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DREDGE Module User's Guide

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INTRODUCTION

DREDGE was developed to assist users in making a priori assessments of environmental impacts from proposed dredging operations. DREDGE estimates the mass rate at which bottom sediments become suspended into the water column as the result of hydraulic and mechanical dredging operations and the resulting suspended sediment concentrations. These are combined with information about site conditions to simulate the size and extent of the resulting suspended sediment plume. DREDGE also estimates particulate and dissolved contaminant concentrations in the water column based upon sediment contaminant concentrations and equilibrium partitioning theory.

The basic features of DREDGE include:

1. Easy and rapid calculation of dredge plume concentrations resulting from mechanical and hydraulic dredging operations.
2. Graphical user interface (GUI) for user data input, spreadsheet output, and graphical output.
3. Relational database system with point-and-click interface for contaminant modeling.
4. Extensive toxic organic chemical and heavy metal database system plus default K_{ow} values for over 200 chemicals.
5. On-line help system to guide user through the application.
6. Spreadsheet and graphical output capabilities.
7. Ability to save all output information in MS Excel (*.xls) file format.
8. Source strength models for mechanical and hydraulic dredging operations.
9. 2-D analytical transport model to predict the fate of resuspended sediments without particle flocculation in a water column.

DREDGE is a module of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS) distributed by the U.S. Army Corps of Engineers through the

Environmental Laboratory, USAE Research and Development Center Waterways Experiment Station. ADDAMS consists of approximately 20 modules to assist in design and evaluation of various aspects of dredging and dredged material disposal operations. Information about other ADDAMS Modules can be found at http://www.wes.army.mil/el/elmodels/ or by contacting Dr. Paul R. Schroeder at (601) 634-3709.

The purpose of this User's Guide is to provide the user with a convenient reference to learn and use DREDGE. It provides essential information for applying the software to specific project sites. The User's Guide includes the following topics:

- Installation and minimum hardware requirements
- DREDGE basis
- Use and operation

HARDWARE REQUIREMENTS

DREDGE utilizes a graphical user interface (GUI) to simplify data entry and editing and provide output in a useful, understandable manner. DREDGE should operate properly for all Microsoft Windows© operating environments and typical PC hardware configurations. DREDGE requires the following minimum system configuration:

- Microsoft Windows 95/98, or Windows NT 3.5 or later (Note that if user is using Windows NT 4.0, user must install the Service Pack 3 before installing DREDGE).
- IBM compatible computer with an Intel 486 or equivalent CPU; Pentium CPU or equivalent is recommended.
- 8 MB of RAM required; 16 MB RAM recommended
- 5 MB available hard disk space
- Mouse
- VGA screen resolution (640 x 480); SVGA (800 x 600 or higher) recommended

USE AND DISTRIBUTION RESTRICTIONS

DREDGE is furnished by the U.S. Government and is accepted and used by the recipient with the express understanding that the U.S. Government gives no warranties, expressed or implied, concerning the accuracy, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith. The United States of America shall be under no liability whatsoever to any person by reason of any use made thereof. This program belongs to the U.S. Government, therefore, the recipient further agrees not to assert any proprietary rights therein, or to represent this program to anyone as other than a U.S. Government program. Distribution of the DREDGE module is restricted by the Export Administration Act of 1979, 50 App. USC 2401-2420, as amended, and other applicable laws or regulations.

HOW DO I OBTAIN THE DREDGE SOFTWARE?

The setup files for DREDGE and all other ADDAMS modules can be downloaded from http://www.wes.army.mil/el/elmodels/ or obtained as a set of floppy disks by sending a written request (preferably on company letterhead) to:

USAE Research and Development Center Waterways Experiment Station
ATTN: CEERD-EE-P/Dr. Paul R. Schroeder, P.E.
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

INSTALLING DREDGE

DREDGE downloads as a single compressed file, DREDGE.EXE, which contains all of the associated setup files. DREDGE.EXE should be placed in a temporary directory (e.g. **C:\TEMP\DREDGE\)** where it can easily be removed after setup is complete. Once DREDGE.EXE is downloaded, executing it expands the setup files into the same directory. If DREDGE is obtained on floppy disks, the setup files are already expanded and contained on the disks.

DREDGE is installed by executing **SETUP.EXE** from either the temporary directory or Disk 1 of the floppy disk set. In either case, setup guides you through the installation process by asking a few simple questions. The general installation procedure is:

Step 1. Insert the floppy diskette into drive A (floppy disk installation only).

Step 2. Run the installation program **SETUP.EXE.** Press the **START** button on the Windows taskbar and select **RUN**. Type in the proper directory and file name (e.g. "**A:\SETUP.EXE**" or "**C:\TEMP\DREDGE\SETUP.EXE**") or press the **BROWSE** button to locate the file. Press the **OK** button to proceed with the installation.

Step 3. DREDGE will ask for the desired installation directory and provide C:\ADDAMS\DREDGE as the default. Modify the directory as desired, then press **NEXT>** to continue the installation.

Step 4. DREDGE installation should complete automatically from this point, then notify you that installation is complete. Press **OK** to complete the installation.

Once installation is complete, click the **START** button on the Windows taskbar, then select **Programs**, then **DREDGE Module**, then **DREDGE** to start the DREDGE software.

USING DREDGE

Three main windows control the operation of DREDGE and display results of requested analyses: 1) **Input Data Entry** window, 2) **Spreadsheet Output** window**,** and 3) **Graphical Output** window. DREDGE begins with the Input Data Entry window displayed, but the user can toggle between the main windows at any time using buttons provided at the bottom of each window or by selecting **Windows** or **View** from the menu at the top of the window. DREDGE recalculates all values (if data are available) anytime the **Spreadsheet Output** or **Graphical Output** window is displayed. This ensures the displayed results always reflect the latest input data, but it can result in slight delays in the window being displayed on slower computers.

The DREDGE interface is designed to be intuitive. Although specific instructions on using the software follow, they are more easily followed if the user spends some time now becoming familiar with the look and feel of the software. Certainly, the user is encouraged to experiment with the options as they read through this guide.

MENUS AND BUTTONS

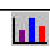
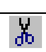
The same menu options and quick-launch buttons are available from all three primary screens. These menus and buttons are described and shown below and operate similarly to those found in many other Windows applications. Pressing the left mouse button while over the menu title displays a dropdown menu with a list of options. Each individual drop-down menu is not shown, but Table 1 shows the lists of options and the specific actions associated with each option.

The button bar provides direct access to the most commonly used menu items. An icon on each button suggests the action that results from pressing the button; allowing the mouse pointer to hover over the button momentarily will display a tool-tip description. Pressing the left mouse button while the pointer is over the rectangular area of the button initiates the associated action. Table 2 describes the available buttons and the associated actions.

Table 1. Menu selections and associated program actions.

