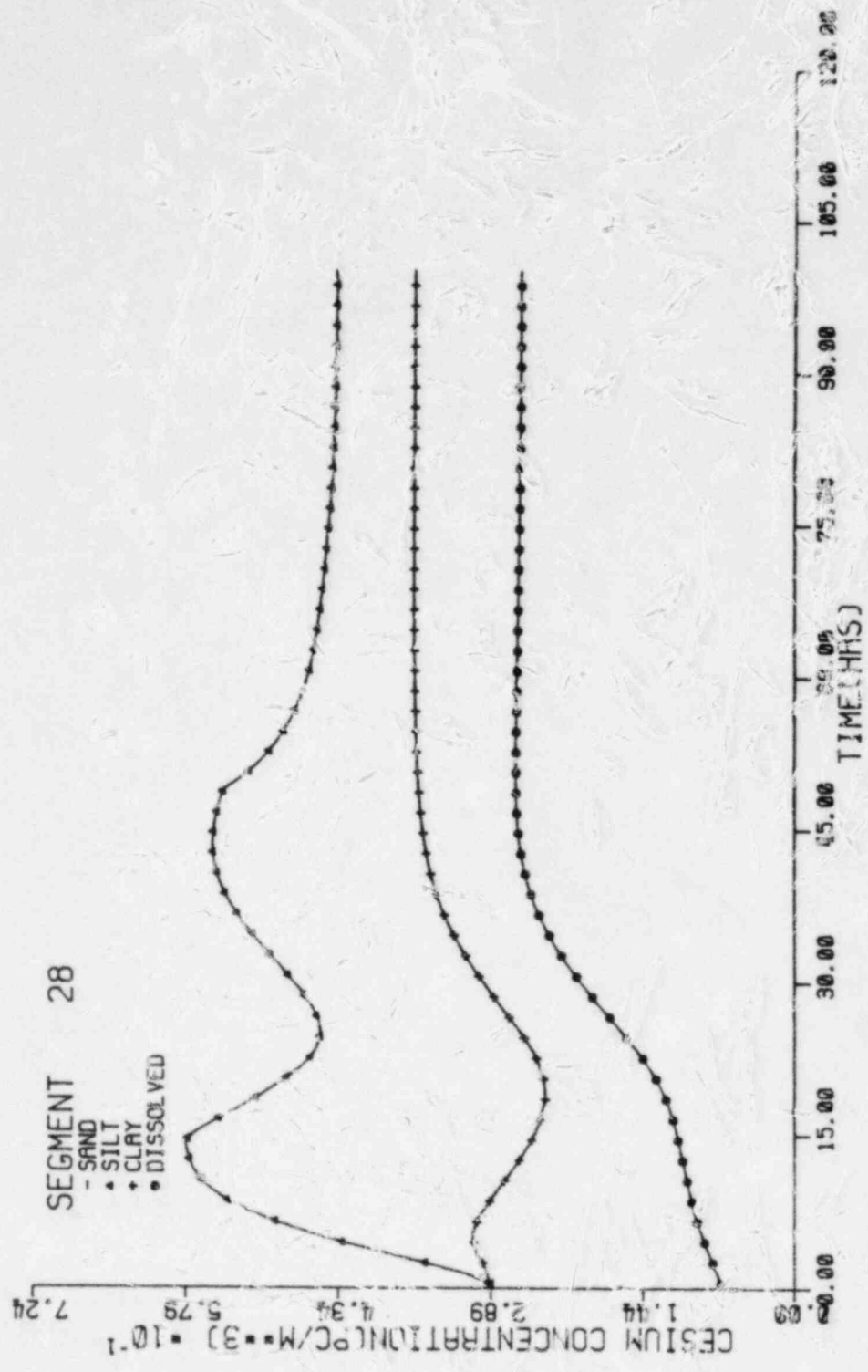


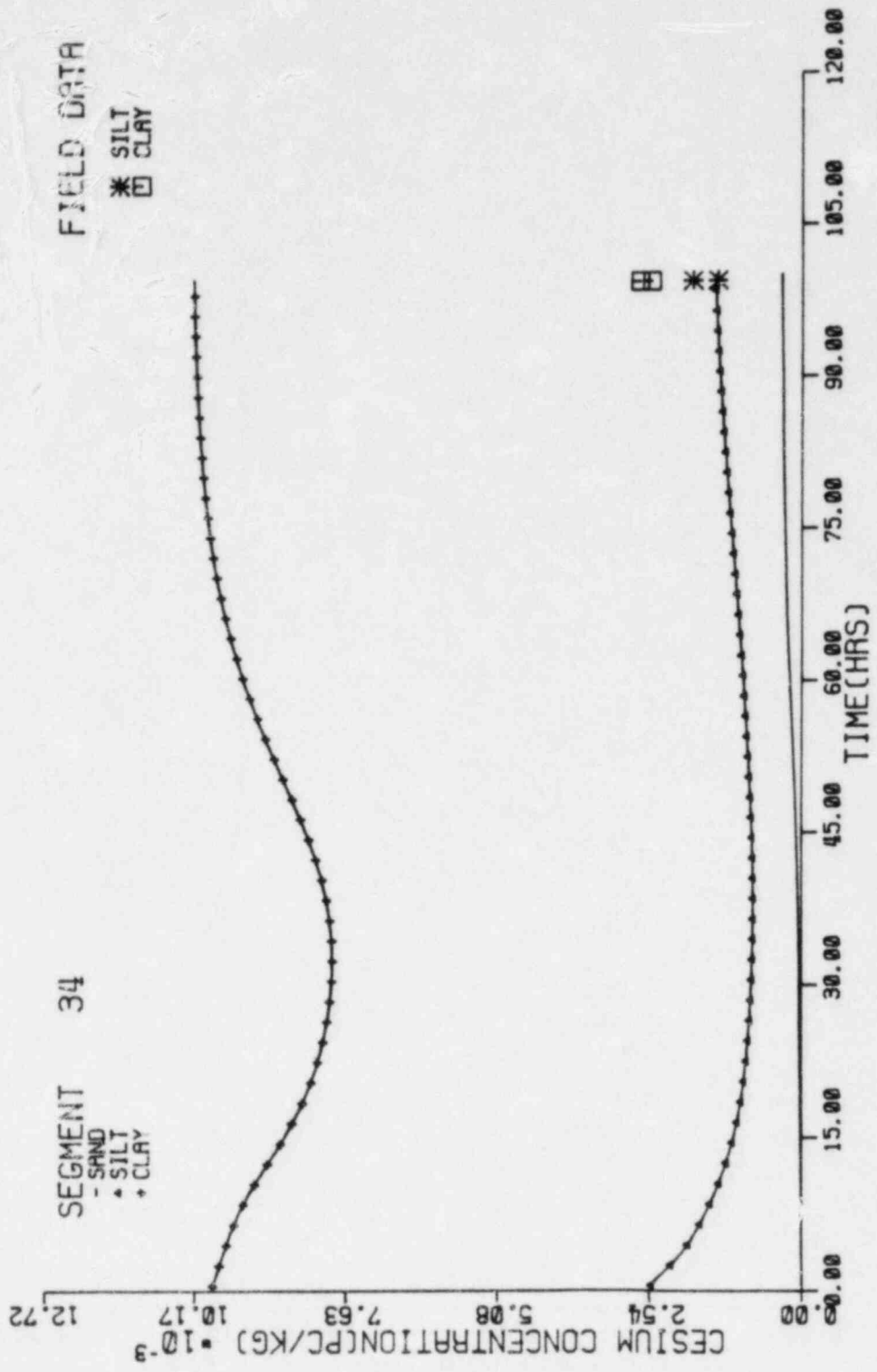


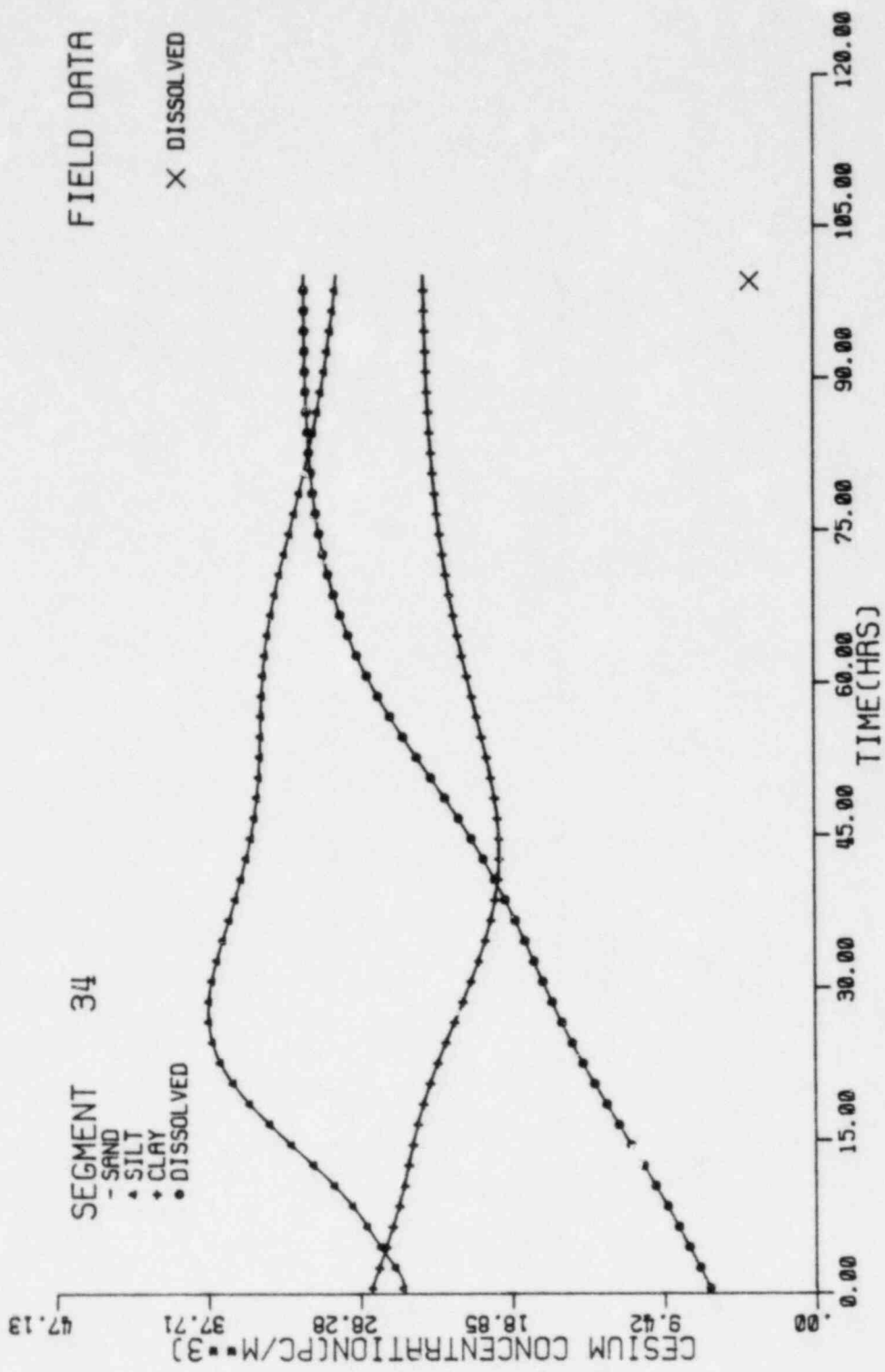


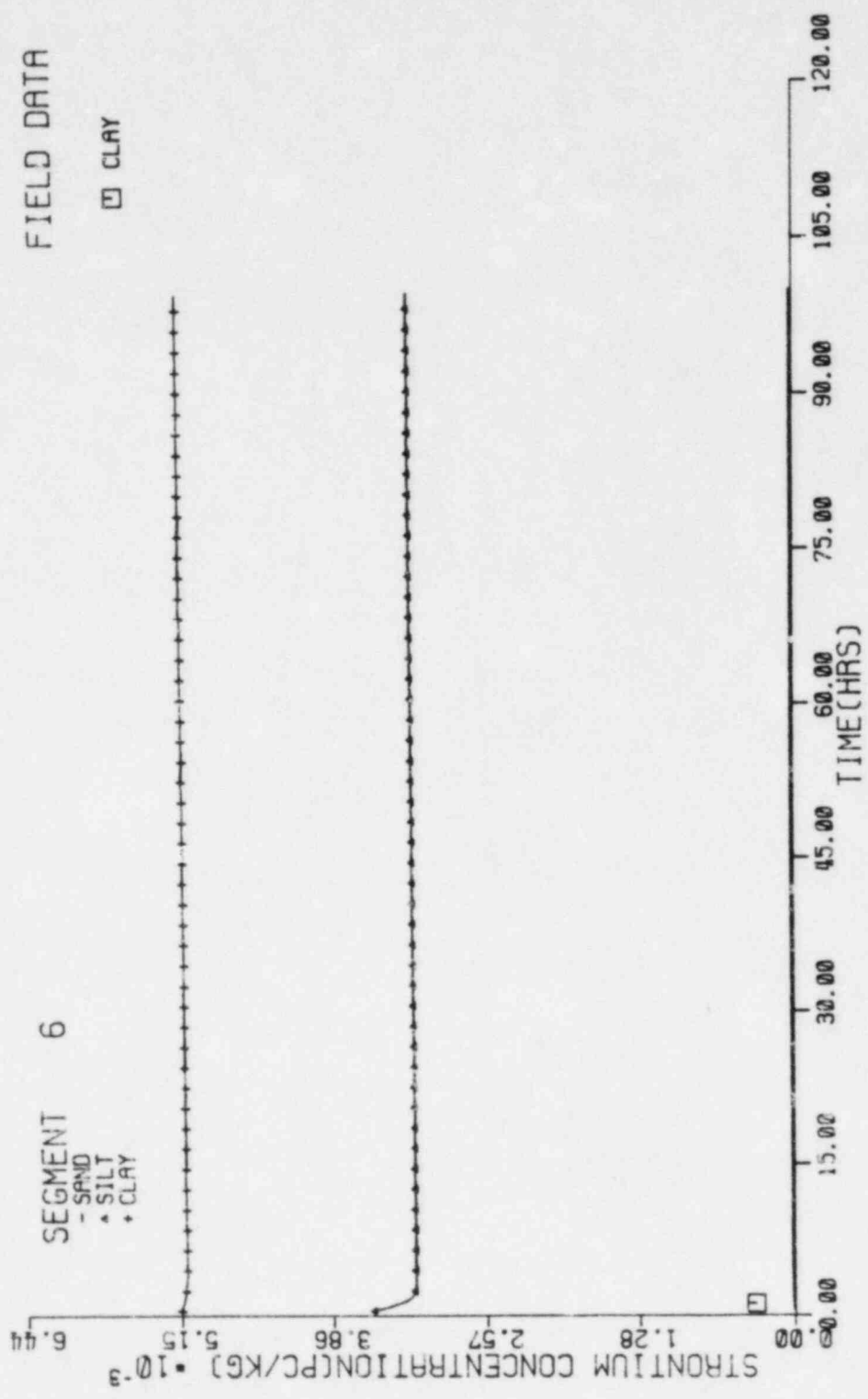


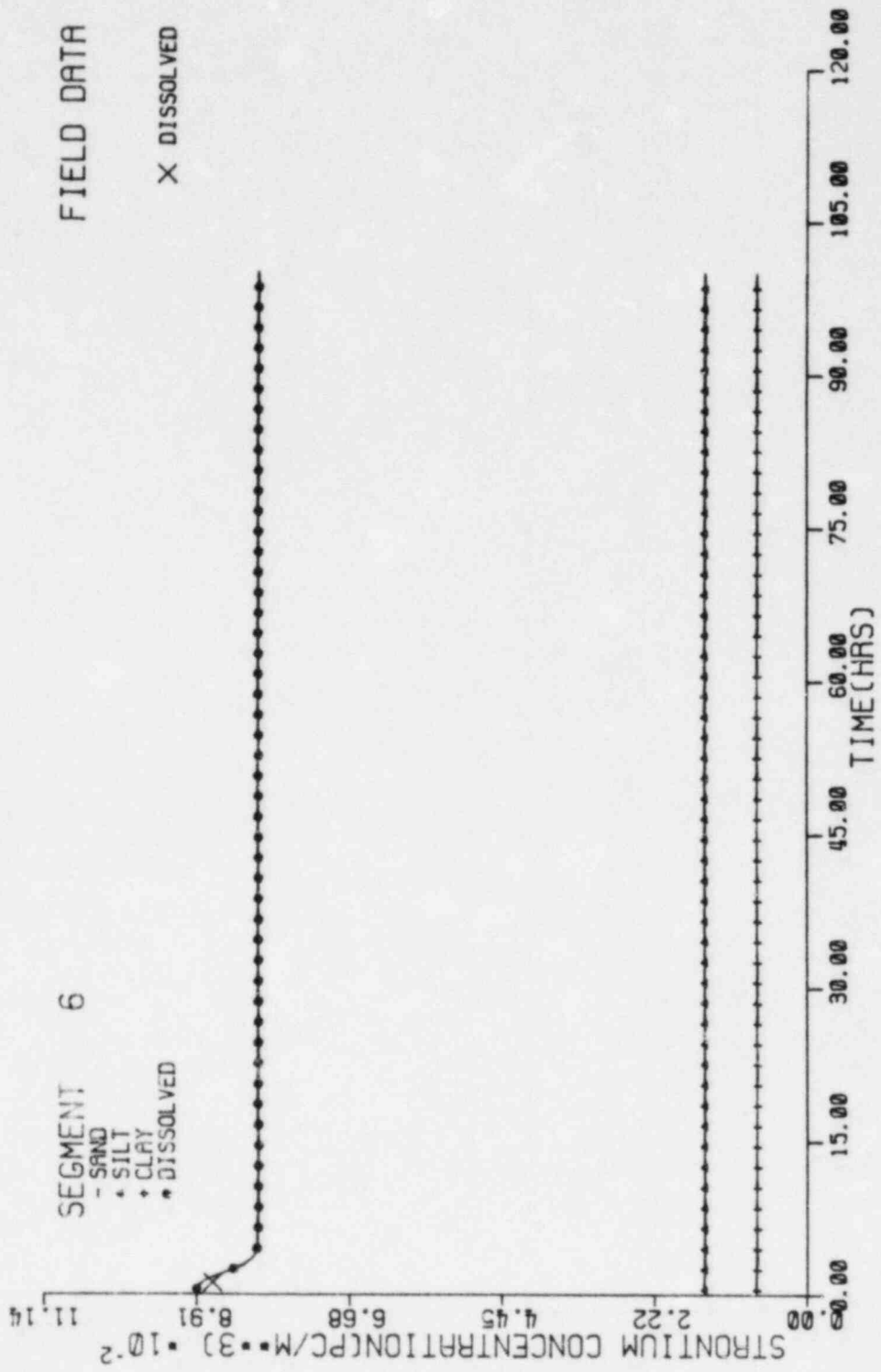




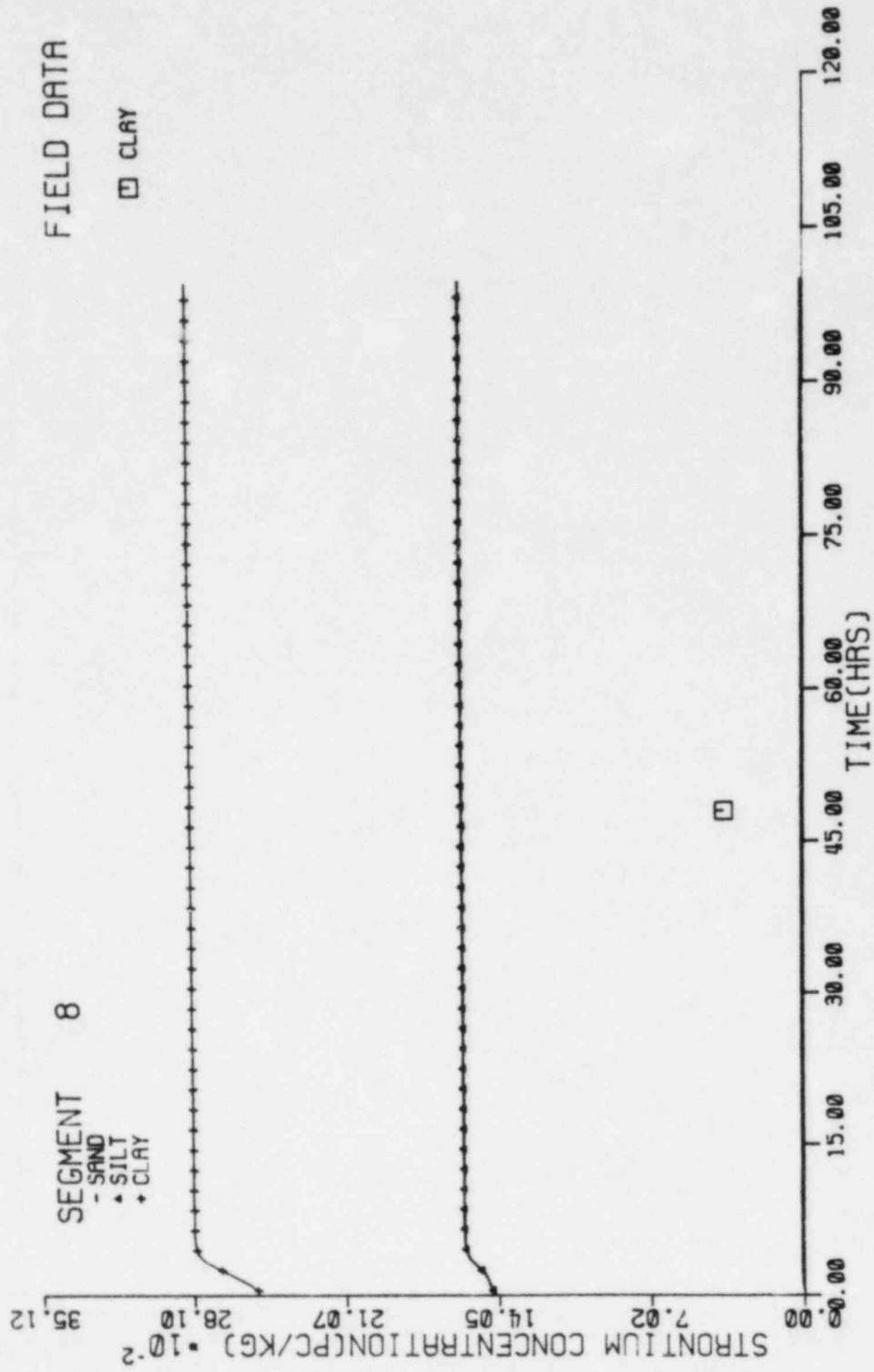


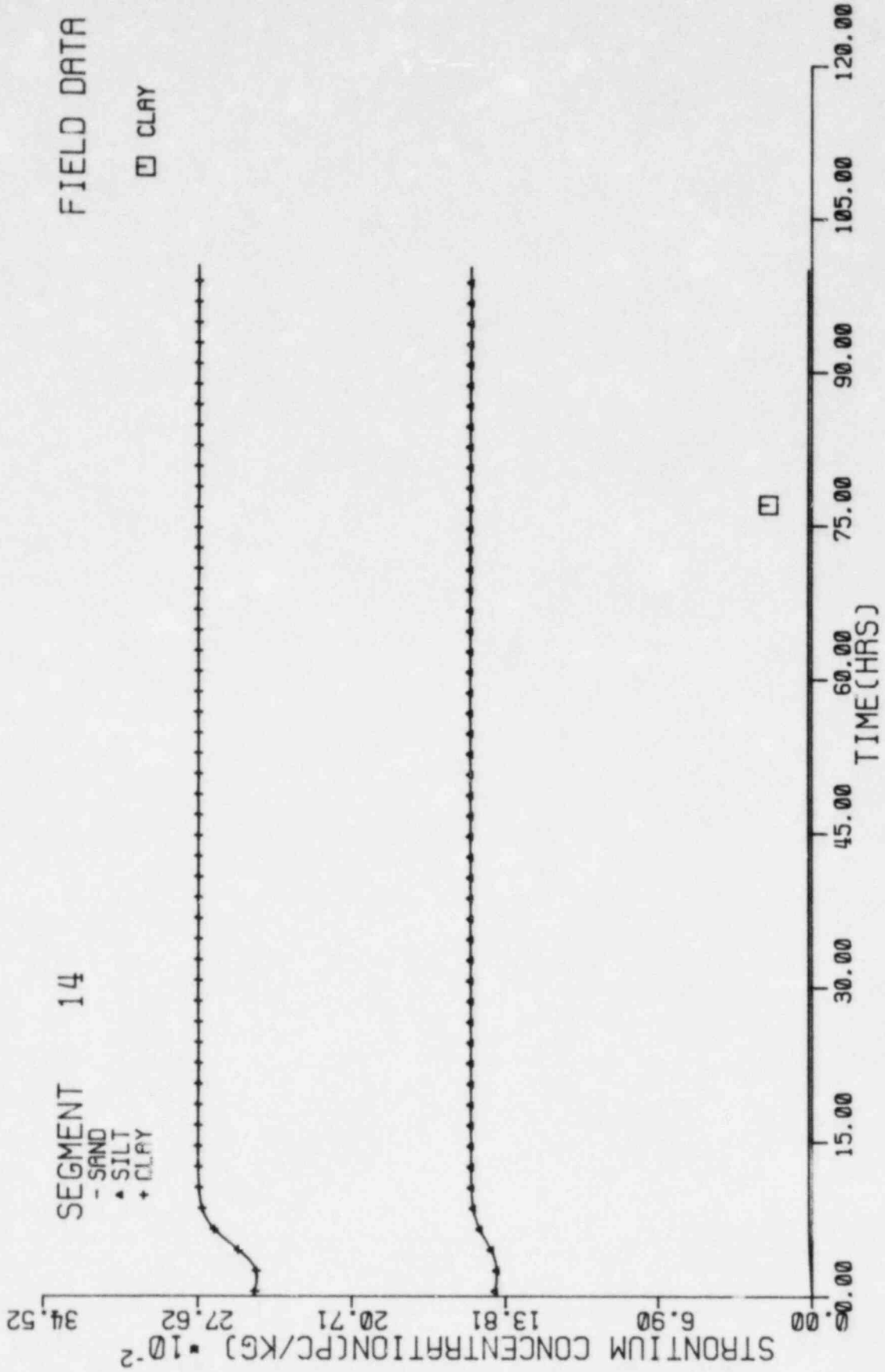


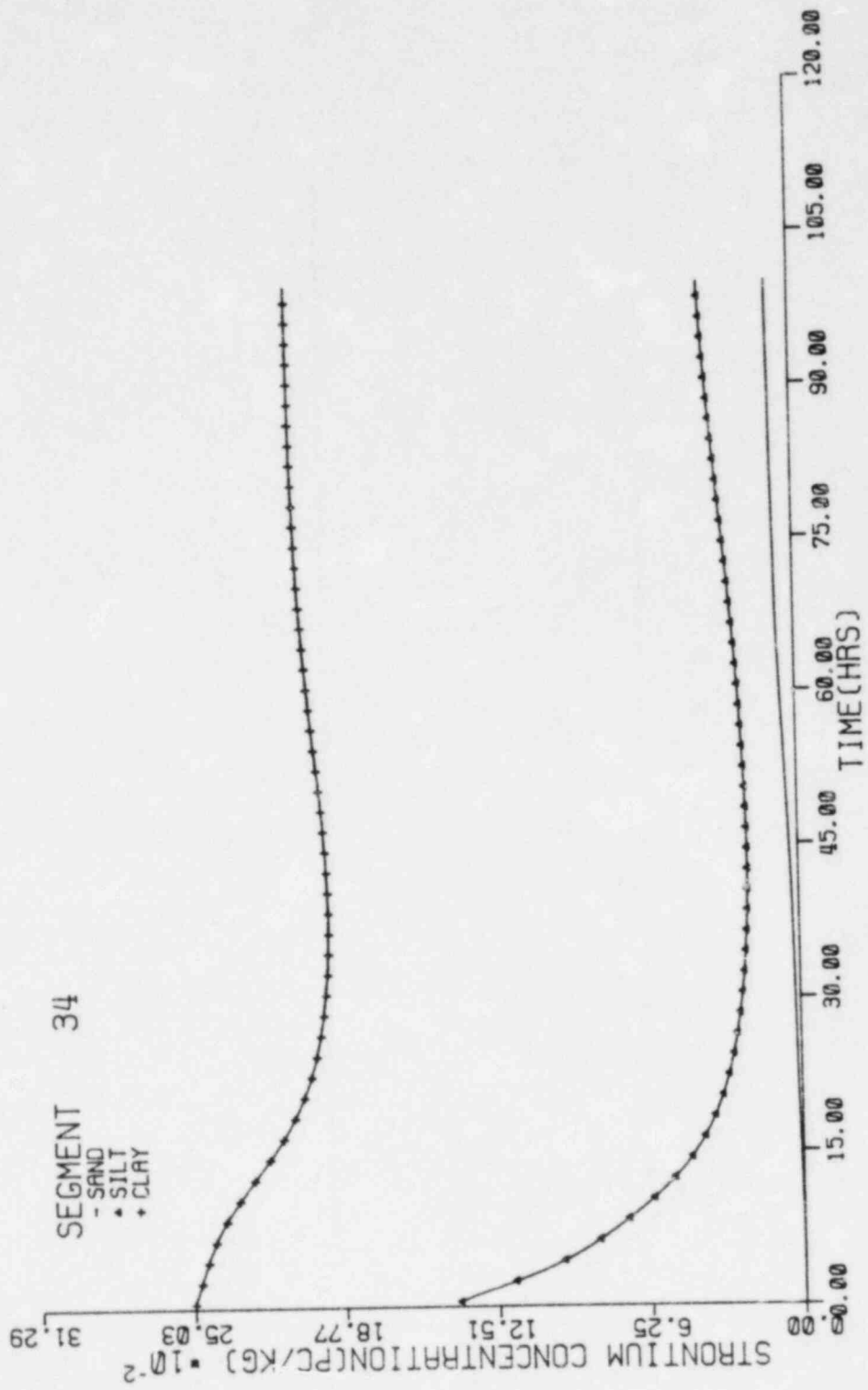


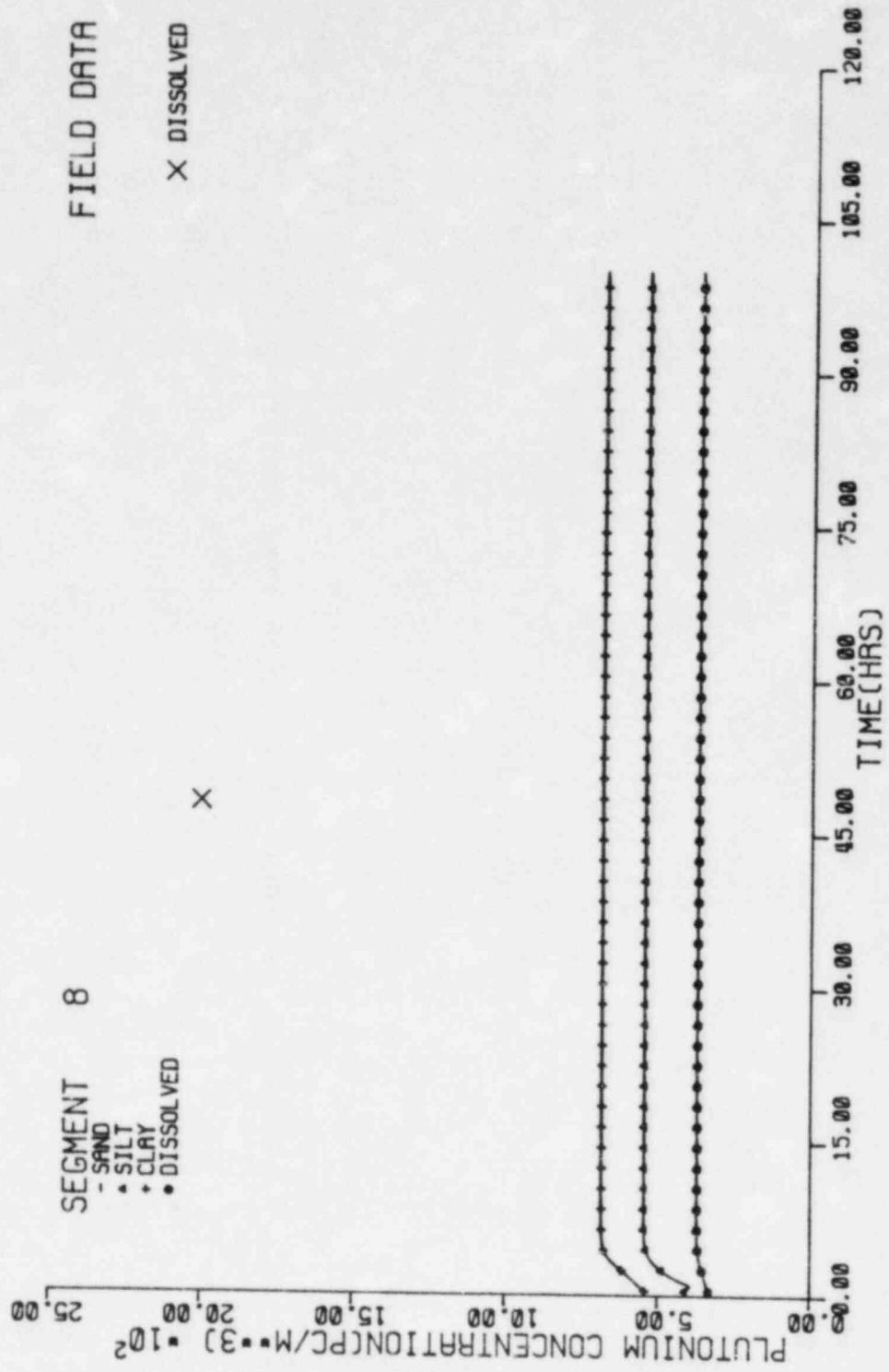


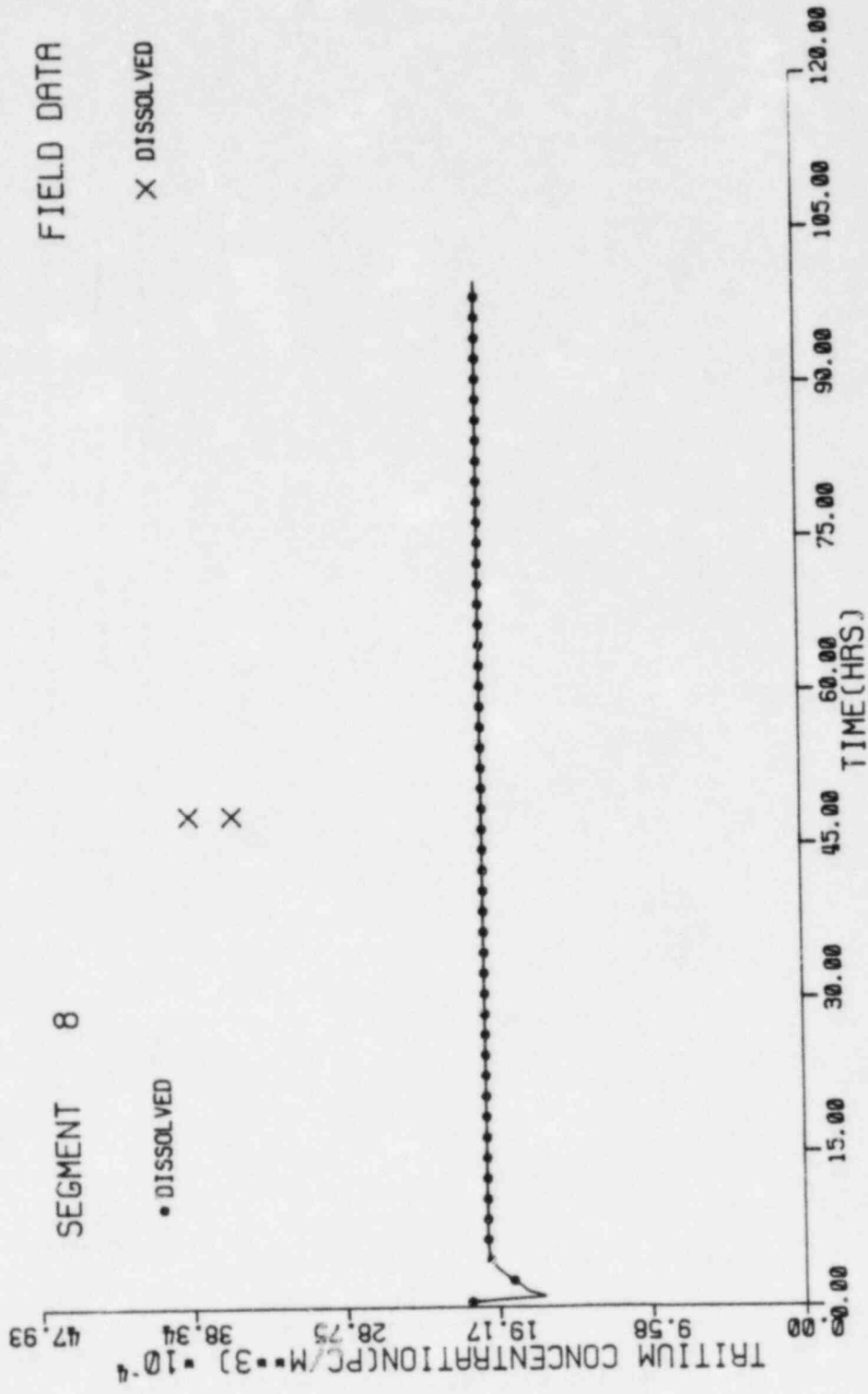


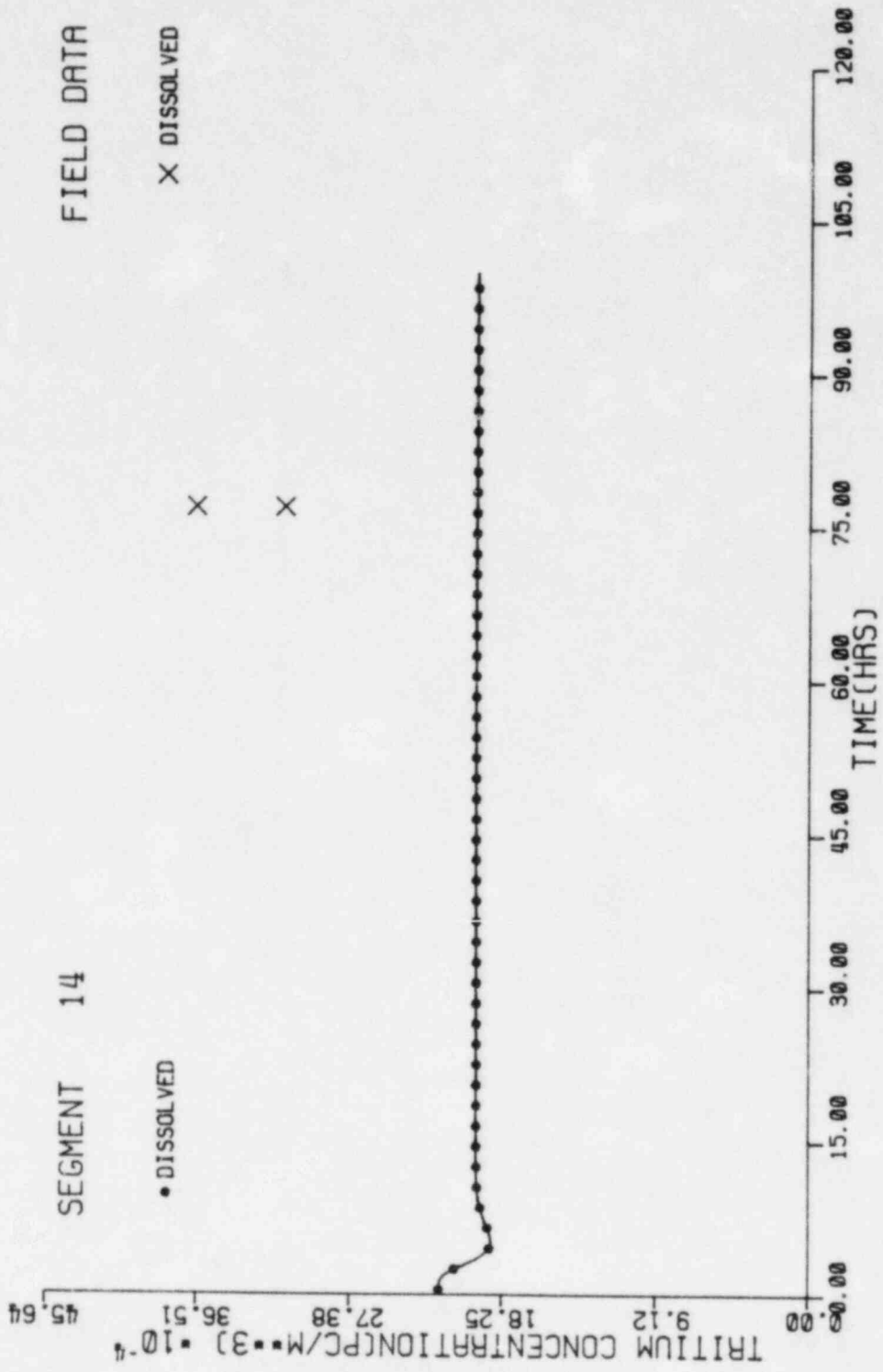


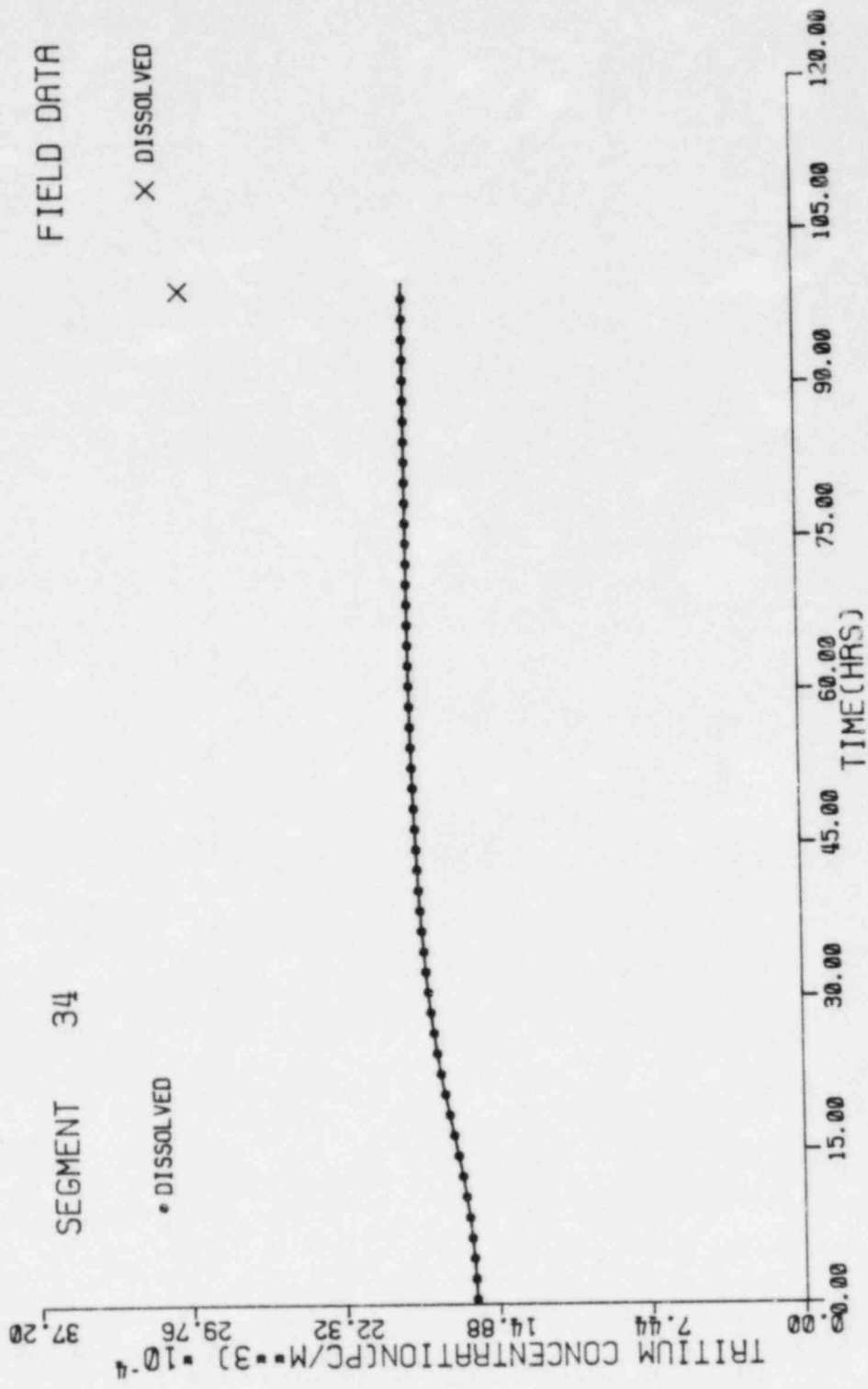






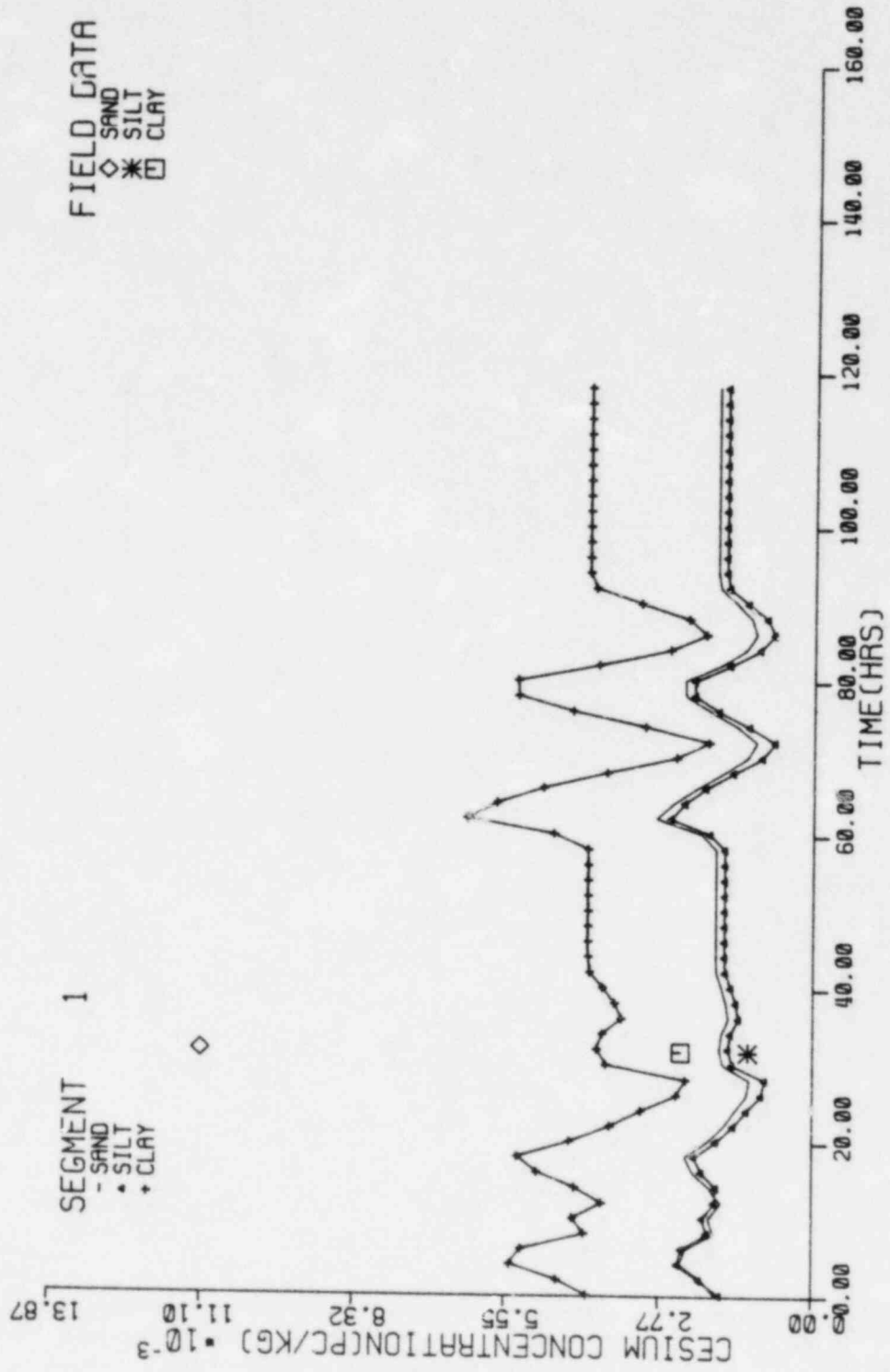


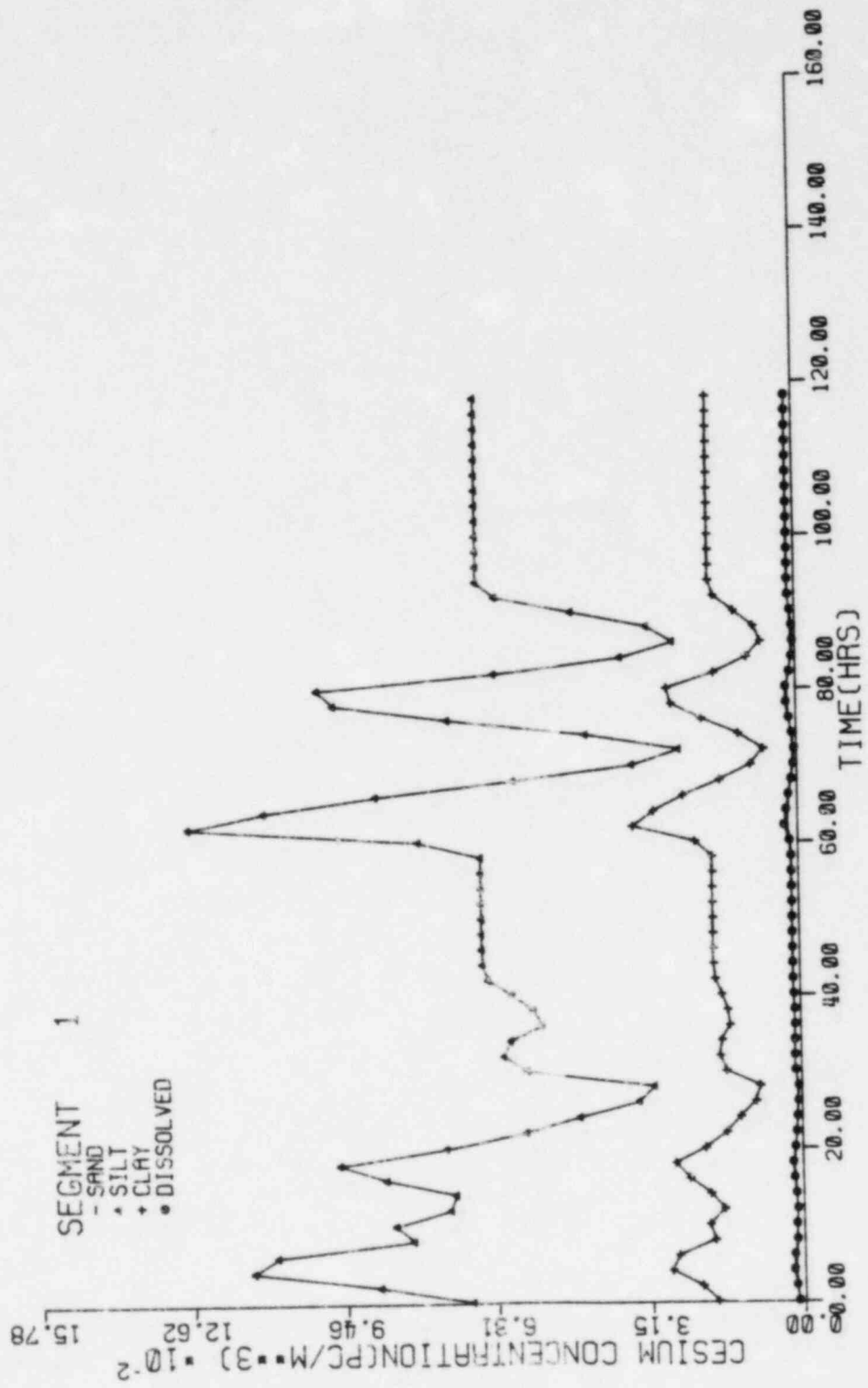


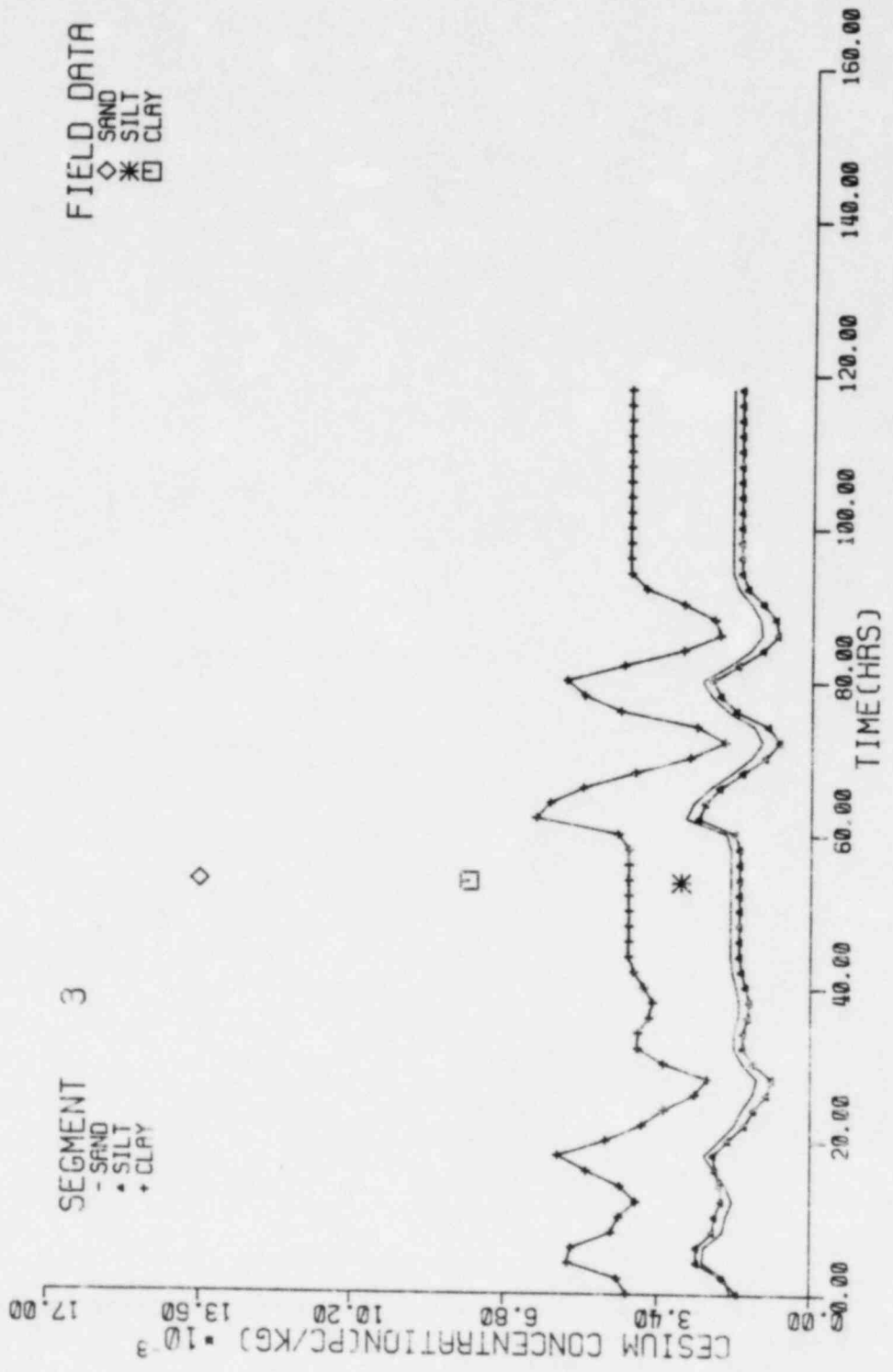


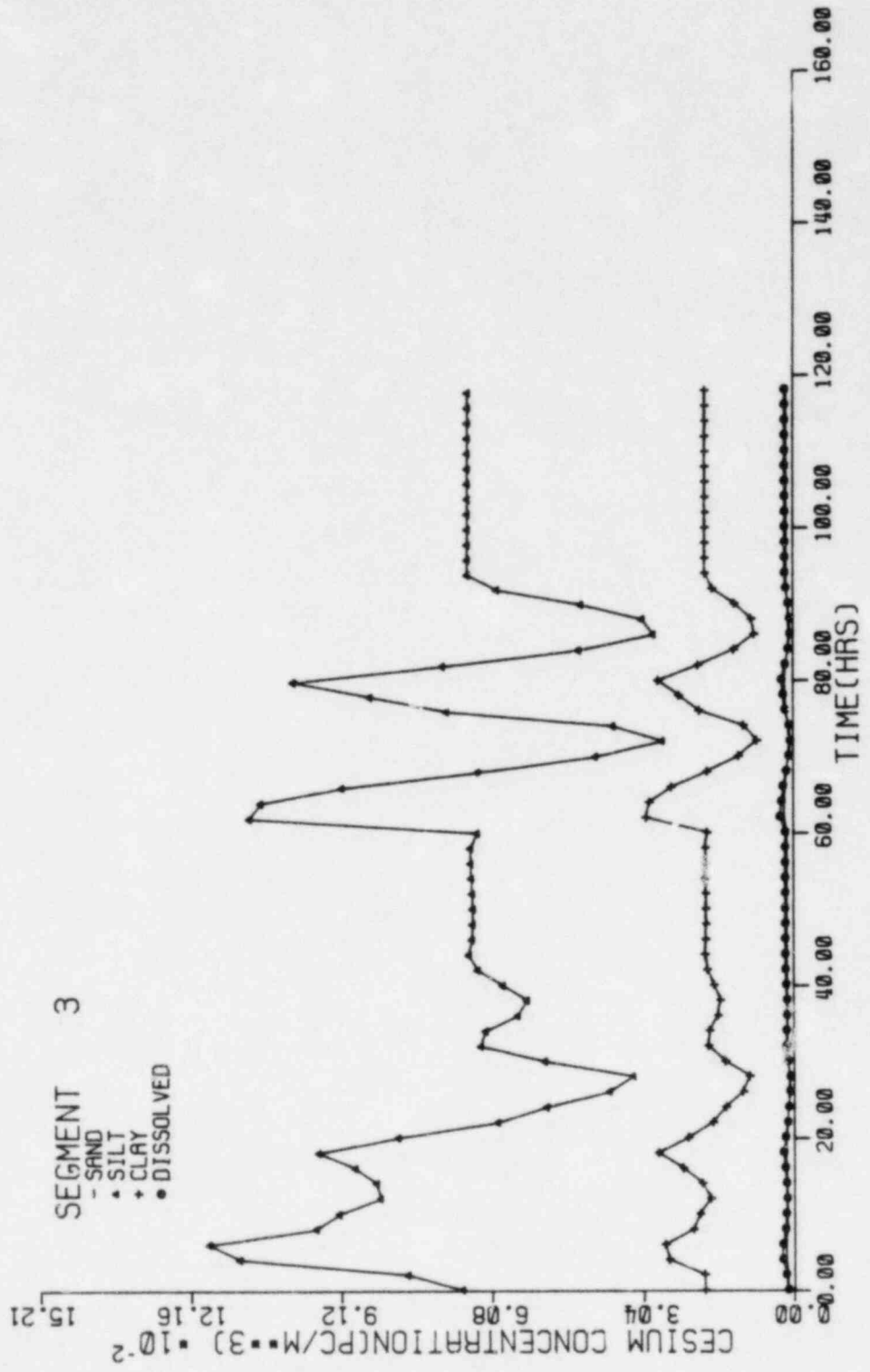
A.2.3. RADIONUCLIDE CONCENTRATIONS FOR PHASE 1

