Users Guide To

# SED2D WES Version 4.5

US Army, Engineer Research And Development Center
Waterways Experiment Station
Coastal and Hydraulics Laboratory

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# Important Notice

This manual and the accompanying computer model STUDH 2000 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. The model is designed to be widely applicable to a range of physical hydrodynamic conditions and is, consequently, a complex model that requires a degree of modeler experience and knowledge of sediment transport to successfully apply the model. An unsuccessful attempt in an application by a relatively new user may not indicate any inherent problem with the model.

# Preface

The program described herein was developed over the period 1972-2000 at several institutions under funding from a number of sources. SED2D WES Version 4.5 described herein and preparation of this user's manual was performed during the period 1993 to 2000 at the US Army Engineer Research and Development Center (ERDC), 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 Coastal and 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 Coastal and 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 1996-2000. In support of USEPA Region II , the current documentation was updated and a special edition of STUDH (version 2000) was created. The version of STUDH 2000 described here is functionally equivalent to SED2D-WES, Version 4.5.

Commanders and Director of the ERDC WES during preparation of this report were COL Bruce K. Howard and COL Robin Cababa. Technical Director was Dr. Robert W. Whalin. The recent work was performed under the general supervision of Dr. James R. Houston, Chief, Coastal and Hydraulics Laboratory, Dr. W. H. McAnally, Chief, Estuaries and Hydrosciences Division.

# Overview

This user's guide described the generalized finite element computer program (model) for vertically averaged sediment transport in open channel flows. It is the sediment transport companion for the RMA2 hydrodynamic model within the TABS-MD Numerical Modeling System.

## Origin Of The 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 2D 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).

## Applications For SED2D

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.

# Capabilities Of SED2D

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 Manning's equation may be used to calculate bed shear stress due to currents. Shear stresses for combined currents and wind waves may be calculated

# Limitations Of SED2D

Both clay and sand may be analyzed, but the model considers a single, effective grain size during each simulation. 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.

In addition, the sediment transport model formulation assumes that the input geometric mesh and the resulting hydrodynamic solution from RMA2 are of adequate resolution, accuracy and quality to allow for an accurate and reasonable solution to the governing sediment transport equation to be solved. This may not always be true. In such a case, then the mathematical solution from SED2D or STUDH will potentially have severe oscillations with negative concentrations. The resolution of such “unstable” solutions cannot always be obtained within the coefficient adjustments of the sediment model. It may be necessary to return to the basic mesh resolution and obtain a better hydrodynamic solution.

# Conceptual Program Design

The program is based on the following conceptual model:

1. Basic processes in sedimentation can be grouped into erosion, entrainment, transportation, and deposition.
2. Flowing water has the potential to erode, entrain, and transport sediment whether or not sediment particles are present.
3. 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.
4. 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.
5. 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.
6. The structure of cohesive sediment beds changes with time and overburden.
7. 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.

## The Derivation

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

1. Convection-Diffusion Governing Equation
2. Bed Shear Stress Calculation
3. The Bed Source/Sink Term
4. The Bed Strata Discretization

## Convection-Diffusion Governing Equation

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

*Equation 1*

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

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, $m^2/sec$ |
| $\alpha_1$ | = | a coefficient for the source term, 1/sec |
| $\alpha_2$ | = | the equilibrium concentration portion of the source term, $kg/m^3/sec = -\alpha_1 C_{eq}$ |

## Bed Shear Stress Calculation

The bed shear stress is needed to evaluate the bed source-sink terms in the governing equation. Several options are available for computing bed shear stresses using

*Equation 2*

$$\tau_b = \rho\left(u^*\right)^2$$

where

| | | |
|---|---|---|
| ρ | = | water density |
| u* | = | shear velocity |

### *Smooth-wall log velocity profile*

*Equation 3*

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

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

*Equation 4*

$$\frac{u^{*}D}{\nu} > 30$$

where

| | | |
|---|---|---|
| u | = | mean flow velocity |
| D | = | water depth |
| ν | = | kinematic viscosity of water |

### The Manning's shear stress equation

*Equation 5*

$$u^{*} = \frac{\sqrt{g}\,\overline{u}\,n}{CME\,D^{1/6}}$$

where

| | | |
|---|---|---|
| g | = | acceleration due to gravity |
| n | = | Manning's roughness value |
| CME | = | coefficient of l.0 for metric units and l.486 for English units |

### A Jonsson-type equation for surface shear stress

The Jonsson-type equation is for plane beds caused by waves and currents.

*Equation 6*

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

where

| | | |
|---|---|---|
| $f_w$ | = | shear stress coefficient for waves |
| $u_{om}$ | = | maximum orbital velocity of waves |
| $f_c$ | = | shear stress coefficient for currents |

### A Bijker-type equation for total shear stress caused by waves and currents

*Equation 7*

$$u^{*} = \sqrt{\frac{1}{2} f_c \overline{u}^{\,2} + \frac{1}{4} f_w u_{om}^{2}}$$

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

When RMA2 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 from one of the options above.

### *Marsh Porosity Corrections*

## The Bed Source/Sink Term

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.

### *Sand Transport*

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

*Equation 8*

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

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 Ackers-White formula computes the total load, including suspended load and bed load, and was developed originally for fine sand.  The formulation was later updated to include coarser sands and these revised coefficients are included in the current model formulation.  However, the appropriateness of the use of SED-2D with the Ackers-White formula diminishes with coarsening of the sediment.

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.

*Equation 9*

$T_c$ = larger of

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.

*Equation 10*

$$t_c \text{ is larger of } \begin{cases} C_e \dfrac{D}{\overline{u}} \\ or \\ DT \end{cases}$$

where

| | | |
|---|---|---|
| Ce | = | coefficient for entrainment |
| V | = | flow speed |

## *Clay Transport*

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

*Equation 11 a and b*

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

where

| | | |
|---|---|---|
| $\tau$ | = | bed shear stress, |
| $\tau_d$ | = | 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

*Equation 12*

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

where

$P$ = erosion rate constant,

$\tau_e$ = 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

*Equation 13*

$$S = \frac{T_L \rho_L}{D \Delta t} for \tau > \tau_s$$

where

$T_L$ = thickness of the failed layer,

$\rho_L$ = density of the failed layer,

$\Delta t$ = time interval over which failure occurs,

$\tau_s$ = bulk shear strength of the layer.

## The Bed Strata Discretization

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*

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*

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

- Thickness.
- Density.
- Age.
- Bulk shear strength.

- Type.

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

- Critical shear stress for erosion.
- Erosion rate constant.
- Initial and 1-year densities.
- Initial and 1-year bulk shear strengths.
- Consolidation coefficient.
- 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:

*Equation 14*

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

where

| | | |
|---|---|---|
| $\rho$ | = | time - varying characteristic of density |
| $\rho_e$ | = | density at some reference end time |
| $\rho_f$ | = | final ultimate density = 1000 kg/m$^3$ default |
| $t_o$ | = | starting time = zero |
| $t_e$ | = | reference end time |
| $t$ | = | time |
| $\beta$ | = | 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 14for β.

*Equation 15*

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

*Equation 16*

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

where $\alpha$ is solved from these reference values above and the general form is obtained by replacing $Qs_e$ and $\rho_e$ 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.

# Lateral Boundary Condition

The lateral boundary condition is applicable to inflow, outflow, or areas of flow reversals.

## Inflow Boundary Conditions

## Outflow Boundary Conditions

## Reversal Boundary Conditions

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.

# Finite Element Formulation

## Galerkin Finite Element Form

The governing equation (1) is then cast into the Galerkin finite element form using quadratic shape functions, $N$ ,

*Equation 17*

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

where

| | | |
|---|---|---|
| $NE$ | = | total number of elements |
| $N$ | = | the quadratic shape(or basis) functions |
| Q | = | 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 |
| $\zeta$ | = | the local coordinate |
| $q_i^s$ | = | flux from source on boundary i |

The transient equation is expressed as

*Equation 18*

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

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

*Equation 19*

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

the steady-state system coefficient matrix [K] is

*Equation 20*

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

the boundary loadings vector $\{F\}$ is

*Equation 21*

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

Applying the Crank-Nicholson scheme, where $\theta$ is the implicitness coefficient, gives the following equation, where n refers to the present, n+1 to the future time-step, and $\Delta t$ the computation time interval.

*Equation 22*

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

## Elements Types Supported

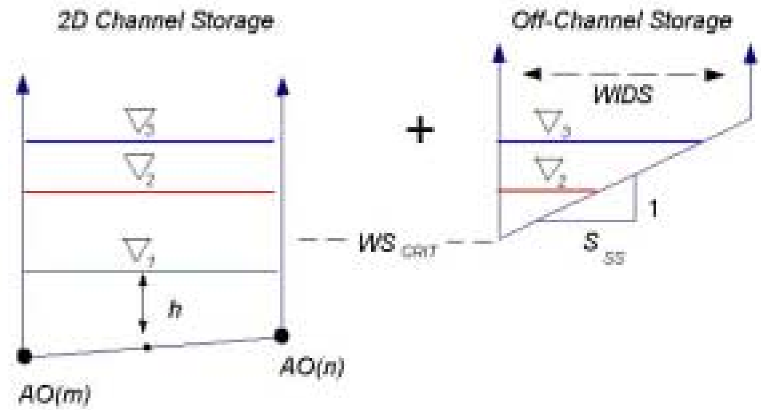
- Two Dimensional Elements
- One-Dimensional Elements
- Special Elements

### *Two Dimensional Elements*

The sediment transport model has always supported the traditional two dimensional 6-noded isoperimetric triangle and 8-noded isoperimetric quadrilateral elements. These are the same types of elements supported by RMA2.

However, the 2D off-channel storage features within RMA2 are not fully supported in SED2D WES. There is no concentration book-keeping in the off-channel storage area in the sediment model.

Rectangular Element Triangular Element

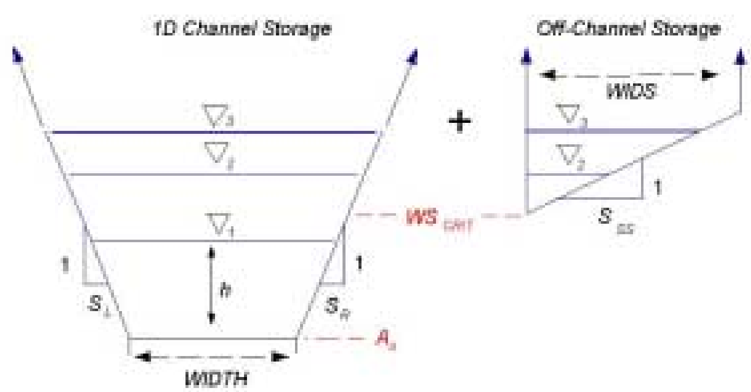



### One Dimensional Elements

The ability to simulate one-dimensional (1D) elements was added to SED2D WES in 1994. 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 current formulation incorporates the traditional isoperimetric 1D element, 1D junctions, and transition elements from 1D to 2D.

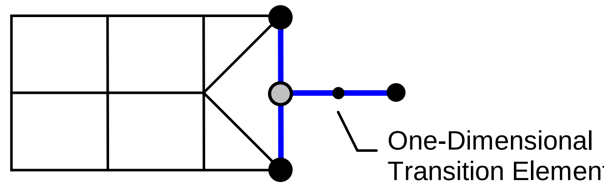
The 1D capability in SED2D WES is not meant to give the ability to seriously model sediment transport as an alternative to HEC-6, for example, which is a fully developed 1D sediment model. This simply allows for use of the benefits of simplified schematization.

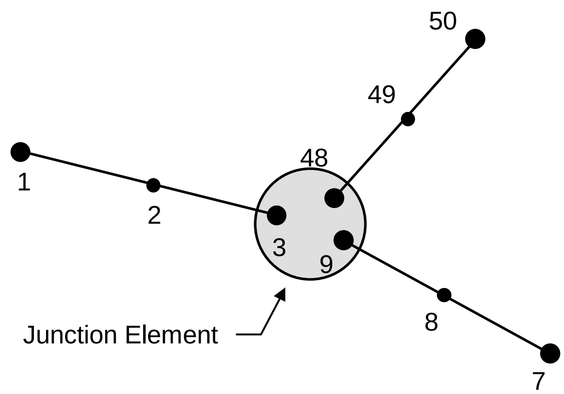
However, the 1D off-channel storage features within RMA2 are not fully supported in SED2D WES. There is no concentration book-keeping in the off-channel storage area in the sediment model.




### Special One-Dimensional Elements

SED2D only supports the transition and junction type 1D elements.




**GE elem# 3 9 48 0 0 0 0 0 901 ≤ imat ≤903**

The formulation for 1D and 2D control structures is not operational at this time.

# Using SED2D

## Assumed User Knowledge Base

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.

## Modeling Process

As mentioned previously, SED2D WES requires that hydrodynamic data be externally supplied, usually by a numerical hydrodynamic model. The TABS-MD modeling system 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. The graphical user interface, SMS, and a number of utility programs are used to develop input, translate data, analyze output, and provide graphical output from the models.

## Modes of Operation

*Typically SED2D is set to automatic, simulation super file, mode for compatibility with simulation super file saved by SMS.*

SED3D may be executed either in *interactive mode, batch mode or automatic mode*. The mode is determined by the value of the `IBATCH` variable within the program. You can change the mode only if you have the source code and a FORTRAN compiler.

## Running in Interactive Mode

To run interactively, execute SED2D directly and answer the series of questions referring to input and output file names. For instructions, enter a “?”.

The figure below illustrates the startup procedure for SED2D in interactive mode. Note that the question regarding a particular file will only be asked if that file is active on the $L card. You may choose to null or prevent that file from being opened by typing “null” in response to a file name prompt. For information on SED2D files, see “Data Files” on page 23.

