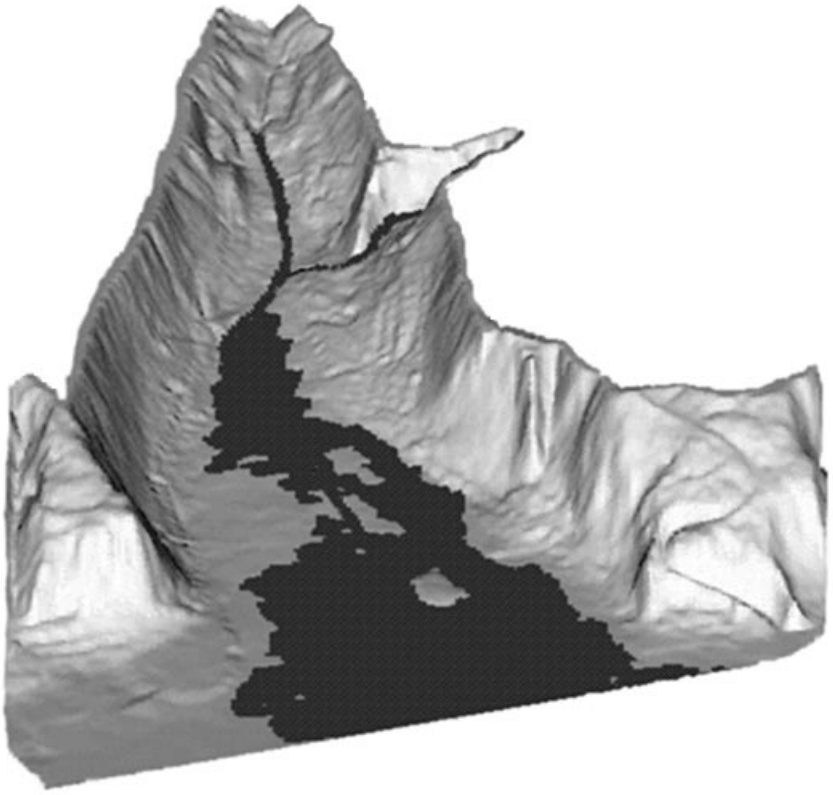
US Army Corps
of Engineers
Hydrologic Engineering Center

HEC-GeoRAS

An application for support of HEC-RAS using ARC/INFO



User's Manual

Version 1.0
March 1999

CPD-75

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 1999	Computer Program Documentation

4. TITLE AND SUBTITLE
HEC-GeoRAS
An Application for support of HEC-RAS using ARC/INFO

5. FUNDING NUMBERS

6. AUTHOR(S)
Cameron T. Ackerman

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US ARMY CORPS OF ENGINEERS
HYDROLOGIC ENGINEERING CENTER (HEC)
609 Second Street
Davis, CA 95616-4687

8. PERFORMING ORGANIZATION REPORT NUMBER
CPD-75

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
N/A

11. SUPPLEMENTARY NOTES
N/A

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release. Distribution of this document is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

HEC-GeoRAS is a package of ARC/INFO* macros specifically designed to view and manipulate geospatial data for use in the Hydrologic Engineering Center's River Analysis System (HEC-RAS). The graphical user interface allows users with minimal GIS experience to create a HEC-RAS import file containing geometric attribute data from an existing digital terrain model (DTM). Water surface profile data exported from HEC-RAS simulations may also be used to create inundation maps using HEC-GeoRAS. The HEC-GeoRAS macros are written in the arc macro language (AML) and require the ARC/INFO program with the TIN feature.

*ARC/INFO is a general purpose Geographic Information System (GIS) software program developed and copyrighted by the Environmental Systems Research Institute, Inc., Redlands, CA.

14. SUBJECT TERMS	15. NUMBER OF PAGES
geographic information systems (GIS), digital terrain model (DTM), triangulated irregular network (TIN), HEC-RAS, ARC/INFO, hydraulic model	111
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

HEC-GeoRAS

An application for support of HEC-RAS using ARC/INFO

User's Manual

Version 1.0
March 1999

US Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

Table of Contents

Foreword

HEC-GeoRAS is a package of scripts for application with ARC/INFO, a general purpose Geographic Information System software program developed and copyrighted by Environmental Systems research Institute, Inc., Redlands, California. HEC-GeoRAS is written in 'arc macro language' (AML) ARC/INFO's scripting language.

The HEC-GeoRAS package AML routines were developed by the Hydrologic Engineering Center (HEC). The data extraction, import, and export algorithms were written by Thomas A. Evans. The user interface was written by Cameron T. Ackerman under the direction of Gary W. Brunner and Thomas A. Evans. Vernon R. Bonner was the Training Division Chief and Darryl Davis was the Director during the development of HEC-GeoRAS.

This manual was written by Cameron T. Ackerman. Appendix B was written by Thomas A. Evans and Gary W. Brunner.

The Hydrologic Engineering Center would like to acknowledge the Honolulu District and Sacramento District for the data sets used in the examples. **Note that the example figures in this manual are provided for illustrative purposes only and are not to be taken as hydraulically accurate.**

C H A P T E R 1

Introduction

HEC-GeoRAS is a package of ARC/INFO macros specifically designed to view and manipulate geospatial data for use in the Hydrologic Engineering Center's River Analysis System (HEC-RAS). The graphical user interface allows users with minimal GIS experience to create a HEC-RAS import file containing geometric attribute data from an existing digital terrain model (DTM). Water surface profile data exported from HEC-RAS simulations may also be viewed using HEC-GeoRAS. The HEC-GeoRAS macros are written in the arc macro language (AML) and require the ARC/INFO program with the TIN extension.

The current version creates an HEC-RAS import file containing river, reach and station identifiers; cross section cut lines, cross section surface lines; cross section bank stations, and downstream reach lengths for the left overbank, main channel, and right overbank. Roughness coefficients and hydraulic structure data are not written to the import file.

Chapter 1 discusses the intended use of HEC-GeoRAS and provides an overview of this manual.

Contents

Intended Application of HEC-GeoRAS

The intended use of HEC-GeoRAS is to create a import file of geometric attribute data for use in HEC-RAS and to view water surface profile data exported from RAS. The import file is created from geometric attributes extracted from an existing DTM. The current version of HEC-GeoRAS requires a DTM represented by a triangulated irregular network (TIN).

Geometric data is extracted from the DTM by intersecting a series of line coverages referred to, herein, as RAS Coverages. The RAS Coverages are created to represent the geometric attributes required to develop a HEC-RAS model: cross section geometry and stationing, bank stations, and reach lengths.

After the geometric data file has been imported into RAS, the geometric data set must be completed before performing hydraulic computations. Results from RAS simulations may be written to a data exchange file. The exported water surface profile data may then be imported back to HEC-GeoRAS for spatial analysis. Inundation mapping options are provided to view the inundation extent and flow depth.

Overview of Requirements

HEC-GeoRAS provides a graphical user interface that allows users with limited geographic information systems (GIS) experience to create, edit, and view geometric attribute data for use with HEC-RAS. Knowledge of ARC/INFO, ARCEDIT, and ARCPLOT is advantageous, but not necessary. Users, however, should have experience modeling with HEC-RAS and have a thorough understanding of river hydraulics to properly construct the necessary coverages.

Hardware and Software Requirements

HEC-GeoRAS is a package of macros written in AML for use in ARC/INFO. ARC/INFO Version 7.1 or higher may be run from the UNIX operating system or Windows NT. The TIN feature of ARC/INFO is also necessary to use HEC-GeoRAS. ARC/INFO is supported by the Environmental Systems Research Institute (1998).

Data Requirements

At this time, HEC-GeoRAS requires a DTM in the form of a triangulated irregular network (TIN). The DTM must be a continuous surface that includes the bottom of the river channel and includes all of the floodplain to be modeled. Because all cross-section data will be extracted from the DTM, only high resolution DTMs should be considered for hydraulic modeling. HEC-GeoRAS does not build a TIN or provide tools for building a TIN.

Overview of the User Interface

The interface for HEC-GeoRAS is divided into three user environments: project management, preprocessing, and postprocessing. The project manager allows the user to maintain projects and provides access to the pre- and postprocessing windows. Preprocessing options include windows for creating a Contour Coverage from a DTM, creating and editing RAS Coverages, and creating the HEC-RAS Import File. Postprocessing windows allow the user to read in a HEC-RAS Export File, select water surface profiles data to analyze, and view the extent and depth of inundation for selected profiles.

User's Manual Overview

This manual provides detailed instruction for using HEC-GeoRAS to create an import file for performing hydraulic modeling with HEC- RAS and viewing exported water surface profile data from RAS simulations. The manual is organized as follows:

- Chapter 1-2 provides an overview of HEC-GeoRAS, as well as instructions for getting started.
- Chapter 3 provides a detailed overview of HEC-GeoRAS.
- Chapter 4 discusses the project manager in detail.
- Chapter 5 describes RAS preprocessing requirements and detailed instruction for developing a HEC-RAS Import File
- Chapter 6 describes RAS postprocessing options for importing the HEC-RAS Export File and viewing water surface profile data.
- Chapter 7 provides an example application of HEC-GeoRAS.
- Appendix A contains a list of references.
- Appendix B contains a sample import file and export file.

C H A P T E R 2

Installing HEC-GeoRAS

The installation procedure for HEC-GeoRAS differs between operating systems. However, automated procedures for both Windows NT and UNIX operating systems will assist the user in installing the package of ARC/INFO macros.

This chapter discusses the ARC/INFO requirements and installation instructions for the Windows NT and UNIX operating systems.

Contents

Hardware and Software Requirements

Before installing HEC-GeoRAS, ARC/INFO Version 7.1 or higher, including the TIN extension, must be installed on the host server. Beyond the hardware and software required to run ARC/INFO, HEC-GeoRAS has minimal additional requirements:

- A mouse.
- A hard disk with 2 megabytes of free space for the HEC-GeoRAS package.
- Disk space for the DTM and RAS Coverages.

The user must also know where to find the ARC/INFO directory before continuing.

Note: If ARC/INFO is reinstalled, HEC-GeoRAS must be reinstalled afterwards.