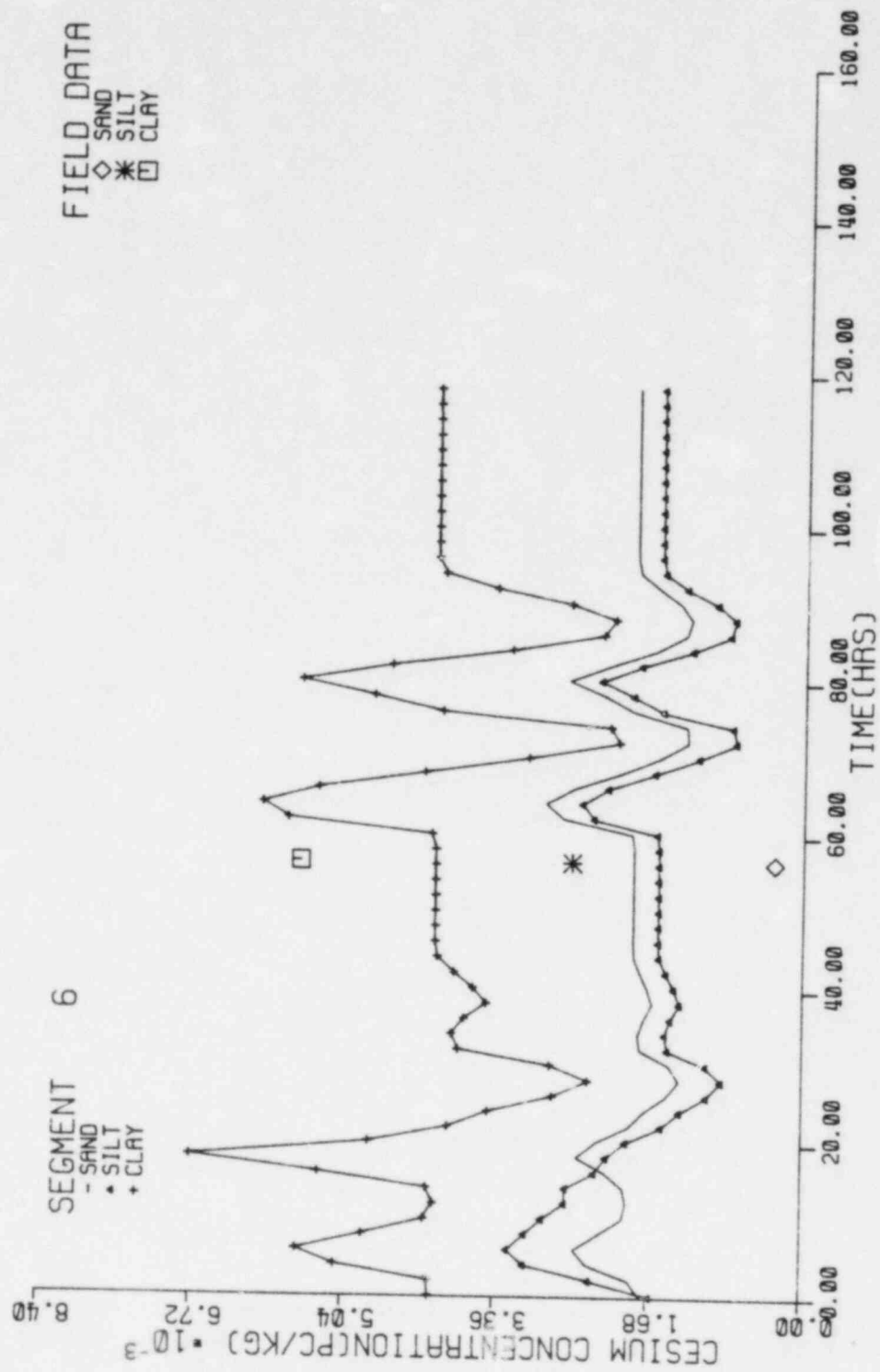


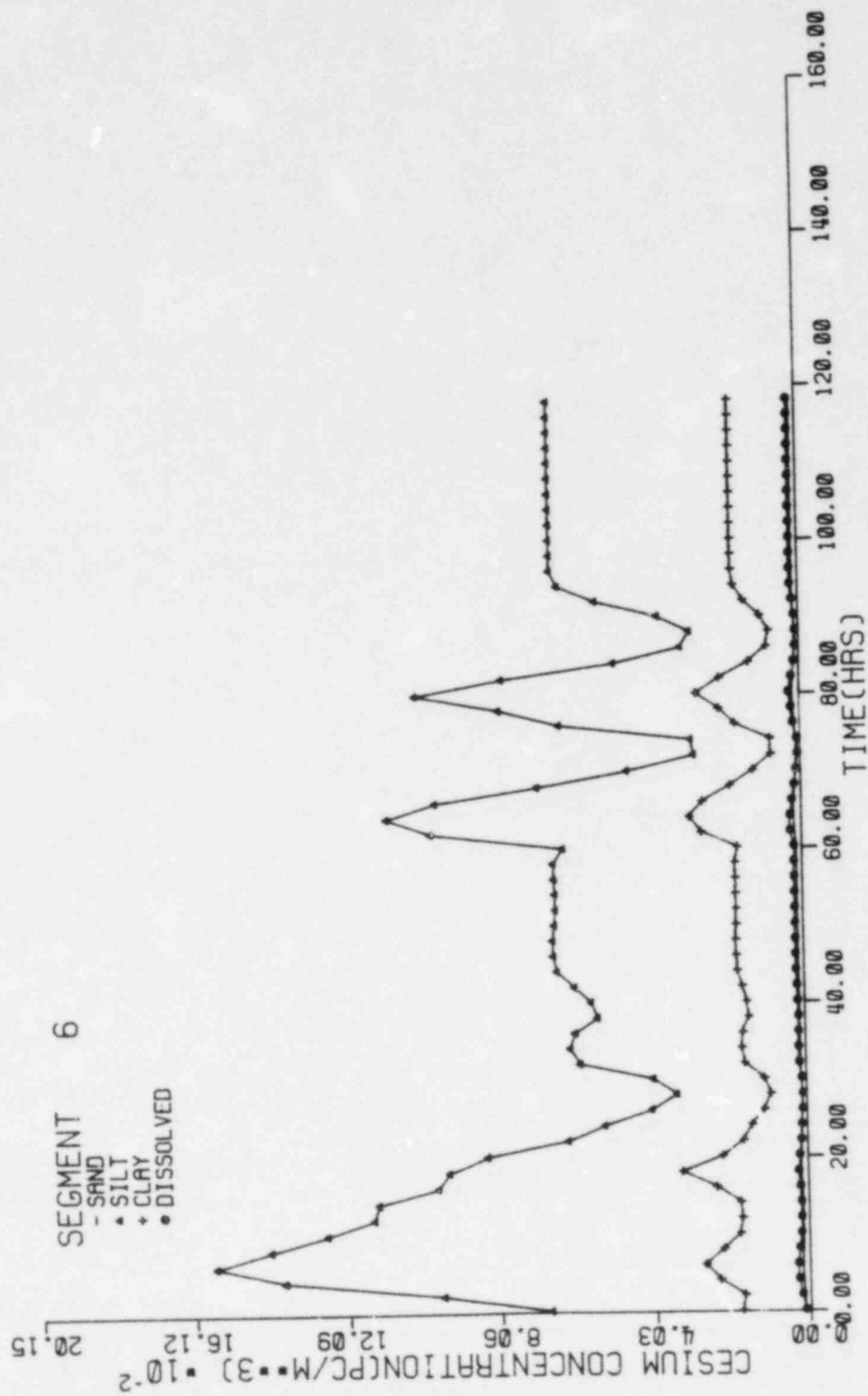


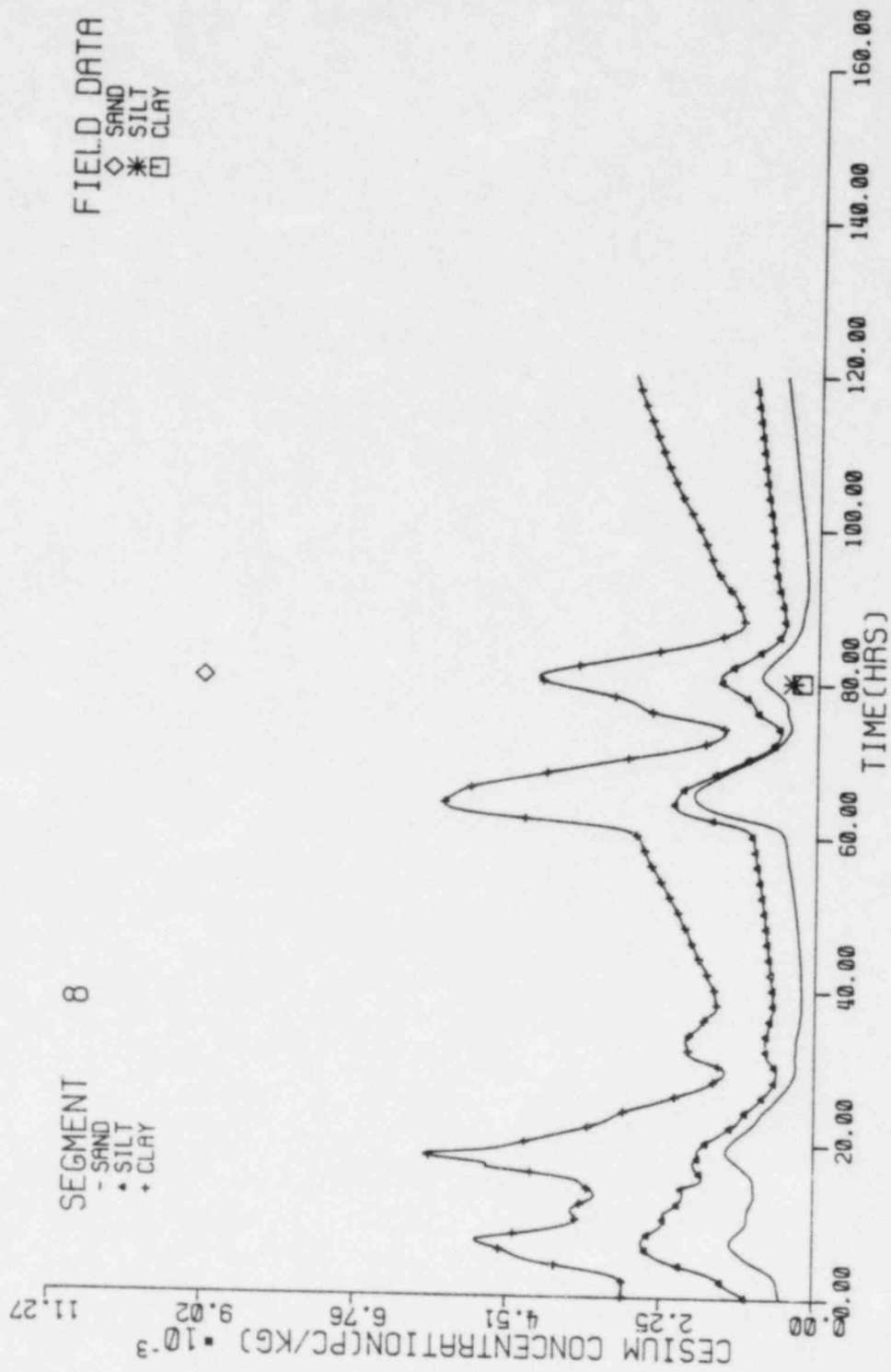


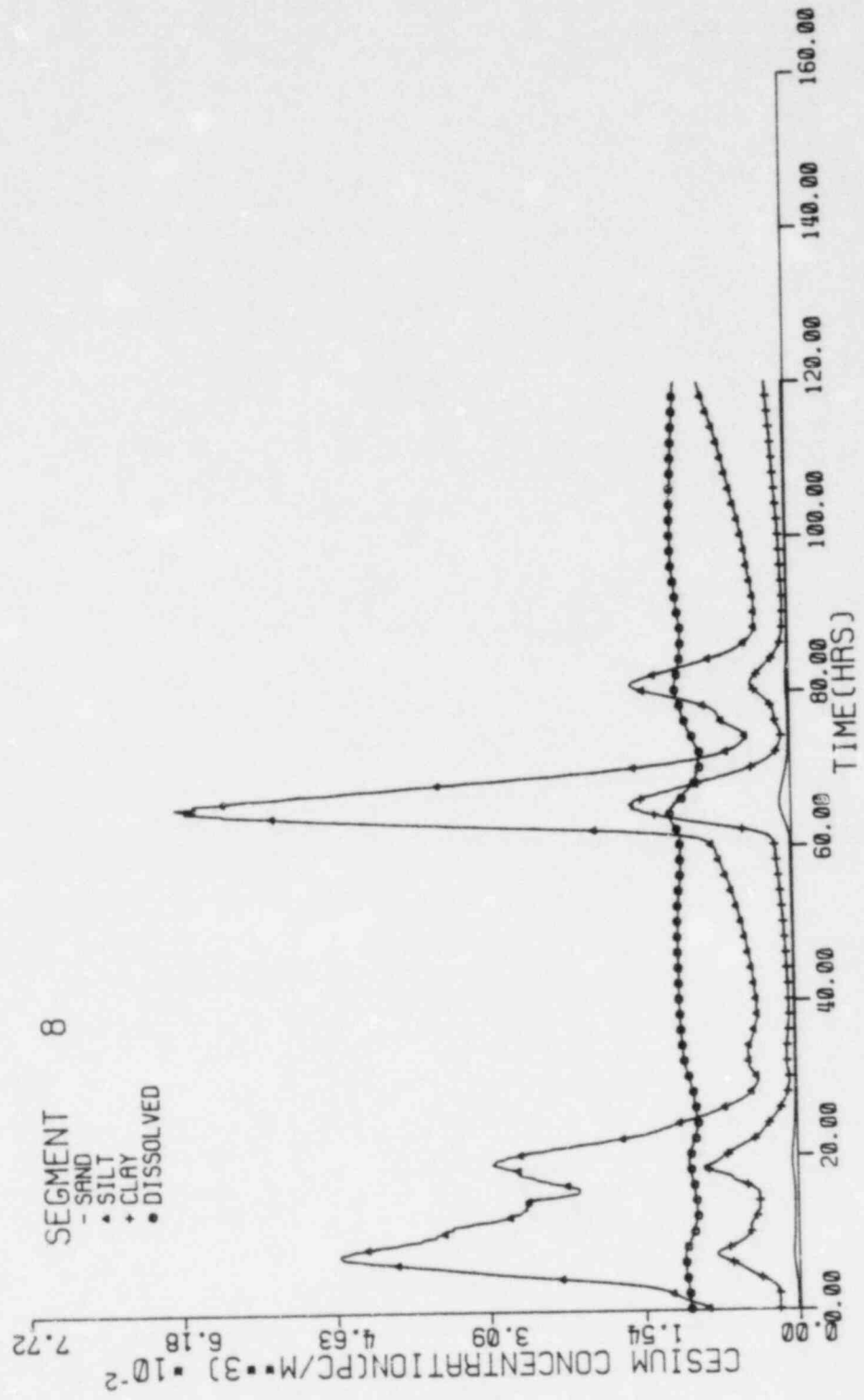




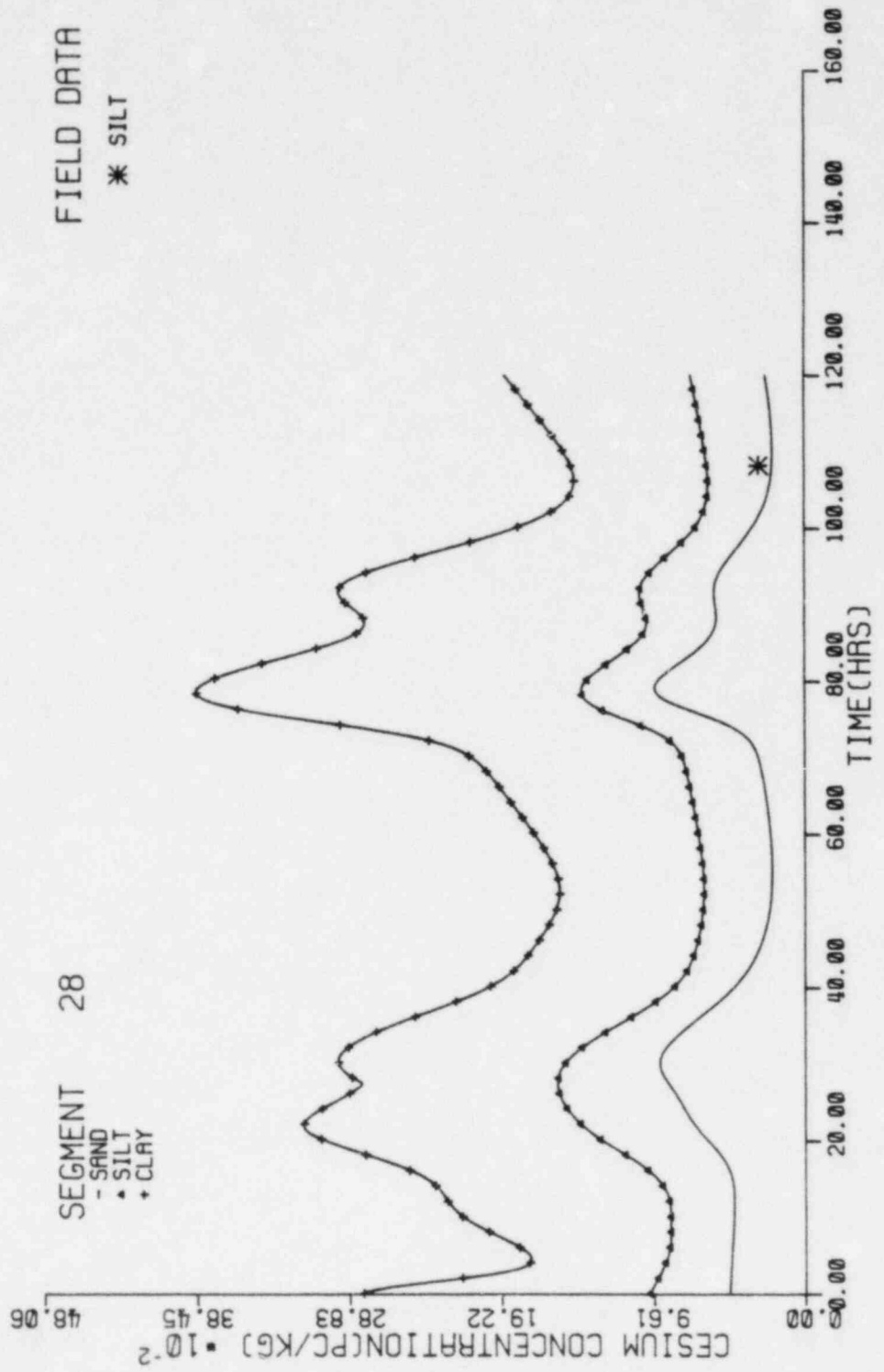


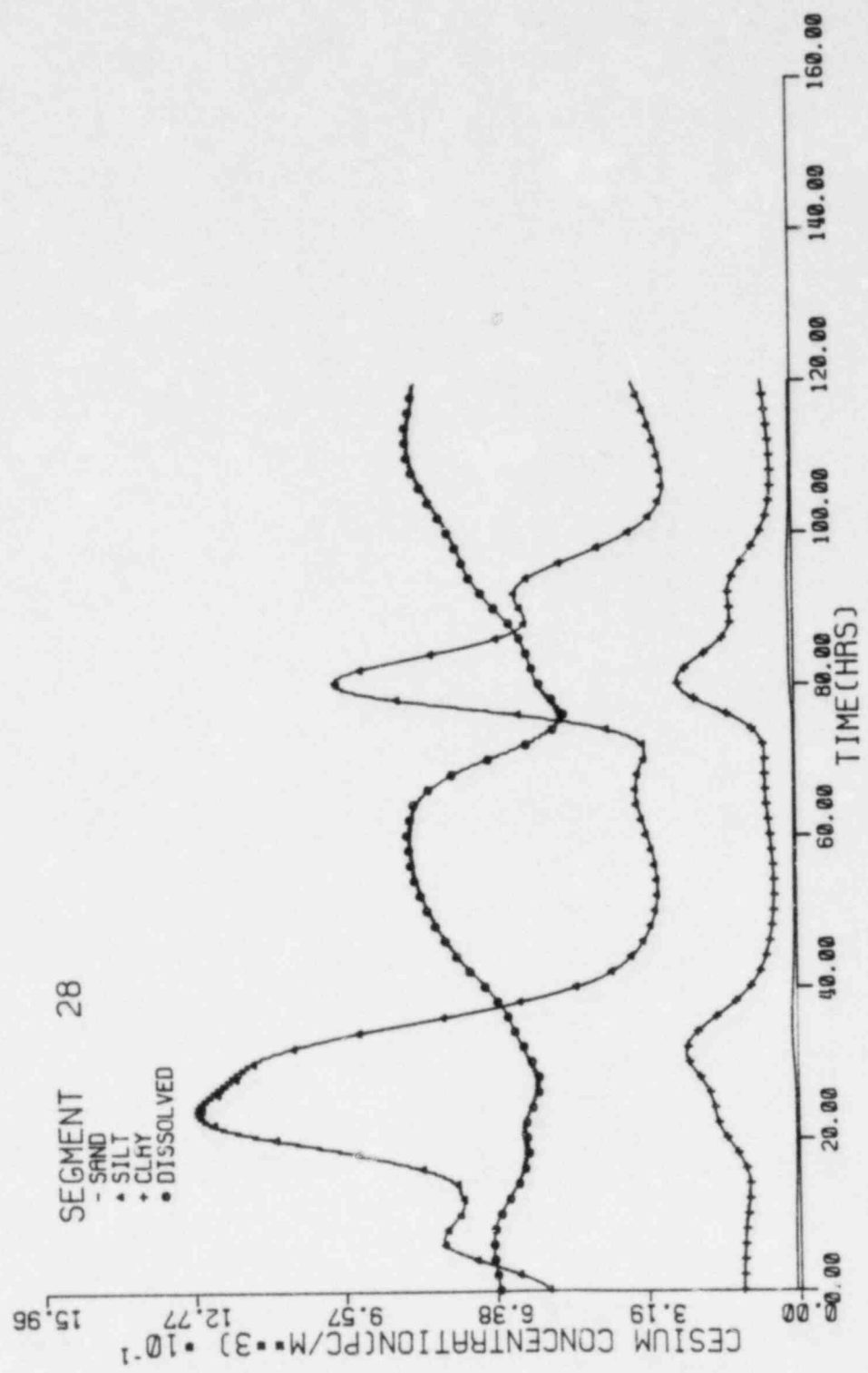


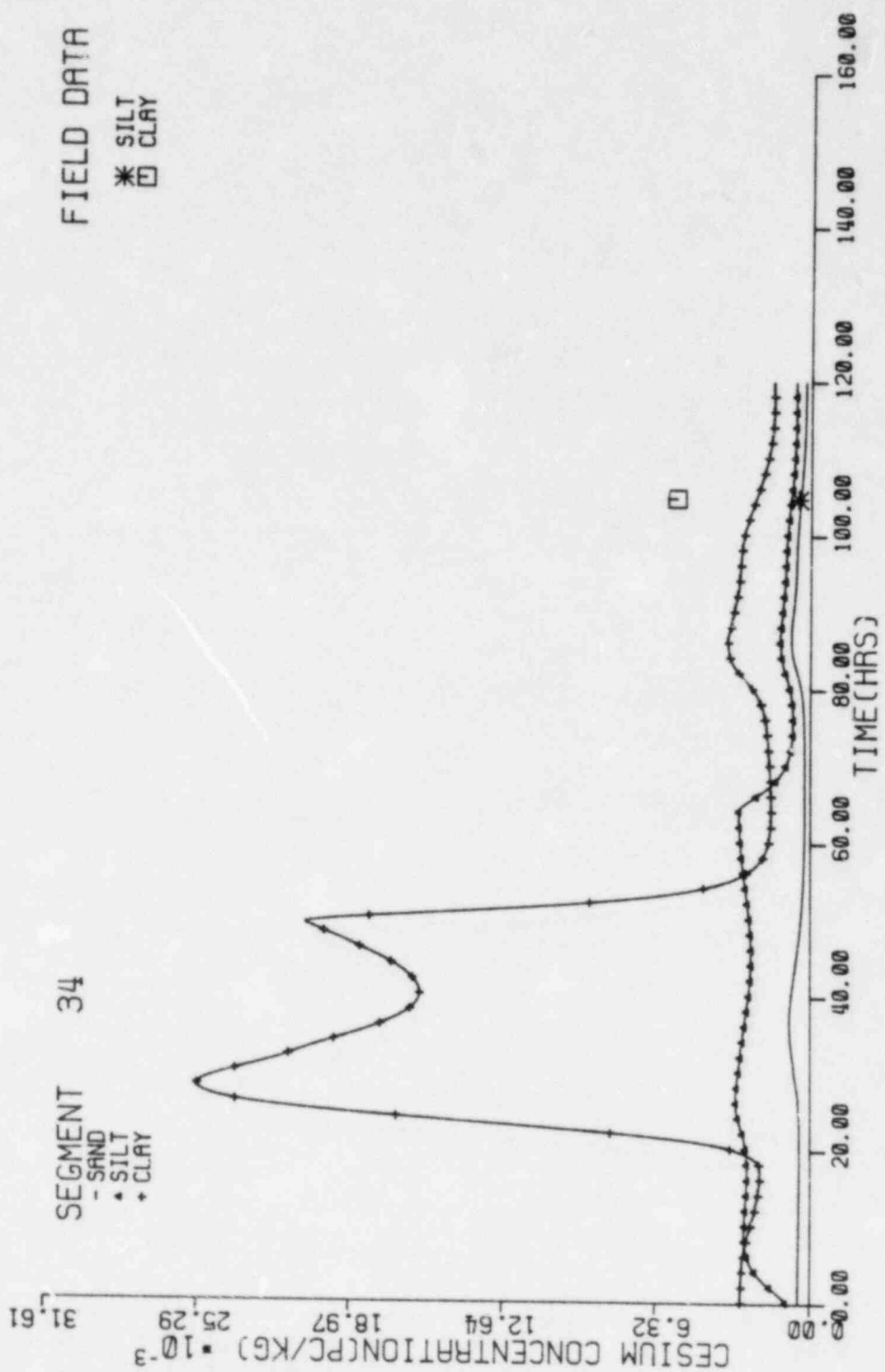


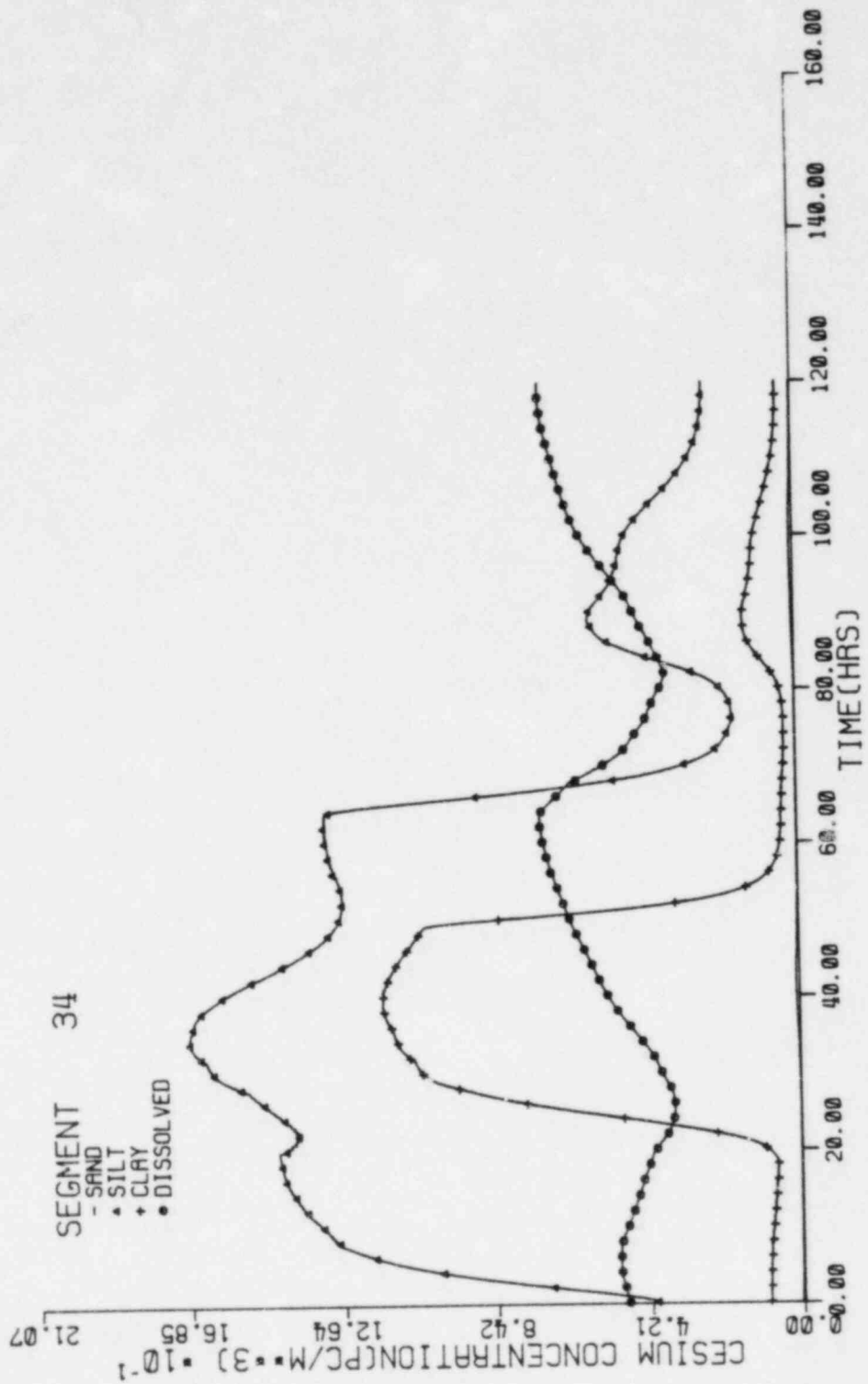


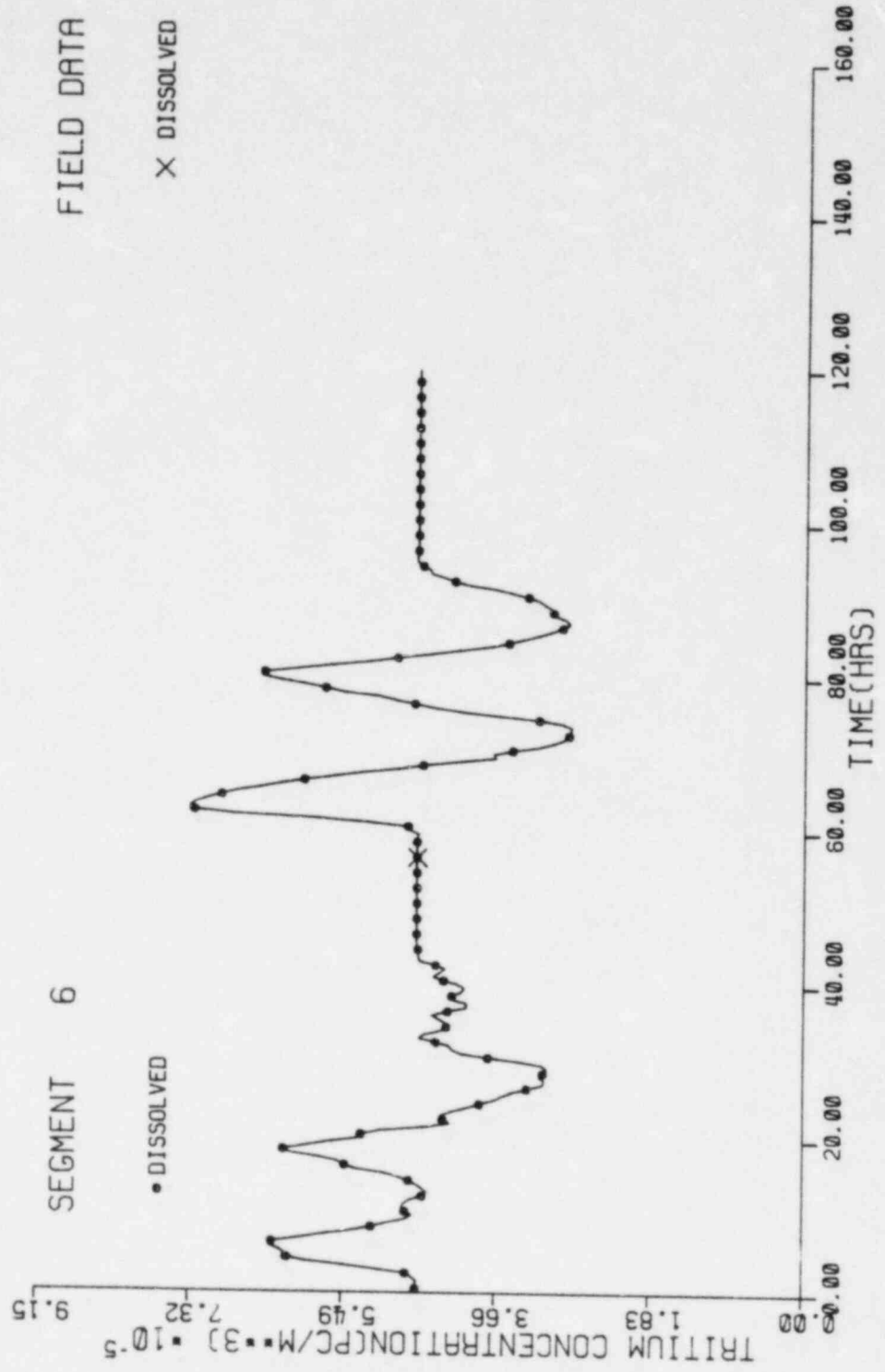












APPENDIX B

LISTING OF SERATRA ROUTINES

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-----  
00001 SUBROUTINE BEDDAT(B,ECHO,NBED,AREA,BDIV,DENS,POR,XY80,TBED)  
00002 C  
00003 C THIS ROUTINE IS RESPONSIBLE FOR READING THE INITIAL BED CONDITIONS.  
00004 C  
00005 C FORMAL PARAMETERS:  
00006 C B = INITIAL BED CONDITIONS  
00007 C ECHO = LINE PRINTER ECHO OPTION CONTROL VARIABLE (L*1)  
00008 C NBED = NUMBER OF BED LAYERS  
00009 C AREA = VERTICAL PROJECTION AREA  
00010 C BDIV = THICKNESS OF BED ELEMENTS  
00011 C DENS = DENSITY  
00012 C POR = POROSITY  
00013 C XY80 = THICKNESS OF TOP BED ELEMENT  
00014 C TBED = WEIGHT OF MATERIAL, TOTAL OF CONTAMINANT IN BED  
00015 C  
00016 C E : BERATRA  
00017 C  
00018 C INCLUDE 'ELMSIZ.PRM'  
00019 C INCLUDE '5YELMSIZ.PRM'  
00020 C  
00021 C LOGICAL*1 ECHO  
00022 C INTEGER SWITCH  
00023 C  
00024 C DIMENSION B(MAXLEV,MAXCON=1), AREA(MXELEM), DENS(3), TBED(MAXCON),  
00025 C 1 CELL(MAXLEV,MAXCON)  
00026 C  
00027 C CARD B,...INITIAL BED CONDITIONS  
00028 C  
00029 C A SET OF INITIAL BED CONDITIONS ARE READ FOR EACH THE SIX  
00030 C PARAMETERS (LAYERS ARE NUMBERED BEGINNING AT THE BOTTOM,  
00031 C (LAYER 1), AND ENDING WITH THE SURFACE LAYER, (LAYER #NBED)).  
00032 C  
00033 C IF THERE IS NO VERTICAL VARIATION, COLUMNS 1-5 CONTAIN A NEGATIVE  
00034 C VALUE AND COLUMNS 6-15 CONTAIN THE CONSTANT VALUE, WHEN THE DATA  
00035 C DOES VARY WITH DEPTH, A VALUE IS READ FOR EACH ELEMENT, THE UNITS  
00036 C OF THE CONTAMINANT CONCENTRATIONS DEPEND UPON THE TYPE OF CONTAMINANT  
00037 C (RADIOISOTOPE,..PC/KG OR PESTICIDE,..KG/KG).  
00038 C  
00039 C PARAMETERS ARE READ IN THE FOLLOWING ORDER:  
00040 C  
00041 C PARAMETER 1...WEIGHT FRACTION OF SAND IN THE BED  
00042 C 2...WEIGHT FRACTION OF SILT IN THE BED  
00043 C 3...WEIGHT FRACTION OF CLAY IN THE BED  
00044 C 4...CONTAMINANT CONCENTRATION IN SAND  
00045 C 5...CONTAMINANT CONCENTRATION IN SILT  
00046 C 6...CONTAMINANT CONCENTRATION IN CLAY  
00047 C  
00048 C DO (K=1,MAXCON=1)  
00049 C . READ(1,2) SWITCH,VALUE  
00050 C . WHEN (SWITCH .LT. 0)  
00051 C . . *** PARAMETER DOES NOT VARY VERTICALLY ***  
00052 C . . DO (J=1,NBED) B(J,K) = VALUE  
00053 C . . .FTN
```

```

00054      * ELSE
00055 C      * * *** PARAMETER VARIES VERTICALLY ***
00056      * * READ(1,1) (H(J,K),J=1,NBED)
00057      * *...FIN
00058      * *...FIN
00059      IF (ECHO)
00060      * * WRITE(6,3)
00061      * * DO (J=1,NBED)
00062      * * * WRITE(6:4) J, (B(J,K),K=1,MAXCON-1)
00063      * *...FIN
00064      * *...FIN
00065 C
00066      DO (J=1,MAXCON) TBED(J)=0.
00067      DO (J=1,MAXCON=1)
00068      * * DO (I=1,NBED)
00069      * * * WHEN (J.LT.4)
00070      * * * * DENSITY = (1.-POR)/(B(I,1)/DENS(1)+B(I,2)/DENS(2)+
00071 1. * * * * * B(I,3)/DENS(3))
00072      * * * * DEL = BDIV
00073      * * * * IF (I.EQ.NBED) DEL = XYSO
00074      * * * * VOL=DEL*AREA(1)
00075      * * * * CELL(I,J) = B(I,J)*VOL*DENSITY
00076      * * *...FIN
00077      * * * ELSE CELL(I,J) = CELL(I,J-3)+B(I,J)
00078      * * * * TBED(J) = TBED(J) + CELL(I,J)
00079      * * *...FIN
00080      * *...FIN
00081      DO (J = 4,MAXCON=1)
00082      * * * TBED(MAXCON) = TBED (MAXCON) + TBED(J)
00083      * *...FIN
00084      RETURN
00085 C
00086 1  FORMAT(1F10.0)
00087 2  FORMAT(15,F10.0)
00088 3  FORMAT(1H0,53X,'INITIAL BED CONDITIONS'/4H0,'LAYER',
00089 1 3(3X,'WEIGHT FRACTION',2X),3(1X,'CONTAMINANT CONC.',2X)/
00090 2 14X,'IN SAND',13X,'IN SILT',13X,'IN CLAY',
00091 3 12X,'IN SAND',13X,'IN SILT',13X,'IN CLAY')
00092 4  FORMAT(2X,I2,2(7X,1PE12.5,2(8X,1PE12.5)))
00093 C
00094      END

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(FLECS VERSION 22.46)

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-----  
00001 SUBROUTINE HEDK(B, DECAY, DELTD, NRED)  
00002 C  
00003 C THIS ROUTINE CALCULATES THE DECAY OF THE CONTAMINANTS IN THE  
00004 C RIVER BED.  
00005 C  
00006 C FORMAL PARAMETERS:  
00007 C B = BED CONCENTRATIONS  
00008 C DECAY = DECAY VALUES  
00009 C DELTD = TIME STEP IN DAYS  
00010 C NRED = NUMBER OF BED LAYERS  
00011 C  
00012 C CALLED BY: TRANSP, BERATRA  
00013 C  
00014 C INCLUDE 'SYJELMIZ.PRM'  
00015 C  
00016 C DIMENSION B(MAXLEV,MAXCDN-1), DECAY(6)  
00017 C  
00018 C IF(DECAY(1) .NE. 0.0)  
00019 C . DO (JJ#4,6)  
00020 C . . *** RADIONUCLIDE DECAY ***  
00021 C . . DO (JK#1,NRED)  
00022 C . . . B(JK,JJ) = B(JK,JJ)*EXP(-DECAY(1)*DELTD)  
00023 C . . . .FIN  
00024 C . . .FIN  
00025 C . . .FIN  
00026 C RETURN  
00027 C END
```

(FLECS VERSION 22.46)

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-----
00001 SUBROUTINE BEDHIS(H, RDIV, RED, COLD, DELTD, DELZ, DENS,
00002 1 FERROR, ILAYR, NBED, NELEM, POR, XNT, XYSO,
00003 2 DEPO, SCOUR, BEDSD)
00004 C
00005 C THIS SUBROUTINE KEEPS A RECORD OF BED HISTORY, INCLUDING BED
00006 C SURFACE ELEVATION, RATIO OF RED SEDIMENT WEIGHT FRACTIONS, AND
00007 C ASSOCIATED CONCENTRATIONS IN THE BED
00008 C
00009 C FORMAL PARAMETERS:
00010 C B = BED CONDITIONS (WEIGHT FRACTION, PC/KG)
00011 C RDIV = STANDARD RED LAYER THICKNESS (M)
00012 C RED = BED THICKNESS (M)
00013 C BEUSD = TRANSFER OF DISSOLVED TO ABSORBED (PC/M2/DAY)
00014 C COLD = CELL-CENTERED CONCENTRATION (KG/M**3,PC/M**3)
00015 C DELTD = TIME STEP (DAYS)
00016 C DELZ = STANDARD ELEMENT THICKNESS (M)
00017 C DENS = DENSITY (KG/M**3)
00018 C DEPO = DEPOSITION RATE (KG(PC)/M2/DAY)
00019 C FERROR = FATAL ERROR FLAG (L*1)
00020 C ILAYR = NO. OF LAYERS COMPLETELY SCOURED BY EACH RESPECTIVE
00021 C SEDIMENT, ILAYR(J)=-1 FOR DEPOSITION
00022 C NBED = NUMBER OF BED LAYERS
00023 C NELEM = NUMBER OF ELEMENTS
00024 C POR = POROSITY
00025 C SCOUR = SCOUR RATE (KG(PC)/M2/DAY)
00026 C XNT = WEIGHT OF THE BED SEDIMENT LAYER (KG/M2)
00027 C XYSO = THICKNESS OF TOP BED LAYER (M)
00028 C ZERO = NORMALIZED TRUNCATION ERROR = SIGNIFICANT DIGITS
00029 C
00030 C CALLED BY: TRANSP
00031 C
00032 C INCLUDE 'BY:ELMSIZ,PRM'
00033 C
00034 C LOGICAL*1 FERROR
00035 C
00036 C DIMENSION ALEFT(3), ARAD(3), R(MAXLEV,MAXCON=1), B2(6),
00037 1 BEDSD(3), COLD(MXELEM,MAXCON), DENS(3), DEPO(4),
00038 2 ILAYR(3), SCOUR(6), SUMSD(3), SUMSDC(3), XNT(3)
00039 C
00040 C DATA ZERO/1.0E-9/
00041 C
00042 C FERROR = .FALSE.
00043 C
00044 C IN=ILAYR(1)
00045 C IP=ILAYR(2)
00046 C IQ=ILAYR(3)
00047 C
00048 C DO (IJ=1,3)
00049 C * SUMSD(IJ)=DEPO(IJ)
00050 C * SUMSDC(IJ)=DEPO(IJ+3)
00051 C * IF(BEDSD(IJ).LT.0.0) SUMSDC(IJ)=BEDSD(IJ)+SUMSDC(IJ)
00052 C **FIN
00053 C * ARAD == AMOUNT OF CHEMICALS LEFT IN TOP BED LAYER.
00054 C * ALEFT == AMOUNT OF SEDIMENT LEFT IN TOP BED LAYER.

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```

00054 C
00055     DO (I=1,3)
00056     . ARAD(I)=0.0
00057     . ALEFT(I)=0.0
00058     ...FIN
00059 C
00060     IF(SCOUR(1)+SCOUR(2)+SCOUR(3).GT.0.0) GO TO 110
00061     THP=(XNT(1)/DENS(1)+XNT(2)/DENS(2)+XNT(3)/DENS(3))/
00062     . (1.0-POW)
00063     TDEPO=DEPO(1)+DEPO(2)+DEPO(3)
00064     DELM=(THP * BOIV)/NDIV
00065     IF(TDEPO.GT.0.0.AND.ABS(DELM).LE.ZERO)
00066 C*****
00067 C     . IF ONLY DEPOSITION OCCURS AND THE TOP LAYER HAS A
00068 C     . THICKNESS OF BOIV...TO AVOID HOMOGENEIZING THE OLD
00069 C     . AND NEW MATERIAL WE CREATE A NEW ELEMENT WITH
00070 C     . XNT(I) = 0, AND ALEFT(I) AND ARAD(I) EQUAL TO
00071 C     . DEPOSITED MATERIAL AND CONTAMINANT RESPECTIVELY.
00072 C*****
00073     . XNT(I)=0.
00074     . XNT(2)=0
00075     . XNT(3)=0.
00076     . HBPD=NDIV+1
00077     . DO (I=1,3)
00078     . . ALEFT(I)=RUND(1)*DELTO
00079     . . ARAD(I)=RUND(1)*DELTO
00080     . . IF(HEOBD(I).GT.0.0) ARAD(I)=ARAD(I)+HEOBD(I)*DELTO
00081     . ...FIN
00082     . GO TO 270
00083     ...FIN
00084 C*****
00085 C     COMPUTER BERINENT (KSAZ) AND CONTAMINANT (PC/M2) =
00086 C     RESIDING IN THE TOP LAYER
00087 C*****
00088 110 IF (IN,LT,0) I=NO
00089     ALEFT(1)=XNT(1)+SUNSD(1)*DELTO
00090     ARAD(1)=XNT(1)+R(INDEU=IN,4)+SUNSD(1)*DELTO
00091     IF (REDS(1).GT.0.0) ARAD(1)=ARAD(1)+REDS(1)*DELTO
00092     IN=ILAYR(1)
00093     IF (IP,LI,0) IP=0
00094     ALEFT(2)=XNT(2)+SUNSD(2)*DELTO
00095     ARAD(2)=XNT(2)+R(INDEU=IP,5)+SUNSD(2)*DELTO
00096     IF (REDS(2).GT.0.0) ARAD(2)=ARAD(2)+REDS(2)*DELTO
00097     IP = ILAYR(2)
00098     IF (IN,LT,0) I=NO
00099     ALEFT(3)=XNT(3)+SUNSD(3)*DELTO
00100     ARAD(3)=XNT(3)+R(INDEU=IP,6)+SUNSD(3)*DELTO
00101     IF (REDS(3).GT.0.0) ARAD(3)=ARAD(3)+REDS(3)*DELTO
00102     ID = ILAYR(3)
00103 C*****
00104 C     IF SAND HAS NOT SCANNED A COMPLETE LAYER ALEFT(I) *
00105 C     AND ARAD(I) ARE COMPLETELY DETERMINED *
00106 C*****
00107     IF (IN,LT,1) GO TO 270
00108 C*****
00109 C     IF SILT AND SAND FUSION (DEPOSITION) ARE WITHIN *

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00110 C THE SAME LAYER ... ALEFT(2), AND ARAD(2) ARE *
00111 C COMPLETELY DETERMINED ... *
00112 C OTHERWISE INCLUDE ADDITIONAL LAYERS *
00113 C*****
00114 IF(IN.GT,IP)
00115 . IPP = IP + 1
00116 . IF (IPP.EQ,0) IPP = 1
00117 . DO (IT=IPP,IN)
00118 . . NB = NBED = IT
00119 . . XND = (1.0-POR)/(B(NB,1)/DENS(1)+B(NB,2)/DENS(2)+
00120 1. . . B(NB,3)/DENS(3))
00121 . . DELXNT=XND*BNDIV*B(NB,2)
00122 . . ALEFT(2)=ALEFT(2) + DELXNT
00123 . . ARAD(2)=ARAD(2) + DELXNT*B(NB,5)
00124 . . .FIN
00125 . . .FIN
00126 C*****
00127 C IF CLAY AND SAND EROSION (DEPOSITION) ARE WITHIN *
00128 C THE SAME LAYER ... ALEFT(3) AND ARAD(3) ARE *
00129 C COMPLETELY DETERMINED... *
00130 C OTHERWISE INCLUDE ADDITIONAL LAYERS *
00131 C*****
00132 IF(IN.GT,IQ)
00133 . IQQ = IQ + 1
00134 . IF (IQQ.EQ,0) IQQ = 1
00135 . DO (IT=IQQ,IN)
00136 . . NR = NBED = IT
00137 . . XND = (1.0-POR)/(B(NB,1)/DENS(1)+B(NB,2)/DENS(2)+
00138 1. . . B(NB,3)/DENS(3))
00139 . . DELXNT=XND*BNDIV*B(NB,3)
00140 . . ALEFT(3) = ALEFT(3) + DELXNT
00141 . . ARAD(3) = ARAD(3) + DELXNT*B(NB,5)
00142 . . .FIN
00143 . . .FIN
00144 C*****
00145 C ESTABLISH THE B MATRIX VALUES FOR THE NEWLY CREATED *
00146 C UED ELEMENTS *
00147 C*****
00148 270 CONTINUE
00149 R1 = ALEFT(1) + ALEFT(2) + ALEFT(3)
00150 XM = (ALEFT(1)/DENS(1) + ALEFT(2)/DENS(2) + ALEFT(3)/
00151 1 DENS(3))/(1.0 - POR)
00152 IW = XM/BNDIV
00153 REMAIN = XM - IW*BNDIV
00154 IF(REMAIN.GT,ZERO) IW = IW + 1
00155 NHED = NBED = IN = 1
00156 IF (IN.LT,0) NBED = NHED-1
00157 NHED1 = NBED + 1
00158 NHED2 = NHED + IW
00159 DO (IX=1,3)
00160 . B2(IX) = ALEFT(IX)/R1
00161 . B2(IX+3) = 0.0
00162 . IF(B2(IX).GT,ZERO) B2(IX+3) = ARAD(IX)/ALEFT(IX)
00163 . . .FIN
00164 DO (IY=NHED1,NBED2)
00165 . DO (IX=1,6)

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```
00166      *      B(IY,IX) = B2(IX)
00167      *      ...FIN
00168      ...FIN
00169      NHED = NHED + IW
00170      XYS0 = REMAIN
00171      IF (REMAIN.LE.ZERO) XYS0 = RDIV
00172      BED = (NHED-1) * RDIV + XYS0
00173      IF (NHED.GT. MAXLEV)
00174      *      WRITE(6,200) NHED
00175 200      *      FORMAT(2X,'DEPOSITION EXCEEDS PERMISSIBLE BED DEPTH IN BEDST',/,
00176      1. 5X,'NHED=',I5)
00177      *      FERROR = .TRUE.
00178      ...FIN
00179  C
00180      RETURN
00181      END
```

(FLECS VERSION 22,46)

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-----
00001 SUBROUTINE COLBY(ALEN, C, DELZ, D50, HRAU, NELEM, QTOT,
00002 1 TEMPR, VOL, GSI, FERROR)
00003 C
00004 C THIS SUBROUTINE USES COLBY'S METHOD TO CALCULATE THE CAPACITY OF
00005 C THE FLOW TO TRANSPORT SAND.
00006 C
00007 C INPUT PARAMETERS:
00008 C ALEN = SEGMENT LENGTH
00009 C C = NODAL VALUES OF CONCENTRATION
00010 C DELZ = STANDARD ELEMENT THICKNESS
00011 C D50 = MEDIAN BED SEDIMENT DIAMETER (M)
00012 C HRAU = HYDRAULIC RADIUS
00013 C NELEM = NUMBER OF VERTICAL ELEMENTS
00014 C QTOT = TOTAL FLOW WITHIN THE SEGMENT
00015 C TEMPR = WATER TEMPERATURE
00016 C V = AVERAGE VELOCITY
00017 C VOL = VOLUME
00018 C
00019 C OUTPUT PARAMETERS:
00020 C GSI = TOTAL SAND TRANSPORT
00021 C FERROR = FATAL ERROR FLAG (L*1)
00022 C
00023 C CALLED BY: SAND
00024 C
00025 C THE COLBY METHOD HAS THE FOLLOWING UNITS AND APPLICABLE RANGES OF
00026 C VARIABLES.
00027 C AVERAGE VELOCITY.....V.....FPS.....1-10 FPS
00028 C HYDRAULIC RADIUS.....FHRAD.....FT.....1-100 FT
00029 C WATER SURFACE WIDTH.....W.....FT.....
00030 C MEDIAN BED MATERIAL SIZE.....D50.....MM.....0.1-0.8 MM
00031 C TEMPERATURE.....TMPR.....DEG F.....32-100 DEG.
00032 C FINE SEDIMENT CONCENTRATION.....FSL.....MG/LITER.....0-200000 PPM
00033 C TOTAL SEDIMENT LOAD.....GSI.....TON.....
00034 C
00035 C INCLUDE 'BY:ELMSIZ,PRM'
00036 C
00037 C LOGICAL*1 FERROR
00038 C
00039 C DIMENSION C(MXELEM,MAXCON),CF(5),DF(10),DG(4),DP(11),D50G(6),
00040 1 F(5,10), G(4,8,6), II(2), JJ(2), KK(2), P(11), I(7,4),
00041 2 TEMP(7), VG(8), X(2,2), XA(2), XCT(2), XF(2,2),
00042 3 XG(2), XT(2,2), XX(2), YY(2), ZZ(2)
00043 C
00044 C DATA G(1,1,1),G(2,1,1),G(3,1,1),G(4,1,1)/1.0, 0.30, 0.06, 0.00/
00045 DATA G(1,2,1),G(2,2,1),G(3,2,1),G(4,2,1)/3.00, 3.50, 2.50, 2.00/
00046 DATA G(1,3,1),G(2,3,1),G(3,3,1),G(4,3,1)/5.40, 4.0, 10.0, 20.0/
00047 DATA G(1,4,1),G(2,4,1),G(3,4,1),G(4,4,1)/11.0, 26.0, 30.0,150.0/
00048 DATA G(1,5,1),G(2,5,1),G(3,5,1),G(4,5,1)/17., 44., 130., 500./
00049 DATA G(1,6,1),G(2,6,1),G(3,6,1),G(4,6,1)/29., 101., 400., 1350./
00050 DATA G(1,7,1),G(2,7,1),G(3,7,1),G(4,7,1)/44., 160., 700., 2500./
00051 DATA G(1,8,1),G(2,8,1),G(3,8,1),G(4,8,1)/60., 220., 1000., 4400./
00052 DATA G(1,1,2),G(2,1,2),G(3,1,2),G(4,1,2)/0.30, 0.06, 0.0, 0.0/
00053 DATA G(1,2,2),G(2,2,2),G(3,2,2),G(4,2,2)/1.00, 1.20, 0.65, 0.10/

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00054 DATA G(1,3,2),G(2,3,2),G(3,3,2),G(4,3,2)/3.70, 5., 4., 3./