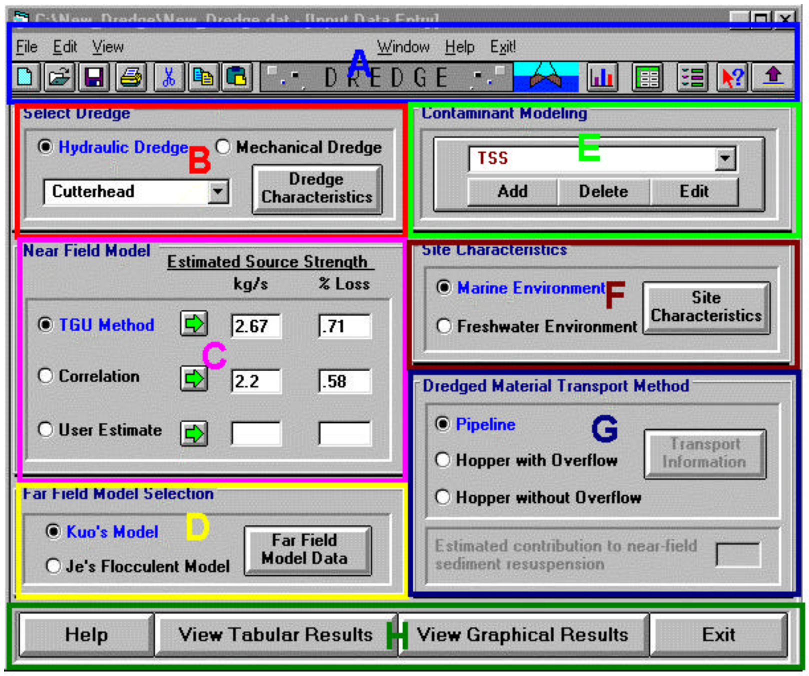
Menu	Submenu	Shortcut	Action
File	New	Alt + f + n	Resets all variables to zero and clears all calculations.
	Open	Alt + f + o	Opens Windows standard dialog box to allow user selection of data files.
	Save	Alt + f + s	Writes the current data to the existing filename; if a filename has not been specified, opens the same dialog box as "Save As"
	Save As	Alt + f + a	Opens a Windows standard dialog box which allows the user to specify a file name and location to save the file.
	Print	Alt + f + p	Prints the input data and results to the default printer.
	Exit	Alt + f + x	Exits DREDGE.
Edit	Cut	Alt + e + t	Cuts a highlighted selection and moves it to the clipboard.
	Copy	Alt + e + c	Copies a highlighted selection to the clipboard.
	Paste	Alt + e + a	Pastes clipboard contents to cursor location.
View	Data Input	Alt + v + d	Displays the **Input Data Entry** window.
	Tabular Output	Alt + v + d	Displays the **Spreadsheet Output** window.
	Graphical Output	Alt + v + d	Displays the **Graphical Output** window.
Window	Data Input	Alt + w + d	Displays the **Input Data Entry** window.
	Tabular Output	Alt + w + d	Displays the **Spreadsheet Output** window.
	Graphical Output	Alt + w + d	Displays the **Graphical Output** window.
Help	Contents	Alt + h + c	Displays HELP contents.
	Search	Alt + h + s	Displays search engine for HELP
	How to use HELP	Alt + h + h	**Not currently used**
	Technical Support	Alt + h + t	**Not currently used**
	About DREDGE	Alt + h + a	Displays an information box about DREDGE.
Exit!	-	Alt + x	Exits DREDGE.

Table 2. Shortcut buttons and associated actions.

Button	Action	Button	Action
	Resets all variables to zero and clears all calculations.		Pastes clipboard contents to cursor location.
	Opens Windows standard dialog box to allow user selection of data files.		Displays the **Graphical Output** window.
	Writes the current data to the existing filename; if a filename has not been specified, opens a Windows standard dialog box to allow the user to specify a file name and location to save the file.		Displays the **Spreadsheet Output** window.
	Prints the input data and results to the default printer.		Displays the **Input Data Entry** window.
	Cuts a highlighted selection and moves it to the clipboard.		Initiates online HELP for DREDGE.
	Copies a highlighted selection to the clipboard.		Exits DREDGE.

ENTERING AND EDITING DATA

DREDGE handles all data entry tasks through the **Input Data Entry** window shown to the right. This window is automatically displayed when the application begins. Specific and detailed data on the dredging project are required to perform the necessary calculations. Data requirements include physical site conditions, physical and chemical sediment properties, sediment volume, and dredge type and operation. The **Input Data Entry** window facilitates data input by dividing the required data into logical groups. The figure to the right outlines the different areas of this initial window.



Areas B – G represent different types of data entry and are described in detail below. The user must enter data for areas B-F, in that order. The data in area G are not currently used, but the space is reserved for use in later versions.

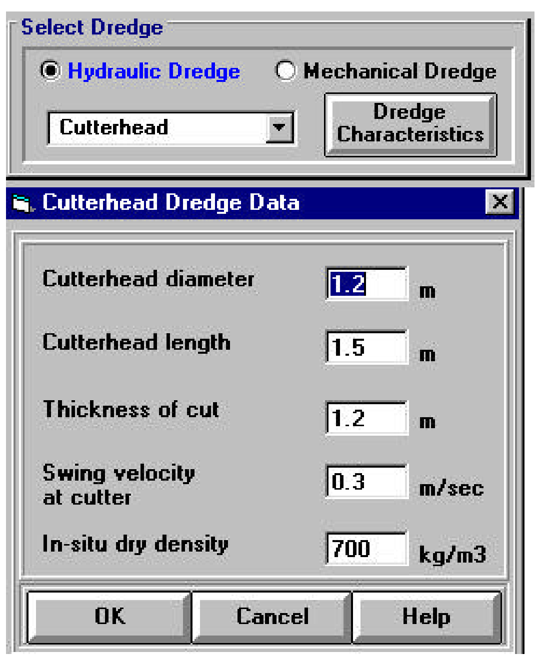
A – Menu and Buttons

The drop-down menus and shortcut buttons are part of all three primary screens. They provide direct access to common software operations and operate similar to most menus and buttons associated with other software applications. These operations were described above with details presented in Tables 1 and 2.

B – Dredge Information

All models included in DREDGE are specific to individual dredge types. Thus, the user should first select the type of dredge they wish to model by pressing either “Hydraulic Dredge” or “Mechanical Dredge.” The user should then select the specific dredge they wish to model. Hydraulic dredges include self-propelled hopper dredges and spud-driven dredges such as cutterhead dredges, although a variety of suction heads may be used; i.e. dustpan, matchbox, traditional cutter, etc. Many types of mechanical dredges exist, but DREDGE only has models for traditional crane-type bucket dredges using either open clamshell or watertight clamshell buckets. At this time, DREDGE only supports the dredge types for which sufficient resuspension data has been collected to support the development of at least a limited source generation model – cutterhead and open bucket dredges.

Once the dredge type is selected, the user should press the DREDGE CHARACTERISTICS button to enter physical and operational information about the dredging operation. These data correspond to the specific dredge type selected and may be lost if the dredge type is modified after they are entered.



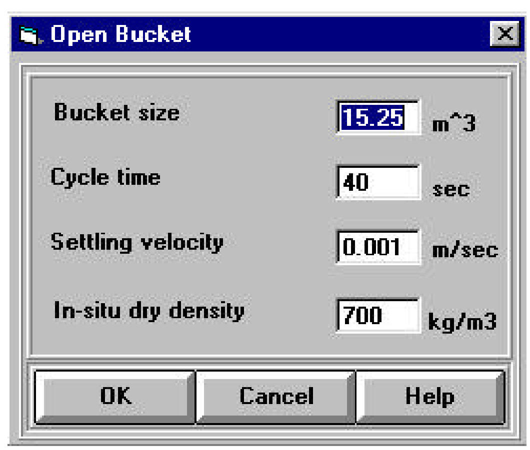
Cutterhead Dredge Characteristics. Pressing the DREDGE CHARACTERISTICS button with Cutterhead Dredge selected displays the dialog box. Values must be entered for every variable (i.e., every box) for DREDGE to calculate the in situ sediment removal rate. The requested data and recommended default values are:

- *Cutterhead diameter* – cutterhead dredges are typically sized according to the pipe diameter associated with the pump, e.g. 12-inch dredge, 18-inch dredge, etc.