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. 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 for a clay SED2D simulation follows.

```
C:\SED2D>        sed2dv45.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 requested to be created were saved. By default, the 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. For further information, see WARNINGS AND ERROR MESSAGES

The program may be run in interactive mode on a mainframe computer, such as the Cray T3E located at the WES High Performance Computer Center (HPC). Because of the way data are stored and accessed on the WES HPC, including the Mass Storage Facility (MSF), and the changing rules regarding the amount of memory available per processor, there is not a straight forward way to just execute the TABS-MD models. In this example, the IBATCH variable is set to interactive. In the /tmp director, compile SED2D using CF77. If you have prepared a run file, containing the input file names in the proper order, you can free up the terminal session for other activities. The actual command to run the SED2D model in this mode would use the direct (<) command re-direct (>) command, and the optional unix C-shell *nohup* utility would be as shown.

*SED2D_executable_file_name<run_file_name>output_file_name & nohup*

## Running in Batch Mode

Batch mode is typically used on a large mainframe computer system, such as the Cray T3E at the Waterways Experiment Station. On the WES Cray computers and other mainframes, the batch mode execution of SED2D requires computer specific job control language. Since the specific syntax changes frequently, it will not be presented in this document. The WES Information Technology Laboratory (ITL) help line is available to assist super computer users. The ITL High Performance computing assistance help line can be reached by calling 1-800-LAB-6WES extension 4400, option 1.

NOTE: The WES High Performance Computer Center (HPC) has extablished policies and procedures that may change the above stated method. Therefore, be sure to check with the HPC before planning and/or executing projects with hard milestone dates that could be affected by the operational demands on the DOD HPC.

### *Why Use Batch Mode*

If you have access to the Cray computers at WES, or another mainframe computer containing the TABS programs, you may wish to execute SED2D in batch mode – especially if you have a large problem. Generally, you will have access to more CPU time and more system RAM when executing in batch mode.

Another advantage of batch mode is that it does not tie up your terminal. Once the job has been submitted to the system, your terminal is free and available for you to perform other tasks.

## Running In Auto Mode (Simulation Super File)

Automatic Super Mode in SED2D (version 4.5 or higher) was designed to be compatible with the simulation super file concept in SMS.

When SED2D is compiled in automatic super mode, all input/output file names are controlled based upon a key-word character string. The user either edits the simulation super file created by SMS or creates a super file containing a list of key-words and file names. The $L card still activates the existence of the input/output files.

The key-word must start in column one and be spelled exactly as shown, note that both upper and lower case is permitted. The user does not have to be overly concerned with the order in which file names are provided. The only order dependency is for the FILE_PATHWAY key-word which sets the directory information defining the pathway for all subsequent files. To de-activate a file I-O request, simply enter the word, “**null**” (in lower case), for the file name, as shown in the SED2D auto mode example.

When SED2D executes, the only interactive question presented to the user is a request for the name of the simulation super file (*site.sup* in this example). The actual command to run the SED2D model in this mode could use the direct (<) and re-direct (>) commands as shown.

SED2D<*site.sup*>site.screen

| Super File Key-Word | File Name | Description |
|---|---|---|
| FILE_PATHWAY | /disk2/proj/ | Sets the pwd for these I/O files |
| S2_BC | site.s2bc | SED2D run control BC file |
| S2_FRL | site.s2frl | SED2D full results listing |
| GEOMETRY_BIN | site.gbn | GFGEN binary geometry |
| R2_SOL | site.sol | RMA2 binary hydro solution file |
| S2_HOTCDB | site.iccdb | SED2D IC Hotstart for conc and/or delbed |
| S2_HOTSTRATA | site.icstrata | SED2D IC Hotstart for bed strata (structure) |

| | | |
|---|---|---|
| S2_WAVE | site.wave | SED2D binary wave input |
| S2_WIND | site.wind | SED2D wind speed /direction input |
| S2_FETCH | site.fetch | SED2D wind fetch length input |
| S2_CDBSOL | site.s2cdb | SED2D binary conc/delbed solution file |
| S2_STRATA | site.s2strata | SED2D binary clay bed structure solution file |
| S2_SRLN | site.s2srl | SED2D summary results listing by node |
| S2_SRLE | site.s2srle | SED2D summary results listing by element |
| S2_GEOMTRY | site.s2geo | SED2D output geometry reflecting delbed changes |
| S2_NONDIM | site.s2nda | SED2D non-dimensional analysis results |
| S2_ALTBC | site.s2altbc | SED2D alternate BC transient file |
| S2_PARAMETER | site.s2param | SED2D auto diffusion echo |

Example of a SMS, GFGEN, RMA2, RMA4, and SED2D simulation super file compatible set. This example assumes the project name to be "site".

| **SMS Simulation File**<br>***site.sim*** | **GFGEN Simulation Super Run File**<br>***site_gfgen.run*** | **RMA2 Simulation Super Run File**<br>***site_rma2.run*** |
|---|---|---|
| `TABSSIM` | `GEOMETRY_INP site.geo` | `R2_BC        site.bc` |
| `GFGEN site_gf.run` | `GEOMETRY_FRL site.gfp` | `R2_FRL       site.frl` |
| `RMA2  site_rma2.run` | `GEOMETRY_BIN site.gbn` | `GEOMETRY_BIN site.gbn` |
| `RMA4  site_rma4.run` | | `R2_SOL       site.sol` |
| `SED2D stie_sed2.run` | | `R2_SRL       site.sum` |
| | | `R2_PARAMETER site.auto` |

| **RMA4 Simulation Super Run File**<br>***site_rma4.run*** | **SED2D Simulation Super Run File**<br>***site_sed2d.run*** |
|---|---|
| `R4_BC        site.r4bc` | `S2_BC        site.s2bc` |
| `R4_FRL       site.r4frl` | `S2_FRL       site.s2frl` |
| `GEOMETRY_BIN site.gbn` | `GEOMETRY_BIN site.gbn` |
| `R2_SOL       site.r4sol` | `R2_SOL       site.sol` |
| `R4_SOL       site.r4sol` | `S2_CDBSOL    site.s2cdb` |
| `R4_PARAMETER site.r4auto` | `S2_PARAMETER site.s2auto` |

# Guidelines for Obtaining a Good Solution

All aspects of a sediment transport simulation must be planned prior to finalization of the hydrodynamic RMA2 simulations. The geometry and hydrodynamic results are all important to a successful sediment transport model. Reference the RMA2 user's manual for the guidelines for obtaining a good hydrodynamic solution.

## Issues Directly Related to Hydrodynamic Solution

### *Conservation of Mass Problems*

Conservation of mass problems are a result of two issues: boundary break angles along the perimeter of the mesh, and interpolation of the original incoming RMA2 time step.

*Shore-Line Boundary Break Angles*

*Interpolated RMA2 Time Step*

### *Nodes with a Negative Depth Calculation*

### *Resolution to Capture Concentration Gradients*

### *Wetting and Drying*

*Identical Marsh Porosity Parameters for RMA2 and SED2D*

### *Time Step Selection*

### *Appropriate Boundary Condition Placement for Sediment*

## Sediment Issues Not Related to Hydrodynamic Solution

### *Sediment Parameter Selection*

### *Additional Resolution Needed to Resolve High Concentration Gradients*

## Sources of Error

### *Bottom Friction*

#### RMA2

Calculations based on elemental properties

Has an accumulative average over the water column

#### SED2D

Calculations based on nodal properties

Directly assigns a bottom shear stress

### *When Boundary Conditions change*

### *No Off Channel Storage Concentration Bookkeeping*

No Auto-Roughness capability in SED2D

## Basic Operation

SED2D WES is written in the FORTRAN programming language. It must be 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.

SED2D may read and write several files during a simulation. The number and type of files depends upon choices you have made about how the simulation will run and what type of information you want to see in the results.

A SED2D WES run control file is always required. This is the "card image" input for SED2D WES described in this document. The other file choices must be specified within the run control file (see the description of the $L cards).

Files used by SED2D fall into two basic format categories: ascii and binary. 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 convenient 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 and compiler should be used to run each of the models. This will ensure that the binary files are compatible between runs.

There are numerous files for both input and output.

## Summary of Possible Input Files

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 |
|---|---|---|---|
| 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.

## Summary of Possible Output Files

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 standard output redirect | 6 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.

## SED2D Run Control File

The SED2D run control file consists of a set of text or ascii data supplied by the modeler. This file is

## Geometry File

*It is possible to code the entire mesh in the SED2D run control file. However, this is highly discouraged. The ability to code mesh geometry forSED2D is intended for making minor geometry modifications when testing a proposed change to the mesh.*

The mesh geometry, which SED2D will use, is normally defined in a binary file produced by the Geometry File Generation program, GFGEN. This mesh geometry file consists of the nodes and elements that define the size, shape, and bathymetry of the study area.

SED2D will not read a text, or ASCII, type file as input for the mesh geometry. If you do not have a binary geometry file, and you do not want to code the mesh geometry in the SED2D run control file, you must run GFGEN to obtain the geometry file before running SED2D. The $L card is used to include the geometry file in the simulation run.

## Hydrodynamic File

*It is possible to code the entire mesh in the SED2D run control file. However, this is highly discouraged. The ability to code mesh geometry forSED2D is intended for making minor geometry modifications when testing a proposed change to the mesh.*

The hydrodyanamic input, which SED2D will use, is normally defined in a binary file produced by the TABS-MD depth averaged hydrodynamic model, RMA2. This binary solution file consists of the u-, and v-velocity components, water depth, water surface elevation, and wet/dry status at each node within the computational domain. This data set may be either steady state or time varying.

SED2D will not read a text, or ASCII, type file as input for the hydrodaynmics. If you do not have a binary hydrodynamic RMA2 file, and you do not want to code the values in the SED2D run control file, you must run RMA2 to obtain the u-,v-,h-hydrodynamic solution file before running SED2D. The $L card is used to include the RMA2 hydrodynamic solution file in the simulation run.

## Wave binary solution file

### *Output Files*

#### *Formatted*

Full Results Listing File

New GFGEN geometry reflecting delbed changes

#### *Binary*

SED2D Concentration and Delbed binary file

SED2D Clay Bed Structure binary file

# Using Titles

The ability to add Titles in the SED2D run control input file provides a means to describe the data which is being modeled. Titles are specified using the T1 and T2 cards, and a T3 card.

**Note:** A Title card must be the *first* card in the run control file, otherwise SED2D will not recognize the file as valid input. The T3 card actually identifies your solution file.

## Including Title Information

Enter the Title and descriptive information about your data on T1, T2, and T3 cards. You may use as many T1 and T2 cards as you wish, and card order is unimportant. Be sure to end your set of Title cards with a T3 card.

## The Last Title Card

The last Title card is the T3 card. Only one T3 card is allowed and it must be the very *last* title card. SED2D reads the '3' to mean the *end* of the Title cards.

**Tip:** The information on the T3 card is retained by SED2D and is written into the binary solution file header. Use the T3 card to your advantage. Supply information which will allow your solution file to be more easily identified in the future.

# What Kind Of Computer Do You Have?

## Why Should You Care?

Because different computer systems may store and retrieve information in different ways, SED2D needs to know the type of system on which it is running so it can properly transfer information on the system.

SED2D solution files and buffer files are written in a binary form. Binary files are strictly associated with the type of system upon which they are created. Word size and record length may be different from one system to the next.

**Note:** The computer identification is vital only if there is insufficient memory allotted during execution of SED2D which would require it to write temporary buffer files to solve the large matrix.

## Want You Need To Do About It?

Tell SED2D what type of system on which you will be running by providing a value for the machine identifier with the $M card. The type of computer you specify determines how temporary buffer files will be written and read.

The $M card is necessary if your system does not have enough memory available for the simulation. In this case, SED2D will write temporary buffer files to your disk. See the chapter entitled "**Error! Reference source not found.**" on page **Error! Bookmark not defined.** for additional information on temporary buffer files.

**Example:** If you are running SED2D on a DOS or Windows-95/98 based PC, the machine identifier value should be 1.