00055 DATA G(1,4,2),G(2,4,2),G(3,4,2),G(4,4,2)/10., 18., 30., 52./

00056 DATA G(1,5,2),G(2,5,2),G(3,5,2),G(4,5,2)/17., 40., 80., 160./

00057 DATA G(1,6,2),G(2,6,2),G(3,6,2),G(4,6,2)/36., 95., 230., 650./

00058 DATA G(1,7,2),G(2,7,2),G(3,7,2),G(4,7,2)/60., 150., 415., 1200./

00059 DATA G(1,8,2),G(2,8,2),G(3,8,2),G(4,8,2)/81., 215., 620., 1500./

00060 DATA G(1,1,3),G(2,1,3),G(3,1,3),G(4,1,3)/0.14, 0.0, 0.0, 0.0/

00061 DATA G(1,2,3),G(2,2,3),G(3,2,3),G(4,2,3)/1., 0.60, 0.15, 0.0/

00062 DATA G(1,3,3),G(2,3,3),G(3,3,3),G(4,3,3)/3.30, 3.00, 1.70, 0.50/

00063 DATA G(1,4,3),G(2,4,3),G(3,4,3),G(4,4,3)/11., 15., 17., 14./

00064 DATA G(1,5,3),G(2,5,3),G(3,5,3),G(4,5,3)/20., 39., 49., 70./

00065 DATA G(1,6,3),G(2,6,3),G(3,6,3),G(4,6,3)/44., 85., 150., 250./

00066 DATA G(1,7,3),G(2,7,3),G(3,7,3),G(4,7,3)/71., 145., 290., 500./

00067 DATA G(1,8,3),G(2,8,3),G(3,8,3),G(4,8,3)/100., 202., 400., 700./

00068 DATA G(1,1,4),G(2,1,4),G(3,1,4),G(4,1,4)/0.0, 0.0, 0.0, 0.0/

00069 DATA G(1,2,4),G(2,2,4),G(3,2,4),G(4,2,4)/0.70, 0.30, 0.06, 0.0/

00070 DATA G(1,3,4),G(2,3,4),G(3,3,4),G(4,3,4)/2.9, 2.3, 1.0, 0.06/

00071 DATA G(1,4,4),G(2,4,4),G(3,4,4),G(4,4,4)/11.5, 13., 12., 7./

00072 DATA G(1,5,4),G(2,5,4),G(3,5,4),G(4,5,4)/22., 31., 40., 50./

00073 DATA G(1,6,4),G(2,6,4),G(3,6,4),G(4,6,4)/47., 84., 135., 210./

00074 DATA G(1,7,4),G(2,7,4),G(3,7,4),G(4,7,4)/75., 140., 280., 410./

00075 DATA G(1,8,4),G(2,8,4),G(3,8,4),G(4,8,4)/108., 190., 350., 630./

00076 DATA G(1,1,5),G(2,1,5),G(3,1,5),G(4,1,5)/0.0, 0.0, 0.0, 0.0/

00077 DATA G(1,2,5),G(2,2,5),G(3,2,5),G(4,2,5)/0.44, 0.05, 0.0, 0.0/

00078 DATA G(1,3,5),G(2,3,5),G(3,3,5),G(4,3,5)/2.8, 1.8, 0.8, 0.0/

00079 DATA G(1,4,5),G(2,4,5),G(3,4,5),G(4,4,5)/12., 12.5, 10., 4.5/

00080 DATA G(1,5,5),G(2,5,5),G(3,5,5),G(4,5,5)/24., 30., 35., 37./

00081 DATA G(1,6,5),G(2,6,5),G(3,6,5),G(4,6,5)/52., 76., 120., 190./

00082 DATA G(1,7,5),G(2,7,5),G(3,7,5),G(4,7,5)/83., 180., 215., 360./

00083 DATA G(1,8,5),G(2,8,5),G(3,8,5),G(4,8,5)/120., 190., 305., 550./

00084 DATA G(1,1,6),G(2,1,6),G(3,1,6),G(4,1,6)/0.0, 0.0, 0.0, 0.0/

00085 DATA G(1,2,6),G(2,2,6),G(3,2,6),G(4,2,6)/0.3, 0.0, 0.0, 0.0/

00086 DATA G(1,3,6),G(2,3,6),G(3,3,6),G(4,3,6)/2.9, 1.4, 0.3, 0.0/

00087 DATA G(1,4,6),G(2,4,6),G(3,4,6),G(4,4,6)/14., 11., 7.7, 3.0/

00088 DATA G(1,5,6),G(2,5,6),G(3,5,6),G(4,5,6)/27., 29., 30., 30./

00089 DATA G(1,6,6),G(2,6,6),G(3,6,6),G(4,6,6)/57., 75., 110., 170./

00090 DATA G(1,7,6),G(2,7,6),G(3,7,6),G(4,7,6)/90., 140., 200., 330./

00091 DATA G(1,8,6),G(2,8,6),G(3,8,6),G(4,8,6)/135., 190., 290., 520./

00092 C

00093 DATA F(1,1),F(1,2),F(1,3),F(1,4),F(1,5)/1., 1.1, 1.6, 2.6, 4.2/

00094 DATA F(1,2),F(2,2),F(3,2),F(4,2),F(5,2)/1., 1.1, 1.65, 2.75, 4.9/

00095 DATA F(1,3),F(2,3),F(3,3),F(4,3),F(5,3)/1., 1.1, 1.7, 3., 5.5/

00096 DATA F(1,4),F(2,4),F(3,4),F(4,4),F(5,4)/1., 1.12, 1.9, 3.6, 7./

00097 DATA F(1,5),F(2,5),F(3,5),F(4,5),F(5,5)/1., 1.17, 2.05, 4.3, 8.7/

00098 DATA F(1,6),F(2,6),F(3,6),F(4,6),F(5,6)/1., 1.2, 2.3, 5.5, 11.2/

00099 DATA F(1,7),F(2,7),F(3,7),F(4,7),F(5,7)/1., 1.22, 2.75, 8., 22./

00100 DATA F(1,8),F(2,8),F(3,8),F(4,8),F(5,8)/1., 1.25, 3., 9.6, 29./

00101 DATA F(1,9),F(2,9),F(3,9),F(4,9),F(5,9)/1., 1.3, 3.5, 12., 43./

00102 DATA F(1,10),F(2,10),F(3,10),F(4,10),F(5,10)/1., 1.4, 4.9, 22., 120./

00103 C

00104 DATA T /1.2, 1.15, 1.10, 0.96, 0.90, 0.85, 0.82, 1.35, 1.25,

00105 1 1.12, 0.92, 0.86, 0.80, 0.75, 1.60, 1.40, 1.20, 0.80,

00106 2 0.80, 0.72, 0.66, 2.00, 1.65, 1.30, 0.85, 0.72, 0.63,

00107 3 0.55/

00108 C

00109 DATA UF /0.10, 0.20, 0.30, 0.60, 1.00, 2.00, 6.00, 10.00,

```
00110      1      20.00, 1.E2/
00111      C
00112      DATA CF /9.00, 1.E4, 5.E4, 1.E5, 1.5E5/
00113      C
00114      DATA P /0.60, 0.90, 1.0, 1.0, 0.83, 0.60, 0.40, 0.25, 0.15,
00115      1      0.09, 0.05/
00116      C
00117      DATA DP /0.10, 0.15, 0.20, 0.30, 0.40, 0.50, 0.60, 0.10,
00118      1      0.80, 0.90, 1.00/
00119      C
00120      DATA DG /0.10, 1.00, 10.0, 100./
00121      C
00122      DATA VG/1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10./
00123      C
00124      DATA D50G/0.10, 0.20, 0.30, 0.40, 0.60, 0.80/
00125      C
00126      DATA TEMP/32., 40., 50., 70., 80., 90., 100./
00127      DH50 = D50 * 1000.0
00128      FHRAD = HRAD * 3.280833
00129      IMPR = TEMPR * 1.8 + 32.0
00130      V = (QTOT * ALEN/VOL) * 3.7975E-5
00131      W = VOL/(HRAD*ALEN) * 3.280833
00132      C      *** FSL,,,FINE SEDIMENT (I.E. COHESIVE SEDIMENT OR WASH) LOAD
00133      C      IN MICRO GRAMS/LITER ***
00134      FSL = 0.0
00135      DO (IX=1,NELEM)
00136      . FSL = FSL + 0.5*(C(IX,2) + C(IX+1,2) + C(IX,3) + C(IX+1,3))
00137      ...FIN
00138      FSL = FSL/NELEM * 1000.0
00139      C
00140      IF((DH50 .LT. D50G(1)) .OR. (DH50 .GT. D50G(6)))
00141      . FERROR = .TRUE.
00142      . WRITE(6,1)
00143      1 . FORMAT(//10X,'***** FATAL ERROR == SUBROUTINE COLBY *****')
00144      . WRITE(6,2)
00145      2 . FORMAT(10X,'***** DOUT *****')
00146      ...FIN
00147      IF((FHRAD .LT. DG(1)) .OR. (FHRAD .GT. DG(4)))
00148      . FERROR = .TRUE.
00149      . WRITE(6,1)
00150      . WRITE(6,3)
00151      3 . FORMAT(10X,'***** ROUT *****')
00152      ...FIN
00153      IF((V .LT. VG(1)) .OR. (V .GT. VG(8)))
00154      . FERROR = .TRUE.
00155      . WRITE(6,1)
00156      . WRITE(6,4) V
00157      4 . FORMAT(10X,'***** VOUT *****',F10.5)
00158      ...FIN
00159      UNLESS (FERROR)
00160      . IF (IMPR .LT. 32.0 .OR. IMPR .GT. 100.0)
00161      . . IMPR = 32.0
00162      . ...FIN
00163      . ID1 = 0
00164      . ID2 = 0
00165      . DO (I=1,3)
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00166      . . IF ((FHRAD .GE. DG(I)) .AND. (FHRAD .LE. DG(I+1)))
00167      . . . ID1 = I
00168      . . . ID2 = I+1
00169      . . . GO TO 114
00170      . . . . .FIN
00171      . . . . .FIN
00172 114    . CONTINUE
00173      . IV1 = 0
00174      . IV2 = 0
00175      . DO (I=1,7)
00176      . . IF ((V .GE. VG(I)) .AND. (V .LE. VG(I+1)))
00177      . . . IV1 = I
00178      . . . IV2 = I+1
00179      . . . GO TO 118
00180      . . . . .FIN
00181      . . . . .FIN
00182 118    . CONTINUE
00183      . ID501 = 0
00184      . ID502 = 0
00185      . DO (I=1,5)
00186      . . IF ((DB50 .GE. D50G(I)) .AND. (DB50 .LE. D50G(I+1)))
00187      . . . ID501 = I
00188      . . . ID502 = I+1
00189      . . . GO TO 122
00190      . . . . .FIN
00191      . . . . .FIN
00192 122    . CONTINUE
00193      . II(1) = ID1
00194      . II(2) = ID2
00195      . JJ(1) = IV1
00196      . JJ(2) = IV2
00197      . KK(1) = ID501
00198      . KK(2) = ID502
00199      . DO (I=1,2)
00200      . . II = II(I)
00201      . . XX(I) = ALOG10(DG(II))
00202      . . DO (J=1,2)
00203      . . . J1 = JJ(J)
00204      . . . YY(J) = ALOG10(VG(J1))
00205      . . . . DO (K=1,2)
00206      . . . . . K1 = KK(K)
00207      . . . . . ZZ(K) = ALOG10(D50G(K1))
00208      . . . . . IF (G(II,J1,K1)=0.) 123,123,127
00209 123    . . . . . CONTINUE
00210      . . . . . DO (J3=J1,7)
00211      . . . . . . IF (G(II,J3,K1)=0.) 124,124,126
00212 124    . . . . . . CONTINUE
00213      . . . . . . . . . .FIN
00214 126    . . . . . CONTINUE
00215      . . . . . X(J,K) = ALOG10(G(II,J3,K1))+(ALOG10(VG(J1)/VG(J3))) *
00216      . . . . . (ALOG10(G(II,J3+1,K1)/G(II,J3,K1)))/(ALOG10(VG(J3+1)/
00217      . . . . . VG(J3)))
00218      . . . . . GO TO 128
00219 127    . . . . . CONTINUE
00220      . . . . . X(J,K) = ALOG10(G(II,J1,K1))
00221 128    . . . . . CONTINUE

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00222      * * * * *FIN
00223      * * * * *FIN
00224      * * * * *XD = ALOG10(OR50) = ZZ(1)
00225      * * * * *XN1 = X(1,2) = X(1,1)
00226      * * * * *XN2 = X(2,2) = X(2,1)
00227      * * * * *XDEN = ZZ(2) = ZZ(1)
00228      * * * * *XA(1) = X(1,1) + XN1*X0/XDEN
00229      * * * * *XA(2) = X(2,1) + XN2*X0/XDEN
00230      * * * * *XNM = XA(2) = XA(1)
00231      * * * * *XDY = YY(2) = YY(1)
00232      * * * * *XG(1) = XA(1) + XNM*XV/XD
00233      * * * * *FIN
00234      * * * * *XNM = XG(2) = XG(1)
00235      * * * * *XD = ALOG10(FHRAD) = XX(1)
00236      * * * * *XDEN = XX(2) = XX(1)
00237      * * * * *GYUC = XD(1) + XNM*X0/XDEN
00238      * * * * *GTUC = 10.0*GYUC
00239      C *
00240      C * ** GTUC IS UNCORRECTED AT IN LB/SEC/FT **
00241      C *
00242      C * ** NEXT APPLY FINE SEDIMENT LOAD AND TEMPERATURE CORRECTIONS **
00243      C *
00244      * WHEN (THPR .EQ. 60.) CFT = 1.0
00245      * ELSE
00246      *   IT1 = 0
00247      *   IT2 = 0
00248      *   DO (I=1,6)
00249      *     * IF ((THPR .GE. TEMP(I)) .AND. (THPR .LE. TEMP(I+1)))
00250      *     *   * IT1 = I
00251      *     *   * IT2 = I+1
00252      *     *   * GO TO 136
00253      *     * * * * *FIN
00254      *     * * * * *FIN
00255      136 * CONTINUE
00256      * * * * *XT(1,1) = ALOG10(T(I1),TD1)
00257      * * * * *XT(2,1) = ALOG10(T(IT2),TD1)
00258      * * * * *XT(1,2) = ALOG10(T(I1),TD2)
00259      * * * * *XT(2,2) = ALOG10(T(IT2),TD2)
00260      * * * * *XNT = ALOG10(THPR/TEMP(I1))/ALOG10(TEMP(IT2)/TEMP(I1))
00261      * * * * *XCT(1) = XT(1,1) + XNT*(XT(2,1) - XT(1,1))
00262      * * * * *XCT(2) = XT(1,2) + XNT*(XT(2,2) - XT(1,2))
00263      * * * * *CFT = XCT(1) + (XCT(2) - XCT(1))*XD/XDEN
00264      * * * * *CFT = 10.0*CFT
00265      * * * * *FIN
00266      C *
00267      C * ** FINE SEDIMENT LOAD CORRECTION **
00268      C *
00269      * WHEN (FSL .LE. 10.) CFFR1.0
00270      * ELSE
00271      *   ID1 = 0
00272      *   ID2 = 0
00273      *   DO (I=1,9)
00274      *     * IF ((FHRAD .GE. DF(I)) .AND. (FHRAD .LE. DF(I+1)))
00275      *     *   * ID1 = I
00276      *     *   * ID2 = I+1
00277      *     *   * GO TO 142

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00278      * * * ...FIN
00279      * * * ...FIN
00280      142      * * * CONTINUE
00281      * * * WHEN (FSL .GT. 1.E+5)
00282      * * *   WRITE(6,5)
00283      5        * * *   FORMAT(/'10X,'***** SUBROUTINE CGLBY == FBL WENT * 1.E+5')
00284      * * *   IF1 = 4
00285      * * *   IF2 = 5
00286      * * * ...FIN
00287      * * * ELSE
00288      * * *   IF1 = 0
00289      * * *   IF2 = 0
00290      * * *   DO (I=1,4)
00291      * * *     * IF ((FBL .GE. CP(I)) .AND. (FBL .LE. CP(I+1)))
00292      * * *       * IF1 = I
00293      * * *       * IF2 = I+1
00294      * * *       * GO TO 148
00295      * * *     * ...FIN
00296      * * *     * ...FIN
00297      145      * * * CONTINUE
00298      * * * ...FIN
00299      * * *   XF(1,1) = ALOG10(P(IF1,1D1))
00300      * * *   XF(2,2) = ALOG10(P(IF2,1D2))
00301      * * *   XF(1,2) = ALOG10(P(IF1,1D2))
00302      * * *   XF(2,1) = ALOG10(P(IF2,1D1))
00303      * * *   XNT = (FBL * CP(IF1)) / (CP(IF2) * CP(IF1))
00304      * * *   XCT(1) = XF(1,1) + XNT*(XF(2,1) - XF(1,1))
00305      * * *   XCT(2) = XF(1,2) + XNT*(XF(2,2) - XF(1,2))
00306      * * *   XNT = ALOG10(PHAD/DF(ID1)) / ALOG10(DF(ID2)/DF(ID1))
00307      * * *   CFF = XCT(1) + XNT*(XCT(2) - XCT(1))
00308      * * *   CFF = 10.**CFF
00309      * * * ...FIN
00310      * * * TCF = CFF * CFF * 1.0
00311      * * * CFB = 1.
00312      * * * UNLESS ((DB50 .GE. 0.20) .AND. (DB50 .LE. 0.30))
00313      * * *   IF1 = 0
00314      * * *   IF2 = 0
00315      * * *   DO (I=1,10)
00316      * * *     * IF ((DB50 .GE. DP(I)) .AND. (DB50 .LE. DP(I+1)))
00317      * * *       * IF1 = I
00318      * * *       * IF2 = I+1
00319      * * *       * GO TO 152
00320      * * *     * ...FIN
00321      * * *     * ...FIN
00322      153      * * * CONTINUE
00323      * * *   P2 = ALOG10(P(IF2))
00324      * * *   P1 = ALOG10(P(IF1))
00325      * * *   XNY = ALOG10(DB50/DF(IP1)) / ALOG10(DP(IP2)/DP(IP1))
00326      * * *   CFB = P1 + XNY * (P2-P1)
00327      * * *   CFB = 10.**CFB
00328      * * * ...FIN
00329      * * * FFF = CFB * TCF
00330      * * * FFF = FFF * 1.0
00331      * * * GSI = FFF * GTUC
00332      C
00333      C      * * * CONVERTING GSI FROM (TONS/DAY/FT) TO (MG/DAY/CM) * * *

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00334 . GSI = GSI \* 2.97632E+3  
00335 ...FIN  
00336 RETURN  
00337 END

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00001 SUBROUTINE COLLAP(ALEN,AREA,C,DELZ,EL,IELM,K,NELEM,
00002 1 CELCTR,TMASS,A=ID,VSET,DFZ,CNODE,XBAREA)
00003 C INTERPRETS INITIAL CONDITIONS
00004 C CROSS-SECTION
00005 C SEDIMENT CONCENTRATIONS KG/M3
00006 C PARTICULATE CONCENTRATIONS PC/KG
00007 C DISSOLVED CONCENTRATIONS PC/M3
00008 C ARRIVES AT BOTH
00009 C NODAL CONCENTRATIONS
00010 C ELEMENT AVERAGE VALUES
00011 C NOTE (1.=DELZ*MS/EZ) MUST BE > 0
00012 C
00013 REAL MSAB,MSBR,MSA1,MSBT
00014 C
00015 INCLUDE 'ELMSIZ.PRN'
00016 C
00017 DIMENSION AREA(MXELEM),C(MXELEM,MAXCON),IELM(MXELEM),
00018 1 EL(MXELEM),CELCTR(MXELEM,MAXCON),TMASS(MAXCON),
00019 2 A=ID(MXELEM),VSET(3),DFZ(4),CNODE(MXELEM,MAXCON),
00020 3 XBAREA(MXELEM)
00021 C
00022 BLEN=1./ALEN
00023 ELTOP=DELZ
00024 WJ=AREA(1)*BLEN
00025 WJ=AREA(2)*BLEN
00026 DELEV=EL(2)-EL(1)
00027 CI=C(1,K)
00028 CJ=C(2,K)
00029 NELM=1
00030 MSAR=DELEV*(CJ*WJ/3.+CJ*WJ/6.+CI*WJ/6.+CI*WJ/3.)
00031 MSBR=0.
00032 TMASS(K)=0.0
00033 C
00034 IF(K.NE.7)
00035 . GI=C(1,K+3)
00036 . GJ=C(2,K+3)
00037 . CON=1./12.
00038 . PMSAR=DELEV*(.25*(WJ*CJ*GJ+WJ*CI*GI)
00039 1. +CON*(WJ*CI*GJ+WJ*CI*GJ+WJ*CI*GJ)
00040 2. WJ*CI*GJ+WJ*CI*GJ+WJ*CI*GJ))
00041 . PMSBR=0.
00042 . TMASS(K+3)=0.0
00043 . . .FIN
00044 DO(I=1,NELEM)
00045 . NELMTP=IELM(I)
00046 . ELTP=EL(NELMTP+1)
00047 . ELBT=EL(NELMTP)
00048 . WJ=AREA(NELMTP)*BLEN
00049 . WJ=AREA(NELMTP+1)*BLEN
00050 . CI=C(NELMTP,K)
00051 . CJ=C(NELMTP+1,K)
00052 . FAC1=(ELTOP-ELBT)/(ELTP-ELBT)
00053 . FAC2=(ELTP-ELMTP)/(ELTP-ELBT)

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00054      * CTOP=CI*FAC1+CI*FAC2
00055      * WTOP=HJ*FAC1+HI*FAC2
00056      * NSAT=(ELTP=ELTOP)*(CJ+HJ/3,+CJ+HTOP/6,+CTOP*HJ/6,
00057      *   +CTOP*HTOP/3,)
00058      * HSBT=(ELTP=ELBT)*(CTOP*HTOP/3,+CTOP*HI/6,
00059      *   +CI*HTOP/6,+CI*HI/3,)
00060      * IF(K .NE. 7)
00061      *   * GINC(NELMTP,K+3)
00062      *   * GJMC(NELMTP+1,K+3)
00063      *   * GTOF=GU*FAC1+GI*FAC2
00064      *   * PHSAT=(ELTP=ELTOP)*(,25*(HJ*CI+HJ*HTOP*CTOP+GTOP)
00065      *     +CONR*(HTOP*CI*GJ+HJ*CTOP*GJ+HJ*CI*GTOP+
00066      *       WTOP*CTOP*GJ+HTOP*CI*GTOP*HJ*CTOP*GTOP))
00067      *   * PHSBT=(ELTP=ELBT)*(,25*(HTOP*CI*GTOP+K*CI*GI)
00068      *     +CONA*(HI*CTOP*GTOP*HTOP*CI*GTOP+HTOP*CI*GTOP*GI
00069      *       +HTOP*CI*GI+HI*CTOP*GI+HI*CI*GTOP))
00070      *   * FIN
00071      *   * INDIC=NELMTP-NELMST
00072      *   * CHASS=0,
00073      *   * PHASS=0,
00074      *   * IF(INDIC .EQ. 0)
00075      *     * CHASS=HSBT+HSBB
00076      *     * IF(K .NE. 7) PHASS=PHSBT+PHSBH
00077      *     * FIN
00078      *   * IF(INDIC .GE. 1)
00079      *     * CHASS=HSBT+NSAB
00080      *     * IF(K .NE. 7) PHASS=PHSBT+PHSAB
00081      *     * FIN
00082      *   * IF(INDIC .GE. 2)
00083      *     * DO(J=NELHBT+1, NELMTP=1)
00084      *       * GINC(J,K)
00085      *       * GJMC(J+1,K)
00086      *       * HJAREA(J)ALEN
00087      *       * HIAREA(J+1)*ALEN
00088      *       * CHASS=CHASS+DELEV*(CJ*HJ/3,+CJ*HI/6,+CI*HJ/6,+CI*HI/3,)
00089      *       * IF(K .NE. 7)
00090      *         * GINC(J,K+3)
00091      *         * GJMC(J+1,K+3)
00092      *         * PHASS=PHASS+DELEV*(,25*(HI*CI*GI+HJ*CI*GJ)+
00093      *           CONR*(HI*CI*GJ+HJ*CI*GJ+HJ*CI*GTOP+
00094      *             HJ*CI*GI+HI*CI*GTOP))
00095      *       * FIN
00096      *     * FIN
00097      *     * THASS(K)=THASS(K)+CHASS*ALEN
00098      *     * IF(K .NE. 7) THASS(K+3)=THASS(K+3)+PHASS*ALEN
00099      *     *
00100      *     * DETERMINE CELL CENTERED VALUES
00101      *     *
00102      *     * CELCTR(I,K)=CHASS/XSAREA(I)
00103      *     * IF(K .NE. 7) CELCTR(I,K+3)=PHASS/XSAREA(K)
00104      *     *
00105      *     * DEVELOP NODAL VALUES OF CONCENTRATION
00106      *     *
00107      *     * WHEN(I .EQ. 1)
00108      *     *   * WHEN(K .LE. 3)

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```

00110 C      * * *
00111 C      * * * NOTE: CHASS IN KG/M
00112 C      * * *
00113      * * * COEF#0.
00114      * * * H0#VDET(K)*AME*(1)/(AWID(1)*ALEN)
00115      * * * EZ#DFZ(K)
00116      * * * CNODE(1,K)#(2, *CHASS/XSAREA(1)+COEF*DELZ/EZ)/(2, *DELZ**8/EZ)
00117      * * * CNODE(2,K)#2, *CHASS/XSAREA(1)+CNODE(1,K)
00118      * * * CNODE(1,K+3)#(2, *PMASS/XSAREA(1)+COEF*DELZ/EZ)/(2, *8*DELZ/EZ)
00119      * * * CNODE(2,K+3)#2, *PMASS/XSAREA(1)+CNODE(1,K+3)
00120      * * * FIN
00121      * * * ELSE
00122      * * * CNODE(1,K)#CHASS/XSAREA(1)
00123      * * * CNODE(2,K)#CNODE(1,K)
00124      * * * FIN
00125      * * * FIN
00126      * * * ELSE
00127      * * * CNODE(I+1,K)#2, *CHASS/XSAREA(I)+CNODE(I,K)
00128      * * * IF(K .LE. 3)CNODE(I+1,K+3)#2, *PMASS/XSAREA(I)+CNODE(I,K+3)
00129      * * * FIN
00130 E
00131 C      * OVERWRITE BOTTOM ELEMENTAL NODE INFORMATION
00132 C      *
00133      * MSAR#MSAT
00134      * MSBS#MSBT
00135      * ELTOP#ELTOP+DELZ
00136      * NDLNSTR#ELMTR
00137      * IF(K .NE. 7)
00138      *   . PMDAB#PMSAT
00139      *   . PKDBB#PM3BT
00140      *   . FIN
00141      * * * FIN
00142 RETURN
00143 END

```

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-----  
00001      SUBROUTINE COMB(M, S, Z, R)  
00002      C  
00003      C      THIS SUBROUTINE MULTIPLIES THE UNSYMMETRIC BAND MATRIX (S)  
00004      C      BY THE KNOWN LOAD VECTOR <Z> AND ADDS THE RESULT TO <R>.  
00005      C  
00006      C      CALLED BY TRANSP.  
00007      C  
00008      C      INCLUDE 'ELMSIZ.PRM'  
00009      C  
00010      C      REAL*8 R,S,Y  
00011      C  
00012      C      DIMENSION S(MXELEM,3), R(MXELEM), Y(MXELEM), Z(MXELEM)  
00013      C  
00014      C      R(1)=R(1)+S(1,2)*Z(1)+S(1,3)*Z(2)  
00015      C      R(M)=R(M)+S(M,1)*Z(M-1)+S(M,2)*Z(M)  
00016      C      DO(I=2,M-1)  
00017      C      .   Y(I)=S(I,1)*Z(I-1)+S(I,2)*Z(I)+S(I,3)*Z(I+1)  
00018      C      .   R(I)=R(I)+Y(I)  
00019      C      ...FIN  
00020      C      RETURN  
00021      C      END
```

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-----
00001      SUBROUTINE DIAG(ECH02, ECH03, ECH04, ECH05, ECH06, ECH07,
00002      1      ECH08, ECH09, ECH010, ISEG, JSEG, SAVECH)
00003      LOGICAL*1 ECH02, ECH03, ECH04, ECH05, ECH06, ECH07, ECH08,
00004      1      ECH09, ECH010, SAVECH, WRTSEG
00005      DIMENSION JSEG(5), SAVECH(10)
00006      ECH02=.FALSE.
00007      ECH03=.FALSE.
00008      ECH04=.FALSE.
00009      ECH05=.FALSE.
00010      ECH06=.FALSE.
00011      ECH07=SAVECH(4)
00012      ECH08=.FALSE.
00013      ECH09=.FALSE.
00014      ECH010=.FALSE.
00015      WRTSEG=.FALSE.
00016      WHEN(JSEG(1).EQ.0) WRTSEG=.TRUE.
00017      ELSE
00018      . DO (J=1,5)
00019      . . IF(JSEG(J).EQ.ISEG) WRTSEG=.TRUE.
00020      . . .FIN
00021      . . .FIN
00022      IF(WRTSEG)
00023      . ECH02=SAVECH(1)
00024      . ECH03=SAVECH(2)
00025      . ECH04=SAVECH(3)
00026      . ECH05=SAVECH(4)
00027      . ECH06=SAVECH(5)
00028      . ECH07=SAVECH(7)
00029      . ECH09=SAVECH(8)
00030      . ECH010=SAVECH(9)
00031      . . .FIN
00032      RETURN
00033      END

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-----
00001      SUBROUTINE DIMDAT(ALEN, AREA, BDIV, BED, DLZSAV, ECHO, ELEV,
00002      1      HLDERR, ISEG, NBED, NELEM, NUMERR, PELEV,
00003      2      POR, RIVER, XY80, EL)
00004      C
00005      C THIS ROUTINE IS RESPONSIBLE FOR READING AND PROCESSING THE DATA
00006      C DESCRIBING THE SEGMENT DIMENSIONS AND AREAS
00007      C
00008      C FORMAL PARAMETERS:
00009      C ALEN = SEGMENT LENGTH
00010      C AREA = SEGMENT AREA
00011      C BDIV = STANDARD BED THICKNESS
00012      C BED = INITIAL BED THICKNESS
00013      C DLZSAV = STANDARD ELEMENT THICKNESS
00014      C ECHO = LINE PRINTER ECHO OPTION CONTROL VARIABLE (L41)
00015      C EL = ELEVATIONS ABOVE THE BED CORRESPONDING TO THE SEGMENT AREAS
00016      C ELEV = ELEVATION OF THE SEGMENT
00017      C HLDERR = HOLDING ARRAY FOR ERROR NUMBERS (8YTE)
00018      C ISEG = CURRENT SEGMENT NUMBER
00019      C NBED = NUMBER OF BED LAYERS
00020      C NELEM = NUMBER OF VERTICAL ELEMENTS
00021      C NUMERR = NUMBER OF INPUT ERRORS DETECTED
00022      C PELEV = UPSTREAM ELEVATION OF SEGMENT NUMBER 1
00023      C POR = POROSITY
00024      C RIVER = SHEAR STRESS COMPUTATION CONTROL VARIABLE
00025      C XY80 = THICKNESS OF THE TOP BED LAYER
00026      C
00027      C CALLED BY: SERATRA
00028      C CALLS: PUTERR
00029      C
00030      C INCLUDE 'ELMSIZ.PRM'
00031      C
00032      C BYTE HLDERR(100)
00033      C
00034      C LOGICAL*1 ECHO,RIVER
00035      C
00036      C DIMENSION AREA(*XNELEM), EL(*XNELEM)
00037      C
00038      C CARD 1.....SEGMENT DIMENSIONS
00039      C
00040      C COL. 1= 5...NELEM.....NUMBER OF VERTICAL ELEMENTS
00041      C 6=10...NBED.....NUMBER OF BED LAYERS
00042      C 11=20...DLZSAV.....STANDARD ELEMENT THICKNESS (METERS)
00043      C 21=30...BDIV.....STANDARD BED LAYER THICKNESS
00044      C 31=40...BED.....INITIAL BED THICKNESS (METERS)
00045      C 41=50...ALEN.....LENGTH OF THE SEGMENT (METERS)
00046      C 51=60...ELEV.....ELEVATION OF THE SEGMENT (METERS)
00047      C 61=70...POR.....POROSITY
00048      C 71=80...PELEV.....UPSTREAM ELEVATION OF SEGMENT 1 ONLY
00049      C 80.0 SHEAR STRESS COMPUTED USING VELOCITY
00050      C DISTRIBUTION AND BED ROUGHNESS
00051      C (RESERVOIR)
00052      C 820.0 SHEAR STRESS COMPUTED USING BOTTOM
00053      C SLOP, HYDRAULIC RADIUS AND SPECIFIC

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00054 C
00055 C          HEIGHT OF WATER (FREE FLOWING
00056 C          RIVER)
00057 C
00058 C      WHEN (ISEG .EQ. 1)
00059 C      . READ(1,1) NELEM,NBED,DLZ8AV,BDIV,BED,ALEN,ELEV,POR,PELEV
00060 C      . WHEN (PELEV .EQ. 0.0) RIVER = .FALSE.
00061 C      . ELSE RIVER = .TRUE.
00062 C      ...FIN
00063 C      ELSE
00064 C      . READ(1,11) NELEM,NBED,DLZ8AV,BDIV,BED,ALEN,ELEV,POR,RIVER
00065 C      ...FIN
00066 C
00067 C      *** XYSO == THICKNESS OF THE TOP BED LAYER
00068 C
00069 C      XYSO = HED = (NBED-1) * BDIV
00070 C      IF (ECHO)
00071 C      . WRITE(6,5) ISEG
00072 C      . WRITE(6,2) NELEM,NBED,DLZ8AV,BDIV,BED,ALEN,ELEV,POR,XYSO
00073 C      . IF (ISEG .EQ. 1)
00074 C      . . WRITE(6,6) PELEV
00075 C      . . WHEN (PELEV .EQ. 0.0) WRITE(6,7)
00076 C      . . ELSE WRITE(6,8)
00077 C      . ...FIN
00078 C
00079 C      IF (NELEM .LT. 0 .OR. NELEM+1 .GT. MXELEM)
00080 C      . WRITE(6,100)NELEM,MXELEM
00081 C      . FORMAT('5X'FROM DIM(1): NELEM='I3'      MXELEM='I3')
00082 C
00083 C      . CALL PUTERR(13,NUMERR,HLDERR)
00084 C      ...FIN
00085 C      IF (NBED .LE. 0) CALL PUTERR(6,NUMERR,HLDERR)
00086 C      IF (NBED .GT. MAXLEV) CALL PUTERR(4,NUMERR,HLDERR)
00087 C      IF (DLZ8AV .LF. 0.0) CALL PUTERR(7,NUMERR,HLDERR)
00088 C      IF (BDIV .LE. 0.0) CALL PUTERR(8,NUMERR,HLDERR)
00089 C      IF (BED .GT. NBED*BDIV .OR. BED .LE. (NBED-1)*BDIV)
00090 C      . CALL PUTERR(9,NUMERR,HLDERR)
00091 C      ...FIN
00092 C      IF (ALEN .LE. 0.0) CALL PUTERR(10,NUMERR,HLDERR)
00093 C      IF (ELEV .LE. 0.0) CALL PUTERR(11,NUMERR,HLDERR)
00094 C      IF (POR .GT. 1.0) CALL PUTERR(12,NUMERR,HLDERR)
00095 C
00096 C      CARD 2.....AREA OF EACH ELEMENT
00097 C
00098 C*****
00099 C      6/4/81
00100 C
00101 C      WARNING!
00102 C      A NONZERO SURFACE AREA IS REQUIRED FOR THE
00103 C      CHANNEL BOTTOM.
00104 C
00105 C*****
00106 C      UD (IM1,MXELEM)
00107 C      . AREA(I)=0.0
00108 C      . EL(I)=0.0
00109 C      ...FIN

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00110      HEAD(1,9) NAREA, VPAREA, DELEV
00111      WHEN (NAREA,EW, 0)
00112      * ELE=0.
00113      * DO(I=1,MXELEM)
00114      *   AREA(I)=VPAREA
00115      *   EL(I)=ELE
00116      *   ELE=ELE+DELEV
00117      *   ...FIN
00118      ...FIN
00119      ELSE
00120      *   READ (1,3) (AREA(I), I=1,NAREA)
00121      *   READ(1,3) (EL(I), I=1,NAREA)
00122      *   IF (NAREA,LT,MXELEM)
00123      *     DO (I = NAREA+1,MXELEM)
00124      *       AREA(I) = VPAREA
00125      *       EL(I) = EL(I-1) + DELEV
00126      *       ...FIN
00127      *     ...FIN
00128      ...FIN
00129      IF(ECHO)
00130      *   WRITE(6,4) (I, AREA(I), I=1,MXELEM)
00131      *   WRITE(6,10)(I,EL(I),I=1,MXELEM)
00132      ...FIN
00133      C
00134      RETURN
00135      C
00136      1  FORMAT(2I5,7F10.0)
00137      2  FORMAT(1H0,13X,15,'...NUMBER OF VERTICAL ELEMENTS'/
00138      1 14X,15,'...NUMBER OF BED LAYERS'/
00139      2 7X,1PE12.5,'...STANDARD ELEMENT THICKNESS (METERS)'/
00140      3 7X,1PE12.5,'...STANDARD BED LAYER THICKNESS (METERS)'/
00141      4 7X,1PE12.5,'...INITIAL BED THICKNESS (METERS)'/
00142      5 7X,1PE12.5,'...LENGTH OF THE SEGMENT (METERS)'/
00143      6 7X,1PE12.5,'...SEGMENT ELEVATION (METERS)'/
00144      7 7X,1PE12.5,'...POROSITY'/
00145      8 7X,1PE12.5,'...THICKNESS OF THE TOP BED LAYER (CALCULATED)')
00146      3  FORMAT(1F10.0)
00147      4  FORMAT(1H0,50X,'ELEMENT AREAS'/4(27X,5(13,1PE12.5)/))
00148      5  FORMAT(1H0,54X,'INPUT DATA FOR SEGMENT ',I3)
00149      6  FORMAT(7X,1PE12.5,'...UPSTREAM ELEVATION (METERS)')
00150      7  FORMAT(19X,'...SHEAR STRESS VALUES COMPUTED USING METHOD'
00151      1 ' FOR RESERVOIR')
00152      8  FORMAT(19X,'...SHEAR STRESS VALUES COMPUTED USING METHOD'
00153      1 ' FOR FREE FLOWING RIVERS')
00154      9  FORMAT(15, 7F10.0)
00155      10 FORMAT(1H0,58X,'NODAL ELEVATIONS'/4(27X,5(13,1PE12.5)/))
00156      11 FORMAT(2I5,6F10.0,L5)
00157      C
00158      END

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-----
00001 SUBROUTINE DISOLV(ABAR, H, BDIV, C, CCIN, COLD, DECAY, DELZ,
00002 1 DELTD, DENS, DIAM, I, KAY1, KAY2,
00003 2 NELEM, NBED, PCOEF, POR, QHIN, QHOUT, QV, DSORB, ALFA,
00004 3 BETA, VEL1, VEL2, BETA1, BETA2,
00005 4 DEPO, SCUR, HEDSD, XYSD, AREA, DSORB, OLOC)
00006 C
00007 C THIS SUBROUTINE CALCULATES COEFFICIENTS OF CONVECTIVE, DECAY
00008 C AND SOURCE/SINK TERMS OF DISSOLVED POLLUTANT CONVECTION-DIFFUSION
00009 C EQUATION
00010 C
00011 C INPUT PARAMETERS:
00012 C ABAR = AVERAGE AREA
00013 C AREA = VERTICAL PROJECTION AREAS (M2)
00014 C B = BED CONCENTRATIONS
00015 C BDIV = STANDARD BED LAYER THICKNESS
00016 C C = NODAL CONCENTRATION
00017 C CCIN = CONCENTRATION OF INFLOW
00018 C COLD = CELL-CENTERED CONCENTRATION
00019 C DECAY = DECAY VALUES
00020 C DELTD = TIME STEP IN DAYS
00021 C DENS = DENSITY
00022 C DEPO = DEPOSITION RATE (KG(PC)/M2/DAY)
00023 C DIAM = PARTICLE DIAMETERS
00024 C DELZ = THICKNESS OF THE ELEMENT
00025 C I = ELEMENT INDEX
00026 C KAY1 = LIGHT EXTINCTION COEFFICIENT OF WATER
00027 C KAY2 = LIGHT EXTINCTION COEFFICIENT OF SUSPENDED
00028 C SEDIMENT IN WATER
00029 C NELEM = NUMBER OF VERTICAL ELEMENTS
00030 C PCOEF = 1ST TERM OF THE PHOTOLYSIS RATE EQUATION, COMPUTED
00031 C IN SUBROUTINE PHOINP.
00032 C POR = POROSITY
00033 C QHIN = INFLOW DISCHARGE
00034 C QHOUT = OUTFLOW DISCHARGE
00035 C QV = VERTICAL DISCHARGE
00036 C SCUR = SCOUR RATE (KG(PC)/M2/DAY)
00037 C DSORB = ADSORPTION ON SEDIMENT
00038 C DSORB = DESORPTION FROM SEDIMENT
00039 C XYSD = TOP BED LAYER THICKNESS
00040 C OUTPUT PARAMETERS:
00041 C ALFA = DECAY TERM
00042 C HEDSD = SCOUR OR DEPOSITION OF ADSORBED CONTAMINANT
00043 C (PC/M2/DAY) WHEN NO SCOUR IS TAKING PLACE
00044 C BETA = SOURCE OR SINK TERM
00045 C BETA1 = INFLUENT SOURCE TERM FOR I-TH NODE
00046 C BETA2 = INFLUENT SOURCE TERM FOR I+1 TH NODE
00047 C VEL1 = FIRST CONVECTIVE TERM
00048 C VEL2 = SECOND CONVECTIVE TERM
00049 C
00050 C CALLED BY TRANSP.
00051 C
00052 C INCLUDE 'ELMSIZ.PRM'
00053 C
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00054 C
00055 REAL KAY,KAY1,KAY2,INFRAC
00056 C
00057 DIMENSION ABAR(MXELEM), R(MAXLEV,MAXCON=1), BEDSD(3),
00058 1 CCIN(MXELEM,MAXCON),COLU(MXELEM,MAXCON), DECAY(6),
00059 2 QHIN(MXELEM), QHOUT(MXELEM), QV(MXELEM), SORBK(9),
00060 3 DENS(3), DIAM(3), C(MXELEM,MAXCON),CBAR(MXELEM,MAXCON),
00061 4 DEPO(6), SCOUR(6), AREA(MXELEM), OSORB(9),
00062 5 OLDC(MXELEM,MAXCON)
00063 C
00064 DATA ZERO/1.0E-30/
00065 C
00066 C CONVECTIVE TERM
00067 C
00068 AQ=QV(I)
00069 VEL1=AQ/ABAR(I)
00070 AQ=QV(I+1)
00071 VEL2=AQ/ABAR(I)
00072 C DECAY TERM
00073 TOTDK = 0.0
00074 WHEN (PCOEF .NE. 0.0) COMPUTE=PHOTOLYSIS=RATE=FOR=ELEMENT=I
00075 ELSE PHOTO = 0.0
00076 DO (IJI=1,5) TOTDK = TOTDK + DECAY(IJI)
00077 ALFA=QHOUT(I)/(ABAR(I)*DELZ)+TOTDK+PHOTO
00078 IF(I .EQ. NELEM) ALFA = ALFA + DECAY(6)
00079 C
00080 C SOURCE OR SINK TERM
00081 BETA1=QHIN(I)/(ABAR(I)*DELZ)*(CCIN(I,7)/3.+CCIN(I+1,7)/6.)
00082 BETA2=QHIN(I)/(ABAR(I)*DELZ)*(CCIN(I,7)/6.+CCIN(I+1,7)/3.)
00083 C *****
00084 C *
00085 C * WARNING: THE VALUE OF CBAR SHOULD BE UPDATED BY ITERATIVELY *
00086 C * SOLVING FOR C AT THE ADVANCED TIME, AND APPROXIMATING *
00087 C * CBAR AS THE NEW AVERAGE CONCENTRATION OVER THE TIME *
00088 C * STEP. *
00089 C *
00090 C *****
00091 DO (IE = 1,NELEM)
00092 . INFRAC = 0.5*QHIN(IE)*DELTD/ABAR(IE)/DELZ
00093 . EXFRAC = 1.0-INFRAC
00094 . DO (IC = 1,MAXCON)
00095 . . CHAR(IE,IC) = CCIN(IE,IC)*INFRAC+OLDC(IE,IC)*EXFRAC
00096 . . .FIN
00097 . . .FIN
00098 C
00099 DO (J = 1,3)
00100 . JP3 = J + 3
00101 . IP1 = I + 1
00102 . IF (CBAR(I,J).GT.0.0.AND.CBAR(IP1,J).GT.0.0)
00103 . . ADJ81 = (SORBK(J)*SORBK(JP3)/12.*(3.*CBAR(I,J)+CHAR(I,7)
00104 1. . +CBAR(I,J)+CHAR(IP1,7)+CBAR(IP1,7)+CBAR(IP1,7)+
00105 2. . CBAR(IP1,J)+CHAR(IP1,7)) - SORBK(JP3)/6.*(2.*
00106 3. . CBAR(I,JP3) + CBAR(IP1,JP3))
00107 . . DSA81 = (DSORB(J)*DSORB(JP3)/12.*(3.*CBAR(I,J)+CBAR(I,7)
00108 1. . +CBAR(I,J)+CBAR(IP1,7)+CHAR(IP1,7)+CBAR(IP1,7)+
00109 2. . CBAR(IP1,J)+CHAR(IP1,7)) - DSORB(JP3)/6.*(2.*

```

```
00110      3. . CBAR(I,JP3) + CBAR(IP1,JP3))
00111      . . ADDS2 = (SORBK(J)*SORBK(JP3)/12.*(CBAR(I,J)*CBAR(I,7)+
00112      1. . CBAR(I,J)*CBAR(IP1,7)+CBAR(IP1,J)*CBAR(I,7)+
00113      2. . 3.*CBAR(IP1,J)*CBAR(IP1,7)) - SORBK(JP3)/6.*
00114      3. . (CBAR(I,JP3) + 2.*CBAR(I+1,JP3))
00115      . . DSAU2 = (DSORB(J)*DSORB(JP3)/12.*(CBAR(I,J)*CBAR(I,7)+
00116      1. . CBAR(I,J)*CBAR(IP1,7)+CBAR(IP1,J)*CBAR(I,7)+
00117      2. . 3.*CBAR(IP1,J)*CBAR(IP1,7)) - DSORB(JP3)/6.*
00118      3. . (CBAR(I,JP3) + 2.*CBAR(I+1,JP3))
00119      . . IF(ADDS1,GT,0.0,OR,ADDS1,EQ,DSAD1)BETA1=BETA1+ADDS1
00120      . . IF(DSAD1,LT,0.0)BETA1=BETA1-DSAD1
00121      . . IF(ADDS2,GT,0.0,OR,ADDS2,EQ,DSAD2)BETA2=BETA2+ADDS2
00122      . . IF(DSAD2,LT,0.0)BETA2=BETA2-DSAD2
00123      . . ...FIN
00124 C
00125      . . ...FIN
00126 C*****
00127 C TRANSFER BETWEEN DISSOLVED STREAM CONTAMINANT AND ABSORBED *
00128 C BED CONTAMINANT IS INCLUDED WHENEVER NO SCOURING OCCURS FOR *
00129 C A PARTICULAR SEDIMENT SIZE (EG SAND, SILT, OR CLAY) *
00130 C*****
00131      BETA = 0.0
00132      IF (I,EQ,1)
00133      . DO (J=1,3) BEDSD(J) = 0.0
00134      . IF(NBED,GT,0)
00135      . . DO (J=1,3)
00136      . . . WHEN(SCOUR(J),GT,0.0,OR,B(NBED,J),LE,ZERO)
00137      . . . . BEDSD(J)=0.0
00138      . . . . ...FIN
00139      . . . . ELSE
00140      . . . . . RHOJ=R(NBED,J)*(1.0-POR)*DENS(J)
00141      . . . . . D = DIAM(J)
00142      . . . . . IF(D,GT,XY80) D=XY80
00143      . . . . . RATE = SORBK(J+6)*(SORBK(J)*(CBAR(1,7)+CBAR(2,7))/2.
00144      1. . . . . -R(NBED,J+3))* D * RHOJ
00145      . . . . . BETA = BETA + RATE /DELZ
00146      . . . . . BEDSD(J)=RATE
00147      . . . . . ...FIN
00148      . . . . . ...FIN
00149      . . . . . ...FIN
00150      . . . . . ...FIN
00151      RETURN
```

```
-----
00152      TO COMPUTE=PHOTOLYSIS=RATE=FOR=ELEMENT=I
00153      . AVGSED = 0.0
00154      . WHEN (I,EQ, NELEM)
00155      . . DO (IJI=1,3) AVGSED = AVGSED + C(I+1,IJI)
00156      . . ...FIN
00157      . ELSE
00158      . . DO (IK=I+1,NELEM+1)
00159      . . . DO (IJI=1,3) AVGSED = AVGSED + C(IK,IJI)
00160      . . . ...FIN
00161      . . AVGSED = AVGSED / (NELEM+1-I)
00162      . . ...FIN
```

```
00163      * KAY = KAY1 + KAY2 * AVGBED
00164      * WHEN (I .EQ. NELEM) TERM1 = 1.0
00165      * ELSE TERM1 = EXP (-KAY*(NELEM-I)*DELZ)
00166      * TERM2 = (1.0 - EXP(-KAY*DELZ)) / (KAY*DELZ)
00167      * PHOTO = PCOEF * TERM1 * TERM2
00168      ...FIN
00169      END
```

-----

PROCEDURE CROSS-REFERENCE TABLE

00152 COMPUTE=PHOTOLYSIS=RATE=FOR=ELEMENT=I  
00074

(FLECS VERSION 22,46)

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-----
00001      SUBROUTINE EQUPCS(PXSAR, UWID, UEL, XSAREA, NELEM, MELEM,
00002      1          RATIO, IELP, HEQXS, FERROR, DELTA)
00003      C
00004      C      THIS SUBROUTINE FINDS CROSS-SECTIONAL AREAS AND HEIGHTS WITHIN THE
00005      C      UPSTREAM CROSS-SECTION WHICH CORRESPONDS TO THE SEGMENT IMMEDIATELY
00006      C      DOWNSTREAM.
00007      C
00008      C      INCLUDE 'ELB1TZ.PRM'
00009      C      LOGICAL*1 FERROR
00010      C
00011      C      DIMENSION PXSAR(MXELEM), UWID(MXELEM), UEL(MXELEM),
00012      1          XSAREA(MXELEM), IELP(MXELEM), HEQXS(MXELEM)
00013      C
00014      C      FERROR=.FALSE.
00015      C      IP=1
00016      C      PXS=PXSAR(1)
00017      C      UBTM=UWID(1)
00018      C      ELBTM=UEL(1)
00019      C      TEMPXS=0.
00020      C
00021      C      DO(I=1,NELEM)
00022      C      . XS=RATIO*XSAREA(I)
00023      C      . UNTIL(XS .LE. PXS .OR. IP .EQ. MELEM)
00024      C      .   . IP=IP+1
00025      C      .   . TEMPXS=PXS
00026      C      .   . UBTM=UWID(IP)
00027      C      .   . ELBTM=UEL(IP)
00028      C      .   . PXS=PXS+PXSAR(IP)
00029      C      .   . ...FIN
00030      C      .   IELP(I)=IP
00031      C      .   WHEN(XS .EQ. PXS)
00032      C      .   . HEQXS(I)=UEL(IP+1)
00033      C      .   . IF(I.EQ.NELEM) HEQXS(I)= UEL(IP) + DELTA
00034      C      .   . ELBTM=UEL(IP+1)
00035      C      .   . UBTM=UWID(IP+1)
00036      C      .   . PXS=0
00037      C      .   . TEMPXS=0
00038      C      .   . ...FIN
00039      C      .   ELSE
00040      C      .   . A=(UWID(IP+1)-UBTM)/(2.*(UEL(IP+1)-ELBTM))
00041      C      .   . B=UBTM
00042      C      .   . C=XS-TEMPXS
00043      C      .   . WHEN (A .EQ. 0.) HEQXS(I)=C/B+ELBTM
00044      C      .   . ELSE
00045      C      .   . . B504AC=B*B+4.*A*C
00046      C      .   . . IF (B504AC .LT. 0.) GO TO 200
00047      C      .   . . HEQXS(I)=(SURT(B504AC)-B)/2./A+ELBTM
00048      C      .   . ...FIN
00049      C      .   . UBTM=2.*A*(HEQXS(I)-ELBTM)+B
00050      C      .   . ELBTM=HEQXS(I)
00051      C      .   . PXS=PXS-XS
00052      C      .   . TEMPXS=0.
00053      C      .   . ...FIN

```

```
00054      ...FIN
00055      RETURN
00056  200  CONTINUE
00057      FERRON=,THUE.
00058      WRITE(6,1)
00059  1    FORMAT(10X,'FATAL ERROR - BRQ9AC IN EQUPCS SUBROUTINE IS < 0')
00060      RETURN
00061      END
```

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-----

```

-----
00001      SUBROUTINE EQUPXS(PXBAR, PWID,PDELZ,XBAREA,NELEM,MELEM,
00002      1      RATIO, IELP, HEQXS)
00003      C
00004      INCLUDE 'SYS/ELMSIZ.PRM'
00005      C
00006      DIMENSION PXBAR(MXELEM), PWID(MXELEM), XBAREA(MXELEM),
00007      1      IELP(MXELEM), HEQXS(MXELEM)
00008      C
00009      IP=1
00010      PXS=PXBAR(1)
00011      WBTM=PWID(1)
00012      ELBTM=0.
00013      TEMPXS=0.
00014      C
00015      DO(I=1,MELEM)
00016      .   XS=RATIO*XBAREA(I)
00017      .   UNTIL(XS .LE. PXS .OR. IP .EQ. MELEM)
00018      .   .   IP=IP+1
00019      .   .   TEMPXS=PXS
00020      .   .   WBTM=PWID(IP)
00021      .   .   ELBTM=PDELZ*(IP-1)
00022      .   .   PXS=PXBAR(IP)
00023      .   ...FIN
00024      .   IELP(I)=IP
00025      .   WHEN(XS .EQ. PXS)
00026      .   .   HEQXS(I)=PDELZ * IP
00027      .   .   PXS=0.
00028      .   .   TEMPXS=0.
00029      .   .   ELBTM=IP*PDELZ
00030      .   .   WBTM=PWID(IP+1)
00031      .   ...FIN
00032      .   ELSE
00033      .   .   HEQXS(I)=(XS-TEMPXS)/WBTM+ELBTM
00034      .   .   PXS=PXBAR-XS
00035      .   .   TEMPXS=0.
00036      .   .   ELBTM=HEQXS(I)
00037      .   ...FIN
00038      ...FIN
00039      RETURN
00040      END

```

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-----

```

-----
00001      SUBROUTINE FCODE(FNAME,BASE,NRRTP,FTYPE,DEV,UIC1,UIC2)
00002      C
00003      C   THIS ROUTINE BUILDS A FILE SPECIFICATION INTO THE OUTPUT
00004      C   PARAMETER FNAME
00005      C
00006      C   BASE = FIRST FIVE CHARACTERS OF THE FILE NAME (BYTE ARRAY)
00007      C   NRRTP = TIME PLANE NUMBER. THIS BECOMES THE LAST 4 CHARACTERS
00008      C           OF THE 9 CHARACTER FILE NAME (INTEGER)
00009      C   FTYPE = THESE 3 CHARACTERS BECOME THE EXTENSION (BYTE ARRAY)
00010      C   DEV = DEVICE (BYTE ARRAY)
00011      C   UIC1 = 1ST UIC (BYTE ARRAY)
00012      C   UIC2 = 2ND UIC (BYTE ARRAY)
00013      C
00014      C   CALLED BY: SERATRA
00015      C
00016      C   BYTE FNAME(27),FTYPE(3),DEV(3),UIC1(3),UIC2(3),COLON,LBRAK,
00017      C   1 RBRAK,PERIOD,COMMA,BLANK,BASE(5)
00018      C
00019      DATA COLON/' ':'/'
00020      DATA LBRAK/' ['/'
00021      DATA RBRAK/' ']'/'
00022      DATA PERIOD/'.'/'
00023      DATA COMMA/'.'//'
00024      DATA BLANK/' '/'
00025      C
00026      ICAR=1
00027      C
00028      C   *** DETERMINE IF A DEVICE HAS BEEN SPECIFIED AND IF SO THE NUMBER
00029      C   CHARACTERS IN THE SPECIFICATION ***
00030      C
00031      N=0
00032      DO (I=1,3)
00033      . IF(DEV(I) .NE. BLANK) N=N+1
00034      ...FIN
00035      IF (N .NE. 0)
00036      C   . *** TRANSFER DEVICE SPECIFICATION ***
00037      . DO (I=1,N)
00038      . . FNAME(ICAR)=DEV(I)
00039      . . ICAR=ICAR+1
00040      . ...FIN
00041      C   . *** INSERT ":" ***
00042      . FNAME(ICAR)=COLON
00043      . ICAR=ICAR+1
00044      . ...FIN
00045      C
00046      C   *** HAVE UIC'S BEEN SPECIFIED ***
00047      N=0
00048      DO (I=1,3)
00049      . IF(UIC1(I) .NE. BLANK) N=N+1
00050      ...FIN
00051      IF (N .NE. 0)
00052      C   .
00053      C   . *** INSERT LEFT BRACKET ***

```

```
00054      . FNAME(ICAR)=LBPAK
00055      . ICAR=ICAR+1
00056      C      .
00057      C      . *** TRANSFER 1ST UIC ***
00058      . DO (I=1,N)
00059      . . FNAME(ICAR)=UICI(I)
00060      . . ICAR=ICAR+1
00061      . ...FIN
00062      C      .
00063      C      . *** INSERT COMMA ***
00064      . FNAME(ICAR)=COMMA
00065      . ICAR=ICAR+1
00066      C      .
00067      C      . *** TRANSFER 2ND UIC ***
00068      . DO (I=1,3)
00069      . . IF (UIC2(I) .NE. BLANK)
00070      . . . FNAME(ICAR)=UIC2(I)
00071      . . . ICAR=ICAR+1
00072      . . ...FIN
00073      . ...FIN
00074      C      .
00075      C      . *** INSERT RIGHT BRACKET ***
00076      . FNAME(ICAR)=RBRAK
00077      . ICAR=ICAR+1
00078      . ...FIN
00079      C      .
00080      C      . *** TRANSFER 5 CHARACTER BASE FILE NAME, ASSUME ALL 5 CHARACTER
00081      C      . ARE BEING USED ***
00082      . DO (I=1,5)
00083      . . FNAME(ICAR)=BASE(I)
00084      . . ICAR=ICAR+1
00085      . ...FIN
00086      C      .
00087      C      . *** CONVERT TIME PLANE NUMBER TO ASCII AND INSERT IT INTO FNAME **
00088      C      .
00089      . N=NRTP
00090      . IDIG=N/1000
00091      . FNAME(ICAR)=IDIG+48
00092      . N=N-IDIG*1000
00093      . IDIG=N/100
00094      . FNAME(ICAR+1)=IDIG+48
00095      . N=N-IDIG*100
00096      . IDIG=N/10
00097      . FNAME(ICAR+2)=IDIG+48
00098      . FNAME(ICAR+3)=(N-IDIG*10)+48
00099      . ICAR=ICAR+4
00100      C      .
00101      C      . *** INSERT PERIOD ***
00102      . FNAME(ICAR)=PERIOD
00103      . ICAR=ICAR+1
00104      C      .
00105      C      . *** TRANSFER THE 3 CHARACTER EXTENSION ***
00106      . DO (I=1,3)
00107      . . FNAME(ICAR)=FTYPE(I)
00108      . . ICAR=ICAR+1
00109      . ...FIN
```

```
00110 C
00111 C   *** INSERT NULL CHARACTER ***
00112     FNAME(ICAH)#0
00113     RETURN
00114     END
```

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.....