Windows NT Installation

HEC-GeoRAS must only be installed on the ARC/INFO server. There are two principle steps to installing HEC-GeoRAS: (1) HEC-GeoRAS must be installed from the setup program and (2) System Environment Variables must be set.

The installation procedure copies a macro into the preexisting directory structure of ARC/INFO; therefore, if ARC/INFO is ever reinstalled, HEC-GeoRAS must be reinstalled.

To install HEC-GeoRAS from Windows NT, complete the following:

1. Know where ARC/INFO is installed.
2. Insert the HEC-GeoRAS 1.0 disk into the drive.
3. From the window explorer, open the HEC-GeoRAS folder.
4. Double click **Setup.exe**.
5. Follow the setup instructions that appear on the screen.
6. Set the Environment Variables.

Installing HEC-GeoRAS requires the user to know the directory where ARC/INFO is installed. This directory is identified as the *Destination Directory* during installation. Based on the location of the *Destination Directory*, a parallel directory *Arc4HEC* will be created to install HEC-GeoRAS. As well, the file *georas.aml* will be copied to the directory Destination Directory\atool\arc.

Setting Environment Variables (Windows NT)

To set the Environment Variables, do the following:

1. Press the **Start ➡Settings ➡ Control Panel** from the Windows NT menu bar.

2. From the Control Panel, open the **System** controls and choose the *Environment* tab.

3. Set the *Variable* and *Value* and listed below.

Variable	Value	
CANVASCOLOR	WHITE	
CROSSHAIRCOLOR	MAGENTA	*recommended*
ARCPANZOOM	ON	
ARCWINDWSTATS	ON	*recommended*
ARCINFOFONTNAME	COURIER NEW	*recommended*
ARCINFOFONTSIZE	8	*recommended*

UNIX Installation

HEC-GeoRAS must only be installed on the ARC/INFO server. ARC/INFO must be in place and the ARCHOME environment variable set before HEC-GeoRAS can be installed. The installation procedure writes one file in the ARC/INFO install area (in the *$ARCHOME/atool/arc* directory), and creates a new directory parallel to the ARC/INFO install directory (i.e., one level above $ARCHOME). You must have write privilege in these directories to perform the installation. Also note that if you reinstall ARC/INFO, you will need to copy the HEC-GeoRAS startup macro to the new atool/arc subdirectory.

There are two principle steps to installing HEC-GeoRAS: (1) HEC-GeoRAS must be installed using the install program and (2) System Environment Variables must be set.

To install HEC-GeoRAS on a Unix system, complete the following:

1. Execute the installation script:

   `<path_to_CD_ROM>/unix/install`

   (On most Sun Solaris systems, this would be

   /cdrom/cdrom0/unix/install)

2. Set the Environment Variables (see next section).

(Alternatively, you can cop the files "install" and "georas.tar" from the unix directory on the CD-ROM to any directory on the file system and run the install program from there. Note that the install script and the georas.tar file must be located in the same directory.)

Installing HEC-GeoRAS requires that the ARCHOME environment variable be set for the user doing the installation. The install program will exit if this variable is not set (you can't run ARC/INFO without this variable, either).

Setting Environment Variables (UNIX)

To set the Environment Variables, add the following lines to the .cshrc file of all HEC-GeoRAS users.

```
setenv CANVASCOLOR WHITE
setenv ARCPANZOOM ON
setenv CROSSHAIRCOLOR MAGENTA
setenv ARCWINDWSTATS ON
```

HEC-GeoRAS Files

HEC-GeoRAS files are copied under the *Arc4HEC\GeoRAS* directory. The startup macro *georas.aml* is copied into the *arcexe\atoolarc* directory established when installing ARC/INFO. The directory structure is shown in Figure 2-1.

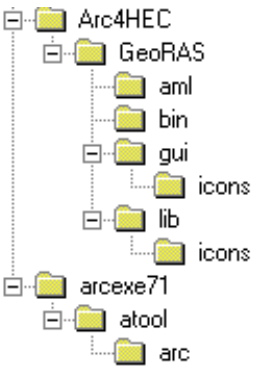


Figure 2.1 HEC-GeoRAS directory structure

A complete list of HEC-GeoRAS files is presented below.

Directory	**Filename**	
\aml	**.eaf (amls)*	**.emf (menus)*
	crosspoint	label_xs
	get_profile_list	
	raspost_fld	
	raspost_read	
	raspost_top_gui	
	raspost_trim	
	raspost_wse	
	rasprep_banks	
	rasprep_label_xs	
	rasprep_reach	
	rasprep_write_xs	
	reachxyz	
	streamroute	

Directory	Filename	
\gui	**.eaf (amls)*	**.emf (menus)*
	check_covers	about
	contour	check_covers
	create_importfile	contour
	draw_covers	create_importfile
	edit_aat	edit
	editor	edit_aat
	environment	edit_bar
	getcolor	getcolor
	import_rasfile	import_rasfile
	new_cover	new_cover
	printmap	printmap
	project	printmap_bar
	selection	printsetup
	wsp	printtext
	wsp_draw	ras_bar
	wsp_drawmaker	ras_form
	wsp_menumaker	save_as
		snap
		wap_draw_bar
	**.text*	
	help_contour	
	help_editaat	
	help_editor	
	help_getcolor	
	help_importras	
	help_mapping	
	help_printing	
	help_prjmgr	
	help_writeras	
	other	
	blue256	
	georas.lin	
	georas.shd	

Directory	Filename	
\gui\icons	**.icon*	
	about	save
	add	select_all
	arrows	select_many
	asterisk16	select_one
	attributes	snap
	contour	snapenv
	copy	split
	cut	switch
	delete	undo
	export32	unselect_all
	flip	unselect_many
	font16	unselect_one
	geom32	unsplit
	get16	vertex_add32
	import32	vertex_del32
	inundation32	vertex_move32
	move	zoomextent16
	open	zoomfull16
	open16	zoomin16
	paint16	zoomout16
	pan16	
\lib	**.aml*	**.menu*
	2button	getcover
	disp_help	getfile
	get_routines	getitem
	getcover	gettin
	getfile	getworkspace
	getitem	msconfirm
	gettin	msinform
	getworkspace	msresponse
	msconfirm	msresponse2
	msinform	msworking
	msresponse	
	msresponse2	
	msworking	
\bin	RASFilter.exe	
\arcexe\atool\arc	georas.aml	

C H A P T E R 3

Working with HEC-GeoRAS - An Overview

HEC-GeoRAS is a package of arc macro language (AML) macros that allows the user to view and process geospatial data in ARC/INFO through a graphical user interface (GUI). The user can create a geometric attribute data file for import into HEC-RAS and view inundation maps from exported RAS water surface profile data.

To create the import file, the user must have an existing digital terrain model (DTM) of the river system. Currently, the DTM must be represented by a TIN. The user creates a series of line coverages pertinent to extracting the geometric attributes from the DTM. A map of the terrain contours is created to help the user lay out the line coverages. The line coverages created are the Main Channel Invert, Main Channel Bank Stations *(optional)*, Overbank Flow Paths *(optional)*, and Cross Section Cut Lines and are referred to, herein, as the RAS Coverages.

Water surface profile data exported from HEC-RAS simulations are read into HEC-GeoRAS and processed. The processed water surface profile coverages may then be viewed.

The collection of the DTM, Contour Coverage, RAS Coverages, and processed water surface profile coverages is termed a project.

Chapter 3 provides an overview of the steps in developing a HEC-GeoRAS project. Chapters 4-6 more completely discuss project development.

Contents

- Exiting HEC-GeoRAS

Getting Started

Start up ARC/INFO and change directories to the workspace containing your DTM using ARC/INFO's WORKSPACE command. WORKSPACE is similar to *cd* on UNIX or at the DOS prompt. Type **HEC-GeoRAS**.

The main window for HEC-GeoRAS is the project manager window. The project manager window allows the user to establish and manage projects and gain access to the preprocessing and postprocessing components. The HEC-GeoRAS Project Manager is shown in Figure 3.1.

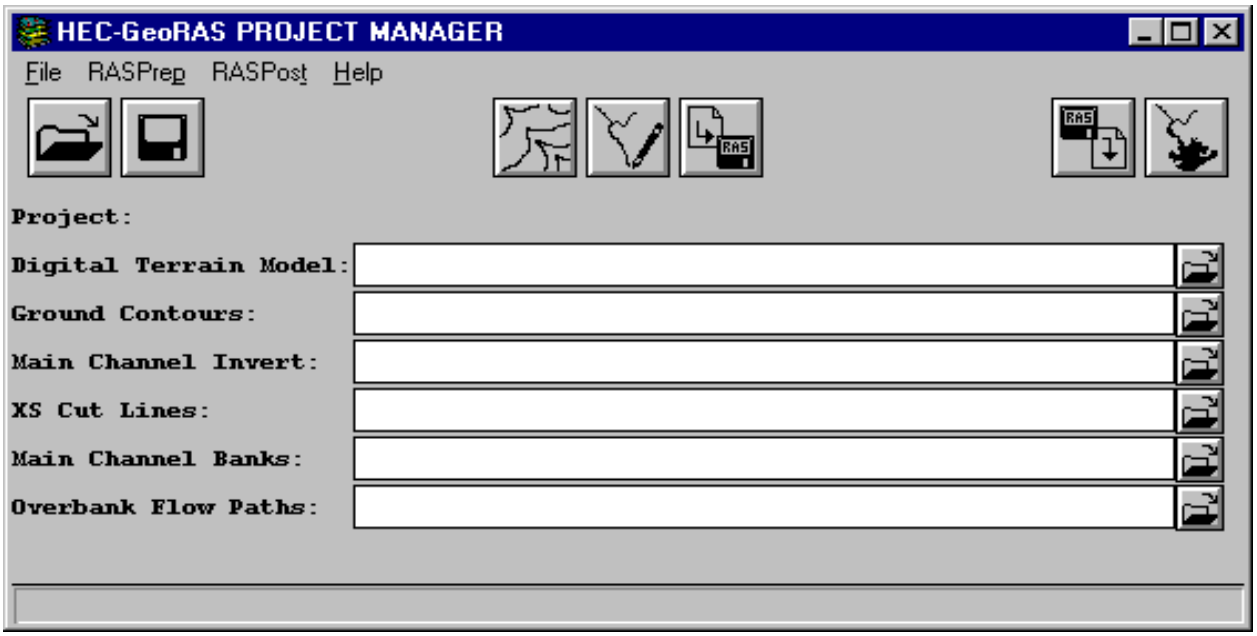


Figure 3.1 HEC-GeoRAS Project Manager Window

At the top of the project manger window is a menu bar. As shown in Figure 3.2, the following menus are available:

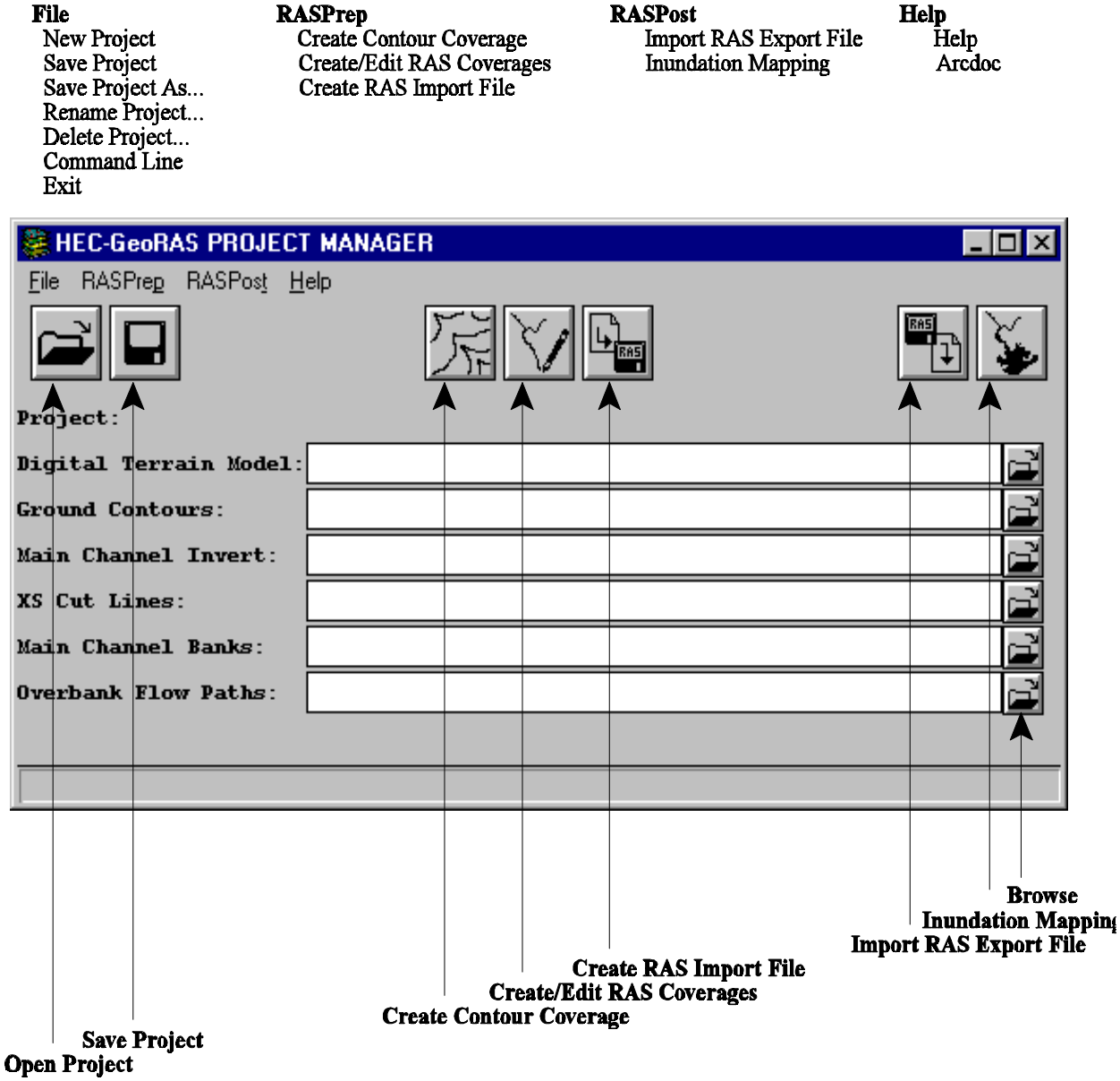


Figure 3-2 HEC-GeoRAS Project Manager options

File: This menu is used for file management. Options under the File menu include: New Project; Open Project; Save Project; Save Project As; Rename Project; Delete Project; Command Line; and Exit.

RASPrep: This menu is used for preprocessing. Preprocessing options are Create Contour Coverage; Create/Edit RAS Coverages; and Create RAS Import File.

RASPost: This menu is used for postprocessing. Postprocessing options are Import RAS Export File and Inundation Mapping.

Help: This option allows the user to get on-line help.

The project window also includes buttons for frequently used options. The description of the button options is shown in Figure 3.2. A description of the button's function is displayed at the bottom of the window by selecting the button and pressing the right mouse button. The message box is delineated by a recessed message box in windows on Windows NT systems but not on UNIX systems.

The *Digital Terrain Model* input field will only allow the user to enter the name of an existing TIN. The other coverage input fields will only allow the user to type in the name of existing line coverages. To import existing coverages, select them using the browser, and they will import when the editor is invoked. Clicking the right mouse button over an input field invokes a selection list of all the valid data sets in the current workspace.

Developing the HEC-RAS Import File

The main steps in developing a HEC-RAS Import File are as follow:

- Starting a new project
- Creating a Contour Coverage
- Creating/Editing RAS Coverages
- Creating a RAS Import File

Starting a New Project

The current ARC/INFO workspace (or current directory) was established before starting HEC-GeoRAS using the WORKSPACE command. Therefore, the default directory will be the current directory and the project, as well as all newly created coverages, will be saved in the default directory. To save the coverages to a different directory, the *entire* pathname must be given.

To start a new project, go to the **File** menu on the HEC-GeoRAS Project Manager and select **New Project**. The response window shown in Figure

3.3 will be displayed. Enter the name of the new project. The file extension *.prj* will be added to the project name. The user is not allowed to change the file extension.

After specifying the project name, press **OK**. If the project name is in conflict with a currently existing project, a message will appear asking the user if the project is to be overwritten. Pressing the **Cancel** button will return the user to the project manager.

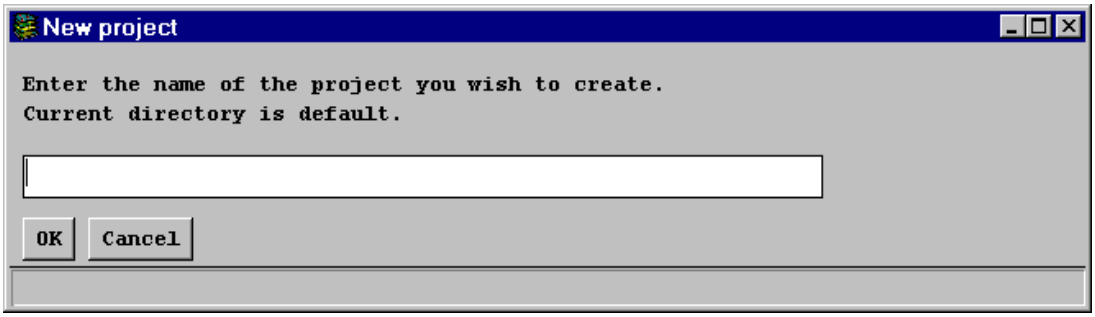


Figure 3.3 New Project window

Creating the Contour Coverage

After a new project is created, the DTM of the river basin must be selected. Press the  button to the right of the input field to invoke a data set browser. Select the DTM using the browsing options. Alternatively, if the DTM is in the current directory, press the right mouse button while the cursor is over the *Digital Terrain Model* input field and select the DTM from the popup list. At this time, only TINs may be selected.

Next, the Contour Coverage is created from the DTM by selecting **Create Contour Coverage** from the **RASPrep** menu on the project manager. This will bring up the Create Contour Coverage window shown in Figure 3.4.

After entering the Contour Coverage name and the Contour Interval, the coverage is created by pressing the **Create Contour Coverage** button. The contour coverage name must be 13 characters or less. The default *Contour Interval* of 1.0 unit may be edited by clicking in the input field. If the interval is too fine in relation to the resolution of the DTM ARC/INFO

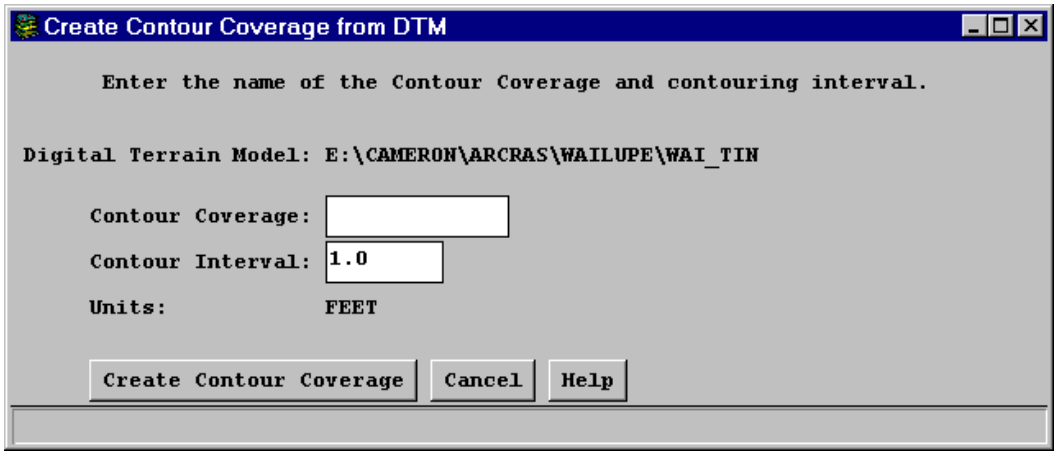


Figure 3.4 Create contour coverage window

will not create the Contour Coverage. If the interval specified is too large, the Contour Coverage created will provide an inadequate description of the land surface for the user when creating RAS Coverages. Pressing the **Cancel** button returns the user to the project window.