```
 .
CO   Running on a DOS PC
$M   1
 .
 .
```

# Obtaining The Mesh Geometry

As with all of the TABS-MD system numerical models, the finite element mesh is typically constructed with a graphical user interface, such as SMS, then processed through the GFGEN program.

A basic rule for constructing a finite mesh geometry to represent a given problem, is to move the boundaries of the model far enough from the area of primary interest such that if something is happening at the boundary its effect will be insignificant in the area of interest. When transport simulations follow a hydrodynamic study, it is imperative to consider transport issues when defining the model domain and its corresponding boundary condition locations.

In almost all model applications the mesh geometry used in RMA2 and SED2D should be identical. The one notable exception would be a deliberate IMAT=0 setting.

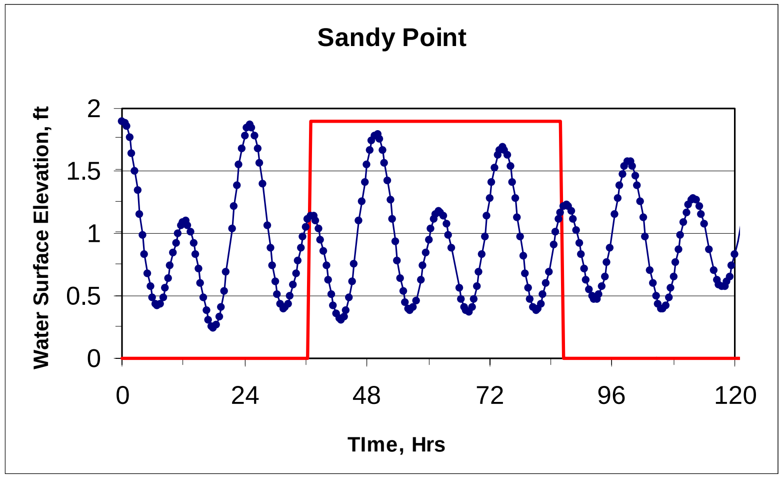
# Obtaining The Velocity Field

The accuracy of SED2D's calculations is dependent on the proper temporal and spatial estimate of the velocity field. There are two alternatives for specifying the velocity field.

First, you may estimate some representative behavior from field experience or statistical analysis for all nodes and for each time interval. The HD-, HU-, and HV-cards will be used to directly specify the velocity field for the SED2D simulation.

The second, and more accurate method is to supply the binary final results solution file from RMA2 as the flow field. You must control the starting and ending time of the RMA2 velocity field (TH card) to be used in the RMA4 simulation. Whenever the RMA4 selected delta time step does not match the RMA2 hydrodynamic delta time step, RMA4 will skip over or interpolate (which ever is appropriate) the RMA2 solution. If the RMA2 solution is shorter than the requested RMA4 simulation, the RMA2 results file will be re-wound and re-used again and again.

Example of hydrodynamic time control, TH card: TCORR=37, TEND=86 hrs.




### *Marsh Porosity Parameters*

## Specifying Initial Concentrations

### *ICP Card*

## Sediment Time Control

### *Time Step Control*

### *Total Simulation Control*

## Hydrodynamic Time Control

### *Simulating with Steady State Input*

### *Simulating with Transient Input*

*Hydrograph*

*Tide*

## Bed Characteristics

### Bed Initialization

*Sand*

SB-Card

*Clay*

Initialization:  CI-Card

Layer:  CL-Card

Apply Stress to Define the Structure:  CS-Card

### Bed Roughness

*Sand*

Shear Stress:  SR-Card

Transport:  ST-Card

*Clay*

## Specifying Lateral Boundary Conditions

### Inflow

*Dirachlet Type*

### Outflow

*Von Neuman Type*

### *Reversals*

## Stopping the Simulation

## Interpretation of the Results

## QA/QC Check

### *Check for Negative Concentrations*

### *Check for Mass Conservation*

### *Check for Unusual Deposition Patterns*

### *Check if Updated Hydrodynamics are needed*

## Re-Starting the Simulation

# Verifying The Simulation

## Verification: A Process

### Run

### Inspect – Compare to Field Data - Adjust

### Re-Run

## Compare to Field Data

### Direct Approach

#### *Compare to Observed Sediment Flux*

#### *Compare to Observed Concentrations*

### Compare to Observed Bed Elevation Evolution

## Indirect Approach

### Shoaling Patterns for Bed Deposition Rates

Example

### Dredging Volume and Distribution

Example

### Turbidity Plume Patterns from Satellite or Aerial Photography

Example

# If Your Verification Fails

## Wrong Choice of Model

## Geometry Related Problems

### Wetting and Drying

### Marsh Porosity

### Resolution Issues

## Hydrodynamic Related Problems

### *Accurate*

### *Representative for Sediment Transport*

## Boundary Condition Problems

### *Boundary Location*

### *Boundary Specifications*

## Initial Condition Effects

The simulation trends to the goal but never achieves it

Massive changes in the bed during start up

## Sediment Class

Really clay – Really sand – or complicated mixture

## Energy Sources

### *Wind*

### *Waves*

# Long Term Predictions

## Just Run It for the Full Period

## Simple Extrapolation

## Joint Probability Method

### Combining Sediment Classes

### Combining Multiple Hydrodynamic Conditions

### Combining Multiple Wave Conditions

# Advanced Techniques

## Analytical Test Cases

## Non-dimensional Analysis of Governing Equation

This section reviews the numerical formulation used in SED2D-WES and presents an analysis of the use of the appropriate numerical coefficients for a given numerical mesh and simulation design. The numerical mesh and hydrodynamic solution present certain dimensional characteristics to the governing equations of sediment transport. For a given mesh and hydrodynamic solution (RMA-2) the transport model will have certain numerical restrictions that will limit the ability of the program to provide accurate solutions. A clear understanding of these limitations can lead to either a redesign of the mesh and hydrodynamic simulation or guidance in the compromises necessary in the numerical coefficients in SED2D-WES.

### Transforming The CD Equation

Recall that the convection-diffusion equation (Equation 1), a.k.a. CD equation, solved by SED2D is of the basic form:

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} - \frac{\partial}{\partial x}D_x\frac{\partial C}{\partial x} - \frac{\partial}{\partial y}D_y\frac{\partial C}{\partial y} - \alpha_1 C - \alpha_2 = 0$$

where

| | | |
|---|---|---|
| $C$ | = | depth-averaged sediment concentration, kg/m$^3$ |
| $T$ | = | time, sec |
| $x,y$ | = | horizontal Cartesian coordinates, meters |
| $u,v$ | = | current velocity components in the x,y directions, m/sec |
| $D_x,D_y$ | = | dispersion/diffusion coefficients for the x,y directions, m$^2$/sec |
| $\alpha_1$ | = | coefficient for the bed source/sink term, 1/sec |

| | | |
|---|---|---|
| $\alpha_2$ | = | coefficient for the bed source/sink terms, kg/(m$^3$-sec) |

The general characteristics of the governing equation are best understood by performing dimensionless analysis of the equation to develop the characteristics for certain conditions. To facilitate the analysis the following scaling factors are applied

| | | |
|---|---|---|
| $C$ | = | $C_0 \; c'$ |
| $T$ | = | $\Delta t \; t'$ |
| $U$ | = | $V \; u'$ |
| $V$ | = | $V \; v'$ |
| $X$ | = | $L \; x'$ |
| $Y$ | = | $L \; y'$ |
| $D_x$ | = | $D_r \; D_x'$ |
| $D_y$ | = | $D_r \; D_y'$ |

The source/sink term coefficients $\alpha_1$ and $\alpha_2$ vary for sand and clay and whether deposition or erosion is occurring. These conditions will be addressed separately later. For the first analysis, sand deposition will be assumed.

## Transform The Sand Deposition Equation

For sand deposition the source sink terms take on the form

*Equation 23*

$$S = \alpha_1 C + \alpha_2 = -\frac{(C - G_p)V_s}{L_{de} D}$$

where

| | | |
|---|---|---|
| $Gp$ | = | transport potential from Ackers-White , kg/m$^3$ |
| $V_s$ | = | sediment fall velocity, m/s |
| $L_{de}$ | = | scale length factor deposition, dimensionless |
| $D$ | = | water depth, m |

For this condition, the following scaling factors are used

| | | |
|---|---|---|
| $G_p$ | = | $\mathbf{C_o} \; G_p'$ |
| $D$ | = | $\mathbf{H} \; D'$ |
| $V_s$ | = | $\mathbf{W_s} \; V_s'$ |

From the application of these scaling factors we get

*Equation 24*

$$\alpha_1 C + \alpha_2 = -\left(\frac{\boldsymbol{C_o Vs}}{\boldsymbol{L_{de} H}}\right)\frac{(C'-G_p')V_s'}{D'}$$

The full equation for sand deposition becomes

*Equation 25*

$$\left(\frac{\boldsymbol{C_0}}{\boldsymbol{\Delta t}}\right)\frac{\partial c'}{\partial t'} + \left(\frac{\boldsymbol{C_0 V}}{\boldsymbol{L}}\right)u'\frac{\partial c'}{\partial x'} + \left(\frac{\boldsymbol{C_0 V}}{\boldsymbol{L}}\right)v'\frac{\partial c'}{\partial y'}$$
$$-\left(\frac{\boldsymbol{D_r C_0}}{\boldsymbol{L^2}}\right)\frac{\partial}{\partial x'}D_x'\frac{\partial c'}{\partial x'} - \left(\frac{\boldsymbol{D_r C_0}}{\boldsymbol{L^2}}\right)\frac{\partial}{\partial y'}D_y'\frac{\partial c'}{\partial y'}$$
$$-\left(\frac{\boldsymbol{C_o Vs}}{\boldsymbol{L_{de} H}}\right)\frac{(C'-G_p')V_s'}{D'} = 0$$

where the first term is storage, the second and third terms are x- and y- advection, the fourth and fifth terms are x- and y-diffusion, and the last term is the bed sink (sand deposition)

These terms in the equation above represent the various aspects of the transport process.   Note that the terms with the primed variables have been scaled such that these terms are non-dimensional, taking on the scale of unity.  The bolded terms now contain the dimensional characteristics of the process.  The normal method for the interpretation of these scaling factors is to develop the ratios of these terms.

There are several dimensional groupings that are independent of the bed source-sink variables.  The ratios of these terms will be addressed first.

### Advection/Diffusion Ratio

For example, the ratio of the advective terms to the diffusion terms yields the Peclet Number

*Equation 26*

$$\boldsymbol{P_e} = \left(\frac{\boldsymbol{C_0 V}}{\boldsymbol{L}}\right)\Bigg/\left(\frac{\boldsymbol{C_0 D_r}}{\boldsymbol{L^2}}\right) = \left(\frac{\boldsymbol{VL}}{\boldsymbol{D_r}}\right)$$

This parameter has been used extensively to deal with numerical oscillations caused by over-advecting the solution.

### Advection/Storage Ratio

Another basic parameter is the ratio of the advection and storage term

*Equation 27*

$$\boldsymbol{C_n} = \left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L}}\right)\Bigg/\left(\frac{\boldsymbol{C_o}}{\boldsymbol{\Delta t}}\right) = \left(\frac{\boldsymbol{V\Delta t}}{\boldsymbol{L}}\right)$$

This term can be called an advective Courant number, using the advective velocity rather than the wave celerity.  This is a measure of the fraction of the element over which a parcel of water is transported within a single time step.

### *Diffusion/Storage Ratio*

For the three basic groupings of dimensional parameters (storage, advection and diffusion), there are only three unique ratios to be defined (ignoring the inverses of each ratio).  When two of the three ratios are known then the other ratio is defined from the other two.

*Equation 28*

$$\left(\frac{C_o D_r}{L^2}\right) \Big/ \left(\frac{C_o}{\Delta t}\right) = \left(\frac{D_r \Delta t}{L^2}\right) = \frac{C_n}{Pe}$$

This term could be called a non-dimensional diffusion coefficient or simply the ratio of the advective Courant number and the Peclet number.

The SED2D model's response to various ranges of these non-dimensional parameters can best be evaluated experimentally.

## Transform The Bed Source-Sink Terms

The bed source-sink terms will now be addressed separately.  There are four basic cases to be considered.  These are:  sand deposition, sand erosion, clay deposition and clay erosion.

### *Sand Deposition*

The sand deposition terms were developed earlier.

*Equation 29*

$$\alpha_1 C + \alpha_2 = -\left(\frac{C_o Vs}{L_{de} H}\right)\frac{(C' - G_p')V_s'}{D'}$$

This dimensional grouping can now be ratioed to the other terms in the equation.

***(sand deposition/storage)***.  The sand deposition to storage ratio is

*Equation 30*

$$\left(\frac{C_o V_s}{L_{de} H}\right) \Big/ \left(\frac{C_o}{\Delta t}\right) = \left(\frac{V_s \Delta t}{L_{de} H}\right) = C_v$$

The term $L_{de}$ ,already dimensionless, so that this non-dimensional term can be viewed as a vertical advective Courant number.

***(sand deposition/convection)***.  The ratio of sand deposition to convection is

*Equation 31*

$$\left(\frac{C_o V_s}{L_{de} H}\right) \Big/ \left(\frac{C_o V}{L}\right) = \left(\frac{V_s L}{V L_{de} H}\right) = \frac{C_v}{C_n}$$

***(sand deposition/diffusion)***. The ratio of sand deposition to diffusion is

*Equation 32*

$$\left(\frac{C_o V_s}{L_{de} H}\right) \Big/ \left(\frac{C_o D_r}{L^2}\right) = \left(\frac{V_s L^2}{D_r L_{de} H}\right) = \frac{C_v}{C_n} Pe$$

## *Sand Erosion*

Sand erosion is represented in SED2D as

*Equation 33*

$$S = \alpha_1 C + \alpha_2 = -\frac{(C - G_p)|V|}{L_{er} D}$$

where:

| | | |
|---|---|---|
| Gp | = | transport potential from Ackers-White, kg/m$^3$ |
| $\|V\|$ | = | velocity magnitude, m/s |
| $L_{er}$ | = | scale length factor erosion entrainment dimensionless |
| $D$ | = | water depth, m |

The velocity magnitude is

*Equation 34*

$$|V| = \sqrt{u^2 + v^2} = \sqrt{(\mathbf{V}u')^2 + (\mathbf{V}v')^2} = \mathbf{V}\sqrt{u'^2 + v'^2} = \mathbf{V}V_m'$$

where $V_m'$ is the non-dimensional velocity magnitude

For this condition, the following scaling factors are used

| | | |
|---|---|---|
| $G_p$ | = | $\mathbf{C_o}\ G_p'$ |
| $D$ | = | $\mathbf{H}\ D'$ |
| $\|V\|$ | = | $\mathbf{V}\ V_m'$ |

From the application of these scaling factors we get

*Equation 35*

$$\alpha_1 C + \alpha_2 = -\left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L_{er} H}}\right)\frac{(C'-G_p{}')V_m{}'}{D'}$$

***(sand erosion/storage)***. The sand deposition to storage ratio is

*Equation 36*

$$\left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L_{er} H}}\right)\Big/\left(\frac{\boldsymbol{C_o}}{\boldsymbol{\Delta t}}\right)=\left(\frac{\boldsymbol{V\Delta t}}{\boldsymbol{L_{er} H}}\right)=\left(\frac{\boldsymbol{V}}{\boldsymbol{V_s L_{er}}}\right)\left(\frac{\boldsymbol{V_s \Delta t}}{\boldsymbol{H}}\right)=\boldsymbol{V_r C_v}$$

The term $L_{de}$ ,already dimensionless, so that this non-dimensional term is the vertical advective Courant number multiplied by a velocity ratio, $V_r$, of the current velocity and the fall velocity times the entrainment length factor $L_{er}$.

***(sand erosion/convection)***. The ratio of sand deposition to convection is

*Equation 37*

$$\left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L_{er} H}}\right)\Big/\left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L}}\right)=\left(\frac{\boldsymbol{L}}{\boldsymbol{L_{er} H}}\right)=\frac{\boldsymbol{C_{ve}}}{\boldsymbol{C_n}}$$

***(sand erosion/diffusion)***. The ratio of sand deposition to diffusion is

*Equation 38*

$$\left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L_{er} H}}\right)\Big/\left(\frac{\boldsymbol{C_o D_r}}{\boldsymbol{L^2}}\right)=\left(\frac{\boldsymbol{VL^2}}{\boldsymbol{D_r L_{er} H}}\right)=\frac{\boldsymbol{C_{ve}}}{\boldsymbol{C_n}}\boldsymbol{P_e}$$

## Clay Deposition

Clay deposition in SED2D is represented by

*Equation 39*

$$\alpha_1 C + \alpha_2 = \frac{V_{se} C}{D}\left(1-\frac{\tau}{\tau_d}\right)$$

where:

| | | |
|---|---|---|
| $\tau$ | = | bottom shear stress, N-m/sec$^2$ |
| $\tau_d$ | = | critical bottom shear stress for deposition, N-m/sec$^2$ |
| $V_{se}$ | = | the effective fall velocity, m/sec |

These terms will all scale as before and the term in parentheses that includes the ratio of shear stresses is already non-dimensional. The effective fall velocity is used for clay deposition because for clay the relationship between concentration and fall velocity, if the option is used in the program, is nonlinear.

*Equation 40*

$$\alpha_1 C + \alpha_2 = -\left(\frac{\boldsymbol{C_o V_{se}}}{\boldsymbol{H}}\right)\frac{V_{se}' c'}{D'}\left(1 - \frac{\tau}{\tau_d}\right)$$

This dimensional grouping for clay deposition can now be ratioed to the other terms.

***(Clay deposition/storage)***. The clay deposition to storage ratio is

*Equation 41*

$$\left(\frac{\boldsymbol{C_o V_{se}}}{\boldsymbol{H}}\right)\bigg/\left(\frac{\boldsymbol{C_o}}{\boldsymbol{\Delta t}}\right) = \left(\frac{\boldsymbol{V_{se} \Delta t}}{\boldsymbol{H}}\right) = \boldsymbol{C_v}$$

This Courant number is essentially the same as for the sand deposition if the term $L_{de}$ for the sand is taken as 1.0.

***(Clay deposition/convection)***. The ratio of clay deposition to convection is

*Equation 42*

$$\left(\frac{\boldsymbol{C_o V_{se}}}{\boldsymbol{H}}\right)\bigg/\left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L}}\right) = \left(\frac{\boldsymbol{V_{se} L}}{\boldsymbol{VH}}\right) = \frac{\boldsymbol{C_v}}{\boldsymbol{C_n}}$$

***(Clay deposition/diffusion)***. The ratio of clay deposition to diffusion is

*Equation 43*

$$\left(\frac{\boldsymbol{C_o V_{se}}}{\boldsymbol{H}}\right)\bigg/\left(\frac{\boldsymbol{C_o D_r}}{\boldsymbol{L^2}}\right) = \left(\frac{\boldsymbol{V_{se} L^2}}{\boldsymbol{D_r H}}\right) = \frac{\boldsymbol{C_v}}{\boldsymbol{C_n}}\boldsymbol{Pe}$$

## Clay Particle Erosion

The clay particle erosion in SED2D is represented as

*Equation 44*

$$\alpha_1 C + \alpha_2 = \frac{E}{D}\left(\frac{\tau}{\tau_e} - 1\right)$$

where:

| | |
|---|---|
| $E$ | erosion rate constant, kg/(m$^2$ sec) |
| $\tau_e$ | critical shear stress for erosion, N-m/sec$^2$ |

The erosion rate constant must be scaled in a manner that reflect the

$$E = \mathbf{E_0}\, E'$$

As before this source-sink term can be scaled as

*Equation 45*

$$\alpha_1 C + \alpha_2 = -\left(\frac{\boldsymbol{E_o}}{\boldsymbol{H}}\right)\frac{E_0'}{D'}\left(\frac{\tau}{\tau_e} - 1\right)$$

***(clay particle erosion/storage)***. The clay particle erosion to storage ratio is

*Equation 46*

$$\left(\frac{\boldsymbol{E_o}}{\boldsymbol{H}}\right)\Big/\left(\frac{\boldsymbol{C_o}}{\boldsymbol{\Delta t}}\right) = \left(\frac{\boldsymbol{E_o \Delta t}}{\boldsymbol{C_o H}}\right) = \left(\frac{\boldsymbol{E_o}}{\boldsymbol{C_o V_s}}\right)\left(\frac{\boldsymbol{V_s \Delta t}}{\boldsymbol{H}}\right) = \boldsymbol{P_d C_v}$$

This ratio reflects the relative speed at which the entrainment of sediment from the bed causes the concentration in the water column to change. It is the product of the vertical advective Courant number and a non-dimensional term, $P_d$, which can be viewed as a particle Peclet number (Teeter, 1984).

***(clay particle erosion/convection)***. The ratio of clay particle erosion to convection is

*Equation 47*

$$\left(\frac{\boldsymbol{E_o}}{\boldsymbol{H}}\right)\Big/\left(\frac{\boldsymbol{C_o V}}{\boldsymbol{L}}\right) = \left(\frac{\boldsymbol{E_o L}}{\boldsymbol{C_o V H}}\right) = \left(\frac{\boldsymbol{E_o}}{\boldsymbol{C_o V_s}}\right)\left(\frac{\boldsymbol{V_s L}}{\boldsymbol{V H}}\right) = \left(\frac{\boldsymbol{C_v}}{\boldsymbol{C_n}}\right)\boldsymbol{P_d}$$

***(clay particle erosion/diffusion)***. The ratio of clay particle erosion to diffusion is

*Equation 48*

$$\left(\frac{\boldsymbol{E_o}}{\boldsymbol{H}}\right)\Big/\left(\frac{\boldsymbol{C_o D_r}}{\boldsymbol{L^2}}\right) = \left(\frac{\boldsymbol{E_o L^2}}{\boldsymbol{C_o D_r H}}\right) = \left(\frac{\boldsymbol{E_o}}{\boldsymbol{C_o V_s}}\right)\left(\frac{\boldsymbol{V_s L^2}}{\boldsymbol{D_r H}}\right) = \frac{\boldsymbol{C_{ve}}}{\boldsymbol{C_n}}\boldsymbol{P_e P_d}$$

### Clay Mass Erosion

When the bottom shear stress is greater than the shear strength of the clay layer the entire layer is entrained into suspension during the model time step. The relationship is encoded as

*Equation 49*

$$S = \frac{\rho_L \delta_L}{Dt_c}$$

where:

| | | |
|---|---|---|
| $\rho_L$ | = | the density of the layer, kg/m$^3$ |
| $\delta_L$ | = | the thickness of the layer, m |
| $t_c$ | = | characteristic time of response, sec |

This term is scaled by the following