```

-----
00001      SUBROUTINE FDCODE(FNAME,BASE,NBRTP,FTYPE,DEV,UIC1,UIC2)
00002      C
00003      C   THIS ROUTINE SPERATES FNAME INTO 6 COMPONENTS
00004      C
00005      C   BASE = 5 CHARACTER BASE FILE NAME (BYTE ARRAY)
00006      C   NBRTP = TIME PLANE NUMBER THAT IS THE LAST 4 CHARACTERS OF THE
00007      C           9 CHARACTER FILE NAME (INTEGER)
00008      C   FTYPE = FILE EXTENSION (BYTE ARRAY)
00009      C   DEV = PHICAL DEVICE SPECIFICATION (BYTE ARRAY)
00010      C   UIC1 = 1ST UIC
00011      C   UIC2 = 2ND UIC
00012      C
00013      C   THE OPTIONAL PARAMETERS DEV, UIC1, AND UIC2 WILL BE SET
00014      C   TO BLANKS IF NOT PRESENT IN THE ORIGINAL FILE SPECIFICATION.
00015      C
00016      C   CALLED BY: STRTUP
00017      C
00018      C   BYTE FNAME(27),BASE(5),FTYPE(3),DEV(3),UIC1(3),UIC2(3),
00019      C   1   LBRAK,RBRAK,COMMA,PERIOD,COLON,BLANK
00020      C
00021      DATA LBRAK/'.'/
00022      DATA RBRAK/'.'/
00023      DATA COMMA/',.'/
00024      DATA PERIOD/'.'/
00025      DATA COLON/':.'/
00026      DATA BLANK/'.'/
00027      C
00028      C   *** FILE SPECIFICATION HAVE FOUR POSSIBLE FORMS ***
00029      C   (1) FILENAME,EXT
00030      C   (2) DEV:FILENAME,EXT
00031      C   (3) [UIC1,UIC2]FILENAME,EXT
00032      C   (4) DEV:[UIC1,UIC2]FILENAME,EXT
00033      C
00034      C   THE FORM CAN BE DETERMINED BY COUNTING THE FOUR SPECIAL
00035      C   CHARACTERS [ ] . :
00036      C
00037      IMB0
00038      DO (I=1,27)
00039      . SELECT (FNAME(I))
00040      . . (COLON) N=N+1
00041      . . (LBRAK) N=N+1
00042      . . (RBRAK) N=N+1
00043      . . (PERIOD) N=N+1
00044      . . .FI
00045      . . .FIN
00046      ICAR=1
00047      DO (I=1,3)
00048      . DEV(I)=BLANK
00049      . UIC1(I)=BLANK
00050      . UIC2(I)=BLANK
00051      . . .FIN
00052      SELECT (N)
00053      . (1) DECODE=FORM1

```

```
00054      . (2) DECODE=FORM2
00055      . (3) DECODE=FORM3
00056      . (4) DECODE=FORM4
00057      ...FIN
00058      RETURN
00059      C
```

-----

```
00060      TO DECODE=FORM1
00061      . DECODE=FILENAME-EXTENSION
00062      ...FIN
00063      C
```

-----

```
00064      TO DECODE=FORM2
00065      . DECODE=DEVICE
00066      . DECODE=FILENAME-EXTENSION
00067      ...FIN
00068      C
```

-----

```
00069      TO DECODE=FORM3
00070      . DECODE=UIC
00071      . DECODE=FILENAME-EXTENSION
00072      ...FIN
00073      C
```

-----

```
00074      TO DECODE=FORM4
00075      . DECODE=DEVICE
00076      . DECODE=UIC
00077      . DECODE=FILENAME-EXTENSION
00078      ...FIN
00079      C
```

-----

```
00080      TO DECODE=FILENAME-EXTENSION
00081      . DO (I#1,5)
00082      . . BASE(I)#FNAME(ICAR)
00083      . . ICAR#ICAR+1
00084      . ...FIN
00085      . WHEN (FNAME(ICAR) .NE. PERIOD)
00086      . . ICHAR1#FNAME(ICAR)
00087      . . ICHAR2#FNAME(ICAR+1)
00088      . . ICHAR3#FNAME(ICAR+2)
00089      . . ICHAR4#FNAME(ICAR+3)
00090      . . NRHTP#(ICAR1-4#)*1000+(ICAR2-4#)*100+(ICAR3-4#)*10+ICAR4-4#
00091      . . *** SKIP OVER PERIOD ***
00092      . . ICAR#ICAR+5
00093      . ...FIN
00094      . ELSE
```



```
00095      . . ICAR=ICAR+1
00096      . . NHRTIP=0
00097      . ...FIN
00098      . DO (I=1,3)
00099      . . FTYPE(I)=FNAME(ICAR)
00100      . . ICAR=ICAR+1
00101      . ...FIN
00102      ...FIN
00103 C
```

```
-----
00104      TO DECODE=DEVICE
00105      . I=1
00106      . REPEAT WHILE (FNAME(ICAR) .NE. COLON)
00107      . . DEV(I)=FNAME(ICAR)
00108      . . ICAR=ICAR+1
00109      . . I=I+1
00110      . ...FIN
00111 C      . *** SKIP OVER COLON ***
00112      . ICAR=ICAR+1
00113      ...FIN
00114 C
```

```
-----
00115      TO DECODE=UIC
00116 C      . *** SKIP OVER LEFT BRACKET ***
00117      . ICAR=ICAR+1
00118      . I=1
00119      . REPEAT WHILE (FNAME(ICAR) .NE. COMMA)
00120      . . UIC1(I)=FNAME(ICAR)
00121      . . ICAR=ICAR+1
00122      . . I=I+1
00123      . ...FIN
00124 C      . *** SKIP OVER COMMA ***
00125      . ICAR=ICAR+1
00126      . I=1
00127      . REPEAT WHILE (FNAME(ICAR) .NE. RBRAK)
00128      . . UIC2(I)=FNAME(ICAR)
00129      . . ICAR=ICAR+1
00130      . . I=I+1
00131      . ...FIN
00132 C      . *** SKIP OVER RIGHT BRACKET ***
00133      . ICAR=ICAR+1
00134      ...FIN
00135      END
```

```
-----
PROCEDURE CROSS-REFERENCE TABLE
```

00060 DECODE=FORM1  
00053

00054 DECODE=FORM2

00054

00115 DECODE=UIC  
00070 00076

00069 DECODE=FUHM3  
00055

00074 DECODE=FUHM4  
00056

00080 DECODE=FILENAME=EXTENSION  
00061 00066 00071 00077

00104 DECODE=DEVICE  
00065 00075

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-----

```
-----
00001      SUBROUTINE GETSPC(BASE,BEGSEG,BEGTIM,CHAIN,EXT,DEV,FILNAM,GUIC,
00002      1      INTSEG,INTTIM,LSTSEG,LSTTIM,TSTEP,UNITS,UUIC)
00003      C
00004      C      THIS ROUTINE IS RESPONSIBLE FOR INTERROGATING THE USER TO LEARN
00005      C      THE SPECIFICATION NEEDED FOR POST PROCESSING.
00006      C
00007      C      FORMAL PARAMETERS:
00008      C      BASE = 5 CHARACTER BASE FILE NAME FOR CHAINED OPERATIONS
00009      C      BEGSEG = BEGINNING SEGMENT NUMBER FOR CHAINED OPERATIONS
00010      C      BEGTIM = BEGINNING TIME PLANE NUMBER
00011      C      CHAIN = LOGICAL FLAG FOR CHAINED OPERATIONS
00012      C      EXT = BASE FILE NAME EXTENSION FOR CHAINED OPERATIONS
00013      C      DEV = BASE FILE NAME DEVICE FOR CHAINED OPERATIONS
00014      C      FILNAM = FILE SPECIFICATION FOR UNCHAINED PROCESSING
00015      C      GUIC = GROUP UIC FOR CHAINED PROCESSING
00016      C      INTSEG = SEGMENT INTERVAL FOR CHAINED PROCESSING
00017      C      INTTIM = TIME PLANE INTERVAL
00018      C      LSTSEG = ENDING SEGMENT NUMBER FOR CHAINED PROCESSING
00019      C      TSTEP = TIME STEP SIZE
00020      C      UNITS = MNEMONICS FOR CONCENTRATION OF CONTAMINANT ATTACHED TO
00021      C      SEDIMENTS (PC OR KG)
00022      C      UUIC = USER UIC FOR CHAINED PROCESSING
00023      C
00024      C      CALLED BY SPPR
00025      C      CALLS FDCODE
00026      C
00027      C      BYTE ANSWER,YES,FILNAM(30),BASE(5),EXT(3),DEV(3),GUIC(3),UUIC(3)
00028      C
00029      C      INTEGER*2 UNITS,BEGSEG
00030      C      INTEGER*4 BEGTIM,LSTTIM
00031      C
00032      C      LOGICAL*1 CHAIN
00033      C
00034      C      DATA YES/'Y'/
00035      C
00036      C      WRITE(1,1)
00037      C      READ(1,19)ANSWER
00038      C      WHEN (ANSWER,EW,YES)
00039      C      . CHAIN =.TRUE.
00040      C      . WRITE(1,3)
00041      C      . READ(1,19)FILNAM
00042      C      . CALL FDCODE(FILNAM,BASE,JSEG,EXT,DEV,GUIC,UUIC)
00043      C      . WRITE(1,4)
00044      C      . READ(1,5)BEGSEG
00045      C      . WRITE(1,6)
00046      C      . READ(1,5)LSTSEG
00047      C      . WRITE(1,7)
00048      C      . READ(1,5)INTSEG
00049      C      . NSEG=(LSTSEG-BEGSEG)/INTSEG+1
00050      C      ...FIN
00051      C      ELSE
00052      C      . NSEG=1
00053      C      . CHAIN=.FALSE.
```

```
00054      * WRITE(1,9)
00055      * READ(1,2) NCHR,(FILNAM(I),I=1,NCHR)
00056      * FILNAM(NCHR+1) = 0
00057      * INTSEG=1
00058      ...FIN
00059  C
00060      WRITE(1,10)
00061      READ(1,11)REGTIM
00062      WRITE(1,12)
00063      READ(1,11)LGTTIM
00064      WRITE(1,13)
00065      READ(1,11)INTTIM
00066      NTIM = (LGTTIM-REGTIM)/INTTIM + 1
00067  C
00068      WRITE(1,17)
00069      READ(1,18) TSTEP
00070      WRITE(1,15)
00071      READ(1,16) UNITS
00072  C
00073      WRITE(1,8) NSEG
00074      WRITE(1,14) NTIM
00075  C
00076      RETURN
00077  C
00078  1  FORMAT(/10X,'***** SERATHA POST PROCESSING *****'//
00079      1 'IS THIS TO BE A CHAINED OPERATION (Y OR N)>')
00080  2  FORMAT(Q,30A1)
00081  3  FORMAT('ENTER BASE FILE NAME>')
00082  4  FORMAT('ENTER BEGINNING SEGMENT NUMBER (I4)>')
00083  5  FORMAT(I4)
00084  6  FORMAT('ENTER ENDING SEGMENT NUMBER (I4)>')
00085  7  FORMAT('ENTER INTERVAL BETWEEN SEGMENTS (I4)>')
00086  8  FORMAT(/10X,I6,'SEGMENTS (FILES) WILL BE PROCESSED')
00087  9  FORMAT('ENTER THE NAME OF THE FILE TO BE PROCESSED (20A1)>')
00088  10 FORMAT('ENTER BEGINNING TIME PLANE NUMBER (I10)>')
00089  11 FORMAT(I10)
00090  12 FORMAT('ENTER ENDING TIME PLANE NUMBER (I10)>')
00091  13 FORMAT('ENTER INTERVAL BETWEEN TIME PLANES (I10)>')
00092  14 FORMAT(/10X,I6,'TIME PLANES FOR EACH SEGMENT WILL BE PROCESSED')
00093  15 FORMAT('ENTER THE CONCENTRATION UNITS (PC OR KG)>')
00094  16 FORMAT(A2)
00095  17 FORMAT('ENTER THE TIME STEP SIZE (F10,0)>')
00096  18 FORMAT(F10,0)
00097  19 FORMAT(30A1)
00098      END
```

(FLECS VERSION 22,46)

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-----
00001 SUBROUTINE HYDAT(ALEN, AREA, DELTH, DELZ, D50, ECHO, HLDERR,
00002 1 NSETS, NUMERR, SIMLEN, DEPMIN, DLZBAV, EL)
00003 C DEPMIN HAS BEEN ADDED TO THE SUBROUTINE CALL
00004 C
00005 C THIS ROUTINE IS RESPONSIBLE FOR READING AND PROCESSING THE
00006 C HYDROLOGY DATA. THE DATA IS READ FROM THE INPUT STREAM (LUN 1)
00007 C AND WRITTEN TO "HYDROLOGY.TMP" (LUN 4) FOR USE DURING THE
00008 C SIMULATION.
00009 C
00010 C FORMAL PARAMETERS:
00011 C ALEN = SEGMENT LENGTH
00012 C AREA = CROSS SECTIONAL AREA OF EACH ELEMENT
00013 C DELTH = TIME STEP IN SECONDS
00014 C DELZ = STANDARD ELEMENT THICKNESS
00015 C D50 = MEDIAN BED SEDIMENT DIAMETER
00016 C ECHO = LINE PRINTER OPTION CONTROL VARIABLE (L*1)
00017 C HLDERR = HOLDING ARRAY FOR ERROR NUMBERS (BYTE)
00018 C NSETS = NUMBER OF TIMES INITIAL CONDITIONS MUST BE WRITTEN
00019 C TO OUTFLO. (NSETS * DELTH) = THE AMOUNT OF TIME IT
00020 C TAKES THE FLOW TO PASS THROUGH THE SEGMENT.
00021 C NUMERR = NUMBER OF INPUT ERRORS
00022 C SIMLEN = SIMULATION LENGTH = SECONDS (I*4)
00023 C
00024 C CALLED BY: SERATRA
00025 C CALLS: PUTERR
00026 C
00027 C INCLUDE 'ELMSIZ.PPH'
00028 C
00029 C BYTE HLDERR(100)
00030 C
00031 C INTFGER*4 ENDTIM,PHETIM,SIMLEN
00032 C
00033 C REAL INFRAC
00034 C
00035 C LOGICAL*1 ECHO
00036 C
00037 C DIMENSION ABAR(MXELEM), AREA(MXELEM), A*ID(MXELEM),
00038 1 EL(MXELEM), XSAREA(MXELEM), H*WID(MXELEM), IELM(MXELEM)
00039 C
00040 C REWIND 4
00041 C NSETS*1
00042 C PEND = 0.0
00043 C IDELTH=IFIX(DELTH)
00044 C REPEAT UNTIL (ENDTIM .EQ. -9999)
00045 C
00046 C * CARD 12.....HYDROLOGY DATA == THIS DATA IS WRITTEN TO LUN 4
00047 C *
00048 C * COL. 1=10...ENDTIM...ENDING TIME FOR THE DATA ON THE CARD. (SEC)
00049 C * AN ENTRY OF -9999 TERMINATES THE DATA.
00050 C * 11=20...QI.....TOTAL DISCHARGE OF THIS SEGMENT (M**3/SEC)
00051 C * 21=30...QO.....TOTAL DISCHARGE OUT OF THIS SEGMENT (M**3/SEC)
00052 C * 31=40...DEPTH...FLOW DEPTH (METERS)
00053 C * 41=50...TEMPR...WATER TEMPERATURE

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00054 C      *
00055      * READ(I,1) ENDTIM,UI,QU,DEPTH,TEMPR
00056      * IF (ENDTIM .NE. -9999)
00057      *   IF (MOD(ENDTIM,DELTH) .NE. 0)
00058      *     WRITE(11,10) ENDTIM,DELTH
00059      *     FORMAT(' WARNING*** ENDTIM',I10,' IS NOT A MUTIPLE OF DELTH',I10)
00060      *     ENDTIM=(ENDTIM/DELTH+1)*DELTH
00061      *     ...FIN
00062      *     ...FIN
00063 C      *
00064 C      *
00065      * IF (ENDTIM .NE. -9999) PRETIM = ENDTIM
00066      * UNLESS (ENDTIM .EQ. -9999)
00067 C      *   MINIMUM DEPTH FLAG TO DIVERT FROM FURTHER CALCULATION
00068      *   NELEM=0
00069      *   VOL=0.
00070      *   VEL=0.
00071      *   DO(I=1,MXELEM)
00072      *     A=ID(I)=0.
00073      *     B=ID(I)=0.
00074      *     ABAR(I)=0.
00075      *     IELM(I)=0.
00076      *     XSAREA(I)=0.
00077      *     ...FIN
00078      *     IF (DEPTH .GT. DEPMIN)
00079 C      *     *
00080 C      *     *** COMPUTE: NELEM...NUMBER OF ELEMENTS CONTAINED WITHIN DEPTH
00081 C      *     ABAR(I)..AVERAGE AREA OF ELEMENTS I AND I+1
00082 C      *     A=ID(I)..WIDTH OF ELEMENT
00083 C      *     VOL.....TOTAL VOLUME OF THE SEGMENT
00084      *     VOL=0.
00085      *     NELEM=DEPTH/DELZ*AV
00086      *     DELZ=DEPTH/NELEM
00087      *     WHEN(NELEM .LE. 1 .OR. NELEM+1 .GT. MXELEM)
00088      *       WRITE(6,100)NELEM,MXELEM
00089      *       FORMAT(5X'FROM HYDDAT: NELEM='I3'  MXELEM='I3)
00090      *       CALL PUTERR (14, NUMERR, HLDERR)
00091      *       WRITE(6,6)
00092      *       ...FIN
00093      *       ELSE
00094      *         CALL TRNPOS(ABAR,AREA,A=ID,ALEN,B=ID,DELZ,EL,IELM,NELEM,
00095      *           1. XSAREA,VOL)
00096      *         CALL RADIUS (ALEN, AREA, CROSEC, DEPTH, EL, HRAD)
00097      *         ...FIN
00098 C      *
00099 C      * IT IS IMPLICITLY ASSUMED THAT A DOWNSTREAM COURANT
00100 C      * NUMBER AT OR NEAR UNITY HAS BEEN EMPLOYED IN THIS
00101 C      * ANALYSIS
00102 C      *
00103      * INFRAC=0.5*QI*DELTH/VOL
00104      * EXFRAC=1.0-INFRAC
00105      * VEL=(INFRAC*QI+EXFRAC*Q0)*ALEN/VOL
00106      * ...FIN
00107      * WRITE(4) ENDTIM,NELEM,DELZ,UI,QU,VOL,VEL,A=ID,AREA,TEMPR,
00108      * 1. XSAREA,IELM,DEPTH,B=ID,ABAR, HRAD, CROSEC
00109 C      *

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```
00110      . . IF (ECHO)
00111      . . . WRITE(6,2) ENDTIM,NELEM,TEMPR,QI,QO,DEWTH
00112      . . . WRITE(6,3)
00113      . . . DO (I=1,NELEM)
00114      . . . . WRITE(6,4)I,AWID(I),ABAR(I),AREA(I),EL(I)
00115      . . . . .FIN
00116      . . . . .FIN
00117      . . . . .FIN
00118      . . . . .FIN
00119      . . . . .FIN
00120      IF (PRETIM .LT. SIMLEN) CALL PUTERR(25, NUMERR, HLDERR)
00121      REWIND 4
00122      C
00123      RETURN
00124      C
00125      1  FORMAT(I10,4F10.0)
00126      2  FORMAT(1H0,58X,'HYDROLOGY DATA'/
00127      1  9X,I10,'...DATA SET ENDING TIME'/
00128      2  14X,I5,'...NUMBER OF ELEMENTS WITHIN THE FLOW DEPTH'/
00129      3  7X,1PE12.5,'...WATER TEMPERATURE'/
00130      6  7X,1PE12.5,'...TOTAL DISCHARGE OF THIS SEGMENT'/
00131      7  7X,1PE12.5,'...TOTAL DISCHARGE OUT OF THIS SEGMENT'/
00132      8  7X,1PE12.5,'...FLOW DEPTH')
00133      3  FORMAT(1H0,'ELEMENT',4X,'SEGMENT',14X,'AVERAGE',12X,'NODE VP=AREA',
00134      1  11X,'NODE ELEV',1X,'NUMBER',6X,'WIDTH',12X,'ELEMENT AREA')
00135      4  FORMAT(3X,I2,4X,1PE12.5,9X,1PE12.5,10X,1PE12.5,10X,1PE12.5)
00136      6  FORMAT(//50X,'DEPTH TOO GREAT FOR THE MAXIMUM NUMBER OF'
00137      1  'ELEMENTS'//)
00138      C
00139      END .
```

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00001      SUBROUTINE HYDFLO(ALEN, AREA, AWID, DELZ, DEPTH, D50,
00002      1          ELEV, ENOHYD, ETIME, FERROR, HRAD, NELEM,
00003      2          NEWQI, PELEV, QHIN, QHOUT, QV, RIVER, SLOPE,
00004      3          STRESS, TEMPR, VEL, VOL, DEPMIN,
00005      4          XSAREA, RWID, ABAR, QI, CROSEC, QO, IELM)
00006      C
00007      C      THIS SUBROUTINE IS CALLED EACH TIME STEP TO READ ANY NEW HYDROLOGY
00008      C      DATA THAT WAS WRITTEN TO LUN 4 BY SUBROUTINE HYDDAT.
00009      C
00010      C      FORMAL PARAMETERS:
00011      C      ALEN   = LENGTH OF THE SEGMENT
00012      C      AREA   = AREA OF EACH ELEMENT
00013      C      AWID   = ELEMENT WIDTHS
00014      C      DELZ   = STANDARD ELEMENT THICKNESS
00015      C      DEPTH  = FLOW DEPTH
00016      C      D50    = MEDIAN BED SEDIMENT DIAMETER (METER)
00017      C      ELEV   = SEGMENT ELEVATION
00018      C      ENOHYD = ENDING TIME OF THE CURRENT HYDROLOGY DATA (I*4)
00019      C      ETIME  = ELAPSED TIME OF THE SIMULATION (I*4)
00020      C      FERROR = FATAL ERROR FLAG (L*1)
00021      C      HRAD   = HYDRAULIC RADIUS
00022      C      NELEM  = NUMBER OF ELEMENTS
00023      C      NEWQI  = NEW QI DATA FLAG (L*1)
00024      C      PELEV  = ELEVATION OF THE UPSTREAM SEGMENT
00025      C      QHIN   = INFLOW DISCHARGE
00026      C      QHOUT  = OUTFLOW DISCHARGE
00027      C      QV     = VERTICAL FLOWS
00028      C      RIVER  = SHEAR STRESS COMPUTATION CONTROL VARIABLE (L*1)
00029      C      SLOPE  = BED SLOPE
00030      C      STRESS = BED SHEAR STRESS
00031      C      TEMPR  = WATER TEMPERATURE
00032      C      VEL    = FLOW VELOCITY OF QHOUT
00033      C      VOL    = SEGMENT VOLUME
00034      C
00035      C      CALLED BY: SERATRA
00036      C      CALLS: SHEARR, SHEARS, PROFIL
00037      C
00038      C      INCLUDE 'ELMSIZ.PRI'
00039      C
00040      C      INTEGER*4 ETIME, ENOHYD
00041      C
00042      C      LOGICAL*1 NEWQI, RIVER, FERROR
00043      C
00044      C      DIMENSION AREA(MXELEM), AWID(MXELEM), QHIN(MXELEM),
00045      1          QHOUT(MXELEM), QV(MXELEM),
00046      2          XSAREA(MXELEM), RWID(MXELEM), ABAR(MXELEM),
00047      3          IELM(MXELEM), DUMMY(MXELEM)
00048      C
00049      C      DATA SECDAY/R6400.,/
00050      C      DATA RHO/1000.,/
00051      C      DATA ZERO/1.0E-05/
00052      C
00053      C

```



```

00054      FERROR = .FALSE.
00055      NEWQI = .FALSE.
00056      IF (ETIME .GT. ENDHYD)
00057      . NEWQI = .TRUE.
00058      . REPEAT UNTIL (ETIME .LE. ENDHYD)
00059      . . READ(4,END=200) ENDHYD,NELEM,DELZ,QI,QO,VOL,VEL,AWID,AREA,TEMPH,
00060      1. . . XSAREA,IELM,DEPTH,BWID,ABAR,HRAD,CROSEC
00061      . . . . FIN
00062      . . . IF (DEPTH .GE. DEPMIN)
00063      . . . . WHEN (HIVER)
00064      C . . . .
00065      . . . . CALL SHEARS(ALEN,ELEV,HRAD,PELEV,SLOPE,STRESS,USTAR)
00066      C . . . .
00067      . . . . . FIN
00068      . . . . ELSE
00069      . . . . . CALL SHEARR(DEPTH,DSO,STRESS,USTAR,VEL)
00070      . . . . . SLOPE=STRESS/(RHO*HRAD)
00071      . . . . . FIN
00072      . . . CALL PROFIL(ALEN, AWID, DELZ, DEPTH, NELEM, QI, USTAR,
00073      1. . . . VOL, QHIN,DUMMY,0,DELZ)
00074      . . . CALL PROFIL(ALEN, AWID, DELZ, DEPTH, NELEM, QO, USTAR,
00075      1. . . . VOL, QHOUT,DUMMY,0,DELZ)
00076      C . . . *** CONVERT UNITS TO M**3/DAY ***
00077      . . . DO (J=1,NELEM)
00078      . . . . QHIN(J) = QHIN(J) * SECDAY
00079      . . . . QHOUT(J) = QHOUT(J) * SECDAY
00080      . . . . . FIN
00081      C . . .
00082      C . . . *** COMPUTE VERTICAL FLOWS ***
00083      . . . QV(1) = 0.0
00084      . . . DO (J=1,NELEM)
00085      . . . . QV(J+1) = QHIN(J) - QHOUT(J) + QV(J)
00086      . . . . . FIN
00087      . . . . . FIN
00088      . . . . . FIN
00089      . . . . . FIN
00090      C . . . RETURN
00091      200 CONTINUE
00092      FERROR = .TRUE.
00093      WRITE(6,1)
00094      1 FORMAT(10X,'FATAL ERROR - HYDROLOGY DATA EXHAUSTED')
00095      RETURN
00096      300 CONTINUE
00097      FERROR=.TRUE.
00098      WRITE(6,3)
00099      WRITE(6,2) (J,QV(J),J=1,NELEM)
00100      3 FORMAT(10X,'FATAL ERROR - VERTICAL FLUX COMPUTATION')
00101      2 FORMAT(15X,15,1PE12.4)
00102      RETURN
00103      C . . .
00104      . . . END

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(FLECS VERSION 22,46)

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-----  
00001      SUBROUTINE ICFLO(CCIN,DEPTH,DELZ,DSO,ENDIC,ETIME,FERROR,  
00002      1          INFLO, ISEG, NELEM, NEWIC,  
00003      2          QMIN,UI,DEPMIN,ALEN,  
00004      3          UEL, UNID, XSAKEA, AREA, AWID, DFZ, VSET,  
00005      4          EL,ELEV,PELEV,RIVER,NEWQI,NEWTRB,  
00006      5          NH,PDEPTH,CNODE)  
00007      C  
00008      C  
00009      C      THIS ROUTINE IS CALLED EACH TIME STEP TO READ THE INITIAL  
00010      C      CONDITIONS TO THE FIRST SEGMENT OR THE INFLOWS  
00011      C      FROM THE PREVIOUS SEGMENT.  
00012      C  
00013      C      FORMAL PARAMETERS:  
00014      C      CCIN   = CONCENTRATION OF INFLOWS= CELL CENTERED  
00015      C      DEPTH  = FLOW DEPTH OF THE CURRENT SEGMENT  
00016      C      DELZ   = STANDARD ELEMENT THICKNESS OF THE CURRENT SEGMENT  
00017      C      ENDIC  = ENDING TIME OF THE CURRENT INITIAL CONDITIONS DATA  
00018      C      ETIME  = ELAPSED TIME OF THE SIMULATION (I*4)  
00019      C      FERROR = FATAL ERROR FLAG (L*1)  
00020      C      INFLO  = LOGICAL UNIT NUMBER FOR DATA FROM PREVIOUS SEGMENT  
00021      C      ISEG  = CURRENT SEGMENT NUMBER  
00022      C      NELEM  = NUMBER OF ELEMENTS IN THE CURRENT SEGMENT  
00023      C      NELEMB = NUMBER OF ELEMENTS IN THE PREVIOUS SEGMENT  
00024      C      NEWIC  = INITIAL CONDITIONS FLAG (L*1)  
00025      C      PDELZ  = STANDARD ELEMENT THICKNESS OF THE PREVIOUS SEGMENT  
00026      C      PDEPTH = FLOW DEPTH OF THE PREVIOUS SEGMENT  
00027      C      QMIN  = INFLOW DISCHARGE  
00028      C      QHOLD  = DISCHARGE INTO THE SEGMENT FROM THE PREVIOUS ONE  
00029      C  
00030      C      CALLED BY: SERATRA  
00031      C      CALLS: EQUPCS, EQUPIX, PROFIL, RADIUS  
00032      C  
00033      C      INCLUDE 'ELMSIZ.PRM'  
00034      C  
00035      C      INTEGER*4 ENDIC,ETIME  
00036      C  
00037      C      LOGICAL*1 NEWIC,NEWQI,NEWTRB,FERROR,RIVER  
00038      C  
00039      C      DIMENSION CCIN(MXELEM,MAXCON), CNODE(MXELEM,MAXCON),  
00040      1          QMIN(MXELEM), QHOLD(MXELEM),XSAREA(MXELEM),  
00041      2          PXSAR(MXELEM),IELP(MXELEM),UNID(MXELEM),UNDAVG(MXELEM),  
00042      3          HEQXS(MXELEM), UEL(MXELEM),THASS(MAXCON),PWID(MXELEM),  
00043      4          OCNODE(MXELEM,MAXCON),  
00044      5          AREA(MXELEM), AWID(MXELEM), DFZ(4), VSET(3),  
00045      6          EL(MXELEM), UAREA(MXELEM)  
00046      C      DATA RHO/1000./  
00047      C      DATA SECDAY/86400./  
00048      C  
00049      C      FERROR = .FALSE.  
00050      C      NEWIC = .FALSE.  
00051      C      IDIM=MXELEM  
00052      C      JDIM=MAXCON  
00053      C      WHEN (ISEG .EQ. 1)
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00054 C . DISTRIBUTES INITIAL CONDITIONS UPSTREAM OF INITIAL SEGMENT BY
00055 C . CONSERVING RELATIVE CROSS-SECTIONAL AREAS AND DISCHARGES---
00056 C . ASSUMES LINEAR PROFILE OF BOTH SEDIMENT AND PARTICULATE, AND
00057 C . WIDTH A LINEAR FUNCTION OF DEPTH.
00058 C . *** INITIAL CONDITIONS ***
00059 . IF (ETIME .GT. ENDIC) NEWIC = .TRUE.
00060 . IF(NEWIC,OH,NEWQI,OR,NEWTRB)
00061 . . UNTIL (ETIME .LE. ENDIC)
00062 . . . READ(2,END=200)ENDIC,NM,PDEPTH,((CNODE(I,J),J=1,MAXCON),I=1,NM)
00063 . . . . .FIN
00064 . . IF(DEPTH .LE. DEPMIN) RETURN
00065 . . XS=0.
00066 . . PXS=0.
00067 . . CON=1./12.
00068 . . DO(I=1,NM)
00069 . . . IF(PDEPTH .LE. UEL(I)) GO TO 10
00070 . . . . WT=UWID(I+1)
00071 . . . . WB=UWID(I)
00072 . . . . ET=UEL(I+1)
00073 . . . . EB=UEL(I)
00074 . . . . IF (PDEPTH .LT. ET)
00075 . . . . . WT=WB+(WT-WB)*(PDEPTH-EB)/(ET-EB)
00076 . . . . . ET=PDEPTH
00077 . . . . .FIN
00078 . . . . DELTA=ET-EB
00079 . . . . PXSAR(I)=(WT+WB)*DELTA/2.
00080 . . . . PXS=PXS+PXSAR(I)
00081 . . . . MELEM=I
00082 . . . . .FIN
00083 10 . CONTINUE
00084 . . DO (I=1,MELEM) XS=XS+XSAREA(I)
00085 . . . RATIO=PXS/XS
00086 . . . CALL EQUPCS(PXSAR,UWID,UEL,XSAREA,MELEM,MELEM,RATIO,IELP,
00087 1. . . . HEQXS,FERROR, DELTA)
00088 . . . IF(FERROR) RETURN
00089 . . . DO(I=1,MELEM-1) UWDAVG(I)=(UWID(I)+UWID(I+1))/2.
00090 . . . UWDAVG(MELEM)=(UWID(MELEM)+WT)/2.
00091 . . . UDEL=UEL(2)
00092 . . . UVOL=PXS*ALEN
00093 . . . VEL=QI/PXS
00094 C*****
00095 C . . CHANGE 3/12/81
00096 C . .
00097 . . . DO (I =1,MELEM) UAREA(I)=UWID(I)*ALEN
00098 . . . CALL RADIUS (ALEN,UAREA,CRUSEC,PDEPTH,UEL,HRAD)
00099 . . . WHEN(RIVER)
00100 . . . . CALL SHEARS(ALEN,ELEV,HRAD,PELEV,SLOPE,STRESS,USTAR)
00101 . . . . .FIN
00102 . . . ELSE
00103 C . .
00104 C*****
00105 . . . . CALL SHEAR(PDEPTH,D50,STRESS,USTAR,VEL)
00106 . . . . .SLOPE=STRESS/(KHU*HRAD)
00107 . . . . .FIN
00108 . . . . CALL PROFIL(ALEN,UWDAVG,UDEL,PDEPTH,MELEM,QI,USTAR,UVOL,QHOLD,
00109 1. . . . .VEL,1,DELTA)

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00110      . . . DO (I=1,MELEM-1)
00111      . . .   UHOLD(I)=UHOLD(I)*SECDAY/(UMDAVG(I)*(UEL(I+1)-UEL(I)))
00112      . . .   ...FIN
00113      . . .   UHOLD(MELEM)=UHOLD(MELEM)*SECDAY/(UMDAVG(MELEM)*DELTA)
00114      . . .   DO(K=1,MAXCON)
00115      . . .     IF(K.LE.3.OR.K.EQ.7)
00116      . . .       UPSQ=UHOLD(I)
00117      . . .       WT=UID(2)
00118      . . .       WB=UID(1)
00119      . . .       DEL=UEL(2)-UEL(1)
00120      . . .       CT=CNODE(2,K)
00121      . . .       CH=CNODE(1,K)
00122      . . .       NELMHT=1
00123      . . .       CHSAB=DEL*(CT*WT/3.+CT*WB/6.+CB*WT/6.+CB*WB/3.)*UPSQ
00124      . . .       CHSB=0.
00125      . . .       TMASS(K)=0.0
00126      . . .       IF (K.NE.7)
00127      . . .         GT=CNODE(2,K+3)
00128      . . .         GB=CNODE(1,K+3)
00129      . . .         PMSAB=DEL*(0.25*(WT*CT*GT+WB*CB*GB)+
00130      . . .         CON*(WT*CB*GB+WB*CT*GB+WB*CB*GT+
00131      . . .         2.  WB*CT*GT+WT*CB*GT+WT*CT*GB))*UPSQ
00132      . . .         PMSB=0.
00133      . . .         TMASS(K+3)=0.
00134      . . .         ...FIN
00135      . . .       DO(I=1,NELEM)
00136      . . .         NELMTP=IELP(I)
00137      . . .         UPSQ=UHOLD(NELMTP)
00138      . . .         ET=UEL(NELMTP+1)
00139      . . .         EB=UEL(NELMTP)
00140      . . .         WT=UID(NELMTP+1)
00141      . . .         WB=UID(NELMTP)
00142      . . .         CT=CNODE(NELMTP+1,K)
00143      . . .         CB=CNODE(NELMTP,K)
00144      . . .         HEL=HEMS(I)
00145      . . .         FAC1=(HEL-EB)/(ET-EB)
00146      . . .         FAC2=(ET-HEL)/(ET-EB)
00147      . . .         CTOP=CT*FAC1+CB*FAC2
00148      . . .         NTOP=WT*FAC1+WB*FAC2
00149      . . .         CHSAT=(ET-HEL)*(CT*WT/3.+CT*NTOP/6.+CTOP*WT/6.+CTOP*NTOP/3.)*
00150      . . .         1.  *UPSQ
00151      . . .         CHSBT=(HEL-EB)*(CTOP*NTOP/3.+CTOP*WB/6.+CB*NTOP/6.+CH*WB/3.)*
00152      . . .         1.  *UPSQ
00153      . . .         IF (K.NE.7)
00154      . . .           GT=CNODE(NELMTP+1,K+3)
00155      . . .           GB=CNODE(NELMTP,K+3)
00156      . . .           GTOP=GT*FAC1+GB*FAC2
00157      . . .           PMSAT=(ET-HEL)*(0.25*(WT*CT*GT+NTOP*CTOP*GTOP)
00158      . . .           1.  +CON*(WT*CTOP*GTOP+WT*CT*GTOP+WTOP*CTOP*GT+
00159      . . .           2.  WTOP*CT*GT+WT*CTOP*GT+WT*CT*GTOP))*UPSQ
00160      . . .           PMSBT=(HEL-EB)*(0.25*(WTOP*CTOP*GTOP+WB*CH*GB)
00161      . . .           1.  +CON*(WTOP*CB*GB+WB*CTOP*GB+WB*CB*GTOP+
00162      . . .           2.  WB*CTOP*GTOP+WTOP*CH*GTOP+WTOP*CTOP*GB))*UPSQ
00163      . . .           ...FIN
00164      . . .           INDIC=NELMTP-NELMHT
00165      . . .           CHASS=0.

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00166      . . . . . PHASS=0.
00167      . . . . . IF(INDIC,EU,0)
00168      . . . . . . CHASS=CHSBT+CHSB
00169      . . . . . . IF(K,NE,7) PHASS=PHSBT+PMSB
00170      . . . . . . . . FIN
00171      . . . . . IF(INDIC,GE,1)
00172      . . . . . . CHASS=CHSBT+CHSAB
00173      . . . . . . IF(K,NE,7) PHASS=PHSBT+PMSAB
00174      . . . . . . . . FIN
00175      . . . . . IF(INDIC,GE,2)
00176      . . . . . . DO(J=NELMHT+1,NELMTP-1)
00177      . . . . . . . DEL=UEL(J+1)-UEL(J)
00178      . . . . . . . CT=CNODE(J+1,K)
00179      . . . . . . . CB=CNODE(J,K)
00180      . . . . . . . UPSQO=QHOLD(J)
00181      . . . . . . . WT=UWID(J+1)
00182      . . . . . . . WB=UWID(J)
00183      . . . . . . . CHASS=CHASS+DEL*(CT*WT/3,+CT*WB/6,+CB*WT/6,+CB*WB/3,)*UPSQO
00184      . . . . . . . IF(K,NE,7)
00185      . . . . . . . . GT=CNODE(J+1,K+3)
00186      . . . . . . . . GB=CNODE(J,K+3)
00187      . . . . . . . . PHASS=PHASS+DEL*(0.25*(WT*CT*GT+WB*CB*GB)
00188      . . . . . . . . +CON*(WB*CT*GT+WT*CB*GB+WT*CT*GB+WT*CB*GB+WB*CT*GB+WB*CB*GT))
00189      . . . . . . . . *UPSQO
00190      . . . . . . . . . . FIN
00191      . . . . . . . . . . FIN
00192      . . . . . . . . . . FIN
00193      . . . . . . THASS(K)=THASS(K)+CHASS
00194      . . . . . . CHASS=CHASS/QHIN(I)
00195      . . . . . . CHSAB=CHSAT
00196      . . . . . . CHSBT=CHSBT
00197      . . . . . . NELMHT=NELMTP
00198      . . . . . . IF(K,NE,7)
00199      . . . . . . . PMSAB=PMSAT
00200      . . . . . . . PMSB=PMSBT
00201      . . . . . . . THASS(K+3)=THASS(K+3)+PHASS
00202      . . . . . . . PHASS=PHASS/QHIN(I)
00203      . . . . . . . . . . FIN
00204      C
00205      C
00206      C
00207      . . . . . . COMPUTE=PROFILE=VALUES
00208      . . . . . . . . . . FIN
00209      . . . . . . . . . . FIN
00210      . . . . . . . . . . FIN
00211      . . . . . . . . . . FIN
00212      . . . . . . . . . . FIN
00213      C
00214      C
00215      C
00216      ELSE
00217      . . . . . . . . . . NEWIC=.TRUE.
00218      . . . . . . . . . . READ(INFLO)PDEPTH,PDELZ,MELEM,(QHOLD(J),PXSAR(J),PWID(J),J=1,
00219      . . . . . . . . . . 1,MELEM),((CNODE(J,K),K=1,MAXCON),J=1,MELEM+1),
00220      . . . . . . . . . . 2,((CNODE(J,K),K=1,MAXCON),J=1,MELEM+1)
00221      . . . . . . . . . . IF(DEPTH,LE,DEPTHIN) GO TO 300

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00222      . XS=0.
00223      . PXS=0.
00224      . DO (I=1,NELEM) XS=XS+XSAREA(I)
00225      . DO (I=1,NELEM) PXS=PXS+PXSAR(I)
00226      . RATIO=PXS/XS
00227      . CALL EQUPXS(PXSAR,PHID,PDELZ,XSAREA,NELEM,MELEM,RATIO,IELP,
00228      1. HEQXS)
00229  C      . ALLOCATES MASS BY CONSERVING RELATIVE CROSS-SECTIONAL AREAS
00230      . DO (K=1,MAXCON)
00231      .   . IF(K,LE,3.OR,K,EQ,7)
00232      .     . K3=K+3
00233      .     . UPSQO=QHOLD(I)
00234      .     . CT=(CNODE(2,K) + OCNODE(2,K))/2.
00235      .     . CB=(CNODE(1,K) + OCNODE(1,K))/2.
00236      .     . NELMHT=1
00237      .     . CMSAR=(CT+CB)/2.*UPSQO
00238      .     . CMSBR=0.
00239      .     . THASS(K)=0.
00240      .     . IF (K,NE, 7)
00241      .       . GT=(CNODE(2,K3) + OCNODE(2,K3))/2.
00242      .       . GB=(CNODE(1,K3) + OCNODE(1,K3))/2.
00243      .       . PMSAB=UPSQO*(GT+GB)/2.
00244      .       . PMSB=0.
00245      .       . THASS(K3)=0.
00246      .     . ...FIN
00247      .     . DO (I=1,NELEM)
00248      .       . NELMTP=IELP(I)
00249      .       . NT=NELMTP+1
00250      .       . NU=NELMTP
00251      .       . ET=NB*PDELZ
00252      .       . ER=(NR-1)*PDELZ
00253      .       . UPSQO=QHOLD(NB)
00254      .       . CT=(CNODE(NT,K) + OCNODE(NT,K))/2.
00255      .       . CB=(CNODE(NR,K) + OCNODE(NR,K))/2.
00256      .       . HEL=HEQXS(I)
00257      .       . FAC1=(HEL-ER)/PDELZ
00258      .       . FAC2=(ET-HEL)/PDELZ
00259      .       . CTOP=CT+FAC1+CB+FAC2
00260      .       . CMSAT=FAC2*(CT+CTOP)*UPSQO/2.
00261      .       . CMSBT=FAC1*(CTOP+CB)/2.*UPSQO
00262      .       . IF(K,NE,7)
00263      .         . GT=(CNODE(NT,K3) + OCNODE(NT,K3))/2.
00264      .         . GB=(CNODE(NR,K3) + OCNODE(NR,K3))/2.
00265      .         . GTOP=GT+FAC1+GB+FAC2
00266      .         . PMSAT=FAC2*(GT+GTOP)*UPSQO/2.
00267      .         . PMSBT=FAC1*(GTOP+GB)*UPSQO/2.
00268      .       . ...FIN
00269      .       . INDIC=NELMTP-NELMHT
00270      .       . CHASS=0.
00271      .       . PHASS=0.
00272      .       . IF(INDIC,EQ,0)
00273      .         . CHASS=CMSBT-CMSBR
00274      .         . IF(K,NE,7) PHASS=PMSBT-PMSB
00275      .       . ...FIN
00276      .       . IF(INDIC,GE,1)
00277      .         . CHASS=CMSBT+CMSAR

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00278      . . . . . IF(K,NE,7) PMASS=PMSBT+PMSAB
00279      . . . . .   ...FIN
00280      . . . . . IF(INDIC,GE,2)
00281      . . . . .   DO(J=NELMHT+1,NELMTP-1)
00282      . . . . .     CT=(CNODE(J+1,K) + OCNODE(J+1,K))/2.
00283      . . . . .     CB=(CNODE(J,K) + OCNODE(J,K))/2.
00284      . . . . .     J=QHOLD(J)
00285      . . . . .     CHASS=CHASS+(CT+CB)/2.*Q
00286      . . . . .     IF(K,NE,7)
00287      . . . . .       GT=(CNODE(J+1,K3) + OCNODE(J+1,K3))/2.
00288      . . . . .       GB=(CNODE(J,K3) + OCNODE(J,K3))/2.
00289      . . . . .       PMASS=PMASS+(GT+GB)/2.*Q
00290      . . . . .     ...FIN
00291      . . . . .   ...FIN
00292      . . . . .   ...FIN
00293      . . . . .   TMASS(K)=TMASS(K)+CHASS
00294      . . . . .   CHASS=CHASS/QHIN(I)
00295      . . . . .   CHSAB=CHSAT
00296      . . . . .   CHSBB=CHSHT
00297      . . . . .   NELMHT=NELMTP
00298      . . . . .   IF(K,NE,7)
00299      . . . . .     TMASS(K3)=TMASS(K3)+PMASS
00300      . . . . .     PMASS=PMASS/QHIN(I)
00301      . . . . .     PMSAB=PMSAT
00302      . . . . .     PMSBH=PMSBT
00303      . . . . .   ...FIN
00304      . . . . .   COMPUTE=PROFILE=VALUES
00305      . . . . .   ...FIN
00306      . . . . .   ...FIN
00307      . . . . .   ...FIN
00308      . . . . .   ...FIN
00309      . . . . . RETURN
00310 200 CONTINUE
00311      . . . . . FERROR = .TRUE.
00312      . . . . . WRITE(6,1)
00313 1   . . . . . FORMAT(10X,'FATAL ERROR - INITIAL CONDITIONS TO SEGMENT 1',
00314 1   . . . . . 1 ' HAVE BEEN EXHAUSTED')
00315      . . . . . RETURN
00316 300 CONTINUE
00317      . . . . . WRITE(6,2)
00318      . . . . . WRITE(6,3) ISEG
00319 2   . . . . . FORMAT(10X,'POTENTIAL DIFFICULTY - DEPTH,LE,DEPMIN')
00320 3   . . . . . FORMAT(10X,'SEGMENT NUMBER #',I5)
00321      . . . . . RETURN

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00322      . . . . . TO COMPUTE=PROFILE=VALUES
00323      . . . . .   WHEN(I,EQ,1)
00324      . . . . .     WHEN(K,EQ,7)
00325      . . . . .       CCIN(1,K)=CHASS
00326      . . . . .       CCIN(2,K)=CHASS
00327      . . . . .     ...FIN
00328      . . . . .   ELSE
00329      . . . . .     COEF=0.
00330      . . . . .     KK=K+3