Creating RAS Coverages

The next step is to create the four RAS Coverages that will be used to extract geometric data from the DTM. The line coverages to be created are the Main Channel Invert, Main Channel Banks *(optional)*, Flow Paths *(optional)*, and Cross Section Cut Lines. Select **Create/Edit RAS Coverages** from the **RASPrep** menu on the project manager to bring up the Edit RAS Coverages window, shown in Figure 3.5. The Edit RAS Coverages window will appear with a display window. The windows may be moved as desired. The display window may be resized to the user's preference, as well. RAS Coverages are created and edited in ARCEDIT which may take a few seconds to load.

From the Edit RAS Coverages window select the *Ground Contours* checkbox and press **Refresh Display,** to draw the Contour Coverage (created earlier) in the editing window. If the terrain is not represented appropriately, create the Contour Coverage again, using a different contouring interval. Coverages are selected and drawn in the display window to assist the user in creating the RAS Coverages.

The following section provides instructions for creating the RAS Coverages. For a more detailed discussion on creating RAS Coverages using the editing tools refer to Chapter 5.

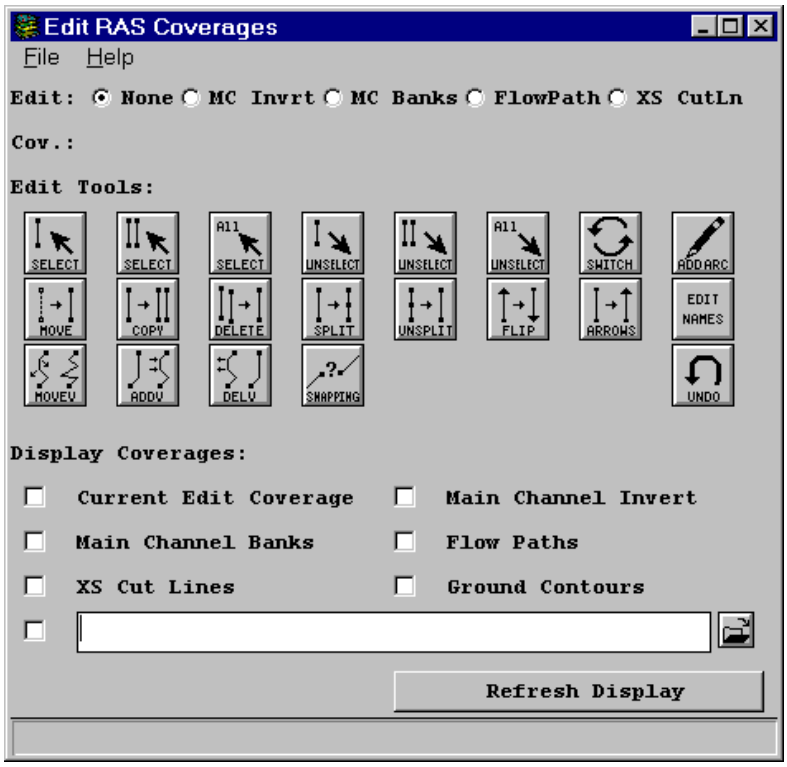


Figure 3.5 Edit RAS Coverages window

Main Channel Invert. The Main Channel Invert Coverage should be created first. From the Edit RAS Coverages window, select the **MC Invert** choice to invoke the window shown in Figure 3.6. Enter the name of the new coverage and press **Create New Coverage**. The coverage name must be 13 characters or less. Pressing the **Cancel** button will return the user to the Edit RAS Coverages window.

After pressing the **ADD ARC** button from the *Edit Tools* palette, cross-hairs will appear over the editing window. Draw the river reaches one by one, from upstream to downstream, using the mouse. Each reach is represented by an arc. An arc is defined by a line containing an upstream and downstream node. A series of vertices may separate the nodes. Each reach may contain no more than 500 points (2 nodes with 498 vertices). To create a node, place the cross-hairs at the desired node location and

press the right mouse button. To create a vertices, press the left mouse button.

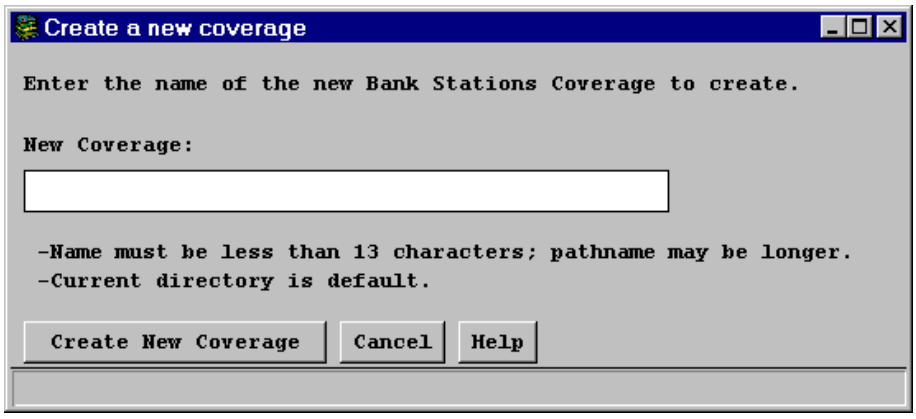


Figure 3.6 New coverage window

After drawing each river reach, the window shown in Figure 3.7 will appear to allow the user to supply the *River Name* and *Reach Name*. The **?** button invokes a selection list of river names previously entered for the current coverage and may be useful for rivers with many reaches. *Reach names for the same river must be unique*. River and reach names may be up to 16 characters long. Pressing **OK** will save the entered names. **Cancel** will quit the window without saving the names.

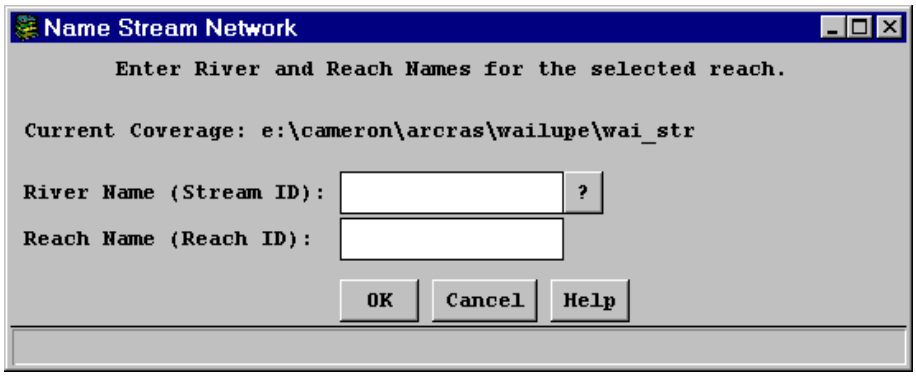


Figure 3.7 Stream and reach identifier window

After the river network coverage has been completed, save the coverage by selecting **Save** from the **File** menu.

Main Channel Banks. Select the **MC Banks** choice from the editor. After supplying the coverage name, create the Main Channel Banks Coverage by

pressing the **Create New Coverage** button from the new coverage window.

Use the **ADD ARC** button from the Edit RAS Coverages window to draw the location of the channel banks. Separate arcs should be used for each bank of each river. Bank lines from tributary rivers may overlap the bank lines of the mainstem. *Creating the Main Channel Banks Coverage is optional.*

Flow Paths. Create the Flow Path coverage by selecting the **FlowPath** choice, on the editor and entering the coverage name. If the Main Channel Invert Coverage already exists, the flow path defining the main channel will be copied to the edit coverage. Add arcs using the **ADD ARC** button for the hydraulic flow path in the left overbank, right overbank and main channel (if necessary). Be sure to check that the flow paths are drawn from upstream to downsteam. *Creating the overbank flow path coverage is optional.*

Cross Section Cut Lines. Create the new Cross Section Cut Lines Coverage by selecting the **Cut Line** choice and entering the coverage name. Add cut lines using the **ADD ARC** option where cross-section data should be extracted from the DTM. Each cut line is represented by an arc drawn from the left overbank to the right overbank when facing downstream. Cut lines must cross the main channel only once and no two cross sections may intersect. Cross section cut lines are multi-segment lines that should be drawn perpendicular to the flow lines.

When finished creating the RAS Coverages, select **Exit** from the **File** menu to quit from the Edit Coverage window.

Creating a RAS Import File

The RAS Coverages are used to extract geometric attribute data from the DTM. After creating the RAS Coverages, select **Create RAS Import File** from the **RASPrep** menu on the project manager. The window shown in Figure 3.8 will be displayed.

Check that the coverage names are correct and select the DTM sampling interval method. Enter the import filename and press the **Create Import File** button to proceed. **Cancel** dismisses the window and returns the user to the project manager.

