SED2D-WES Version 4.3 Beta

4/20/98

A USER'S MANUAL FOR, SED2D-WES,

A GENERALIZED COMPUTER PROGRAM FOR

TWO-DIMENSIONAL, VERTICALLY AVERAGED SEDIMENT TRANSPORT

by

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IMPORTANT NOTICE

This manual and the accompanying computer model SED2D-WES Version 4.3 is in Beta test mode. It is being distributed to a limited number of users in order to test the capabilities of the model, and to determine if there are bugs that persist in the code. By accepting either this manual or the computer code you are indicating your assent to be a Beta test user. Beta test users are responsible for reporting bugs and/or errors in the manual to the TABS-MD system consultants by sending email to “tabs@hl.wes.army.mil”. We will attempt to respond to reported bugs in a timely manner, but the response time will vary according to the availability of the program development staff. Beta test users are also responsible for performing model testing and model sensitivity analyses to determine the model capabilities. The Beta test version should not be used for engineering design and analysis by any person who has not undertaken a comprehensive program of model testing and analysis. The user must first determine if the model is appropriate and accurate for the type of problem that he or she expects to simulate, and that coding errors do not exist that may yield erroneous results.

PREFACE

The program described herein was developed over the period 1972-1998 at several institutions under funding from a number of sources. SED2D-WES Version 4.3 Beta described herein and preparation of this user's manual was performed during the period 1993 to 1995 at the US Army Engineer Waterways Experiment Station (WES) under the Army Corps of Engineers Rehabilitation, Evaluation, and Maintenance Research Program (REMR). SED2D-WES is a rewrite of an earlier program called STUDH. Additional model enhancements have been made by project specific needs, supported by USACE Districts

The original STUDH program development was performed by Dr. Ranjan Ariathurai under the direction of Dr. R. B. Krone at the University of California, Davis (UCD). It was extended by Drs. Ariathurai, Krone, and R. C. MacArthur at UCD with funding provided by the US Army Engineer Dredged Material Research Program. The result of that effort was program SEDIMENT II. Enhancements were subsequently made by Dr. Ariathurai while working at Nielson Engineering and Research, Inc., under contract to WES. Funds were provided by the US Army Engineer District, Portland. Major revisions to the program were performed by personnel of WES (in consultation with Dr. Ariathurai) with funds from the OCE research program, IOMT. Dr. Ariathurai developed new versions of SEDIMENT II called SEDIMENT 4H and SEDIMENT 4H.MLT, also funded by the IOMT program. Some of the features of those programs were then adapted by WES personnel for use in the program called STUDH. During the period 1993 to 1995 STUDH was substantially rewritten and modernized to create the program SED2D-WES Version 1.2 Beta. During the period of 1996-1998 SED2D-WES has been further expanded in its capability well beyond the previous version of STUDH.

Personnel of the WES Hydraulics Laboratory that performed the development of the STUDH program did so under the direction of Messrs. H. B. Simmons and F. A. Herrmann, Jr., former and present Chiefs of the Hydraulics Laboratory; M. B. Boyd, Chief of the Hydraulics Analysis Division; R. A. Sager, Chief of the Estuaries Division, G. M. Fisackerly, Chief of the Harbor Entrance Branch, and E. C. McNair, Chief of the Sedimentation Branch. Mr. W. A. Thomas designed the program structure, wrote much of the code, and supervised program development. Additional coding was performed by Messrs. W. H. McAnally, Jr., and S. A. Adamec, Jr. Other WES personnel participating in coding and testing were C. B. Berger, B.P. Donnell, J. D. Ethridge, Jr., J. V. Letter, Jr., and R. D. Schneider.

Personnel of the WES Hydraulics Laboratory that performed the development of the SED2D-WES program did so under the direction of Messrs. F. A. Herrmann, Jr. and R. A. Sager, former Chief and present

Acting Chief of the Hydraulics Laboratory, W. H. McAnally, Chief of the Waterways and Estuaries Division, and W. D. Martin, Chief of the Hydrosciences Division. Dr. Lisa C. Roig restructured the code and performed most of the code modernization in the original version of SED2D-WES (version 1.2). Ms. Barbara P. Donnell wrote several new subroutines. Other WES personnel participating in coding and testing were Mr. Chris Callegan, Dr. Greg Nail, Ms. Lisa Benn, Ms. Jackie Pettway, and Ms. Cassandra Gaines. This report was prepared by Dr. Roig and Ms. Donnell. Much of this report is derived from the 1983 STUDH manual prepared by Messrs. Thomas, McAnally, and Adamec. Revisions to SED2D-WES to bring it to its present form were performed by Mr. J. V. Letter, Jr. from 1996-1998.

Commanders and Director of WES during preparation of this report were COL Bruce K. Howard and COL Robin Cababa. Technical Director was Dr. Robert W. Whalin.

SED2D-WES

1. INTRODUCTION

1.1 Purpose

This report describes the use of a generalized computer program (model) for two,-dimensional, vertically averaged sediment transport in open channel flows. The current version of this program is SED2D-WES Version 4.3 Beta.

1.2 Origin of Program

The initial code development was accomplished by Dr. Ranjan Ariathurai (l974) in partial fulfillment of the requirements for his Doctor of Philosophy degree at the University of California, Davis. That work, a 2-D model in the horizontal plane, was extended to include the vertical plane by Ariathurai, MacArthur, and Krone (l977) under contract with the US Army Corps of Engineers, Dredged Material Research Program. Dr. Ariathurai consulted with Waterways Experiment Station (WES) personnel during the early testing phases of the program during which time he made several enhancements to the program.

Starting with that basic work, WES personnel and Dr. Ariathurai produced a code known as STUDH. Dr. Ariathurai subsequently developed several new versions of the models with funding from WES. Selected features of those models were adopted and placed in the STUDH model. STUDH Version 3.3 was a standard tool for sediment transport analysis during the period 1983 to 1993. During the period 1993 to 1995 STUDH was substantially rewritten and modernized by WES personnel to create the program SED2D-WES (version 1.2). This modernization was undertaken in order to improve model maintenance and to facilitate the addition of new features to the code. A series of major revisions to SED2D-WES have been performed recently; adding marsh porosity compatibility and rewriting the cohesive bed layering routines (version 2.0); adding one-dimensional (1-D) elements (version 3.0); and adding the automatic boundary specification in reversing tidal flows including boundary buffering and automatic computation options for dispersion coefficients (version 4.0).

1.3 Potential Applications

SED2D-WES can be applied to clay or sand bed sediments where flow velocities can be considered two-dimensional in the horizontal plane (i.e., the speed and direction can be satisfactorily represented as a depth-averaged velocity). It is useful for both deposition and erosion studies and, to a limited extent, for stream width studies. The program treats two categories of sediment: 1) noncohesive, which is referred to as sand herein; and 2) cohesive, which is referred to as clay.

1.4 Limitations

Both clay and sand may be analyzed, but the model considers a single, effective grain size during each run. Therefore, a separate model run is required for each effective grain size. Fall velocity must be prescribed along with the water surface elevations, x-velocity, y-velocity, diffusion coefficients bed density, critical shear stresses for erosion, erosion rate constants, and critical shear stress for deposition.

The program does not compute water surface elevations or velocities; these data must be provided from an external calculation of the flow field. For most problems, a numerical model for hydrodynamic computations, RMA2-WES, is used to generate the water surface elevations and velocities. An implicit assumption of the SED2D-WES model is that the changes in the bed elevation due to erosion and/or deposition do not significantly affect the flow field. When the bed change calculated by the model does become significant and the externally calculated flow field supplied by the user is no longer valid, then the SED2D-WES run should be stopped, a new flow field calculation should be made using the new channel bathymetry generated by SED2D-WES, and the SED2D-WES run should be restarted with the new flow field as input.

2. PROGRAM DESIGN

2.1 Capabilities of the Program

Either steady-state or transient flow problems can be analyzed. The exchange of material with the bed can be calculated or suppressed. Default values may be used for many sediment characteristics or these values may be prescribed by input data. Either the smooth wall velocity profile or the Mannings equation may be used to calculate bed shear stress due to currents. Shear stresses for combined currents and wind waves may be calculated.

2.2 Conceptual Basis

The program is based on the following conceptual model:

a. Basic processes in sedimentation can be grouped into erosion, entrainment, transportation, and deposition.

b. Flowing water has the potential to erode, entrain, and transport sediment whether or not sediment particles are present.

c. Sediment on the streambed will remain immobile only as long as the energy forces in the flow field remain less than the critical shear stress threshold for erosion.

d. Even when sand particles become mobile, there may be no net change in the surface elevation of the bed. A net change would result only if the rate of erosion was different from the rate of deposition - two processes which go on continuously and independently.

e. Cohesive sediments in transport will remain in suspension as long as the bed shear stress exceeds the critical value for deposition. In general, simultaneous deposition and erosion of cohesive sediments do not occur.

f. The structure of cohesive sediment beds changes with time and overburden.

g. The major portion of sediment in transport can be characterized as being transported in suspension, even that part of the total load that is transported close to the bed.

2.3 Theoretical Basis

The derivation of the basic finite element formulation is presented in Ariathurai (1974) and Ariathurai , MacArthur, and Krone (1977) and summarized below. There are four major computations.

a. Suspended sediment concentration using convection - diffusion equation with a bed source term

b. Bed shear stress

c. Bed source quantity

d. Bed model

a. Convection-diffusion equation. The basic convection - diffusion equation is presented in Ariathurai, MacArthur, and Krone (l977),

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = \frac{\partial}{\partial x}\left(D_x \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_y \frac{\partial C}{\partial y}\right) + \alpha_1 C + \alpha_2 \qquad (1)$$

where

C = concentration, kg/m^3

t = time, sec

u = flow velocity in x - direction, m/sec

x = primary flow direction, m

v = flow velocity in y - direction, m/sec

y = direction perpendicular to x , m

D_x = effective diffusion coefficient in x-direction, m^2/sec

D_y = effective diffusion coefficient in y-direction, m^2/sec

α_1 = a coefficient for the source term, 1/sec

α_2 = the equilibrium concentration portion of the source term, kg/m^3/sec = $-\alpha_1 C_{eq}$

This equation is then cast into the finite element form using quadratic shape functions, N ,

$$\sum_{ne=1}^{NE} \iint_{D_{ne}} \left[N_j \left\{ Q + u \frac{\partial \hat{C}}{\partial x} + v \frac{\partial \hat{C}}{\partial y} - \alpha_1 \hat{C} \right\} + \frac{\partial N_j}{\partial x} D_x \frac{\partial \hat{C}}{\partial x} + \frac{\partial N_j}{\partial y} D_y \frac{\partial \hat{C}}{\partial y} \right] dxdy + \sum_{i=1}^{NL} \int_{\zeta} N_j q_i^s d\zeta = 0 \qquad (2)$$

where

NE = total number of elements

N = the quadratic shape functions

Q = $\left(\partial \hat{C} / \partial t\right) + \alpha_2$ for the transient problem