Cutterheads come in all shapes and sizes, but most cutters are 2 to 3 times the size of the pump size (in terms of pipe diameter). If better information is not available, assuming a cutter diameter approximately equal to 2.5 times the pump size in pipe diameter is a good rule of thumb.

- *Cutterhead length* – the discussion above applies here too, but a general rule of thumb is the cutter length equals 3.0 times the pump size.
- *Thickness of cut* – the sediment depth being removed on each swing; typically this should not be much larger than the cutter diameter nor should it be extremely thin except for clean-up cuts.
- *Swing velocity at cutter* – the tangential speed of the dredge at the tip of the cutter; typically, this value is between 0.1 m/sec and 0.4 m/sec.
- *In-situ dry density* – the dry density of the sediment in units of kg/m^3. Most recently deposited sediments (e.g. maintenance dredging) are unconsolidated with a density of about 700 kg/m^3. Sediments with high organic content can have lower densities of near 500 kg/m^3, but these are quite uncommon. Consolidated sediments often have densities near 1000 kg/m^3 or greater. A density of 1500 kg/m^3 is not unusual in consolidated clays or dense sands. Because of the potential variation in density, sediment samples should be collected to determine the actual value for any given system.

<u>*Open Bucket Dredge Characteristics.*</u> Pressing the DREDGE CHARACTERISTICS button with Open Bucket Dredge selected displays the dialog box below. Values must be entered for every variable (i.e., every box) so DREDGE can calculate the in situ sediment removal rate. Descriptions of the data required for open bucket dredges and recommended default values follow:

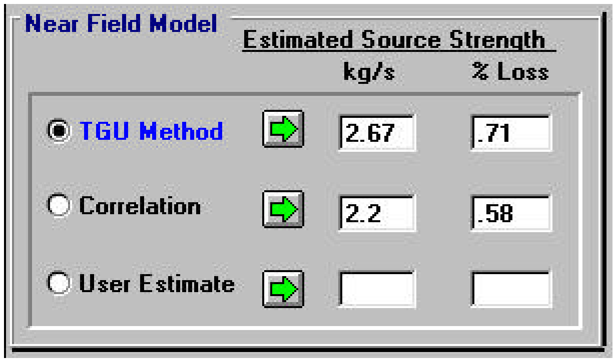


- *Bucket size* – volumetric capacity of dredge bucket being used. Buckets are available in volumes ranging from about

1 m^3 to 100 m^3 because of the range of crane capacities available. A 20-m^3 bucket would be considered by most to be a mid-sized bucket. Note the input box requires units of m^3 even though bucket volumes in the US are usually expressed in units of yd^3; the conversion factor is 1 yd^3 = 0.765 m^3.

- *Cycle time* – the cumulative time it takes for the bucket to fall through the water column, grab sediment from the bottom, be raised to the surface, swing over to the sediment barge, empty its load, and swing back to the water surface; this varies with many factors and with each cycle. But, the average cycle time normally ranges from 30 to 90 seconds, with about 60 seconds being most common under normal operating circumstances. Note that this may be intentionally slowed in some environmental dredging operations in an attempt to reduce sediment loss to the environment.
- *Settling velocity* – average settling velocity of the sediment being dredged.
- *In-situ dry density* – the dry density of the sediment in units of kg/m^3. Most recently deposited sediments (e.g. maintenance dredging) are unconsolidated with a density of about 700 kg/m^3. Sediments with high organic content can have lower densities of near 500 kg/m^3, but these are quite uncommon. Consolidated sediments often have densities near 1000 kg/m^3 or greater. A density of 1500 kg/m^3 is not unusual in consolidated clays or dense sands. Because of the potential variation in density, sediment samples should be collected to determine the actual value for any given system.

C – Near-field TSS Models



DREDGE provides three ways for the user to estimate the rate at which a dredging operation releases sediment into the water column as suspended sediment – the TGU method, the correlation method, or a user estimate. The desired method is selected by clicking the left mouse button while over the circle to the left of the method. If data for the selected method have not been entered, DREDGE automatically displays the appropriate data entry dialog. If data have been entered, the user can review and edit the values by pressing the green arrow to the right of the selected procedure.

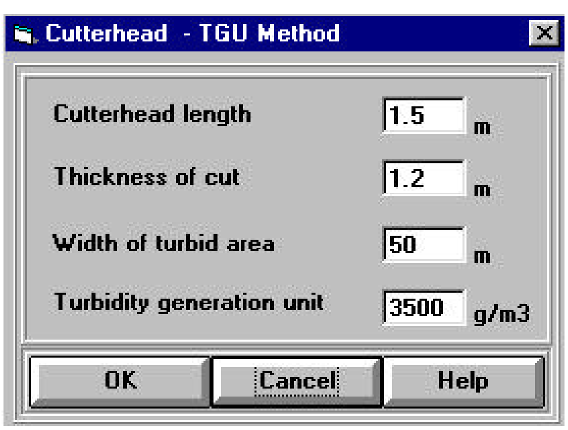
> **What is a Near-field Model?**
>
> DREDGE breaks suspended sediment transport from dredges into two distinct areas. The area in the immediate vicinity of the dredging operation is dominated by mixing and currents induced by the dredging operation itself and is termed the "near-field." The suspended sediment in this area results primarily from the dredge operation. Thus, the near-field models require information about the dredging operation to provide estimates of this "source-strength" in mass per time units. The physical extent of the "near-field" is not definitive, but generally ends 10 to 20 meters downstream from the dredging operation.

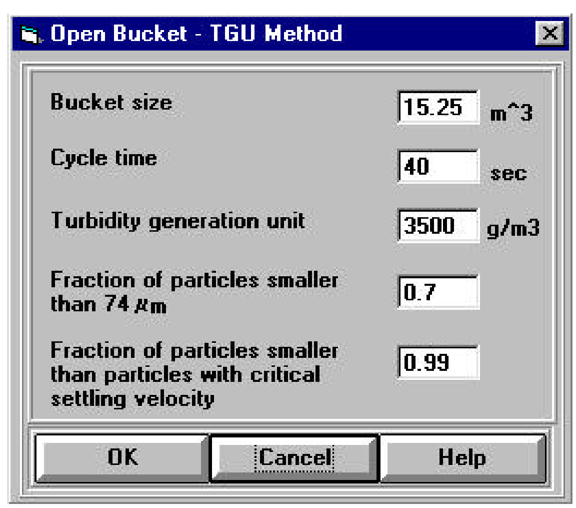
Near-field model results are provided in both kg/sec (mass flux) and % loss. The latter units are more easily understood in an environmental context. In the absence of additional information, a conservative estimate of 1% loss would be appropriate for typical dredging operations. Because there is considerable uncertainty associated with source strength estimates, the user is encouraged to utilize both models then enter a judgment-based value as the user estimate. A sensitivity analysis should be conducted by entering a range of values in the user estimate box.