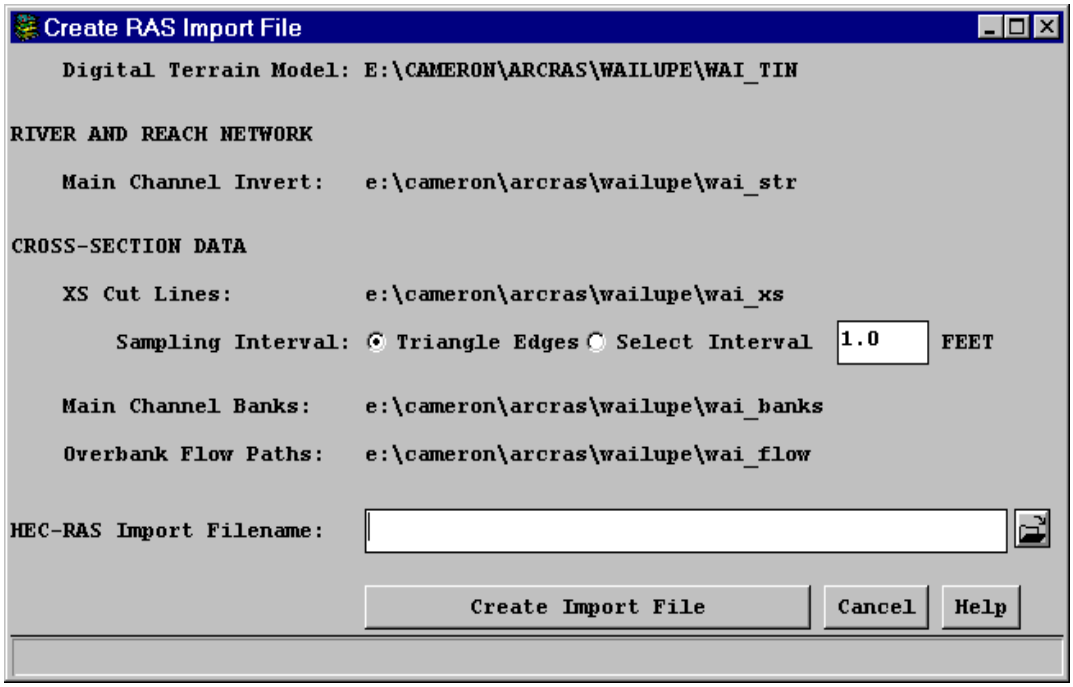


Figure 3.8 Create RAS Import File window

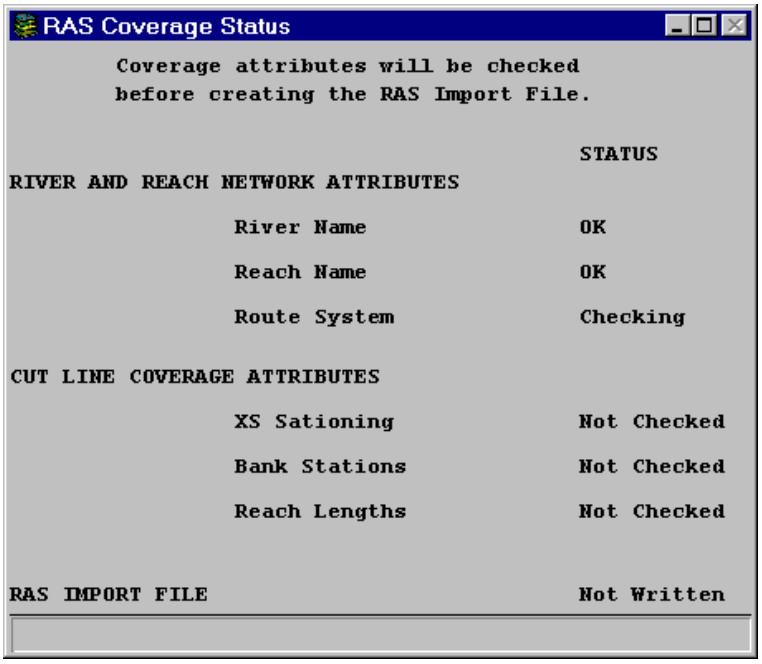


Figure 3.9 RAS Coverage Status window

Once the **Create Import File** button is pressed, the RAS Coverage attributes will be checked for missing data. Progress updates will be displayed in the Create RAS Import File status window shown in Figure 3.9. The user will be asked to verify updates to the geometric attribute data before the import file is written. If any data is missing, the user will be prompted to return to the editor to make the appropriate changes.

Running HEC-RAS

After importing the geometric data extracted from the GIS, completion of hydraulic data will be necessary. Hydraulic data that is not imported includes roughness coefficients, expansion and contraction losses, and hydraulic structure data. Complete the required data entry before running any simulations for your hydraulic model. For a more complete discussion on importing geometric data refer to the HEC-RAS User's Manual, Chapter 13 (Hydrologic Engineering Center, 1998).

After running various simulations in HEC-RAS, export the water surface profile results. For a more complete discussion on exporting GIS data refer to the HEC-RAS User's Manual, Chapter 13 (Hydrologic Engineering Center, 1998).

Viewing the HEC-RAS Exported Water Surface Profiles

The main steps in viewing HEC-RAS exported water surface profiles are as follow:

- Importing a RAS Export File
- Viewing Inundation Extent and Depth

Importing a RAS Export File

Import the exported RAS data file by selecting **Import RAS Export File** from the **RASPost** menu. The window shown in Figure 3.10 will appear. Specify the file (*.*gis*) to import and enter the name of a new coverage that

will be created. The new coverage will contain the water surface elevations for each profile (selected later) at each cross section. Press **OK**

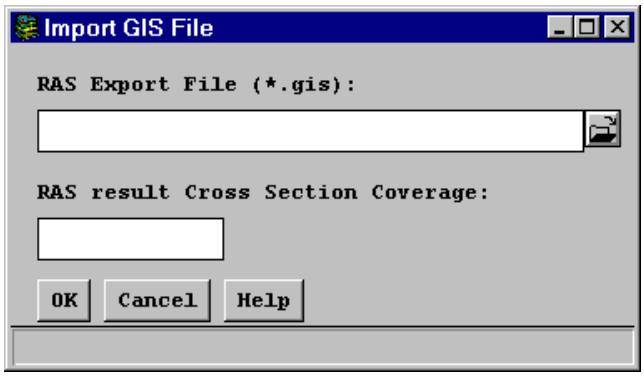


Figure 3.10 Import GIS File window

to import the data file or **Cancel** to quit.

Importing the GIS data file results in creating an index file (*tempindex9999*) of the water surface profile names. The index file is written to the current workspace, and will be referred to as the user creates water surface coverages for mapping. **Currently, water surface profile names must be 11 characters or less (including spaces)**. (Caution: HEC-RAS allows the user to provide water surface profile names up to 16 characters long when creating the export file.)

Pressing **OK** will invoke the window, previously written to the current workspace (filename *wsp.menu*) displayed in Figure 3.11. From the

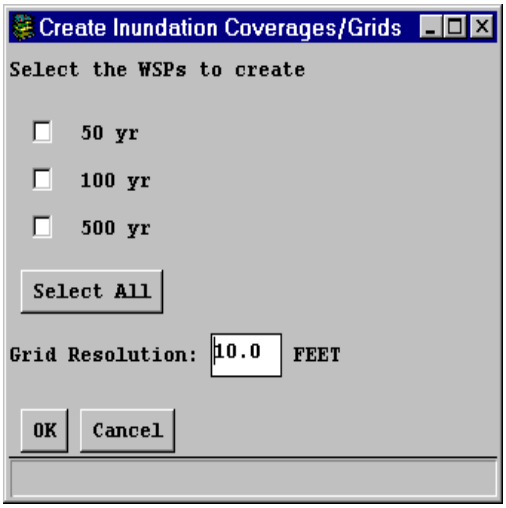


Figure 3.11 Create mapping coverages window

window, select the water surface profiles coverages to create and enter the grid-cell resolution for the associated depth grid. The grid-cell resolution refers to the dimensions of a square cell having a single water depth as averaged value of the surrounding depths. Press **OK** to create the coverages or **Cancel** to quit.

Two coverages will be created for mapping each water surface profile. A polygon coverage having the prefix *f_* and a grid having the prefix *d_* followed by the water surface profile name. A TIN having the prefix *t_* will be temporarily created, but will be deleted after the water surface profile processing is complete. Underscores replace any blanks in the water surface profile names. The coverages are created in the current workspace.

Viewing Inundation Extent and Depth

The extent of inundation and flow depth grids may be viewed by selecting **Inundation Mapping** from the **RASPost** menu on the project manager. The Inundation Mapping window shown in Figure 3.12 will be displayed on the screen along with a viewing window. Inundation mapping options are performed in ARCPLOT, which may take a few seconds to load.

Select the water surface profile data to be displayed by selecting the corresponding *Fill* and *Bndry* checkboxes. Press **Refresh Display** to view the extent of inundation for the various profiles. Selecting *Bndry* will map an outline of the inundation polygon, while checking *Fill* will color the entire polygon.

To view the variation in depth for a profile, select a *Depth Grid* by right clicking over the input box. A popup menu will appear and allow the user to select from the list of available grids. Next from the *Display* choice, select *Grid* and press **Refresh Display**. The variation in depth for the selected profile will be displayed as shades of blue. To interactively determine the water depth at a certain location, press the **Depth?** button. Use the cross-hairs displayed to select the location with the left mouse button. The water depth is displayed to the right of the **Depth?** button. Press the right mouse button to finish selecting locations.

When finished viewing the water surface profile coverages, choose **Exit** from the **File** menu to quit from the Inundation Mapping window and exit ARCPLOT.

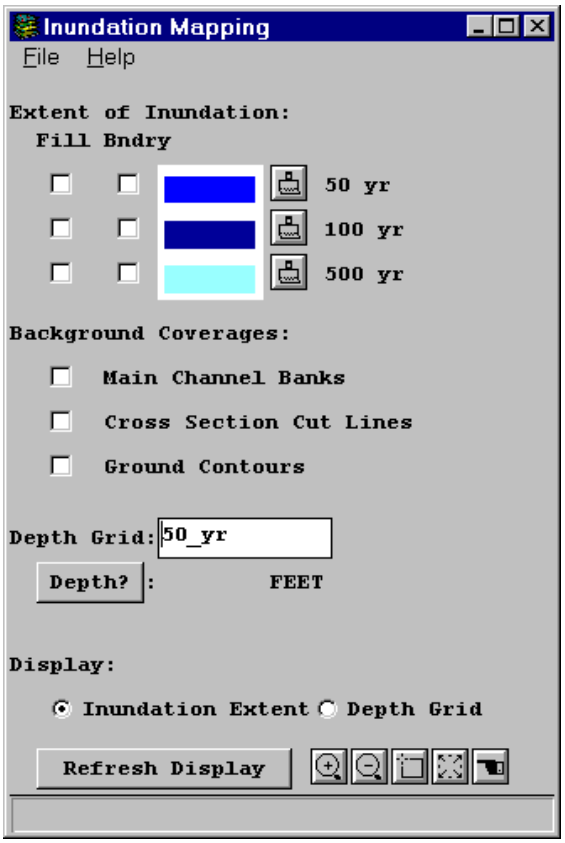


Figure 3.12 Inundation Mapping window

Printing Map Results

Maps viewed using the Inundation Mapping window option may be printed using the options provided by Print Map window. To access the Print Map window select **Print** from the **File** menu on the Inundation Mapping window. The Print Map window shown in Figure 3.13 will be displayed.