$\hat{C}$ = the approximate concentration in an element as evaluated from shape functions and nodal point values of C

NL = total number of boundary segments

ζ = the local coordinate

q_i^s = flux from source on boundary i

The transient equation is expressed as

$$[T]\frac{\partial\{C\}}{\partial t}+[K]\{C\}-\{F\}=0 \tag{3}$$

where each element in the computation mesh contributes the following terms to the global matrix

$$[T]=\iint_D [N]^T[N]dxdy\ ;$$

$$[K]=\iint_D\left[K_j\left\{u\frac{\partial\hat{C}}{\partial x}+v\frac{\partial\hat{C}}{\partial y}-\alpha_1\hat{C}\right\}+\frac{\partial N_j}{\partial x}D_x\frac{\partial\hat{C}}{\partial x}+\frac{\partial N_j}{\partial y}D_y\frac{\partial\hat{C}}{\partial y}\right]dxdy$$

(the steady-state system coefficient matrix);

$$\{F\}=-\iint_D[N]^T\{\alpha_2\}dxdy+\int_\zeta[N]^T\{q\}d\zeta$$

(the boundary loadings vector);

Applying the Crank-Nicholson scheme, where θ is the implicitness coefficient, gives the following equation, where n refers to the present, n+1 to the future time - step, and Δt the computation time interval.

$$\left\{\frac{[T]}{\Delta t}+\theta[K]^{n+1}\right\}\{C\}^{n+1}=\left\{\frac{[T]}{\Delta t}-(1-\theta)[K]^n\right\}\{C\}^n+\theta\{F\}^{n+1}+(1-\theta)\{F\}^n \tag{4}$$

b. Bed shear stress. Several options are available for computing bed shear stresses using

$$\tau_b=\rho\left(u^*\right)^2 \tag{5}$$

where

ρ = water density

u^* = shear velocity

a. Smooth-wall log velocity profile,

$$\frac{\bar{u}}{u^*}=5.75\log\left(3.32\frac{u^*D}{\nu}\right) \tag{6}$$

which is applicable to the lower 15 percent of the boundary layer when

$$\frac{u^* D}{\nu} > 30 \qquad (7)$$

where

$\bar{u}$ = mean flow velocity

D = water depth

ν = kinematic viscosity of water

b. The Manning shear stress equation,

$$u^* = \frac{\sqrt{g}\ \bar{u}\ n}{CME\ D^{1/6}} \qquad (8)$$

where

g = acceleration due to gravity

n = Mannings roughness value

CME = coefficient of l.0 for metric units and l.486 for English units

c. A Jonsson - type equation for surface shear stress (plane beds) caused by waves and currents,

$$u^* = \sqrt{\frac{1}{2}\left(\frac{f_w u_{om} + f_c \bar{u}}{u_{om} + u}\right)\left(\bar{u} + \frac{u_{om}}{2}\right)} \qquad (9)$$

where

f_w = shear stress coefficient for waves

u_{om} = maximum orbital velocity of waves

f_c = shear stress coefficient for currents

d. A Bijker - type equation for total shear stress caused by waves and currents,

$$u^* = \sqrt{\frac{1}{2} f_c \bar{u}^2 + \frac{1}{4} f_w u_{om}^2} \tag{10}$$

For further information on the shear stress computation equations, see McAnally and Thomas (1980).

When RMA-2 has used the marsh porosity option (DM cards) shear stresses should be adjusted in the SED2D-WES simulation for more accurate estimates of the bed exchange. Therefore, the marsh porosity information must be provided (in appropriate units) and the program will compute the needed adjustments. The adjustment is made by computing a conveyance distribution within the marsh porosity depth distribution based on Manning's equation. This is then extended to a shear stress distribution that is averaged and a correction factor developed for the conventionally derived shear stress form one of the options above.

c. **The bed source.** The form of the bed source term, $S = \alpha_1 C + \alpha_2$, as given in Equation 1 is the same for deposition and erosion of both sands and clays. Methods of computing the alpha coefficients depend on the sediment type and whether erosion or deposition is occurring.

For **sand transport,** the supply of sediment from the bed (i.e., the sediment reservoir) is controlled by the transport potential of the flow and availability of material in the bed. The bed source term is

$$S = \frac{C_{eq} - C}{t_c} \tag{11}$$

where

S = source term

C_{eq} = equilibrium concentration (transport potential)

C = sediment concentration in the water column

t_c = characteristic time for effecting the transition

There are many transport relations for calculating C_{eq} for sand size material. The Ackers-White (1973) formula was adopted for this model because it performed satisfactorily in tests by WES and others (White, Milli, and Crabbe 1975; Swart 1976), because it seems to be complete, and because it is reasonably simple. The transport potential is related to sediment and flow parameters by the expressions in the following paragraphs.

The characteristic time, t_c , is somewhat subjective. It should be the amount of time required for the concentration in the flow field to change from C to C_{eq} . In the case of deposition, t_c is related to fall velocity. The following expression was adopted.

$$t_c = \text{larger of} \begin{cases} C_d \dfrac{D}{V_s} \\ \text{or} \\ DT \end{cases} \qquad (12)$$

where

t_c = characteristic time

C_d = coefficient for deposition

D = flow depth

V_s = fall velocity of a sediment particle

DT = computation time interval

In the case of scour, there are no simple parameters to employ. The following expression is used.

$$t_c = \text{larger of} \begin{cases} C_e \dfrac{D}{\bar{u}} \\ \text{or} \\ DT \end{cases} \qquad (13)$$

where

C_e = coefficient for entrainment

V = flow speed

For **clay transport,** deposition rates of clay beds are calculated with the equations of Krone (1962).

$$S = \begin{cases} -\dfrac{2V_s}{D} C \left(1 - \dfrac{\tau}{\tau_d}\right) & \text{for} \quad C < C_c \\ -\dfrac{2V_k}{D} C^{5/3} \left(1 - \dfrac{\tau}{\tau_d}\right) & \text{for} \quad C > C_c \end{cases} \qquad \text{(14) and (15)}$$

where

τ = bed shear stress,

τ_d = critical shear stress for deposition,

C_c = critical concentration = 300 mg/l.

Erosion rates are computed by a simplification of Partheniades (1962) results for particle by particle erosion. The source term is computed by

$$S = \frac{P}{D}\left(\frac{\tau}{\tau_e} - 1\right) \qquad (16)$$

where

P = erosion rate constant,

τ_e = critical shear stress for particle erosion.

When bed shear stress is high enough to cause mass failure of a bed layer, the erosion source term is

$$S = \frac{T_L \rho_L}{D \Delta t} \quad \text{for} \quad \tau > \tau_s \qquad (17)$$

where

T_L = thickness of the failed layer,

ρ_L = density of the failed layer,

Δt = time interval over which failure occurs,

τ_s = bulk shear strength of the layer.

d. **The bed model.** The sink - source term in Equation 1 becomes a source - sink term for the bed model, which keeps track of the elevation, composition, and character of the bed. Bed change computations utilize the Crank - Nicholson weighting of the time - step contributions.

Sand beds are considered to consist of a sediment reservoir of finite thickness, below which is a nonerodible surface. Sediment is added to or removed from the bed at rate determined by the value of the sink/source term at the previous and present time - steps. The mass rate of exchange with the bed is converted to a volumetric rate of change by the bed porosity parameter.

Clay beds are treated as a sequence of layers. Each layer has its own characteristics as follows:

a. Thickness.

b. Density.

c. Age.

d. Bulk shear strength.

e. Type.

In addition, the layer type specifies a second list of characteristics.

a. Critical shear stress for erosion.

b. Erosion rate constant.

c. Initial and 1 - year densities.

d. Initial and 1 - year bulk shear strengths.

e. Consolidation coefficient.

f. Clay or sand.

New clay deposits form layers up to a specified initial thickness and then increase in density and strength with increasing overburden pressure and age. Variation with overburden occurs by increasing the layer type value by one for each additional layer deposited above it. The original version of SED2D-WES and all previous versions of

STUDH did not perform ongoing consolidation. Rather, the age was specified and at the beginning of the simulation the parameters were computed. This strategy worked well when simulations were always relatively short because of historical limitations of computer resources. However, as computing power has evolved we now have included active consolidation during the model simulation. The present change in density with time is governed by the following equations:

$$\rho = \rho_f - \left(\rho_f - \rho_i\right)e^{-\beta t} \tag{18}$$

where

ρ = time - varying characteristic of density

ρ_e = density at some reference end time

ρ_f = final ultimate density = 1000 kg/m^3 default

t_o = starting time = zero

t_e = reference end time

t = time

β = consolidation coefficient, 1/sec

The consolidation coefficient β is computed from user input for initial density and density at the reference time by solving Equation 18 for β.

$$\beta = -\frac{1}{t_e}\ln\left[1 - \frac{\rho_e - \rho_i}{\rho_f - \rho_i}\right]$$

The bulk shear strength, QS, of the deposits is related to the density by the relation ship

$$\frac{QS_e}{QS_i} = \left(\frac{\rho_e}{\rho_i}\right)^{\alpha} \Rightarrow \alpha = \frac{\ln\left(QS_i\right) - \ln\left(QS_e\right)}{\ln\left(\rho_i\right) - \ln\left(\rho_e\right)}$$

were α is solved from these reference values above and the general form is obtained by replacing Qs_e and ρ_e with the time-varying values of each.

Mass deposition rates are converted to volumetric deposits by the specified density for the type 1 layer, and erosion rates are converted to a corresponding volume by the actual density of the eroding layer.

Use of the layer type can be used to control whether or not erosion and consolidation are allowed to occur, and to keep track of sand layers in a mixed bed problem. The layer structure and time - varying consolidation can be used to specify a subsidence rate for the modeled area.

e. Boundary Condition Buffering. In the case of tidally fluctuating flow across a model boundary the specification of an accurate concentration is not simple. In earlier versions of STUDH and SED2D-WES the boundary condition was either always specified or always not specified. If a node along the boundary had flow entering the model the normal convention would be to specify a concentration. However, in older versions when the tide turned and flow left the model that specification was still applied. This creates artificial conditions that lead to severe oscillations near the boundary.

In the current version (4.3) this situation has been addressed in two steps. First, the logic has been added to the code to allow the model to determine whether to apply the concentration specification (Dirichlet BC) or whether to apply a zero concentration gradient BC (von Neuman). The gradient BC allows the concentration to be solved from the interior concentration field of the model. This provides some relief; but strong concentration gradients reaching the boundary can result in abrupt jumps in the concentration as the tide turns to enter the model and the concentration returns to the Dirichlet specification. This is the result of not accounting for the concentration history of waters that have crossed the boundary.