TGU Method Data Entry

The most popular method for estimating sediment resuspension rates from dredging operations has been the method published by Nakai (1978). The method, described in detail in the DREDGE HELP file, is mostly conceptual and relies on a value called the "turbidity generation unit" (thus, the acronym TGU) to distinguish between the resuspension rates of various dredge types. Nakai's method then converts that TGU value to a source generation rate. The input screens below show the data required for DREDGE to make the TGU calculations. Note that many of the values are repeated from other input screens. When a value is changed in one screen, the change is automatically reflected in all other DREDGE calculations. Descriptions of the individual data follow:

- *Cutterhead length* – the discussion above applies here too, but a general rule of thumb is the cutter length equals 3.0 times the pump size.
- *Thickness of cut* – the sediment depth being removed on each swing in meters; typically this should not be much larger than the cutter diameter nor should it be extremely thin except for clean-up cuts.
- *Width of Turbid Area* – the width of the turbidity plume generated by the cutterhead dredge. A logical assumption for this value is the width of the dredge swing or cutting path that is anticipated.
- *Bucket size* – volumetric capacity of dredge bucket being used. Buckets are available in volumes ranging from about 1 m^3 to 100 m^3 because of the range of crane capacities available.





A 20-m^3 bucket would be considered by most to be a mid-sized bucket. Note the input box requires units of m^3 even though bucket volumes in the US are usually expressed in units of yd^3; the conversion factor is 1 yd^3 = 0.765 m^3.

- *Cycle time* – the cumulative time it takes for the bucket to fall through the water column, grab sediment from the bottom, be raised to the surface, swing over to the sediment barge, empty its load, and swing back to the water surface; this varies with many factors and with each cycle. But, the average cycle time normally ranges from 30 to 90 seconds, with about 60 seconds being most common under normal operating circumstances. Note that this may be intentionally slowed in some environmental dredging operations in an attempt to reduce sediment loss to the environment.
- *Fraction of Particles Less than 74 mm* – the fraction of fine sediments in the bottom sediments to be dredged, expressed as a fraction, i.e. the value must be between 0.0 and 1.0.
- *Fraction of Particles Smaller than Particles with the Critical Settling Velocity* – particles with settling velocities less than the Critical Settling Velocity will not settle, but rather remain in suspension due to the ambient currents in the area. The TGU method needs to know the fraction of bottom sediments that have a particle diameter smaller than the diameter associated with the critical velocity.
- *Turbidity Generation Unit* – this value is the rate at which sediment is resuspended into the water column and transported away from the dredging site, reported in kg/m^3. Nakai (1978) published the only TGU values available for different dredging operations. These values are available in the DREDGE HELP files and Table 3.

Table 3. Observed values of Turbidity Generation Unit, G, presented by Nakai (1978)

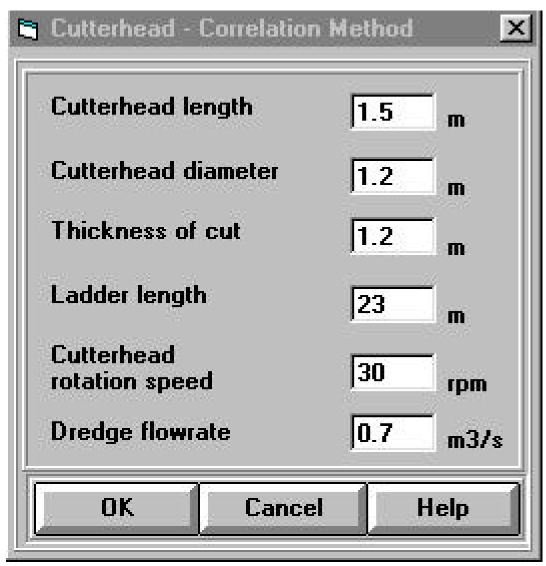
Dredge Type	Pump HP or Volume	Dredged Material Characteristics d* < 74 μm	d* < 5 μm	Classification	TGU kg/m^3
Cutter	4,000 HP	99.0 %	40.0 %	silty clay	5.3
		98.5 %	36.0 %	silty clay	22.5
		99.0 %	47.5 %	clay	36.4
		31.8 %	11.4 %	sandy loam	1.4
		69.2 %	35.4 %	clay	45.2
		74.5 %	50.5 %	sandy loam	12.1
	2,500 HP	94.4 %	34.5 %	silty clay	9.9
	2,000 HP	3.0 %	3.0 %	sand	0.2
		2.5 %	1.5 %	sand	0.3
		8.0 %	2.0 %	sand	0.1
Hopper	2,400 HP x 2	92.0 %	20.7 %	silty clay loam	7.1
		88.1 %	19.4 %	silty loam	12.1
	1,800 HP	83.2 %	33.4 %	silt	25.2
Bucket	8 m^3	58.0 %	34.6 %	silty clay	89.0
	4 m^3	54.8 %	41.2 %	clay	84.2
	3 m^3	45.0 %	3.5 %	silty loam	15.8
		62.0 %	5.5 %	silty loam	11.9
		87.5 %	6.0 %	silty loam	17.1

Correlation Method Data Entry

A series of empirical models have been developed that relate dredge operating characteristics and sediment resuspension rates. Hayes et al (2000) published the latest empirical models for cutter dredges, and Collins (1995) published the latest empirical models for bucket dredging operations. DREDGE makes these models available under the "correlation models" option. Details of the models are provided in the DREDGE HELP file.

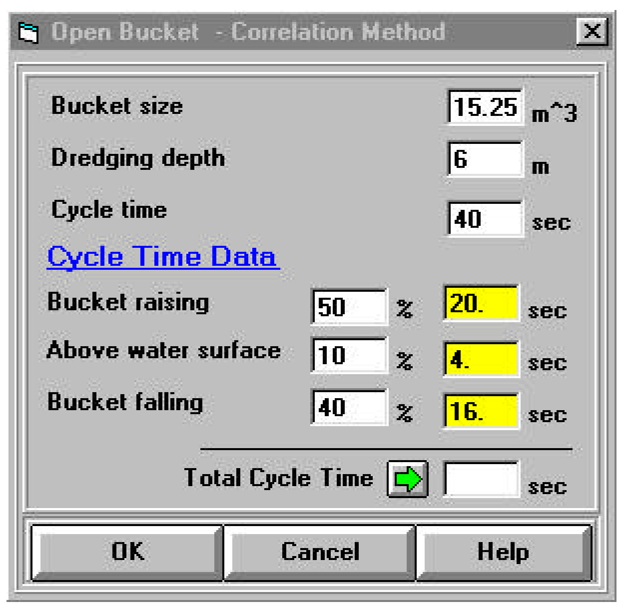
Each model requires dredge size and operating information, specific for the dredge type selected. Much of the data is also required for other computations and, thus, may be entered through other input screens. All previously entered values will be shown on the input screen when it is displayed. Any changes made on this screen will be reflected in all DREDGE computations once the OK button is pressed.

The cutterhead correlation model input screen is shown to the right. The data needed for the cutterhead model include:



- *Cutterhead length* – the discussion above applies here too, but a general rule of thumb is the cutter length equals 3.0 times the pump size.
- *Cutterhead diameter* – cutterhead dredges are typically sized according to the pipe diameter associated with the pump, e.g. 12-inch dredge, 18-inch dredge, etc. Cutterheads come in all shapes and sizes, but most cutters are 2 to 3 times the size of the pump size (in terms of pipe diameter). If better information is not available, assuming a cutter diameter approximately equal to 2.5 times the pump size in pipe diameter is a good rule of thumb.