Using the page presentation options provided in concert with **Preview** to prepare the map for printing. Pressing the **Print** button will write the map to a temporary file (permanent, if specified) and then invoke the ARC/INFO printing interface. Using the interface options select the printer *Driver* and press **Print**. The image, as viewed during preview, will be printed.

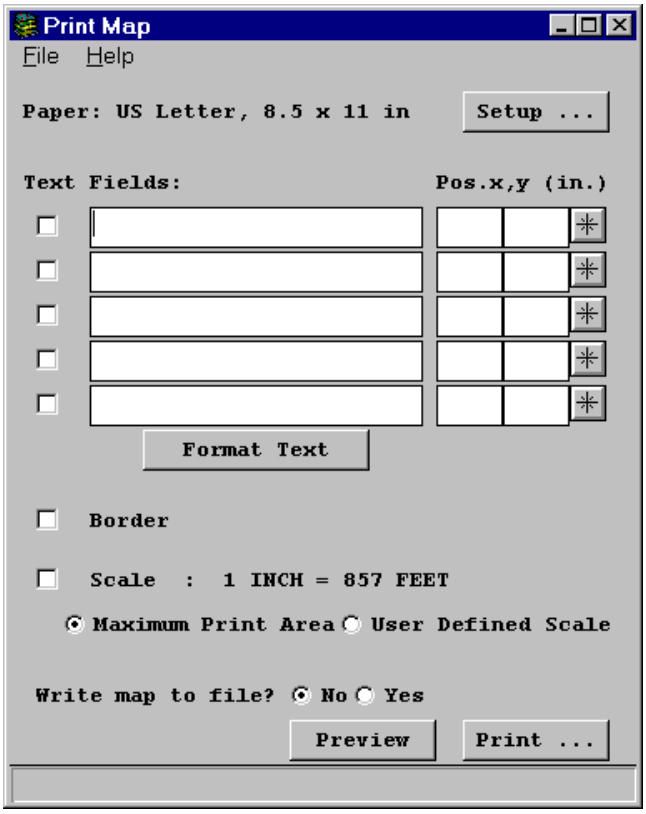


Figure 3.13 Print Map window

Exiting HEC-GeoRAS

When finished editing coverages and viewing water surfaces return to the project manager. From the **File** menu on the HEC-GeoRAS Project Manager select **Exit**. Upon exiting, the user will always be asked to save the current project. The user will be returned to the ARC prompt.

C H A P T E R 4

Using the Project Manager

The project manager window of HEC-GeoRAS is the initial window available to the user. The project manager allows the user to access project management and data processing options.

This chapter discusses project management options and summarizes data processing windows.

Contents

Project Definition and the Default Directory

A complete project is the collection of all the GIS data necessary to create an HEC-RAS import file and the converted HEC-RAS export file data for inundation mapping. Project pathnames are stored in an ascii file using the *.prj* extension. The user is not allowed to change to change the extension. The project file is composed of the following:

Project Component	Description
Project	The project name.
DTM	The Digital Terrain Model (DTM) for the river network and channel geometry.
Units	The units of the project as read from the DTM header.

Project Component	Description
Contour Coverage	The Contour Coverage constructed from a DTM.
Main Channel Invert Coverage	The line coverage of the river and reach network.
Main Channel Banks Coverage *(optional)*	The line coverage of the location of the channel banks.
Flow Paths Coverage *(optional)*	The line coverage of the hydraulic flow path in the left overbank, main channel, and right overbank.
Cross Section Cut Lines Coverage	The line coverage of the location and expanse of cross sections.
RAS Import File	The data file created from extracting geometric data from the DTM using the RAS Coverages.
RAS Export File	The file of water surface profiles and bounding polygons formatted for import into GIS. Exported from RAS.
Water Surface Elevation Coverage	A cross section cut line coverage containing the elevation of the water surface at each cross section for each profile.
RAS Water Surface Profile List	A list of the water surface profiles exported from RAS.
GIS Water Surface Profile List	A list of the water surface profiles which have an associated inundation coverage and depth grid.
Bounding Polygon Coverage	The polygon coverage of the modeled region for the given water surface.
Depth Grid	The depth grid for the given water surface profile.

The default project directory is the directory from which ARC/INFO is

initiated. All coverages and files created are placed in the default directory, unless the entire pathname is specified.

Project Manager Options

The project manager provides options from managing projects and processing data. The project manager is shown in Figure 4-1.

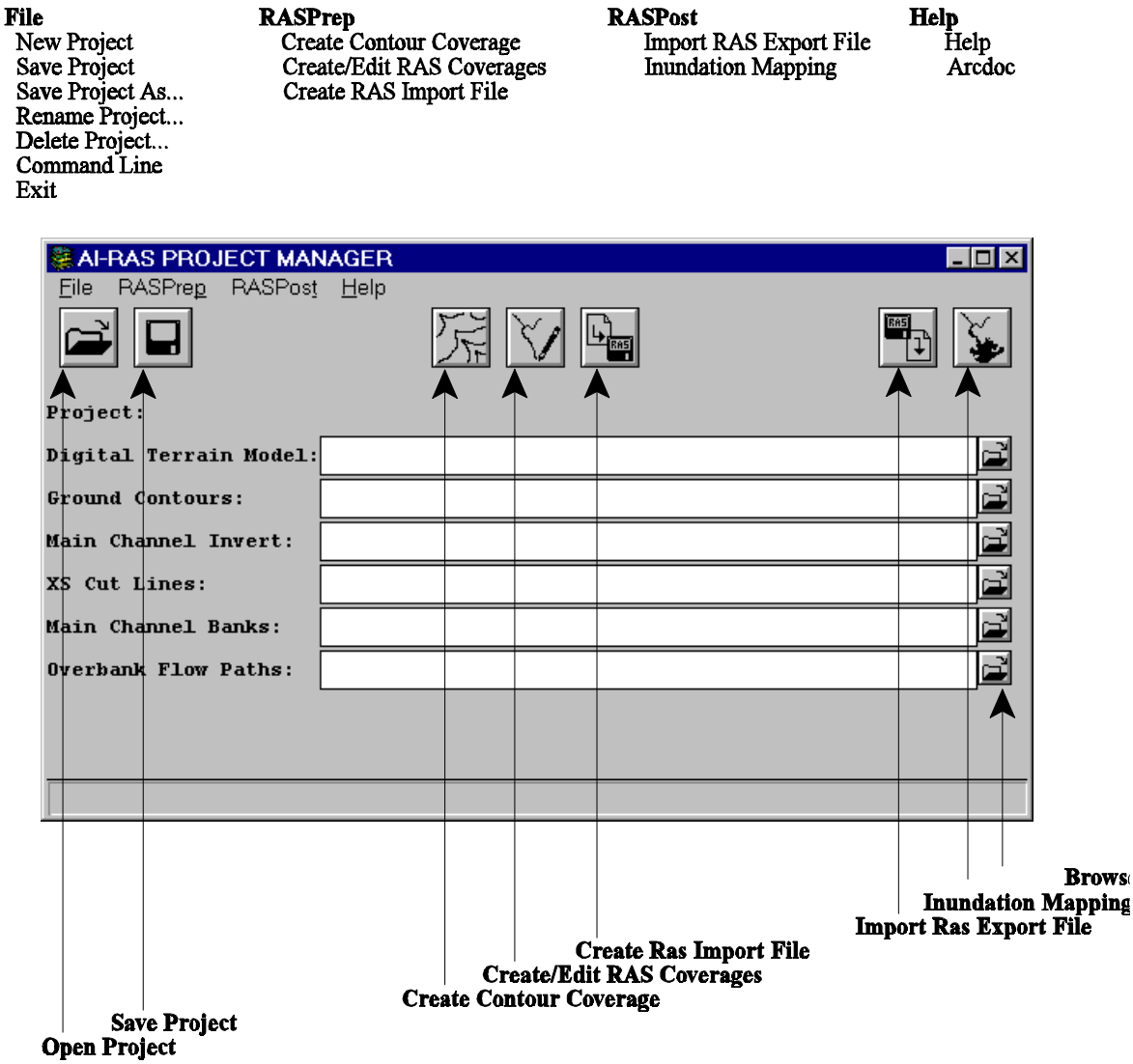


Figure 4-1 HEC-GeoRAS Project Manager options

Project Management

Projects are managed with options available from the **File** menu of the project manager. The options are listed:

File menu command	Description
New Project	Creates a new project. Closes the current project, prompting the user to save the project, and then to enter the new project name.
Open Project	Opens an existing project. Closes the current project, prompting the user to save the project if anything has been changed.
Save Project	Saves the current project.
Save Project As	Saves the current project to a new filename. Prompts the user, if the new name conflicts with an existing project.
Rename Project	Allows the user to rename the current project.
Delete Project	Deletes the project file. The user is prompted for confirmation of deletion.
Command Line	Returns the user to the ARC Prompt for command line execution. Type &RETURN to return to the Project Manager window. *Only very experienced ARC/INFO users should use the interactive Command Line option.*
Exit	Quits HEC-GeoRAS.

Processing Windows

The project manager window allows access to preprocessing and postprocessing windows. The windows accessed are as follow:

Window	Description
Create Contour Coverage	Creates a contour coverage from a DTM. The user may supply the contouring interval. The default contouring interval is one unit as read from the DTM. Run from ARC.
Create/Edit RAS Coverages	Provides the user with arc editing tools and an editing window to display coverages. Run from ARCEDIT.
Create RAS Import File	Provides the user with a window that displays the coverages to be used in creating the import file. Allows for the user to select the cross section sampling method. Run from ARC.
Import RAS Export File	Imports an HEC-RAS Export File containing water surface profiles. Allows the user to select the file (*.*gis*) to import. Creates a coverage to hold water surface elevations at each cross section and an index file: *tempindex9999*. Provides the user with a menu to select the water surface profiles to be created and the grid-cell resolution for the associated depth grid. Creates the file *wsp.menu* in the current workspace, from which the window is invoked. Creates the polygon coverage with the prefix *f_*, the flow depth grid prefixed *d_*, and the water surface tin prefixed by *t_* (later deleted). Run from ARCPLOT.