In order to provide a form of memory of the concentration history under dynamic tidal conditions a method termed "*boundary condition buffering*" was developed. This technique assigns a finite (MBB parameter in the program include file) number of buffer chambers to each boundary node. The program maintains the specified nominal boundary concentration C_b in the last chamber. At the beginning of the simulation all buffer chambers are initialized to C_b. As flow leaves the model the concentration of the exiting water is stored in the first chamber and all remaining buffer chamber concentrations are shifted to the next higher chamber, keeping the last chamber at C_b. Then a mixing factor is applied to the chambers to simulate the diffusive processes external to the model. When the currents turn and begin to enter the model the chamber values are shifted back one chamber per time step and the mixing process repeated. This procedure results in memory of the history of concentrations crossing the boundary, delays full specification of the nominal boundary concentration C_b and generally provides more realistic boundary conditions. Furthermore, the buffering also provides a buffer for the changes that any plan alternatives to be tested may have on the boundary conditions.

f. One-Dimensional Elements. The ability to simulate 1D elements was added to SED2D-WES. The formulation assumes a trapezoidal cross section, consistent with the 1D formulation in RMA2. The implementation is provided as a convenience to allow the user to efficiently utilize the benefits of 1D elements in RMA2 for ease of domain discretization and boundary condition placement.

The 1D capability in SED2D-WES is not meant to give the ability to seriously model sediment transport as an alternative to HEC-6, for example, which is a fully developed 1D sediment model This simply allows for use of the benefits of simplified schematization.

The current formulation incorporates 1D junctions, and transitions to 2D elements. The formulation for control structures is not fully operational at this time.

3. PROGRAM USE

3.1 Introduction to Program Use

SED2D-WES can be used by engineers and scientists to solve sediment transport problems that are satisfactorily described as unsteady, suspended transport in two horizontal dimensions with bed interaction. Users are cautioned that the program is relatively easy to use but somewhat more difficult to use properly. Persons using the program are assumed to be familiar with using a computer system. Knowledge of basic concepts in numerical methods is necessary. It is essential that the user possess considerable knowledge of hydraulic and sedimentation processes and that he or she understand the computer program and its proper use. At least one person on the modeling team should be familiar with the prototype system being modeled. In order to supply data to the model, verify the model, and understand the model results it is usually necessary to undertake a complimentary data collection program. The adage “Garbage in, garbage out” applies here.

3.2 Use of the Modeling System

As mentioned previously, SED2D-WES requires that hydrodynamic data be externally supplied, usually by a numerical hydrodynamic model. The TABS-MD modeling sytem has been designed to satisfy this and other needs for a comprehensive modeling package. TABS-MD consists of RMA2-WES, a general purpose program for hydrodynamic modeling, in addition to SED2D-WES and a number of utility programs that develop input, translate data, analyze output, and provide graphical output from the models. Refer to the TABS-MD World Wide Web homepage for more information (http://hlnet.wes.army.mil/software/tabs/tabs.htm).

3.3 Input/Output Files for Executing SED2D-WES

SED2D-WES Version 1.1 is a FORTRAN program. It is compiled prior to execution time. The assignment of file names for all of the input and output files required by the program is accomplished interactively. Once the program is launched, the user will be queried (on the computer screen) to supply the names of the input and output files. A SED2D-WES run control file is always required, and its name will be requested first. This is the card image input for SED2D-WES described in this document. There are many other files that may or may not be required. The user specifies which ones will be required for a particular run within the run control file (see the description of the $L cards). Once the $L cards have been read, the program will continue to query the user for the names of the other requested files. To run SED2D-WES in batch mode, the user may create a master file containing the answers to the screen queries in the order that they are normally supplied when running in interactive mode. The master file is redirected to the program in place of the standard input file (the screen). For more information on file redirection refer to the operating system manual for your computer If the files specified are not in the directory from which the program was launched, then the full path to the files must be specified. Otherwise, the program will abort on input file reads.

Files created by the user (such as the SED2D-WES run control file) are usually created with an editor and consequently use the ASCII character set. These files can be transferred back and forth from one computer to another. This is handy when a “front end” computer is being used to create files that will eventually be passed to a batch processing computer. On the other hand, files that are referred to as “binary” or “unformatted” files are specific to the computer on which they were generated. These files cannot be transferred arbitrarily between computing platforms. Since SED2D-WES requires binary solution files created by GFGEN and RMA2-WES, the user should be aware that same type of computer should be used to run each of the models. This will ensure that the binary files are compatible between runs.

Table 1 shows the required and optional input data files for SED2D-WES.

Table 1: Standard Input Files

Generic File Name*	Standard Logical Unit	Contents	Status
screen or master file	depends on operating system (required)	User specified names of input and output files as requested on the $L cards. FORM= FORMATTED	OLD (created interactively by the user during program execution, or with an editor for batch processing)
project1.sed	9 (required)	SED2D-WES run control file. FORM= FORMATTED	OLD (created by the user: see users manual)
project0.gbn	10 (required)	Information about the numerical mesh geometry, connectivity, bathymetry, and material type associations. FORM= UNFORMATTED	OLD (created by GFGEN)
project0.sol	20 (required)	Information about the steady state or dynamic flow field. FORM= UNFORMATTED	OLD (created by RMA2-WES)
project0.cdb	30 (required to hotstart either concentration and/or bed change; not required for coldstart)	Information about the concentration field and the net bed change calculated from a previous SED2D-WES run. FORM= UNFORMATTED	OLD (created by SED2D-WES)
project0.bs	40 (required to hotstart clay bed structure; not required for coldstart)	Information about the clay bed structure calculated from a previous SED2D-WES run. FORM= UNFORMATTED	OLD (created by SED2D-WES)
project1.fch	50 (required for wave shear stress option; otherwise not required)	Information about wind fetch by node. FORM= FORMATTED	OLD (created by the user: see description of HS card)
project1.wnd	60 (required for wave shear stress option; otherwise not required)	Information about the wind speed and direction by node. FORM= FORMATTED	OLD (created by the user: see description of HS card)
project1.psc	70 (required for point source option; otherwise not required)	Information about the point source loadings. FORM= FORMATTED	OLD (created by the user: see description of PC card)

* These are examples only; the user may develop any organized file naming strategy.

Table 2 shows the required and optional output data files for SED2D-WES.

Table 2: Standard Output Files

Generic File Name*	Standard Logical Unit	Contents	Status
screen or screen output redirect	depends on operating system (required)	Run-time information for monitoring the progress of the SED2D-WES run. FORM= FORMATTED	UNKNOWN (created by SED2D-WES)
project1.out	15 (not required)	SED2D-WES printed output. FORM= FORMATTED	UNKNOWN (created by SED2D-WES)
project1.spn	55 (not required)	Special summary output by node. FORM= FORMATTED	UNKNOWN (created by SED2D-WES)
project1.spe	65 (not required)	Special summary output by element. FORM= FORMATTED	UNKNOWN (created by SED2D-WES)
project1.geo	75 (required to make a follow-on RMA2-WES run with new bathymetry; otherwise not required)	Saves a new GFGEN input geometry file with new bed elevations resulting from the SED2D-WES run. FORM= FORMATTED	UNKNOWN (created by SED2D-WES)
project1.cdb	35 (required to hotstart either concentration and/or bed change in a follow-on SED2D-WES run; otherwise not required)	Information about the concentration field and the net bed change calculated from a previous SED2D-WES run. FORM= UNFORMATTED	UNKNOWN (created by SED2D-WES)
project1.cdb	45 (required to hotstart clay bed structure in a follow-on SED2D-WES run; otherwise not required)	Information about the clay bed structure calculated from a previous SED2D-WES run. FORM= UNFORMATTED	UNKNOWN (created by SED2D-WES)

* These are examples only; the user may develop any organized file naming strategy.

3.5 Description of Card Image Input Data

Input to the program consists of card image data in data files. The following paragraphs describe the input data in detail.

Information cards (T1,T2,T3,$D). These cards contain descriptive information used to identify a model run. As many T1 and T2 cards can be used as are needed. The final title card must be a T3 card. Information on the T3 card is saved with the program output files (along with data management banners, if used), so it can be used to identify the data file. The $D card permits the user to tag the beginning date of simulation for information purposes (but this information is not used by the program).

Run control cards ($L1,$L2, $H, END, STOP, TO, TR, EF). These cards are used to control various aspects of program control. The $L1 and $L2 cards are used to specify which input and output files the program will use. The END card signals the end of the card list pertaining to a specific time step. One END card must be supplied for every time step. The STOP card signals the end of the card list pertaining to the entire simulation period.

The $H card is used to control HOTSTART runs of the program. In a coldstart, a model run begins fresh, not using the results of any previous run as a starting point. In a hotstart, some of the variables, such as concentration or bed thickness, begin with values that were computed in a previous run. The files needed for hotstarting a model run are written if so requested on the $L2 card . In order to make a hotstart run, first submit a coldstart model run in which bed structure and/or concentrations and bed elevation changes are saved (see $L2 card). Then submit a run with the appropriate hotstart switches on the $H card, and specify the appropriate hotstart unit numbers on the $L1 card.

In a coldstart run, all of the important processes must spin - up from an artificial condition such as a uniform sediment concentration field. The spin - up time is the length of time a simulation must run before the solution has recovered from the artificial initial condition. For example, in a sand bed problem, if the initial sediment concentrations are too low in one area the bed may erode during spin - up until an equilibrium concentration is reached. This may happen even if the prototype bed is stable in that area. To overcome this problem, a hotstart run would be made in which concentrations are hotstarted from the previous run, but bed structure and bed elevation changes are coldstarted.

The TO card specifies the frequency for printing the binary solution. The TR card specifies the frequency for printing to the ASCII output file, and provides the user with options for the volume of information to be printed. The primary purpose of the trace printout controls is to assist in diagnosing problems with a run, but they also provide for printing of some parameters that may be useful in interpreting model results. If a trace printout is selected, it will print only at the locations specified on the TRE, TRT and TRN cards if they are present (Note: the TRN and TRT cards are not fully operational in this version of SED2D-WES).

The EF card specifies two flags that affect how the computations proceed. The flag denoted as IHYDOPT permits the user to allow the flow field to be “adjusted” during the run. That is, as the bed moves up and down because of erosion or deposition, the depth of flow is adjusted at each node to maintain the same water surface elevation and the velocities are adjusted to maintain the same unit flow at each node. This option is included to be consistent with earlier versions of STUDH. Whether this adjustment is appropriate is a matter of significant differences in opinion, even among the authors of this documentation.