- *Thickness of cut* – the sediment depth being removed on each swing; typically this should not be much larger than the cutter diameter nor should it be extremely thin except for clean-up cuts.
- *Ladder length* – the length of pipe between the cutterhead and the dredge pump.
- *Cutter Rotation Speed* – the rotational velocity of the cutter in revolutions per minute. This speed can vary considerably, but is generally much slower than expected, especially for large cutters. Typical values range from 2 to 10 rpm with the upper range more applicable to small cutters. As a rule of thumb, the tangential speed of the cutter blades should not exceed 0.5 m/sec for most normal dredging operations.
- *Dredge flowrate* – the volumetric discharge of the dredge in m^3/sec; if better values are not available, this can be estimated using the diameter of the discharge pipe and an average discharge velocity of 4 to 5 m/sec.



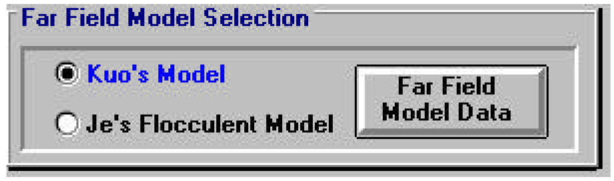
The open bucket correlation model input screen is shown to the right. The data needed for the open bucket model include:

- *Bucket size* – volumetric capacity of dredge bucket being used. Buckets are available in volumes ranging from about 1 m^3 to 100 m^3 because of the range of crane capacities available. A 20 m^3 bucket would be considered by most to be a mid-sized bucket. Note the input box requires units of m^3 even though bucket volumes in the US are usually expressed in units of yd^3; the conversion factor is 1 yd^3 = 0.765 m^3.
- *Dredging depth* – the depth from the water surface to the bottom of the dredging prism in meters.

- *Cycle time* – the cumulative time it takes for the bucket to fall through the water column, grab sediment from the bottom, be raised to the surface, swing over to the sediment barge, empty its load, and swing back to the water surface; this varies with many factors and with each cycle. But, the average cycle time normally ranges from 30 to 90 seconds, with about 60 seconds being most common under normal operating circumstances. Note that this may be intentionally slowed in some environmental dredging operations in an attempt to reduce sediment loss to the environment.
- *Cycle Time Data* – DREDGE also needs to know the breakdown of the cycle time in percent of the total cycle time. Although the values can vary under different conditions, field data under normal operating conditions have shown the following fractional times are reasonable estimates in the absence of better data:

Bucket Fall	Bucket Raise	Above Water
22%	30%	48%

D – Far-field TSS Models

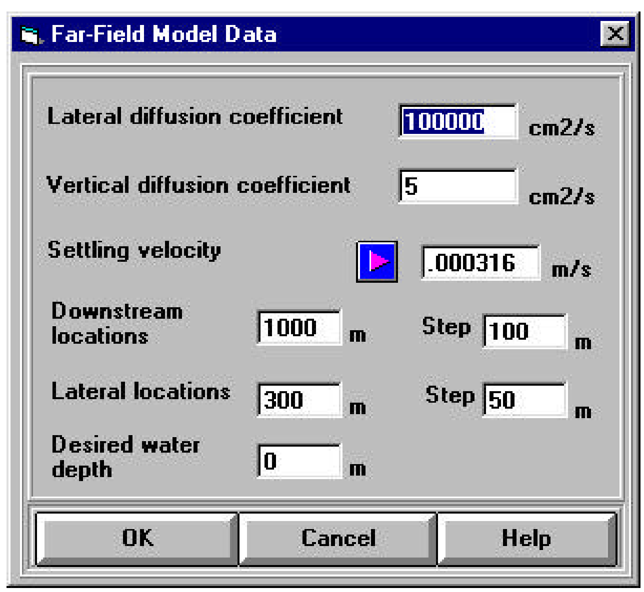


Because of the uncertainty in the source term and its intended application, DREDGE uses relatively simple far-field models to transport suspended sediments downstream. Although different models are used for cutterhead and bucket dredges, the models are conceptually similar. Both models are adequately simple that analytical solutions were obtained, thereby requiring very little computer time to make transport calculations. This allows DREDGE to make numerous calculations with very little noticeable delay.

What is a Far-field Model?

DREDGE breaks suspended sediment transport from dredges into two distinct areas. The near-field area in the immediate vicinity of the dredging operation is dominated by mixing and currents induced by the dredging operation itself. Beyond that zone, suspended sediment transport is dominated by advection, turbulent diffusion, and sedimentation. This is the "far-field" zone and transport models applied in this zone are conveniently termed "far-field models" in the DREDGE software and associated documents.

The transport model used for cutterhead dredges is a 2-D, laterally-averaged steady-state model published by Kuo, et al (1985). Bucket dredge transport calculations utilize a 2-D vertically-averaged transport model published by Kuo and Hayes (1991). Je (1998) developed enhancements to these models that will be included in future versions of DREDGE. For now, that option is disabled. Data for the far-field models are entered using a screen that is displayed when the Far Field Model Data button is pressed (see box to the right). The data required for the far-field models include:



- *Lateral diffusion coefficient* – turbulent diffusion of suspended sediment in the lateral dimension in units of cm^2/sec; typical values are 10^5 cm^2/sec to 10^7 cm^2/sec. The lower values are more representative of laterally bounded water bodies (widths of 100 feet or less); higher values are more representative of water bodies sufficiently wide that the plume never strikes the boundaries.

- *Vertical diffusion coefficient* – turbulent diffusion of suspended sediment in the vertical dimension in units of cm^2/sec; typical values are 10^0 cm^2/sec to 10^1 cm^2/sec unless stratification exists. If density stratification exists, it may inhibit vertical transport sufficiently that vertical diffusion coefficients as low as 10^{-3} cm^2/sec are possible.
- *(Average) Settling velocity* – average settling velocity of the particles in suspension; it should be remembered that only the fine fraction of the sediments is transported downstream. Pressing the arrow brings up a dialog box that calculates the Stokes' law settling velocity for a known particle size and places it in the box.

DREDGE also needs to know the downstream locations at which the output is desired. Each location is considered a node and has a lateral, vertical, and longitudinal component. To avoid having the user enter individual locations for calculations, DREDGE asks for only the total distance from the dredge location and the equal step distances in the lateral and longitudinal dimension. Output is calculated for a single water depth. The actual data requested include:

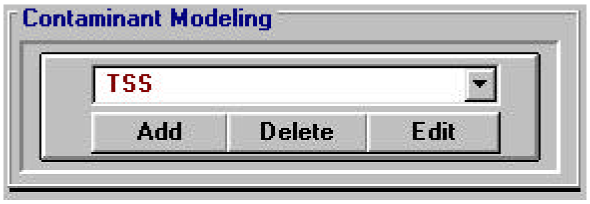
- *Downstream locations (for output)* – enter the maximum distance downstream (meters) that you wish DREDGE to provide any output for in the first box, followed by the increments beginning at 0 that you would like values for in the second box. For the values in the screen shown, DREDGE will provide output for 100 m, 200 m, 300 m, … to a maximum of 1,000 m. Hint: only in unusual circumstances will a plume be distinguishable beyond 1000 m and in most cases 500 m is adequate.
- *Lateral locations (for output)* – enter the maximum lateral distance (meters) on either side of the centerline that you wish DREDGE to provide any output for in the first box, followed by the increments beginning at 0 that you would like values

for in the second box. For the values in the screen shown, DREDGE will provide output for 50 m, 100 m, 150 m, … to a maximum of 300 m (a total width of 600 m).