Window	Description
Inundation Mapping	Provides the user with a window for displaying the extent and depth of inundation for various water surface profiles. Creates the file *wsp_draw.menu*, from which the window is invoked. Provides access to printing options. Run from ARCPLOT.

C H A P T E R 5

Developing the HEC-RAS Import File

The HEC-RAS Import File consists of geometric attribute data necessary to perform hydraulic computations in HEC-RAS. The import file is developed from an existing Digital Terrain Model (DTM) of the channel and surrounding land surface. Geometric data are extracted from the DTM by locating the points of intersection of the RAS Coverages with the DTM. Currently, a triangulated irregular network (TIN) is the only supported type of DTM.

RAS Coverages created by the user include coverages for the Main Channel Invert, Main Channel Banks *(optional),* Flow Paths *(optional),* and Cross Section Cut Lines. Data extracted from the DTM and RAS Coverages form an import file which contains: river, reach, and station identifiers; cross section cut lines; cross section surface lines; cross section main channel bank stations; and downsteam reach lengths for the left overbank, main channel, and right overbank.

At this time, channel and overbank roughness coefficients, hydraulic structure data, and optional cross-section properties such as levees and ineffective flow areas are not written to the import file.

Chapter 5 discusses the steps in developing the HEC-RAS Import File.

Contents

Digital Terrain Model

HEC-GeoRAS requires an existing DTM from which the geometric data will be extracted. Currently, a TIN representation must be used for the DTM. The DTM must be representative of both the land surface of the surrounding floodplain and channel bottom.

Developing a hydraulic model begins with an accurate geometric description of the surrounding landform, especially the channel geometry. Channel geometry will dominate flow in river systems; therefore, **only DTMs describing channel geometry with a high resolution should be considered to perform hydraulic analysis**. Further, RAS Coverages should be created with thoughtful evaluation of the hydraulics as governed by the terrain.

Creating a Contour Coverage

Before creating a Contour Coverage, select the DTM using the browsing button or right clicking over the *Digital Terrain Model* field and selecting from the popup list. Create a Contour Coverage from the DTM by selecting **Create Contour Coverage** from the **RASPrep** menu on the project manager. Enter the name of the *Contour Coverage* and *Contour Interval* in the form that appears (see Figure 5.1). The contouring interval should be selected based on the definition of the DTM. Contouring interval units are read from the DTM header and displayed below the *Contour Interval* field.

It should only take a few minutes to create the Contour Coverage depending on the *Contour Interval* and number of points in the DTM. The Contour Coverage is used to establish the geographic limits for creating new coverages and to visually aid the user in properly drawing the RAS Coverages. The Contour Coverage is not used for data extraction.

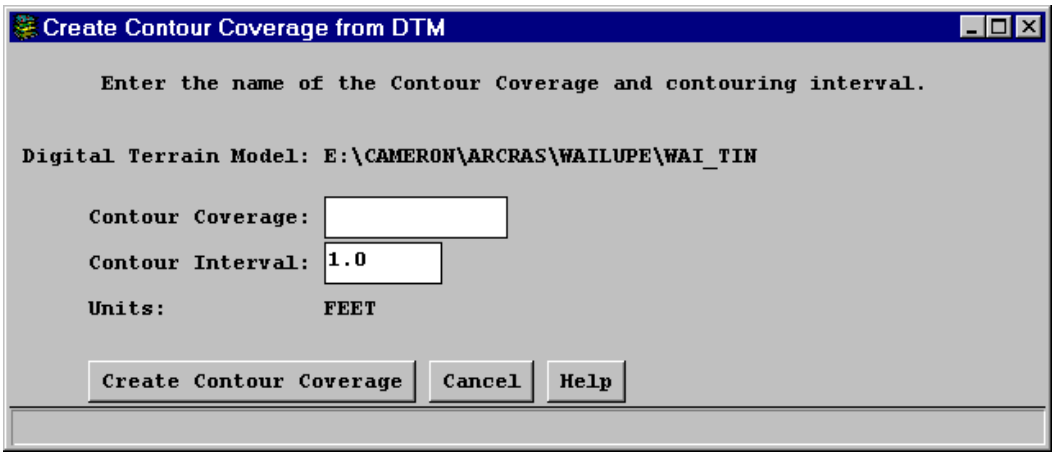


Figure 5.1 Create contour coverage window

Creating and Editing RAS Coverages

Throughout this manual, the coverages used for extracting geometric attribute data from the DTM are collectively referred to as RAS Coverages. The RAS Coverages are created by drawing arcs (lines) which represent the geometric data needed to create a HEC-RAS model. The four RAS coverages are the Main Channel Invert, Main Channel Banks *(optional)*, Flow Paths *(optional)*, and Cross Section Cut Lines.

Creating and editing the RAS Coverages is accomplished in ARCEDIT using the Edit RAS Coverages window. The editing environment is accessed from the project menu by selecting **Create/Edit RAS Coverages** from the **RASPrep** menu. An editing window will appear to the right of the Edit RAS Coverages window. The windows may be moved, and the editing window may be sized to the users preference.

To import existing coverages, select them from the project manager before accessing the coverage editing environment. The coverages will be imported into the editing environment as each coverage is selected for editing.

Coverage Editor

The Edit RAS Coverages window is organized by function. A menu bar at the top of the window provides access to the File and Help menus. The upper portion of the window allows the user to select the type of coverage to be edited and displays the entire pathname for the current edit coverage. The middle portion of the edit window provides the user with tools for editing the RAS Coverages. The bottom portion of the window allows the user to display background coverages when editing a coverage. Editing options are shown in Figure 5.2.

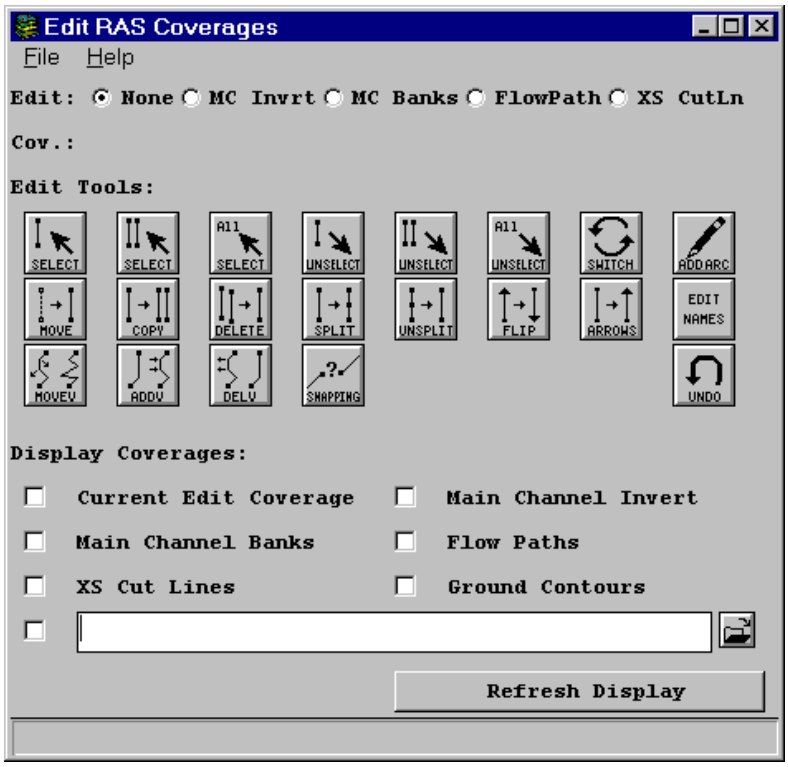


Figure 5.2 Edit RAS Coverages window

Managing Coverages

Coverages are managed in the edit environment under the File menu, the *Edit* type choices, and the *Cov.* display field.

New, Open, Save, and Save As options are available from the File menu option and cannot be used until a *Edit* type is chosen. The Command Line option and Exit are available under the File menu, as well.

New: Creates a new coverage of the *Edit* type selected. A message box will allow the user to input the new coverage name. If the name conflicts with an existing coverage, the user will be prompted to overwrite the existing coverage. The coverage will be created in the default directory if the entire pathname is not given.

Open: Opens an existing coverage. The coverage is opened as the current *Edit* type.

Save: Saves the current edit coverage. Operations are also performed on the edit coverage which create nodes at intersecting arcs. Dangling arcs are created when an intersection is created and an arc overshoots the intersecting node. Dangling arcs should be removed from the Main Channel Invert Coverage.

Save As: Saves the current edit coverage with the new name entered. If the name is in conflict with an existing coverage, the user will be prompted to overwrite the existing coverage. The coverage will be saved in the default directory if an entire pathname is not given.

Command Line: Allows the user to provide line commands at the ARCEDIT prompt. Type &RETURN to return to the user interface. *This option should only be used by experienced ARC/INFO users.*

Exit: Quits from the editing environment and returns the user to the project manager.

The Help menu allows the user to access online help using the Help and ArcDoc options.

Help: Results in the display of a popup window with an ascii help file specific to the editing window.

ArcDoc: Activates the ARC/INFO online help document.

Edit: Allows the user to select the RAS Coverage type to edit. If no coverage has been entered in the corresponding text field on the project manager, a new coverage of the *Edit* type will be created. If the coverage has been entered, it will be loaded as the current edit coverage and drawn in the editing window at the full extent of the coverage.

Cov.: Displays the pathname of the current edit coverage.

Edit Tools

The edit tools allow the user to create and edit the RAS Coverages using a mouse. The edit coverage is displayed in black, while the currently selected arcs are displayed in magenta. The following edit options are available:

SELECT One: Selects one arc to be edited. Use the left mouse button to select an arc. Select an arc before performing edits such as COPY, DELETE, MOVE, etc ...

SELECT Many: Selects many arcs to be edited. Use the left mouse button to select arc. When finished selecting arcs press, Ctrl + right mouse button to exit.

SELECT All: Selects all the arcs in the edit coverage.

UNSELECT One: Unselects one arc. Use the left mouse button to unselect an arc.

UNSELECT Many: Unselects many arcs. Use the left mouse button to unselect arcs. When finished unselecting arcs press, Ctrl + right mouse button to exit.