One side of the issue maintains that this artificial adjustment of the flow field can lead to numerical inaccuracies, and is physically unsupportable. That position **highly recommends** that the user choose the default option, IHYDOPT = 0. However, by choosing IHYDOPT = 0 the user must realize that he or she is accepting the assumption that the changes in the bed calculated by SED2D-WES are small, and they do not have a significant impact on the hydrodynamic solution. When the bed changes become large enough that this assumption is no longer valid, the user should stop the SED2D-WES run and generate a new hydrodynamic flow field using the new geometry file generated by SED2D-WES (which contains the new bed elevations). The user may then “hotstart” the sediment run using the new flow field and the initial conditions saved from the previous sediment run. This process is repeated until the whole period of simulation has been covered.

The counter position to the above argument is that by not adjusting the flow field the model may produce excessive erosion or deposition. As the sediment deposits, if the flow field is adjusted the velocities will increase, increasing the shear stress and potentially reaching a level that will inhibit further deposition. If the sediment is being eroded, then adjusting the flow field will result in lower velocity, lower shear stresses and potentially reach a level where erosion will be inhibited. The adjustment can provide some measure of control on excessive bed change. Both positions on the issue agree that the user must ultimately be responsible for interpreting the model results and insuring that when the bed changes reach a level where the hydrodynamics will be dramatically altered that the hydrodynamics are reassessed.

The second variable on the EF card is the DEPLIMIT variable. This variable causes the sediment run to abort when a “significant” bed change occurs at one or more nodes. That is, the user may specify a percentage of the total water column as the characteristic length beyond which the assumption of a pre-calculated flow field is no longer valid. The default is DEPLIMIT = 0.25, or when the bed change at a node is greater than 25% of the water depth at that node then the program will abort. The hotstart files requested on the $L cards will be saved, so that the user may generate a new hydrodynamic flow field and then “hotstart” the sediment simulation from the point when the depth tolerance was exceeded. For greatest accuracy, make DEPLIMIT as small as possible and generate new flow fields often.

c. Geometry cards (G1, GC,DM).

The G1 card allows the user to scale the coordinates provided in the GFGEN binary file by a constant value. The GC card allows the user to specify lists of nodes that define channel cross-sections. The GC cards are useful for specifying boundary conditions along cross-sections that lie on the mesh boundary. The DM cards are used to specify the marsh porosity parameters, using the same format as RMA2. However, the user must remember to convert the first three variables if the units are changes between RMA2 and SED2D-WES.

d. Timing and run length control (TZ card). The TZ card specifies the computational interval and number of time - steps to be run. Choice of a computational interval is dependent on the size of mesh cells used, speed of the flow, effective settling velocity of the sediment, and how well the modeler wishes to resolve small - scale bed features. It is recommended that the time interval for SED2D-WES be identical to the RMA2-WES time interval. To obtain the number of time-steps needed to reach a given length of run, use the equation

$$\text{No. of time-steps} = \frac{\text{Run Length}}{\text{Computational Interval}} + 1$$

e. Implicitness factor (TT card). The program uses the Crank-Nicholson time - stepping scheme that employs an implicitness factor. A value of 0.66 is recommended, but variations from 0.5 (equal weighting of this time - step and the previous time - step) to l.0 (no influence from the previous time - step) are permitted. A higher value of Theta produces results that are more stable but numerical (artificial) dispersion of sediment is increased.

f. Sediment size classes for sand (SA,SR,ST). The program requires that sediment sizes and/or their characteristics be specified. For noncohesive sediment bed problems, input allows for multiple grain sizes on the SA card, BUT AT PRESENT THE PROGRAM CONSIDERS ONLY ONE EFFECTIVE GRAIN SIZE. (The input reflects some changes that are planned for the SED2D-WES program, but are not currently functional). The grain size specified on the SA card is applied to every node in the mesh. Values at specific nodes may be changed by use of the SR and ST cards. The ST card specifies grain sizes to be used in noncohesive sediment transport equations and the SR card specifies the effective grain size to be used in bed roughness calculations (Ackers-White transport equations only). These two sizes will be the same only for plane beds in straight channels. Bed forms and channel curvature introduce form roughness that causes the roughness size to be larger than the size used for transport computations.

Note that the SA, SR, and ST cards constitute a cascading set of defaults. The SA card should precede the SR and ST cards. If neither an SR nor ST card is present, the grain size on the SA card will be used at all nodes for both transport and effective roughness. If SR cards are present, they override the roughness size on the SA card at those nodes specified. The ST cards override the transport size on the SA card at every node specified on the ST card.

Two characteristic length parameters are requested on the SA card. CLDE is the length factor for deposition. The default is a value of 1, corresponding to an average settling depth equal to the water depth. For fine sediments that are distributed throughout the water column, a value of 0.5 is recommended. For coarser sediments in less turbulent flows, a smaller value is suggested. CLER is the length factor for erosion. The default value of l0 is suggested, but more investigation is needed to find the best value.

g. **Settling velocity (WC cards).** Settling velocities are specified on the WC cards. This settling velocity is an effective fall velocity which goes up with grain size, goes down with increasing turbulence, goes up with increasing aggregation (cohesive sediments), and goes up if a too large value of CLDE is used. The best starting point for noncohesive sediments are fall velocities for spherical particles of equal diameters. For data on appropriate values for settling velocities see "Some Fundamentals of Particle Size Analysis," 1957, Committee on Sedimentation, Interagency Committee on Water Resources. For cohesive sediments, the settling velocity of particles can vary enormously with sediment type, salinity, turbulence, and other chemical and physical conditions. Laboratory or field tests are needed to define effective settling velocities.

h. **Cohesive sediment characteristics (CC and CI cards).** Figure 1 illustrates the relation between the various critical shear stresses for cohesive sediments. These values must generally be determined by laboratory or field experimentation, but published results for similar sediments can be used if caution is exercised. Values specified on the CC card for critical shear stresses for erosion and the erosion rate constant are overridden by those contained on the CI cards. The CC card should precede the CI cards. The CI cards are used to assign characteristics to various types of cohesive sediment bed layers. These characteristics are assigned to existing bed layers as specified on the CL cards and to new layers as they are deposited. Freshly deposited sediments are assigned a type 1 designation and increase to higher numbered types as the thickness of sediment above them increases. Data for the CI cards should come from laboratory tests on the sediments to be modeled.

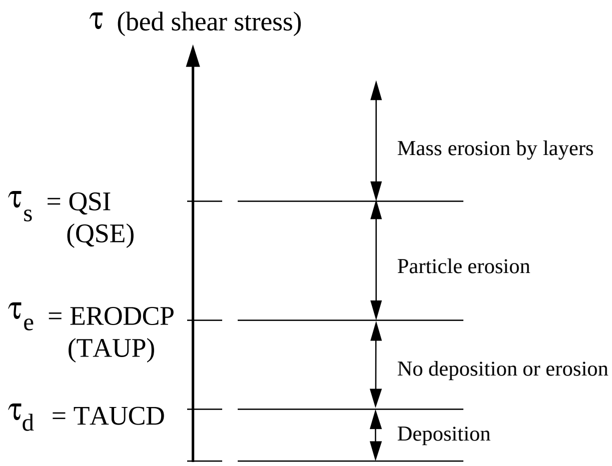

Figure 1. Cohesive bed behavior as a function of shear stress

Dry density as specified on the CI cards can be calculated by the following formula:

$$\rho_{dry} = \rho_S \frac{(\rho_B - \rho_w)}{(\rho_S - \rho_w)} \tag{19}$$

where

ρ_S = density of individual sediment particles

ρ_B = bulk (wet) density of sediment

ρ_w = density of water entrained in the sediment

Note that a lower density for layer types 1 - 4 will result in fluffier deposits, increased thickness of deposited layers, and greater bed change.

In the field, the density and shear strength of cohesive layers generally increase as they consolidate. The shifting to higher layer types in the program accounts for this, but the user must accurately specify the parameters for each layer type in order to obtain a realistic solution. The greatest accuracy will be achieved by specifying a larger number of layers, each having a small thickness. When a thin layer is filled up it will move down into the bed and be given a higher layer type, and the effect of the overburden will be calculated more accurately than if a small number of thicker layers are used.

i. Bed structure (SB and CL cards). The initial thickness of the sediment bed at the beginning of a run is specified on the SB (noncohesive) and CL (cohesive) cards. If that thickness is eroded, it is assumed that nonerodible rock has been reached. The CL cards specify which layer types (CI cards) are present, the thickness of each layer, and the age of each layer. In hotstart runs ($H card), the bed structure from a previous run is used and information on the CL and SB cards is disregarded.

j. Effective diffusion (ED, PE and DD cards). Diffusion of suspended sediment occurs because of turbulence in the flow field. When the transport equation is simplified by averaging over depth, as in SED2D-WES, dispersion is introduced because of vertical variations in the flow field and settling of the sediment through the water column. In practice, this effect is lumped together with turbulent diffusion and the effect of averaging in time and the combined effect is called dispersion or effective diffusion.. In this program, these various effects are combined in a pair of effective diffusion coefficients given on the ED card.

Selection of appropriate values for the dispersive coefficients is not a straightforward task. Elder (1959) gave approximate expressions for longitudinal (direction of flow) turbulent diffusion coefficients as

$$D_e = 5.93\ Du^* \tag{20}$$

and for the transverse (perpendicular to the flow direction) diffusion coefficient as

$$D_t = 0.23\ Du^* \tag{21}$$

where

D = water depth, and

u^* = shear velocity as given by equation 8.

Experimentally derived values of the constants in Equations 20 and 21 are often orders of magnitude greater than those given. This is attributed to nonuniformity of the flow, wind effects, wave effects, and so on.

In choosing an effective diffusion coefficient to use in numerical modeling, consideration must also be given to the mesh cell size. Exact relations are not available, but generally, larger element sizes require larger diffusion coefficients.

Allen Teeter of the WES Hydraulics Laboratory has suggested that an equation of the form

$$D_e = \mathrm{K}_1\left(\mathrm{K}_2 D u^* + 10^{-5} \; l^{\,2}\right) \tag{22}$$

where

λ = the element size

K_1 and K_2 = constants

This formulation is provided through the DD card, where the variables K_1, K_2 and K_3 (10^{-5} above) are specified.

Equations 20 through 22 differentiate between dispersion coefficients parallel and transverse to the direction of flow. Since the coefficients in the present version of SED2D-WES apply in the x - and y - directions, not necessarily in the flow directions, these equations can be used only as a guide.