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```
00331      * * * MS=VSET(K)*AREA(1)/(A*ID(1)*ALEN)
00332      * * * EZ=DFZ(K)
00333      * * * CCIN(1,K)=(2.*CHASS=COEF*DELZ/EZ)/(2.*MS*DELZ/EZ)
00334      * * * CCIN(2,K)=2.*CHASS=CCIN(1,K)
00335      * * * CCIN(1,KK)=(2.*PHASS=COEF*DELZ/EZ)/(2.*MS*DELZ/EZ)
00336      * * * CCIN(2,KK)=2.*PHASS=CCIN(1,KK)
00337      * * * ..FIN
00338      * * * ..FIN
00339      * * * ELSE
00340      * * * CCIN(I+1,K)=2.*CHASS=CCIN(I,K)
00341      * * * IF (K,NE,7)
00342      * * * CCIN(I+1,K+3)=2.*PHASS=CCIN(I,K+3)
00343      * * * ..FIN
00344      * * * ..FIN
00345      * * * ..FIN
00346      * * * END
```

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PROCEDURE CROSS-REFERENCE TABLE

00322 COMPUTE=PHOFIE=VALUES  
00207 00300

(FLECS VERSION 22.46)  
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-----  
00001 SUBROUTINE INIDAT(ANALMT, ANALYS, DELTH, ECHO, HLDERR, ITPRT,  
00002 1 NSEG, NSTEPS, NUMERR, SIMLEN, DEPMIN)  
00003 C  
00004 C THIS ROUTINE READS THE INITIAL DATA COMMON TO ALL SEGMENTS AND IS  
00005 C ONLY CALLED FOR SEGMENT NUMBER 1.  
00006 C  
00007 C FORMAL PARAMETERS:  
00008 C ANALMT = ANALYSIS CONCENTRATION LIMIT  
00009 C ANALYS = TIME SERIES ANALYSIS CONTROL VARIABLE (L*1)  
00010 C DELTH = TIME STEP LENGTH (SECONDS)  
00011 C ECHO = LINE PRINTER ECHO CONTROL VARIABLE (L*1)  
00012 C HLDERR = HOLDING ARRAY FOR ERROR NUMBERS (BYTE)  
00013 C ITPRT = PRINT FREQUENCY  
00014 C NSEG = NUMBER OF SEGMENTS  
00015 C NSTEPS = NUMBER OF TIME STEPS TO BE TAKEN (I*4)  
00016 C NUMERR = NUMBER OF INPUT ERRORS DETECTED  
00017 C SIMLEN = SIMULATION LENGTH (SECONDS = I*4)  
00018 C DEPMIN = MINIMUM (CUTOFF) FLOW DEPTH (METERS)  
00019 C  
00020 C CALLED BY: SERATRA  
00021 C CALLES: PUTERR  
00022 C  
00023 C BYTE HLDERR(100)  
00024 C  
00025 C INTEGER*4 SIMLEN, NSTEPS  
00026 C  
00027 C LOGICAL*1 ECHO, ANALYS  
00028 C  
00029 C DIMENSION TITLE(40)  
00030 C  
00031 C DATA MAXSEG /35/  
00032 C IF (ECHO)  
00033 C *  
00034 C * *** PRINT HEADING ***  
00035 C * WRITE(6,1)  
00036 C * WRITE(6,2)  
00037 C *...FIN  
00038 C  
00039 C CARDS 1 AND 2.....SIMULATION IDENTIFICATION TITLE  
00040 C  
00041 C HEAD(1,3) (TITLE(I), I=1,40)  
00042 C IF (ECHO) WRITE(6,4) (TITLE(I), I=1,40)  
00043 C  
00044 C CARD 3.....GENERAL INFORMATION COMMON TO ALL SEGMENTS  
00045 C  
00046 C COL. 1-10...NSTEPS...NUMBER OF TIME STEPS TO BE TAKEN  
00047 C 11-15...NSEG.....NUMBER OF SEGMENTS  
00048 C 16-20...ITPRT.....PRINT FREQUENCY  
00049 C 21-25...ANALYS...TIME SERIES ANALYSIS CONTROL VARIABLE  
00050 C 26-35...DELTH...TIME STEP LENGTH (SECONDS)  
00051 C 36-45...ANALMT...LOWER LIMIT OF AVERAGE DISSOLVED  
00052 C CONCENTRATION, BEFORE THE RESULTS OF A  
00053 C TIME STEP ARE SAVED, THE AVERAGE
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00054 C          DISSOLVED CONC. MUST BE > ANALMT.
00055 C          46=55,...DEPHIN,...MINIMUM (CUTOFF) FLOW DEPTH BELOW WHICH
00056 C          THE CHANNEL IS CONSIDERED DRIED.
00057 C
00058 C          READ(1,5) NSTEPS,NSEG,ITPRT,ANALYS,DELTH,ANALMT,DEPHIN
00059 C
00060 C          *** COMPUTE SIMULATION LENGTH (SECONDS) ***
00061 C          SIMLEN = DELTH
00062 C          SIMLEN = SIMLEN * NSTEPS
00063 C          IF (ECHO)
00064 C          . WRITE(6,6) NSTEPS,NSEG,ITPRT,ANALYS,DELTH,ANALMT,SIMLEN,DEPHIN
00065 C          ...FIN
00066 C
00067 C          IF (NSTEPS .LE. 0) CALL PUTERR(1,NUMERR,HLDERR)
00068 C          IF (NSEG.LE.0 .OR. NSEG.GT.MAXSEG) CALL PUTERR(2,NUMERR,HLDERR)
00069 C          IF (ITPRT .LE. 0) CALL PUTERR(3,NUMERR,HLDERR)
00070 C          IF (DELTH .LE. 0.0) CALL PUTERR(5,NUMERR,HLDERR)
00071 C
00072 C          RETURN
00073 C          1  FORMAT(1H0,34X,'SEDIMENT AND CONTAMINANT TRANSPORT SIMULATION',
00074 C          1  ' PROGRAM = SERATRA')
00075 C          2  FORMAT(1H0,54X,'PROBLEM SPECIFICATIONS')
00076 C          3  FORMAT(20A4)
00077 C          4  FORMAT(1H0,25X,20A4/26X,20A4)
00078 C          5  FORMAT(I10,2I5,L5,2F10.0,E10.3)
00079 C          6  FORMAT(1H0,8X,I10,'...NUMBER OF TIME STEPS TO BE TAKEN'/
00080 C          1  14X,I5,'...NUMBER OF SEGMENTS'/
00081 C          2  14X,I5,'...PRINT FREQUENCY (# OF TIME STEPS)'/
00082 C          4  18X,L1,'...TIME SERIES ANALYSIS CONTROL'/
00083 C          5  7X,1PE12.5,'...TIME STEP LENGTH (SECONDS)'/
00084 C          6  7X,1PE12.5,'...TIME SERIES CONCENTRATION LIMIT'/
00085 C          7  9X,I10,'...COMPUTED SIMULATION LENGTH (SECONDS)'/
00086 C          8  9X,E10.3,'...MINIMUM (CUTOFF) FLOW DEPTH (METERS)')
00087 C
00088 C          END

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(FLECS VERSION 22,46)

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-----  
00001 SUBROUTINE LISTER(BASE,REGSEG,REGTIM,CHAIN,DEV,EXT,FILNAM,GUIC,  
00002 1 INTSEG,INTTIM,LSTSEG,LSTTIM,TSTEP,UNITS,UUIC)  
00003 C  
00004 C THIS ROUTINE HAS THE RESPONSIBILITY OF LOCATING AND PRINTING THE  
00005 C SPECIFIED MATRICES FROM THE SPECIFIED FILES.  
00006 C  
00007 C FORMAL PARAMETERS:  
00008 C BASE = 5 CHARACTER BASE FILE NAME FOR CHAINED OPERATIONS  
00009 C REGSEG = BEGINNING SEGMENT NUMBER FOR CHAINED OPERATIONS  
00010 C REGTIM = BEGINNING TIME PLANE NUMBER  
00011 C CHAIN = LOGICAL FLAG FOR CHAINED OPERATIONS  
00012 C DEV = BASE FILE NAME DEVICE FOR CHAINED OPERATIONS  
00013 C EXT = BASE FILE NAME EXTENSION FOR CHAINED OPERATIONS  
00014 C FILNAM = FILE SPECIFICATION FOR UNCHAINED PROCESSING  
00015 C GUIC = GROUP UIC FOR CHAINED PROCESSING  
00016 C INTSEG = SEGMENT INTERVAL FOR CHAINED PROCESSING  
00017 C INTTIM = TIME PLANE INTERVAL  
00018 C LSTSEG = LAST SEGMENT NUMBER FOR CHAINED OPERATIONS  
00019 C LSTTIM = LAST TIME PLANE NUMBER  
00020 C TSTEP = TIME STEP SIZE  
00021 C UNITS = MNEMONICS FOR CONCENTRATION OF CONTAMINANT ATTACHED TO  
00022 C SEDIMENTS (PC OR KG)  
00023 C UUIC = USER UIC FOR CHAINED PROCESSING  
00024 C  
00025 C CALLED BY: SPPH  
00026 C CALLS: FCODE  
00027 C  
00028 C INCLUDE 'ELMSIZ.PRM'  
00029 C BYTE BASE(5),DEV(3),EXT(3),FILNAM(30),GUIC(3),UUIC(3)  
00030 C  
00031 C INTEGER*2 REGSEG,UNITS  
00032 C INTEGER*4 REGTIM,ITIM,LSTTIM,NSTEP  
00033 C  
00034 C LOGICAL*1 CHAIN  
00035 C  
00036 C DIMENSION WELEV(MXELEM), C(MXELEM,7), CHASS(MXELEM),  
00037 1 CVOLM(MXELEM), CTOTL(MXELEM), BEL(10), B(10,6),  
00038 2 BAVG(10), D(MXELEM,3), CELAV(MXELEM,MAXCON),  
00039 3 QCIN(MXELEM,MAXCON), QCOUT(MXELEM,MAXCON),  
00040 4 UVCEL(MXELEM,MAXCON), BELAV(MAXLEV,MAXCON-1),  
00041 5 UVVIF(MXELEM,MAXCON), JJ(MXELEM),  
00042 6 BAL(MAXCON), DIF(MAXCON), TBED(MAXCON), TOTDIF(MAXCON)  
00043 C  
00044 C DO (JSEG=REGSEG,LSTSEG,INTSEG)  
00045 C . IF (CHAIN)CALL FCODE (FILNAM,BASE,JSEG,EXT,DEV,GUIC,UUIC)  
00046 C . OPEN(UNIT=2,NAME=FILNAM,TYPE='OLD',READONLY,FORM='UNFORMATTED')  
00047 C . WRITE(1,9) FILNAM  
00048 C .  
00049 C . READ(2) NUMBEG  
00050 C .  
00051 C . IF(REGTIM .NE. 1)  
00052 C . . NM = REGTIM - 1  
00053 C . . SKIP=NM-MATRICES
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00054      . . . . FIN
00055      . . . . DO (ITIM=BEGTIM,LATTIM,INTTIM) /
00056      . . . . IF (INTTIM .NE. 1 .AND. ITIM .NE. BEGTIM)
00057      . . . . . NM = INTTIM - 1
00058      . . . . . SKIP=NM=MATRICES
00059      . . . . . . . . FIN
00060      . . . . READ (2) NSTEP,NELEM,NBED,ELEV,DELZ,BDIV,XYSD,STRESS
00061      . . . . READ (2) (WELEV(J), (C(J,K),K=1,7),CMASS(J),CVOLM(J),CTOTL(J),
00062      1. . . . . J=1,NELEM)
00063      . . . . READ(2) ((D(J,K), K=1,3), J=1,NELEM)
00064      . . . . READ (2) (BEL(J), (B(J,K),K=1,6),BAVG(J),J=1,NBED)
00065      . . . . NELMO=NELEM-1
00066      . . . . DO(J=1,NELEM) JJ(J)=J-1
00067      . . . . READ(2) VOLUME
00068      . . . . READ(2) ((CELAV(J,K), K=1,MAXCON), J=1,NELEM)
00069      . . . . READ(2) ((WCIN(J,K), K=1,MAXCON), J=1,NELEM)
00070      . . . . READ(2) ((QCOUT(J,K), K=1,MAXCON), J=1,NELEM)
00071      . . . . READ(2) ((VCEL(J,K), K=1,MAXCON), J=1,NELMO)
00072      . . . . READ(2) ((VUIF(J,K), K=1,MAXCON), J=1,NELMO)
00073      . . . . READ(2) (BAL(J),J=1,MAXCON),TBAL
00074      . . . . READ(2) (UIF(J),J=1,MAXCON),TOIF
00075      . . . . READ(2) ((BELAV(J,K), K=1,MAXCON=1), J=1,NBED)
00076      . . . . READ(2) (TBED(J),J=1,MAXCON)
00077      . . . . READ(2) (TOTUIF(J),J=1,MAXCON)
00078      . . . . ELAPSE = TSTEP*NSTEP
00079      . . . . WRITE(3,1)
00080      . . . . WRITE(3,2) NUMSEG,NSTEP,ELAPSE,ELEV,NELMO,DELZ,NBED,BDIV,
00081      1. . . . . XYSD,STRESS
00082      . . . . WRITE(3,3)
00083      . . . . WRITE(3,4) (UNITS,J=1,6)
00084      . . . . DO (J=1,NELEM)
00085      . . . . . WRITE(3,5) WELEV(J),C(J,1),C(J,2),C(J,3),C(J,7),C(J,4),C(J,5),
00086      1. . . . . C(J,6),CMASS(J),CTOTL(J)
00087      . . . . . . . . FIN
00088      . . . . WRITE(3,6)
00089      . . . . WRITE(3,7) (UNITS,J=1,4)
00090      . . . . DO (J=1,NBED)
00091      . . . . . WRITE(3,8) BEL(J), (B(J,K),K=1,6),BAVG(J)
00092      . . . . . . . . FIN
00093      . . . . WRITE(3,12)
00094      . . . . WRITE(3,13) (UNITS, J=1,4)
00095      . . . . WRITE(3,14) (WELEV(J), (D(J,K), K=1,3), CVOLM(J), J=1,NELEM)
00096      . . . . WRITE(3,15)
00097      . . . . WRITE(3,16) (UNITS, J=1,4)
00098      . . . . WRITE(3,17) (JJ(J), (CELAV(J,K), K=1,MAXCON), J=1,NELEM)
00099      . . . . WRITE(3,14)
00100      . . . . WRITE(3,16) (UNITS,J=1,4)
00101      . . . . WRITE(3,17) (JJ(J), (WCIN(J,K), K=1,MAXCON), J=1,NELEM)
00102      . . . . WRITE(3,17)
00103      . . . . WRITE(3,16) (UNITS, J=1,4)
00104      . . . . WRITE(3,17) (JJ(J), (QCOUT(J,K), K=1,MAXCON), J=1,NELEM)
00105      C . . . . WRITE(3,20)
00106      L . . . . WRITE(3,16) (UNITS, J=1,4)
00107      C . . . . WRITE(3,17) (J, (VCEL(J,K), K=1,MAXCON), J=1,NELMO)
00108      C . . . . WRITE(3,24)
00109      C . . . . WRITE(3,16) (UNITS, J=1,4)

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00110 C . . WRITE(3,17) (J,(UVDIF(J,K), K=1,MAXCON), J=1,NELMO)
00111 . . WRITE(3,21)
00112 . . WRITE(3,22) (UNITS, J=1,3)
00113 . . WRITE(3,23) (J, (BELAY(J,K), K=1,MAXCON=1), J=1,NPED)
00114 . . WRITE(3,25)
00115 . . WRITE(3,26) (UNITS, J=1,5)
00116 . . WRITE(3,27) (BAL(J), J=1,MAXCON), TBAL
00117 . . WRITE(3,27) (DIF(J), J=1,MAXCON), TDIF
00118 . . WRITE(3,24) (TBED(J), J=1,MAXCON)
00119 . . WRITE(3,24) (TODIF(J), J=1,MAXCON)
00120 . . .FIN
00121 . . CLOSE (UNIT=2)
00122 . . .FIN
00123 CLOSE (UNIT=3)
00124 RETURN
00125 C
00126 1 FORMAT(1H1)
00127 2 FORMAT(/10X,'RIVER SEGMENT NUMBER: ',8X,I6/
00128 1 10X,'TIME STEP NUMBER: ',8X,I6/
00129 2 10X,'ELAPSED TIME: ',3X,F11.2/
00130 3 10X,'DATUM: ',4X,F10.4/
00131 4 10X,'NUMBER OF ELEMENTS: ',8X,I6/
00132 5 10X,'STANDARD ELEMENT THICKNESS: ',1PE14.7/
00133 7 10X,'NUMBER OF BED LAYERS: ',8X,I6/
00134 8 10X,'STANDARD BED LAYER THICKNESS: ',1PE14.7/
00135 9 10X,'TOP LAYER THICKNESS: ',1PE14.7/
00136 1 10X,'SHEAR STRESS VALUE: ',1PE14.7)
00137 3 FORMAT(/55X,'WATER CONCENTRATIONS')
00138 4 FORMAT(/10X,3(3X,'SUSPENDED'),3X,'DISSOLVED ',1X,3('CONTAM'
00139 1 'INANT'),5X,'TOTAL',6X,' TOTAL'/
00140 2 2X,'ELEVATION',4X,'SAND',8X,
00141 3 'SILT',8X,'CLAY',5X,'CONTAMINANT WITH SAND WITH SILT',
00142 4 3X,'WITH CLAY',3X,'PARTICULATE',4X,'CONC. '/
00143 5 3X,'(METERS)',3X,3('KG/M**3',5X),1X,A2,'/M**3',5X,2(A2,'/M**3',
00144 6 5X),A2,'/M**3',5X,A2,'/M**3',5X,A2,'/M**3')
00145 5 FORMAT(1X,F10.4,1PE12.4)
00146 6 FORMAT(/56X,'BED CONCENTRATIONS')
00147 7 FORMAT(/16X,'SAND WEIGHT',5X,'SILT WEIGHT',5X,'CLAY WEIGHT',
00148 1 3(5X,'CONTAMINANT'),7X,'AVERAGE'/2X,'ELEVATION',6X,
00149 2 3('FRACTION',8X),'WITH SAND',7X,'WITH SILT',7X,'WITH CLAY',
00150 3 9X,'CONC. '/
00151 4 3X,'(METERS)',7X,3(7X,9X),1X,3(A2,'/KG',11X),A2,'/KG')
00152 8 FORMAT(1X,F10.4,7(2X,1PE14.7))
00153 9 FORMAT(' PROCESSING= ',30A1)
00154 10 FORMAT(50X,'(IMPLICIT FALL VELOCITY SCHEME)')
00155 11 FORMAT(48X,'(POST-MATRIX-SOLUTION FALL ROUTINE)')
00156 12 FORMAT(/45X,'CONTAMINANT ASSOCIATED WITH SEDIMENT')
00157 13 FORMAT(/42X,3('CONTAMINANT '),2X,'AVERAGE'/31X,'ELEVATION',
00158 13X,'WITH SAND',3X,'WITH SILT',3X,'WITH CLAY',4X,'CONC. '/
00159 232X,'(METERS)',5X,A2,'/KG',7X,A2,'/KG',7X,A2,'/KG',6X,A2,'/KG')
00160 14 FORMAT(30X,0PF10.4,1PE12.4)
00161 15 FORMAT(/33X,'INTEGRATED VALUES OF TOTAL MASS OR CONTAMINANT IN EA
00162 1CH ELEMENT')
00163 16 FORMAT(/28X,3('SUSPENDED '),3('CONTAMINANT '), ' DISSOLVED'/
00164 120X,'ELEMENT SAND',9X,'SILT',9X,'CLAY',7X,'WITH SAND',3X,
00165 2'WITH SILT WITH CLAY',3X,'CONTAMINANT'/31X,'KG',19X,'KG',

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00166      310X,'KG',11X,A2,10X,A2,10X,A2,17X,A2)
00167 17  FORMAT(22X,I2,2X,1P3E12.4,1X,1P2E12.4,1X,1PE12.4,1X,1PE12.4)
00168 18  FORMAT(/37X,'FLUX OF SEDIMENT MASS OR CONTAMINANT INFLUENT TO ELE
00169      1MENT')
00170 19  FORMAT(/37X,'FLUX OF SEDIMENT MASS OR CONTAMINANT EFFLUENT FROM E
00171      1ELEMENT')
00172 20  FORMAT(/34X,'VERTICAL FLUX OF SEDIMENT MASS OR CONTAMINANT TO EAC
00173      1H ELEMENT')
00174 21  FORMAT(/36X,'INTEGRATED VALUES OF TOTAL MASS OR CONTAMINANT IN TH
00175      1E BED')
00176 22  FORMAT(/14X,'ELEMENT',5X,'SAND WEIGHT',5X,'SILT WEIGHT',5X,'CLAY
00177      1 WEIGHT',3(5X,'CONTAMINANT')/75X,'WITH SAND',7X,'WITH SILT',7X,'
00178      2 WITH CLAY'/30X,'KG',2(14X,'KG'),15X,A2,2(14X,A2))
00179 23  FORMAT(16X,I3,2X,1P6E16.7)
00180 24  FORMAT(/36X,'DISPERSION OF SEDIMENT MASS OR CONTAMINANT THROUGH E
00181      1ACH ELEMENT')
00182 26  FORMAT('0',9X,'SAND',12X,'SILT',12X,'CLAY',11X,'W/SAND',10X,'W/SIL
00183      1T',10X,'W/CLAY',7X,'DISSOLVED',3X,'TOTAL CONTAMINANT'/11X,'KG',
00184      214X,'KG',14X,'KG',14X,A2,14X,A2,14X,A2,14X,A2,14X,A2)
00185 27  FORMAT(2X,8(2X,1PE14.7))
00186 25  FORMAT('0', '(1) OLDC + INFLUENT = EFFLUENT'/' ' ,
00187      1      '(2) NEWC = (1)'/' ' ,
00188      2      '(3) NEWBED = SUMMATION (B(I,J)*VOLUME*DENSITY)'/' ' ,
00189      3      '(4) NEWBED = OLDBED + (2)'')
00190 29  FORMAT(2X,6(2X,1PE14.7),16X,1PE16.7)
00191 C

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00192      TO SKIP=NM=MATRICES
00193      . DO (M=1,NM)
00194 C      . . *** THERE ARE 15 RECORDS FOR EACH TIME STEP ***
00195      . . DO (M=1,15) READ (2)
00196      . ...FIN
00197      ...FIN
00198 C
00199      END

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PROCEDURE CROSS-REFERENCE TABLE

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00192 SKIP=NM=MATRICES
00053 00058

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00001 SUBROUTINE PARTIC(AHAR, ALEN, B, C, CCIN, COLD, DECAY, DELTO,
00002 1 DFZ, I, J, NBED, NELEM, QHOUT, QHIN, QV, SORBK,
00003 2 SD, SR, ALFA, BETA, VEL1, VEL2, VSET,
00004 3 UELZ, DEPTH, BWID, AWID, BETA1, BETA2, DSORB, ULDC)
00005 C
00006 C THIS SUBROUTINE CALCULATES COEFFICIENTS OF CONVECTIVE, DECAY AND
00007 C SOURCE TERMS FOR TRANSPORT OF POLLUTANT ATTACHED TO SEDIMENT,
00008 C
00009 C INPUT PARAMETERS:
00010 C ABAR = AVERAGE ELEMENT AREA
00011 C B = BED CONDITIONS
00012 C C = WATER CONDITIONS
00013 C CCIN = CONCENTRATION OF INFLOW
00014 C COLD = CELL-CENTERED CONCENTRATION
00015 C DECAY = FIRST ORDER DECAY
00016 C DELTO = TIME STEP (DAYS)
00017 C DFZ = DIFFUSION COEFFICIENT
00018 C DELZ = ELEMENT THICKNESS
00019 C I = ELEMENT INDEX
00020 C J = PARAMETER INDEX
00021 C NBED = NUMBER OF BED LAYERS
00022 C NELEM = NUMBER OF ELEMENTS
00023 C QHIN = INFLOW DISCHARGE
00024 C QV = VERTICAL DISCHARGE
00025 C SORBK = ADSORPTION ON SEDIMENT, (1-3) M**3/KG, (4-9) 1/DAY
00026 C DSORB = DESORPTION FROM SEDIMENT, (1-3) M**3/KG, (4-9) 1/DAY
00027 C SR = EROSION RATE, KG(PC)/M**3/DAY
00028 C SD = DEPOSITION RATE, KG(PC)/M3/DAY
00029 C OUTPUT PARAMETERS:
00030 C ALFA = DECAY TERM, 1/DAY
00031 C BETA = SOURCE OR SINK TERM, PC (KG)/M**3/DAY
00032 C BETA1 = INFLUENT SOURCE TERM FOR I-TH NODE, PC (KG)/M**3/DAY
00033 C BETA2 = INFLUENT SOURCE TERM FOR I+1 TH NODE, PC (KG)/M**3/DAY
00034 C VEL1 = FIRST CONVECTIVE TERM, M/DAY
00035 C VEL2 = SECOND CONVECTIVE TERM, M/DAY
00036 C
00037 C CALLED BY TRANSP.
00038 C
00039 C INCLUDE 'ELMSIZ.PRM'
00040 C
00041 C REAL INFRAC
00042 C
00043 C DIMENSION ABAR(MXELEM), AREA(MXELEM), B(MAXLEV,MAXCON-1),
00044 1 CCIN(MXELEM,MAXCON), DECAY(6), DFZ(4), QHIN(MXELEM),
00045 2 QV(MXELEM), SORBK(9), SR(6), COLD(MXELEM,MAXCON),
00046 3 C(MXELEM,MAXCON), VSET(3), QHOUT(MXELEM),
00047 4 SD(MXELEM,6), BWID(MXELEM), AWID(MXELEM), CHAR(MXELEM,MAXCON)
00048 5 , DSORB(9), ULDC(MXELEM,MAXCON)
00049 C
00050 C
00051 C ZERO = 1.0E-10
00052 C JM3MJ = 3
00053 C IP1 = I + 1

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00054 C
00055 C *** CONVECTIVE TERM ***
00056 C
00057 C AQ = QV(I)
00058 C VEL1 = (AQ - VSET(JM3) * BWID(I) * ALEN) / ABAR(I)
00059 C
00060 C AQ = QV(IP1)
00061 C VEL2 = (AQ - VSET(JM3) * BWID(I+1) * ALEN) / ABAR(I)
00062 C
00063 C *** DECAY TERM *** (EFFLUENT)
00064 C
00065 C ALFA = RHOUT(I) / (ABAR(I) * DELZ) + DECAY(I)
00066 C
00067 C *** SOURCE OR SINK TERM *** (INFLUENT)
00068 C
00069 C BETA1 = QHIN(I) / (ABAR(I) * DELZ) * (CCIN(I,J) / 3 + CCIN(I+1,J) / 6)
00070 C BETA2 = QHIN(I) / (ABAR(I) * DELZ) * (CCIN(I,J) / 6 + CCIN(I+1,J) / 3)
00071 C *****
00072 C *
00073 C * WARNING: CCIN IS WRITTEN INTO CBAR AS A FIRST *
00074 C * APPROXIMATION TO THE EVENTUAL AVERAGE *
00075 C * CONCENTRATION. THE ONLY MEANS BY WHICH *
00076 C * TO ASSURE THE ACCURACY OF THIS *
00077 C * ASSUMPTION IS TO ITERATE TO THE CORRECT *
00078 C * SOLUTION, AND USE NEW ITERATES TO BETTER *
00079 C * APPROXIMATE CBAR. *
00080 C *
00081 C *****
00082 C
00083 C *** ABSORPTION / DESORPTION ***
00084 C
00085 C DO (JE = 1, NELEM)
00086 C
00087 C . INFRAC = 0.5 * QHIN(IE) * DELTD / ABAR(IE) / DELZ
00088 C . EXFRAC = 1.0 - INFRAC
00089 C . DO (IC = 1, MAXCUN)
00090 C . . CHAR(IE, IC) = CCIN(IE, IC) * INFRAC + OLDC(IE, IC) * EXFRAC
00091 C . . . FIN
00092 C . . . FIN
00093 C IF (CHAR(I, JM3) .GT. 0.0 .AND. CHAR(I+1, JM3) .GT. 0.0)
00094 C . ADDS1 = SORHK(J) * SORHK(JM3) / 12. * (3. * CHAR(I, JM3) * CHAR(I, 7)
00095 C 1. + CHAR(I, JM3) * CHAR(I+1, 7) + CHAR(I+1, JM3) * CHAR(I, 7) +
00096 C 2. CHAR(I+1, JM3) * CHAR(I+1, 7)) - SORHK(J) / 6. * (2. * CHAR(I, J) +
00097 C 3. CHAR(I+1, J))
00098 C . DSAD1 = USORHB(J) * DSURHB(JM3) / 12. * (3. * CHAR(I, JM3) * CHAR(I, 7)
00099 C 1. + CHAR(I, JM3) * CHAR(I+1, 7) + CHAR(I+1, JM3) * CHAR(I, 7) +
00100 C 2. CHAR(I+1, JM3) * CHAR(I+1, 7)) - DSORHB(J) / 6. * (2. * CHAR(I, J) +
00101 C 3. CHAR(I+1, J))
00102 C . ADDS2 = SORHK(J) * SORHK(JM3) / 12. * (CHAR(I, JM3) * CHAR(I, 7)
00103 C 1. + CHAR(I, JM3) * CHAR(I+1, 7) + CHAR(I+1, JM3) * CHAR(I, 7)
00104 C 2. + 3. * CHAR(I+1, JM3) * CHAR(I+1, 7)) - SORHK(J) / 6. * (CHAR(I, J)
00105 C 3. + 2. * CHAR(I+1, J))
00106 C . DSAU2 = USORHB(J) * DSURHB(JM3) / 12. * (CHAR(I, JM3) * CHAR(I, 7)
00107 C 1. + CHAR(I, JM3) * CHAR(I+1, 7) + CHAR(I+1, JM3) * CHAR(I, 7)
00108 C 2. + 3. * CHAR(I+1, JM3) * CHAR(I+1, 7)) - DSORHB(J) / 6. * (CHAR(I, J)
00109 C 3. + 2. * CHAR(I+1, J))

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00110 . IF(ADDS1,GT,0,0,OR,ADDS1,EQ,DSAD1)BETA1=BETA1+ADDS1
00111 . IF(DSAD1,LT,0,0)BETA1=BETA1+DSAD1
00112 . IF(ADDS2,GT,0,0,OR,ADDS2,EQ,DSAD2)BETA2=BETA2+ADDS2
00113 . IF(DSAD2,LT,0,0)BETA2=BETA2+DSAD2
00114 ...FIN
00115 C
00116 C *** SCOUR OR DEPOSITION ***
00117 C
00118 BETA = SR(J) - SDY1,J)
00119 RETURN
00120 END
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(FLECS VERSION 22,46)

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00001      SUBROUTINE PHOINP(ECHO,JULIAN,KAY1,KAY2,PCOEF)
00002      C
00003      C THIS SUBROUTINE IS RESPONSIBLE FOR READING THE PHOTOLYSIS INPUT
00004      C DATA AND COMPUTING THE FIRST TERM OF THE RATE OF CHANGE EQUATION.
00005      C
00006      C FORMAL PARAMETERS:
00007      C ECHO = LINE PRINTER ECHO CONTROL VARIABLE = L*1
00008      C JULIAN = JULIAN STARTING DATE OF THE SIMULATION
00009      C KAY1 = LIGHT EXTINCTION COEFFICIENT OF WATER
00010      C KAY2 = LIGHT EXTINCTION COEFFICIENT OF SUSPENDED SEDIMENTS
00011      C IN WATER
00012      C PCOEF = FIRST TERM OF THE RATE OF CHANGE EQUATION
00013      C
00014      C CALLED BY: SERATRA
00015      C
00016      C INTEGER*4 SECDAY
00017      C LOGICAL*1 ECHO
00018      C
00019      C REAL KAY1,KAY2
00020      C
00021      C DIMENSION E(18),SI(18,4),WL(18),PCOEF(4)
00022      C
00023      C DATA SECDAY/86400/
00024      C *** THESE ARE THE SUNLIGHT WAVE LENGTHS THAT DATA IS EXPECTED FOR
00025      C DATA WL / 300.00, 303.75, 308.75, 313.75, 318.75, 323.10,
00026      C 1 346.00, 370.00, 400.00, 430.00, 460.00, 490.00,
00027      C 2 536.25, 586.50, 637.50, 687.50, 756.00, 800.00/
00028      C
00029      C ....FIRST DATA SET
00030      C COL. 1= 5...JULIAN,...JULIAN STARTING DATE OF THE SIMULATION
00031      C WHEN THIS IS INPUT AS A ZERO, NO
00032      C PHOTOLYSIS CALCULATIONS ARE MADE.
00033      C 6=15...PHI.....THE REACTION QUANTUM YIELD FOR THE
00034      C CHEMICAL IN AIR-SATURATED, PURE WATER,
00035      C A MEASURE OF THE EFFICIENCY WITH WHICH
00036      C A PHOTOCHEMICAL PROCESS CONVERTS
00037      C ADSORBED LIGHT INTO CHEMICAL REACTION.
00038      C 16=25...KAY1.....LIGHT EXTINCTION COEFFICIENT OF WATER
00039      C (1/M)
00040      C 26=35...KAY2.....LIGHT EXTINCTION COEFFICIENT OF
00041      C SUSPENDED SEDIMENTS IN WATER (SELF-
00042      C SHADING COEFFICIENT) M**4/KG**2
00043      C
00044      C READ(1,1) JULIAN,PHI,KAY1,KAY2
00045      C WHEN (JULIAN .EQ. 0)
00046      C . DO (I=1,4) PCOEF(I) = 0.0
00047      C . PHI = 0.0
00048      C . KAY1 = 0.0
00049      C . KAY2 = 0.0
00050      C . IF (ECHO) WRITE(6,2)
00051      C ...FIN
00052      C ELSE
00053      C .

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00054 C . ....SECOND DATA SET = ADSORPTION COEFFICIENTS TABLE
00055 C . THIS IS THE TABLE OF ADSORPTION COEFFICIENTS FOR 18
00056 C . DIFFERENT WAVELENGTHS THAT ARE A MEASURE OF THE CHEMICAL'S
00057 C . ABILITY TO ADSORB LIGHT AT THE DIFFERENT WAVELENGTHS.
00058 C . WAVELENGTH UNITS ARE NANOMETERS.
00059 C . ....RECORD 1
00060 C . COL. 1-10...E( 1)...COEF. FOR WAVELENGTH OF 300.00
00061 C . 11-20...E( 2)...COEF. FOR WAVELENGTH OF 303.75
00062 C . 21-30...E( 3)...COEF. FOR WAVELENGTH OF 308.75
00063 C . 31-40...E( 4)...COEF. FOR WAVELENGTH OF 313.75
00064 C . 41-50...E( 5)...COEF. FOR WAVELENGTH OF 318.75
00065 C . 51-60...E( 6)...COEF. FOR WAVELENGTH OF 323.10
00066 C . 61-70...E( 7)...COEF. FOR WAVELENGTH OF 346.00
00067 C . 71-80...E( 8)...COEF. FOR WAVELENGTH OF 370.00
00068 C .
00069 C . ....RECORD 2
00070 C . COL. 1-10...E( 9)...COEF. FOR WAVELENGTH OF 400.00
00071 C . 11-20...E(10)...COEF. FOR WAVELENGTH OF 430.00
00072 C . 21-30...E(11)...COEF. FOR WAVELENGTH OF 460.00
00073 C . 31-40...E(12)...COEF. FOR WAVELENGTH OF 490.00
00074 C . 41-50...E(13)...COEF. FOR WAVELENGTH OF 536.25
00075 C . 51-60...E(14)...COEF. FOR WAVELENGTH OF 577.50
00076 C . 61-70...E(15)...COEF. FOR WAVELENGTH OF 637.50
00077 C . 71-80...E(16)...COEF. FOR WAVELENGTH OF 687.50
00078 C .
00079 C . ....RECORD 3
00080 C . COL. 1-10...E(17)...COEF. FOR WAVELENGTH OF 756.00
00081 C . 11-20...E(18)...COEF. FOR WAVELENGTH OF 800.00
00082 C .
00083 C . READ(1,4) (E(L),L=1,18)
00084 C .
00085 C . ....THIRD DATA SET = SOLAR INTENSITY TABLE
00086 C . THIS TABLE CONSISTS OF FOUR SETS OF 18 VALUES, THE
00087 C . FOUR SETS CORRESPOND TO SPRING, SUMMER, FALL, AND WINTER,
00088 C . RESPECTIVELY. THE 18 VALUES CORRESPOND TO THE 18 WAVELENGTHS
00089 C . AS DESCRIBED ABOVE IN THE ADSORPTION COEFFICIENT TABLE.
00090 C . THE INCLUSIVE DATES FOR EACH SEASON ARE GIVEN BELOW:
00091 C . CALENDER DATES JULIAN DATES
00092 C . -----
00093 C . SPRING MARCH 1 - MAY 31 60-151
00094 C . SUMMER JUNE 1 - AUG. 31 152-243
00095 C . FALL SEP. 1 - NOV. 30 244-334
00096 C . WINTER DEC. 1 - FEB. 28 335-365; 1-59
00097 C .
00098 C . HEAD(1,4) ((SI(L,I),L=1,18),I=1,4)
00099 C .
00100 C . IF (ECHO)
00101 C . . WRITE(6,3)
00102 C . . WRITE(6,7) JULIAN,PHI,KAY1,KAY2
00103 C . . WRITE(6,5)
00104 C . . DO (L=1,18)
00105 C . . . WRITE(6,6) WL(L),E(L),(SI(L,I),I=1,4)
00106 C . . . .FIN
00107 C . ...FIN
00108 C .
00109 C . *** THE JULIAN DATE IS ADJUSTED TO MAKE THE FIRST DAY OF

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00110 C      *      SPRING JULIAN DAY 1 ***
00111 C      *      WHEN (JULIAN .GE. 60) JULIAN = JULIAN - 59
00112 C      *      ELSE JULIAN = JULIAN + 306
00113 C      *
00114 C      *      *** COMPUTE THE FIRST TERM OF THE RATE OF CHANGE EQUATION
00115 C      *      FOR EACH OF THE FOUR SEASONS ***
00116 C      *      DO (I=1,4)
00117 C      *      *      PCOEF(I) = 0.0
00118 C      *      *      DO (L=1,18) PCOEF(I) = PCOEF(I) + E(L) * SI(L,I)
00119 C      *      *      PCOEF(I) = PHI * PCOEF(I) * (2.303/6.02E20) * SEC/DAY
00120 C      *      ...FIN
00121 C      *      ...FIN
00122 C      *      RETURN
00123 C
00124 C      1      FORMAT(15,3F10.0)
00125 C      2      FORMAT(1H0,13X,'NO PHOTOLYSIS DEGRADATION WILL BE COMPUTED')
00126 C      3      FORMAT(1H0,48X,'PHOTOLYSIS TABLES AND COEFFICIENTS')
00127 C      4      FORMAT(8F10.0/8F10.0/2F10.0)
00128 C      5      FORMAT(1H0,56X,'PHOTOLYSIS TABLES'/39X,'ABSORPTION',
00129 C      1 23X,'SOLAR INTENSITIES'/23X,'LAMBDA CENTER',
00130 C      2 2X,'COEFFICIENTS',5X,'SPRING',8X,'SUMMER',9X,'FALL',
00131 C      3 9X,'WINTER'/23X,6(12(' '),2X))
00132 C      6      FORMAT(26X,F6.2,3X,5(2X,1PE12.4))
00133 C      7      FORMAT(26X,15,'...JULIAN STARTING DATE'/
00134 C      1 14X,1PE12.5,'...REACTION QUANTUM YIELD'/
00135 C      2 14X,1PE12.5,'...LIGHT EXTINCTION COEFFICIENT OF WATER'/
00136 C      3 14X,1PE12.5,'...LIGHT EXTINCTION COEFFICIENT OF SUSPENDED',
00137 C      4      ' SOLIDS IN WATER')
00138 C
00139 C      END
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00001      SUBROUTINE PROFIL(ALEN, AWID, DELZ, DEPTH, NELEM, Q,
00002      1          USTAR, VOL, QH, EL, IFLAG, DELTA)
00003      C
00004      C      THIS ROUTINE ASSIGNS A LOGARITHMIC OR UNIFORM PROFILE FOR THE
00005      C      BULK VOLUMETRIC FLOWS.
00006      C
00007      C      INPUT PARAMETERS:
00008      C          ALEN = SEGMENT LENGTH
00009      C          AWID = SEGMENT WIDTH
00010      C          DELZ = STANDARD ELEMENT THICKNESS
00011      C          DEPTH = FLOW DEPTH
00012      C          NELEM = NUMBER OF VERTICAL ELEMENTS IN THE SEGMENT
00013      C          Q = FLOW TO BE DISTRIBUTED
00014      C          USTAR = SHEAR VELOCITY
00015      C          VOL = SEGMENT VOLUME
00016      C      OUTPUT PARAMETERS:
00017      C          QH = DISTRIBUTED FLOW
00018      C
00019      C      CALLED BY: HYDFLO, ICFLO
00020      C
00021      C      INCLUDE 'ELMSIZ.PRM'
00022      C
00023      C      DIMENSION QH(MXELEM), Z(MXELEM), Z1(MXELEM), AWID(MXELEM),
00024      1          EL(MXELEM)
00025      C      DATA XK/0.4/
00026      C      DATA G/9.81/
00027      C
00028      C      DO (I = 1, MXELEM)
00029      C          . QH(I) = 0.0
00030      C          ...FIN
00031      C          UBAR=Q / VOL * ALEN
00032      C      Z0=DEPTH/(10.**((UBAR*XK/(2.3*USTAR) + 1./2.3))
00033      C      ICOUNT=0
00034      C      Z0=0.001
00035      C      C1=UBAR*XK/USTAR+1.0
00036      C      CON=DEPTH*(C1-2.303*ALOG10(DEPTH))
00037      C      REPEAT UNTIL (ABS(EPS).LT.0.01.OR.ICOUNT.GT.10)
00038      C          . ICOUNT=ICOUNT+1
00039      C          . FZ0=CON-Z0*C1+2.303*DEPTH*ALOG10(Z0)
00040      C          . FPZ0=DEPTH/Z0-C1
00041      C          . ZP=Z0-FZ0/FPZ0
00042      C          . EPS=(ZP-Z0)/ZP
00043      C          . Z0=ZP
00044      C          . IF(Z0.LT.0.0)
00045      C          . . Z0=DEPTH/(10.**((UBAR*XK/(2.303*USTAR)+1./2.303))
00046      C          . . ICOUNT=11
00047      C          . ...FIN
00048      C          ...FIN
00049      C
00050      C      WHEN (Z0 .GT. DELZ/4.0.OR.NELEM.EQ.1)
00051      C          . *** DISTRIBUTE VELOCITY UNIFORMLY ***
00052      C          . WHEN(IFLAG.EQ.0)
00053      C          . . DO (I=1, NELEM)

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00054      . . . QH(I)=UBAR*DELZ*AWID(I)
00055      . . . . .FIN
00056      . . . . .FIN
00057      . ELSE
00058      . . DO (I=1,NELEM-1)
00059      . . . QH(I)=UBAR*(EL(I+1)-EL(I))*AWID(I)
00060      . . . . .FIN
00061      . . QH(NELEM)=UBAR*DELTA*AWID(NELEM)
00062      . . . . .FIN
00063      . . . . .FIN
00064      ELSE
00065 C      . *** DISTRIBUTE VELOCITY INTO A LOGARITHMIC PROFILE ***
00066      . NUMB=NELEM+1
00067      . Z(1)=Z0
00068      . Z(NUMB)=DEPTH
00069      . Z1(NUMB)=0.
00070 C      .
00071      . JX = 1
00072      . J=NUMB
00073      . REPEAT UNTIL (JX .EQ. NELEM .OR. Z(J) .LE. Z0)
00074      . . JX = JX + 1
00075      . . J=NELEM - JX + 2
00076      . . WHEN (IFLAG.EQ.0) Z1(J)=Z1(J+1)+DELZ
00077      . . ELSE
00078      . . . WHEN (J.EQ.NELEM) Z1(J)=Z1(J+1)+DELTA
00079      . . . ELSE Z1(J)=Z1(J+1)+EL(J+1)-EL(J)
00080      . . . . .FIN
00081      . . Z(J)=DEPTH - Z1(J)
00082      . . . . .FIN
00083      . WHEN (Z(J) .GT. Z0) J = 1
00084      . ELSE
00085      . . J1 = J-1
00086      . . DO (I=1,J1)
00087      . . . QH(I)=0.
00088      . . . . .FIN
00089      . . . . .FIN
00090 C      .
00091 C      .
00092      . A=2.303 * USTAR / XK
00093      . SUM=0.
00094 C      . XLOGD=ALOG10(DEPTH)
00095 C      . DO (I=J,NELEM)
00096 C      . IP1=I+1
00097 C      . DLZ = Z(IP1) - Z(I)
00098 C      . T1=A*DLZ * XLOGD
00099 C      . T2 =A*(Z(IP1) * ALOG10(Z(IP1)) - Z(I) * ALOG10(Z(I))-DLZ)
00100 C      . QH(I)=(UBAR*DLZ-T1+T2)*AWID(I)
00101 C      . SUM = SUM + QH(I)
00102 C      . FIN
00103      . T1=A/(DEPTH-Z0)*(Z0*ALOG10(Z0)-DEPTH*ALOG10(DEPTH))+UBAR
00104      . DO (I=J,NELEM)
00105      . . IP1=I+1
00106      . . T2=A*(Z(IP1)*ALOG10(Z(IP1))-Z(I)*ALOG10(Z(I)))
00107      . . QH(I)=AWID(I)*(T2+(Z(IP1)-Z(I))*T1)
00108      . . SUM=SUM+QH(I)
00109      . . . . .FIN

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```
00110      . DO (I=1,NELEM)
00111      . .   QH(I)=QH(I)/SUM * Q
00112      . . .   FIN
00113      . . . . FIN
00114      RETURN
00115      END
```

(FLECS VERSION 22.46)

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-----  
00001      SUBROUTINE PUTERR(ID, NUMERR, HLDERR)  
00002      C  
00003      C      WHEN AN ERROR IS DETECTED IN THE INPUT STREAM ,  
00004      C      THIS SUBROUTINE IS CALLED TO PLACE THE ERROR IDENTIFICATION  
00005      C      CODE (ID) INTO THE HOLDING ARRAY (HLDERR) AND INCREMENTS  
00006      C      THE NUMBER OF ERRORS (NUMERR).  
00007      C  
00008      C      CALLED BY: DINDAT, INIDAT, TRBDAT, UPSDAT  
00009      C  
00010      C      BYTE HLDERR(100)  
00011      C  
00012      C      NUMERR=NUMERR+1  
00013      C      HLDERR(NUMERR)=ID  
00014      C      RETURN  
00015      C      END
```

(FLECS VERSION 22,46)

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-----  
00001 SUBROUTINE RADIUS (ALEN, AREA, CROSEC, DEPTH, EL, HRAD)  
00002 C  
00003 C THIS ROUTINE CALCULATES THE HYDRAULIC RADIUS OF A CROSS-SECTION.  
00004 C  
00005 C INPUT PARAMETERS:  
00006 C ALEN = SEGMENT LENGTH  
00007 C AREA = SURFACE AREA AT NODAL DEPTHS  
00008 C DEPTH = DEPTH OF CROSS-SECTION  
00009 C EL = ELEVATION OF NODAL AREAS  
00010 C OUTPUT PARAMETERS:  
00011 C CROSEC = TOTAL CROSS-SECTIONAL AREA  
00012 C HRAD = HYDRAULIC RADIUS  
00013 C  
00014 C CALLED BY: HYDDAT, ICFLO  
00015 C  
00016 C INCLUDE 'ELMSIZ.PRM'  
00017 C DIMENSION AREA(MXELEM), EL(MXELEM)  
00018 C  
00019 C CROSEC = 0.  
00020 C BLEN = 1./ALEN  
00021 C WETPER = AREA(1)*BLEN  
00022 C ELBTH = EL(1)  
00023 C WBTM = AREA(1)*BLEN  
00024 C  
00025 C DO (I=2,MXELEM)  
00026 C . ELTOP = EL(I)  
00027 C . WTOP = AREA(I)*BLEN  
00028 C . IF (ELTOP,GE,DEPTH) GO TO 10  
00029 C . CROSEC = (ELTOP - ELBTH)*(WTOP + WBTM)/2. + CROSEC  
00030 C . WETPER = SQRT((ELTOP - ELBTH)**2 + ((WTOP - WBTM)/2. )**2) * 2.0  
00031 C . + WETPER  
00032 C . ELBTH = ELTOP  
00033 C . WBTM = WTOP  
00034 C . . .FIN  
00035 C WRITE (6,1) CROSEC, WETPER, I  
00036 C 1 FORMAT ('11', ' ERROR IN SUBROUTINE RADIUS'/  
00037 C 1 '0 CROSEC = ', E12.4, 'M**3'/  
00038 C 2 '0 WETTED PERIMETER = ', E12.4, 'M**2'/  
00039 C 3 '0 ELEMENT = ', I3)  
00040 C GO TO 20  
00041 C 10 WTOP = WBTM + (WTOP - WBTM) * (DEPTH - ELBTH)/(ELTOP - ELBTH)  
00042 C ELTOP = DEPTH  
00043 C CROSEC = CROSEC + (ELTOP - ELBTH) * (WTOP + WBTM)/2.  
00044 C WETPER = SQRT((ELTOP - ELBTH)**2 + ((WTOP - WBTM)/2. )**2) * 2.0  
00045 C + WETPER  
00046 C 20 HRAD = CROSEC / WETPER  
00047 C RETURN  
00048 C END
```

(FLFCS VERSION 22,46)

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00001      SUBROUTINE RDSFLO(ALEN, AREA, AWID,C, DELZ, DFZ, NELEM, NELEMP,
00002      1 PDELZ, PWID, PXSAR, VSET, XSAREA)
00003      C
00004      C THIS SUBROUTINE IS CALLED EACH TIME STEP (EXCEPT THE FIRST) WHEN THE
00005      C DEPTH WITHIN THE SEGMENT HAS CHANGED. ITS TASK IS TO REDISTRIBUTE
00006      C THE CONCENTRATIONS.
00007      C
00008      C FORMAL PARAMETERS:
00009      C   AWID   = WIDTH * CURRENT TIME STEP
00010      C   C     = THE NELMPT+1 NODAL CONCENTRATIONS THAT ARE TO BE
00011      C           REDISTRIBUTED
00012      C   DELZ   = THE STANDARD ELEMENT THICKNESS FOR THE CURRENT TIME STEP
00013      C   DFZ    = DIFFUSION=DISPERSION COEFFICIENT
00014      C   NELEM  = THE NUMBER OF ELEMENTS FOR THE CURRENT TIME STEP
00015      C   NELEMP = THE NUMBER OF ELEMENTS DURING THE PREVIOUS TIME STEP
00016      C   PDELZ  = THE STANDARD ELEMENT THICKNESS USED DURING THE PREVIOUS
00017      C           TIME STEP
00018      C   PXSAR  = PRESS SECTION * PREVIOUS TIME STEP
00019      C   PWID   = WIDTH * PREVIOUS TIME STEP
00020      C   XSAREA = CROSS SECTION * CURRENT TIME STEP
00021      C   VSET  = SETTLING VELOCITY OF SEDIMENT
00022      C
00023      C CALLED BY: SERATRA
00024      C
00025      C   INCLUDE 'ELMSIZ.PRM'
00026      C
00027      C   DIMENSION AREA(MXELEM), AWID(MXELEM), C(MXELEM,MAXCON),
00028      C   1CP(MXELEM,MAXCON), DFZ(4), PWID(MXELEM), PXSAR(MXELEM),
00029      C   2VSET(3), XSAREA(MXELEM), IELP(MXELEM), H*XS(MXELEM), TMASS(7)
00030      C
00031      C   PXS = 0.
00032      C   XS  = 0.
00033      C
00034      C   DO (I=1,NELEM) XS = XS + XSAREA(I)
00035      C   DO (I=1,NELEMP) PXS = PXS + PXSAR(I)
00036      C   DO (I=1,NELEMP+1)
00037      C     . DO (J=1,MAXCON)
00038      C     .   CP(I,J) = C(I,J)
00039      C     .   ...FIN
00040      C     .   ...FIN
00041      C   RATIO = PXS/XS
00042      C   CALL EQUIPKS(PXSAR, PDELZ, XSAREA, NELEM, NELEMP, RATIO,
00043      C   IELP, H*XS)
00044      C   DO (K=1,MAXCON)
00045      C     . TMASS(K)=0.
00046      C     . CT=CP(2,K)
00047      C     . CB=CP(1,K)
00048      C     . NELMHT=1
00049      C     . CHASAB=(CT+CB)/2.*PXSAR(1)
00050      C     . CHASBB=0.
00051      C     . DO (I=1,NELEM)
00052      C     .   . NELMTP=IELP(I)
00053      C     .   . NB=NELMTP

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00054      . . NT=NB+1
00055      . . ET=NB*PDELZ
00056      . . EB=ET-PDELZ
00057      . . CT=CP(NT,K)
00058      . . CB=CP(NB,K)
00059      . . HEL=HEQS(1)
00060      . . FAC1=(HEL-EB)/PDELZ
00061      . . FAC2=(ET-HEL)/PDELZ
00062      . . CTOP=CT+FAC1+CB*FAC2
00063      . . CHASAT=(CT+CTOP)/2.*PWID(NB)*(ET=HEL)
00064      . . CHASBT=(CTOP+CB)/2.*PWID(NB)*(HEL=EB)
00065      . . INDIC=NELMTP-NELMRT
00066      . . CHASS=0.
00067      . . IF(INDIC,EQ,0) CHASS=CHASBT-CHASBB
00068      . . IF(INDIC,GT,0) CHASS=CHASBT+CHASAB
00069      . . IF(INDIC,GT,1)
00070      . . . . UO(J=NELMRT+1,NELMTP=1)
00071      . . . . . CT=CP(J+1,K)
00072      . . . . . CB=CP(J,K)
00073      . . . . . CHASS=CHASS+PXSAR(J)*(CT+CB)/2.
00074      . . . . . FIN
00075      . . . . . FIN
00076      . . THASS(K)=THASS(K)+CHASS
00077 C      . . NODAL VALUE IN BOTTOM ELEMENT
00078      . . WHEN(I,EQ,1)
00079      . . . . WHEN(K,NE,7)
00080 C      . . . .
00081 C      . . . . SAND SILT CLAY
00082 C      . . . .
00083      . . . . . WHEN(K,LT,4)
00084      . . . . . COEF=0.
00085      . . . . . WS=VSET(K)*AREA(1)/(AWID(1)*ALEN)
00086      . . . . . EZ=DFZ(K)
00087      . . . . . FIN
00088 C      . . . .
00089 C      . . . . POLLUTANT ASSOCIATED WITH SAND SILT CLAY
00090 C      . . . .
00091      . . . . . ELSE
00092      . . . . . COEF=0.
00093      . . . . . WS=VSET(K=3)*AREA(1)/(AWID(1)*ALEN)
00094      . . . . . EZ=DFZ(K=3)
00095      . . . . . FIN
00096 C      . . . .
00097 C      . . . . NOTE: CHASS IS IN (KG/H)
00098 C      . . . .
00099      . . . . . C(1,K)=(2.*CHASS/XSAREA(1)-COEF*DELZ/EZ)/(2.*WS*DELZ/EZ)
00100      . . . . . C(2,K)=2.*CHASS/XSAREA(1)-C(1,K)
00101      . . . . . FIN
00102 C      . . . .
00103 C      . . . . DISSOLVED POLLUTANT
00104 C      . . . .
00105      . . . . . ELSE
00106      . . . . . C(1,K)=CHASS/XSAREA(1)
00107      . . . . . C(2,K)=C(1,K)
00108      . . . . . FIN
00109      . . . . . FIN
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00110 C      . .  NODAL VALUES ABOVE BOTTOM ELEMENT
00111      . .  ELSE C(I+1,K) = 2.*CHASS/XSAREA(I)-C(I,K)
00112      . .  CHASAB=CHASAT
00113      . .  CHASBB=CHASBT
00114      . .  NELMBT=NELMTP
00115      . . .FIN
00116      . . .FIN
00117      RETURN
00118      END
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(FLECS VERSION 22.46)

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00001      SUBROUTINE RPTERR(NUMERR, HLDERR, FERROR)
00002      C
00003      C   THIS ROUTINE IS RESPONSIBLE FOR REPORTING ANY INPUT ERRORS
00004      C   UNCOVERED BY THE INPUT ROUTINES AND DETERMINING THEIR SEVERITY.
00005      C
00006      C   CALLED BY: SERATRA, STARTUP
00007      C
00008      C   BYTE HLDERR(100),BUFF(80,2)
00009      C
00010      C   LOGICAL*1 FERROR
00011      C
00012      C   CALLED BY: SERATRA
00013      C
00014      C   OPEN(UNIT=10, NAME='SERATERR.MSG', TYPE='OLD', ACCESS='DIRECT',
00015      C   1 FORM='FORMATTED', MAXREC=200, RECORDSIZE=80,
00016      C   2 ASSOCIATEVARIABLE=III, READONLY)
00017      C
00018      C   NUMW=0
00019      C   NUMF=0
00020      C   WRITE(6,4)
00021      C   DO (I=1, NUMERR)
00022      C     IND=(HLDERR(I)-1)*2+1
00023      C     READ(10'IND,1)(BUFF(K,1),K=1,80)
00024      C     IND=IND+1
00025      C     READ(10'IND,1)(BUFF(K,2),K=1,80)
00026      C     IF(BUFF(1,1).EQ.'W')NUMW=NUMW+1
00027      C     IF(BUFF(1,1).EQ.'F')NUMF=NUMF+1
00028      C     WRITE(6,2)((BUFF(K,J),K=1,80),J=1,2)
00029      C     **FIN
00030      C     WRITE(6,3)NUMW,NUMF
00031      C     CLOSE(UNIT=10)
00032      C     IF (NUMF .GT. 0) FERROR = .TRUE.
00033      C     RETURN
00034      C
00035      C   1  FORMAT(80A1)
00036      C   2  FORMAT(1H0,A1,2X,3A1,3X,76A1/10X,80A1)
00037      C   3  FORMAT(//,10X,15,' WARNING DIAGNOSTICS'/11X,15,' FATAL ERROR(8)')
00038      C   4  FORMAT('/***** DIAGNOSTIC SUMMARY *****)
00039      C
00040      C   END

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-----
00001      SUBROUTINE SAND(ABAR, ALEN, AREA, B, BDIV, CCIN, DELTD, DELZ,
00002      1          DENS, D50, HRAD, NBED, NELEM, POR, QHIN,
00003      2          QHOUT, SCSHR, SLOPE, SMETH, STRESS, TEMPR,
00004      3          VSET, VOL, XYSO, DEPO, ILAYR, SD, SR,
00005      4          XNT, COLD, C, CROSEC, BWID, ECHO7, SCOUR)
00006      C
00007      C      THIS SUBROUTINE COMPUTES THE SOURCE/SINK TERMS REQUIRED FOR
00008      C      SCOUR/DEPOSITION OF SAND.  TRANSPORT CAPACITY IS CALCULATED
00009      C      ONCE PER SEGMENT.
00010      C
00011      C      INPUT PARAMETERS:
00012      C          ABAR  = AVERAGE VERTICAL PROJECTION AREA
00013      C          ALEN  = SEGMENT LENGTH
00014      C          AREA  = ELEMENT (REAL) VERTICAL PROJECTION AREA @ DATA NODES
00015      C          B     = BED CONDITIONS
00016      C          BDIV  = STANDARD BED LAYER THICKNESS
00017      C          BWID  = BEAL WIDTH AT CROSS-SECTION BREAK POINTS
00018      C          C     = WATER CONDITIONS
00019      C          CCIN  = CONCENTRATION OF INFLOW
00020      C          CROSEC = TOTAL CROSS-SECTIONAL AREA, M**2
00021      C          DELTD = TIME STEP (DAYS)
00022      C          DELZ  = STANDARD ELEMENT THICKNESS
00023      C          DELZT = THICKNESS OF THE TOP ELEMENT
00024      C          DENS  = DENSITY
00025      C          D50  = MEDIAN BED SEDIMENT DIAMETER (METER)
00026      C          HRAD  = HYDRAULIC RADIUS
00027      C          NBED  = NUMBER OF BED LAYERS
00028      C          NELEM = NUMBER OF ELEMENTS
00029      C          POR   = POROSITY
00030      C          QHIN  = INFLOW DISCHARGE
00031      C          QHOUT = OUTFLOW DISCHARGE
00032      C          SCSHR = CRITICAL SHEAR STRESS FOR SCOUR
00033      C          SLOPE = ENERGY OR RIVER BED SLOPE
00034      C          SMETH = METHOD TO BE USED WHEN COMPUTING SAND CAPACITY (BYTE
00035      C                  *I; TOFFALETTI'S METHOD
00036      C                  *C; COLBY'S METHOD
00037      C          STRESS = BED SHEAR STRESS
00038      C          TEMPR  = WATER TEMPERATURE
00039      C          VSET  = PARTICLE SETTLING VELOCITY
00040      C          VOL   = VOLUME
00041      C          XYSO  = THICKNESS OF TOP BED LAYER
00042      C      OUTPUT PARAMETERS:
00043      C          ILAYR = NO. OF BED LAYERS AFFECTED BY SED. DEPOSITION AND ER
00044      C          SD    = DEPOSITION RATE, (KG(PC)/M**3/DAY)
00045      C          SR    = EROSION RATE, (KG(PC)/M**3/DAY)
00046      C          XNT   = HEIGHT OF TOP BED SEDIMENT LAYER, (KG/M**2)
00047      C          DEPO  = BED DEPOSITION RATE (KG(PC)/M2/DAY)
00048      C          SCOUR = BED SCOUR RATE (KG(PC)/M2/DAY)
00049      C
00050      C      CALLED BY: TRANSP.
00051      C      CALLS: TOFFAL, COLBY
00052      C
00053      C      INCLUDE 'ELMSIZ.PRM'

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00054 C
00055     BYTE SMETH
00056 C
00057     LOGICAL*1 FERROR, ECH07
00058     REAL INFRAC
00059 C
00060 C
00061     DIMENSION ABAR(MXELEM), AREA(MXELEM), B(MAXLEV,MAXCON=1),
00062 1         COLD(IXELEM,MAXCON),CCIN(MXELEM,MAXCON), DENS(3),
00063 2         QHIN(MXELEM), QHOUT(MXELEM), QCSHR(3),
00064 3         SD(MXELEM,6), SR(6), VSET(3), XNT(3), EE(MXELEM),
00065 4         ILAYR(3), C(MXELEM,MAXCON), HNSD(MXELEM),
00066 5         DEPU(6), SCOUR(6)
00067 C
00068 C
00069 C     INITIALIZE SCALAR AND ARRAY VARIABLES
00070     ILAYR(1) = 0
00071     RS=0.0
00072     CS=0.0
00073     DEPU(1) = 0.0
00074     DEPU(4) = 0.0
00075     SRC = 0.0
00076     GSI = 0.0
00077     QTOT = 0.0
00078     SR(1)=0.0
00079     SR(4)=0.0
00080     SCOUR(1)= 0.0
00081     SCOUR(4)= 0.0
00082     RATE = 0.0
00083     VPCROS = ALEN * B=ID(1)
00084     VOLUME = CROSEC * ALEN
00085     DO (K=1,NELEM)
00086     .   SD(K,1)=0.0
00087     .   SD(K,4)=0.0
00088     .   ...FIN
00089     XNT(1) = 0.
00090     IF (NBED,NE,0)
00091     .   XNT(1)=(1.0-POR)/(R(NBED,1)/DENS(1)+B(NBED,2)/DENS(2)+
00092 1.     B(NBED,3)/DENS(3))*XYSD*B(NBED,1)
00093     .   ...FIN
00094     IF (ECH07)
00095     C
00096     C     CALCULATE ACTUAL SAND TRANSPORT WITHIN THE RIVER REACH, SRC(KG/DAY)
00097     C
00098     C     NOTE: CCIN IS A TIME AVERAGED QUANTITY, COLD IS NOT. AN
00099     C     ITERATIVE LOOP IS CALLED FOR WHERE SRC IS UPDATED UNTIL
00100     C     RESULTS ARE UNCHANGED.
00101     C
00102     .   DO (IX=1,NELEM)
00103     .     INFRAC=0.5*(QHIN(IX)*DELTD/ABAR(IX)/DELZ
00104     .     EXFRAC=1.0-INFRAC
00105     .     SRC=SRC+INFRAC*QHIN(IX)*(CCIN(IX,1)+CCIN(IX+1,1))/2.
00106     .     +EXFRAC*QHOUT(IX)*COLD(IX,1)
00107 1.     QTOT=QTOT+INFRAC*QHIN(IX)+EXFRAC*QHOUT(IX)
00108     .     ...FIN
00109     C

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00110 C . IT IS IMPLICITLY ASSUMED THAT A DOWNSTREAM COURANT NUMBER
00111 C . AT OR NEAR UNITY IS EMPLOYED IN THIS ANALYSIS
00112 C .
00113 C .
00114 C . CALCULATIONS OF STREAM CAPACITY FOR SAND
00115 C . SELECT (SMETH)
00116 C . . ('T')
00117 C . . .
00118 C . . . THE TUFFALETI TECHNIQUE MAY NOT BE WELL SUITED FOR CHANNEL
00119 C . . . CROSS-SECTIONS WHICH DIFFER MARKEDLY FROM RECTANGULAR.
00120 C . . .
00121 C . . . CALL TUFFAL(ALEN, D50, GSI, HRAD, QTOT, SLOPE, TEMPR, VOL, VSET,
00122 1. . . . GSI, GSM, GSL, GSB, YU, YM, YL)
00123 C . . . . .FIN
00124 C . . . ('C')
00125 C . . . CALL COLBY(ALEN, C, DELZ, D50, HRAD, NELEM, QTOT, TEMPR,
00126 1. . . . VOL, GSI, FERROR)
00127 C . . . IF(FERROR)
00128 C . . . . CALL TUFFAL(ALEN, D50, GSI, HRAD, QTOT, SLOPE, TEMPR, VOL, VSET,
00129 1. . . . GSI, GSM, GSL, GSB, YU, YM, YL)
00130 C . . . . FERROR = .FALSE.
00131 C . . . . .FIN
00132 C . . . . .FIN
00133 C . . . . .FIN
00134 C . . . . GSI = GSI * HWID(NELEM + 1)
00135 C .
00136 C . DETERMINE IF DEPOSITION, SCOUR, OR NEITHER OCCURS.
00137 C .
00138 C . DIF = GSI - SRC
00139 C . IF (UIP) 50, 100, 150
00140 C .
00141 C . SAND WITHIN THE WATER COLUMN EXCEEDS CAPACITY = DEPOSITION OCCURS
00142 C .
00143 50 . DEPO(1) = -DIF/ AREA(1)
00144 C . RATE = -DIF/VOLUME
00145 C . ILAYR(1) = -1
00146 C . DO (K=1, NELEM)
00147 C . . SU(K,1) = RATE
00148 C . . VOLK = ABAR(K)*DELZ
00149 C . . INFRAC=0.5*QHIN(K)*DELTD/VOLK
00150 C . . EXFRAC=1.0-INFRAC
00151 C . . SED=INFRAC*QHIN(K)*(CCIN(K,1)+CCIN(K+1,1))/2.
00152 1. . . + EXFRAC*QHOUT(K)*COLD(K,1)
00153 C . . CONT=INFRAC*QHIN(K)*(CCIN(K,4)+CCIN(K+1,4))/2.
00154 1. . . + EXFRAC*QHOUT(K)*COLD(K,4)
00155 C . . RATEK = RATE * VOLK
00156 C . . SU(K,4) = RATEK/SED/VOLK*CONT
00157 C . . DEPO(4) = DEPO(4)+SU(K,4)/AREA(1)*VOLK
00158 C . . . . .FIN
00159 C . RETURN
00160 C .
00161 C . CAPACITY EQUALS LOAD = NOTHING EXCHANGES
00162 C .
00163 100 . RETURN
00164 C .
00165 C . CAPACITY IS GREATER THAN LOAD = SCOUR OCCURS
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00166 C .
00167 C .
00168 C . DETERMINE WHICH (IF ANY) BED LAYERS ARE SCURED
00169 C .
00170 150 . TRSUSP = DIF * DELTD
00171 . ILAYR(1) = 0
00172 . IF (NBED.EQ.0) GO TO 200
00173 . DO (K=1,NBED)
00174 . . NB = NBED - K + 1
00175 . . TDENS = (1.0 - POW) / (B(NB,1)/DENS(1) + B(NB,2)/DENS(2)
00176 . . + B(NB,3)/DENS(3))
00177 . . DEL = BDIV
00178 . . IF (NB.EQ.NBED) DEL = XYSO
00179 . . TINBED = TDENS * DEL * B(NB,1) * VPCROS
00180 . . WHEN (TRSUSP.GE.TINBED)
00181 . . . RS = RS + TINBED
00182 . . . CS = CS + TINBED * B(NB,4)
00183 . . . TRSUSP = TRSUSP - TINBED
00184 . . . TINBED = 0.0
00185 . . . ILAYR(1) = ILAYR(1) + 1
00186 . . . IF (ILAYR(1).EQ.NBED) GO TO 175
00187 . . . ...FIN
00188 . . . ELSE
00189 . . . . RS = RS + TRSUSP
00190 . . . . CS = CS + TRSUSP * B(NB,4)
00191 . . . . TINBED = TINBED + TRSUSP
00192 . . . . GO TO 175
00193 . . . ...FIN
00194 . . . ...FIN
00195 175 . SCOUR(1) = RS / DELTD / AREA(1)
00196 . SCOUR(4) = CS / DELTD / AREA(1)
00197 . XNT(1) = TINBED / VPCROS
00198 . SR(1) = RS / DELTD / VOLUME
00199 . SR(4) = CS / DELTD / VOLUME
00200 . ...FIN
00201 200 RETURN
00202 . END
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(FLECS VERSION 22,46)