$$\rho_L = \boldsymbol{\rho_0}\ \rho'$$

$$\delta_L = \boldsymbol{\delta_0}\ \delta'$$

$$t_c = \boldsymbol{\Delta t}\ t'$$

This leads to the non-dimensionalized term

*Equation 50*

$$S = \left( \frac{\rho_0 \delta_0}{\boldsymbol{H} \Delta \boldsymbol{t}} \right) \frac{\rho' \delta'}{D' t'}$$

***(clay mass erosion/storage).*** The clay mass erosion to storage ratio is

*Equation 51*

$$\left( \frac{\rho_0 \delta_0}{\boldsymbol{H \Delta t}} \right) \Big/ \left( \frac{\boldsymbol{C_o}}{\boldsymbol{\Delta t}} \right) = \left( \frac{\rho_o \delta_0}{\boldsymbol{C_o H}} \right) = \boldsymbol{M_r}$$

This ratio reflects the relative mass entrained from the bed to the mass in the water column.

***(clay mass erosion/convection)***. The ratio of clay mass erosion to convection is

*Equation 52*

$$\left( \frac{\rho_0 \delta_0}{\boldsymbol{H \Delta t}} \right) \Big/ \left( \frac{\boldsymbol{C_o V}}{\boldsymbol{L}} \right) = \left( \frac{\rho_0 \delta_0 \boldsymbol{L}}{\boldsymbol{C_o H V \Delta t}} \right) = \frac{\boldsymbol{M_r}}{\boldsymbol{C_n}}$$

***(clay mass erosion/diffusion)***. The ratio of clay mass erosion to diffusion is

*Equation 53*

$$\left( \frac{\rho_0 \delta_0}{\boldsymbol{H \Delta t}} \right) \Big/ \left( \frac{\boldsymbol{C_o D_r}}{\boldsymbol{L^2}} \right) = \left( \frac{\rho_0 \delta_0 \boldsymbol{L^2}}{\boldsymbol{C_o D_r H \Delta t}} \right) = \frac{\boldsymbol{M_r}}{\boldsymbol{C_n}} \boldsymbol{P_e}$$

## Summary: Non-D Terms in the CD Equation

Non-dimensional Terms in the Convective-Diffusion Equation (SED2D-WES)

| | Term in Numerator |
|---|---|

| Term in Denominator | Storage | Advection | Diffusion | Sand Deposition | Sand Erosion | Clay Deposition | Clay Particle Erosion | Clay Mass Erosion |
|---|---|---|---|---|---|---|---|---|
| Storage | 1 | $C_n$ | $C_n / P_e$ | $C_v$ | $C_v V_r$ | $C_v$ | $C_v P_d$ | $M_r$ |
| Advection | $1/C_n$ | 1 | $1/ P_e$ | $C_v / C_n$ | $C_v V_r / C_n$ | $C_v / C_n$ | $P_d C_v / C_n$ | $M_r / C_n$ |
| Diffusion | $P_e / C_n$ | $P_e$ | 1 | $(C_v / C_n) P_e$ | $P_e C_v V_r / C_n$ | $(C_v / C_n) P_e$ | $(C_v / C_n) P_e P_d$ | $M_r P_e / C_n$ |
| Sand Deposition | $1/ C_v$ | $C_n / C_v$ | $(C_n / C_v) P_e$ | 1 | - | - | - | - |
| Sand Erosion | $1/ (C_v V_r)$ | $C_n / (C_v V_r)$ | $C_n / (C_v V_r P_e)$ | - | 1 | - | - | - |
| Clay Deposition | $1/ C_v$ | $C_n / C_v$ | $C_n / (C_v P_e)$ | - | - | 1 | - | - |
| Clay Particle Erosion | $1/ (C_v P_d)$ | $C_n / (P_d C_v)$ | $C_n / (C_v P_e P_d)$ | - | - | - | 1 | - |
| Clay Mass Erosion | $1/M_r$ | $C_n / M_r$ | $C_n / (M_r P_e)$ | - | - | - | - | 1 |

Where

$C_n = V \Delta t / L$

$C_v = V_s \Delta t / H$

$P_e = V L / D_r$

$P_d = E_0 / (C_0 V_s)$

$V_r = V / (V_s L_{er})$

$M_r = \rho_0 \delta_0 / (C_0 H)$

$V$ = current velocity, m/sec

$\Delta t$ = time step, sec

$L$ = horizontal size of element, m

$D_r$ = diffusion coefficient, $m^2$/sec

$V_s$ = fall velocity, m/sec

$L_{er}$ = horizontal entrainment factor, m

$H$ = water depth, m

$E_0$ = particle rate of entrainment for clay, kg/($m^2$ sec)

$C_0$ = suspended sediment concentration, kg/$m^3$

$\rho_0$ = density of clay bed layer, kg/$m^3$

$\delta_0$ = thickness of clay bed layer, m

## Test problems

The model performance will be tested with a series of test problems designed to evaluate the response of SED2D to these parameters. These tests will utilize the following test meshes:

1. A simple settling column problem. There may be a range of these meshes with progressively greater resolution, but the simplest is a single element. The settling column is 1m by 1m and 10m deep. The hydrodynamics for the test is zero velocity throughout. This test case eliminates the advective terms in the equation and allows for the isolation of the storage, diffusion and bed source-sink terms.

2. A long flume through which a steady-state discharge is run. The discharge itself can be varied to achieve various shear stresses. The water depth can also be changed by varying the downstream head boundary condition.
3. A schematic tidal wetland mesh

# Run Control

## Overview

SED2D obtains its run control data from a set of input data cards provided in run control files. These data cards conform to what is known as HEC format. Each card has 80 columns of characters in which to hold its data. The first three columns are reserved for the card name, so there are actually 77 columns in which to hold functional data.

A data card occupies a single line in the run control input file. The card line is divided into data fields, of which the first contains the card name, and is designated as field 0. Field 1 begins the actual data for the card. SED2D uses a free field format for data card input. Each item of data constitutes a field. There can be as many fields on a card as there is room within the 80 columns of characters.

Note: If more than one card modifies a variable, the last card rules.

## Summary of Run Control Data Cards

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 cold start, a model run begins fresh, not using the results of any previous run as a starting point. In a hot start, some of the variables, such as concentration or bed thickness, begin with values that were computed in a previous run. The files needed for hot starting a model run are written if so requested on the $L2 card. In order to make a hot start run, first submit a cold start 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 hot start switches on the $H card, and specify the appropriate hot start unit numbers on the $L1 card.

In a cold start 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 equilibrium concentration is reached. This may happen even if the prototype bed is stable in that area. To overcome this problem, a hot start run would be made in which concentrations are hot started from the previous run, but bed structure and bed elevation changes are cold started.

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 “hot start” 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 hot start files requested on the $L cards will be saved, so that the user may generate a new hydrodynamic flow field and then "hot start" 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.

## Geometry cards: GE, GNN, GT, GS, GC, DM

The GE card permits the user to put in an element connection table. The GNN card permits the user to assign the (x,y) coordinate, and z-elevation of a node. The GT permits the user to assign or modify an element's material type number. The GS 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.

## 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

$$\#TimeSteps = \frac{RunLength}{ComputationalInterval} + 1$$

## 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.

## 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 flow, 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.

## 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.

## Cohesive sediment characteristics: CC and CI cards

The Figure below 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.

Cohesive bed behavior as a function of shear stress

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

*Equation 54*

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

where

| | | |
|---|---|---|
| $\rho_S$ | = | density of individual sediment particles |
| $\rho_B$ | = | bulk (wet) density of sediment |
| $\rho_w$ | = | 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.

## 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.

## 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

*Equation 55*

$$D_e = 5.93\ Du^*$$

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

*Equation 56*

$$D_t = 0.23\ Du^*$$

where

D = water depth, and

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

Experimentally derived values of the constants in Equation 55 and Equation 56 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 Coastal and Hydraulics Laboratory has suggested that an equation of the form

*Equation 57*

$$D_e = K_1\left(K_2 D u^* + 10^{-5}\lambda^2\right)$$

where

| | | |
|---|---|---|
| $\lambda$ | = | 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.

Equation 55 through Equation 57 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, and 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:

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

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

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

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).

The table below lists some previous applications and the effective diffusion coefficients that were used.

Table Example Dispersion Coefficients

| Typical Location | Current Speed, mps | Typical Element Size, km | Dispersion Coefficient $m^2$sec |
|---|---|---|---|
| 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 |

## Initial concentration: IC cards

The nodal concentrations at the first time-step are specified on the IC cards, or in a file if a hot start 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 hot start the run that simulates the period of interest.

## 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 out flowing concentrations. However, invoking *boundary condition buffering* for tidal situations is controlled by the variables IBCFACT and BCFACT on the BC card.

## 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 hot start 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.

# Required Run Control Data Cards

*Although most of the data cards are independent of order, there are indeed some dependencies.*

The following table lists all the data cards available in SED2D, and whether or not the card is required. The order of the list is the suggested order in which the cards should appear in the SED2D run control file.

| Card | Descriptive Content | Required |
|---|---|---|
| T1-T2 | Title cards | No |
| T3 | Title card | Yes |
| $D | Start date control | No |
| $M | Machine type identifier | No |
| $L1 | Input file numbers | Yes |
| $L2 | Output file numbers | Yes |
| SI | System international units | No |
| BF | Bed Flux Controls | |
| CC | Clay characteristics | Yes for Clay |
| CI | Clay characteristics by ID | Yes for Clay |
| CL | Clay distribution by layer | Yes for Clay |
| CO | Comment (anywhere except the first line) | No |
| DD | Effective diffusion coefficients via EQ 22 | |
| DM | Wet / dry by marsh porosity | No |
| ED | Effective diffusion coefficient | No |
| EF | Error flags | No |
| FD | Fluid density | Yes |
| FT | Fluid temperature | Yes |
| ~~GC~~ | Geometry,continuity check line (use GCL) | Replaced |
| GCL | Geometry,continuity check line (new) | No |
| GE | Geometry,element connection table | No |
| GNN | Geometry,nodal coordinates,bottom elevations | No |
| *GS* | *Geometry, scale factors* | *No* |
| GT | Geometry, element type (IMAT) | No |
| GV | Geometry, eddy viscosity tensor | No |
| GW | Geometry, width and off-channel parameters | No |
| HD | Hydrodynamic water depth | No |
| HN | Hydraulics, Manning's n-values | No |
| HS | Hydraulics, Shear Stress | No |
| HU | Hydrodynamic Fluid velocity in x-direction | No |
| HV | Hydrodynamic Fluid velocity in y-direction | No |
| HW | Wave Model Input Control | No |
| IC | Initial conditions, water-surface elevation | Yes |
| ND | Non-dimensional Analysis | No |

| | | |
|---|---|---|
| ~~PC~~ | Point source (see BL card) | No |
| PE | Peclet Method for Automatic Turbulence | No |
| PV | Physical parameters | No |
| SA | Sand characteristics | Yes for sand |
| SB | Sand bed thickness | Yes for sand |
| SR | Grain size for roughness | Yes for sand |
| ST | Sand grain size for transport | Yes for sand |
| TH | Timing for the hydrodynamic RMA2 input file | Yes |
| TO | Timing for binary output write | No |
| TR | Trace print controls | Yes |
| TRE | Summary print by element list | No |
| TRN | Summary print by node list | No |
| TRT | Summary print by material list (equivalent to TRE card) | No |
| TT | Crank-Nicholson Theta | Yes |
| TZ | Timing, of simulation | Yes |
| WC | Settling velocity | Yes |
| WF | Settling velocity function option | No |
| BC | Boundary condition control parameters | Yes * |
| BL | Boundary mass loading | Yes * |
| END | End of boundary condition specification for the time step | Yes |
| STOp | Stop the simulation | Yes |

* *At least one of these specifications of boundary conditions is required.*

# SED2D Execution Job Sheet

JOB EXECUTED ________________ DATE OF RUN ____/____/____

TIME OF RUN _______________

JOB PRINTED ________________ SUBMITTED BY ___________________

CPUs ________ PRIORITY_________

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

PURPOSE:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

SIMULATION TIME: Start _________________ Finish __________________

FILES:

Primary Run Control File (.sed) ________________________________

Geometry file from GFGEN (binary) _________________________

RMA2 Input hydrodynamics (binary) _________________________

SED2D Input Hot start (binary) ________________________________

SED2D full results listing _______________________________________

SED2D summary results listing ________________________________

SED2D Output Hot start (binary) ________________________________

SED2D output conc/delbed file _________________________

SED2D output bed strata file (binary) _________________________

SED2D output new geometry bathymetry file _______________________

GRAPHICAL ANALYSIS:

Film Loops _______________________________________

Time Series plots _______________________________________

COMMENT: ________________________________________________________

______________________________________________________________________

______________________________________________________________________

# Input Variables

The following is a table of input variables which are the parameters found on the SED2D data cards (except those in italics, which are not actually input on the card, but are related to the card). The table lists the variable name, a description, and the card or cards to which it is associated.

| Variable | Description | Content |
|---|---|---|
| AC1 | Marsh Porosity offset depth from mean elevation | DM |
| AC2 | Marsh Porosity depth range | DM |
| AC3 | Marsh Porosity minimum fractional area | DM |
| AC4 | Marsh Porosity override of min elevation | DM |
| AGE | Clay layer age, in years | CL |
| ACGR | Acceleration due to gravity | PV |
| ALFA1 | Angles of control structure in radians counterclockwise from the positive x-axis | CS |
| ALOCF | Locking frequency per hour | CS |
| BCFACT | Boundary buffering chamber mixing factor | BC |
| CCC | Consolidating coefficient | CI |
| CLDE | Characteristic length factor for sand deposition | SA |
| CLER | Characteristic length factor for sand erosion | SA |
| CORD(j,1-2) | X- and Y- nodal (J) coordinate | GNN |
| CONC(j) | Initial suspended sediment concentration at node J | IC |
| CRFLOC | Critical concentration above which flocculation increased the fall velocity | WF |
| CRHIND | Critical concentration above which hindered settling leads to a constant fall velocity | WF |
| DEPLIMIT | Max depth change permitted before program stops | EF |
| DIF(j,1) | Turbulent exchange coefficient in x-dir, element J | ED |
| DIF(j,2) | Turbulent exchange coefficient in y-dir | ED |
| DK1(i) | Turbulent exchange coefficient K1 in eq | DD |
| DK2(i) | Turbulent exchange coefficient K2 | DD |
| DK3(i) | Turbulent exchange coefficient K3 | DD |
| DT | Length of a SED2D simulation time step (dec hrs) | TZ |
| EFDR(j) | Effective sand grain size for roughness | SR |
| EFDT(j) | Effective sand grain size for transport | ST |
| ELEV(j) | Nodal (J) elevation | GNN |
| EROCON | Constant for the clay erosion equation | CC |
| ERODCP | Critical shear stress for particle erosion for clay | CC |
| ESPLPT | List of element type numbers for special print | TRT |

| | | |
|---|---|---|
| FALLFACT | Factor applied to the water depth of which the sediment falls | BF |
| FRCTIC | Fraction of transport potential applied | IC |
| GAMLK | Mixing exchange factor a locking event | CS |
| GSF | Grain shape factor | SA |
| HSFACT | Factor applied to wave height | HW |
| HSLIM | Max allowable wave height | HW |
| HSVAR | Scaling factor for the variance about the mean wave height | HW |
| IBCFACT | On/Off switch for boundary buffering | BC |
| ICBOT | On/Off switch for concentration correction for bed flux for clay. | BF |
| IDA | Starting day of the simulation | $D |
| IECHO | On/Off switch for echo of run control input | TR |
| IHR | Starting hour of the simulation | $D |
| IHYDOPT | On/Off switch to adjust velocity as delbed changes | EF |
| ILOADE | On/Off switch for boundary mass loading of an element | BL |
| IMAT(j) | Material type for element J | NE |
| IMN | Starting minute of the simulation | $D |
| IMO | Starting month of the simulation | $D |
| INGEOM | Input request for GFGEN binary geometry file | $L1 |
| INFETCH | Input request for Wind fetch length file | $L1 |
| INHOT | Input request for Hotstart concentration delbed binary file | $L1 |
| INHOTB | Input request for Hotstart clay bed strata binary file | $L1 |
| ~~INPSC~~ | Input request for point source concentration file | $L1 |
| INRMA2 | Input request for RMA2 hydrodynamic binary file | $L1 |
| INWAVE | Input request for wave model results binary file | $L1 |
| INWIND | Input request for wind speed/direction file | $L1 |
| ISC | Starting second of the simulation | $D |
| ITRACE | Trace print control for debug | TR |
| ITRINC | Increment for printing for full results listing | TR |
| ITYPE | Layer ID type (also see CI card) | CL |
| IVRSID | Machine type identifier | $M |
| IVSC | On/Off switch controlling adjustment of ave flux over a time step | |
| IWAV | On/Off switch to adjust wave model input | HW |
| IWBIN | Increment for saving to binary output files | TO |

| | | |
|---|---|---|
| KAUTO | Output request to save table of status regarding automatic assignments for diffusion coefficients | $L2 |
| KBSHOT | Hotstart the clay bed strata (structure) | $H |
| KCHOT | Hotstart sediment concentration | $H |
| KDBHOT | Hotstart delta bed change | $H |
| KGEOM | Output request to save new GFGEN ascii geometry | $L2 |
| KOHOTB | Output request to save bed strata (structure) information | $L2 |
| KPU | Output request to save concentration/delbed binary solution file | $L2 |
| KSPN | Output request for summary resulting listing via TRN | $L2 |
| KSPE | Output request for elemental summary resulting listing | $L2 |
| LAYER | Clay Layer number | CL |
| LINE(j,k) | Corner nodes (k=1,LMT) which define check line J | GCL |
| LMT | Number of nodes on a continuity check line | GCL |
| METRIC | System international for GFGEN and RMA2 input | SI |
| MNCL | Max number of consolidating clay layers | CC |
| MSC | Option for shear stress computation | HS |
| MSETV | Switch to control fall velocity activity | WF |
| MTC | Ackers-White sand transport function | SA |
| MTCL | Apply the original Krone & Partheniades eqn. For deposition and erosion for clay | CC |
| KNODIM | Output request to save non-dimensional analysis results | $L2 |
| NDEL | Flag for elemental summary of non-dimensional parameters (not yet operational) | ND |