Fortunately, in most applications, effective diffusion is smaller than convection by the calculated flow velocities, so a wrong choice does not affect the results very much unless the chosen coefficient is far too large. The best approach then is to use a moderately high value (say 50 m^2/sec) during the first few runs, then reduce the coefficients until the run becomes numerically unstable. This will allow the user to determine a range of values for which the model gives a converged solution. The user can then perform sensitivity analyses to determine how the solution changes as the effective diffusion is varied over this range. If the solution does not vary greatly then the model is “insensitive” to this coefficient, and no further testing is needed. If the solution varies widely as this coefficient is varied then the user must rely upon validation of the model against field measurements in order to determine the appropriate values. If no field data is available for comparison, the user should use as small a value as possible, effectively de-emphasizing the importance of these terms in the overall solution of the system of equations.

The PE card provides a method of specifying the effective diffusion in an automatic fashion based on the Peclet number:

$$P_e = \frac{l\,\bar{u}}{D_e}$$

If the user specifies the Peclet number, then the effective diffusion is

$$D_e = \frac{l\bar{u}}{P_e}$$

which provides generally for the diffusion coefficient proportional to the current velocity. However, as prescribed on the PE card there is a minimum value of De based on a specified minimum velocity (VPEC).

Table 3 lists some previous applications and the effective diffusion coefficients that were used.

Table 3

Example Dispersion Coefficients

Typical Location	Current Speed, mps	Typical Element Size, km	Dispersion Coefficient m^2sec
Medium-size river	1 - 1.5	0.1 - 0.5	100
Open bay	0.5 - 1.0	0.75	100
Tidal river	0.2 - 1.0	0.1 - 0.3	5 - 10

k. Initial concentration (IC cards). The nodal concentrations at the first time-step are specified on the IC cards, or in a file if a hotstart is used.

Depending on the length of a run, the initial concentrations can have a significant effect on the results. If they are too high, deposition will be high for the first few time - steps. The run should be long enough to overcome start - up anomalies. If the initial concentrations are too low, the model may artificially erode the bed until an equilibrium concentration is reached. It is best to use field data to obtain an approximation to the actual initial concentrations; to make a spin-up run to stabilize the concentrations (see $H card), then hotstart the run that simulates the period of interest.

l. Boundary conditions (BC cards). BC cards are used to prescribe concentrations at the water boundaries of the models. Concentrations need not be specified at land boundaries. Boundary concentrations should be based on field measurements.

If sand concentrations are too low on an incoming flow boundary, the model will erode material from the bed (if the specified bed thickness is adequate) to transport a volume of sediment that is equal to the bed material transport capacity. If sand concentrations are too high, the excess material will deposit, again bringing the concentration to that needed to satisfy transport capacity. The rows of computational elements near the boundaries will have erroneous deposition/erosion effects under these conditions. For example, a too-high boundary concentration will form a delta at the inflow point. If the model run is long enough, the delta will propagate throughout the area of interest, producing erroneous results. The boundaries should be sufficiently removed from the problem area and an attempt should be made to adjust boundary concentrations that are seriously different from near-equilibrium conditions. This process does not apply to cohesive sediments.

For boundaries at which there is always flow out of the model, for example, a downstream section in a nontidal river, boundary concentrations can be left unspecified, and the program will calculate the outflowing concentrations. However, invoking *boundary condition buffering* for tidal situations is controlled by the variables IBCFACT and BCFACT on the BC card.

3.6 Description of Output

Output from a model run consists of summaries of input data, computed parameters, and computed results. Input data summaries include an echo of all card image input data and a tabulation of options and sediment characteristics that have been chosen. A number of data set codes are output that are of use primarily in debugging. A listing of program dimensions is provided and data management system banners from input files (geometry, hydrodynamics, and hotstart data) are printed. These summaries should be carefully reviewed to ensure that input data were correctly specified and interpreted by the program.

At selected time-steps, some results and some associated parameters are printed for selected elements, if requested on the TRE card. Standard results output includes suspended sediment concentration in kilograms per cubic meter at the nodes, flow speed in meters per second; water depth in meters; total bed change in meters from the start of the run; volume of bed change in cubic meters for the elements; and net bed change (algebraic sum) and gross bed change (sum of absolute values) in cubic meters over the entire mesh to that point in the run.

A number of specialized output results are available through the trace printout (TR) cards. Most are detailed listings of the input data or parameters calculated from input data.

4.0 REFERENCES

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5.0 NOTATION

α_1 = coefficient for the source term 1/sec

α_2 = equilibrium concentration portion of the source term kg/m^3/sec

C = Chezy roughness coefficient

c = concentration of sediment, kg/m^3

CME = coefficient of 1 for metric units and l.486 for English units

C_c = critical concentration = 300 mg/l

C_d = coefficient for deposition

C_e = coefficient for entrainment

C_{eq} = equilibrium concentration

$\hat{C}$ = approximate concentration in an element as evaluated from the shape functions and nodal point values of c

D = water depth

D_s = effective grain size

D_x = effective diffusion coefficient in x-direction, m^2/sec

D_y = effective diffusion coefficient in y-direction, m^2/sec

DT = computation time interval

t = time

f(t) = time-varying characteristic

f_c = shear stress coefficient for currents

f_w = shear stress coefficient for waves

GP = transport potential

GS = transport capacity

g = acceleration due to gravity

i = number of grain size class

M = consolidation coefficient

N = quadratic shape functions

NE = total number of elements

NL = total number of boundary segments

n = Mannings roughness value

P = erosion rate constant

PI = percent of bed surface covered by grain size, expressed as a function

Q = $\left(\hat{C}/\Delta t\right) + \alpha_2$ for the transient problem

q_i^s = flux from source on boundary i

ρ	= water density
L	= density of the failed layer
S	= source term
T_1	= thickness of the failed layer
t	= time, sec
t_c	= characteristic time
t_o	= time zero
t_1	= time, 1 year
τ	= bed share stress
τ_d	= critical shear stress for deposition
τ_e	= critical shear stress for particle erosion
τ_s	= bulk shear strength of the layer
u	= flow velocity in x-direction, m/sec
u_{om}	= maximum orbital velocity of waves
u_*	= shear velocity
v	= flow velocity in y-direction, m/sec
γ	= kinematic viscosity of water
V_k	= $V_s/(C_c)^{4/3}$
V_s	= fall velocity of a sediment particle
V	= mean flow velocity
x	= primary flow direction, m
y	= direction perpendicular to x , m
ζ	= local coordinate

6.0 USERS MANUAL / DATA CARDS

This SED2D-WES version is in Beta test mode.

Please report problems to tabs@chl.wes.army.mil.

Date of last documentation revision is Monday 20 April 1998.

BETA VERSION 4.3 NOTE:

This version of SED2D is designed to work with the SMS Graphical User Interface. If you are using FastTABS you will need to convert the binary “concentration/delbed” file to a different format in order to view your results within FastTABS. A utility program call “v12_2_ft.exe” has been developed to accomplish this. This utility program will yield a solution file that FastTABS recognizes as an RMA4 file, where

concentration 1 = suspended sediment concentration (ppt),

concentration 2 = cumulative bed elevation change (feet),

concentration 3 = bed shear stress (kg/ m sec^2).

To run the conversion program, simply type “v12_2_ft.exe<cr>“, then answer the questions from the screen. If you are using SMS you can view the “concentration/delbed” file generated by SED2D directly from within SMS.

However, note that SMS will convert the bed change units to be the same as specified in the geometry file (SI card). The program v12_2_ft.exe converts from meters to feet, regardless of units.

T1-T3 CARD **TITLE DESCRIPTION** **T1-T3 CARD**

A “T” card must be the first user input line in the primary SED2D-WES run control file. Any number of T1 and T2 lines may be used and the sequence is not significant. Only one T3 line may be used, and it must be the last title line in the set. The program reads the ‘3’ as meaning the END of the “t” cards.

T3 Required

Field	Variable	Value	Description
0,C1	IC1	T	Card group identifier
0,C2	IC3	1,2,3	
1	TITLE	A	Any alpha-numeric data, up to 77 characters

$D CARD **START DATE CONTROL** **$D CARD**

This data may be included for the benefit of the user to distinguish between runs. It is not used by SED2D.

Not Required

Field	Variable	Value	Description
0,C1-3	IC1	$D	Card group identifier
1	IYR	+	Last 2 integers digits of the year of simulation. Used for run identification purposes only.
2	IMO	+	Month
3	IDA	+	Day
4	IHR	+	Hour
5	IMN	+	Minute
6	ISC	+	Second

$H CARD **HOTSTART CONTROL** **$H CARD**

The parameters on this card cause the program to read a previously computed solution to use as the initial condition for the current run (HOTSTART)

Required for hotstart

Field	Variable	Value	Description
0,C1-2	IC1	$H	Card group identifier
1	KCHOT	+	Hotstart sediment concentration
		0	Do not hotstart concentration
2	KDBHOT	+	Hotstart bed change (delbed)
		0	Do not hotstart bed change
3	KBSHOT	+	Hotstart bed structure (applicable for cohesive only)
		0	Do not hotstart bed structure

NOTE: The previous run must have saved output file (see $L1 and $L2 cards) of the desired parameters.

$L1 CARD **INPUT FILE CONTROL** **$L1 CARD**

Active parameters on this card cause the program to read data from the requested file. The user will be asked to interactively supply file names for the requested files.

Required

Field	Variable	Value	Description
0,C1-3	IC1	$L1	Card group identifier
1	ING	+	GFGEN binary geometry. (Input LU= 10. No default) *See note below.*
		0	Off (GNN and GE cards required)
2	INRMA2	+	RMA2 binary hydrodynamic. (Input LU = 20. No default) This file is mandatory
3	INHOT	+	HOTSTART Concentration/Delbed binary (Input LU = 30)
		0	Off (This is the default)
4	INHOTB	+	HOTSTART Bed structure binary (Input LU = 40)
		0	Off (This is the default)
5	INFETCH	+	Wind fetch (Input LU = 50)
		0	Off (This is the default)
6	INWIND	+	Wind speed and direction (Input LU = 60)
		0	Off (This is the default)
7	INPSC	+	Point source concentration (Input LU = 70)
		0	Off (This is the default)

NOTE: One-dimensional elements are currently not supporte by SED2D-WES. Any one dimensional elements within the mesh will be modified to have material type = 0 when the geometry file is read in.

$L2-CARD **OUTPUT FILE CONTROL** **$L2 CARD**

Active parameters on this card cause the program to write data to the requested file. . The user will be asked to interactively supply file names for the requested files.