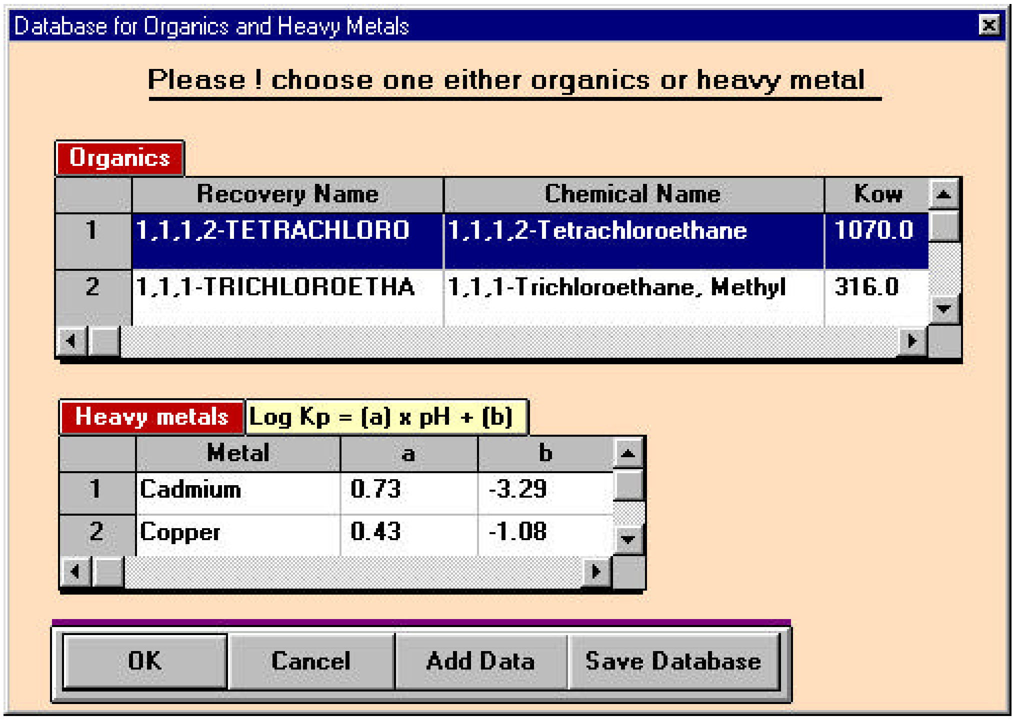
- *Desired water depth (for output)* – enter the water depth at which you desire output; DREDGE will need to be rerun for multiple depths.

E – Contaminant Selection

The discussion thus far has focused exclusively on suspended sediment transport, and all DREDGE modeling efforts must include TSS as the primary constituent of interest. However, DREDGE also allows the user to model additional chemical constituents – one metal constituent and one organic constituent during each run. DREDGE includes a database of partitioning coefficients based upon USACE's RECOVERY database (Ruiz and Gerald 2000). The database contains an extensive list of octanol-water partitioning coefficients (K_{ow}) for organic contaminants; partitioning coefficients for most common metal constituents are also included. The user can also update the database by modifying existing values or adding new constituents. The user should follow the steps below to select contaminants from the existing database in DREDGE.



1) Move the mouse to the **Contaminant Modeling** rectangle box in the main **Input Data Entry** window.
2) Click the **Add** button to select the contaminant from the existing database.
3) Then, a database window similar to the one below will be displayed to select either organics or heavy metal for contaminant modeling.
4) By clicking the **OK** button, user will be asked to enter or edit the data required to estimate the partitioning coefficient for specific organics or metal.
5) After completing the data input, simply click the **OK** button to exit input window.
6) Repeat step (1) to step (5) if user wants to add more contaminants for modeling.



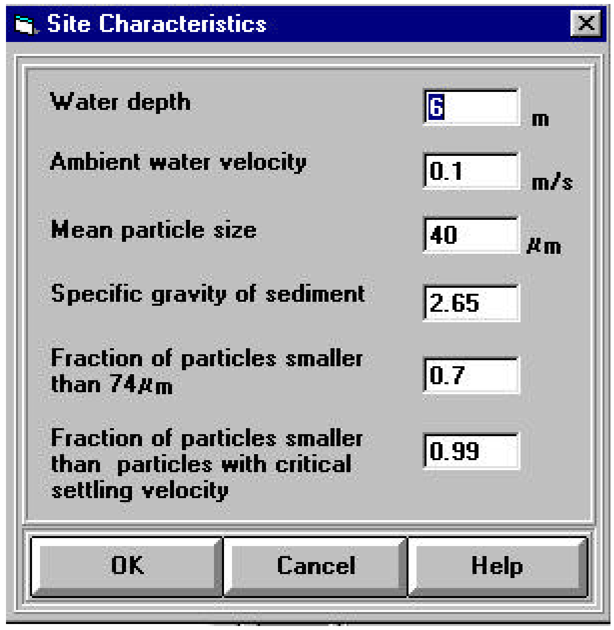
F – Site Characteristics

Although the site characteristics box shows two options on the left side - **Marine Environment** and **Freshwater Environment,** these are not used in the current version of DREDGE. Thus, all site characteristic information is requested through the screen displayed when the Site Characteristics button is pressed (see below).

The site characteristics data required include:

- *Water depth* – the depth from the water surface to the bottom of the dredging prism in meters.
- *Ambient water velocity* – average water velocity in the downstream direction in meters/second.
- *Mean particle size* – average particle size of the bottom sediments in µm.
- *Specific gravity of the sediment* – specific gravity of the bottom sediment; this value typically ranges from 2.4 for highly organic silts to 2.7 for consolidated clays with 2.65 being a common value for sands.

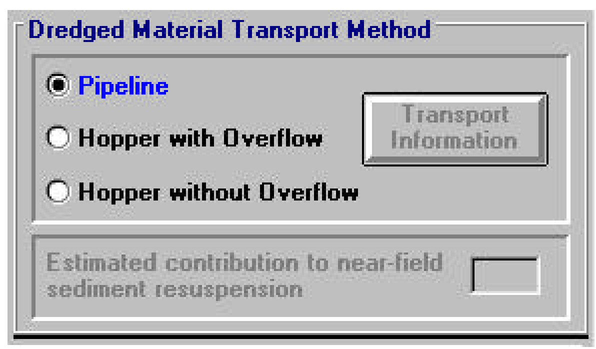
- *Fraction of Particles Less than 74 mm* – the fraction of fine sediments in the bottom sediments to be dredged, expressed as a fraction, i.e. the value must be between 0.0 and 1.0.



- *Fraction of Particles Smaller than Particles with the Critical Settling Velocity* – particles with settling velocities less than the Critical Settling Velocity will not settle, but rather remain in suspension due to the ambient currents in the area. The TGU method needs to know the fraction of bottom sediments that have a particle diameter smaller than the diameter associated with the critical velocity.