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00001      SUBROUTINE SAVEIT(H, HDIV, BED, ELEV, C, DELZ, NBED,
00002      1          NELEM, NXEQ, RESELN, STRESS, XYSO, OLDC,
00003      2 ALEN, QHIN, QHOUT, CCIN, QV, AWID, BWID, VSET, DENS, DELTD, DFZ,
00004      3          POR, TBED)
00005      C
00006      C THIS ROUTINE WRITES THE SIMULATION RESULTS TO THE RESULT FILE
00007      C (LUN 5) THAT HAS BEEN OPENED BY SERATRA
00008      C
00009      C FORMAL PARAMETERS:
00010      C      B          = BED CONCENTRATIONS
00011      C      HDIV       = STANDARD BED LAYER THICKNESS
00012      C      BED        = BED THICKNESS
00013      C      C          = WATER CONCENTRATIONS
00014      C      DELZ       = STANDARD ELEMENT THICKNESS
00015      C      ELEV       = SEGMENT ELEVATION (DATUM ELEVATION)
00016      C      NBED      = NUMBER OF BED LAYERS
00017      C      NELEM     = NUMBER OF ELEMENTS
00018      C      NXEQ      = CURRENT TIME STEP (I*4)
00019      C      RESELN    = WATER SURFACE ELEVATION
00020      C      STRESS    = SHEAR STRESS
00021      C      XYSO     = THICKNESS OF THE TOP BED LAYER
00022      C
00023      C      CALLED BY: SERATRA,
00024      C
00025      C      INCLUDE 'ELMSIZ.PR1'
00026      C
00027      C      INTEGER*4 NXEQ
00028      C
00029      C      DIMENSION B(MAXLEV,MAXCON-1),BAVG(MAXLEV), BEL(MAXLEV),
00030      1          C(MXELEM,MAXCON), CHASS(MXELEM), CVOLM(MXELEM),
00031      2          CTOTL(MXELEM), WELEV(MXELEM), D(MXELEM,MAXCON)
00032      3 , QHIN(MXELEM),QHOUT(MXELEM),CCIN(MXELEM,MAXCON),
00033      4 QV(MXELEM),AWID(MXELEM),BWID(MXELEM),VSET(3),
00034      5 DENS(3),QCIN(MXELEM,MAXCON),QCOU(MXELEM,MAXCON),
00035      6 CELAV(MXELEM,MAXCON),QVCEL(MXELEM,MAXCON),
00036      7 OLDC(MXELEM,MAXCON),DFZ(4),QVDIF(MXELEM,MAXCON),
00037      8          DTBED(MAXCON),TBED(MAXCON),BAL(MAXCON),DIF(MAXCON),
00038      9          OCELAV(MAXCON),TOTDIF(MAXCON)
00039      DATA EPSI/1.0E-30/
00040      NEMPI=NELEM+1
00041      NBEDPI = NBED + 1
00042      C
00043      C      *** WATER CONCENTRATIONS ***
00044      C
00045      J = NELEM + 1
00046      WRITE(5) NXEQ,J,NBED,ELEV,DELZ,HDIV,XYSO,STRESS
00047      REPEAT UNTIL (J .EQ. 0)
00048      . CHASS(J) = C(J,4) + C(J,5) + C(J,6)
00049      . SUM = C(J,1) + C(J,2) + C(J,3)
00050      . WHEN (SUM .GT. 0.0) CVOLM(J) = CHASS(J) / SUM
00051      . ELSE CVOLM(J) = 0.0
00052      . CTOTL(J) = CHASS(J) + C(J,7)
00053      . SELECT (J)

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00054      . . (NELEM+1) WELEV(NELEM+1) = RESELN
00055      . . (OTHERWISE) WELEV(J) = WELEV(J+1) = DELZ
00056      . . . . FIN
00057      . . J = J - 1
00058      . . . . FIN
00059      DO(K=1,MAXCON)
00060      . . DO(I=1,NELEM+1)
00061      . . . . WHEN (K .LE. 3 .OR. K .EQ. 7) D(I,K)=C(I,K)
00062      . . . . ELSE
00063      . . . . . D(I,K)=0.
00064      . . . . . IF (C(I,K=3) .GT. 1.0E-10) D(I,K)=C(I,K)/C(I,K=3)
00065      . . . . . FIN
00066      . . . . . FIN
00067      . . . . FIN
00068      WRITE(5) (WELEV(J), (C(J,K),K=1,MAXCON),CHASS(J),CVOLM(J),
00069      1      CTOTL(J),J=NELEM+1,1,-1)
00070      WRITE(5) ((D(J,K),K=4,6),J=NELEM+1,1,-1)
00071      C
00072      C      *** BED CONCENTRATIONS ***
00073      C
00074      BELEV = (NBED-1) * BDIV + XY80 + ELEV
00075      J = NBED
00076      REPEAT UNTIL (J .EQ. 0)
00077      . . BAVG(J) = H(J,1)*B(J,4) + B(J,2)*B(J,5) + B(J,3)*B(J,6)
00078      . . SELECT (J)
00079      . . . . (NBED) BEL(NBED) = BELEV
00080      . . . . (NBED-1) BEL(NBED-1) = BELEV - XY80
00081      . . . . (OTHERWISE) BEL(J) = BEL(J+1) - BDIV
00082      . . . . FIN
00083      . . J = J - 1
00084      . . . . FIN
00085      WRITE(5) (BEL(J), (B(J,K),K=1,MAXCON=1),BAVG(J),J=NBED,1,-1)
00086      C      *** ELEMENT MASS AND CONVECTED MASS ***
00087      DO (J=1,MAXCON)
00088      . . QCELV(J) = 0.
00089      . . QCELV(NELMP1,J)=0
00090      . . QCIN(NELMP1,J)=0
00091      . . QCOU(NELMP1,J)=0
00092      . . DO(I = 1,NELEM)
00093      . . . . VOL=AWID(I)*DELZ*ALEN
00094      . . . . XS=AWID(I)*DELZ
00095      . . . . VPX3=AWID(I)*ALEN
00096      . . . . QMEAN = (OLDC(I,J) + OLDC(I+1,J))/2.
00097      . . . . CMEAN=(C(I,J)+C(I+1,J))/2.
00098      . . . . CELAV(I,J)=VOL*CMEAN
00099      . . . . QCIN(I,J)=QHIN(I)*(CCIN(I,J)+CCIN(I+1,J))/2.*DELTD
00100      . . . . QCOU(I,J)=QHOUT(I)*DELTD*(CMEAN+(OLDC(I,J)+OLDC(I+1,J))/2.)/2.
00101      . . . . CELAV(NELMP1,J)=CELAV(NELMP1,J)+CELAV(I,J)
00102      . . . . QCIN(NELMP1,J)=QCIN(NELMP1,J)+QCIN(I,J)
00103      . . . . QCOU(NELMP1,J)=QCOU(NELMP1,J)+QCOU(I,J)
00104      . . . . QCELV(J) = QCELV(J) + QMEAN*VOL
00105      . . . . K=J
00106      . . . . IF(J .GT. 3) K=J-3
00107      . . . . WHEN (K .EQ. 4) WS=0.
00108      . . . . ELSE WS=VSET(K)
00109      . . . . WHEN(I .EQ. 1) WVCBTH=QV(1)*(C(1,J)+OLDC(1,J))/2.
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00110      . . ELSE QVCBTH=(QV(I)*WS*BWID(I)*ALEN)*(C(I,J)+OLDC(I,J))/2.
00111      . . WHEN (I .EQ. NELEM)
00112      . . . QVCTOP=QV(NELEM+1)*(C(NELEM+1,J)+OLDC(NELEM+1,J))/2.
00113      . . . FIN
00114      . . ELSE
00115      . . . QVCTOP=(QV(I+1)*WS*BWID(I+1)*ALEN)*(C(I+1,J)+OLDC(I+1,J))/2.
00116      . . . FIN
00117      . . QVCEL(I,J)=(QVCBTH-QVCTOP)*DELTD
00118      . . QVDIF(I,J)=DFZ(K)*DELTD*AWID(I)*ALEN*
00119      1. . (C(I+1,J)-C(I,J)+OLDC(I+1,J)-OLDC(I,J))/(2.*DELZ)
00120      . . . FIN
00121      . . . FIN
00122      VOLUME=0.0
00123      DO (J=1,NELEM) VOLUME=VOLUME+AWID(J)*DELZ*ALEN
00124      WRITE(5)VOLUME
00125      WRITE(5)((CELAV(J,K),K=1,MAXCON),J=NELMP1,1,-1)
00126      WRITE(5)((QCIN(J,K),K=1,MAXCON),J=NELMP1,1,-1)
00127      WRITE(5)((QCOU(J,K),K=1,MAXCON),J=NELMP1,1,-1)
00128      WRITE(5)((QVCEL(J,K),K=1,MAXCON),J=NELEM,1,-1)
00129      WRITE(5)((QVDIF(J,K),K=1,MAXCON),J=NELEM,1,-1)
00130      C
00131      DO (J=1,MAXCON)
00132      . . BAL(J) = QCIN(NELMP1,J)-QCOU(NELMP1,J)+CELAV(J)
00133      . . DIF(J) = CELAV(NELMP1,J)-BAL(J)
00134      . . . FIN
00135      TBAL=0.
00136      TDIF=0.
00137      DO (J=4,MAXCON)
00138      . . TBAL = TBAL + BAL(J)
00139      . . TDIF = TDIF + DIF(J)
00140      . . . FIN
00141      WRITE(5) (BAL(J),J=1,MAXCON),TBAL
00142      WRITE(5) (DIF(J),J=1,MAXCON),TDIF
00143      C
00144      C *** BED SEDIMENT AND CONTAMINANT (KG, PC)/ELEMENT ***
00145      C
00146      DO (J=1,MAXCON)
00147      . . THED(J) = THED(J)
00148      . . THED(J) = 0.
00149      . . . FIN
00150      VPTS=HWID(I)*ALEN
00151      DO (J=1,MAXCON-1)
00152      . . DO (I=1,NBED)
00153      . . . WHEN (J .LT. 4)
00154      . . . . DENSITY=(1.0-PUR)/(B(I,1)/DENS(1)+B(I,2)/DENS(2)+B(I,3)/DENS(3))
00155      . . . . DEL=BDIV
00156      . . . . IF(I.EQ. NBED) DEL=XYSD
00157      . . . . VOL=DEL*VPTS
00158      . . . . CELAV(I,J)=B(I,J)*VOL*DENSITY
00159      . . . . . FIN
00160      . . . . ELSE CELAV(I,J)=CELAV(I,J-3)*B(I,J)
00161      . . . . THED(J) = THED(J) + CELAV(I,J)
00162      . . . . . FIN
00163      . . . . . FIN
00164      WRITE(5) ((CELAV(J,K),K=1,MAXCON-1),J=NBED,1,-1)
00165      DO (J=4,MAXCON-1)

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00166      * TBED(MAXCON) = TBED(MAXCON) + TBED(J)
00167      ...FIN
00168      WRITE(S) (TBED(J),J=1,MAXCON)
00169      DO (J=1,MAXCON-1)
00170      * TOTDIF(J) = TBED(J) - OTBED(J) + DIF(J)
00171      ...FIN
00172      TOTDIF(MAXCON) = TBED(MAXCON) - OTBED(MAXCON) + TDIF
00173      WRITE(S) (TOTDIF(J),J=1,MAXCON)
00174      RETURN
00175      END
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(FLECS VERSION 22.46)

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00001      SUBROUTINE SEDDAT(DECAY, DENS, DFZ, DIAM, DSHR, D50, ECHO,
00002      1      ERODE, HLDERR, NUMERR, SCSHR, SURBK, VSET,
00003      2      USORB)
00004      C
00005      C THIS SUBROUTINE IS RESPONSIBLE FOR READING AND PROCESSING THE
00006      C SEDIMENT CHARACTERISTICS.
00007      C
00008      C FORMAL PARAMETERS:
00009      C DECAY = DECAY PARAMETERS
00010      C DENS = SPECIFIC WEIGHT
00011      C DFZ = VERTICAL DIFFUSION COEFFICIENTS
00012      C DIAM = PARTICLE DIAMETERS
00013      C DSHR = CRITICAL SHEAR STRESS VALUE FOR DEPOSITION
00014      C D50 = MEDIAN BED SEDIMENT DIAMETER
00015      C ECHO = LINE PRINTER ECHO CONTROL VARIABLE (L*1)
00016      C ERODE = ERODABILITY
00017      C HLDERR = HOLDING ARRAY FOR ERROR NUMBERS (BYTE)
00018      C NUMERR = NUMBER OF INPUT ERRORS
00019      C SCSHR = CRITICAL SHEAR STRESS VALUE FOR SCOUR
00020      C SURBK = ADSORPTION VALUES
00021      C USORB = DESORPTION VALUES
00022      C VSET = VERTICAL SETTLING VELOCITIES
00023      C
00024      C CALLED BY ISERATRA
00025      C CALLES: PUTERR
00026      C
00027      C HYIE HLDERR(100)
00028      C
00029      C LOGICAL*1 ECHO
00030      C
00031      C DIMENSION DECAY(6), DENS(3), DFZ(4), DIAM(3), DSHR(3), ERODE(3),
00032      1      SCSHR(3), SURBK(9), USORB(9), VSET(3)
00033      C
00034      C ....PARTICLE SETTLING VELOCITY (M/SEC)
00035      C
00036      C COL. 1-10....VSET(1)....SAND SETTLING VELOCITY
00037      C      11-20....VSET(2)....SILT SETTLING VELOCITY
00038      C      21-30....VSET(3)....CLAY SETTLING VELOCITY
00039      C
00040      C READ(1,1) (VSET(I), I=1,3)
00041      C IF(ECHO)
00042      C   * WRITE(6,2)
00043      C   * WRITE(6,12) (VSET(I), I=1,3)
00044      C   ...FIN
00045      C
00046      C ....DENSITY (KG/M**3)
00047      C
00048      C COL. 1-10....DENS(1)....DENSITY OF SAND
00049      C      11-20....DENS(2)....DENSITY OF SILT
00050      C      21-30....DENS(3)....DENSITY OF CLAY
00051      C
00052      C READ(1,1) (DENS(I), I=1,3)
00053      C IF(ECHO)

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00054      . WRITE(6,3)
00055      . WRITE(6,12) (DENS(I),I=1,3)
00056      ...FIN
00057      IF(DENS(1) .LE. 0.0) CALL PUTERR(17,NUMERR,HLDEHR)
00058      IF(DENS(2) .LE. 0.0) CALL PUTERR(18,NUMERR,HLDEHR)
00059      IF(DENS(3) .LE. 0.0) CALL PUTERR(19,NUMERR,HLDEHR)
00060      C
00061      C      ....DIAMETER (METERS)
00062      C
00063      C      COL.  1-10,....DIAM(1)....DIAMETER OF SAND
00064      C      11-20,....DIAM(2)....DIAMETER OF SILT
00065      C      21-30,....DIAM(3)....DIAMETER OF CLAY
00066      C      31-40,....D50.....MEDIAN BED SEDIMENT DIAMETER
00067      C
00068      HEAD(1,1) (DIAM(I),I=1,3),D50
00069      IF(ECHO)
00070      . WRITE(6,4)
00071      . WRITE(6,12) (DIAM(I),I=1,3)
00072      . WRITE(6,13) D50
00073      ...FIN
00074      IF(DIAM(1) .LE. 0.0) CALL PUTERR(20,NUMERR,HLDEHR)
00075      IF(DIAM(2) .LE. 0.0) CALL PUTERR(21,NUMERR,HLDEHR)
00076      IF(DIAM(3) .LE. 0.0) CALL PUTERR(22,NUMERR,HLDEHR)
00077      C
00078      C      ....CRITICAL SHEAR STRESS FOR SCOUR (KG/M**2)
00079      C
00080      C      COL.  1-10,....SCSHR(1)....CRITICAL SHEAR STRESS FOR SAND
00081      C      11-20,....SCSHR(2)....CRITICAL SHEAR STRESS FOR SILT
00082      C      21-30,....SCSHR(3)....CRITICAL SHEAR STRESS FOR CLAY
00083      C
00084      HEAD(1,1) (SCSHR(I),I=1,3)
00085      IF(ECHO)
00086      . WRITE(6,5)
00087      . WRITE(6,12) (SCSHR(I),I=1,3)
00088      ...FIN
00089      IF(SCSHR(1) .LE. 0.0) CALL PUTERR(26,NUMERR,HLDEHR)
00090      IF(SCSHR(2) .LE. 0.0) CALL PUTERR(27,NUMERR,HLDEHR)
00091      IF(SCSHR(3) .LE. 0.0) CALL PUTERR(28,NUMERR,HLDEHR)
00092      C
00093      C      ....CRITICAL SHEAR STRESS FOR DEPOSITION (KG/M**2)
00094      C
00095      C      COL.  1-10,....DSHR(1)....CRITICAL SHEAR STRESS FOR SAND
00096      C      11-20,....DSHR(2)....CRITICAL SHEAR STRESS FOR SILT
00097      C      21-30,....DSHR(3)....CRITICAL SHEAR STRESS FOR CLAY
00098      C
00099      HEAD(1,1) (DSHR(I),I=1,3)
00100      IF(ECHO)
00101      . WRITE(6,6)
00102      . WRITE(6,12) (DSHR(I),I=1,3)
00103      ...FIN
00104      IF(DSHR(1) .LE. 0.0) CALL PUTERR(29,NUMERR,HLDEHR)
00105      IF(DSHR(2) .LE. 0.0) CALL PUTERR(30,NUMERR,HLDEHR)
00106      IF(DSHR(3) .LE. 0.0) CALL PUTERR(31,NUMERR,HLDEHR)
00107      C
00108      C      ....ERODIBILITY (KG/M**2/SEC)
00109      C
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00110 C COL. 1-10...ERODE(1)...ERODABILITY OF SAND
00111 C 11-20...ERODE(2)...ERODABILITY OF SILT
00112 C 21-30...ERODE(3)...ERODABILITY OF CLAY
00113 C
00114 HEAD(1,1) (ERODE(1),I=1,3)
00115 IF(ECHO)
00116 * WRITE(6,7)
00117 * WRITE(6,12) (ERODE(1),I=1,3)
00118 ...FIN
00119 IF(ERODE(1) .LE. 0.0) CALL PUTERR(32,NUMERR,HLERR)
00120 IF(ERODE(2) .LE. 0.0) CALL PUTERR(33,NUMERR,HLERR)
00121 IF(ERODE(3) .LE. 0.0) CALL PUTERR(34,NUMERR,HLERR)
00122 C
00123 C ....VERTICAL DIFFUSION COEFFICIENTS (M**2/SEC)
00124 C
00125 C COL. 1-10...DFZ(1)...COEFFICIENT FOR SAND
00126 C 11-20...DFZ(2)...COEFFICIENT FOR SILT
00127 C 21-30...DFZ(3)...COEFFICIENT FOR CLAY
00128 C 31-40...DFZ(4)...COEFFICIENT FOR DISSOLVED CONTAMNANT
00129 C
00130 HEAD(1,1) (DFZ(I),I=1,4)
00131 IF(ECHO)
00132 * WRITE(6,8)
00133 * WRITE(6,12) (DFZ(I),I=1,3)
00134 * WRITE(6,14) DFZ(4)
00135 ...FIN
00136 C
00137 C ....ADSORPTION VALUES (2 CARDS)
00138 C
00139 C CARD #1
00140 C COL. 1-10...SORBK(1)...KD VALUE WITH SAND (M**3/KG)
00141 C 11-20...SORBK(2)...KD VALUE WITH SILT (M**3/KG)
00142 C 21-30...SORBK(3)...KD VALUE WITH CLAY (M**3/KG)
00143 C 31-40...SORBK(4)...SUSPENDED SAND MASS TRANSFER RATE (1/S
00144 C 41-50...SORBK(5)...SUSPENDED SILT MASS TRANSFER RATE (1/S
00145 C 51-60...SORBK(6)...SUSPENDED CLAY MASS TRANSFER RATE (1/S
00146 C 61-70...SORBK(7)...BED SAND MASS TRANSFER RATE (1/SEC)
00147 C 71-80...SORBK(8)...BED SILT MASS TRANSFER RATE (1/SEC)
00148 C
00149 C CARD #2
00150 C COL. 1-10...SORBK(9)...BED CLAY MASS TRANSFER RATE (1/SEC)
00151 C
00152 HEAD(1,1) (SORBK(I),I=1,9)
00153 C
00154 C ....DESORPTION VALUES (2 CARDS)
00155 C
00156 C CARD #1
00157 C COL. 1-10...DSORR(1)...KD VALUE WITH SAND (M**3/KG)
00158 C 11-20...DSORR(2)...KD VALUE WITH SILT (M**3/KG)
00159 C 21-30...DSORR(3)...KD VALUE WITH CLAY (M**3/KG)
00160 C 31-40...DSORR(4)...SUSPENDED SAND MASS TRANSFER RATE (1/S
00161 C 41-50...DSORR(5)...SUSPENDED SILT MASS TRANSFER RATE (1/S
00162 C 51-60...DSORR(6)...SUSPENDED CLAY MASS TRANSFER RATE (1/S
00163 C 61-70...DSORR(7)...BED SAND MASS TRANSFER RATE (1/SEC)
00164 C 71-80...DSORR(8)...BED SILT MASS TRANSFER RATE (1/SEC)
00165 C
00166 C CARD #2
00167 C COL. 1-10...DSORR(9)...BED CLAY MASS TRANSFER RATE (1/SEC)

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00166 C
00167 READ(1,1) (DSURB(I),I=1,9)
00168 IF(ECHO)
00169 . WRITE(6,9)
00170 . WRITE(6,12) (SORBK(I),I=1,3)
00171 . WRITE(6,15) (SORBK(I),I=4,9)
00172 . WRITE(6,16)
00173 . WRITE(6,12) (OSURB(I),I=1,3)
00174 . WRITE(6,15) (OSURB(I),I=4,9)
00175 ...FIN
00176 C
00177 C ....DECAY PARAMETERS (2 CARDS)
00178 C
00179 C CARD #1
00180 C COL. 1-10....DECAY(1)....RADIONUCLIDE DECAY (1/SEC)
00181 C 11-20....DECAY(2)....TOTAL DECAY, SUM OF ALL DECAY EXCEPT
00182 C FOR RADIONUCLIDE DECAY, IF GIVEN, THE
00183 C REMAINING PARAMETERS ARE NOT TO BE
00184 C SUPPLIED, PESTICIDE ONLY (1/SEC)
00185 C 21-30....DECAY(6)....VOLATIZATION DEGRADATION RATE,
00186 C PESTICIDE ONLY (1/SEC)
00187 C 31-40....PH.....DEGREE OF ACIDITY OF ALKALINITY
00188 C 41-50....AKA.....SECOND ORDER ACID RATE CONSTANT
00189 C FOR HYDROLYSIS
00190 C 51-60....AKB.....SECOND ORDER BASE RATE CONSTANT
00191 C FOR HYDROLYSIS
00192 C 61-70....AKN.....SECOND ORDER RATE CONSTANT OF NEUTROL
00193 C REACTION WITH WATER
00194 C 71-80....AKOX.....SECOND ORDER RATE CONSTANT OF FREE
00195 C RADICAL OXYGEN FOR OXIDATION
00196 C
00197 C CARD #2
00198 C COL 1-10....RO2.....CONCENTRATION OF FREE RADICAL OXYGEN
00199 C 11-20....AKBIO.....SECOND ORDER RATE CONSTANT
00200 C BIODEGRADATION
00201 C 21-30....BIOMAS.....BIOMASS PER UNIT VOLUME
00202 C
00203 READ(1,1) DECAY(1),DECAY(2),DECAY(6),PH,AKA,AKB,AKN,AKOX,RO2,
00204 1 AKBIO,BIOMAS
00205 DO (I=3,5) DECAY(I) = 0.0
00206 WHEN (DECAY(2) .NE. 0.0)
00207 . IF(ECHO) WRITE(6,10) DECAY(1),DECAY(2)
00208 ...FIN
00209 ELSE
00210 C . *** COMPUTE: DECAY(3) = CHEMICAL DEGRADATION DUE TO HYDROLYSIS
00211 C . DECAY(4) = CHEMICAL DEGRADATION DUE TO OXIDATION
00212 C . DECAY(5) = BIODEGRADATION ***
00213 C . DECAY(3) = 10.0**(PH-14.0)*AKB + 10.0**(-PH)*AKA + AKN
00214 C . DECAY(4) = AKOX * RO2
00215 C . DECAY(5) = AKBIO * BIOMAS
00216 C . IF(ECHO)
00217 C . . WRITE(6,11) DECAY(1),PH,AKA,AKB,AKN,DECAY(3),AKOX,RO2,DECAY(4),
00218 C . . . . AKBIO,BIOMAS,DECAY(5),DECAY(6)
00219 C . ...FIN
00220 C . ...FIN
00221 C
00222 RETURN

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00222 C
00223 1 FORMAT(8F10.0)
00224 2 FORMAT(1H0,13X,'PARTICLE SETTLING VELOCITY (M/SEC)')
00225 3 FORMAT(1H0,13X,'DENSITY (KG/M**3)')
00226 4 FORMAT(1H0,13X,'DIAMETER (METERS)')
00227 5 FORMAT(1H0,13X,'CRITICAL SHEAR STRESS FOR SCOUR (KG/M**2)')
00228 6 FORMAT(1H0,13X,'CRITICAL SHEAR STRESS FOR DEPOSITION (KG/M**2)')
00229 7 FORMAT(1H0,13X,'ERODABILITY (KG/M**2/SEC)')
00230 8 FORMAT(1H0,13X,'VERTICAL DIFFUSION COEFFICIENTS (M**2/SEC)')
00231 9 FORMAT(1H0,13X,'ADSORPTION KD VALUES')
00232 10 FORMAT(1H0,13X,'DECAY PARAMETERS')
00233 1 14X,1PE12.5,'...RADIONUCLIDE DECAY (1/SEC)'/
00234 2 14X,1PE12.5,'...TOTAL DECAY (EXCEPT RADIONUCLIDE) = (1/SEC)'/
00235 11 FORMAT(1H0,13X,'DECAY PARAMETERS')
00236 1 14X,1PE12.5,'...RADIONUCLIDE DECAY (1/SEC)'/
00237 2 14X,1PE12.5,'...PH = DEGREE OF ACIDITY OR ALKALINITY (PH)'/
00238 3 14X,1PE12.5,'...SECOND ORDER ACID RATE CONSTANT FOR HYDROLYSIS'
00239 4 ' (AKA)'/
00240 5 14X,1PE12.5,'...SECOND ORDER BASE RATE CONSTANT FOR HYDROLYSIS'
00241 6 ' (AKB)'/
00242 7 14X,1PE12.5,'...SECOND ORDER RATE CONSTANT OF NEUTROL REACTION'
00243 8 ' WITH WATER (AKN)'/
00244 9 14X,1PE12.5,'...CHEMICAL DEGRADATION DUE TO HYDROLYSIS'
00245 1 14X,1PE12.5,'...SECOND ORDER RATE CONSTANT OF FREE RADICAL'
00246 2 ' OXYGEN (AKOX)'/
00247 3 14X,1PE12.5,'...CONCENTRATION OF FREE RADICAL OXYGEN (RO2)'/
00248 4 14X,1PE12.5,'...CHEMICAL DEGRADATION DUE TO OXIDATION'
00249 5 14X,1PE12.5,'...SECOND ORDER RATE CONSTANT FOR BIODEGRADATION'
00250 6 ' (AKBIO)'/
00251 7 14X,1PE12.5,'...BIOMASS PER UNIT VOLUME (BIOMAS)'/
00252 8 14X,1PE12.5,'...BIODEGRADATION'
00253 9 14X,1PE12.5,'...VOLATILIZATION')
00254 12 FORMAT(14X,1PE12.5,'...SAND')
00255 1 14X,1PE12.5,'...SILT'
00256 2 14X,1PE12.5,'...CLAY')
00257 13 FORMAT(14X,1PE12.5,'...MEDIAN BED SEDIMENT DIAMETER')
00258 14 FORMAT(14X,1PE12.5,'...DISSOLVED CONTAMINANT')
00259 15 FORMAT(1H0,13X,'MASS TRANSFER RATES (1/SEC)')
00260 1 14X,1PE12.5,'...SUSPENDED SAND'
00261 2 14X,1PE12.5,'...SUSPENDED SILT'
00262 3 14X,1PE12.5,'...SUSPENDED CLAY'
00263 4 14X,1PE12.5,'...SAND ATTACHED TO THE BED'
00264 5 14X,1PE12.5,'...SILT ATTACHED TO THE BED'
00265 6 14X,1PE12.5,'...CLAY ATTACHED TO THE BED')
00266 16 FORMAT(1H0,13X,'DESORPTION KD VALUES')
00267 C
00268 END

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(FLECS VERSION 22.46)

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00001      SUBROUTINE SEDIME(ABAR, ALEN, CCIN, DELTD, I, J, NELEM,
00002      1      QHIN, QHOUT, QV, SD, SR, ALFA, BETA, VEL1,
00003      2      VEL2, VSET, DELZ, HWID, AWID, DEPTH,
00004      3      BETA1, BETA2)
00005      C
00006      C      THIS ROUTINE CALCULATES COEFFICIENTS OF CONVECTION, DIFFUSION,
00007      C      DECAY AND SOURCE TERMS IN THE SEDIMENT TRANSPORT CONVECTION
00008      C      =DIFFUSION EQUATION
00009      C
00010      C      INPUT PARAMETERS:
00011      C      ABAR   = AVERAGE AREA
00012      C      CCIN   = CONCENTRATION OF INFLOW
00013      C      DELTD  = TIME STEP IN DAYS
00014      C      DEPTH  = DEPTH OF RIVER SEGMENT
00015      C      I      = ELEMENT INDEX
00016      C      J      = PARAMETER INDEX
00017      C      NELEM  = NUMBER OF ELEMENTS
00018      C      QHIN   = INFLOW DISCHARGE
00019      C      QHOUT  = OUTFLOW DISCHARGE
00020      C      QV     = VERTICAL DISCHARGE
00021      C      SD     = SEDIMENT DEPOSITION RATE, (KG/M**3/DAY)
00022      C      SR     = SEDIMENT EROSION RATE, (KG/M**3/DAY)
00023      C      OUTPUT PARAMETERS:
00024      C      ALFA   = DECAY TERM, (1/DAY)
00025      C      BETA   = SOURCE OR SINK TERM, (KG/M**3/DAY)
00026      C      BETA1  = INFLUENT SOURCE TERM FOR THE I-TH NODE, (KG/M**3/DAY)
00027      C      BETA2  = INFLUENT SOURCE TERM FOR THE I+1-TH NODE, (KG/M**3/D
00028      C      VEL1   = FIRST CONVECTIVE TERM, (M/DAY)
00029      C      VEL2   = SECOND CONVECTIVE TERM, (M/DAY)
00030      C
00031      C      CALLED BY TRANSP.
00032      C
00033      C      INCLUDE 'ELMSIZ.PHM'
00034      C
00035      C      DIMENSION ABAR(MXELEM), AREA(MXELEM), CCIN(MXELEM,MAXCON),
00036      1      QHIN(MXELEM), QHOUT(MXELEM), QV(MXELEM), SD(MXELEM,6),
00037      2      SR(6), VSET(3), HWID(MXELEM), AWID(MXELEM)
00038      C
00039      C      CONVECTIVE TERM WITH CORRECTION FOR A CONTINUOUS SETTLING FLUX
00040      C
00041      C      AQ = QV(I)
00042      C      VEL1=(AQ-VSET(J)*HWID(I)*ALEN)/ABAR(I)
00043      C
00044      C      AQ = QV(I+1)
00045      C      VEL2=(AQ-VSET(J)*HWID(I+1)*ALEN)/ABAR(I)
00046      C
00047      C      DECAY TERM
00048      C
00049      C      ALFA = QHOUT(I) / (ABAR(I) * DELZ)
00050      C
00051      C      SOURCE OR SINK TERM
00052      C
00053      C      BETA=SR(J) - SD(I,J)

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00054      BETA1#WHIN(I)/(ABAR(I)*DELZ)*(CCIN(I,J)/3.+CCIN(I+1,J)/6.)
00055      BETA2#WHIN(I)/(ABAR(I)*DELZ)*(CCIN(I,J)/6.+CCIN(I+1,J)/3.)
00056      RETURN
00057      END
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(FLECS VERSION 22,46)

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00001 C (106,1)SERATRA,FLX
00002 C*****
00003 C VERSION: DRIED CHANNEL OPTION
00004 C WITH SELECTION FOR IMPLICIT SETTLING VELOCITY SCHEME
00005 C OR SUPERPOSITION OF SETTLING VELOCITY SCHEME
00006 C*****
00007 C
00008 C
00009 C THIS COMPUTER PROGRAM, SERATRA, IS AN UNSTEADY, TWO=
00010 C DIMENSIONAL (LONGITUDINAL AND VERTICAL) MODEL TO SIMULATE
00011 C SEDIMENT-CONTAMINANT TRANSPORT IN RIVERS AND RIVER=RUN
00012 C RESERVOIRS.
00013 C
00014 C THE MODEL HAS GENERAL CONVECTION-DIFFUSION EQUATIONS
00015 C WITH DECAY AND SINK/SOURCE TERMS WITH APPROPRIATE BOUNDARY
00016 C CONDITIONS.
00017 C
00018 C SERATRA UTILIZES THE FINITE ELEMENT COMPUTATION METHOD WITH
00019 C THE GALERKIN WEIGHTED RESIDUAL TECHNIQUE.
00020 C
00021 C THE FOLLOWING REPORTS DESCRIBE SERATRA MODEL FORMULATION, USER'S
00022 C MANUAL AND SOME MODEL RESULTS:
00023 C
00024 C**
00025 C 1 ONISHI, Y., P.A. JOHANSON, R.G. BACA, AND E.L. HILTY, 1976.
00026 C "STUDIES OF COLUMBIA RIVER WATER QUALITY--DEVELOPMENT OF
00027 C MATHEMATICAL MODELS FOR SEDIMENT AND RADIONUCLIDE TRANSPORT
00028 C ANALYSIS." BNWL-B-452, BATTELLE, PACIFIC NORTHWEST
00029 C LABORATORIES, RICHLAND, WA.
00030 C**
00031 C 2 ONISHI, Y. 1977. "FINITE ELEMENT MODELS FOR SEDIMENT AND CONTAMINANT
00032 C TRANSPORT IN SURFACE WATERS--TRANSPORT OF SEDIMENT AND RADIONUCLIDES
00033 C IN THE CLINCH RIVER." BNWL-2227, BATTELLE, PACIFIC NORTHWEST
00034 C LABORATORIES, RICHLAND, WA.
00035 C**
00036 C 3 ONISHI, Y. 1977. "MATHEMATICAL SIMULATION OF SEDIMENT AND RADIO=
00037 C NUCLIDE TRANSPORT IN THE COLUMBIA RIVER." BNWL-2228, BATTELLE,
00038 C PACIFIC NORTHWEST LABORATORIES, RICHLAND, WA.
00039 C**
00040 C 4 ONISHI, Y., D.L. SCHREIBER AND R.B. CODELL, 1979. "MATHEMATICAL
00041 C SIMULATION OF SEDIMENT AND RADIONUCLIDE TRANSPORT IN THE CLINCH
00042 C RIVER, TENNESSEE," PROCEEDINGS OF ACS/CSJ CHEMICAL CONGRESS,
00043 C HONOLULU, HAWAII, APRIL 1-6, 1979. "CONTAMINANTS AND SEDIMENTS",
00044 C H.A. HAKER (ED.), ANN ARBOR SCIENCE PUBLISHERS, INC., ANN ARBOR, MI.
00045 C**
00046 C 5 ONISHI, Y., B.H. BROWN, A.R. OLSEN, M.A. PARKHURST, S.E. WISE, AND
00047 C W.H. WALTERS, 1979. "METHODOLOGY FOR OVERLAND AND INSTREAM MIGRATION
00048 C AND RISK ASSESSMENT OF PESTICIDES," BATTELLE, PACIFIC NORTHWEST
00049 C LABORATORIES, RICHLAND, WA.
00050 C**
00051 C 6 ONISHI, Y. AND S.E. WISE, 1979. "MATHEMATICAL MODEL, SERATRA, FOR
00052 C SEDIMENT AND CONTAMINANT TRANSPORT IN RIVERS AND ITS APPLICATION TO
00053 C PESTICIDE TRANSPORT IN FOUR MILE AND WOLF CREEKS IN IOWA." BATTELLE,

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00054 C PACIFIC NORTHWEST LABORATORIES, RICHLAND, WA,
00055 C**
00056 C 7 ONISHI, Y. AND S.E. WISE, 1979, "USER'S MANUAL FOR THE INSTREAM
00057 C SEDIMENT-CONTAMINANT TRANSPORT MODEL, BERATHA," BATTELLE, PACIFIC
00058 C NORTHWEST LABORATORIES, RICHLAND, WA,
00059 C
00060 C
00061 C CALLS: BEDDAT, COLAPS, DIMDAT, FCODE, HYDDAT, HYDFLU, ICFLO, INIDAT,
00062 C POSFLO, RPTERR, SAVEIT, SENDAT, STRTUP, TRANSP, TRBDAT,
00063 C TRHFLO, UPBDAT, WTRDAT, PHOINP
00064 C
00065 C INCLUDE 'ELMSIZ.PRM'
00066 C
00067 C BYTE FNAME(29), HASE(5), FTYPE(3), DEV(3), GUIC(3), UUI(3),
00068 C 1 HLOERR(100), NOW(8)
00069 C
00070 C LOGICAL*1 ECHO, ANALYS, NENTRB, NENIC, FERROR, NEWQI, RIVER,
00071 C 1 ECHO2, ECHO3, ECHO4, ECHO5, ECHO6, ECHO7, ECHO8, ECHO9, ECHO10,
00072 C 2 SAVECH
00073 C
00074 C INTEGER*2 OUTFLD, TRBPT
00075 C
00076 C INTEGER*4 ETIME, ENDHYD, ENDIC, ENDTRB, SIMLEN, DUM2,
00077 C 1 NSTEPS, NXED, NFRST, DUM1, NSP, SECYR, JULSEC
00078 C
00079 C
00080 C DIMENSION AWID(MXELEM), CLAST(MXELEM, MAXCON), CTRB(MXELEM, MAXCON),
00081 C 1 PTQAVG(MXELEM), ELMVUL(MXELEM),
00082 C 2 QAVG(MXELEM), CTRIB(MAXCON), PCDEF(4), CNODE(MXELEM, MAXCON),
00083 C 3 EL(MXELEM), XSAREA(MXELEM), BWIU(MXELEM), TRASS(MAXCON),
00084 C 4 IELM(MXELEM), UNID(MXELEM), UEL(MXELEM), ABAR(MXELEM), PHID(MXELEM),
00085 C 5 PXSAR(MXELEM), OLDC(MXELEM, MAXCON), COUNMY(MXELEM),
00086 C 6 TBED(MAXCON), JSEG(5), SAVECH(10)
00087 C
00088 C INCLUDE 'TRANS.COM'
00089 C
00090 C DATA SECDAY/86400./
00091 C DATA SECYR /31536000/
00092 C DATA ECHO/.FALSE./
00093 C DATA FERROR/.FALSE./
00094 C DATA ZERO/1.0E-10/
00095 C DATA SAVECH/.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE./
00096 C 1.,.FALSE.,.FALSE.,.FALSE./
00097 C
00098 C I81=1
00099 C I82=0
00100 C CALL STRTUP(RASE, DEV, ECHO, FNAME, FTYPE, GUIC, INFLU, IBRT,
00101 C 1 NFRGT, OUTFLO, SMETH, UUI, SAVECH, JSEG,
00102 C 2 NSTEPS, ISEG, ITPRI, ANALYS, DELTH, ANALMT, DEPTH, SIMLEN,
00103 C 3 PELEV)
00104 C
00105 C *** READ INPUT DATA FOR BEGINNING SEGMENT ***
00106 C NUMERR = 0
00107 C
00108 C THIS IS THE RESTANT OPTION.
00109 C

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00110      WHEN(ISTRT,NE,1)DELTD=DELTH/SECDAY
00111      C
00112      ELSE
00113      . CALL INIDAT(ANALMT, ANALYS, DELTH, ECHO, HLDERR, IIPRT,
00114      1.      NSEG, NSTEPS, NUMERR, SIMLEN, DEPMIN)
00115      . DELTD=DELTH/SECDAY
00116      . IF(ECHO)
00117      . . CALL TIME(NOW)
00118      . . WRITE(6,3) ISTRT, NOW
00119      . ...FIN
00120      . CALL DIMDAT(ALEN, AREA, BOIV, BED, DLZSAV, ECHO, ELEV, HLDERR,
00121      1.      ISTRT, NRED, NELEM, NUMERR, PELEV, POR, RIVER,
00122      2.      XY80, ZL)
00123      . CALL SEDDAT(DECAY, DENS, DFZ, DIAM, DSHR, D50, ECHO, ERODE,
00124      1.      HLDERR, NUMERR, SCSHR, SORBK, VSET, DRORB)
00125      . CALL PHOINP(ECHO, JULIAN, KAY1, KAY2, PCOEF)
00126      . CALL BEDDAT(B, ECHO, NBED, AREA, BOIV, DENS, POR, XY80, TBED)
00127      C
00128      C . READS INITIAL CONDITIONS FOR SEDIMENT AND CUNTAMINANT
00129      C
00130      . CALL WTRDAT(C, ECHO, NELEM)
00131      C
00132      C . READS UPSTREAM BOUNDARY CONDITIONS FOR FIRST SEGMENT
00133      C
00134      . CALL UPSDAT(ECHO, HLDERR, NUMERR, SIMLEN, UNID, UEL)
00135      . CALL TRBDAT(ECHO, HLDERR, NELEM, NTRIBS, NUMERR,
00136      1.      SIMLEN, TRRUPT)
00137      . CALL HYDDAT(ALEN, AREA, DELTH, DELZ, D50, ECHO, HLDERR, NBETS,
00138      1.      NUMERR, SIMLEN, DEPMIN, DLZSAV, EL)
00139      C
00140      . IF (NUMERR .GT. 0)
00141      . . CALL RPTERR(NUMERR, HLDERR, FERROR)
00142      . . IF (FERROR) REPORT=FATAL-ERROR=AND=STOP
00143      . ...FIN
00144      C
00145      . ...FIN
00146      C
00147      IF (ANALYS)
00148      . OPEN(UNIT#8, NAME='SY:TIMSERIES.DAT', TYPE='NEW',
00149      1.      FURM='UNFORMATTED')
00150      . ...FIN
00151      C*****
00152      C SEGMENT LOOP *
00153      C*****
00154      DO (ISEG=1STRT, NSEG)
00155      . CALL DIAG(ECHO2, ECHO3, ECHO4, ECHO5, ECHO6, ECHO7, ECHO8,
00156      1.      ECHO9, ECHO10, ISEG, JSEG, SAVECH)
00157      3 . FORMAT('1', 10X, 'SEGMENT NO.', I3, 1X, 8A1)
00158      . RESET=DATA=TIME=CONTROLS
00159      . CAVGMX=0.0
00160      . JULSEC = JULIAN * SECDAY
00161      C
00162      . UNLESS (ISEG .EQ. 1)
00163      . . IF (ECHO)
00164      . . . CALL TIME(NOW)
00165      . . . WRITE (6,3) ISEG, NOW

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00166      . . . . .FIN
00167      . . . . .FERROR = .FALSE.
00168      . . . . .NUMERR = 0
00169      . . . . .CALL DIMDAT(ALEN, AREA, HDIV, BED, DLZSAV, ECHO, ELEV, HLDERR,
00170      1. . . . .ISEG, NBED, NELEM, NUMERR, PELEV, POR, RIVER,
00171      2. . . . .XY80, EL)
00172      . . . . .CALL SEDDAT(DECAY, DENS, DFZ, DIAM, DBHR, D50, ECHO, ERUDE,
00173      1. . . . .HLDERR, NUMERR, SCSHR, SORBK, VSET, DSORB)
00174      . . . . .CALL HEDDAT(H, ECHO, NBED, AREA, BDIV, DENS, POR, XY80, TBEU)
00175      C      . . . . .
00176      C      . . . . .READS INITIAL CONDITIONS FOR SEDIMENT AND CONTAMINANT
00177      C      . . . . .
00178      . . . . .CALL WTRDAT(C, ECHO, NELEM)
00179      . . . . .CALL TRRDAT(ECHO, HLDERR, NELEM, NTRIBS, NUMERR,
00180      1. . . . .SIMLEN, TRBOPT)
00181      . . . . .CALL HYDDAT(ALEN, AREA, DELTH, DELZ, D50, ECHO, HLDERR, NBETR.
00182      1. . . . .NUMERR, SIMLEN, DEPHIN, DLZSAV, EL)
00183      C      . . . . .
00184      . . . . .IF (NUMERR .GT. 0)
00185      . . . . .CALL RPTERR(NUMERR, HLDERR, FERROR)
00186      . . . . .IF (FERROR) REPORT=FATAL=ERROR=AND=STOP
00187      . . . . .FIN
00188      . . . . .FIN
00189      . . . . .REBELN=ELEV+BED
00190      C      . . . . .
00191      C      . . . . .*** READ THE HYDROLOGICAL DATA ***
00192      . . . . .READ(4) DUM1, NELEM, DELZ, Q1, Q0, VOL, VEL, AWID, AREA, TEMPR, XSAREA, IELM,
00193      1. . . . .DEPTH, BWID, ABAR, HRAU, CRUSEC
00194      . . . . .REWIND 4
00195      C      . . . . .
00196      C      . . . . .PROCESSING OF INITIAL DATA
00197      C      . . . . .
00198      . . . . .IF (NELEM .GT. 0)
00199      . . . . .DO (K=1, MAXCUN)
00200      C      . . . . .*** NELEM VALUES OF CLAST MUST BE CALCULATED FROM NELEM+1
00201      C      . . . . .VALUES OF C ***
00202      . . . . .IF (K .LE. 3 .OR. K .EQ. 7)
00203      C      . . . . .
00204      C      . . . . .PROVIDES A CONSISTENT INITIAL CONDITION FOR THE DELZ DEFINED
00205      C      . . . . .IN HYDDAT = BOTH NODAL VALUES (CNODE=C), AND ELEMENT
00206      C      . . . . .AVERAGES (CLAST=COLD)
00207      C      . . . . .
00208      . . . . .CALL COLLAP(ALEN, AREA, C, DELZ, EL, IELM, K, NELEM, CLAST, THASS, AWID,
00209      1. . . . .VSET, DFZ, CNODE, XSAREA)
00210      . . . . .FIN
00211      . . . . .FIN
00212      C      . . . . .
00213      C      . . . . .DIAGNOSTIC WRITES
00214      C      . . . . .
00215      . . . . .IF (ECHO)
00216      . . . . .WRITE(6, 1500)
00217      . . . . .WRITE(6, 1510)
00218      . . . . .WRITE(6, 1520) (I, AREA(I), EL(I), ABAR(I), AWID(I), BWID(I),
00219      1. . . . .XSAREA(I), THASS(I), I=1, NELEM+1)
00220      . . . . .WRITE(6, 1530)
00221      . . . . .WRITE(6, 1520) (I, (C(I, J), J=1, MAXCUN), I=1, MXELEM)

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00222      . . . WRITE(6,1540)
00223      . . . WRITE(6,1520) (I,(CNODE(I,J),J=1,MAXCON),I=1,NELEM+1)
00224      . . . WRITE(6,1550)
00225      . . . WRITE(6,1520) (I,(CLAST(I,J),J=1,MAXCON),I=1,NELEM)
00226  1500 . . . FORMAT('IMMEDIATELY FOLLOWING COLLAP, THE INITIAL CONDITION')
00227  1510 . . . FORMAT('ELEMENT/NODE',5X,'AREA',10X,'EL',12X,'ABAR',
00228      1. . . . . 11X,'AWID',11X,'BWID',10X,'XSAREA',10X,'THASS')
00229  1520 . . . FORMAT(2X,15,3X,1P7E15,4)
00230  1530 . . . FORMAT('NODAL CONCENTRATIONS PRIOR TO COLLAP')
00231  1540 . . . FORMAT('NODAL CONCENTRATIONS FOLLOWING COLLAP')
00232  1550 . . . FORMAT('ELEMENT AVERAGE CONCENTRATION FOLLOWING COLLAP')
00233      . . . FIN
00234      . . . DO (I=1,NELEM)
00235      . . . . DO (J=1,MAXCON)
00236      . . . . . COLD(I,J)=CLAST(I,J)
00237      . . . . . C(I,J)=CNODE(I,J)
00238      . . . . FIN
00239      . . . FIN
00240      . . . DO (J=1,MAXCON) C(NELEM+1,J)=CNODE(NELEM+1,J)
00241      . . . DO (J=1,MAXCON) COLD(NELEM+1,J)=0.0
00242      . . . IF(NELEM+1.LT.MXELEM)
00243      . . . . DO (I=NELEM+2,MXELEM)
00244      . . . . . DO (J=1,MAXCON)
00245      . . . . . . COLD(I,J) = 0.0
00246      . . . . . . C(I,J) = 0.0
00247      . . . . . FIN
00248      . . . . FIN
00249      . . . FIN
00250      . . . FIN
00251      . . . CALL FCODE(FNAME, BASE, ISEG, FTYPE, DEV, GUIC, UUIC)
00252      . . . OPEN(UNIT=5,NAME=FNAME,TYPE='NEW',FORM='UNFORMATTED')
00253      . . . OPEN(UNIT=9,NAME='HSTRT.FIL',TYPE='NEW',FORM='UNFORMATTED')
00254      . . . WRITE(5) ISEG
00255  C
00256  C      . . . *** CONVERT INPUT VALUES TO THOSE UNITS USED BY MODEL ***
00257      . . . DO (J=1,3) VSET(J)=VSET(J) * SECDAY
00258      . . . DO (J=1,4) DFZ(J)=DFZ(J) * SECDAY
00259      . . . DO (I=1,6) DECAY(I) = DECAY(I) * SECDAY
00260      . . . DO (I=4,9) SORHK(I) = SORHK(I) * SECDAY
00261      . . . DO (I=4,9) DSURB(I) = DSURB(I) * SECDAY
00262  C*****
00263  C      . . . TIME STEP LOOP *
00264  C*****
00265  C
00266      . . . NXEQ = NFRST
00267      . . . IF (NXEQ.EQ.1)
00268      . . . . PTDPTH = DEPTH
00269      . . . . PDELZ = DELZ
00270      . . . . NELMPT = NELEM
00271      . . . . FIN
00272      . . . ETIME = NXEQ = 1
00273      . . . ETIME = ETIME + DELTH
00274      . . . UNTIL (NXEQ.GT. NSTEPS)
00275      . . . . IF (IS1.EQ.1) WRITE(11,4) ISEG,NXEQ
00276  4      . . . . FORMAT(' SEGMENT #',I3,' TIME STEP',I10)
00277      . . . . ETIME = ETIME + DELTH

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00278 C      . .  *** UPDATE THE FLOW AND CONCENTRATION ARRAYS ***
00279      . .  CALL HYDFLO(ALEN, AREA, AWID, DELZ, DEPTH, D50, ELEV,
00280      1. . .  ENDHYD, ETIME, FERROR, HRAD, NELEM, NEWQI, PELEV,
00281      2. . .  QHIN, QHOUT, QV, RIVER, SLOPE, STRESS, TEMPR,
00282      3. . .  VEL, VOL, DEPMIN, XSAEA, BWID, ABAR, QI, CRUBEC,
00283      4. . .  QO, IELM)
00284 C      . .
00285      . .  IF (FERROR) REPORT=FATAL-ERROR-AND-STOP
00286      . .  IF (NTRIBS .GT. 0)
00287      . .  . CALL TRBFLO(CTRB, CTRIR, ENDRH, ETIME, FERROR, DEPTH, NELEM,
00288      1. . .  . NEWQI, NENTRH, QHIN, TRBOPY, DEPMIN)
00289      . .  . IF(ECHO3)
00290      . .  . . WRITE(6,1100)
00291      1100 . .  . . FURMAT('AFTER TRBFLO, MASS FLUX VALUES OF CTRB')
00292      . .  . . WRITE(6,1110)
00293      1110 . .  . . FURMAT('ELEMENT NO.,',2X,3(3X,'CONC. OF',4X),3(1X,'CONC.',
00294      1. . .  . 'ASSOC.',2X),2X,'CONTAMINANT'/13X,'SUSPENDED SAND',1X,
00295      2. . .  . 'SUSPENDED SILT',1X,'SUSPENDED CLAY',3X,'WITH SAND',6X,
00296      3. . .  . 'WITH SILT',6X,'WITH CLAY',4X,'DISSOLVED CONC.')