Required

Field	Variable	Value	Description
0,C1-3	IC1	$L2	Card group identifier
1	IOUT	+	Full print (Output LU = 15. This is the default)
		0	Off
2	KSPN	+	Summary node print requested via TRN-card (Output LU = 55)
		0	Off (This is the default)
3	KSPE	+	Summary element print requested via TRE-card (Output LU = 65)
		0	Off (This is the default)
4	KGEOM	+	Save new GFGEN input with new bathymetry update (Output LU = 75. This is the default)
		0	Off
5	KPU	+	Save concentraiton and del-bed solution (Output LU [binary] = 35. This is the default)
		0	Off
6	KOHOTB	+	Save bed structure solution (Output LU [binary] = 45. This is the default)
		0	Off

NOTE: A scratch file (file code NSCR = 2) is created if the parameter variable NBS is set too small to fit the problem in memory. The $M-card is controls the way this scratch file is handled.

$M-CARD **MACHINE IDENTIFIER** **$M CARD**

NOTE: the optimization for different machines that is implied by this card is not fully implemented in this version of SED2D-WES. This card is supported in anticipation of future model enhancements. It is listed as required in order that files created for this version of the model will be compatible with future versions.

Required

Field	Variable	Value	Description
0,C1-2	IC1	$M	Card group identifier
1	IVRSID	1	Direct access record length unlimited, and defined in terms of bytes. Examples systems are: DOS PC
		2	Direct access record length unlimited, and defined in terms of short words (2 bytes). Example systems are: Prime mini-computers
		3	Direct access record length limited to 32 bytes, and defined in teems of long words (4 bytes) Example systems are: DEC Vax
		4	Direct access defined using multiple sequential access file that are opened as required. Note that this may generate and leave many file on disc. Example systems are: APPLE MAC II under ABSOFT FORTRAN, Definicon 020 beard, DEC Vax to avoid short record lengths. HP Workstation
		5	Direct access defined for a system using 64 bit or 8 byte words and where record lengths are defined in bytes

Example systems are:

Cray Y-MP or Cray C90

6 Direct access defined using multiple sequential access files that are opened as required. Note that this version does not put a period (.) in the file names. It may generate and leave many files on disc.

Example systems are:

CDC Cyber

8 Same as 4 except PAUSE statement is activated

MacIntosh PC

BC CARD **BOUNDARY CONDITIONS** **BC CARD**

Boundary condition control, parameters may be specified by node or by continuity line number, for which sediment concentration will be specified. Initial and dynamic solutions.

Required

Field	Variable	Value	Description
0,C1-2	IC1	BC	Card group identifier
0,C3	IC3	L	Option 1: Boundary condition control, parameters specified by continuity line number for which concentration will be specified. Initial and dynamic solutions.
		N	Option 2: Boundary condition control parameter specified by node number.
1	J	+	node or continuity line number
2	SPEC (J)	+	Sediment Concentration (ppt)
3	IBCFACT	0,1	Switch for *boundary buffering*; 0 off, 1 on
		blank	Default = 0
4	BCFACT	+	*Boundary buffering* chamber mixing factor
		blank	Default = 0 is the only option at this time

NOTE: GC card must precede BCL card type.

CC CARD **CLAY CHARACTERISTICS** **CC CARD**

Active parameters on this card cause the program to use the specified parameter values in place of the default values.

Required for clay

Field	Variable	Value	Description
0,C1-2	IC1	CC	Card group identifier
1	MTCL	1	Original Krone and Partheniades equations for deposition and erosion. This is the only valid option in the present version of SED2D-WES.
2	MNCL	≥ 0	Maximum number of consolidating layers (<10)
		< 0	Default = 4
3	TAUCD	≥ 0	Critical shear stress for deposition
		< 0	Default = 0.06 newton/sq m
4	ERODCP	≥ 0	Critical shear stress for particle erosion
		< 0	Default = 0.06 kg/sq m/sec
5	EROCON	≥ 0	Constant for the erosion equation
		< 0	Default = 0.002 kg/sq m/sec

CI CARD **CLAY CHARACTERISTIC by ID** **CI CARD**

Active parameters on this card cause the program to use the specified parameter values in place of the default values.

Required for clay

Field	Variable	Value	Description
0,C1-2	IC1	CI	Card group identifier
1	IDCL	≥ 0	ID type number (#1 is freshly deposited and unconsolidated) If IDCL > MNCL (CC card) do not consolidate
2	THKTYPE	≥ 0	Typical layer thickness (m) for this id type
		< 0	Default = .03 meters
3	TAUP	≥ 0	Bed shear stress at which cohesive particles begin to erode (newtons/sq m)
		< 0	Default = 0.06 n/m^2
4	PERC	≥ 0	Erosion rate constant for particle erosion
		< 0	Default = 0.002 kg/m^2/sec
5	QSI	≥ 0	Bed shear stress at which cohesive layers begin to erode in mass (newtons/m2)
		< 0	Default = 0.06,.12,.41, and 3.4 for layers 1 through 4 and 3.4 (n/m^2) for layers 5 through MNCL
6	QSE	≥ 0	Bed shear stress at which cohesive at age = 1 year begin to erode in mass (n/m^2
		< 0	Default = 1.1 x QSI values (see above)
7	RHOI	≥ 0	Initial dry density of a deposit of this type of cohesive material (kg/m^3)

		< 0	Default = 90, 108, 144, and 263 for layers 1 through 4 and 402 for layers type 5 through MNCL
8	RHOE	≥ 0	The consolidated dry density of deposits of this type of cohesive material at age = 1 year.
		< 0	Default = 1.1 times default values for RHOI (above)
9	CCC	≥ 0	Consolidation coefficient relating the change from RHOE and QSE to time in years
		< 0	CCC=reference time (***days***) for QSE and RHOE

NOTE: Values of the variables in Fields 5-8 vary widely among sediment types. The default values may be wrong for a given sediment. ID types are numbered such that the highest number is the deepest core.

NOTE: CC card should precede CI cards.

CL CARD **CLAY DISTRIBUTION BY LAYER** **CL CARD**

Active parameters on this card cause the program to use the specified parameter values in place of the default values.

Required for clay

Field	Variable	Value	Description
0,C1-2	IC1	CL	Card group identifier
C3		b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT J
		E	Option 3: Explicit assignment for Element J
		N	Option 4: Explicit assignment for Node J
1	J	+	Starting or explicit value
2	LAYER	+	Layer number to be applied to J
3	ITYPE	+	Layer ID type (see CI-card)
4	THICKL	≥ 0	Layer thickness (m)
		< 0	Default value from CI card used
5	AGE	≥ 0	Layer age (years)
		< 0	Default = 0.0

NOTE: Layer numbers are arranged such that the highest number is the first to erode.

NOTE: CI cards should precede CL cards.

CO CARD **COMMENTS** **CO CARD**

Comments may be supplied on this card anywhere within the run control input, except as the first card.

Not required

Field	Variable	Value	Description
0,C1	IC1	CO	Card group identifier
1	FLD	A	Any alpha-numeric data, up to 77 characters

NOTE: Comments may be incorporated on the same line as the END-card

DD CARD **EFFECTIVE DIFFUSION COEFFICIENT VIA EQ 22** **DD CARD**

Optional

Field	Variable	Value	Description
0,C1-2	IC1	E DD	Card group identifier
0,C3	IC3	b/	Option 1 Global: Starting with node = J
		T	Option 2 Explicit by material type = J
		E	Option 3: Explicit assignment for Element = J
		N	Option 4: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	DK1 (J)	≥ 0	Turbulent exchange coefficient K1 in Eq. 22 (units = m^2/sec)
		< 0	Default = 1.0
3	DK2 (J)	≥ 0	Turbulent exchange coefficient K2 in Eq. 22
		< 0	Default = 5.0
4	DK3(J)	≥ 0	Turbulent exchange coefficient K3 in Eq. 22
		< 0	Default = 10^{-5}

DM CARD **MARSH POROSITY PARAMETERS** **DM CARD**

Optional

Field	Variable	Value	Description
0,C1-2	IC1	DM	Card group identifier
0,C3	IC3	b/	Option 1 Global: Starting with node = J
		T	Option 2 Explicit by material type = J
		E	Option 3: Explicit assignment for Element = J
		N	Option 4: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	AC1 (J)	≥ 0	Offset depth from mean elevation (m)
		< 0	Default = 3.0
3	AC2 (J)	≥ 0	Marsh surface depth range (m)
		< 0	Default = 2.0
4	AC3(J)	≥ 0	Minimum fractional area for marsh
		< 0	Default = 0.05
5	AC4(J)	≥ 0	Override minimum elevation
		< 0	Default = 0.0

ED CARD **EFFECTIVE DIFFUSION COEFFICIENT** **ED CARD**

Required

Field	Variable	Value	Description
0,C1-2	IC1	ED	Card group identifier
0,C3	IC3	b/	Option 1 Global: Starting with node = J
		T	Option 2 Explicit by material type = J
		E	Option 3: Explicit assignment for Element = J
		N	Option 4: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	DIF (J,1)	≥ 0	Turbulent exchange coefficient in X direction (X plane). (units = m^2/sec)
		< 0	Default = 0.0
3	DIF (J,2)	≥ 0	Turbulent exchange coefficient in Y direction (Y plane). (units = m^2/sec)
		< 0	Default = 0.0

EF CARD **ERROR FLAGS** **EF CARD**

Not required

Field	Variable	Value	Description
0,C1-2	IC1	EF	Card group identifier
2	IHYDOPT	1	The hydrodynamic flow field is "adjusted" during the SED2D run such that as the bed moves up and down the depth of flow is changed and the velocities are changed to preserve the same unit flow as was calculated by RMA2. **This option is NOT recommended** and is supplied here only to be consistent with earlier versions of STUDH. Two types of errors occur when using this option 1) the flow field is no longer a true solution to the shallow water equations, and thus mass is not conserved according to the finite element formula; 2) as sediment deposits in backwater areas this adjustment will cause velocities to increase over the sediment bed which may artificially reduce the rate of deposition, or even erode the newly deposited bed. Advanced users: go ahead and use it, but be aware.
		0	No adjustment of the hydrodynamic solution is performed during the SED2D run. The implicit assumption of the model is that the change in the bed geometry is small enough that it does not significantly affect the flow field. When significant erosion or deposition does occur, the user should stop the SED2D run and rerun RMA2 using the new bed geometry generated by SED2D. (See the definition of DEPLIMIT below to establish a stopping criterion). This is the default value.
3	DEPLIMIT	≥ 0	Execution of the program is stopped when the bed change (due to either erosion or deposition) at any node exceeds DEPLIMIT*(the water column depth at that node). This check prevents the user from continuing to caculate the sediment transport based on a hydrodynamic solution that is not valid for the current bed geometry. When this criterion is exceed the user should re-run RMA2 using the new bed geometry generated by SED2D.
		< 0	Default = 0.25

NOTE: If no EF card is present the default values will be assigned.

END CARD **END OF TIME STEP SEPERATION** **END CARD**

This card signals the end of boundary input for a given time step.