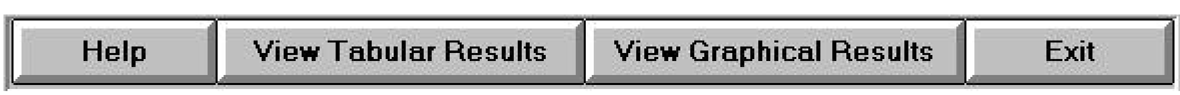
G – Transport Losses

This section, shown to the right, is not used in the current version of DREDGE, but is reserved for later use.



H – Navigation and HELP buttons

DREDGE facilitates navigation between its three primary windows by a button bar at the bottom of each screen. The same bar, shown below, provides direct access to the



DREDGE HELP system and allows the user to exit DREDGE. The two buttons in the middle of the bar change depending upon the screen shown.

VIEWING RESULTS

DREDGE provides the transport calculation results in both tabular and graphical forms for the convenience of the user. These results can be viewed by pressing either the "View Tabular Results" button or "View Graphical Results" button at the bottom of the data entry screen. Because DREDGE is able to complete the model calculations quickly, the results are not stored as part of the project file; the models are executed automatically each time either output button is pressed. The output screens are described below.

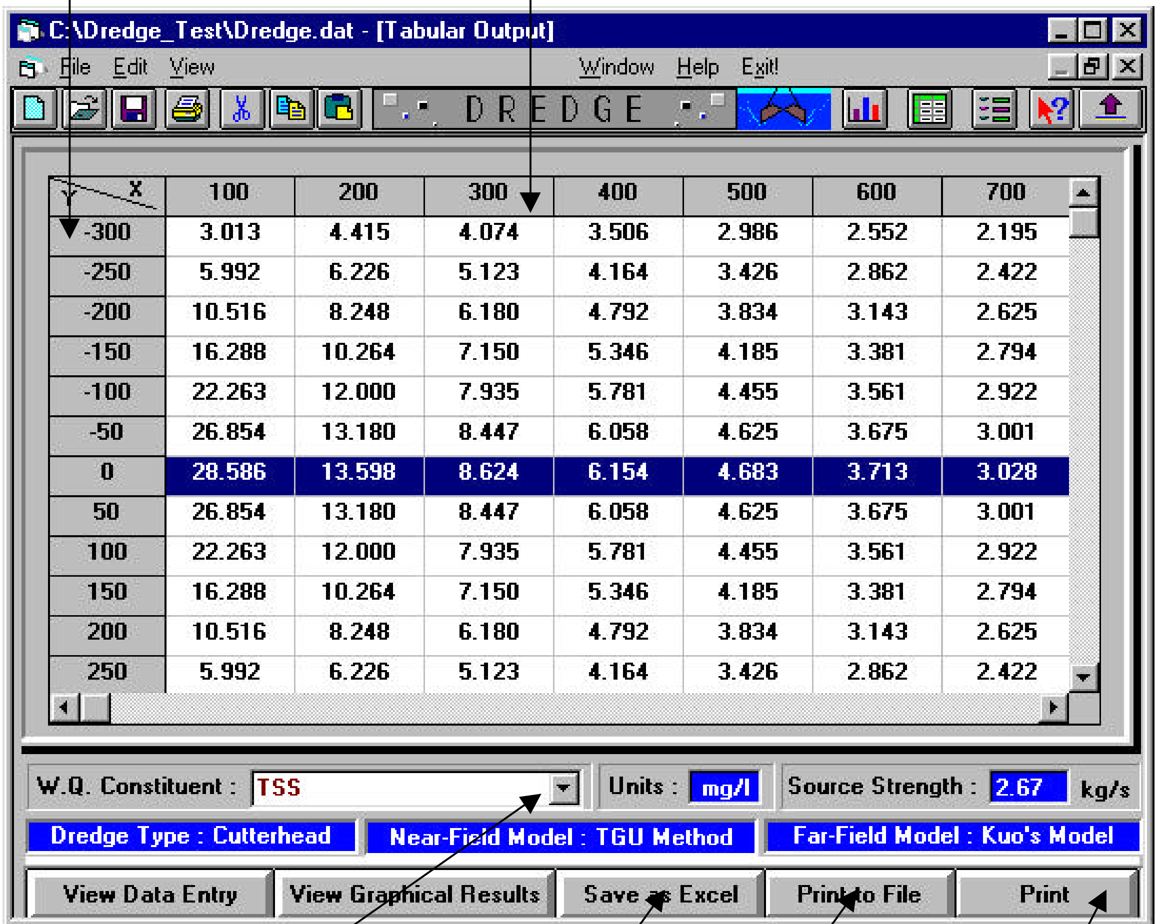
SPREADSHEET OUTPUT

The **Spreadsheet Output** screen displays plume concentration at each of the nodes (nodes are intersections of the lateral, longitudinal, and vertical grids specified by the user). The screen, shown below, initially displays TSS concentrations in mg/L, but other constituents can be displayed by selecting them from the dropdown box below the output grid. The **Spreadsheet Output** window summarizes the calculation options selected by the user - dredge type, near-field model and resulting source strength, and far-field model used – and the current constituent being displayed along with its concentration units. All contaminants are displayed in total concentration units, the sum of both particulate and dissolved fractions.

The **Spreadsheet Output** window also allows the user to save the displayed output as either an Excel or ASCII text file by simply pressing the appropriate button on the bottom of the form. The user can print the displayed output by pressing the **Print** button at the bottom of the **Spreadsheet Output** window. In each case, DREDGE saves or prints only plume concentrations for the currently displayed constituent. Other constituents must first be displayed, and then the results can be exported or printed.

Lateral distance

Distance downstream



Y \ X	100	200	300	400	500	600	700
-300	3.013	4.415	4.074	3.506	2.986	2.552	2.195
-250	5.992	6.226	5.123	4.164	3.426	2.862	2.422
-200	10.516	8.248	6.180	4.792	3.834	3.143	2.625
-150	16.288	10.264	7.150	5.346	4.185	3.381	2.794
-100	22.263	12.000	7.935	5.781	4.455	3.561	2.922
-50	26.854	13.180	8.447	6.058	4.625	3.675	3.001
0	28.586	13.598	8.624	6.154	4.683	3.713	3.028
50	26.854	13.180	8.447	6.058	4.625	3.675	3.001
100	22.263	12.000	7.935	5.781	4.455	3.561	2.922
150	16.288	10.264	7.150	5.346	4.185	3.381	2.794
200	10.516	8.248	6.180	4.792	3.834	3.143	2.625
250	5.992	6.226	5.123	4.164	3.426	2.862	2.422

Click the arrow to change the constituent for which plume concentrations are displayed.