| NDND | On/Off switch to summarize non-dim parameters | ND |
| NESPRT | List of element for special print | TRE |
| NNSPRT | List of nodes for special print | TRN |
| NSACI | Sand class number | SA |
| NSRC | Point source control | PC |
| NOP(j,k) | Element (J) connection table composed of nodes (K) | GE |
| PERC | Erosion rate constant for particle erosion | CI |
| PWCORR | Time shift for starting time in wave model input | HW |
| QSE | Bed shear stress at which cohesive at age=1 yr begin to erode in mass | CI |
| QSI | Bed shear stress at which cohesive layers begin to erode in mass | CI |

| | | |
|---|---|---|
| RHO(i) | Fluid density at node I | FD |
| TCORR | Time to subtract from RMA2 time | TH |
| TEND | RMA2 time for last time step to use | TH |
| TETA | Crank-Nickolson theta | TT |
| THICKL | Layer thickness | CL |
| THOE | The consolidated dry density of deposits of this type of cohesive material at age = 1 yr. | CI |
| TMAX | Max time for the simulation (dec hrs) | TZ |
| RHOI | Initial dry density of a deposit of this type of cohesive material | CI |
| SACLL | Min sand grain size | SA |
| SACUL | Max sand grain size | SA |
| SGSA | Specific gravity of sand grain | SA |
| SPEC(j) | Sediment concentration array for each node j | BC |
| TAUCD | Critical shear stress for deposition | CC |
| TAUP | Bed shear stress at which cohesive particles begin to erode | CI |
| TH(j) | Direction of eddy viscosity tensor for element J | GE |
| THKTYPE | Typical clay layer thickness for a given id type | CI |
| TTHICK | Sand bed thickness in meters | SB |
| TITLE | Character identifier for the run and all output files | T1-T2, T3 |
| VOLLK | Volume of the lock ($m^3$) | CS |
| VPEC(j) | Min velocity to use in computing effective diffusion | PE |
| VS(j) | Settling velocity at node J | WC |
| WPFACT | Factor applied to the wave period | HW |
| WPLIM | Max allowable wave period (sec) | HW |
| WPVAR | Scaling factor for variance about he mean wave period | HW |
| WTC | Water temperature in degrees centigrade | FT |
| XICMAX | Maximum value limit placed on transport potential associated with init concentration | IC |
| XNVALU(j) | Manning's n-value for node J | HN |
| XPEC(j) | Peclet number | PE |
| XSCALE | X-coordinate scale factor | GS |
| YSCALE | Y-coordinate scale factor | GS |

# SED2D DATA CARDS

This section describes all of the data cards used by SED2D.  Every effort has been made to describe each card in a clear and complete manner.  However, the appropriate sections in the manual text should be consulted when further explanation is desired.

## T1-T3 CARD: Title Description

**Required**

**Card Description:** 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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | T | Card group identifier. |
| 0, C 3 | IC3 | 1,2,3 | Card type identifier. |
| 1 | TITLE | | Any alpha-numeric data, up to 77 characters |

# $D CARD:  Start Date Control

**Optional**

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

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Required for Hotstart**

**Card Description:** 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)

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Required**

**Card Description:** 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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | $L1 | Card group identifier. |
| 1 | INGEOM | + | 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 | INWAVE | + | Wave model results input (Input LU= 80) |
| | | 0 | Off (This is the default) |

NOTE: One-dimensional elements are currently not supported 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

**Required**

**Card Description:** 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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 concentration and delbed 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 |
| 7 | KNONDIM | + | Save non-dimensional analysis results (LU = 69) |
| | | 0 | Off (This is the default) |
| 8 | KAUTO | + | Save table showing the status of automatic diffusion coefficient assignments (LU=59) |
| | | 0 | Off (This is the default) |

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 Type Identifier

**Required**

**Card Description:** 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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | $M | Card group identifier. |
| 1 | IVRSID | 1 | Direct access record length unlimited, and defined in terms of bytes.  Examples systems are:<br>DOS PC |
| | | 2 | Direct access record length unlimited, and defined in terms of short words (2 bytes).  Example systems are:<br>Prime mini-computers |
| | | 3 | Direct access record length limited to 32 bytes, and defined in teems of long words (4 bytes) Example systems are:<br>DEC Vax |
| | | 4 | Direct access defined using multiple sequential access files that are opened as required.  Note that this may generate and leave many files on disc.  Example systems are:<br>APPLE MAC II under ABSOFT FORTRAN<br>Definicon 020 beard, DEC Vax to avoid short record lengths<br>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:<br>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:<br>CDC Cyber |
| | | 8 | Same as 4 except PAUSE statement is activated<br>MacIntosh PC |

# BC CARD: Boundary Conditions

**Required**

**Card Description:** 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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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.

# BL Card:  Boundary Loading (Mass)

**Optional**

**Card Description:** Used to assign mass loading on the boundary.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | BL | Card group identifier. |
| 0, C 3 | IC3 | | Card type identifier. |
| | | ƀ | Specifies **Option 1:** The mass boundary loading in data field 2 and 3 of this card will be used for all values (J) equal to or greater than ISTART. |
| | | E | Specifies **Option 2:** The mass boundary loading are coded by *element* number. |
| | | T | Specifies **Option 3:** The mass boundary loading are coded by *material type* number (IMAT). |
| 1 | ISTART | | Code the node number, element number or material type as specified by IC3 above in data field 0, column 3. |
| | | -,+ | **Option 1 and 2:** The *starting element* number. Will load all the elements that are ≥ISTART. |
| | | -,+ | **Option 3:** The element *material type* number. Will load all the elements which satisfy the material type. |
| 2 | SRCEL(J) | -,0, + | Mass loading at ISTART=J. |
| | | | Units= kg/sec. |

Units:  Total mass/sec in the appropriate units of the simulation.

# BF CARD:  Bed Flux Controls

**Not Required**

**Card Description**:  Active parameters on these cards cause the program to use the specified parameter values in place of the default values.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | BF | Card group identifier. |
| 1 | ICBOT | 1 | (Default)  Flag controlling the application of a correction factor to the concentration used for bed flux for clay reflecting the fact that the bottom concentration is larger than the depth-averaged value.  The correction factor is function of the vertical fall velocity, the horizontal velocity. |
| | | 0 | No correction is made |
| 2 | IVSC | + | Flag controlling the adjustment of the average flux over a time step based on development in Appendix B |
| | | 0 | No adjustment made (default) |
| 3 | FALLFACT | 0<-<1 | A factor applied to the water depth over which the sediment falls.  This value has historically been set to 0.5.  Based on conversations with Dr. Ray Krone, it is now recommended that this be set to 1.0 (default).  For backward compatibility use 0.5. |

## CC CARD: Clay Characteristics

**Required for Clay**

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

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 Characteristics By ID

**Required for Clay**

**Card Description:**  Active parameters on this card cause the program to use the specified parameter values in place of the default values

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 | THKTYP | ≥ 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

### Required for Clay

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

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Optional**

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

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

# CS Card: Concentrations at a Flow Control Structures

**Optional**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | CS | Card group identifier. |
| 1 | NJN | + | Flow controller identifier (904 or larger). Applies these parameters to IMAT = NJN. |
| 2 | NJT | + | RMA4 flow controller type:<br>**1** = match concentrations<br>**2** = lock operation; specify fields 3 through 6. |
| 3* | ALFA1 | + | Angle of control structure in radians counterclockwise from the positive *x* axis. |
| 4* | VOLLK | + | Volume of the lock (use either $ft^3$ or $m^3$) |
| 5* | GAMLK | + | Mixing exchange factor for a locking event<br>(0.0 ≤ ( GAMLK ≤ 1.0). |
| 6* | ALOCF | + | Locking frequency per hour. |

* *Use if NJT = 2.*

**NOT ACTIVATED!**

# DD CARD: Effective Diffusion Coefficient By Equation 57

**Optional**

**Card Description:** Effective diffusion may be activated by using the ED, PE, and DD cards.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | 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 = $10^{-5}$ |

The DD card uses an equation of the form suggested by Allen Teeter, Coastal and Hydraulics Laboratory.

Equation 57 simplified

$$D_e = K_1 \left( K_2 D u^* + 10^{-5} \lambda^2 \right)$$

where

| | | |
|---|---|---|
| $\lambda$ | = | the element size |
| $K_1$ and $K_2$ | = | constants |

the variables $K_1$, $K_2$ and $K_3$ ( $10^{-5}$ above) are specified.

# DM CARD:  Marsh Porosity Parameters

**Optional**

**Card Description:** Used to specify information for the Marsh Porosity wetting and drying option. The marsh porosity method makes a more realistic and *gradual* transition when wetting and drying than does the method of Elemental Elimination (DE card). All nodes on the element must be flagged before the element is considered dry.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 (m) |
| | | < 0 | Default = 0.0 |

*The order in which DM cards should appear is: DMƀ (DM blank), DMT, DME, and finally, DMN. If a DMT card, for example, appears after a DME card, the DME card is potentially overruled by the DMT card..*

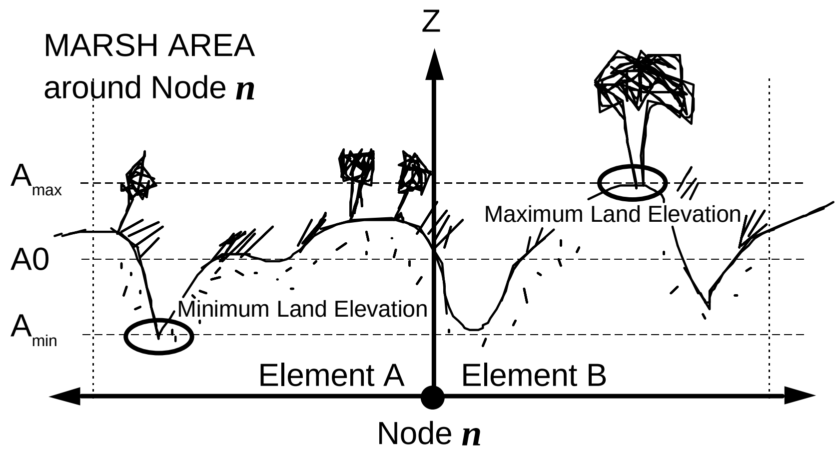
**Note:** To include computations for the Marsh Porosity option, at least one DMƀ (DM blank) card is required, then optionally followed by DMT, DME, or DMN cards (in that order). If a node receives multiple assignments, the last assignment is processed.

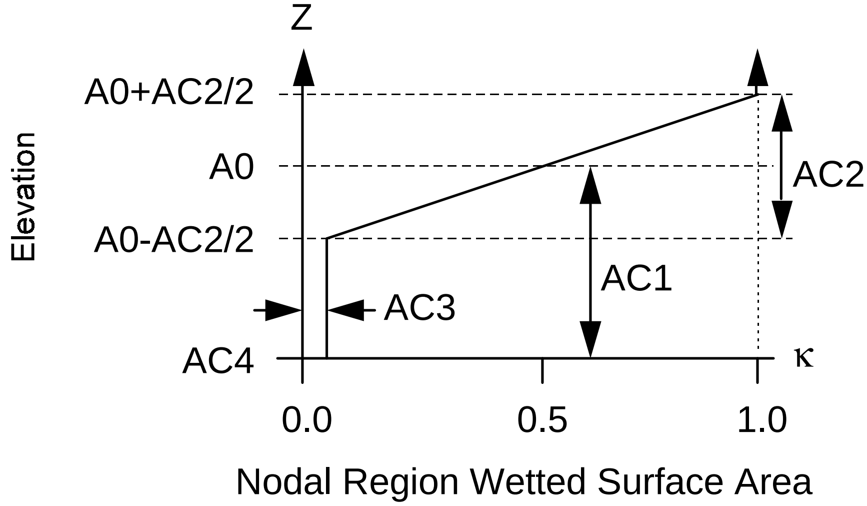
The values for AC1 through AC4 are used as an “initial guess” for SED2D.

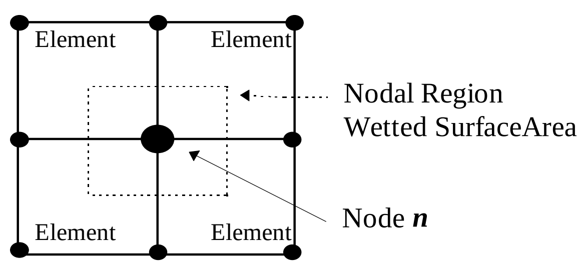
If an element becomes completely wet, DM card information for all nodes comprising that element is ignored until the water depth of the element falls within the transitional range and begins to dry.

Default values are automatically converted to metric if the SI card indicates System International units.

**See also** page , and the DE card.




Where:

- **A0** = average nodal area bed elevation (‘**z**’ value from GFGEN GNN Card). **A0** is the mean land elevation in the vicinity of node ***n***.
- **AC1** = distance from **A0** to minimum regional bed elevation.
- **AC2** = transition range of the distribution.
- **AC3** = minimum wetted area of the distribution.
- **AC4** = minimum regional bed elevation.

*“Regional” refers to the “nodal area”; the area in the immediate vicinity of node **n**.*

## ED CARD:  Effective Diffusion Coefficient

**Required**

**Card Description:** 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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Optional**

**Card Description: This option *is NOT* recommended**. It is supplied here only to be consistent with STUDH, an earlier version of SED2D.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 | $\geq 0$ | 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 calculate the sediment transport based on a hydrodynamic solution that is not valid for the current bed geometry. When this criterion is exceeded 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

**Required**

**Card Description:** This card signals the end of boundary input for a given time step.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Optional**

**Card Description:** Used to supply a fluid density for all nodes or a specified node.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 of 1000.00 $kg/m^3$ will be assigned globally.

*Densities for Fresh Water and Sea Water.*

| Type of Water | English Units slugs/$ft^3$ | Metric Units $kg/m^3$ |
|---|---|---|
| Fresh Water | 1.935 | 998.46 |
| Sea Water | 1.990 | 1026.84 |

# FT CARD:  Fluid Temperature

**Optional**

**Card Description:**  Used to supply the average initial water temperature for the entire mesh.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 centigrade |

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

**Question ????**  RMA2 v45 uses 15 degrees Celsius for default – if user applied defaults to RMA2 and SED2D  ????

# GCL Card: Geometry, Continuity Check Line

**Optional**

**This GCL card replaces the GC card.**

**Card Description:** The GCL card is used to specify a line within the grid where the flow rate is of interest. GCL lines may be used to specify the location of boundary conditions.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | GC | Card group identifier. |
| 0, C 3 | IC3 | L | Card type identifier. |
| 1 | J | + | Continuity check line number described by this GCL card. |
| 2-n | LINE(J,K) | + | List the nodes that define this continuity check line. **Note:** If there are more node numbers specifying a continuity check line than will fit in the data fields remaining on the current GCL card, continue coding the remaining node numbers starting in data field 1 of the next GCL card. |
| n | End of List | -1 | A node number of -1 is required to mark the end of the list of nodes that specify this continuity check line. |

**Example:**

CO Line# Node numbers...Negative number marks the end
GCL 1 10 11 12 13 14 15
GCL 16 17 18 19 20 21
GCL 22 23 **-1**
GCL 2 100 101 102 109 107 99 **-1**

# GC CARD: Geometry, Continuity Check Lines

**Optional**

**Card Description:** *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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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.

GCL card has replaced the old GC line format.

# GE CARD:  Grid, Element Connection Table

**Optional**

**Card Description:**  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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Optional**

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

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | GNN | 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.

## GS CARD: Geometry, Nodal Scale Factor

**Optional**

**Card Description:** Used to apply scale factors to the x and y coordinates**.**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | GS | Card group identifier. |
| 1 | XSCALE | > 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 GS card is present, the default values will be applied.

## GT Card:  Geometry, Element Material Types

**Optional**

**Card Description:** Used to specify or modify element material types.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | GT | Card group identifier. |
| 1 | J | + | Element number. |
| 2 | IMAT(J) | 0, + | Element material type number. |
| 3-10 | | + | You may provide (J, IMAT(J)) sets of values. |

**Tip:** To effectively remove an element from the computational mesh, set the material type (IMAT) for the element to a value of zero (the element will appear to be land).

**See also:** GFGEN manual

# GW Card:  Geometry, Channel Width Attributes

### Required for one-dimensional nodes if GN cards with the N option are not used

**Card Description:** Used to only specify or modify *one-dimensional* trapezoidal channel attributes at the node specified.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | GW | Card group identifier. |
| 0, C 3 | IC3 | | Card type identifier. |
| | | ƀ (blank) | Specifies **Option 1:** Universal assignment for all nodes ≥ NODE. |
| | | N | Specifies **Option 2:** Individual node assignment. |
| 1 | NODE | | The *one dimensional* starting node or node number as specified by IC3 above. |
| | | | **Note:** Enter one dimensional corner nodes and transition nodes. |
| | | + | **Option 1:** The *starting* node number. |
| | | + | **Option 2:** The node number. |
| 2 | WIDTH | + | Channel surface width at zero depth for NODE. |
| 3 | SS1 | -, + | Left side slope at NODE. |
| 4 | SS2 | -, + | Right side slope at NODE. |
| | | | **Note:** Off-Channel Variables Follow. |
| 5 | WIDS | + | Off-Channel Storage width associated with NODE at zero depth. |
| 6 | WSCRIT | -,+ | Water surface elevation to activate Off-Channel storage |
| 7 | SSS | -,0,+ | Side slope for off-channel storage |

**Note:** Code only *one* corner node per GW card. All slopes are with respect to one unit of rise.

If you are using SMS, the GW card is the preferred method for defining one-dimensional channel width attributes as opposed to the GN card.

**SMS Note:** As of this writing, SMS will read and interpret, but will not update GW card data. Be aware that if the grid is renumbered by SMS, the node numbers on GW cards may no longer agree with the new element connection table. If this is the case, you will have to update the GW cards manually.

**See also:** GFGEN manual

# HD Card:  Hydrodynamic, Water Depth

.

**Optional**

**Card Description:**  This card assigns the water depth when no RMA2 hydrodynamics are specified.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | HD | Card group identifier. |
| 1 | J | + | Starting node number at which this global assignment will be made. |
| 2 | VEL(3,J) | + | Depth of water at node J (meters) |

**Note:**  If no HD card is read, the input RMA2 solution will be used to specify depth at each individual node.

# HN CARD: Roughness, (Manning's n-Value)

**Required if an HS card is used and MSC = 2**

**Card Description:** Used to assign a Manning's n roughness value to the entire grid, or to an individual material type.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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.

# HU Card:  Hydrodynamic, X-Velocity

.

**Optional**

**Card Description:** This card assigns the water depth when no RMA2 hydrodynamics are specified.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | HU | Card group identifier. |
| 1 | J | + | Starting node number at which this global assignment will be made. |
| 2 | VEL(1,J) | + | X component of velocity at node J (meters/sec) |

**Note:** If no HU card is read, the input RMA2 solution will be used to specify velocity components at each individual node.

## HV Card:  Hydrodynamic, Y-Velocity

.