Required

Field	Variable	Value	Description
0,C1-2	IC1	EN	Card group identifier
0,C3	IC3	D	Card group identifier
1-10	ENDCOM	A	May be used for comments

FD CARD **FLUID DENSITY** **FD CARD**

Not required

Field	Variable	Value	Description
0,C1-2	IC1	FD	Card group identifier
0,C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 3: Explicit assignment for Element = J
		N	Option 4: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	RHO (J)	≥ 0	Fluid Density at location J (units = kg/m^3)
		< 0	Default = 1000.00 kg/m^3

NOTE: If no FD card is present the default value will be assigned globally.

FT CARD **FLUID TEMPERATURE** **FT CARD**

Not required

Field	Variable	Value	Description
0,C1-2	IC1	FT	Card group identifier
0,C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 3: Explicit assignment for Element = J
		N	Option 4: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	WTC	≥ 0	Fluid temperature in degrees centigrade at location J
		< 0	Default = 10 degrees centrigrade

NOTE: If no FT card is present the default value will be assigned globally.

G1 CARD **GEOMETRY, NODAL SCALE FACTOR** **G1 CARD**

Not required

Field	Variable	Value	Description
0,C1-2	IC1	G1	Card group identifier
1	XSCAL:E	> 0	Scale factor for X coordinate input
		≤ 0	Default = 1.0
2	YSCALE	> 0	Scale factor for Y coordinate input
		≤ 0	Default = 1.0

NOTE: If no G1 card is present, the default values will be applied.

GC CARD GEOMETRY, CONTINUITY CHECK LINES GC CARD

Code corner nodes only. Code all lines in the same direction. The lines will be numbered (J = 1, number of lines) according to their order of appearance in this file.

Automatic calculation of the sediment flux across a continuity check line is not available in current version of SED2D-WES. At some future date the capability will be added to calculate flux at up to MCC lines across part or all the grid with up to MCCN nodes per line. The flux through the first continuity check line that is specified will be used as a reference load for all subsequent continuity lines (as in RMA2). Code all lines in the same direction to ensure a consistent sign for the flux direction. . In general, code left to right when facing downstream.

Not required

Field	Variable	Value	Description
0,C1-2	IC1	GC	Card group identifier
1	NNL	+	Number of corner nodes to be specified in this continuity line.
2 to NNL plus 1	Line (J,K)	+	List of corner nodes which define line segments for automatic generation of boundary conditions (K = 1, NNL).

NOTE: If a continuation line is necessary, start the next corner node in field1 of the next GC card.

GE CARD **GRID, ELEMENT CONNECTION TABLE** **GE CARD**

The element connection table will usually be provided by the GFGEN pre-processor and will reside on logical unit ING on the $L1-card. If so, omit GE and GNN cards.

Not required

Field	Variable	Value	Description
0,C1-2	IC1	GE	Card group identifier
1	J	+	Element number
2-9	NOP (J,K)	+	Up to 8 node numbers for element J, listed counterclockwise around the element starting from any corner.
10	IMAT (J)	+	Element material type
11	TH (J)	+	Direction of eddy viscosity tensor in RMA2. Optional, may be specified on the GV card. Radians, counter-clockwise from the X-axis. For 1D elements, the direction is automatically aligned with the orientation of the 1D element

NOTE: Use GE and GNN cards only to create simple grids for model testing. SED2D-WES does not contain grid generation or band width optimization routines.

GNN CARD **GEOMETRY, NODAL COORDINATE** **GNN CARD**

The coordinate values read from this card are multiplied by the appropriate scale factors, XSCALE and ZSCALE from the G1 card, and should result in the proper X and Y coordinates (units are determined by the SI card) after transformation.

Not required

Field	Variable	Value	Description
0,C1-2	IC1	GN	Card group identifier
0,C3	IC3	N	Card group identifier
1	J	+	Node number
2	CORD (J,1)	+	The X node coordinate (m or ft).
3	CORD (J,2)	+	The Y nodal coordinate (m or ft)
4	ELEV (J)	+	The bottom elevation at node J (m or ft)

NOTE: Use GE and GNN cards only to create simple grids for model testing. SED2D-WES does not contain grid generation or band width optimization routines.

HN CARD **HYDRAULIC ROUGHNESS (N-Value)** **HN CARD**

Required for MSC = 2 (see HS card)

Field	Variable	Value	Description
0,C1-2	IC1	HN	Card group identifier
0,C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 2: Explicit assignment for Element = J
		N	Option 2: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	XNVALU (J)	≥ 0	Manning’s n-value for location J
		< 0	Default = 0.0

SED2D-WES applies Manning’s n-values by node. The node will retain the n - value it receives from the last HN card that affects that node.

HS CARD **HYDRAULIC RED SHEAR STRESS** **HS CARD**

Required

Field	Variable	Value	Description
0,C1-2	IC1	HS	Card group identifier
1	MSC		Code the option number for shear stress computation
		1	Log-velocity distribution for a smooth wall (This is the default)
		2	Manning equations (HN-cards are required)
		3	Wave shear stress by ACKRSHR. Wind direction, speed, and wind fetch must be specified in INWIND and INFETCH files (see $L1 card). See subroutine JONFW for descriptions of these files.

IC CARD **INITIAL CONDITIONS** **IC CARD**

Required for coldstart

Field	Variable	Value	Description
0,C1-2	IC1	IC	Card group identifier
0,C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 2: Explicit assignment for Element = J
		N	Opiton 2: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	CONC (J)	≥ 0	Initial suspended sediment concentration for location = J (kg/m^3)
		< 0	Default = 0.0 kg/m^3

PC CARD **POINT SOURCE CONTROL** **PC CARD**

Not required

Field	Variable	Value	Description
0,C1-2	IC1	PC	Card group identifier
1	NSRC		Point source control
		≥ 0	Number of point sources (supply point source data file in file INPSC - see $L1 card)
		< 0	Default = 0

NOTE: The format of the INPSC file is (I10,F10.0), where the integer is the element where the source is located and the real variable is the mass load of the source in kg over the time step. Specify one source per line, and NSRC lines per time step.

PE CARD — EFFECTIVE DIFFUSION COEFFICIENT VIA PECLET NUMBER — PE CARD

Optional

Field	Variable	Value	Description
0,C1-2	IC1	PE	Card group identifier
0,C3	IC3	b/	Option 1 Global: Starting with node = J
		T	Option 2 Explicit by material type = J
		E	Option 3: Explicit assignment for Element = J
		N	Option 4: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	XPEC (J)	≥ 0	Peclet Number
		< 0	Default = 0.0
3	VPEC (J)	≥ 0	Minimum velocity to use in computing Effective Diffusion units = m/sec
		< 0	Default = 0.0
4	DIF(j,1)	≥ 0	Diffusion scaling factor; applied to Peclet derived De
		< 0	Default = 0.0
5	DIF(j,2)	≥ 0	Diffusion scaling factor; applied to Peclet derived De
		< 0	Default = 0.0

PV CARD **PHYSICAL VARIABLES** **PV CARD**

Active parameters on this card cause the program to use the specified parameter values in place of the default values.

Not required

Field	Variable	Value	Description
0,C1-2	IC1	CA	Card group identifier
1	ACGR	≥ 0	Acceleratrion due to gravity (m/sec2)
		< 0	Default = 9.807 m/sec^2

SA CARD **SAND CHARACTERISTICS** **SA CARD**

Active parameters on this card cause the program to use the specified parameter values in place of the default values.

Required for sand

Field	Variable	Value	Description
0,C1-2	IC1	SA	Card group identifier
1	MTC	7	Ackers-White transport function. This is the only option available in the current version of SED2D-WES.
2	SACLL	≥ 0	Minimum sand grain size for NSACI
		< 0	Default = 0.0625 mm. *See note below.*
3	SACUL	≥ 0	Maximum sand grain size for NSACI
		< 0	Default = 0.0625 mm. *See note below.*
4	NSACI	+	Class number. The class interval is calculated for the log of particular sizes. *See note below*
5	SGSA	≥ 0	Specific gravity of sand grains
		< 0	Default = 2.65
6	GSF	≥ 0	Grain shape factor
		< 0	Default = 0.67
7	CLDE	≥ 0	Characteristic length factor for deposition
		< 0	Default = 1 times the depth
8	CLER	≥ 0	Characteristic length factor for erosion
		< 0	Default = 10 times the depth

NOTE: The current version of SED2D-WES handles only one size class. Therefore NSACI must equal 1, and SACLL must equal SACUL. A multiple grain size algorithm is under development.

SB CARD **SAND BED THICKNESS** **SB CARD**

Required for sand

Field	Variable	Value	Description
0,C1-2	IC1	SB	Card group identifier
C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 3: Explicit assignment for Element = J
		N	Option 4: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	TTHICK(J)	≥ 0	Sand bed thickness in meters
		< 0	Default = 0.0 m

SR CARD **SAND GRAIN SIZE FOR ROUGHNESS** **SR CARD**

Required for sand

Field	Variable	Value	Description
0,C1-2	IC1	SR	Card group identifier
0,C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 2: Explicit assignment for Element = J
		N	Option 2: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	EFDR(J)	≥ 0	Effective grain size for roughness (mm)
		< 0	Value of SACLL from SA card will be used

NOTE: SA card must precede SR card.

ST CARD **SAND GRAIN SIZE FOR TRANSPORT** **ST CARD**

Required for sand

Field	Variable	Value	Description
0,C1-2	IC1	ST	Card group identifier
0,C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = j
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 2: Explicit assignment for Element = J
		N	Option 2: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	EFDT(J)	≥ 0	Effective grain size for transport (mm)
		< 0	Value of SACLL from SA card will be used

NOTE: SA card must precede ST card.

SI CARD **SYSTEM INTERNATIONAL UNITS** **SI CARD**

Required

Field	Variable	Value	Description
0,C1-2	IC1	SI	Card group identifier
1	METRIC		Units for binary input.
		0	The GFGEN binary geometry file and the RMA2 binary solution file are expected to be in English units. The data from these files will be converted to metric units upon being read. Other parameters specified on cards should be input according to the units specified in this manual. SED2D-WES output will be in Metric units, except for the new GFGEN geometry created on unit KGEOM (see the $L2 card). The KGEOM file will revert to English units if METRIC = 0.
		1	The GFGEN binary geometry file and the RMA2 binary solution file are expected to be in Metric units. Other parameters specified on cards should be input according to the units specified in this manual. SED2D-WES output will be in Metric units.