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00334 1580 . . . FORMAT('ELEMENT AVERAGE CONCENTRATIONS PRIOR TO RDSFLO')
00335 . . . ...FIN
00336 . . . IF (DEPTH .GT. DEPMIN)
00337 . . . . T = ABS(PTDPTH/DEPTH-1.)
00338 . . . . IF (NXEQ .GT. 1 .AND. T .GT. ZERO)
00339 . . . . . CALL RDSFLO(ALEN, AREA, AWID, C, DELZ, DFZ, NELEM, NEMPT,
00340 1. . . . . PTDDELZ, PWID, PXSAR, VSET, XSAREA)
00341 . . . . . DO(J=1, MAXCON)
00342 . . . . . . DO(K=1, NELEM)
00343 . . . . . . . CULD(I, J) = (C(I, J) + C(I+1, J)) / 2.
00344 . . . . . . . ...FIN
00345 . . . . . . ...FIN
00346 . . . . . IF (ECHO6)
00347 . . . . . . WRITE(6, 1590)
00348 . . . . . . WRITE(6, 1010)
00349 . . . . . . WRITE(6, 1020) (J, (C(J, K), K=1, MAXCON), J=1, NELEM+1)
00350 . . . . . . WRITE(6, 1600)
00351 . . . . . . WRITE(6, 1110)
00352 . . . . . . WRITE(6, 1020) (J, (CULD(J, K), K=1, MAXCON), J=1, NELEM)
00353 1590 . . . . . FORMAT('MODAL CONCENTRATIONS FOLLOWING RDSFLO')
00354 1600 . . . . . FORMAT('ELEMENT AVERAGE CONCENTRATIONS FOLLOWING RDSFLO')
00355 . . . . . ...FIN
00356 . . . . . ...FIN
00357 . . . . . COMPUTE=BED=AND=WATER=SURFACE=ELEVATIONS
00358 . . . . . ...FIN
00359 C . . .
00360 C . . . *** AVERAGE THE INFLOW CONCENTRATIONS INTO THE SEGMENT BY TAKING
00361 C . . . INTO ACCOUNT THE THIRTY-3 INPUT.
00362 C . . .
00363 . . . IF (DEPTH .GT. DEPMIN)
00364 . . . . WHEN (NTRIBS .GT. 0)
00365 . . . . . IF (NENTRB .OR. NEWIC .OR. NEWQI)
00366 . . . . . . DO (K=1, MAXCON)
00367 . . . . . . . DO (J=1, NELEM+1)
00368 . . . . . . . . CDUMMY(J) = CCIN(J, K)
00369 . . . . . . . . ...FIN
00370 . . . . . . . DO (J=1, NELEM)
00371 . . . . . . . . CHASS = (CDUMMY(J) + CDUMMY(J+1)) / 2. * QHIN(J)
00372 . . . . . . . . CHASS = (CHASS + CTRB(J, K) * SECDAY) / QHIN(J)
00373 C . . . . .
00374 C . . . . . NOTE: CHASS IS IN (KG/M**3)
00375 C . . . . .
00376 . . . . . WHEN (J.EQ.1)
00377 . . . . . . WHEN (K.EQ.7)
00378 . . . . . . . CCIN(1, K) = CHASS
00379 . . . . . . . CCIN(2, K) = CHASS
00380 . . . . . . . ...FIN
00381 . . . . . . . ELSE
00382 . . . . . . . . KK=K
00383 . . . . . . . . IF (K.GT.3) KK=KK-3
00384 . . . . . . . . COEF=0.
00385 . . . . . . . . NS=VSET(KK)*AREA(1)/(AWID(1)*ALEN)
00386 . . . . . . . . EZ=DFZ(KK)
00387 . . . . . . . . CCIN(1, K) = (2.*CHASS-COEF*DELZ/EZ)/(2.-NS*DELZ/EZ)
00388 . . . . . . . . CCIN(2, K) = 2.*CHASS - CCIN(1, K)
00389 . . . . . . . . ...FIN

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00446      . . . . WRITE(6,1720) (I,AREA(I),ABAR(I),AWID(I),BWID(I),QV(I),QHIN(I),
00447      1. . . . QHOUT(I),I=1,NELEM+1)
00448      1700 . . . . FORMAT('GEOOMETRY AND DISCHARGE INFO PRIOR TO TRANSP')
00449      1710 . . . . FORMAT('ELEMENT/NODE',6X,'AREA',9X,'ABAR',11X,'AWID',11X,'BWID',
00450      1. . . . 12X,'QV',12X,'QHIN',11X,'QHOUT')
00451      1720 . . . . FORMAT(2X,15,3X,1P7E15,4)
00452      . . . . ...FIN
00453      C      . . . . WRITE(6,1111)NRED,NELEM,SMETH,FERROR,ECHO4,ECHO7,ECHO8,ECHO9,
00454      C      1 PCOEFF,DEPTH,CRUSEC,ALEN,BDIV,RED,DEPHIN,DELTH,DELZ,
00455      C      2 D50,HRAD,KAY1,KAY2,POR,SLOPE,STRESS,TEMPR,VOL,XYSO
00456      C      . . . . WRITE(6,2222)
00457      C      3 ((OLDC(M,N),C(M,N),CCIN(M,N),COLD(M,N),N=1,7),
00458      C      4 (R(M,N),N=1,6),BWID(M),AWID(M),ABAR(M),AREA(M),QHIN(M),
00459      C      5 QHOUT(M),QV(M),M=1,10), (DECAY(M),M=1,6), (SORHK(M),
00460      C      6 USORH(M),M=1,9), (DFZ(M),M=1,4), (DENS(M),DIAM(M),DBHR(M),
00461      C      7 ERODE(M),VSET(M),SCSHR(M),M=1,3)
00462      1111 . . . . FORMAT(5X'BEFORE TRANSP'2I3,A2,5L2/40(10E10,3/))
00463      2222 . . . . FORMAT(40(10E10,3/))
00464      . . . . CALL TRANSP(FERROR,PCOEFF,BWID,AWID,ABAR,DEPTH,OLDC,ECHO4,
00465      1. . . . CRUSEC,ECHO7, ECHO8, ECHO9)
00466      C      . . . . WRITE(6,1112)NRED,NELEM,SMETH,FERROR,ECHO4,ECHO7,ECHO8,ECHO9,
00467      C      1 PCOEFF,DEPTH,CRUSEC,ALEN,BDIV,RED,DEPHIN,DELTH,DELZ,
00468      C      2 D50,HRAD,KAY1,KAY2,POR,SLOPE,STRESS,TEMPR,VOL,XYSO
00469      C      . . . . WRITE(6,2222)
00470      C      3 ((OLDC(M,N),C(M,N),CCIN(M,N),COLD(M,N),N=1,7),
00471      C      4 (R(M,N),N=1,6),BWID(M),AWID(M),ABAR(M),AREA(M),QHIN(M),
00472      C      5 QHOUT(M),QV(M),M=1,10), (DECAY(M),M=1,6), (SORHK(M),
00473      C      6 USORH(M),M=1,9), (DFZ(M),M=1,4), (DENS(M),DIAM(M),DBHR(M),
00474      C      7 ERODE(M),VSET(M),SCSHR(M),M=1,3)
00475      1112 . . . . FORMAT(5X'AFTER TRANSP'2I3,A2,5L2/40(10E10,3/))
00476      . . . . IF(ECHO5)WRITE(6,2000)((C(I,J),J=1,MAXCON),I=1,NELEM+1)
00477      2000 . . . . FORMAT('AFTER TRANSP'/50(1X,1P7E15,5/))
00478      C      . . . .
00479      . . . . IF (FERROR) REPORT=FATAL=ERROR=AND=STOP
00480      C      . . . .
00481      . . . . COMPUTE=RED=AND=WATER=SURFACE=ELEVATIONS
00482      C      . . . .
00483      . . . . ...FIN
00484      C      . . . .
00485      C      . . . . *** SAVE THE RESULTS OF THIS TIME STEP. IT WILL BECOME INPUT TO
00486      C      . . . . THE NEXT SEGMENT ***
00487      . . . . WRITE(OUTFLO) DEPTH,DELZ,NELEM,(QHOUT(K),XSAREA(K),AWID(K),
00488      1. . . . K=1,NELEM),((C(L,K),K=1,MAXCON),L=1,NELEM+1),
00489      2. . . . ((OLDC(L,K),K=1,MAXCON),L=1,NELEM+1)
00490      C      . . . .
00491      . . . . WRITE(9) DEPTH,DELZ,NELEM,(QHOUT(K),XSAREA(K),AWID(K),
00492      1. . . . K=1,NELEM),((C(L,K),K=1,MAXCON),L=1,NELEM+1),
00493      2. . . . ((OLDC(L,K),K=1,MAXCON),L=1,NELEM+1)
00494      C      . . . .
00495      C      . . . .
00496      . . . . IF (ANALYS) SAVE=THE=RESULTS=FOR=TIME=SERIES=ANALYSIS
00497      C      . . . .
00498      . . . . IF (MOD(NXER,ITPNT) .EQ. 0)
00499      C      . . . . *** SAVE THE RESULTS FOR PRINTING AND OTHER POST PROCESSING ***
00500      . . . . CALL SAVEIT(R, BDIV, RED, ELEV, C, DELZ, NRED, NELEM,
00501      1. . . . NXEW, RESELN, STRESS, XYSO, OLDC,

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00502      2. . . ALEN,QHIN,QHOUT,CCIN,QV,AWID,BWID,VSET,DENS,DELTD,DFZ,
00503      3. . .     PGR,THED)
00504      . . . ...FIN
00505      C . . .
00506      . . . NELMPT#NELEM
00507      . . . PTOPTH#DEPTH
00508      . . . PTOELZ#DELZ
00509      . . . DO {I#1,NELEM)
00510      . . . . PXSAR(I)#XSAREA(I)
00511      . . . . PWID(I)#AWID(I)
00512      . . . ...FIN
00513      C . . .
00514      C . . . *** CHECK SENSE SWITCH #2 TO SEE IF THE RUN IS TO BE STOPPED ***
00515      . . . IF (IS2.E9.1)
00516      . . . . CLOSE=THE=OPEN=FILES
00517      . . . . OPEN(UNIT#1,NAME='TT1')
00518      . . . . WRITE(1,2) NXEQ,ISEQ
00519      2 . . . . FORMAT(/,21X,'***** SERATRA *****/
00520      1. . . . SX,'TERMINATED BY OPERATER AFTER TIME PLANE #',I10/
00521      2. . . . SX,'IN SEGMENT #',I5)
00522      . . . . STOP
00523      . . . ...FIN
00524      C . . . . . END OF TIME STEP LOOP
00525      . . . NXEQ = NXEQ + 1
00526      . . . ...FIN
00527      C . . . . . END OF SEGMENT LOOP
00528      . . . PELEV = ELEV
00529      . . . NFRST = 1
00530      . . . LUNTMP#INFLO
00531      . . . INFLO#OUTFLO
00532      . . . OUTFLO#LUNTMP
00533      . . . REWIND INFLO
00534      . . . REWIND OUTFLO
00535      . . . CLOSE(UNIT#5)
00536      . . . CLOSE(UNIT#9)
00537      . . . ...FIN
00538      . . . CLOSE=THE=OPEN=FILES
00539      . . . STOP
00540      C

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00541      TO COMPUTE=BED=AND=WATER=SURFACE=ELEVATIONS
00542      . . . HELEV = ELEV + BED
00543      . . . RESELN = DEPTH + BELEV
00544      . . . ...FIN

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-----
00545      TO CLOSE=THE=OPEN=FILES
00546      . . . CLOSE(UNIT#1)
00547      . . . CLOSE(UNIT#2)
00548      . . . CLOSE(UNIT#3)
00549      . . . CLOSE(UNIT#4)
00550      . . . CLOSE(UNIT#5)
00551      . . . CLUSE(UNIT#9)

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00552 . CLOSE(UNIT#6)
00553 . CLOSE(UNIT#7)
00554 . CLOSE(UNIT#8)
00555 ...FIN
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00556 TO REPORT=FATAL=ERROR=AND=STOP
00557 . CLOSE=THE=OPEN=FILES
00558 . OPEN (UNIT#1,NAME='TT;')
00559 . WRITE(,1)
00560 1 . FORMAT(/10X,'**** BERATRA == FATAL ERROR ****'/
00561 1. ' PRINT *SED,LST* FOR DETAILS')
00562 C . *** THE IF STATEMENT BELOW IS A CONCESSION TO THE COMPILER ***
00563 . IF(FERROR) STOP
00564 ...FIN
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00565 TO RESET=DATA=TIME=CONTROLS
00566 . ENDIC = 0
00567 . ENDDYD = 0
00568 . ENDRB = 0
00569 ...FIN
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00570 TO SAVE=THE=RESULTS=FOR=TIME=SERIES=ANALYSIS
00571 C .
00572 C . *** COMPUTE THE VOLUME OF EACH ELEMENT AND THE TOTAL VOLUME
00573 C . OF THE WATER COLUMN ***
00574 C .
00575 . AVOL=0.
00576 . DO (I=1,NELEM)
00577 . . ELMVOL(I) = DELZ*ABAR(I)
00578 . . AVOL=AVOL+ELMVOL(I)
00579 . ...FIN
00580 C .
00581 C . *** AVERAGE DISSOLVED (KG/M**3) ***
00582 . AVGDIS = 0.0
00583 . DU(I=1,NELEM)AVGDIS=AVGDIS+(C(I,7)+C(I+1,7))*ELMVOL(I)/2.
00584 . AVGDIS = AVGDIS / AVOL
00585 . IF (AVGDIS .GT. ANALMT)
00586 C .
00587 C . *** AVERAGE SEDIMENT (KG/M**3) ***
00588 . . AVGSED = 0.0
00589 . . DO(I=1,NELEM)
00590 . . . AVGSED=AVGSED+(C(I,1)+C(I+1,1)+C(I,2)+C(I+1,2)+
00591 1. . . C(I,3)+C(I+1,3))/2.
00592 . . ...FIN
00593 . . AVGSED = AVGSED / AVOL
00594 C .
00595 C . **** AVERAGE (PARTICULATE (PC/KG)*SEDIMENT(KG/M**3))
00596 . . PARPCH = 0.0
00597 . . DO (I=1,NELEM)
00598 . . . PARPCH = PARPCH +ELMVOL(I)*(C(I,4)+C(I,5)+C(I,6))
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00599      1. . . +C(I+1,4)+C(I+1,5)+C(I+1,6))/2.
00600      . . ...FIN
00601      . . PARPCM = PARPCM / AVOL
00602      C . .
00603      C . . *** AVERAGE PARTICULATE (PC/KG) ***
00604      . . PARPCK = PARPCM / AVGSEU
00605      C . .
00606      . . TOTKG = ( PARPCM + AVGDIS ) * AVOL
00607      C . .
00608      . . CAVGMX = MAX(CAVGMX, AVGDIS)
00609      . . TFLOW = 0.0
00610      . . DO (I=1,NELEM) TFLOW = TFLOW + PTQAVG(I)
00611      . . TFLUM = TFLOW / SECDAY
00612      . . WRITE(8) ISEG,NXEO,TFLOW,AVGSED,AVGDIS,PARPCM,PARPCK,TOTKG
00613      . . ...FIN
00614      ...FIN
00615      C
00616      END

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PROCEDURE CROSS-REFERENCE TABLE

- 00565 RESET=DATA=TIME=CONTROLS  
00158
- 00570 SAVE=THE=RESULTS=FOR=TIME=SERIES=ANALYSIS  
00496
- 00545 CLOSE=THE=OPEN=FILES  
00516 00538 00557
- 00541 COMPUTE=BED=AND=WATER=SURFACE=ELEVATIONS  
00357 00481
- 00556 REPORT=FATAL=ERROR=AND=STOP  
00142 00186 00285 00299 00319 00479

(FLECS VERSION 22,46)

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00001 SUBROUTINE SETUP(I1, DD, P, S, R, VEL, NELEM,ECHO4,WIDTH)
00002 C
00003 C THIS SUBROUTINE SETS UP THE FINITE ELEMENT MATRICES
00004 C
00005 C CALLED BY TRANSP.
00006 C
00007 LOGICAL*1 ECHO4
00008 REAL*8 SEL,P,H,S
00009 INCLUDE 'SY,ELMSIZ,PRM'
00010 C
00011 DIMENSION DD(10), P(MXELEM,3), PEL(2,2), R(MXELEM), S(MXELEM,3),
00012 1 SEL(2,2)
00013 C
00014 C
00015 PEL(1,1) = 1./3.
00016 PEL(1,2) = 1./6.
00017 PEL(2,1) = 1./6.
00018 PEL(2,2) = 1./3.
00019 SEL(1,1) = DD(1) + DD(3) + DD(7)/3.
00020 SEL(1,2) = -DD(1) + DD(4) + DD(7)/6.
00021 SEL(2,1) = -DD(1) - DD(5) + DD(7)/6.
00022 SEL(2,2) = DD(1) + DD(6) + DD(7)/3.
00023 IF(I1.EQ.1) SEL(1,1) = SEL(1,1) + VEL
00024 IF(I1.EQ.NELEM) SEL(2,2) = SEL(2,2) + VEL
00025 C
00026 DO (I=1,2)
00027 . DO (J=1,2)
00028 . . PEL(I,J) = PEL(I,J) * WIDTH
00029 . . SEL(I,J) = SEL(I,J) * WIDTH
00030 . ...FIN
00031 ...FIN
00032 DO (I=8,10,1) DD(I) = DD(I) * WIDTH
00033 DD2 = DD(8)/2.0
00034 DO (J=1,2)
00035 . NR = I + J - 1
00036 . DO (K=1,2)
00037 . . MC = 2 + (I + K - 1) * NR
00038 . . P(NR,MC) = P(NR,MC) + PEL(J,K)
00039 . . S(NR,MC) = S(NR,MC) + SEL(J,K)
00040 . ...FIN
00041 . R(NR) = R(NR) + DD2 + DD(8+J)
00042 ...FIN
00043 IF (ECHO4)
00044 . WRITE(6,999)
00045 999 . FORMAT(' *****IN SETUP')
00046 . WRITE(6,1000)(I,(SEL(I,J),J=1,2),I=1,2)
00047 . WRITE(6,1100)
00048 . WRITE(6,1200)(I,(P(I,J),J=1,3),(S(I,J),J=1,3),R(I),I=1,NELEM+1)
00049 1000 . FORMAT(' SEL(I,J), I=1,2,1X, J=1,2 ',5X,1P2E14.4)
00050 1100 . FORMAT(' 0NODE',7X,'P(I,1)',10X,'P(I,2)',10X,'P(I,3)',10X,
00051 1. 'S(I,1)',10X,'S(I,2)',10X,'S(I,3)',10X,'R(1)')
00052 1200 . FORMAT(1X,I3,1P7E16.5)
00053 ...FIN

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00054 RETURN  
00055 END

(FLECS VERSION 22,46)

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00001      SUBROUTINE SHEARR(DEPTH, D50, STRESS, USTAR, VEL)  
00002      C  
00003      C THIS SUBROUTINE CALCULATES BED SHEAR STRESS AND SHEAR VELOCITY FOR  
00004      C A SEDIMENT LADEN FLOW. METHOD IS APPLICABLE FOR RESERVOIRS.  
00005      C REF. HYDRAULICS OF SEDIMENT TRANSPORT BY W.H. GRAP. EQ 8.49  
00006      C  
00007      C FORMAL PARAMETERS:  
00008      C   DEPTH = FLOW DEPTH (METERS)  
00009      C   D50  = MEDIAN BED SEDIMENT DIAMETER (METERS)  
00010      C   STRESS = BED SHEAR STRESS (KG/M**2)  
00011      C   USTAR = SHEAR VELOCITY (M/SEC)  
00012      C   VEL  = AVERAGE VELOCITY (M/SEC)  
00013      C  
00014      C CALLED BY: HYDFLO, ICFL0  
00015      C  
00016      C RHO = WATER DENSITY (KG(FORCE)/M**3)  
00017      C   DATA RHO /1000./  
00018      C  
00019      C AKAPPA = KARMAN CONSTANT  
00020      C   DATA AKAPPA /0.4/  
00021      C  
00022      C   USTAR=VEL/(17.56+(ALOG10(DEPTH/(96.5*D50)))*2.3/AKAPPA)  
00023      C   STRESS=RHO*USTAR**2.0/9.8  
00024      C   RETURN  
00025      C   END
```

(FLECS VERSION 22.46)

```
-----
```

```
-----  
00001      SUBROUTINE SHEARS(ALEN,ELEV, HRAD, PELEV,SLOPE,STRESS,USTAR)  
00002      C  
00003      C THIS METHOD OF COMPUTING BED SHEAR STRESS AND SHEAR VELOCITY  
00004      C IS APPLICABLE TO RIVERS AND STREAMS.  
00005      C  
00006      C FORMAL PARAMETERS:  
00007      C ALEN = SEGMENT LENGTH  
00008      C ELEV = ELEVATION OF THE CURRENT SEGMENT  
00009      C HRAD = HYDRAULIC RADIUS OF THE SEGMENT  
00010      C PELEV = ELEVATION OF THE PREVIOUS SEGMENT  
00011      C SLOPE = BED SLOPE  
00012      C STRESS = BED SHEAR STRESS  
00013      C USTAR = SHEAR VELOCITY  
00014      C  
00015      C CALLED BY HYDFLO  
00016      C  
00017      C G = GRAVITY (M/S**2)  
00018      C RHO = DENSITY OF WATER (KG(FORCE)/M**3)  
00019      C DATA RHO/1000./  
00020      C DATA G/9.801/  
00021      C SLOPE = (PELEV - ELEV) / ALEN  
00022      C STRESS = SLOPE * RHO * HRAD  
00023      C USTAR = SQRT(G * SLOPE * HRAD)  
00024      C  
00025      C RETURN  
00026      C END
```

(FLECS VERSION 22,46)

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-----
00001      SUBROUTINE SILCLA(ABAR, B, BDIY, CCIN, DELTD, DELZ, DEPTH,
00002      1          DENS, DSHR, ERODE, HRAO, J1, NBED, COLD,
00003      2          NELEM, POR, QHIN, QHOUT, SCSHR, STRESS, VSET,
00004      3          XYSD, DEPO, ILAYR, SD, SR, XNT,
00005      4          CROSEC, B*ID, ALEN, ECHO7, SCOUR)
00006      C
00007      C      THIS SUBROUTINE COMPUTES THE RATE AND SOURCE TERMS FOR THE
00008      C      TRANSPORT OF SILT (J1=2) AND CLAY (J1=3)
00009      C
00010      C      INPUT PARAMETERS:
00011      C      ABAR = AVERAGE AREA
00012      C      B = BED CONDITIONS
00013      C      BDIY = STANDARD BED LAYER THICKNESS
00014      C      C = WATER CONDITIONS
00015      C      CCIN = CONCENTRATION OF INFLOW
00016      C      DELTD = TIME STEP (DAYS)
00017      C      DELZ = STANDARD ELEMENT THICKNESS
00018      C      DENS = DENSITY
00019      C      DEPTH = DEPTH OF FLOW
00020      C      DSHR = CRITICAL SHEAR STRESS FOR DEPOSITION
00021      C      ERODE = ERODABILITY, (KG/M**2/SEC)
00022      C      HRAO = HYDRAULIC RADIUS
00023      C      J1 = #1; SILT #2; CLAY
00024      C      NBED = NUMBER OF BED LAYERS
00025      C      NELEM = NUMBER OF ELEMENTS
00026      C      POR = POROSITY
00027      C      QHIN = INFLOW DISCHARGE
00028      C      QHOUT = OUTFLOW DISCHARGE
00029      C      SCSHR = CRITICAL SHEAR STRESS FOR SCOUR
00030      C      STRESS = BED SHEAR STRESS
00031      C      VSET = PARTICLE SETTLING VELOCITY
00032      C      XYSD = THICKNESS OF TOP BED LAYER
00033      C      OUTPUT PARAMETERS:
00034      C      ILAYR = NO. OF BED LAYERS AFFECTED BY DEPOSITION AND EROSION
00035      C      SD = DEPOSITION RATE, (KG(PC)/M**3/DAY)
00036      C      SR = EROSION RATE, (KG(PC)/M**3/DAY)
00037      C      XNT = WEIGHT OF TOP BED SEDIMENT LAYER, (KG/M**2)
00038      C      DEPO = BED DEPOSITION RATE (KG(PC)/M2/DAY)
00039      C      SCOUR = BED SCOUR RATE (KG(PC)/M2/DAY)
00040      C
00041      C      CALLED BY: TRANSP
00042      C      CALLS: DEPCAL
00043      C
00044      C      INCLUDE 'ELMSIZ.PRM'
00045      C
00046      C      REAL K4FUNC,K7,INFRAC
00047      C      LOGICAL*1 ECHO7
00048      C
00049      C      DIMENSION ABAR(MXELEM), B(MAXLEV,MAXCON-1),COLD(MXELEM,MAXLON),
00050      1          DENS(3), DSHR(3), ERODE(3), ILAYR(3),
00051      2          QHIN(MXELEM), QHOUT(MXELEM), SCSHR(3),
00052      3          SD(MXELEM,6), SR(6), VSET(3), XNT(3),
00053      4          CCIN(MXELEM,MAXCON), H*ID(MXELEM), DEPO(6), SCOUR(6)

```

```

00054 DATA SECDAY/86400./
00055 C
00056 J2=J1+3
00057 XNT(J1)=0.
00058 IF (NBED,LT,0)
00059 . XDTOP=(1.0-POR)/(B(NBED,1)/DENS(1)+B(NBED,2)/DENS(2) +
00060 1. R(NBED,3)/DENS(3))
00061 . XNT(J1) = XDTOP * B(NBED,J1) * XY80
00062 ...FIN
00063 DEPO(J1) = 0.0
00064 DEPO(J2) = 0.0
00065 SR(J1) = 0.0
00066 SR(J2) = 0.0
00067 SCOUR(J1) = 0.0
00068 SCOUR(J2) = 0.0
00069 RS = 0.0
00070 CS = 0.0
00071 VOLUME = CROSEC * ALEN
00072 DO (IX = 1,NELEM)
00073 . SD(IX,J1) = 0.0
00074 . SD(IX,J2) = 0.0
00075 ...FIN
00076 ILAYR(J1) = 0
00077 IF(ECHU7)
00078 . IF (STRESS .LT. DBHR(J1))
00079 C
00080 C SEDIMENT DEPOSITION
00081 C
00082 . . ILAYR(J1) = -1
00083 . . AVGC = 0.0
00084 . . TOTQ = 0.0
00085 . . DO (IX = 1,NELEM)
00086 C
00087 . . . IT IS IMPLICITLY ASSUMED THAT A DOWNSTREAM COURANT NUMBER
00088 C . . . AT OR NEAR UNITY IS EMPLOYED IN THIS ANALYSIS
00089 C
00090 . . . INFRAC=0.5*QHIN(IX)*DELTO/ABAR(IX)/DELZ
00091 . . . EXFRAC=1.0-INFRAC
00092 . . . TOTQ = TOTQ + INFRAC*QHIN(IX)+EXFRAC*QHOUT(IX)
00093 . . . AVGC=AVGC+INFRAC*QHIN(IX)*(CCIN(IX,J1)+CCIN(IX+1,J1))/2.
00094 1. . . +EXFRAC*QHOUT(IX)*COLD(IX,J1)
00095 . . . ...FIN
00096 . . . AVGC = AVGC / TOTQ
00097 . . . DEPO(J1) = VSET(J1) * AVGC * (1.0-(STRESS/DBHR(J1)))
00098 . . . RATE = DEPO(J1) * BWID(1) * ALEN / VOLUME
00099 . . . DO (K = 1,NELEM)
00100 . . . . SD(K,J1) = RATE
00101 . . . . VOLK = ABAR(K) * DELZ
00102 . . . . INFRAC=0.5*QHIN(K)*DELTO/VOLK
00103 . . . . EXFRAC=1.0-INFRAC
00104 . . . . SED=INFRAC*QHIN(K)*(CCIN(K,J1)+CCIN(K+1,J1))/2.
00105 1. . . . + EXFRAC*QHOUT(K)*COLD(K,J1)
00106 . . . . CONT=INFRAC*QHIN(K)*(CCIN(K,J2)+CCIN(K+1,J2))/2.
00107 1. . . . + EXFRAC*QHOUT(K)*COLD(K,J2)
00108 C
00109 C*****

```

```
00110      * * * RATEK = RATE * VOLK
00111      * * * SD(K,J2) = RATEK / SED / VOLK * CONT
00112      * * * DEPO(J2) = DEPO(J2) + SD(K,J2) / BWID(1) * VOLK
00113      * * *...FIN
00114      * * *...FIN
00115      * IF (STRESS .GT. SCSHR(J1),AND. NBED. GT. 0)
00116 C   SEDIMENT SCOURING
00117 C
00118      * * * RS = ERODE(J1) * SECDAY * (STRESS / SCSHR(J1) - 1.0)
00119      * * * ILAYR(J1) = 0
00120 C
00121 C   * * * COMPUTE AVAILABILITY OF COHESIVE SEDIMENT IN BED LAYERS.
00122 C   * * * MAXIMUM NUMBER OF LAYERS SCOURED IS RESTRICTED BY SAND SCOURING.
00123 C
00124      * * * RS = RS * DELTD
00125      * * * WHEN (.NOT.(RS .GT. XNT(J1) .AND. ILAYR(1) .GT. 0) )
00126      * * *   RS = AMIN1(RS,XNT(J1))
00127      * * *   CS = RS * B(NBED,J2)
00128      * * *   XNT(J1) = XNT(J1)-RS
00129      * * *...FIN
00130      * * * ELSE
00131      * * *   FAC=B(NBED,J2)
00132      * * *   RSUSP = RS
00133      * * *   NB = 0.
00134 140      * * *   ILAYR(J1) = ILAYR(J1)+1
00135      * * *   NB = NBED-ILAYR(J1)
00136      * * *   RSUSP = RSUSP-XNT(J1)
00137      * * *   RS = RS+XNT(J1)
00138      * * *   CS = CS + FAC*XNT(J1)
00139      * * *   XNT(J1) = 0.0
00140      * * *   FAC = 0.0
00141      * * *   IF (NB.NE.0)
00142      * * *     * XND=(1.0-POR)/(B(NB,1)/DENS(1)+B(NB,2)/DENS(2)+B(NB,3)/DENS(3))
00143      * * *     * XNT(J1) = BDIV * B(NB,J1) * XND
00144      * * *     * FAC = B(NB,J2)
00145      * * *     *...FIN
00146 C
00147      * * *   IF (ILAYR(J1).EQ.ILAYR(1)) GO TO 155
00148      * * *   IF (RSUSP.GE.XNT(J1),AND,ILAYR(1).GT,ILAYR(J1))
00149      * * *     * GO TO 140
00150      * * *     *...FIN
00151 C
00152 155      * * * CONTINUE
00153      * * * DEL = AMIN1(RSUSP,XNT(J1))
00154      * * * RS = RS + DEL
00155      * * * CS = CS + DEL * FAC
00156      * * * XNT(J1) = XNT(J1) - DEL
00157      * * *...FIN
00158      * * *...FIN
00159      * * * SCOUR(J1) = RS / DELTD
00160      * * * SCOUR(J2) = CS / DELTD
00161      * * * SR(J1) = RS / DELTD * BWID(1) * ALEN / VOLUME
00162      * * * SR(J2) = CS / DELTD * BWID(1) * ALEN / VOLUME
00163 C
00164      * * *...FIN
00165      * * * RETURN
```

00166 END

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```
-----  
00001 C  
00002 C (106,5)BPPR,FLX  
00003 C  
00004 C SERATHA POST PROCESSING PROGRAM  
00005 C - - -  
00006 C  
00007 C THIS PRUGNAM IS USED TO MANIPULATE THE RESULT FILES FROM THE  
00008 C SEDIMENT TRANSPORT MODEL , SERATHA. LISTED BELOW ARE THE FUNCTIONS  
00009 C THAT IT CAN PERFORM:  
00010 C  
00011 C (1) LIST = READ THE SPECIFIED FILES AND PRINT PROPER MATRICES,  
00012 C  
00013 C CALLS: GETSPC, LISTER  
00014 C  
00015 C BYTE FILNAM(30),BASE(5),EXT(3),DEV(3),GUIC(3),UUIC(3)  
00016 C  
00017 C INTEGER*2 BEGSEG,UNITS  
00018 C INTEGER*4 BEGTIM,LSTTIM  
00019 C  
00020 C LOGIC*1 LIST,CHAIN  
00021 C  
00022 C DATA FILNAM(29),FILNAM(30)/2* ' '  
00023 C  
00024 C CALL GETSPC(BASE,BEGSEG,BEGTIM,CHAIN,EXT,DEV,FILNAM,GUIC,INTSEG,  
00025 C 1 INTTIM,LSTSEG,LSTTIM,TSTEP,UNITS,UUIC)  
00026 C  
00027 C LIST = .TRUE.  
00028 C CALL LISTER(BASE,BEGSEG,BEGTIM,CHAIN,DEV,EXT,FILNAM,GUIC,INTSEG,  
00029 C 1 INTTIM,LSTSEG,LSTTIM,TSTEP,UNITS,UUIC)  
00030 C  
00031 C STOP  
00032 C END
```

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-----
00001      SUBROUTINE WRTTUP(BASE, DEV, ECHO, FNAME, FTYPE, GUIC, INFLO,
00002      1          IBTRT, NFRST, OUTFLO, SMETH, UUIC,
00003      2          SAVECH, JSEG, NSTEPS, NSEG, ITPRT, ANALYS,
00004      3          DELTH, ANALMT, DEPMIN, SIMLEN, PELEV)
00005      C
00006      C THIS ROUTINE IS RESPONSIBLE FOR THE INTERACTIVE I/O AND OPENING THE
00007      C PROPER FILES.
00008      C
00009      C
00010      C FORMAL PARAMETERS:
00011      C   BASE   = 5-CHARACTER BASE FILE NAME (BYTE)
00012      C   DEV   = BASE OUTPUT FILE DEVICE (BYTE)
00013      C   ECHO   = LINE PRINTER ECHO CONTROL VARIABLE (L*1)
00014      C   SAVECH(1)= ECHO CONTROL FOR SERATRA HEADINGS
00015      C   SAVECH(2)= ECHO CONTROL FOR INFLUENT CONCENTRATIONS
00016      C   SAVECH(3)= ECHO CONTROL FOR SETUP OF ELEMENT MATRIX
00017      C   SAVECH(4)= ECHO CONTROL FOR GEOMETRY AND CONCENTRATIONS
00018      C   SAVECH(5)= ECHO CONTROL FOR RDSFLO, BEFORE AND AFTER
00019      C   SAVECH(6)= ECHO CONTROL FOR SEDIMENTATION
00020      C   SAVECH(7) = ECHO CONTROL FOR DIAGNOSTICS WITHIN BAND, SILCLA
00021      C   SAVECH(8)= ECHO CONTROL FOR PRINTOUT OF SCOUR/DEPOSITION DETAIL
00022      C   SAVECH(9)= ECHO CONTROL = UNDEFINED = TRANSFER TO TRANSP
00023      C   SAVECH(10)= ECHO CONTROL = UNDEFINED
00024      C   FNAME  = FILE DESCRIPTION FOR THE RESULT FILE (BYTE)
00025      C   FTYPE  = BASE OUTPUT FILE EXTENSION (BYTE)
00026      C   GUIC   = GROUP NUMBER FROM UIC OF BASE FILE NAME (BYTE)
00027      C   INFLO  = LUN NUMBER TO THE DATA FROM THE PREVIOUS SEGMENT
00028      C   IBTRT  = STARTING SEGMENT NUMBER
00029      C   NFRST  = STARTING TIME PLANE NUMBER (I*4)
00030      C   OUTFLO = LUN NUMBER TO THE FILE RECEIVING THE RESULTS OF THE
00031      C           CURRENT SEGMENT (I*2)
00032      C   SMETH  = METHOD TO BE USED TO CALCULATE THE BAND CAPACITY (BYTE)
00033      C   UUIC   = USER NUMBER FROM UIC OF BASE FILE NAME (BYTE)
00034      C
00035      C CALLED BY: SERATRA
00036      C CALLS: FDCODE
00037      C
00038      C
00039      C   BYTE ANSWER, YES, N, FNAME(29), FTYPE(3), DEV(3), GUIC(3), UUIC(3),
00040      1   BASE(5), SMETH, INPFIL(30)
00041      C
00042      C   INTEGER*2 OUTFLO
00043      C
00044      C   INTEGER*4 NFRST, SIMLEN, NSTEPS
00045      C
00046      C   LOGICAL*1 ECHO, SAVECH, WRTSEG, ANALYS
00047      C
00048      C   DIMENSION JSEG(4), SAVECH(10)
00049      C
00050      C   DATA N/'R'/
00051      C   DATA YES/'Y'/
00052      C   DATA WRTSEG/,FALSE./
00053      C

```

```
00054      WRITE(8,1)
00055      READ(8,2) NCHR,(INPFIL(I),I=1,NCHR)
00056      INPFIL(NCHR+1) = 0
00057      OPEN(UNIT=1,NAME=INPFIL,TYPE='OLD',READONLY)
00058      C
00059      WRITE(8,3)
00060      READ(8,4) ANSWER
00061      IF (ANSWER, EQ, YES) ECHO = .TRUE.
00062      C
00063      WRITE(8,6)
00064      READ(8,4) (FNAME(I), I=1,29)
00065      CALL FDCODE(FNAME,BASE,JSEG,FTYPE,DEV,GUIC,UMIC)
00066      C
00067      WRITE(8,7)
00068      READ(8,4) SMETH
00069      C
00070      WRITE(8,8)
00071      READ(8,4) ANSWER
00072      IF (ANSWER, EQ, YES) SAVECH(1) = .TRUE.
00073      C
00074      WRITE(8,9)
00075      READ(8,4) ANSWER
00076      IF (ANSWER, EQ, YES) SAVECH(2) = .TRUE.
00077      C
00078      WRITE(8,10)
00079      READ(8,4) ANSWER
00080      IF (ANSWER, EQ, YES) SAVECH(3) = .TRUE.
00081      C
00082      WRITE(8,11)
00083      READ(8,4) ANSWER
00084      IF (ANSWER, EQ, YES) SAVECH(4) = .TRUE.
00085      C
00086      WRITE (8,12)
00087      READ(8,4) ANSWER
00088      IF (ANSWER, EQ, YES) SAVECH(5) = .TRUE.
00089      C
00090      WRITE (8,13)
00091      READ(8,4) ANSWER
00092      IF (ANSWER, EQ, YES) SAVECH(6) = .TRUE.
00093      C
00094      WRITE (8,14)
00095      READ(8,4) ANSWER
00096      IF (ANSWER, EQ, YES) SAVECH(7) = .TRUE.
00097      C
00098      WRITE (8,15)
00099      READ(8,4) ANSWER
00100      IF (ANSWER, EQ, YES) WRTSEG = .TRUE.
00101      WHEN (WRTSEG) JSEG(1) = 0
00102      ELSE
00103      . WRITE (8,16)
00104      . READ(8,17) (JSEG(J), J=1,5)
00105      . . . FIN
00106      WRITE(8,18)
00107      READ(8,4) ANSWER
00108      C
00109      WHEN(ANSWER, EQ, YES)
```

```
00110      * WRITE(8,19)
00111      * READ(8,2) NCHR,(INPFIL(1),I=1,NCHR)
00112      * INPFIL(NCHR+1) = 0
00113      * OPEN(UNIT=2,NAME=INPFIL,TYPE='OLD',FORM='UNFORMATTED')
00114 C      *
00115      *
00116      * WRITE(8,20)
00117      * READ(8,17)ISTRT
00118 C      *
00119      * WRITE(8,21)
00120      * READ(8,17)HSEG
00121 C      *
00122      * WRITE(8,22)
00123      * READ(8,17)HFRST
00124 C      *
00125      * WRITE(8,23)
00126      * READ(8,17)NSTEPS
00127 C      *
00128      * WRITE(8,24)
00129      * READ(8,17)ITPNT
00130 C      *
00131      * WRITE(8,25)
00132      * READ(8,4)ANSWER
00133      * IF(ANSWER.EQ.YES)ANALYS=.TRUE.
00134 C      *
00135      * WRITE(8,26)
00136      * READ(8,27)DELTH
00137      * SIMLEN = DELTH * NSTEPS
00138 C      *
00139      * WRITE(8,28)
00140      * READ(8,27)ANALMT
00141 C      *
00142      * WRITE(8,29)
00143      * READ(8,27)DEPMIN
00144 C      *
00145      * WRITE(8,30)
00146      * READ(8,27)PELEV
00147 C      *
00148      *..FIN
00149      ELSE
00150      * NFRST = 1
00151      * ISTRT=1
00152      * OPEN(UNIT=2,NAME='DUMMY.DT1',TYPE='NEW',FORM='UNFORMATTED')
00153      *..FIN
00154      CLOSE(UNIT=2)
00155      INFLU=2
00156      OUTFLU=3
00157      OPEN(UNIT=3,NAME='DUMMY.DT2',TYPE='NEW',FORM='UNFORMATTED')
00158      OPEN(UNIT=4,NAME='HYDROLOGY.THP',TYPE='NEW',FORM='UNFORMATTED')
00159      OPEN(UNIT=7,NAME='TRIBUTARY.THP',TYPE='NEW',FORM='UNFORMATTED')
00160      OPEN(UNIT=6,NAME='SED.LST',TYPE='NEW')
00161      RETURN
00162 C
00163 C      ** FORMATS **
00164      1  FORMAT('SENTEN NAME OF INPUT FILE>')
00165      2  FORMAT(I,30A1)
```

```
00166 3 FORMAT('DO YOU WANT THE INPUT FILE ECHOED (Y OR N)?')
00167 4 FORMAT(29A1)
00168 6 FORMAT('ENTER BASE FILE NAME')
00169 7 FORMAT(' WHICH SAND CAPACITY METHOD IS TO BE USED? /
00170 1 'ENTER T (TOPFALLT1) OR C (COLBY)?')
00171 8 FORMAT('DO YOU WANT SERTRA HEADINGS ECHOED (Y OR N)?')
00172 9 FORMAT('DO YOU WANT INFLUENT CONCENTRATIONS ECHOED (Y OR N)?')
00173 10 FORMAT('DO YOU WANT ELEMENT MATRICES ECHOED (Y OR N)?')
00174 11 FORMAT('DO YOU WANT GEOMETRY AND CONCENTRATIONS ECHOED (Y OR N)',
00175 1 ' ?')
00176 12 FORMAT('DO YOU WANT CONCENTRATION ECHOED BEFORE AND AFTER HUBFLO',
00177 1 ' (Y OR N)?')
00178 13 FORMAT('DO YOU WANT SCOUR/DEPOSITION TO OCCUR? (Y OR N)?')
00179 14 FORMAT('DO YOU WANT COMPLETE SCOUR/DEPOSITION INFORMATION',
00180 1 ' RECORDED? (Y OR N)?')
00181 15 FORMAT('DO YOU WANT COMPLETE ECHO# INFORMATION FOR ALL',
00182 1 ' SEGMENTS? (Y OR N)?')
00183 16 FORMAT('FOR WHICH SEGMENTS DO YOU WANT COMPLETE ECHO#',
00184 1 ' INFORMATION? (MAXIMUM OF 5)')
00185 17 FORMAT(5I5)
00186 18 FORMAT('IS THIS TO BE A RESTART OF A PREVIOUS RUN (Y OR N)?')
00187 19 FORMAT('ENTER NAME OF RESTART FILE')
00188 20 FORMAT('ENTER THE BEGINNING SEGMENT NUMBER')
00189 21 FORMAT('ENTER THE ENDING SEGMENT NUMBER')
00190 22 FORMAT('ENTER THE BEGINNING TIME PLANE NUMBER')
00191 23 FORMAT('ENTER THE ENDING TIME PLANE NUMBER')
00192 24 FORMAT('ENTER THE PRINT FREQUENCY')
00193 25 FORMAT('DO YOU WANT THE TIME SERIES ANALYSIS? (Y OR N)?')
00194 26 FORMAT('ENTER THE TIME INCREMENT')
00195 27 FORMAT(F10.0)
00196 28 FORMAT('ENTER THE MINIMUM CONCENTRATION LIMIT')
00197 29 FORMAT('ENTER THE MINIMUM DEPTH LIMIT')
00198 30 FORMAT('ENTER THE UPSTREAM ELEVATION')
00199 C
00200 END
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(FLECS VERSION 22.46)

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-----
00001 SUBROUTINE TOFFAL(ALEN, D50, GSI, HRAD, QTOT, SLOPE, TEMPR, VOL,
00002 1 VSET, QSU, QSM, GSL, QSB, YU, YM, YL)
00003 C
00004 C THIS SUBROUTINE USES TOPFALETTI'S METHOD TO CALCULATE THE CAPACITY
00005 C OF THE FLOW TO TRANSPORT SAND. A SUMMARY OF THIS METHOD CAN BE
00006 C FOUND IN THE ASCE 1975 EDITION OF "SEDIMENTATION ENGINEERING"
00007 C PAGES 209 - 213.
00008 C
00009 C FORMAL PARAMETERS:
00010 C ALEN = SEGMENT LENGTH
00011 C D50 = MEDIAN BED SEDIMENT DIAMETER (METERS)
00012 C QSI = TOTAL CAPACITY OF THE SEGMENT (KG/DAY/M)
00013 C HRAD = HYDRAULIC RADIUS
00014 C QTOT = TOTAL FLOW WITHIN THE SEGMENT
00015 C SLOPE = ENERGY OR RIVER BED SLOPE
00016 C TEMPR = WATER TEMPERATURE
00017 C VOL = VOLUME
00018 C VSET = SETTLING VELOCITY
00019 C
00020 C CALLED BY: SAND
00021 C
00022 C REAL K4FUNC,K4
00023 C
00024 C DIMENSION VSET(3)
00025 C
00026 C CONST1 = 3.7975E-5
00027 C CONST2 = 5.60249E+22
00028 C CONST3 = 2.976328E+3
00029 C FDIAH=D50 * 3.280833
00030 C THPR=TEMPR * 1.80 + 32.0
00031 C V=(QTOT * ALEN / (VOL)) * CONST1
00032 C FHRAD=HRAD * 3.280833
00033 C
00034 C FOR WATER TEMPERATURES GREATER THAN 32F AND LESS THAN 100F
00035 C THE KINEMATIC VISCOSITY CAN BE WRITTEN AS THE FOLLOWING:
00036 C
00037 C  $VIS=4.106E-4 * (THPR ** -0.864)$ 
00038 C
00039 C ASSUMING THE D50 GRAIN SIZE (DIAH) IS APPROXIMATELY
00040 C EQUAL TO THE GEOMETRIC MEAN GRAIN SIZE AND  $SIGMA=G = 1.5$ ,
00041 C THE D65 GRAIN SIZE CAN BE DETERMINED TO BE  $1.17 * D50$ .
00042 C
00043 C  $D65=1.17 * FDIAH$ 
00044 C  $CNV=0.1198 + 0.00048 * THPR$ 
00045 C  $CZ=260.67 - 0.667 * THPR$ 
00046 C  $IT=1.10 * (0.051 + 0.00009 * THPR)$ 
00047 C  $ZI=VSET(1) * CONST1 * V / (CZ * FHRAD * SLOPE)$ 
00048 C  $IF(ZI.LT.CNV) ZI=1.5 * CNV$ 
00049 C
00050 C THE MANNING-STRICKLER EQUATION IS USED HERE TO
00051 C DETERMINE THE HYDRAULIC RADIUS COMPONENT DUE TO
00052 C GRAIN ROUGHNESS (R'), TAKEN FROM THE 1975 ASCE
00053 C "SEDIMENTATION ENGINEERING", PG. 128.

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00054 C
00055 C SUBSTITUTIONS ARE MADE IN EQUATION 2.141 FOR SHEAR VELOCITY
00056 C AND K(SUB)S. THE FORMER IS REPLACED BY EQUATION 2.142, AND
00057 C THE LATTER BY D(SUB)65.
00058 C
00059 RPRIME=((V**1.5) * (D65 **0.25) / (SLOPE ** 0.75)) * 0.00349
00060 USTAR=(RPRIME * SLOPE * 32.2) ** 0.5
00061 AFUNC=(VIS * 1.0E5) ** 0.333 / (10.0 * USTAR)
00062 CONDITIONAL
00063 . (AFUNC .LE. 0.500) AC = (AFUNC/4.89)** -1.45
00064 . (AFUNC .LE. 0.660) AC = (AFUNC/0.0036)**0.67
00065 . (AFUNC .LE. 0.720) AC = (AFUNC/0.29)**4.17
00066 . (AFUNC .LE. 1.25) AC = 48.0
00067 . (AFUNC .GT. 1.25) AC = (AFUNC/0.304)**2.74
00068 ...FIN
00069 C
00070 K4FUNC=AFUNC * SLOPE * D65 * 1.0E5
00071 COHDITIONAL
00072 . (K4FUNC.LE.0.25) K4 = 1.0
00073 . (K4FUNC.LE.0.35) K4 = (K4FUNC**1.10) * 4.81
00074 . (K4FUNC.GT.0.35) K4 = (K4FUNC** -1.05) * 0.49
00075 ...FIN
00076 C
00077 ACK4=AC * K4
00078 IF (ACK4 .LT. 16.0)
00079 . ACK4=16.0
00080 . K4=16.0 / AC
00081 ...FIN
00082 OCZM=1.0 + CNV * 1.5 * ZI
00083 OCZM=1.0 + CNV * ZI
00084 OCZL=1.0 + CNV * 0.756 * ZI
00085 ZINV=CNV * 0.756 * ZI
00086 ZM=ZINV
00087 ZN=1.0 + ZINV
00088 ZU=0.756 * ZI
00089 ZP=0.244 * ZI
00090 ZQ=0.5 * ZI
00091 C
00092 C CLI HAS BEEN MULTIPLIED BY 1.0E30 TO KEEP IT FROM
00093 C EXCEEDING THE COMPUTER OVERFLOW LIMIT
00094 C
00095 WHEN((OCZL*ALOG10(2.0*FDIAM)-20.0).GT.38.)CLI=0.0
00096 ELSE
00097 . CLI=(1.0E=20)*CONST2 * OCZL * (V ** 2.333) / FHRAD ** (ZM) /
00098 1. ((TY * AC * K4 * FDIAM) ** 1.667) / (1.0 + CNV) /
00099 2. ((FHRAD / 11.24) ** (ZN=20./ALOG10(FHRAD/11.24))) =
00100 3. ((2.0*FDIAM)**(OCZL=20./ALOG10(2.0*FDIAM)))
00101 ...FIN
00102 WHEN(CLI.EQ.0.0)C2D=0.0
00103 ELSE
00104 . C2D=CLI*(2.0*FDIAM/FHRAD)**(ZO=30./ALOG10(2.0*FDIAM/FHRAD))
00105 ...FIN
00106 C
00107 C CHECK TO SEE IF THE CALCULATED VALUE IS REASONABLE
00108 C (< 100.0), AND ADJUST IT IF IT IS NOT.
00109 C

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00110      IF(CZU.GT.100.0) CLIMCLIA100.0/CZU
00111      C
00112      C CHI HAS BEEN MULTIPLIED BY 1.0E30 TO KEEP IT FROM
00113      C EXCEEDING THE COMPUTER OVERFLOW LIMIT
00114      C
00115      C P(SUB)I APPEARING IN EQUATIONS 2.236H, J, K, L, M, AND
00116      C N IS THE WEIGHT FRACTION OF TOTAL SAND THAT THE I-TH
00117      C SIZE FRACTION CONTAINS. SINCE WE ARE MODELING ALL
00118      C SAND AS A SINGLE SIZE FRACTION == P(SUB)I = 1.0, AND
00119      C HENCE DOES NOT APPEAR IN THE MODEL EQUATIONS.
00120      C
00121      WHEN(CLI.EQ.0.0) CHI=0.0
00122      ELSE
00123      . CHI=43.2 * CLI * (1.0 + CNV) * V * (FHRAD ** (ZM))
00124      ...FIN
00125      C
00126      WHEN(CHI.EQ.0.0)
00127      . GSUM=0.0
00128      . GSH=0.0
00129      . GSL=0.0
00130      . GSB=0.0
00131      ...FIN
00132      ELSE
00133      C
00134      C CALCULATE TRANSPORT CAPACITY OF THE UPPER LAYER
00135      C
00136      . FD11=FHRAD / 11.24
00137      . FD25=FHRAD / 2.5
00138      . GSUM=(CHI * (FD11 ** (ZP)) * ((FD25 ** (ZQ)) *
00139      1. (FHRAD ** (UCZU) - (FD25 ** (UCZU)))) / (UCZU * 1.0 E+30)
00140      C
00141      C CALCULATE THE CAPACITY OF THE MIDDLE LAYER.
00142      C
00143      . GSH=(CHI * (FD11 ** (ZP)) * ((FD25 ** (UCZM)) *
00144      1. (FD11 ** (UCZM)))) / (UCZM * 1.0E+30)
00145      C
00146      C CALCULATE THE CAPACITY OF THE LOWER LAYER
00147      C
00148      . GBL=CHI*(FD11**((ZN-30./ALOG10(FD11))-(2.0*FDIAM)**(OCZL-
00149      1. 30./ALOG10(2.0*FDIAM)))/UCZL
00150      C CALCULATE THE CAPACITY OF THE BED LAYER
00151      C
00152      . GSB=CHI*(2.0*FDIAM)**(ZN-30./ALOG10(2.0*FDIAM))
00153      ...FIN
00154      C
00155      C*****
00156      C TOTAL CAPACITY OF THE SEGMENT (GSI HAS UNITS OF TONS/DAY/FT)
00157      C
00158      GSI=GSM + GSH + GSL + GSB
00159      C
00160      C CONVERTING TO KG/DAY/M
00161      C
00162      GSM = GSM * CONST3
00163      GSH = GSH * CONST3
00164      GSL = GSL * CONST3
00165      GSB = GSB * CONST3

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00166 YU = HRAD / 2.5  
00167 YM = HRAD / 11.24  
00168 YL = 2.0 \* 050  
00169 GSI=GSI \* CONST3  
00170 C  
00171 RETURN  
00172 END

(FLECS VERSION 22,46)

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00001      SUBROUTINE TRANSP(FERROR,PCOEF,BNID,ANID,ABAR,DEPTH,OLDC,ECH04,
00002      1      CR0SEC,ECH07, ECH08, ECH09)
00003      C
00004      C THIS ROUTINE SOLVES THE MASS TRANSPORT EQUATIONS BY AN IMPLICIT
00005      C FINITE-ELEMENT METHOD. A CRANK-NICHOLSON METHOD IS USED TO
00006      C APPROXIMATE THE SOLUTION THROUGH TIME.
00007      C
00008      C VARIABLE DEFINITIONS:
00009      C ALEN = SEGMENT LENGTH
00010      C AREA = ELEMENT AREA
00011      C B = BED CONDITIONS
00012      C BDIV = STANDARD BED LAYER THICKNESS
00013      C BED = BED THICKNESS
00014      C C = WATER CONDITIONS
00015      C CCIN = CONCENTRATION OF INFLOW
00016      C COLD = CELL-CENTERED CONCENTRATION
00017      C CR0SEC = TOTAL CROSS-SECTIONAL AREA, M**2
00018      C DECAY = FIRST ORDER DECAY
00019      C DELTH = TIME STEP (SECONDS)
00020      C DELZ = STANDARD ELEMENT THICKNESS
00021      C DENS = DENSITY
00022      C DFZ = DIFFUSION COEFFICIENT
00023      C DIAM = DIAMETER
00024      C DSHR = CRITICAL SHEAR STRESS FOR DEPOSITION
00025      C D50 = MEDIAN BED SEDIMENT DIAMETER (M)
00026      C ERODE = ERODABILITY
00027      C FERROR = FATAL ERROR FLAG (L*1)
00028      C HHAD = HYDRAULIC RADIUS
00029      C KAY1 = LIGHT EXTINCTION COEFFICIENT OF WATER
00030      C KAY2 = LIGHT EXTINCTION OF SUSPENDED SEDIMENT IN WATER
00031      C NBED = NUMBER OF BED LAYERS
00032      C NELEM = NUMBER OF ELEMENTS
00033      C PCOEF = FIRST TERM OF THE PHOTOLYSIS RATE OF CHANGE EQUATION
00034      C POR = POROSITY
00035      C QHIN = INFLOW DISCHARGE
00036      C QHOUT = OUTFLOW DISCHARGE
00037      C QV = VERTICAL DISCHARGE
00038      C SCSHR = CRITICAL SHEAR STRESS FOR SCOUR
00039      C SLOPE = ENERGY OR RIVER BED SLOPE
00040      C SMETH = CONTROL VARIABLE TO SELECT THE METHOD TO BE USED
00041      C      WHEN COMPUTING THE SAND CARRYING CAPACITY. (BYTE)
00042      C SR = SEDIMENT EROSION RATE
00043      C STRESS = BED SHEAR STRESS
00044      C TEMPR = WATER TEMPERATURE
00045      C VOL = VOLUME
00046      C VSET = PARTICLE SETTLING VELOCITY
00047      C XYSO = THICKNESS OF TOP BED LAYER
00048      C
00049      C CALLED BY: SERATRA
00050      C CALLS: BEDDK, BEDHIS, COLAPS, CUMB, DISOLV, FALL, PARTIC, SAND,
00051      C SEDINE, SETUP, SILCAL, TRISOL
00052      C
00053      C INCLUDE 'ELMSIZ.PH1'

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00054 C
00055 LOGICAL=1 FERROH, ECHO4, ECHO7, ECHO8, ECHO9
00056 REAL=8 PHAR,P,R,S
00057 C
00058 C
00059 DIMENSION A(MXELEM), ABAR(MXELEM), DD(10), ILAYR(3), P(MXELEM,3),
00060 1 R(MXELEM), S(MXELEM,3), SD(MXELEM,6),
00061 2 BR(6), XNT(3), Z(MXELEM), SHID(MXELEM), ANID(MXELEM)
00062 3 ,OLOC(MXELEM,MAXCON), DEPO(6), SCOUR(6), BEDSD(3)
00063 C
00064 INCLUDE 'TRANS.COM'
00065 C
00066 C
00067 DATA EP01/1.0E-30/
00068 C
00069 MPI = NELEM + 1
00070 MLI = NELEM = 1
00071 C
00072 C *** PERFORM CALCULATIONS OVER THE TIME STEP DELTD ***
00073 C
00074 DELTD = DELTH / 86400.
00075 DO (J=1,MAXCON)
00076 . DO (L = 1,MPI)
00077 . . R(L) = 0.0
00078 . . DO (N = 1,3)
00079 . . . S(L,N) = 0.0
00080 . . . P(L,N) = 0.0
00081 . . . PIN
00082 . . . PIN
00083 C
00084 C
00085 . DO (I=1,NELEM)
00086 . . HCDZ = 0.0
00087 . . IF (I .EQ. 1)
00088 . . . SELECT(J)
00089 . . . (1)
00090 C . . . . WRITE(6,1119)NHED,NELEM,(ILAYR(N),NH1,3),ECHO7,SMETH,ALEN,HDIV,
00091 C 1 DELTD,DELZ,DSO,HRAD,POR,SLOPE,STRESS,TEMPR,VOL,XYSD,
00092 C 2 CROSEC,((B(M,N),SD(M,N),NH1,6),(CCIN(M,N),COLD(M,N),
00093 C 3 C(M,N),NH1,7),NH1,10),(DENS(N),SCSHR(N),VSET(N),XNT(N),
00094 C 4 NH1,3),(DEPO(N),SCOUR(N),NH1,6)
00095 1119 . . . . . FORMAT(5X'BEFORE SAND'S13,L2,A2/Z0(10E10.3/))
00096 . . . . . CALL SAND (ABAR, ALEN, AREA, B, HDIV, CCIN, DELTD, DELZ,
00097 1. . . . . DENS, DSO, HRAD, NHED, NELEM, POR, QHIN, QHUT,
00098 2. . . . . SCSHR, SLOPE, SMETH, STRESS, TEMPR, VSET, VOL, XYSD,
00099 3. . . . . DEPO, ILAYR, SD, SH, XNT, COLD, C,
00100 4. . . . . CROSEC, NHID, ECHO7, SCOUR)
00101 C . . . . . WRITE(6,1120)NHED,NELEM,(ILAYR(N),NH1,3),ECHO7,SMETH,ALEN,HDIV,
00102 C 1 DELTD,DELZ,DSO,HRAD,POR,SLOPE,STRESS,TEMPR,VOL,XYSD,
00103 C 2 CROSEC,((B(M,N),SD(M,N),NH1,6),(CCIN(M,N),COLD(M,N),
00104 C 3 C(M,N),NH1,7),NH1,10),(DENS(N),SCSHR(N),VSET(N),XNT(N),
00105 C 4 NH1,3),(DEPO(N),SCOUR(N),NH1,6)
00106 1120 . . . . . FORMAT(5X'AFTER SAND'S13,L2,A2/Z0(10E10.3/))
00107 . . . . . IF(ECHO8)
00108 . . . . . . WRITE(6,1000)
00109 . . . . . . WHEN(ILAYR(1).LT.0)

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00110      . . . . . WRITE(6,1010) J,ILAYR(1),DEPO(1),DEPO(4),SD(1,1),XNT(1),
00111      1. . . . .      (SD(11,4),II=1,NELEM)
00112      . . . . .      ...FIN
00113      . . . . .      ELSE
00114      . . . . .      WRITE(6,1015) J,ILAYR(1),SCOUR(1),SR(1),XNT(1),SCOUR(4),SR(4)
00115      . . . . .      ...FIN
00116      1010 . . . . .      FORMAT(' J=',I2,' ILAYR=',I2,' DEPO=',E15.7,' DEPO(+3)=' ,
00117      1. . . . .      E15.7,' SD=',E15.7,' XNT=',E15.7,9X,'SD(I,+3)=' /
00118      2. . . . .      (5X,E15.7))
00119      1015 . . . . .      FORMAT(' J=',I2,' ILAYR=',I2,' SCOUR=',E15.7,' SR=',E15.7,
00120      1. . . . .      ' XNT=',E15.7,' SCOUR(+3)=' ,E15.7,' SR(+3)=' ,E15.7)
00121      . . . . .      ...FIN
00122      1000 . . . . .      FORMAT('OIN TRANSP FOLLOWING SAND')
00123      . . . . .      ...FIN
00124      . . . . .      (2)
00125      . . . . .      CALL SILCLA(ABAR, B, BDIV, CCIN, DELTD, DELZ, DEPTH, DENS,
00126      1. . . . .      DSHR, ERODE, HRAD, 2, NBED,COLD,NELEM, PUR, QMIN,
00127      2. . . . .      QHOUT, SCSHR, STRESS, VSET, XY80, DEPO, ILAYR,
00128      3. . . . .      SD, SR, XNT, CROSEC, BWID, ALEN, ECH07, SCOUR)
00129      . . . . .      IF(ECH08)
00130      . . . . .      WRITE(6,1020)
00131      . . . . .      WHEN(ILAYR(2),LT,0)
00132      . . . . .      WRITE(6,1010) J,ILAYR(2),DEPO(2),DEPO(5),SD(1,2),XNT(2),
00133      1. . . . .      (SD(11,5),II=1,NELEM)
00134      . . . . .      ...FIN
00135      . . . . .      ELSE
00136      . . . . .      WRITE(6,1015) J,ILAYR(2),SCOUR(2),SR(2),XNT(2),SCOUR(5),SR(5)
00137      . . . . .      ...FIN
00138      . . . . .      ...FIN
00139      1020 . . . . .      FORMAT('OIN TRANSP FOLLOWING SILT')
00140      . . . . .      ...FIN
00141      . . . . .      (3)
00142      . . . . .      CALL SILCLA(ABAR, B, BDIV, CCIN, DELTD, DELZ, DEPTH, DENS,
00143      1. . . . .      DSHR, ERODE, HRAD, 3, NBED,COLD,NELEM, PUR, QMIN,
00144      2. . . . .      QHOUT, SCSHR, STRESS, VSET, XY80, DEPO, ILAYR,
00145      3. . . . .      SD, SR, XNT, CROSEC, BWID, ALEN, ECH07, SCOUR)
00146      . . . . .      IF(ECH08)
00147      . . . . .      WRITE(6,1030)
00148      . . . . .      WHEN(ILAYR(3),LT,0)
00149      . . . . .      WRITE(6,1010) J,ILAYR(3),DEPO(3),DEPO(6),SD(1,3),XNT(3),
00150      1. . . . .      (SD(11,6),II=1,NELEM)
00151      . . . . .      ...FIN
00152      . . . . .      ELSE
00153      . . . . .      WRITE(6,1015) J,ILAYR(3),SCOUR(3),SR(3),XNT(3),SCOUR(6),SR(6)
00154      . . . . .      ...FIN
00155      . . . . .      ...FIN
00156      1030 . . . . .      FORMAT('OIN TRANSP FOLLOWING (SILT) CLAY')
00157      . . . . .      ...FIN
00158      . . . . .      ...FIN
00159      . . . . .      ...FIN
00160      . . . . .      CONJUNCTIONAL
00161      . . . . .      (J .LE. 3)
00162      C      . . . . .      WRITE(6,1117)I, J, NELEM, ALEN, DELTD, ALFA, BETA, VEL1, VEL2,
00163      C      1 DELZ, DEPTH, BETA1, BETA2, ((CCIN(M,N), M=1,7), (SD(M,N),
00164      C      2 M=1,5), ABAR(M), QMIN(M), QHOUT(M), QV(M), BWID(M), AWID(M),
00165      C      3 M=1,10), (SR(M), M=1,6), (VSET(M), M=1,3)

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00166 1117 . . . . FORMAT(5X'BEFORE BEDIME'313/20(10E10.3/))
00167 . . . . CALL SEDIME(AHAR, ALEN, CCIN, DELT0, I, J, NELEM, WHIN,
00168 1. . . . . QHOUT, QV, SD, SK, ALFA, BETA, VEL1, VEL2, VSET,
00169 2. . . . . DELZ, BWID, AWID, DEPTH, BETA1, BETA2)
00170 C . . . . WRITE(6,1118)I,J,NELEM,ALEN,DELT0,ALFA,BETA,VEL1,VEL2,
00171 C 1 DELZ,DEPTH,BETA1,BETA2,((CCIN(M,N),NM1,7),(SD(M,N),
00172 C 2 NM1,6),AHAR(M),QHIN(M),QHOUT(M),QV(M),BWID(M),AWID(M),
00173 C 3 NM1,10),(SR(M),NM1,6),(VSET(M),NM1,3))
00174 1118 . . . . FORMAT(5X'AFTER BEDIME'313/20(10E10.3/))
00175 . . . . IF(ECH08) WRITE(6,1500)
00176 1500 . . . . FORMAT('OIN TRANSP FOLLOWING BEDIME')
00177 . . . . ...FIN
00178 . . . . (J,LE,4,AND,J,LE,6)
00179 . . . . CALL PARTIC(AHAR, ALEN, B, C, CCIN, COLD, DECAY, DELT0, DPZ,
00180 1. . . . . I, J, NBED, NELEM, QHOUT, QHIN, QV, SOHOK, SD, SK, ALFA, BETA,
00181 2. . . . . VEL1, VEL2, VSET, DELZ, DEPTH, BWID, AWID,
00182 3. . . . . BETA1, BETA2, USOH, OLUC)
00183 . . . . IF(ECH08) WRITE(6,1510)
00184 1510 . . . . FORMAT('OIN TRANSP FOLLOWING PARTIC')
00185 . . . . ...FIN
00186 . . . . (J,LE,7)
00187 . . . . CALL DISOLV(AHAR, H, HOIV, C, CCIN, COLD, DECAY, DELZ,
00188 1. . . . . DELT0, DENS, DIAM, I, KAY1, KAY2, NELEM, NBED,
00189 2. . . . . PCOEF, POR, QHIN, QHOUT, QV, SOHOK, ALFA, BETA, VEL1,
00190 3. . . . . VEL2, BETA1, BETA2, DEPO, SCOUN, SEDSD, XYSD, AREA,
00191 4. . . . . USOH, OLUC)
00192 . . . . IF(ECH08) WRITE(6,1520) (BEDSD(I),I=1,3)
00193 1520 . . . . FORMAT('OIN TRANSP FOLLOWING DISOLV BEDSD(1-3) =',E10.7)
00194 . . . . ...FIN
00195 . . . . ...FIN
00196 . . . . IF(ECH08) WRITE(6,1530) VEL1,VEL2
00197 1530 . . . . FORMAT(' VEL1 =',E15.7,10X,'VEL2 =',E15.7)
00198 C . . . .
00199 C . . . . *** CONSTRUCT THE FINITE ELEMENT MATRICES FOR EACH LAYER ***
00200 . . . . WHEN (J,LE,3) DIFUSE = DFZ(J)
00201 . . . . ELSE DIFUSE = DFZ(J-3)
00202 . . . . DD(1) = DIFUSE/(DELZ*DELZ)
00203 . . . . DD(2) = 6.0 * DELZ
00204 . . . . DD(3) = (VEL2 = 4. * VEL1) / DD(2)
00205 . . . . DD(4) = (VEL1 + 2. * VEL2) / DD(2)
00206 . . . . DD(5) = (2. * VEL1 + VEL2) / DD(2)
00207 . . . . DD(6) = (4. * VEL2 - VEL1) / DD(2)
00208 . . . . DD(7) = ALFA
00209 . . . . DD(8) = BETA
00210 . . . . DD(9) = BETA1
00211 . . . . DD(10) = BETA2
00212 . . . . IF (ECH04)
00213 . . . . . WRITE(6,2500)
00214 2500 . . . . . FORMAT('O I',1X,'J',6X,'DD(1)',7X,'DD(2)',7X,'DD(3)',7X,'DD(4)',7
00215 1. . . . . X,'DD(5)',7X,'DD(6)',7X,'DD(7)',7X,'DD(8)',7X,'DD(9)',7X,'DD(10)')
00216 . . . . . WRITE(6,2000)I,J,(DD(K),K=1,10)
00217 2000 . . . . . FORMAT(1X,13,1X,I1,1X,10(1PE12.4))
00218 . . . . ...FIN
00219 C . . . .
00220 . . . . VEL = VEL1/DELZ
00221 . . . . IF(1.EQ,NELEM) VEL=VEL2/DELZ

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00222      . . WIDTH = ANID(I)
00223      . . CALL SETUP(I, DD, P, S, R, VEL, NELEM, ECHO4, WIDTH)
00224      . . . . FIN
00225  C
00226      . . HALFD = DELTD / 2.0
00227      . . DO (L = 1, MP1)
00228      . . . . R(L) = H(L) * DELTD
00229      . . . . Z(L) = C(L, J)
00230      . . . . DU (N = 1, 3)
00231      . . . . . P1 = S(L, N) * HALFD
00232      . . . . . PBAR = P(L, N) + P1
00233      . . . . . S(L, N) = P(L, N) - P1
00234      . . . . . P(L, N) = PBAR
00235      . . . . . FIN
00236      . . . . FIN
00237  C
00238      . . IF (ECHO4)
00239      . . . . WRITE(6, 5760)
00240  5760 . . . . FORMAT(' BEFORE COMB*****BEFORE COMB**')
00241      . . . . WRITE(6, 5761)
00242  5761 . . . . FORMAT('0MODE', 6X, 'P(1,1)', 10X, 'P(1,2)', 10X, 'P(1,3)', 10X,
00243      . . . . 'S(1,1)', 10X, 'S(1,2)', 10X, 'S(1,3)', 11X, 'Z(I)', 12X, 'R(I)')
00244      . . . . WRITE(6, 5762) (I, (P(I, K), K=1, 3), (S(I, K), K=1, 3), Z(I), R(I),
00245      . . . . I=1, MP1)
00246  5762 . . . . FORMAT(1X, I2, 1P8E16.5)
00247      . . . . FIN
00248  C
00249  1113 . . WRITE(6, 1113) MP1, ((S(M, N), N=1, 3), Z(M), R(M), M=1, 10)
00250      . . . . FORMAT('SX' BEFORE COMB' I3/10(10E10.3/))
00251  C
00252  1114 . . CALL COMB(MP1, S, Z, R)
00253      . . . . WRITE(6, 1114) MP1, ((S(M, N), N=1, 3), Z(M), R(M), M=1, 10)
00254      . . . . FORMAT('SX' AFTER COMB' I3/10(10E10.3/))
00255  6000 . . IF (ECHO4) WRITE(6, 6000) (R(L), L=1, MP1)
00256      . . . . FORMAT(' R AFTER COMB', 8(1PE12.4, 2X))
00257  C
00258      . . *** SOLVE THE SYSTEM OF EQUATIONS BY GAUSSIAN ELIMINATION ***
00259  C
00260      . . WRITE(6, 1111) MP1, P(2, 1), P(1, 2), P(1, 3), (R(M), M=1, 10)
00261  1111 . . . . FORMAT('SX' BEFORE TRISOL' I3/10(10E10.3/))
00262      . . . . CALL TRISOL(MP1, P(2, 1), P(1, 2), P(1, 3), R)
00263  C
00264      . . WRITE(6, 1112) MP1, P(2, 1), P(1, 2), P(1, 3), (R(M), M=1, 10)
00265  1112 . . . . FORMAT('SX' AFTER TRISOL' I3/10(10E10.3/))
00266  C
00267      . . DO (I=1, MP1)
00268      . . . . ULOC(I, J)=C(I, J)
00269      . . . . C(I, J)=K(I)
00270      . . . . FIN
00271      . . COMPUTE=CELL-CENTERED=VALUES
00272  C
00273      . . . . FIN
00274      . . CALL MEDHIS(S, HOIV, MED, GOLD, DELTD, DELZ, DENS,
00275      . . . . FERRON, ILAYR, NBED, NELEM, PUR, XNI, XYSU,
00276      . . . . DEPU, SCOUR, MEDSD)
00277      . . IF (DECAY(1).GT.0.0) CALL MEDDK(S, DECAY, DELTD, NBED)
00278      . . RETURN