**Optional**

**Card Description:** This card assigns the water depth when no RMA2 hydrodynamics are specified.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | HV | Card group identifier. |
| 1 | J | + | Starting node number at which this global assignment will be made. |
| 2 | VEL(2,J) | + | Y component of velocity at node J (meters/sec) |

**Note:** If no HU card is read, the input RMA2 solution will be used to specify velocity components at each individual node.

## HS CARD:  HYDRAULIC BED SHEAR STRESS

**Required**

**Card Description:** Used to assign the option for shear stress computation.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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’s 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. |

# HW CARD:  Wave Model Input Control

**Optional**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0,C 1-2 | IC1 | HW | Card group identifier. |
| 1 | IWAV | 1 | Flag for performing adjustments to wave model input.  IWAV = 1 invokes adjustments |
| | | 0 | No adjustments are made (default) |
| 2 | PWCORR | + | Time shift for starting time in wave model input file (hr) |
| 3 | HSFACT | + | Factor applied to the wave height |
| 4 | HSLIM | + | Maximum allowable wave height (m) |
| 5 | HSVAR | + | Scaling factor for the variance about the mean wave height.  A value of 0.0 would return a constant mean wave height over the entire model. |
| 26 | WPFACT | + | Factor applied to the wave period |
| 7 | WPLIM | + | Maximum allowable wave period (sec) |
| 8 | WPVAR | + | Scaling factor for the variance about the mean wave period.  A value of 0.0 would return a constant mean wave period over the entire model |

# IC CARD:  Initial Conditions

**Required for cold start**

**Card Description:**  Used to assign initial conditions for a cold start.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 3:  Explicit assignment for Element = J |
| | | N | Option 4:  Explicit assignment for Node = J |
| | | P | Option 5:  Global assignment of transport potential (sand only) |
| 1 | J | + | Starting or explicit value |
| 2 | CONC (J) | ≥ 0 | Initial suspended sediment concentration for location = J($kg/m^3$) |
| | | < 0 | Default = 0.0 $kg/m^3$ |

For Option 5:

| Field | Variable | Value | Description |
|---|---|---|---|
| 1 | IGCP | 1 | Flag to apply the initial concentration based on transport potential (Acker-White) |
| | | 0 | Disables specification by transport potential |
| 2 | FRCTIC | + | Fraction of transport potential applied (unitless) |
| 3 | XICMAX | + | Maximum value limit placed on transport potential ($kg/m^3$; only associated with initial concentrations) |

# ND CARD: Non-dimensional Analysis

**Optional**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0,C 1-2 | IC1 | ND | Card group identifier. |
| 1 | NDEL | - | Flag for elemental summary of non-dimensional parameters (This is not currently operational) |
| 2 | NDND | >0 | Flag for nodal summary of non-dimensional parameters |
| | | 0 | No nodal summary |

# ~~PC CARD~~: Point Source Control

**Optional**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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.

PC-Card is no longer available. The capability is on the BL card.

# PE CARD:  Control Of The Effective Diffusion Coefficient By Peclet Number

**Optional**

**Card Description:**  Used to provide for *real time* adjustment of diffusion based upon the computed velocity and individual size of each element.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Optional**

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

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | PV | Card group identifier. |
| 1 | ACGR | ≥ 0 | Acceleration due to gravity (m/sec2) |
| | | < 0 | Default = 9.807 m/sec$^2$ |

# SA CARD: Sand Characteristics

**Required for Sand**

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

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 |
| | | | This variable name is basically not used. |
| | | < 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

**Required for Sand**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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

**Required for Sand**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 3:  Explicit assignment for Element = J |
| | | N | Option 4:  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

**Required for Sand**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 3: Explicit assignment for Element = J |
| | | N | Option 4: 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

**Required**

**Card Description:** Used to identify the units on the input binary formats of GFGEN and RMA2.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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. |

# STO(P) CARD:  Stop The SED2D Simulation

**Required**

**Card Description:** Required to stop the SED2D simulation.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | ST | Card group identifier. |
| 0,C3 | IC3 | 0 | Card type identifier |
| 2-10 | FLD | A | May be used for comments |

## T1-T3 CARD:  Title Description

**Required**

**Card Description:** 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.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | T | Card group identifier. |
| 0, C 3 | IC3 | 1,2,3 | Card type identifier. |
| 1 | TITLE | | Any alpha-numeric data, up to 77 characters |

# TH CARD:  Timing of the Hydrodynamic File

**Required**

**Card Description:**

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | TH | Card group identifier. |
| 0,C3 | IC3 | b/ | Card type identifier |
| 1 | TCORR | Real | Time (hr) to subtract from the RMA2 time to define SED2D time 0. |
| 2 | TEND | Real | RMA2 Time value of the last time step on RMA2 file. |
| 4 | DT_REPEAT | $\geq 0$ | 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 to the delta  time step value on the TZ card (DT variable) |

**See also**  TZ CARD:  Computational Time Control

# TO CARD:  Timing Of Binary Write

**Optional**

**Card Description:** Used to prevent SED2D from writing to the solution file until he simulated hour matches a user specified time.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | TO | Card group identifier. |
| 1 | IWBIN | $\geq 0$ | 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

**Optional**

**Card Description:**  Used to specify what information will appear on the special print file.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | TR | Card group identifier. |
| 1 | IREPRT | ≤ 0 | No reporting |
| | | > 0 | Report the input parameters to the full results listing file. |
| | | | The value of IREPRT serves as an incremental counter for input parameters that are nodal or elemental based. |
| 2 | ITRINC | > 0 | Increment for printing to full print output file (print every ITRINC'th time step) |
| | | ≤ 0 | Default = 1 |
| 3 | IECHO | < 0 | Do not echo the run control input cards |
| | | ≥ 0 | Echo the run control input cards (This is the default) |
| 4 | ITRACE | 0 | No trace  for debug purposes |
| | | | (This is the default) |
| | | 1 | Trace between major subroutine calls for debug purposes |
| | | 2 | Exhaustive debug trace to the standard output ("screen") |

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

# TRE CARD:  Element List For Special Summary Trace Print

**Optional**

**Card Description:**  Used to assign the elements whose properties will appear on the special print file.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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.

# TRN CARD: Node List For Special Summary Trace Print

**Optional**

**Card Description:** Used to assign the nodes whose properties will appear on the special print file.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | TRN | Card group identifier. |
| 1-10 | NNSPRT(I) | + | List of node number for special print summary.<br>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.

# TRT CARD:  Material Type List For Special Summary Trace Print

**Optional**

**Card Description:**  Used to assign the material types whose properties will appear on the special print file.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | TRT | Card group identifier. |
| 1-10 | ESPLPT(I) | + | List of element type (IMAT) numbers for special print summary.<br>Note:  This will become an equivalent TRE card list. |

NOTE:  Multiple TRT 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

**Required**

**Card Description:** Used to specify a value for THETA in the Crank-Nicholson time-stepping scheme.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | TT | Card group identifier. |
| 0,C3 | IC3 | b/ | |
| 1 | TETA | | Crank-Nicholson 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. |

.

NOTE: 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.

# TZ CARD: Computational Time Control

**Required**

**Card Description:** Used to control the simulation time.

| 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 |

# WC CARD:  Settling Velocity

**Required**

**Card Description:** 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. WC is used by both sand and clay.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | 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 3: Explicit assignment for Element = J |
| | | N | Option 4: Explicit assignment for Node = J |
| 1 | J | + | Starting or explicit value |
| 2 | VS(J) | ≥ 0 | Settling velocity (m/sec) |
| | | < 0 | Default = 0.0 (no deposition) |

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.

# WF CARD: Settling Velocity Function Option

**Optional**

**Card Description:** Used to select the function used to define the fall velocity, for both Sand and Clay.

| Field | Variable | Value | Description |
|---|---|---|---|
| 0, C 1-2 | IC1 | WF | Card group identifier. |
| 1 | MSETV | 0 | Make fall velocity a function of concentration. The functional form is<br>If concentration is greater than or equal to 0.3 $kg/m^3$ then<br>VS(NN) = VS(NN) from WC cards<br>If concentration is greater than or equal to 0.3 $kg/m^3$ then<br>VS(NN) = VS(NN) from WC cards*CONN(NN)**(4/3) |
| | | 1 | Make fall velocity a function of concentration. The functional form is<br>If concentration is greater than or equal to 1 $kg/m^3$ then VS(NN) = VS(NN) from WC cards<br>If concentration is greater than or equal to 0.01 $kg/m^3$ and less than 1 $kg/m^3$ then<br>VS(NN) = VS(NN) from WC cards * CONC(NN) ** (4/3)<br>If concentration is less than or equal to 0.01 $kg/m^3$ then<br>VS(NN) = 0.02158 * VS(NN) from WC cards * SQRT(CONC(NN)) |
| | | 2 | Make fall velocity a function of concentration. The functional form is<br>If concentration is less than or equal to CRFLOC $kg/m^3$ then<br>VS(NN) = VS(NN) from WC cards<br>If concentration is greater than or equal to CRFLOC and less than CRHIND then<br>VS(NN) = VS(WC cards) * CONC(NN)/CRFLOC ** (4/3) |
| 2 | CRFLOC | + | Critical concentration ($kg/m^3$) above which flocculation increased the fall velocity (used only for MSETV=2) |
| 3 | CRHIND | + | Critical concentration ($kg/m^3$) above which hindered settling leads to a constant fall velocity (used only for MSETV=2) |

# Performance Enhancements

## Redimensioning SED2D

There are several arrays whose size can be modified, and it should be determined by your problem and the system on which you are running SED2D. These array dimensions can be changed in the source code by editing the SED2D include file and recompiling. The array dimension variables are as listed in the table below.

| Variable | Description |
|---|---|
| MNN | Maximum number of nodes |
| MNE | Maximum number of elements |
| MNEQ | Maximum number of system |
| MNL | Maximum number of clay bed layers |
| MNFE | Maximum number of matrix columns |
| MBUF | Buffer size |
| MCCN | Maximum number of continuity |
| MNSPRT | Maximum number of special print |
| MQAL | Maximum number of quality |
| MBNP | Maximum number of BC buffer nodes |
| MBB | Maximum number of BC buffer cells |

## 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 sed2dv45.exe -O4 -static sed2dv45.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 sed2dv45.f is the name of the source file. The source file contains an “INCLUDE” statement which will require the presence of the file “sed2dv45.inc” in the working directory at the time of compilation. The file “sed2dv45.inc” contains the global variable declarations for SED2D WES. 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”.

# COMMON PROBLEMS

## 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 $sec^2$).

# WARNINGS AND ERROR MESSAGES

# SED2D FILE FORMATS

## TABS Binary File Header Format

All TABS-MD models operate on and generate binary files, each of which have several header or banner records that describe critical features about the contents of the file. The binary files are written by standard FORTRAN 77 unformatted write statements. The variable types follow standard FORTRAN assignments, where variables are REAL, except for those beginning with the characters ‘I’ through ‘N’ which are INTEGER.

### Record 1

MFLG, IREC, NP, NE

where

| | |
|---|---|
| MFLG | Model identifier flag<br>(120-129 for RMA2 results)<br>(135-139 for RMA2 Hotstart file) |
| IREC | Version number of the RMA2 program |
| NP | Number of nodes in the mesh |
| NE | Number of elements in the mesh |

### Record 2

IWRT1, (IBAN(i),i=1,IWRT1)

where

| | |
|---|---|
| IWRT1 | Number of items contained in the banner array |
| IBAN | Integer interpretation of the banner character strings |

### Record 3

IWRT2, IWRT3 , (IREC(i),i=1,IWRT2), (FREC(i),i=1,IWRT3)

where

| | |
|---|---|
| IWRT2 | Number of items contained in the IREC array |
| IWRT3 | Number of items contained in the FREC array |
| IREC | Integer flags which are set during execution |
| FREC | Floating point flags which are set during execution |

### Record 4

IWRT4, (ITIT(i),i=1,IWRT4)

where

| | |
|---|---|
| ITIT | Integer interpretation of the title character string |
| IWRT | Number of items contained in the ITIT array |

### Records 5-End are not header records….

The contents of record number 5 through the end varies depending upon the type of file you are dealing with (RMA2 u-v-h solution, SED2D concentration/delbed solution, etc.)

# GFGEN Binary Geometry File Format

**Records 1-4** are the same as the header records in "TABS Binary File Header Format" on page 128.

**Record 5**

NP, NE, ((CORD(j,k),k=1,2), ALFA(j), AO(j), j=1,N),

((NOP(j,k),k=1,8), IMAT(j), TH(j), NFIXH(j),j=1,M),

**Record 6**

(WIDTH(j),SS1(j),SS2(j),WIDS(j), j=1,N)

where

| | |
|---|---|
| NP | Number of nodes in the mesh |
| NE | Number of elements in the mesh |
| CORD | Array containing X- and Y-coordinate |
| ALFA | Array containing |
| AO | Array containing bottom elevation |
| NOP | Array containing element connection |
| IMAT | Array containing each elements material type assignment |
| TH | Array containing elemental direction for Eddy Viscosity |
| NFIXH | Array containing elemental direction for Eddy Viscosity |
| WIDTH | Array containing 1D element, channel bottom width |
| SS1 | Array containing 1D element, left side slope |
| SS2 | Array containing 1D element, right side slope |
| WIDS | Array containing each element's off-channel storage width |
| WSCRIT | Array containing each element's off-channel storage width criticle water surface elevation switch |
| SSS | Array containing each elements off-channel storage side slope |

# RMA2 Binary Solution (u,v,h) File Format

**Records 1-4** are the same as the header records in "TABS Binary File Header Format" on page 128.

**Record 5**

TET, NP, ((VEL(j,k),j=1,3), k=1,NP), (NDRY(k), k=1,NP), NE,

(IMAT(k),k=1,NE), (WSEL(k), k=1,NP)

where

| | |
|---|---|
| TET | Simulation time, in decimal hours |
| NP | Number of nodes in the mesh |
| VEL | Array containing --> X-velocity, Y-velocity, and Depth |
| NDRY | Array containing wet/dry status for each node<br>(1 = wet, 2 = dry, -1 = About to become re-wet) |
| NE | Number of elements in the mesh |
| IMAT | Array containing each elements material type assignment |
| WSEL | Array containing water surface elevation for each node |

**Records 6 (through the *Last record*)**

Continue reading simulation records in a loop until an end-of-file is reached.

# SED2D Binary Concentration and DelBed Format

**Records 1-4** are the same as the header records in "TABS Binary File Header Format" on page 128.

**Records 5 (startup time)**

NTTS, *IYR, IMO, IDA, IHR, IMN, ISC*

**Records 6 (geometry and initial condition)**

NP, NE, ((CORD(i,J),J=1,2),i=1,NP),
((NOP(i,J),J=1,8),i=1,NE), (AT(i),i=1,NE),
(ELEV(i),i=1,NP), (CONC(i),i=1,NP)

where

| | |
|---|---|
| NTTS | Maximum number of SED2D time steps (see TZ card) |
| *start time* | Starting year/month/day/hour/min/second |
| NP | Number of nodes in the mesh |
| NE | Number of elements in the mesh |
| CORD | Array of (x,y) coordinates for each node point (m) |
| NOP | Element connection table for each element |
| AT | Element surface area ($m^2$) |
| ELEV | Initial Bed elevation (m) |
| CONC | Initial concentration ($kg/m^{3)}$ |

**Records 7 (solution arrays for current time step)**

TETHR, (CONC(i),i=1,NP), (DELBED(i),i=1,NP),
(IMAT(i),i=1,NE), (ELDELBED(i),i=1,NE), (BSHEAR(i),i=1,NP),
(DEP(i),i=1,NP), (NDRY(i),i=1,NP)

where

| | |
|---|---|
| TETHR | Simulation time, in elapsed decimal hours |
| CONC | Sediment concentration at current time, $kg/m^3$ |
| DELBED | Bed change by node (m) |
| IMAT | Element material type |
| ELDELBED | Bed change by element (m) |
| BSHEAR | Bed shear stress (Pa) |
| DEP | Water depth |
| NDRY | Array containing wet/dry status for each node<br>(1 = wet, 2 = dry, -1 = About to become re-wet) |

**Records 7 (through the *Last record*)**

Continue reading simulation in a loop until an end-of-file is reached.

# SED2D Binary Bed Strata (a.k.a Structure) File Format

**Records 1-4** are the same as the header records in "TABS Binary File Header Format" on page 128.

**Records 5 (bed strata, density, thickness, age, strength)**

TETHR, NP, NE, MNL,

(NLAY(i),(i=1,NP),

((RHOB(i,j),i=1,NP),

(THICKL(i,j),i=1,NP),

(AGE(i,j),i=1,NP),

(ITYPE(i,j),i=1,NP),

(SST(i,j),i=1,NP),j=1,MNL)

where

| | |
|---|---|
| TETHR | Simulation time, in decimal hours |
| NP | Number of nodes in the mesh |
| NE | Number of elements in the mesh |
| MNL | |
| NLAY | |
| RHOB | |
| THICKL | |
| AGE | |
| ITYPE | |
| SST | |

**Records 5 (through the *Last record*)**

Continue reading simulation records in a loop until an end-of-file is reached.

**Note:**

# New GFGEN Ascii Geometry File Format

**Records 1-3 (Titles)**

'T1  New SED2D Geometry.  NE=',I7,' NP=',I7

'T2  Delbed results after ',F15.1,' seconds. Units=',A

'T3  ', A

**Element Connection Table Section**

'GE ',10I7, F6.2

**Geometry Nodal coordinate and bottom elevation**

'GNN ',I7, 2F15.2,F10.4

**Geometry 1D and 2D Off Channel Storage**

I, CHWIDTH(I),SS1(I),SS2(I),WIDS(I)

GWN ', I7, 4F12.4

| | |
|---|---|
| NE | Number of elements in the mesh |
| NP | Number of nodes in the mesh |
| NOP | Element connection table for each element |
| ALFA | Reference angel for the element |