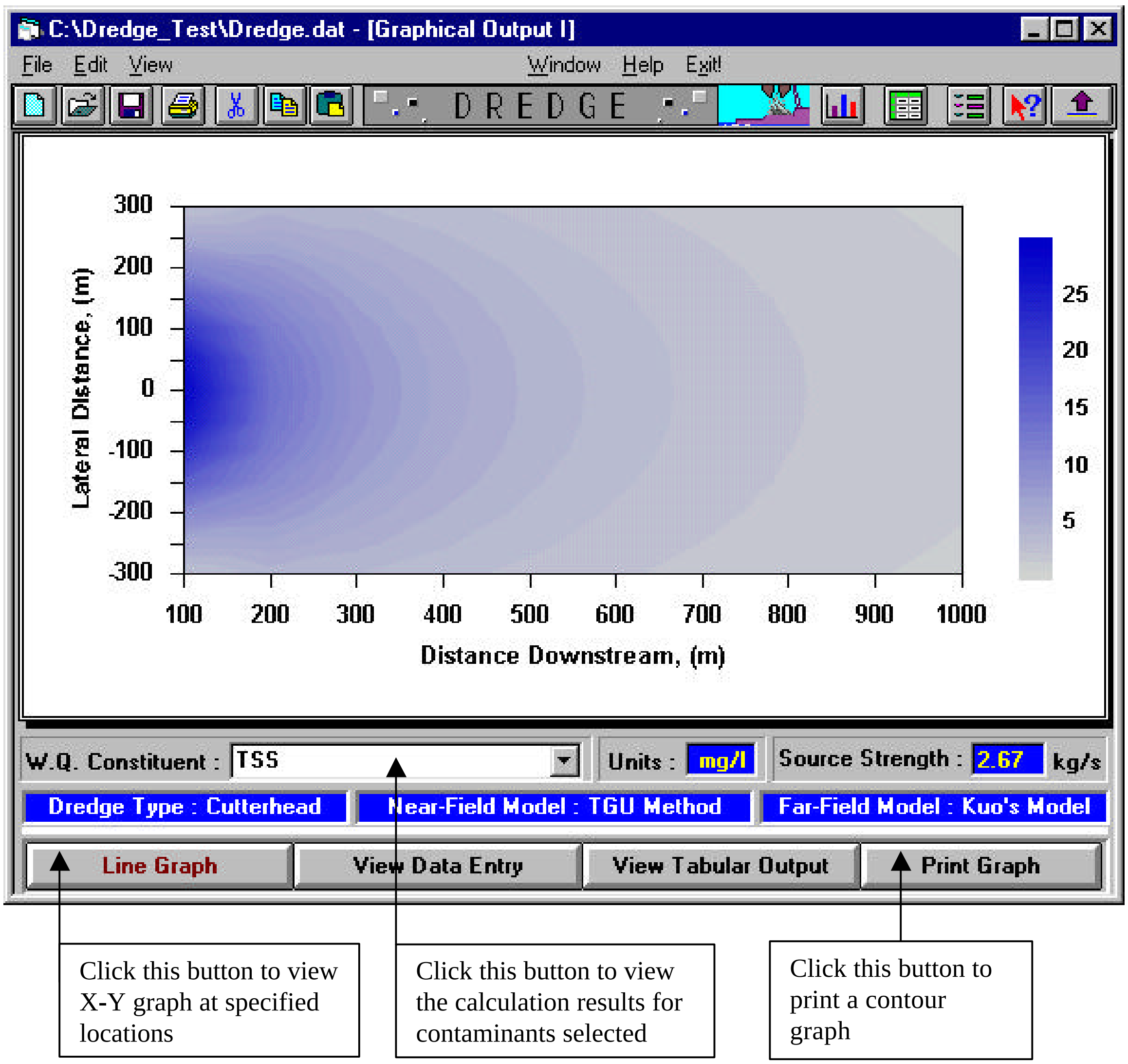
Click this button to save the displayed plume concentrations as an Excel file

Click this button to save output as a text file

Click this button to print spreadsheet output

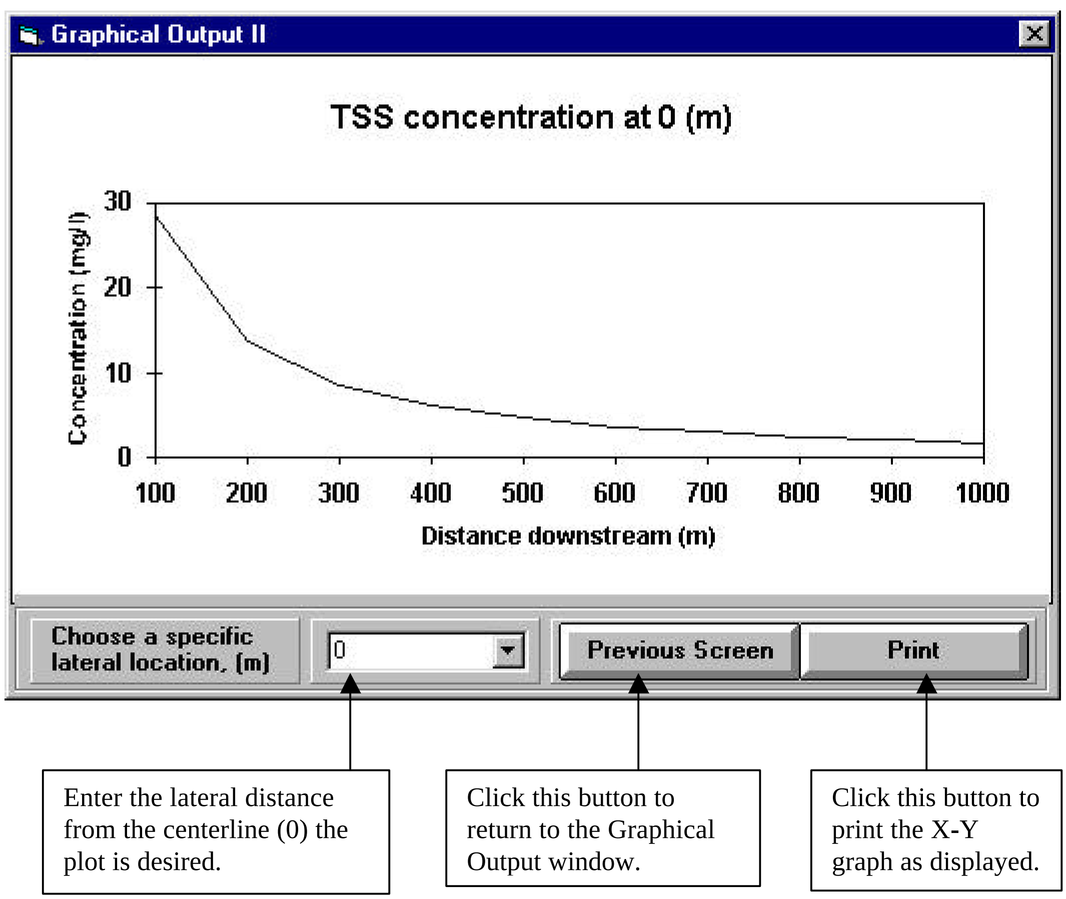
GRAPHICAL OUTPUT

DREDGE provides both contour and X-Y graphs for viewing the output in addition to the spreadsheet display described above. These are available by pressing the "View Graphical Results" button at the bottom of any main screen. This action displays the **Graphical Output** window shown below.



The default graph is a contour graph in which the concentration ranges are displayed using a gradually varying color bar. The user can reformat the graph by pressing the right mouse button while hovering over the graph. This allows the user to format the graph by modifying the scales, color schemes, or axis titles as they wish to have it displayed. The user can then, using the same technique of pressing the right mouse button, save the graph as a graphics file that can be imported into other Windows applications. DREDGE also will print the graph if the user presses the “Print Graph” button at the bottom.

The **Graphical Output** window provides the same model information as the Spreadsheet Output Window. Similarly, the default constituent is TSS, but other constituents can be displayed by selecting them from the drop-down box. DREDGE can also display the results as a more traditional X-Y graph. The user just presses the “Line Graph” button and DREDGE displays a concentration versus distance plot for a given depth and lateral location. This plot can be formatted or saved as a graphics file in a manner similar to that described above for the contour plot. An example is shown below.



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