```

-----

```
00276      TO COMPUTE-CELL-CENTERED-VALUES
00277      C      *
00278      C      * *** COLLAPSE THE NODAL VALUES OF C INTO CELL CENTERED VALUES
00279      C      *      IN COLD ***
00280      C      *
00281      C      * DO (I=1,NELEM)
00282      C      *   . COLD(I,J) = (C(I,J) + C(I+1,J))/2.
00283      C      *   . ...FIN
00284      C      * 6200 . FORMAT(' C IN PROCEDURE I=',I2,2X,1P7E14.4)
00285      C      *   . IF (ECHO4)
00286      C      *     . IF (J.EQ.MAXCON)
00287      C      *       . . WRITE(6,6200)(I,(C(I,JJ),JJ=1,MAXCON),I=1,MP1)
00288      C      *       . . WRITE(6,6300)(I,(COLD(I,JJ),JJ=1,MAXCON),I=1,NELEM)
00289      C      *     . . ...FIN
00290      C      *   . ...FIN
00291      C      * 6300 . FORMAT(' COLD IN PROCEDURE I=',I2,2X,1P7E14.4)
00292      C      *   . ...FIN
00293      C      * END
```

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PROCEDURE CROSS-REFERENCE TABLE

00276 COMPUTE-CELL-CENTERED-VALUES  
00268

(FLECS VERSION 22.46)

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-----  
00001      SUBROUTINE TRHDAT(ECHO, HLDERR, NELEM, NTRIBS, NUMERR,  
00002      1          SIMLEN, TRBOPT)  
00003      C  
00004      C THIS ROUTINE IS RESPONSIBLE FOR READING AND PROCESSING THE  
00005      C TRIBUTARY INFLOW MASS FLUX DATA. THE DATA IS READ FROM  
00006      C THE INPUT STREAM (LUN 1) AND WRITTEN TO "TRIBUTARY.TMP" (LUN 7)  
00007      C FOR USE DURING THE SIMULATION.  
00008      C  
00009      C FORMAL PARAMETERS:  
00010      C ECHO = LINE PRINTER ECHO OPTION CONTROL VARIABLE (L*1)  
00011      C HLDERR = HOLDING ARRAY FOR ERROR NUMBERS (BYTE)  
00012      C NELEM = NUMBER OF VERTICAL ELEMENTS  
00013      C NOTE: NELEM IS LATER REDEFINED IN HYDDAT  
00014      C NTRIBS = NUMBER OF TRIBUTARIES (0 OR 1)  
00015      C NUMERR = NUMBER OF INPUT ERRORS  
00016      C SIMLEN = SIMULATION LENGTH (SECONDS = I*4)  
00017      C TRBOPT = TRIBUTARY INPUT CONTROL VARIABLE  
00018      C  
00019      C CALLED BY: SERATRA  
00020      C CALLS: PUTERR  
00021      C  
00022      C INCLUDE 'ELMBIZ.PRM'  
00023      C  
00024      C BYTE HLDERR(100)  
00025      C  
00026      C INTEGER*2 TRBOPT  
00027      C  
00028      C INTEGER*4 ENDTIM,PHETIM,SIMLEN  
00029      C  
00030      C LOGICAL*1 ECHO  
00031      C  
00032      C DIMENSION CTRB(MXELEM,MAXCON)  
00033      C  
00034      C ....TRIBUTARY INFLOW MASS FLUX  
00035      C  
00036      C FIRST RECORD.....  
00037      C  
00038      C COL. 1= 5...NTRIBS....NUMBER OF TRIBUTARIES (0 OR 1)  
00039      C 6=10...TRBOPT....TRIBUTARY INPUT OPTION  
00040      C *0: THE USER WANTS THE MODEL TO  
00041      C DISTRIBUTE THE MASS FLUX THRU  
00042      C THE ELEMENTS.  
00043      C *1: THE USER WILL SUPPLY THE  
00044      C MASS FLUX VALUES FOR EACH ELEMENT  
00045      C  
00046      C REWIND 7  
00047      C  
00048      C READ(1,2) NTRIBS,TRBOPT  
00049      C  
00050      C IF (ECHO) WRITE(6,3) NTRIBS,TRBOPT  
00051      C  
00052      C IF (NTRIBS .GT. 0)  
00053      C . IF(ECHO) WRITE(6,4)
```



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00054      . REPEAT UNTIL (ENDTIM .EQ. -9999)
00055      C      .
00056      C      . . CARD 11-B
00057      C      . . COL. 1=10...ENDTIM...ENDING TIME FOR THE DATA THAT FOLLOWS.
00058      C      . .                               A VALUE OF -9999 TERMINATES THE DATA
00059      C      . .                               (SECONDS).
00060      C      .
00061      C      . . READ(1,6) ENDTIM
00062      C      .
00063      C      . . UNLESS (ENDTIM .EQ. -9999)
00064      C      .
00065      C      . . . RECORD TWO.....TRIBUTARY MASS FLUX AND DEPTH
00066      C      . . . ***** CAUTION *****
00067      C      . . . THE MASS FLUX UNITS ARE DIFFERENT FROM THOSE OF
00068      C      . . . INITIAL WATER AND UPSTREAM WATER CONCENTRATIONS.
00069      C      . . . RADIONUCLIDE IS PC/SEC, PESTICIDE IS KG/SEC,
00070      C      . . . SEDIMENT IS KG/SEC
00071      C      . . . ***** CAUTION *****
00072      C      .
00073      C      . . . COL. 1=10...CTRB(1,1)...MASS FLUX OF SAND (KG/M**3)*(M**3/SEC)
00074      C      . . . 11=20...CTRB(1,2)...MASS FLUX OF SILT
00075      C      . . . 21=30...CTRB(1,3)...MASS FLUX OF CLAY
00076      C      . . . 31=40...CTRB(J,4)...MASS FLUX OF CONTAMINANT ASSOCIATED
00077      C      . . . WITH SAND (PC/KG)*(KG/M**3)*(M**3/SEC)
00078      C      . . . 41=50...CTRB(J,5)...MASS FLUX OF CONTAMINANT ASSOCIATED
00079      C      . . . WITH SILT
00080      C      . . . 51=60...CTRB(J,6)...MASS FLUX OF CONTAMINANT ASSOCIATED
00081      C      . . . WITH CLAY
00082      C      . . . 61=70...CTRB(J,7)...MASS FLUX OF DISSOLVED CONTAMINANT
00083      C      . . . (PC/M**3)*(M**3/SEC)
00084      C      .
00085      C      . . . WHEN (IRRUPT .EQ. 0) N = 1
00086      C      . . . ELSE N = NELEM
00087      C      . . . DO (J=1,N)
00088      C      . . . . READ(1,1) (CTRB(J,I),I=1,MAXCON)
00089      C      . . . . IF (ECHO)
00090      C      . . . . . WRITE(6,5) ENDTIM,(CTRB(J,I),I=1,MAXCON)
00091      C      . . . . . FIN
00092      C      . . . . FIN
00093      C      . . . . WHITE(7) ENDTIM,((CTRB(J,I),I=1,7),J=1,N)
00094      C      . . . . PRETIM = ENDTIM
00095      C      . . . . FIN
00096      C      . . . . FIN
00097      C      . . . REWIND 7
00098      C      . . . IF (PRETIM .LT. SIMLEN) CALL PUTERR(23, NUMERR, HLDERR)
00099      C      . . . FIN
00100      C
00101      C      RETURN
00102      C
00103      1  FORMAT(7F10.0)
00104      2  FORMAT(2I5)
00105      3  FORMAT(1H0,4X,'TRIBUTARY DATA'/14X,I5,' ',,NUMBER OF TRIBUTARIES'
00106      1  /14X,I5,'...TRIBUTARY INPUT CONTROL VARIABLE')
00107      4  FORMAT(1H0,'ENDING TIME',1X,3(3X,'CONC. OF',4X),3(1X,'CONC.'
00108      1  ' ASSOC.',2X),2X,'CONTAMINANT',7X,'FLOW'/13X,'SUSPENDED SAND'
00109      2  ,1X,'SUSPENDED SILT',1X,'SUSPENDED CLAY',3X,'WITH SAND',6X.

```

```
00110      3 'WITH SILT',6X,'WITH CLAY',4X,'DISSOLVED CONC',2X,  
00111      4 '(M**3/SEC)'  
00112      5 FORMAT(2X,I10,2X,7(1PE12.5,3X),1PE12.5)  
00113      6 FORMAT(I10)  
00114      C  
00115      END
```

(FLECS VERSION 22.06)

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-----
00001      SUBROUTINE TRHFLO(CTRB, CTRIB, ENDTRB, ETIME, FERROR, DEPTH,
00002      1      NELEM, NEWQI, NEWTRB, QHIN, TRBOPT, DEPMIN)
00003      C
00004      C      WHEN THERE IS A TRIBUTARY TO THE SEGMENT THIS SUBROUTINE IS
00005      C      CALLED EACH TIME STEP TO READ THE DATA FROM LUN 7
00006      C      WHICH WAS WRITTEN BY SUBROUTINE TRBDAT.
00007      C
00008      C      FORMAL PARAMETERS:
00009      C      CTRB = REDISTRIBUTED CONCENTRATIONS
00010      C      CTRIB = ORIGINAL TRIBUTARY MASS FLUX
00011      C      ENDTRB = ENDING TIME OF THE CURRENT TRIBUTARY DATA (I*4)
00012      C      ETIME = ELAPSED TIME OF THE SIMULATION (I*4)
00013      C      FERROR = FATAL ERROR FLAG
00014      C      NELEM = NUMBER OF ELEMENTS
00015      C      CAUTION: NELEM HAS BEEN REDEFINED IN HYDDAT
00016      C      SINCE ITS USE IN TRBDAT
00017      C      NEWQI = NEW QHIN DATA FLAG (L*1)
00018      C      NEWTRB = NEW TRIBUTARY DATA FLAG (L*1)
00019      C      QHIN = INFLOW TO CURRENT SEGMENT
00020      C      TRBOPT = TRIBUTARY INPUT OPTION CONTROL VARIABLE (I*2)
00021      C
00022      C      CALLED BY: SERATRA
00023      C
00024      C      INCLUDE 'SY:ELMSIZ,PRM'
00025      C
00026      C      INTEGER*2 TRBOPT
00027      C
00028      C      INTEGER*4 ENDTRB,ETIME
00029      C
00030      C      LOGICAL*1 NEWTRB,NEWQI,FERROR
00031      C
00032      C      DIMENSION CTRB(MXELEM,MAXCON), CTRIB(MAXCON), QHIN(MXELEM)
00033      C
00034      C      NEWTRB = .FALSE.
00035      C      IF (ETIME .GT. ENDTRB)
00036      C      . NEWTRB = .TRUE.
00037      C      . REPEAT UNTIL(ETIME .LE. ENDTRB)
00038      C      100 . . CONTINUE
00039      C      . . WHEN (TRBOPT .EQ. 0)
00040      C      . . . HEAD(7,END=200) ENDTRB, (CTHIB(J),J=1,MAXCON)
00041      C      . . . .FIN
00042      C      . . ELSE READ(7,END=200) ENDTRB,((CTRB(I,J),J=1,MAXCON),I=1,NELEM)
00043      C      . . . .FIN
00044      C      . . . .FIN
00045      C      IF (DEPTH .LE. DEPMIN) RETURN
00046      C      IF (TRBOPT .EQ. 0 .AND. (NEWTRB .OR. NEWQI))
00047      C      . QHTOT = 0.0
00048      C      . DO (I=1,NELEM) QHTOT = QHTOT + QHIN(I)
00049      C      . *** DISTRIBUTE THE MASS FLUX THROUGHOUT THE ELEMENTS ***
00050      C      . NOTE: UNITS ARE
00051      C      .      SEDIMENT KG/SEC
00052      C      .      PARTICULATE PC/SEC OR KG/SEC
00053      C      .      DISSOLVED PC/SEC

```

```
00054      . DO (K=1,MAXCON)
00055      . . DO (I=1,NELEM)
00056      . . . CTRB(I,K) = CTRB(K) * QHIN(I) / QHTOT
00057      . . . .FIN
00058      . . .FIN
00059      . .FIN
00060      RETURN
00061  C
00062  200 CONTINUE
00063      FERROR = .TRUE.
00064      WRITE(6,1)
00065  1  FORMAT(10X,'FATAL ERROR - TRIBUTARY DATA EXHAUSTED')
00066      RETURN
00067  C
00068      END
```

(FLECS VERSION 22.46)

-----

```
-----  
00001 SUBROUTINE TRISOL(MP1,D1,D2,R)  
00002 C CALLED BY TRANSP.  
00003 C USED IN ORIGINAL VERSION OF SERATRA  
00004 C INCLUDE 'ELMSIZ.PRM'  
00005 C  
00006 REAL*8 D,R,D1,D2  
00007 C DIMENSION D(MXELEM), D1(MXELEM), D2(MXELEM), R(MXELEM)  
00008 C  
00009 N=MP1  
00010 NI=N-1  
00011 C  
00012 C FORWARD ELIMINATION  
00013 C  
00014 DO(I=1,NI)  
00015 . D1D=D1(I)/D(I)  
00016 . D(I+1)=D(I+1)-D2(I)*D1D  
00017 . R(I+1)=R(I+1)-R(I)*D1D  
00018 . ...FIN  
00019 C  
00020 C BACKWARD SUBSTITUTION  
00021 C  
00022 R(N)=R(N)/D(N)  
00023 DO (I=1,NI)  
00024 . K=N-I  
00025 . R(K)=(R(K)-D2(K)*R(K+1))/D(K)  
00026 . ...FIN  
00027 C  
00028 RETURN  
00029 END
```

(FLECS VERSION 22.46)

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-----
00001      SUBROUTINE TRNPOS(AHAR,AREA,AHID,ALEN,BHID,DELZ,EL,
00002      1      IELM,NELEM,XBAREA,VOL)
00003      C
00004      C      THIS SUBROUTINE CONSERVE THE GROSS CROSS-SECTIONAL AREA AS A FUNCTION
00005      C      OF DEPTH DURING THE CONVERSION OF THE REAL CROSS-SECTION TO ITS
00006      C      IDEALIZED RECTILINEAR SHAPE.
00007      C
00008      C      INCLUDE 'SYIELMSIZ,PHM'
00009      C
00010      C      DIMENSION AHAR(MXELEM), AREA(MXELEM), AHID(MXELEM),
00011      1      BHID(MXELEM), EL(MXELEM), IELM(MXELEM),
00012      2      XBAREA(MXELEM)
00013      C
00014      C
00015      HLEN=1./ALEN
00016      ELTOP=DELZ
00017      HB=AREA(1)*BLEN
00018      B=ID(1)*WB
00019      AHAB=(HB+AREA(2)*BLEN)*(EL(2)-EL(1))/2.
00020      AHBB=0.
00021      HB=1
00022      C
00023      C      DETERMINE LOCATION OF TOP NODE WITH RESPECT TO ORIGINAL DATA
00024      C
00025      DO(I=1,NELEM)
00026      . DO(J=1,MXELEM-1)
00027      . . IF(ELTOP .GE. EL(J) .AND. ELTOP .LE. EL(J+1))
00028      . . . ER=EL(J)
00029      . . . ET=EL(J+1)
00030      . . . HB=AREA(J)*BLEN
00031      . . . HT=AREA(J+1)*HLEN
00032      . . . NT=J
00033      . . . IELM(I)=J
00034      . . . GO TO 10
00035      . . . . .FIN
00036      . . . . .FIN
00037      10 . CONTINUE
00038      C
00039      C      LINEARLY INTERPOLATE WIDTH AT ELEMENT'S TOP NODE
00040      C
00041      . WTOP=HB + (ELTOP-EB)*(HT-HB)/(ET-EB)
00042      C
00043      C      ASSUME TRAPZOIDAL SHAPES TO FIND CROSS-SECTIONAL AREAS
00044      C
00045      . ARAT=(HT+WTOP)*(ET-ELTOP)/2.
00046      . ARBT=(HTOP+HB)*(ELTOP-EB)/2.
00047      C
00048      C      DETERMINE IF NEW ELEMENT SURFACES HAVE BEEN FOUND TO
00049      C      (A) LIE WITHIN A SINGLE DATA SET
00050      C      (B) LIE IN SEQUENTIAL DATA SETS, OR
00051      C      (C) BE SEPARATED BY ONE OR MORE DATA SETS
00052      C      FINALLY, FORM THE CROSS-SECTIONAL AREA
00053      C

```

```
00054      * INDIC=NT-NR
00055      * IF(INDIC .EQ. 0) XSAHEA(I)=ARHT-ARHB
00056      * IF (INDIC .GE. 1) XSAREA(I)=ARHT+ARAB
00057      * IF (INDIC .GE. 2)
00058      *   * XSAR=0.
00059      *   * DO(I=NR+1,NT-1)
00060      *     * XSAR=XSAR+(AREA(I)+AREA(I+1))*(EL(I+1)-EL(I))*DLN/2.
00061      *     * ...FIN
00062      *     * XSAHEA(I)=XSAREA(I)+XSAR
00063      *     * ...FIN
00064      C
00065      C * DETERMINE AVERAGE VERTICAL PROJECTION, AVERAGE WIDTH, REAL WIDTH,VOLUM
00066      C
00067      * AWID(I)=XSAREA(I)/DELZ
00068      * ABAR(I)=AWID(I)*ALEN
00069      * BWID(I+1)=HTOP
00070      * VOL=VOL+XSAREA(I)*ALEN
00071      C
00072      C * OVERWRITE INITIAL INFORMATION FOR NEXT ELEMENT
00073      C
00074      * ELTOP=ELTOP+DELZ
00075      * ARAB=ARAT
00076      * ARHB=ARBT
00077      * NR=NT
00078      * ...FIN
00079      RETURN
00080      END
```

(FLECS VERSION 22.46)

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-----
00001      SUBROUTINE UPSDAT(ECHO, HLDERR, NUMERR, SIMLEN, UHID, UEL)
00002      C
00003      C THIS ROUTINE IS RESPONSIBLE FOR READING THE UPSTREAM INFLOW
00004      C CONDITIONS TO SEGMENT 1. THE DATA IS READ FROM THE INPUT STREAM
00005      C (LUN 1) AND THEN WRITTEN TO 'DUMMY.DT1' (LUN 2) FOR SUBSEQUENT
00006      C USE DURING THE SIMULATION.
00007      C
00008      C FORMAL PARAMETERS:
00009      C ECHO = LINE PRINTER ECHO OPTION CONTROL VARIABLE (L*1)
00010      C HLDERR = HOLDING ARRAY FOR ERROR NUMBERS (BYTE)
00011      C NUMERR = NUMBER OF INPUT ERRORS
00012      C SIMLEN = SIMULATION LENGTH (SECONDS = I*4)
00013      C
00014      C CALLED BY: SEPATRA
00015      C CALLS: PVEERR
00016      C
00017      C INCLUDE 'ELMSIZ.PRM'
00018      C
00019      C BYTE HLDERR(100)
00020      C
00021      C INTEGER*4 ENDTIM, PRETIM, SIMLEN
00022      C
00023      C LOGICAL*1 ECHO
00024      C
00025      C DIMENSION CCIN(MXELEM, MAXCON), UHID(MXELEM), UEL(MXELEM)
00026      C
00027      C REWIND 2
00028      C
00029      C IF (ECHO) WRITE(6,6)
00030      C
00031      C .....UPSTREAM INFLOW CONDITIONS TO SEGMENT 1
00032      C
00033      C REPEAT UNTIL (ENDTIM .EQ. -9999)
00034      C
00035      C * RECORD ONE.....
00036      C * COL. 1-10...ENDTIM...ENDING TIME FOR DATA THAT FOLLOWS,
00037      C * A VALUE OF -9999 TERMINATES THE DATA,
00038      C * (SECONDS)
00039      C * 11-15...NM.....NUMBER OF ELEMENTS
00040      C * 16-25...UDEPTH...ELEVATION OF FREE SURFACE ABOVE BED
00041      C
00042      C * READ(1,5) ENDTIM, NM, UDEPTH
00043      C
00044      C * IF (ENDTIM .NE. -9999)
00045      C *
00046      C * * RECORD TWO.....WATER CONDITIONS. ONE CARD IS READ FOR EACH NODE.
00047      C * * THE UNITS OF THE CONTAMINANT CONCENTRATIONS DEPEND
00048      C * * UPON THE TYPE OF CONTAMINANT (RADIOISOTOPE, PC/KG
00049      C * * OR PESTICIDE, KG/KG). THE PARAMETERS ARE READ IN
00050      C * * THE FOLLOWING ORDER:
00051      C * *
00052      C * * PARAMETER 1...CONCENTRATION OF SAND (KG/M**3)
00053      C * * 2...CONCENTRATION OF SILT (KG/M**3)

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00054 C      . .      3...CONCENTRATION OF CLAY (KG/M**3)
00055 C      . .      4...CONCENTRATION OF CONTAMINANT ASSOCIATED WITH
00056 C      . .      SAND
00057 C      . .      5...CONCENTRATION OF CONTAMINANT ASSOCIATED WITH
00058 C      . .      SILT
00059 C      . .      6...CONCENTRATION OF CONTAMINANT ASSOCIATED WITH
00060 C      . .      CLAY
00061 C      . .      7...CONCENTRATION OF DISSOLVED CONTAMINANT
00062 C      . .
00063      . .      WHEN(NM .GT. 0)
00064      . .      . DO (I=1,NM)
00065      . .      . . READ (1,1) (CCIN(I,K), K=1, MAXCON)
00066      . .      . . . . .FIN
00067      . .      . . . . .FIN
00068      . .      . . . . .ELSE
00069      . .      . . . . .MMMXELEM
00070      . .      . . . . .READ (1,1) (CCIN(I,K), K=1, MAXCON)
00071      . .      . . . . .DO (I=2,NM)
00072      . .      . . . . .DO (K=1, MAXCON) CCIN(I,K)=CCIN(I,K)
00073      . .      . . . . .FIN
00074      . .      . . . . .FIN
00075      . .      . . IF (ECHO)
00076      . .      . . . . .WRITE(6,4) ENDTIM
00077      . .      . . . . .WRITE(6,3)
00078      . .      . . . . .DO (I=1,NM)
00079      . .      . . . . .WRITE(6,2) I,(CCIN(I,K),K=1,MAXCON)
00080      . .      . . . . .FIN
00081      . .      . . . . .FIN
00082 C      . .
00083      . .      WRITE(2) ENDTIM,NM,UDEPTH,((CCIN(I,K),K=1,MAXCON),I=1,NM)
00084      . .      PRETIM = ENDTIM
00085      . .      . . . . .FIN
00086      . .      . . . . .FIN
00087      . .      IF (PRETIM .LT. SIMLEN) CALL PUTERR(24, NUMERR, HLDERR)
00088 C      . .
00089      . .      REWIND 2
00090 C      . .      RECORD THREE.....CHANNEL CROSS-SECTION DATA
00091 C      . .      . . . . .UWID == WIDTH OF SEGMENT AT NODES
00092 C      . .      . . . . .UEL == ELEVATION OF NODE ABOVE BOTTOM
00093 C*****
00094 C
00095 C      CAUTION!
00096 C      IF CONCENTRATIONS ARE INPUT AT VARIOUS DEPTHS,
00097 C      THE CHANNEL CROSS-SECTIONAL DATA MUST BE INPUT
00098 C      AT THOSE SAME DEPTHS.
00099 C
00100 C*****
00101      . .      READ(1,7) NWID, UWIDTH, DEL
00102      . .      WHEN (NWID.EQ.0)
00103      . .      . E=0.
00104      . .      . DO (I=1,MXELEM)
00105      . .      . . UWID(I)=UWIDTH
00106      . .      . . UEL(I)=E
00107      . .      . . E=E+DEL
00108      . .      . . . . .FIN
00109      . .      . . . . .FIN

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00110      ELSE
00111      .   READ(1,1) (UMID(I),I=1,NMID)
00112      .   READ(1,1) (UEL(I),I=1,NMID)
00113      .   IF(NMID.LT.MXELEM)
00114      .     DO (I = NMID + 1, MXELEM)
00115      .       .   UMID(I) = UNIDTM
00116      .       .   UEL(I) = UEL(I-1) + DEL
00117      .       .   ...FIN
00118      .     ...FIN
00119      .   ...FIN
00120      IF(ECHO)
00121      .   WRITE(6,8) (I,UMID(I),I=1,MXELEM)
00122      .   WRITE(6,9) (I, UEL(I),I=1,MXELEM)
00123      .   ...FIN
00124      C
00125      RETURN
00126      C
00127      1   FORMAT(8F10.0)
00128      2   FORMAT(2I,13,1X,4(3X,1PE12.5),4X,1PE12.5)
00129      3   FORMAT(1H0,'ELEMENT',1X,
00130      1   3(3X,'CONC. OF',4X),3(1X,'CONC. ASSOC.',2X),2X,'CONTAMINANT'/
00131      2   9X,'SUSPENDED SAND',1X,'SUSPENDED SILT',1X,'SUSPENDED CLAY',
00132      3   3X,'WITH SAND',6X,'WITH SILT',6X,'WITH CLAY',4X,'DISSOLVED '
00133      4   'CONC.')
00134      4   FORMAT(1H0,8X,I10,'...DATA SET ENDING TIME')
00135      5   FORMAT(I10,15,F10.0)
00136      6   FORMAT(1H0,80X,'UPSTREAM INFLOW WATER CONDITIONS')
00137      7   FORMAT (15,2F10.0)
00138      8   FORMAT (1H0,50X,'X-SECTION WIDTHS'/4(27X,5(13,1PE12.5)/))
00139      9   FORMAT (1H0,50X,'X-SECTION ELEVATIONS'/4(27X,5(13,1PE12.5)/))
00140      C
00141      END

```

(FLECS VERSION 22.46)

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-----
00001      SUBROUTINE WTRDAT(C, ECHO, NELEM)
00002      C
00003      C   THIS ROUTINE IS RESPONSIBLE FOR READING THE INITIAL WATER CONDITIONS.
00004      C
00005      C   FORMAL PARAMETERS:
00006      C       C   = INITIAL WATER CONDITIONS
00007      C       ECHO = LINE PRINT ECHO OPTION CONTROL VARIABLE (L=1)
00008      C       NELEM = NUMBER OF VERTICAL ELEMENTS
00009      C
00010      C   CALLED BY: SERATRA
00011      C
00012      C   INCLUDE 'ELMSIZ.PHM'
00013      C   LOGICAL*1 ECHO
00014      C   INTEGER SWITCH
00015      C
00016      C   DIMENSION C(MXELEM,MAXCON)
00017      C
00018      C   ....INITAL WATER CONDITIONS
00019      C
00020      C   A SET OF INITIAL WATER CONDITIONS ARE READ FOR EACH NODE
00021      C   OF THE SEGMENT (ELEMENTS ARE NUMBERED BEGINNING AT THE BOTTOM,
00022      C   (ELEMENT 1), AND ENDING WITH THE SURFACE ELEMENT, (ELEMENT #NELEM))
00023      C
00024      C   IF THERE IS NO VERTICAL VARIATION, COLUMNS 1-5 CONTAIN A NEGATIVE
00025      C   VALUE AND COLUMNS 6-15 CONTAIN THE CONSTANT VALUE. WHEN THE DATA
00026      C   DOES VARY WITH DEPTH, A VALUE IS READ FOR EACH ELEMENT. THE UNITS
00027      C   OF THE CONTAMINANT CONCENTRATIONS DEPEND UPON THE TYPE OF CONTAMINANT
00028      C   (RADIONUCLIDE..PC/KG OR PESTICIDE..KG/KG).
00029      C
00030      C           THE UNITS OF THE CONTAMINANT CONCENTRATIONS DEPEND
00031      C           UPON THE TYPE OF CONTAMINANT (RADIONUCLIDE..PC/KG
00032      C           OR PESTICIDE..KG/KG). THE PARAMETERS ARE READ IN
00033      C           THE FOLLOWING ORDER:
00034      C
00035      C           PARAMETER 1...CONCENTRATION OF SAND (KG/M**3)
00036      C           2...CONCENTRATION OF SILT (KG/M**3)
00037      C           3...CONCENTRATION OF CLAY (KG/M**3)
00038      C           4...CONCENTRATION OF CONTAMINANT ASSOCIATED WITH
00039      C           SAND
00040      C           5...CONCENTRATION OF CONTAMINANT ASSOCIATED WITH
00041      C           SILT
00042      C           6...CONCENTRATION OF CONTAMINANT ASSOCIATED WITH
00043      C           CLAY
00044      C           7...CONCENTRATION OF DISSOLVED CONTAMINANT
00045      C   DO(K=1,MAXCON)
00046      C   .   DO(J=1,MXELEM) C(J,K)=0.0
00047      C   .   ...FIN
00048      C
00049      C
00050      C   DO (K=1,MAXCON)
00051      C   .   READ(1,2) SWITCH,VALUE
00052      C   .   WHEN(SWITCH .LT. 0)
00053      C   .   .   *** PARAMETER DOES NOT VARY VERTICALLY ***

```

```
00054      . . DO (J=1,MXELEM) C(J,K) = VALUE
00055      .   ...FIN
00056      . ELSE
00057 C      . . *** PARAMETER VARIES VERTICALLY ***
00058      . . READ(1,1) (C(J,K),J=1,NELEM+1)
00059      .   ...FIN
00060      .   ...FIN
00061      IF (ECHO)
00062      . WRITE(6,3)
00063      . WRITE(6,5)
00064      . DO (J=1,NELEM+1)
00065      . . WRITE(6,4)J,(C(J,K),K=1,MAXCON)
00066      .   ...FIN
00067      .   ...FIN
00068 C      RETURN
00069
00070 C
00071 1      FORMAT(8F10.0)
00072 2      FORMAT(15,F10.0)
00073 3      FORMAT(1H0,52X,'INITIAL WATER CONDITIONS')
00074 4      FORMAT(3X,I2,1X,6(3X,1PE12.5),4X,1PE12.5)
00075 5      FORMAT(1H0,'ELEMENT',1X,
00076      1 3(3X,'CONC. OF',4X),3(1X,'CONC. ASSOC.',2X),2X,'CONTAMINANT'/
00077      2 9X,'SUSPENDED SAND',1X,'SUSPENDED SILT',1X,'SUSPENDED CLAY',
00078      3 3X,'WITH SAND',6X,'WITH SILT',6X,'WITH CLAY',4X,'DISSOLVED '
00079      4 'CONC. ')
00080 C
00081      END
```

(FLECS VERSION 22.46)

-----

APPENDIX C

SAMPLE INPUT AND OUTPUT FOR SERATRA

INPUT

```
3 SEGMENTS      5 TIMESTEPS
5      3      1 FALSE 3 0 0 0      0 0 0      0 0 0
0,4,1,0,0,1,0,30,4350,0,120,5,0,5,121,0,
7,1,67E+6,1,22
2,32E+5,7,03E+5,9,60E+5,1,16E+6,1,35E+6,1,51E+6,1,67E+6
0,0,1,22,2,44,3,66,4,88,0,10,7,32
1,0E=3,1,0E=5,1,0E=6,
2650,0,2650,0,2650,0
1,0E=3,3,0E=5,2,0E=6,2,5E=3,
1,0,2,0,3,0
0,50,0,10,0,01
1,74E=6,1,74E=6,1,74E=6,
6,0E=3,6,0E=3,6,0E=3,6,0E=3
0,25,1,25,2,50,1,16E=5,1,16E=5,1,16E=5,0,0,0,0,
0,0,
2,50,12,5,25,0,1,16E=5,1,16E=5,1,16E=5,0,0,0,0,
0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,
0,0,0,0,0,0,0,
-1,0,80
-1,0,12
-1,0,02
-1,0,0
-1,0,0
-1,2,0E=3
-1,6,0E=3
-1,2,0E=3
-1,3,54E=6
-1,1,77E=5
-1,3,54E=5
-1,1,42E=6
2160000,-1,4,726
2,0E=3,6,0E=3,2,0E=3,3,54E=6,1,77E=5,3,54E=5,1,42E=6,
=9999,
5,274,3,1,22
103,6,192,0,201,2,222,5,274,3
0,0,1,22,2,44,3,66,4,88,
0,
2160000,1019,4,1019,4,5,94,12,5
=9999,
7,4,1,0,0,1,0,36,16050,0,116,9,0,5,TRUE
7,5,31E+6,1,22
5,63E+5,1,78E+6,2,96E+6,3,69E+6,4,26E+6,5,03E+6,5,31E+6
0,0,1,22,2,44,3,66,4,88,0,10,7,32,
1,0E=3,1,0E=5,1,0E=6,
2650,,2650,,2650,
1,0E=3,3,0E=5,2,0E=6,2,5E=3
1,0,2,0,3,0
0,50,0,10,0,01
1,74E=6,1,74E=6,1,74E=6
6,0E=3,6,0E=3,6,0E=3,6,0E=3
0,25,1,25,2,50,1,16E=5,1,16E=5,1,16E=5,0,0,0,0,
0,0
2,50,12,5,25,0,1,16E=5,1,16E=5,1,16E=5,0,0,0,0,
0,0
0,,0,,0,,0,,0,,0,,0,,0,,0,,
0,,0,,0,,0,,
-1,0,80
-1,0,12
-1,0,02
-1,0,0
-1,0,0
-1,0,0
-1,2,0E=3
-1,6,0E=3
-1,2,0E=3
-1,3,54E=6
-1,1,77E=5
-1,3,54E=5
-1,1,42E=6
0,
2160000,1019,0,1019,0,6,82,12,5
=9999,
```

SEGMENT 1 PARAMETERS  
CROSS-SECTIONAL GEOMETRY

FALL VELOCITY  
PARTICLE DENSITY  
PARTICLE DIAMETER  
CRITICAL SCOUR SHEAR STRESS  
CRITICAL DEPOSITION SHEAR STRESS

SEGMENT 2 PARAMETERS

```

7,4,1.0,0.1,0.36,16050.0,116.9,0.5,TRUE
7,5,31E+6,1.22
5.63E+5,1.8E+6,2.46E+6,3.69E+6,4.26E+6,5.03E+6,5.31E+6
0.0,1.22,2.44,3.66,4.88,6.10,7.32,
1.0E=3,1.0E=5,1.0E=6,
2650.,2650.,2650.
1.0E=3,3.0E=5,2.0E=6,2.5E=3
1.0,2.0,3.0
0.50,0.10,0.01
1.74E=6,1.74E=6,1.74E=6
6.0E=3,6.0E=3,6.0E=3,6.0E=3
0.25,1.25,2.50,1.16E=5,1.16E=5,1.16E=5,0.0,0.0,
0.0
2.50,12.5,25.0,1.16E=5,1.16E=5,1.16E=5,0.0,0.0,
0.0
0.0,0.0,0.0,0.0,0.0,0.0,0.0,
0.0,0.0,0.0,0.0,
-1,0.36
-1,0.12
-1,0.02
-1,0.0
-1,0.0
-1,0.0
-1,2.0E=3
-1,6.0E=3
-1,2.0E=3
-1,3.54E=6
-1,1.77E=5
-1,3.54E=5
-1,1.42E=6
0,

```

SEGMENT 2 PARAMETERS

```

2160000,1019.0,1019.0,6.62,12.5
=9999,

```

```

7,4,1.0,0.1,0.36,16050.0,113.4,0.5,TRUE
7,1.07E+7,1.22
5.14E+4,5.14E+5,4.79E+5,1.52E+6,2.49E+6,3.67E+6,4.60E+6,6.70E+6
1.07E+7,
0.0,1.22,2.44,3.66,4.88,6.10,7.32,8.54
9.70,
1.0E=3,1.0E=5,1.0E=6,
2650.,2650.,2650.
1.0E=3,3.0E=5,2.0E=6,2.5E=3
1.0,2.0,3.0
0.50,0.10,0.01
1.74E=6,1.74E=6,1.74E=6
6.0E=3,6.0E=3,6.0E=3,6.0E=3
0.25,1.25,2.50,1.16E=5,1.16E=5,1.16E=5,0.0,0.0,
0.0
2.50,12.5,25.0,1.16E=5,1.16E=5,1.16E=5,0.0,0.0,
0.0
0.0,0.0,0.0,0.0,0.0,0.0,0.0,
0.0,0.0,0.0,0.0,
-1,0.86
-1,0.12
-1,0.02
-1,0.0
-1,0.0
-1,0.0
-1,2.0E=3
-1,6.0E=3
-1,2.0E=3
-1,3.54E=6
-1,1.77E=5
-1,3.54E=5
-1,1.42E=6
1,0
2160000,
0.0,0.0,0.0,0.0,0.0,2.05E=4
=9999,
2160000,1019.0,1019.0,6.63,12.5
=9999,

```

SEGMENT 3 PARAMETERS

OUTPUT

WIREM SIGHT NO NUMBER 1  
 TIME STEP NUMBER 1  
 ELAPSED TIME 3600.00  
 DATE 120.5000  
 NUMBER OF ELEMENTS 3  
 STANDARD ELEMENT THICKNESS 1.100000E+00  
 NUMBER OF NEW LAYERS 4  
 STANDARD BED LAYER THICKNESS 1.000000E+01  
 TOP LAYER THICKNESS 5.999100E+02  
 SHEAR STRESS VALUE 4.5000120E+01

WATER CONCENTRATIONS

ELEVATION (METERS)	SUSPENDED SAND KG/MS3	SUSPENDED SILT KG/MS3	SUSPENDED CLAY KG/MS3	DISSOLVED CONTAMINANT KG/MS3	CONTAMINANT WITH SAND KG/MS3	CONTAMINANT WITH SILT KG/MS3	CONTAMINANT WITH CLAY KG/MS3	TOTAL PARTICULATE KG/MS3	TOTAL CONC. KG/MS3
120.6000	1.2110E-03	5.9570E-03	1.990E-03	1.4203E-06	3.4577E-09	1.0594E-07	7.0654E-06	1.7054E-07	1.5994E-06
125.0120	1.5810E-03	5.9440E-03	1.980E-03	1.4140E-06	4.6677E-09	1.0521E-07	7.0396E-06	1.6062E-07	1.5992E-06
124.4240	2.3594E-03	6.0093E-03	2.000E-03	1.4242E-06	7.2772E-09	1.0631E-07	7.0003E-06	1.6843E-07	1.6007E-06
123.2360	2.774E-03	6.010E-03	1.990E-03	1.4222E-06	8.5087E-09	1.0631E-07	7.0759E-06	1.6203E-07	1.6070E-06
122.0480	3.7094E-03	6.0910E-03	2.013E-03	1.4363E-06	1.1672E-08	1.0785E-07	7.1970E-06	1.917E-07	1.6274E-06
120.6000	4.055E-03	6.1447E-03	2.034E-03	1.4455E-06	1.4647E-08	1.0875E-07	7.1950E-06	1.953E-07	1.6400E-06

RED CONCENTRATIONS

ELEVATION (METERS)	SAND WEIGHT FRACTION	SILT WEIGHT FRACTION	CLAY WEIGHT FRACTION	CONTAMINANT WITH SAND KG/KG	CONTAMINANT WITH SILT KG/KG	CONTAMINANT WITH CLAY KG/KG	AVERAGE CONC. KG/RS
120.6000	0.5940054E-01	1.200146E-01	2.002777E-02	0.000000E+01	0.000000E-01	0.000000E-01	0.000000E-01
120.6000	8.600000E-01	1.200000E-01	2.000000E-02	0.000000E+01	0.000000E-01	0.000000E-01	0.000000E-01
120.7000	6.600000E-01	1.200000E-01	2.000000E-02	0.000000E+01	0.000000E-01	0.000000E-01	0.000000E-01
120.6000	6.600000E-01	1.200000E-01	2.000000E-02	0.000000E+01	0.000000E-01	0.000000E-01	0.000000E-01

CONTAMINANT ASSOCIATED WITH SEDIMENT

ELEVATION (METERS)	CONTAMINANT WITH SAND KG/KG	CONTAMINANT WITH SILT KG/KG	CONTAMINANT WITH CLAY KG/KG	AVERAGE CONC. KG/KG
120.6000	2.053E-06	1.769E-05	3.537E-05	1.950E-05
125.0120	2.918E-06	1.769E-05	3.537E-05	1.893E-05
124.4240	3.051E-06	1.769E-05	3.537E-05	1.775E-05
123.2360	3.063E-06	1.769E-05	3.537E-05	1.721E-05
122.0480	3.131E-06	1.769E-05	3.537E-05	1.606E-05
120.6000	3.144E-06	1.769E-05	3.537E-05	1.521E-05



INTEGRATED VALUES OF TOTAL MASS OR CONTAMINANT IN EACH ELEMENT

ELEMENT	SUSPENDED SAND KG	SUSPENDED SILT KG	SUSPENDED CLAY KG	CONTAMINANT WITH SAND KG	CONTAMINANT WITH SILT KG	CONTAMINANT WITH CLAY KG	DISSOLVED CONTAMINANT KG
0	1.3980E+04	3.5552E+04	1.1649E+04	4.2512E-02	6.2921E-01	4.1942E-01	6.4299E+00
1	2.3407E+03	9.9746E+03	3.3365E+03	6.7568E-03	1.7654E-01	1.1817E-01	2.3755E+00
2	2.4969E+03	6.7674E+03	2.9326E+03	6.6844E-03	1.5552E-01	1.0380E-01	2.0664E+00
3	3.2042E+03	7.5057E+03	2.4985E+03	9.6142E-03	1.3264E-01	6.0440E-02	1.7775E+00
4	3.2109E+03	5.9305E+03	1.9692E+03	9.9874E-03	1.0496E-01	6.4704E-02	1.4008E+00
5	2.3153E+03	3.3531E+03	1.1103E+03	7.2664E-03	5.9345E-02	3.4303E-02	7.6967E-01

FLUX OF SEDIMENT MASS OR CONTAMINANT INFLUENT TO ELEMENT

ELEMENT	SUSPENDED SAND KG	SUSPENDED SILT KG	SUSPENDED CLAY KG	CONTAMINANT WITH SAND KG	CONTAMINANT WITH SILT KG	CONTAMINANT WITH CLAY KG	DISSOLVED CONTAMINANT KG
0	7.3397E+03	2.2019E+04	7.3397E+03	2.5982E-02	3.8974E-01	2.5982E-01	5.2112E+00
1	2.2909E+03	6.8727E+03	2.2909E+03	5.1094E-03	1.2169E-01	8.1098E-02	1.6265E+00
2	1.9277E+03	5.7832E+03	1.9277E+03	6.8242E-03	1.0206E-01	6.8242E-02	1.3687E+00
3	1.5345E+03	4.6036E+03	1.5345E+03	5.4522E-03	8.1883E-02	5.4522E-02	1.0695E+00
4	1.0517E+03	3.1550E+03	1.0517E+03	3.7229E-03	5.5894E-02	3.7229E-02	7.4664E-01
5	5.3485E+02	1.6085E+03	5.3485E+02	1.8934E-03	2.8400E-02	1.8934E-02	3.7974E-01

FLUX OF SEDIMENT MASS OR CONTAMINANT EFFLUENT FROM ELEMENT

ELEMENT	SUSPENDED SAND KG	SUSPENDED SILT KG	SUSPENDED CLAY KG	CONTAMINANT WITH SAND KG	CONTAMINANT WITH SILT KG	CONTAMINANT WITH CLAY KG	DISSOLVED CONTAMINANT KG
0	7.7682E+03	2.2009E+04	7.3376E+03	2.5402E-02	3.8954E-01	2.5974E-01	5.2150E+00
1	1.9874E+03	6.9928E+03	2.3357E+03	6.5021E-03	1.2377E-01	6.2679E-02	1.6601E+00
2	1.9414E+03	5.8562E+03	1.9532E+03	6.3500E-03	1.0365E-01	6.9141E-02	1.3682E+00
3	1.7710E+03	4.6554E+03	1.5508E+03	5.7906E-03	8.2390E-02	5.4899E-02	1.1022E+00
4	1.4304E+03	3.2621E+03	1.0853E+03	4.6749E-03	5.7736E-02	3.8416E-02	7.7127E-01
5	6.3801E+02	1.2421E+03	4.1265E+02	2.0847E-03	2.1988E-02	1.4607E-02	2.9323E-01

C.4

INTEGRATED VALUES OF TOTAL MASS OR CONTAMINANT IN THE BED

ELEMENT	SAND WEIGHT KG	SILT WEIGHT KG	CLAY WEIGHT KG	CONTAMINANT WITH SAND KG	CONTAMINANT WITH SILT KG	CONTAMINANT WITH CLAY KG
1	1.5859277E+07	2.2132798E+06	3.6887991E+05	0.0000000E-01	0.0000000E-01	0.0000000E-01
2	2.6436398E+07	3.6887997E+06	6.1879994E+05	0.0000000E-01	0.0000000E-01	0.0000000E-01
3	2.6436398E+07	3.6887997E+06	6.1879994E+05	0.0000000E-01	0.0000000E-01	0.0000000E-01
4	2.6436398E+07	3.6887997E+06	6.1879994E+05	0.0000000E-01	0.0000000E-01	0.0000000E-01

- (1) OLDG + INFLUENT - EFFLUENT
- (2) NEWC = (1)
- (3) NEWBED = SUMMATION (M(I,J)\*VOLUME\*DENSITY)
- (4) NEWBED = OLDRED + (2)

SAND KG	SILT KG	CLAY KG	M/SAND KG	M/SILT KG	M/CLAY KG	DISSOLVED KG	TOTAL CONTAMINANT KG
1.1418569E+04	3.5551523E+04	1.1849160E+04	4.2518605E-02	6.2927920E-01	4.1947188E-01	0.4075775E+00	9.4988470E+00
2.5614561E+03	1.5625000E-02	-3.9062500E-03	-6.8135560E-06	-7.2240829E-05	-4.8364169E-05	2.2350311E-02	2.222888E-02
9.5188472E+07	1.3274679E+07	2.2132798E+06	0.0000000E-01	0.0000000E-01	0.0000000E-01	0.0000000E-01	0.0000000E-01
1.4560547E+00	1.5625000E-02	-2.5390625E-01	-6.8135560E-06	-7.2240829E-05	-4.8364169E-05		2.222888E-02

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