| IMAT | Material type for the element |
| CORD | Array of (x,y) coordinates for each node point (m) |
| AO (new) | Bottom elevation as computed to date |
| SS1 | Array containing 1D element, left side slope |
| SS2 | Array containing 1D element, right side slope |
| WIDS | Array containing each element's off-channel storage width |
| WSCRIT | Array containing each element's off-channel storage width criticle water surface elevation switch |
| SSS | Array containing each elements off-channel storage side slope |

# SED2D Binary Wave File Format

**Records 1-4** are the same as the header records in "TABS Binary File Header Format" on page 128.

**Records 5 (vorticity arrays)**

WAVE_HR,  NSET,  NPPW2, (WAVEHIT(k), k=1,NPPW2),

(WAVEDIR(k), k=1,NPPW2),(WAVEPER(k), k=1,NPPW2),

NEPW2_VOID, (IMAT_VOID(k),k=1,NE)

where

| | |
|---|---|
| WAVE_HR | Wave time, in decimal hours |
| NSET | Number of nodal arrays to follow (NSET=3 for wave) |
| NPPW2 | Number of nodes represented in the wave file |
| WAVEHIT | Array containing wave height results at each node |
| WAVEDIR | Array containing wave direction results at each node |
| WAVEPER | Array containing wave period results at each node |
| NEPW2_void | Number of elements represented (NEPW2=0 for wave) |
| IMAT_void | Array containing each elements material type assignment.<br>IMAT_void is read but not used. |

**Records 6 (through the *Last record*)**

Continue reading simulation records in a loop until an end-of-file is reached

**Note:** The wave binary file is primarily used by advanced users.  The file format mimics the RMA4 solution file format to permit easy visualization by the SMS graphical user interface.  SMS will label the contents as constituents 1-3, but they are actually the wave height, direction, period, respectively.

# UTILITIES

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.

# TECHNICAL SUPPORT

There are several technical support options available to TABS-MD users. We are continually striving to improve your support options to provide you with the answers you need as simply and as quickly as possible.

## On-Line Support

Technical support is available on the Internet 24 hours a day, 7 days a week.

### Option 1: World Wide Web

Check out our list of Frequently Asked Questions on the Internet at URL

http://hlnet.wes.army.mil.

### Option 2: E-mail

If you cannot find a solution to your problem yourself, you can send us E-mail at tabs@hl.wes.army.mil. We will try to obtain a solution to your problem and reply with our findings.

## TABS Hotline

Currently there is one person to handle Hotline support phone calls for TABS, so we request that you try all possible avenues to find a solution to your problem before calling for support. If you must call, please have the following pertinent data available:

- The GFGEN Geometry file
- The RMA2 run control file (.rc2 file)
- Computer information: type, memory capacity, etc.
- Any error messages
- Your E-mail and FTP addresses if applicable

The Hotline phone number if (601) 634-2730, FAX (601)634-4208.

# REFERENCES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# Notation

| | | |
|---|---|---|
| $\square_1$ | = | coefficient for the source term 1/sec |
| $\square_2$ | = | 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 |
| $\square$ | = | 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 | = | Manning's roughness value |
| P | = | erosion rate constant |
| PI | = | percent of bed surface covered by grain size, expressed as a function |
| Q | = | □ for the transient problem |
| $q_i^s$ | = | flux from source on boundary i |
| □ | = | 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 |
| □ | = | bed share stress |
| □$_d$ | = | critical shear stress for deposition |
| □$_e$ | = | critical shear stress for particle erosion |
| □$_s$ | = | 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 |
| □ | = | 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 |
| □ | = | local coordinate |

# Glossary of Terms

NOTE: We used EM 1110-2-4000, 15 Dec 89, Appendix B, Sedimentation Glossary of Terms, and have added other glossary entries for the SED2 manual.

*ASCII*

The **A**merican **S**tandard **C**ode for **I**nformation **I**nterchange 8-bit character set. ASCII values represent letters, digits, special symbols, and other characters.

An ASCII file, or text file, is a file which contains only ASCII characters in the range from 0 to 127.

*Achers-White Transport Equation*

The transport formulation for assessing sediment transport for sand adopted for the SED2D numerical model. The Achers-White formula (see Eq11-13) computes the total bed load, including suspended load and bed load, and was developed originally for fine sand. The formulation was later updated to include coarser sands and these revised coefficients are included in SED2D. See reference Ackers P. and White W. Sediment Transport: New Approach and Analysis. Journal of the Hydraulics Division, American Society of Civil Engineers, 1973, 99, HY11 ,2041-2060.

See Also Equations 11-13

*Aggradation*

The geologic process by which stream beds, flood plains, and the bottoms of other water bodies are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of degradation.

*Alluvial*

Pertains to alluvium deposited by a stream of flowing water.

*Alluvium*

A general term for all detrital deposits resulting directly or indirectly from the sediment transported of (modern) streams, thus including the sediments laid down in riverbeds, flood plains, lakes, fans, and estuaries.

*Banner*

An alphanumeric set of information included in all TABS-MD binary output files which describes the flow of data between GFGEN, RMA2, RMA4, and SED2D.

*Base to Plan comparisons*

The process of identifying differences in numerical model results between existing conditions and revised conditions, usually a change in geometry.

# Basis Function

The interpolation polynomial used to approximate the spatial distribution of the solution over a portion of the model domain (element). Also called Shape function.

*Batch mode*

A quequeing procedure and computer specific job control language which permits dedicated resources for a numerical simulation.

*Bathymetry*

The measurement of the depth of large bodies of water.

*Bed load*

Material moving on or near the stream bed by rolling, sliding, and sometimes making brief excursions into the flow a few diameters above the bed

*Bed material*

The sediment mixture of which the bed is composed. In alluvial streams bed material particles are likely to be moved at any moment or during some future flow condition.

*Bed Source Term*

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.

*Binary*

A numbering system consisting of only the numerals 0 and 1.

The TABS-MD system uses some binary files. A binary file permits an efficient means to store numerical results.

Binary files are dependent on the word length of the computer from which they were created. They cannot be directly moved across computer platforms.

A TABS binary file is created by an unformatted FORTRAN WRITE statement.

*Boundary Condition Buffering*

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.   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.

### *Boundary conditions*

Water levels, flows, concentrations, stage/discharge relationships, etc., that are specified at the boundaries of the area being modeled.  A specified tailwater elevation and incoming upstream discharge are typical boundary conditions.

### *Boundary effect*

A consequence of dissimilarities between the model boundary conditions and the conditions occurring in the prototype at the location of the model boundaries.  This effect may be minimized if the model's boundaries are far from the area of interest.

### *Boundary node*

Any node which lies along an *exterior element* edge, or demarcates the wet/dry interface.

### *Bulk Shear Stress*

### *Card*

A term which comes from the 1960-1980's when computers received data on punched cards. Each card supplied the computer with a line of data.

The TABS-MD programs use cards in the same way.  The difference is that the card data are stored in a disk file and not in a filing cabinet.

### *Card image*

An ASCII line of data for the computer to read.

### *Coastal and Hydraulics Laboratory (CHL)*

The US Army Engineer Research and Development Center, at the Waterways Experiment Station, Coastal Hydraulics Laboratory, Vicksburg, Mississippi, is the principal Corps agency for engineering research and experimentation in hydraulics and hydrodynamics and is one of the largest hydraulics laboratories in the world.

The Coastal Hydraulics Laboratory provides TABS Numerical Model maintenance and support for Army Corps installations.  To find out about availability and support for the TABS modeling system, contact the Coastal and Hydraulics Laboratory via e-mail at **tabs@hl.wes.army.mil**, or call (601) 634-3339.

### *Cohesiveness*

The cohesion of a sediment particle is associated with soil type and particle size. Cohesion increases with decreasing particle size for the same type of material. Cohesive sediment is characterized by the dispersed particle fall velocity, flocculated fall velocity of the suspension, the clay and nonclay mineralogy, organic content, and the cation exchange capacity.

### *Cohesive Sediment*

Sediments whose resistance to initial movement or erosion is affected mostly by cohesive bonds between particles. A sediment grain size descriptor, commonly known as clay.

### *Cold start*

A model run using initial conditions that are not expected to be close to conditions as solved by the model, i.e., a level water surface elevation and velocity values of zero.

### *Compiler*

A special computer program which converts a higher level language (such as FORTRAN) to a coded set of machine dependent instructions (fetch the contents of REGISTER 1). All TABS-MD programs are written for a FORTRAN-77 compiler.

### *Concentration of sediment*

The dry weight of sediment per unit volume of water-sediment mixture, i.e., mg/L.

### *Consolidation*

Consolidation is the process of compaction of a deposit with time or with overburden pressure.

### *Continuity*

The term continuity refers to conserving mass within the model. The continuity check lines are typically used to estimate the flow rates and serve as an error indicator. The SED2D model ???? satisfied mass conservation in a weighted residual manner. The continuity lines can be used to check mass conservation a different way, by direct integration. Large discrepancies between the two methods indicate probable oscillations and a need to improve model resolution and/or to correct large boundary break angles.

Although continuity checks are optional, they are a valuable tool for diagnosing a converged steady state solution. For steady state, the continuity check lines should represent *total flow in equals total flow out.* However, if the continuity checks indicate a mass conservation discrepancy of ± 3%, you may want to address the resolution in the geometry. Large mass conservation discrepancies can lead to difficulty when the hydrodynamics are used for transport models, RMA4 and/or SED2D.

### *Continuity line*

(or Continuity Check Line)

A string of corner nodes across which the total flow (or constituent if running RMA4) can be measured. The use of continuity lines also provides a convenient way to specify boundary conditions.

### *Control structure element*

A special 2-node element with an IMAT $\geq$ 904. The first node in the element connection table should be the side of the structure with the typical higher elevation.

### *Convergence*

The process of obtaining a solution by way of an iterative solution technique, such as the Newton-Raphson method.

**See Also:**

### *Consolidation*

### *Convection*

### *Crank-Nicholson*

### *Critical Shear Stress*

### *Curved boundary*

An optional aesthetic means to outline key landmarks within the computational domain. A quadratic curved side is created by assigning ($x$, $y$) coordinates to the mid-side node of an element. Curving can help conserve mass in the transport models.

**SMS Note:** Curved boundaries may be created within the SMS program by unlocking the nodes and moving the mid-side node. Some automatic curving features are available as well.

### *Data Field*

A specific location on a record (card in TABS-MD programs) in a data file where a data value occurs.

### *Delta time step*

The increment of prototype time between two time steps.

### *Density*

The mass of a substance per unit volume. In the English system the units are pounds-seconds square/feet to the fourth power. In the metric system the units are kg/L

### *Deposition*

The mechanical or chemical processes through which sediments accumulate in a resting place.

### *Diffusion*

### *Dirichlet Boundary Condition Specification*

### *Dispersion*

To de-flocculate or disaggregate compound particles, such as clays and fine silts, into individual component particles.

### *Diverge*

The inability of the numerical model to achieve convergence by the iteration technique.

### *Element*

A segment, triangle, or quadrilateral shape composed of corner nodes and mid-side nodes. An element must be 'connected' to a neighboring element.

An element is composed of a list of nodes in a counterclockwise fashion and may define a 1, 2, or 3 dimensional problem. A line segment defines a one dimensional area, a triangle or quadrilateral defines a two dimensional area, while the three dimensional area is defined by adding layers to an element.

SED2D can handle one dimensional and two dimensional elements.

### *Entrainment*

The carrying away of bed material produced by erosive action of moving water.

### *Erosion*

The wearing away of the land surface by detachment and movement of soil and rock fragments through the action of moving water and other geological agents.

### *Exit boundary*

A boundary condition location at which flow exits the mesh.

### *FastTABS*

This was the predecessor to SMS. A computer program that provides a graphical, point and click means for performing pre- and post-processing for surface water numerical models.

Developed at the Waterways Experiment Station (WES) and Brigham Young University (BYU).

*Field data*

Data which has been collected at an existing, physical site, used when verifying the simulation.

*Fine material*

Particles of a size finer than the particles present in appreciable quantities in the bed material; normally silt and clay particles (particles finer than 0.062 mm).

*Fine-material load*

That part of the total sediment load that is composed of particles smaller than the particles present in appreciable quantities in the stream bed. Normally, that is of sediment particles smaller than 0.062 mm.

*Finite element*

A method of solving the basic governing equations of a numerical model by dividing the spatial domain into elements in each of which the solution of the governing equations is approximated by some continuous function. This method lends itself well to the river/estuarine environments because of its diversity in computational mesh (element size, shape, orientation), flexibility of boundary conditions, and continuity of the solution over the area.

*Flocculent*

An agent that produces flocs or aggregates from small suspended particles.

*Flocculation agent*

A coagulating substance which, when added to water, forms a flocculent precipitate that will entrain suspended matter and expedite settling; for example, alum, ferrous sulfate, or lime.

*Flow fields*

The domain in which the water flows.

*Fluvial*

(1) Pertaining to streams. (2) Growing or living in streams or ponds. (3) Produced by river action, as a fluvial plain.

*Fluvial sediment*

Particles derived from rocks or biological materials which are transported by, suspended in, or deposited by streams

*Flux*

### *Free field*

A data format where spaces or commas separate the data items on the input line. There is no fixed position in which the data is required to be located. Only the order of the items is important.

### *Froude Number*

A non-dimensional number indicating the ratio of inertial forces to gravitational forces in a fluid. The Froude number is not important in SED2D because there are no terms for gravity in the formulation.

### *Gaging station*

A selected cross section of a stream channel where one or more variables are measured continuously or periodically to index discharge and other parameters.

### *Gate*

A movable barrier, such as a tide gate, in a river or stream.

### *GFGEN*

**G**eometry **F**ile **GEN**eration program used to create the computational mesh for all TABS-MD applications.

### *Grain Size*

See particle size.

### *HEC-6*

### *HEC format*

A naming convention for the style of run control input derived by Hydrologic Engineering Center (HEC) in which each line of input is defined by a ‘Card Type in data field 0’ and the data follows in fields 1 through n.

Example, GN card with the N option:

| Field 0 | Field 1 | Field 2 | Field 3 | Field 4 |
| --- | --- | --- | --- | --- |
| GNN | node | x coordinate | y coordinate | bottom elevation |

*Hotstart*

The process of supplying the numerical model a set of initial conditions which were obtained from the results of a previous simulation.

*Hydraulics Laboratory*

See Coastal and Hydraulic Laboratory.

The US Army Corps of Engineers, Waterways Experiment Station, Hydraulics Laboratory, Vicksburg, Mississippi, merged with the Coastal Engineering Research Laboratory in 1996 to form the Coastal and Hydraulics Laboratory (WES-CHL). The CHL provides TABS-MD Numerical Model maintenance and support for Army Corps installations.  .

*Hydrodynamic*

Relates to the specific scientific principles that deal with the motion of fluids and the forces acting on solid bodies immersed in fluids, and in motion relative to them.

*Hydrograph*

A time series recording of the measurement of flow across a river or stream.

*IMAT*

**Material Type**.  A variable name used in TABS-MD programs to specify a number representing the type of material within an element.  The IMAT is located on the GE card and is used to aid in assigning modeling coefficients.

**Note:**  IMAT=0 is equivalent to assigning a land boundary around the element.

*Inflow boundary*

A boundary condition location at which flow and sediment concentration enter the mesh.

*Interactive mode*

Opposite of  Batch mode.  The program requires the user to respond to questions.

If the program is running on a mainframe computer, the program is time sharing the CPU with other jobs, which can cause delays in some cases.

*Iteration*

Repeating a sequence of instructions a specific number of times, changing parameters and obtaining a new solution each time, until a predetermined condition is met.

**See also:**

*Junction element*

A special element, consisting of 3 to 8 nodes, which defines the intersection of 3 to 8 one dimensional elements.

### *Load*

See sediment load

### *Logical unit*

Computer lingo used to associate a device number with a data file. In this FORTRAN statement, **10** is the logical unit number:

```
READ(10,*) DATA
```

### *Marsh Porosity*

### *Manning's* n *value*

*n* is the coefficient of roughness with the dimensions of $T^*L^{-1/3}$. *n* accounts for energy loss due to the friction between the bed and the water. In fluvial hydraulics, the Manning's *n* value includes the effects of all losses, such as grain roughness of the movable bed, form roughness of the movable bed, bank irregularities, vegetation, bend losses, and junction losses. Contraction and expansion losses are not included in Manning's *n*, but are typically accounted for separately.

### *Material type*

A number representing the type of material within an element. The associated variable is IMAT.

### *Mesh*

A collection of nodes and elements which defines the domain of the study area.

### *Mixed Bed*

### *Node*

A point containing an *x*, *y*, and *z* coordinate which defines a location in space. Mid-side nodes (*x*, *y*, *z*) are linearly interpolated from adjacent corner nodes, unless the element side is curved.

### *Noncohesive Sediments*

Sediments consisting of discrete particles. For given erosive forces, the movement of such particles depends only on the properties of shape, size, and density, and on the position of the particle with respect to surrounding particles.

See Sand.

### *Non-Dimensional Analysis*

See ND card and Appendix

### *Off-channel storage*

A one dimensional element feature. The storage width associated with the node at zero depth, as specified on GN or GW cards using the N option.

### *One dimensional element*

A line segment composed of two corner nodes and one mid-side node. The geometry is defined by cross section (a straight bottom line between corner nodes) and reach length. The calculated velocity is averaged over the cross section.

### *Parameter revision*

The process of modifying a run control input parameter during a simulation in the middle of a time step. The REV card is used for this purpose.

### *Particle fall velocity*

The falling or settling rate of a particle in a given medium. The standard fall velocity of a particle is the average rate of fall that the particle would finally attain if falling alone in quiescent distilled water of infinite extent and at a temperature of 24°C. Fall velocity is the most fundamental property governing the motion of the sediment particle in a fluid; it is a function of the volume, shape, and density of the particle and the viscosity and density of the fluid.

### *Particle shape*

Sediment property defined by the shape factor, SF.

$$SF = \frac{c}{\sqrt{ab}}$$

where $a$,$b$, and $c$ are the lengths of the longest axis, the intermediate axis, and the shortest axis, respectively.

### *Particle size*

A linear dimension, usually designated as "diameter," used to characterize the size of a particle. The dimension may be determined by any of several different techniques, including sedimentation sieving, micrometric measurement, or direct measurement.

### *Particle-size classification*

See Table B-1

### *Particle-size distribution*

The frequency distribution of the relative amounts of particles in a sample that are within specified size ranges, or a cumulative frequency distribution of the relative amounts of particles coarser or fiver than specified sizes. Relative amounts are usually expressed as percentages by weight.

*Peclet number*

Defines the relationship between element properties, velocity, and eddy viscosity for the Peclet Method of assigning automatic turbulence.

$$P = \frac{\rho u dx}{E}$$

*Porosity*

Porosity of deposited sediment is volume of voids divided by the total volume of sample.

*Prototype*

Field data or physical model data.

The original, or basis for the new study.

*Record length*

In this context, a FORTRAN specific term dealing with the size of a data type in a binary file.

*Resource Management Associates*

The TABS numerical models were initially developed by Dr. Ian King at Resource Management Associates, (RMA), in Lafayette, California. An RMA representative can be reached at (707) 864-2950. Dr. King now resides in Australia.

Add web site ??

*RMA10*

RMA10 is a multi-dimensional (combining 1-D, 2-D either depth or laterally averaged, and 3-D elements) finite element numerical model written in FORTRAN-77. It is capable of steady or dynamic simulation of 3-dimensional hydrodynamics, salinity, and sediment transport. It utilizes an unstructured grid and uses a Galerkin-based finite element numerical scheme. The US Army ERDC-WES-CHL version is based upon the work of Dr. Ian King of Resource Management Associates. Many enhancements have been made to the WES version. Charlie Berger is the WES point of contact. Add Charlie's E-mail ???

*RMA2*

The one dimensional/two dimensional depth averaged hydrodynamic Finite Element numerical model within TABS-MD.

*RMA4*

The one dimensional/two dimensional depth averaged water constituent transport Finite Element numerical model within TABS-MD.

*Roughness*

In a river or stream bed, the material on the side slopes or the bottom, such as stones, etc., which inhibit the flow.

**See Also:**

*Run control file*

An input data file which provides parameters that control the RMA2 simulation run.

*Sand*

See non-cohesive

See Table B-1

*Scour*

The enlargement of a flow section by the removal of boundary material through the action of the fluid in motion.

*SED2D*

Originally known as STUDH, SED2D is a two dimensional depth averaged sediment transport Finite Element numerical model within TABS-MD. Joe Letter is the WES point of contact for SED2D theory. Add E-mail address ??

*Sediment*

(1) Particles derived from rocks or biological materials that have been transported by a fluid. (2) Solid material (sludges) suspended in or settled from water.

*SEDIMENT II*

*SEDIMENT 4H.MLT*

*Sedimentation*

A broad term that embodies the processes of erosion, entrainment, transportation, deposition, and the compaction of sediment.

*Sedimentation Processes*

Erosion, entrainment, transportation, deposition

*Sediment classification system*

The relationship between sieve diameter and fall diameter as a function of shape for a specific gravity of 2.65 was determined by the Interagency Committee on Water Resources (1957) and is shown in Figure XX.

| American Geophysical Union Sediment Classification System | | | |
|---|---|---|---|
| Sediment Size Range | | | |
| Sediment | millimeters | microns | Inches |
| Very large boulders | 4096-2048 | | 160-80 |
| Large cobbles | 256-128 | | 80-40 |
| Medium boulders | 1024-512 | | 40-20 |
| Small boulders | 512-256 | | 20-10 |
| Large cobbles | 256-128 | | 10-5 |
| Small cobbles | 128-64 | | 5-2.5 |
| Very coarse gravel | 64-32 | | 2.5-1.3 |
| Coarse gravel | 32-16 | | 1.3-0.6 |
| Medium gravel | 16-8 | | 0.6-0.3 |
| Fine gravel | 8-4 | | 0.3-0.16 |
| Very fine gravel | 4-2 | | 0.16-0.08 |
| Very coarse sand | 2.0-1.0 | 2000-1000 | |
| Coarse sand | 1.0-0.5 | 1000-500 | |
| Medium sand | 0.5-0.25 | 500-250 | |
| Fine sand | 0.25-0.125 | 250-125 | |
| Very fine sand | 0.125-0.062 | 125-62 | |
| Coarse silt | 0.062-0.031 | 62-31 | |
| Medium silt | 0.031-0.016 | 31-16 | |
| Fine silt | 0.016-0.008 | 16-8 | |
| Very fine silt | 0.008-0.004 | 8-4 | |
| Coarse clay | 0.004-0.002 | 4-2 | |
| Medium clay | 0.002-0.001 | 2-1 | |
| Fine clay | 0.0010-0.0005 | 1.0-0.5 | |
| Very fine clay | 0.0005-0.00024 | 0.5-0.24 | |

### *Sediment concentration*

The weighty of dry sediment in a water-sediment mixture per volume of mixture and is expressed in milligrams/liter (mg/l), or sometimes parts per million (ppm).

### *Sediment discharge*

The mass or volume of sediment (usually mass) passing a stream cross section in a unit of time.  The term may be qualified, for example; as suspended-sediment discharge, bed load discharge, or total-sediment discharge.

*Sediment grade scale*

The grouping of sediment particles into size classes based on particle diameters uses the American Geophysical Union size classification scale of 1947.

See Table B-1

*Sediment load*

A general term that refers to material in suspension and/or in transport. It is not synonymous with either discharge or concentration.

See total sediment load

*Sedimentology*

The scientific study of sediment, sedimentary rocks, and the processes by which they are formed—more specifically for this report, it is a study of detachment, transport, and deposition of sediment particles in streams and other water bodies.

*Sediment particles*

Fragments of mineral or organic material in either a singular or aggregate state.

*Sediment property categories*

Sediment properties can be divided into two categories: (a) those related to the particle itself and (b) those related to the sediment mixture or deposit.

*Sediment transport (rate)*

See sediment discharge.

*Sediment yield*

The total sediment outflow from a drainage basin in a specific period of time. It includes bed load as well as suspended load, and usually is expressed in terms of mass, or volume per unit of time.

*Settling*

The downward movement of suspended-sediment particles.

*Shape Function*

See Basis function

*Shear Stress (Bed)*

Frictional force per unit of bed area exerted on the bed by the flowing water. An important factor in the movement of bed material.

### *Silt*

See Table B-1

### *Siltation*

An unacceptable term.  Use sediment deposition, sediment discharge, or sediment yield as appropriate.

### *Sink-Source*

### *Source-Sink*

### *SMS*

SMS officially replaced *FastTABS* in 1996.  A computer program that provides a graphical, point and click means for performing pre- and post-processing for surface water numerical models.

Developed at the Waterways Experiment Station and Brigham Young University. Corps of Engineers employees may contact the Waterways Experiment Station for more information via e-mail at **tabs@hl.wes.army.mil**, or call (601) 634-3339.

### *Source code*

The US Army Corps of Engineers, Waterways Experiment Station, Hydraulics Laboratory, Vicksburg, Mississippi, provides TABS-MD Numerical Model maintenance and support for Army Corps installations.  To find out about availability and support for the TABS modeling system, contact the Coastal and Hydraulics Laboratory via e-mail at **tabs@hl.wes.army.mil**, or call (601) 634-3339.

### *Special elements*

Junction element, transition element, or control structure element.

### *Specific gravity*

Ratio of the mass of any volume of a substance to the mass of an equal volume of water at 4 degrees C.

### *Specific weight of sediment deposits*

The dry weight of sediment particles within a unit volume of the deposit expressed as pounds per cubic foot.

### *Specific weight of sediment particles*

The dry weight of sedimentary material per cubic foot of volume assuming no voids.

### *Spin-up*

The process by which a model moves from an unrealistic set of initial conditions to more realistic results that represent a solution that is not strongly influenced by the initial conditions.

To estimate spin-up, calculate the time for a wave to travel the length of the mesh and return.

The speed of the gravity wave is calculated as

$$S = \sqrt{gh}$$

where

$S$ = wave speed
$g$ = gravity
$h$ = depth

### *Steady state*

A simulation in which the boundary conditions are static. The variables being investigated do not change with time. SED2D considers the steady state simulation time as hour zero.

### *STUDH*

Predecessor to the SED2D numerical model.

### *Suspended load*

That part of the sediment load which is suspended sediment.

See Sediment load

### *Suspended sediment*

Sediment that is carried in suspension by the turbulent components of the fluid or by Brownian movement.

### *Suspended-sediment concentration*

See concentration of sediment

### *System International*

(SI) Formally named in 1960 by an international general conference on weights and measures. This system provides exact definitions of the metric system units for the fields of science and industry.

### *TABS-MD*

The TABS-MD Modeling System is comprised of four main programs: GFGEN, RMA2, RMA4, and SED2D. Maintained by US Army ERDC-WES-CHL

*Tide*

The periodic variation in the surface level of the oceans and of bays, gulfs, inlets, and estuaries, caused by gravitational attraction and relative motions of the moon and sun.

The types of tides are:

- Diurnal tide
- Mixed tide
- Neap tide
- Semidiurnal tide
- Spring tide

*Total-sediment load (total load)*

All of the sediment in transport; that part moving as suspended load plus that moving as bed load.

**EXPLAINATION OF TOTAL LOAD**

| MODE OF TRANSPORT | AVAILABILITY IN STREAMBED | METHOD OF MEASUREMENT |
|---|---|---|
| SUSPENDED | WASH LOAD | MEASURED LOAD |
| + | + | + |
| BED LOAD | BED MATERIAL LOAD | UNMEASURED LOAD |
| TOTAL LOAD | TOTAL LOAD | TOTAL LOAD |

*Transition element*

A special ‘T’ shaped 5 node element which makes the transition between a one dimensional element and a two dimensional element.

*Transient Flow*

Changes with time.

*Transportation (sediment)*

The complex processes of moving sediment particles from place to place. The principal transporting agents are flowing water and wind.

*Turbidity*

Only a general definition is possible because of the wide variety of methods in use. This term has been used as an expression of the optical properties of a sample which causes light rays to be scattered and absorbed rather than transmitted through the sample.

### *Turbulence*

In a turbulent motion, the true velocity and pressure vary in a disorderly manner. A turbulent motion is always unsteady, since at a given point the velocity changes continuously in a very irregular way.

### *Turbulent Diffusion*

### *Two delta-X*

A numerical instability which presents itself as a high value followed by a low value followed by a high value at the corners of the elements. When contoured, a two delta-X oscillation looks like a case of mesh measles.

### *Two dimensional element*

A triangle (3 corners and 3 mid-side nodes) or quadrilateral (4 corners and 4 mid-side nodes) shape which defines the geometry in two space coordinates and averages over the third space coordinate. In a two dimensional *Horizontal* model, the averaging occurs over depth. In a two dimensional *Vertical* model, the averaging occurs over width. Several two dimensional horizontal elements aligned side by side may accurately define the bottom elevation of a navigation channel.

### *Verification*

The process by which we gain confidence in the ability of our model to predict behavior of the prototype. Field data, like the model results, are only an approximation of reality and must be treated with skepticism. In verifying SED2D, the primary adjustments to be made are ???? to the geometry, boundary conditions, roughness, and eddy viscosity. These adjustments are made interactively until the model agrees satisfactorily with field (prototype) observations.

### *Von Neuman Boundary Condition Specification*

### *Water column*

An elemental projection in the *z* direction. The water profile from the surface to the bottom of the water body.

### *Waterways Experiment Station*

The US  Engineering Research and Development Center (ERDC), at the Waterways Experiment Station (WES), located in Vicksburg, Mississippi, is the principal research, testing, and development facility of the ERDC.  Its mission is to conceive, plan, study, and execute engineering investigations and research and development studies in support of civil and military missions of the Chief of Engineers and other federal agencies.

ERDC at WES is composed of the following laboratories:

Coastal and Hydraulics Laboratory

> NOTE: Hydraulics Laboratory and Coastal Engineering Research Center Merged, Aug 1996.

Geotechnical-Structures Laboratory (Official new Lab title not yet determined)

> NOTE:  Geotechnical Laboratory and Structures Laboratory Merged, Feb 2000.

Environmental Laboratory

Information Technology Laboratory

### *Wave Model Input*

### *Weir*

An obstruction placed in a stream, diverting the water through a prepared aperture for measuring the rate of flow.

### *Word size*

A Computer term.  A word is made up of a group of bytes.  A system's word size is defined by the number of bytes necessary to make a word on that particular type of computer system.  For example, a typical PC uses a two byte word (16 bits), where the Unix platforms ???  use an eight byte word (64 bits).

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# Notes