STOP CARD **STOP THE STUDH SIMULATION** **STOP CARD**

Required

Field	Variable	Value	Description
0,C1-2	IC1	ST	Card group identifier
0,C3	IC3	0	Card type identifier
2-10	FLD	A	May be used for comments

TO CARD **TIMING OF BINARY PRINTOUT** **TO CARD**

Not required

Field	Variable	Value	Description
0,C1-2	IC1	TO	Card group identifier
1	IWBIN	≥ 0	Increment for printing to binary output files (print every IWBIN'th time step). Files affected include KOHOTB, KPU, and KGEOM - see $L2 card)
		< 0	Default = 1

TR CARD **TRACE PRINT CONTROL** **TRCARD**

Not required

Field	Variable	Value	Description
0,C1-2	IC1	TR	Card group identifier
1	IECHO	≥ 0	Echo the run control input cards (This is the default)
		< 0	Do not echo the run control input cards
2	ITRINC	> 0	Increment for printing to full print output file (print every ITRINC’th time step)
		≤ 0	Default = 1
3	ITRC	0	No trace printout for debug purposes (This is the default)
		1	Trace between major subroutine calls for debug purposes
		2	Exhaustive debug printout

NOTE: If no TR card is present the default values will be applied.

ELEMENT LIST FOR

TRE CARD **SPECIAL SUMMARY TRACE PRINT** **TRE CARD**

Not Required

Field	Variable	Value	Description
0,C1-3	IC1	TRE	Card group identifier
1-10	NESPRT(I)	+	List of element numbers for special print summary. Auto count of total number of elements = JESPRT

NOTE: Multiple TRE cards may be required to enter all requested elements.

NODE LIST FOR

TRN CARD **SPECIAL SUMMARY TRACE PRINT** **TRN CARD**

Not required

Field	Variable	Value	Description
0,C1-3	IC1	TRN	Card group identifier
1-10	NNSPRT(I)	+	List of node number for special print summary. Auto total = JNSPRT

NOTE: Multiple TRN cards may be required to enter all requested nodes.

Special node printout is not implemented in the current version of SED2D-WES. An algorithm for this option is under development.

ELEMENT TYPE LIST FOR

TRT CARD **SPECIAL SUMMARY TRACE PRINT** **TRT CARD**

Not required

Field	Variable	Value	Description
0,C1-3	IC1	TRT	Card group identifier
1-10	ESPLPT(I)	+	List of element type (IMAT) numbers for special print summary. Note: This will become an equivalent TRE card list.

NOTE: Mulitple TRN cards may be required to enter all requested nodes.

Special element type printout is not implemented in the current version of SED2D-WES. An algorithm for this option is under development.

TT CARD **CRANK-NICHOLSON THETA** **TT CARD**

Required

Field	Variable	Value	Description
0,C1-2	IC1	TO	Card group identifier
0,C3	IC3	b/	
1	TETA		Crank-Nickolson THETA
		> 0	A value between zero and one (0.66 is recommended)
		≤ 0	Default = 0.5 This produces the most sensitive model response but often causes oscillations in the solution.

TZ CARD **COMPUTATION TIME CONTROL** **TZ CARD**

Required

Field	Variable	Value	Description
0,C1-2	IC1	TZ	Card group identifier
3	NTTS	≥ 0	Maximum number of cycles
		< 0	Default = 0
1	DT	≥ 0	Length of a time step for SED2D-WES simulation (decimal hours). **Note:** The capability exists to specify a time step that is different from the RMA2 time step when using a dynamic RMA2 solution file. However, this is **NOT RECOMMENDED.** If the SED2D time step is less than the RMA2 time step then a linear interpolation will be performed to evaluate the velocities at the intermediate time steps. The SED2D time step cannot be larger than the RMA2 time step. **WARNING: It is highly recommended that the SED2D time step be set exactly equal to the RMA2 time step.** Severe accuracy errors can result from using an interpolated flow field.
		< 0	Default = 0.0
2	TMAX	≥ 0	Maximum time for a simulation (decimal hours)
		< 0	Default = 0.0
4	DT_REPEAT	≥ 0	Time increment for RMA2 solution file rewind (decimal hours). When using a repeating hydrodynamic solution (such as a repeating tide or a steady state hydrodynamic solution) the time increment between the last time step in the RMA2 solution file and the first time step of the rewound RMA2 solution file must be specified. For steady state hydrodynamics let DT_REPEAT = TMAX to avoid re-reading the RMA2 file every time step.
		< 0	Default = DT

WC CARD **SETTLING VELOCITY** **WC CARD**

Used for both Sand and Clay.

Required

Field	Variable	Value	Description
0,C1-2	IC1	WC	Card group identifier
0,C3	IC3	b/	Option 1: Global assignment to all nodes, starting with = J
		T	Option 2: Explicit assignment for IMAT = J
		E	Option 2: Explicit assignment for Element = J
		N	Option 2: Explicit assignment for Node = J
1	J	+	Starting or explicit value
2	VS(J)	≥ 0	Settling velocity (m/sec)
		< 0	Default = 0.0

WF CARD **SETTLING VELOCITY FUNCTION OPTION** **WF CARD**

Used for both Sand and Clay.

Not required

Field	Variable	Value	Description
0,C1-2	IC1	WF	Card group identifier
1	MSETV	0	Use WC cards alone to define fall velocity.

		1	Make fall velocity a function of concentration. The functional form is
			If concentration is greater than or equal to 1 kg/m^3 then VS(NN) = VS(NN) from WC cards
			If concentration is greater than or equal to 0.01 kg/m^3 & less than 1 kg/m^3 then
			VS(NN) = VS(NN) from WC cards * CONC(NN) ** (4/3)
			If concentration is less than or equal to 0.01 kg/m^3 then
			VS(NN) = 0.02158 * VS(NN) from WC cards * SQRT(CONC(NN))

7.0 PROGRAM EXECUTION

Compiling SED2D-WES

SED2D-WES is a FORTRAN program that can be compiled on any computer where a FORTRAN compiler resides. The exact command for compiling SED2D-WES on your computer will depend upon the brand of your compiler. In general, Unix based computers will use a command similar to the following:

```
f77 -o sed2dv43.exe -O4 -static sed2dv43.f
```

where "-o" is a flag to set the filename of the executable file," -O4" is an optimization flag (this happens to be the default optimization flag for DEC FORTRAN), "-static" is a flag that causes all local variables to be statically allocated (this is the same as the "SAVE" flag for some PC compilers), and sed2dv43.f is the name of the source file. The source file contains an "INCLUDE" statement which will require the presence of the file "sed2dv40.inc" in the working directory at the time of compilation. The file "sed2dv40.inc" contains the global variable declarations for SED2D-WES Version 4.3. In particular, the array sizes (the number of nodes and elements permitted) are set in this file. For large grids, you may need to increase the array sizes and recompile the program in order to successfully run your application. If you need help with this process contact the TABS-MD consultants at "tabs@hl.wes.army.mil".

Running SED2D-WES

What follows is an example interactive session for a "coldstart" run from an IBM compatible computer running the MS-DOS operating system. This example uses the "madora" example problem that is described in the FastTABS and the SMS users manuals. The required data files for this example problem are supplied with the SED2D-WES source files. It is assumed that the user has already run GFGEN and RMA2 prior to executing the SED2D-WES program. The GFGEN input file is "madora.geo". Run GFGEN to generate a binary geometry file called "madora.gbn". The RMA2-WES input file is "madora.bc". The RMA2-WES alternate boundary condition file is "madora.abc". Run RMA2-WES to generate a binary hydrodynamic solution file called "madora.sol". Now you are ready to run SED2D-WES. Assume that the executable file, "sed2dv43.exe", and all of the required data files reside in the directory "C:\SED2D\". The program is launched by entering "sed2dv43.exe" at the DOS prompt. Responses to the screen queries should be as follows:

filename	- save as requested
null	- do not save file
quit	- stop program, now

An example interactive session follows. The input file “claysed.sed” is supplied with the SED2D-WES source code.

```
C:\SED2D>        sed2dv43.exe

To receive a response menu, type ?.
ENTER RUN CONTROL INPUT FILE NAME
claysed.sed
ENTER FULL PRINT OUTPUT FILE NAME
claysed.out
ENTER INPUT GEOMETRY FILE FROM GFGEN (binary)
madora.gbn
ENTER INPUT RMA2 HYDRODYNAMIC FILE (binary)
madora.sol
ENTER OUTPUT CONCENTRATION/DELBED FILE (binary)
claysed.cd
ENTER OUTPUT BED STRUCTURE (binary)
claysed.bs
ENTER OUTPUT GEOMETRY CONTAINING NEW BATHYMETRY (ascii)
claysed.geo
```

The program now will run. Some information will be written to the screen as the program progresses. If the process finishes normally, the prompt appears. Check that the files that you requested to be created were saved. Output files will be saved to the same directory from which the program was launched. If the process does not finish normally, an error message will be written to the screen. Examine the error message carefully to determine the cause of the error. Also check the bottom of the full print file (“claysed.out”) to find clues about when and how the program was aborted.

Displaying your results with FastTABS

This version of SED2D-WES was designed to run with the SMS Graphical User Interface. If you are using FastTABS (the predecessor to SMS) you must first run a conversion program to convert your SED2D-WES output to a format that is compatible with FastTABS. The conversion program is written in FORTRAN and is called “v12_2_ft.f”. The compiled version of this program is typically called “v12_2_ft.exe”. You will be prompted at the terminal for the input data required to run this program. The input is self-explanatory. Simply answer the questions as they appear on the screen. The following is an example interactive session to run “v12_2_ft.exe”:

```
C:\SED2D>v12_2_ft.exe

enter studh concentration/delbed file (binary) name
claysed.cd
enter fasttabs concentration/delbed file name
clsed_ft.sol
do you want the concentration in log10 form (def=n)
n
enter the number of time steps to retrieve, or
enter a negative number to specify a time window.
-1
enter minimum and maximum times (in hours)
0,500
enter the save increment n (save every nth time step)
1
```

The program will process. Some information will be written to the screen as the program proceeds. When the program is complete, the prompt will appear.

You may now run FastTABS. Once FastTABS has been launched, open the geometry file. To look at the solution file, read the solution “clsed_ft.sol” under the solution menu. FastTABS interprets this file as an RMA4 output file containing three concentration fields. You should interpret these three fields as follows: 1) concentration 1 is the concentration of suspended sediment in ppt; 2) concentration 2 is the net bed change (“delbed”) in feet; 3) concentration 3 is the bed shear stress in kg/(m sec^2).

Displaying your results with SMS

Run SMS. Under [File] select open geometry. Open the file called madora.geo. In the data browser, import the TABS file called “claysed.cd”. This will import the “concentration / delbed” file from SED2D-WES and report the correct names of the data sets.

Sand test case

In addition to the “claysed” test case described above, an input file for a sand test case called “sandsed.sed” is also supplied. This test case uses the “madora.gbn” and “madora.sol” files that were previously generated.