UNSELECT All: Unselects all the arcs in the edit coverage.

SWITCH: Switches the selection. Unselected arcs are selected as selected arcs are unselected.

ADD ARC: Adds an arc. The right mouse button begins and ends an arc by drawing a node. The left mouse button draws a vertex. An arc must be composed of at least two nodes: a FROM node and a TO node. Press Ctrl + right mouse button when finished. Arcs may contain no more than 500 points (498 vertices and 2 nodes).

MOVE: Moves the selected arc(s). Use the left mouse button to drag and drop the selection.

COPY: Copies the selected arc(s). The selection is copied parallel at the position indicated by the cross-hairs by pressing the left mouse button.

DELETE: Deletes the selected arc(s).

SPLIT: Splits the selected arc into two arcs by placing a node at the selected location.

UNSPLIT: Combines two arcs into one by removing a shared node. If this option does not combine the arcs, zoom in and check that the nodes lie on top of each other (share the same point). If the nodes do not share the same point, use the **MOVEVertex** option to snap the nodes to the same point.

FLIP: Reverse the direction of the selected arc(s) by reversing the FROM and TO nodes. Use the **ARROWS** option to determine arc orientation.

ARROWS : Indicates the direction the arc was constructed by placing an arrow in the direction of the TO node.

EDIT NAMES: Edits the river and reach name of the selected arc. River reaches will be labeled and cross-hairs will appear to allow the user to select the reach to edit. The window shown in Figure 5.3 appears, after selecting a river reach. River and reach names must be 16 characters long or less. Reach names on the same river must be unique. The **?** button provides a list of previously used river names which may be selected. **OK** accepts the entered names, dismisses the window, and saves the edit coverage. **Cancel** dismisses the window without changing the names.

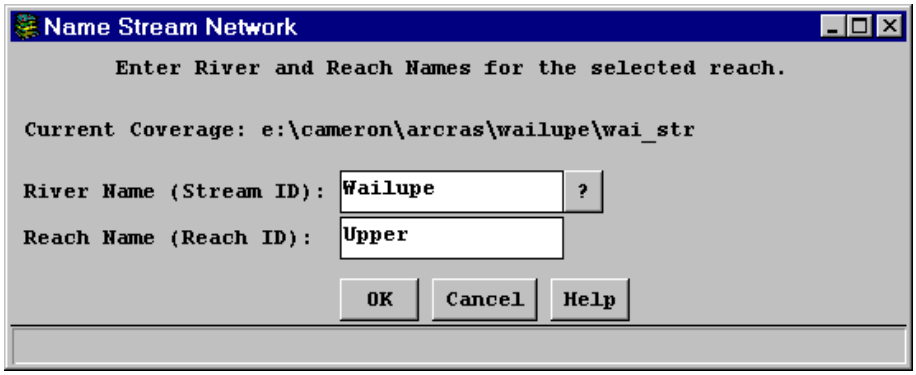


Figure 5.3 Stream network editing window

MOVEVertex: Moves a vertex on the selected arc. Select a vertex by placing the cross-hairs over a vertex and pressing the left mouse button. Move the cross-hairs to the new location and press the left mouse button a second time. The cross-hairs will remain on the editing window allowing the user to continue to move vertices. If trouble is encountered, zoom in on the vertex so that the exact location of the vertex may more easily be selected. Press the right mouse button when finished moving vertices.

ADDVertex: Adds a vertex to the selected arc. Place the cross-hairs over the location to add a vertex and press the left mouse button. Cross-hairs will remain allowing the user to continue to add vertices. Press the right mouse button when finished adding vertices.

DELETEVertex: Deletes a vertex from the selected arc. Place the cross-hairs over the vertex and press the left mouse button. This option will also delete a node making the vertex on the end the new node. However, if an node is on top of a vertex the user must delete both the node and vertex. Cross-hairs will remain, allowing the user to continue to delete vertices. Press the right mouse button when finished deleting vertices.

SNAPPING: Sets the node snap environment. This option will invoke the node snap environment window shown in Figure 5.4. The snapping tolerance determines the distance between nodes before they will snap when drawing *new* arcs (or moving nodes and arcs) and is shown in the units taken from the DTM header. The ✳ button allows the user to set the snapping tolerance visually in the editing window. Node snapping may be turned on or off. The default is ON with the snapping tolerance set to 1/1,000 of the width or height, whichever is greatest, of the current edit

coverage. Press **OK** to dismiss the window with the current node snap environment.

Figure 5.4 Node Snap Environment window

The node snap tolerance will determine the minimum allowable distance between two nodes. When a coverage is saved, any vertices or nodes that are separated by less than the snap tolerance will snap together, altering the construction of the corresponding arc.

UNDO: Undoes the last edit. Undo keeps track of the edits since the coverage was last saved. Undo will not work with the EDIT NAMES option.

Display Coverages

To aid the user in creating and editing the Edit Coverage, coverages may be displayed in the background of the editing window by selecting the corresponding checkbox. The empty input field allows the user to select a background coverage other than the Contour Coverage and RAS Coverages. At this time, the background coverage must be a line coverage. Each coverage is displayed in a unique color as summarized below.

Coverage	Color
Current Edit Coverage	Black
Main Channel Invert	Blue
Bank Stations	Red
XS Cut Lines	Green
Overbank Flow Paths	Blue
Ground Contours	Grey

Coverage	Color
Background Coverage	Orange

Refresh Display: Redraws the editing window, displaying the coverages corresponding to the depressed checkboxes. Maintains the current extent and position of the of the editing window.

Editing Window

There are several options available from the Pan/Zoom menu on the editing window, shown in Figure 5.5 will be displayed. The pan and zoom options may be used in the middle of a editing operation such as ADD ARC. After execution of a menu option the editing window will be redrawn. The Pan/Zoom menu options are described below:

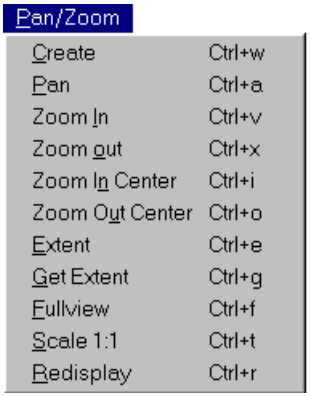


Figure 5.5 Pan/Zoom menu options

Create: Creates another window using the extent provided by the user. Use the left mouse button to select opposite corners of the extent to be created.

Pan: Pans the view in the direction of the mouse. Use the left mouse button to pan.

Zoom In: Zooms in at the location of the mouse. Use the left mouse button to zoom.

Zoom out: Zooms out at the location of the mouse. Use the left mouse button to zoom.

Zoom In Center: Zooms in to the center of the window by a factor of 2.

Zoom Out Center: Zooms out of the center of the window by a factor of 2.

Extent: Allows the user to specify the window extent (area to zoom into). Use the cross-hairs and left mouse button to select opposite corners of the extent to be viewed.

Get Extent: Prints the window extent to the ARCEDIT prompt.

Fullview: Displays the entire extent defined by the Contour Coverage.

Scale 1:1: Displays the window contents at a 1 to 1 scale.

Redisplay: Redraws the editing display window.

The geospatial position of the cursor is also shown at the bottom of the editing window in Windows NT and at the top on UNIX systems. The change in distance in the vertical direction and horizontal direction is shown along with the total distance the cursor has moved from a specified origin. To select a specified origin, select the location with the mouse and press the left or right mouse button. The cursor position statistics displayed on the ARCPLOT window are turned on and off using the ARCWINDOWSTATS environment variable.

Main Channel Invert Coverage

The river and reach network is represented by the Main Channel Invert Coverage. The network is created on a reach by reach basis, starting from the upstream end and working downstream following the channel thalweg. Construct arcs with the TO node downstream of the FROM node (in the direction of flow) as done in HEC-RAS. Each reach is identified by a *River Name* and a *Reach Name*. A river is made up of one or more reaches with the same River Name. All reaches within a river must have unique Reach Names. Refer to the HEC-RAS User's Manual, Chapter 6 for more details.

Creating the Network

Begin by selecting the **MC Invert** choice from the Edit RAS Coverages window. In the response window, enter the name of the coverage to create and press **OK**. The name of the coverage may be no longer than 13 characters. The blank coverage will be set as the coverage to edit.

Each reach is represented by an arc. To draw a reach, press the **ADD ARC** button from the edit palette. Place the mouse cursor at the upstream end of the reach and press the right mouse button to "drop" a node. Draw the reach downstream stream using the left mouse button to create vertices along the channel. At the end of the reach, press the right mouse button to create the end node. After the end node is placed, a window will appear to enter the *River Name* and *Reach Name*. The river and reach names may be 16 characters or less. The **?** button may be used to select a *River Name* used previously in the Main Channel Invert Coverage. The **?** button will only list the river names since the last save.

To begin a connected reach, press the right mouse button to create a new node and begin to draw the reach downstream. A junction is formed when two or more nodes are placed one on top of another. A least one of the nodes must be the FROM node on the downstream reach. Each reach may be constructed with no more than 500 points.

It is recommended that the node snap tolerance be set by the user before creating the stream network. Greater snap tolerances ensure that reaches are connected at junctions; however, snap tolerance that are too large will create problems with nodes snapping to the wrong junction nodes. Each time that a coverage is Saved, nodes and vertices that are separated by less than the node snap tolerance will be combined, thereby moving the delineation of the main channel. If this problem occurs, reduce the node snap tolerance.

Editing the river and reach network is accomplished using the editing tools described earlier. The EDIT NAMES option should be used to check that the *River Names* and *Reach Names* are correctly named and that all reach names within a river are unique.

Be sure to select **MC Invert** from the *Edit* choice on the Edit RAS Coverages window to indicate that the edit coverage is the Main Channel

Invert Coverage. If another *Edit* choice is selected, the *River Name* and *Reach Name* cannot be edited.

The Main Channel Invert Coverage is shown in Figure 5.6. Ground Contours displayed in the background, clearly delineate the main channel. (Note that the "V" of the contours points in the upstream direction.) Reaches are separated by nodes, displayed in ARCEDIT as black squares.

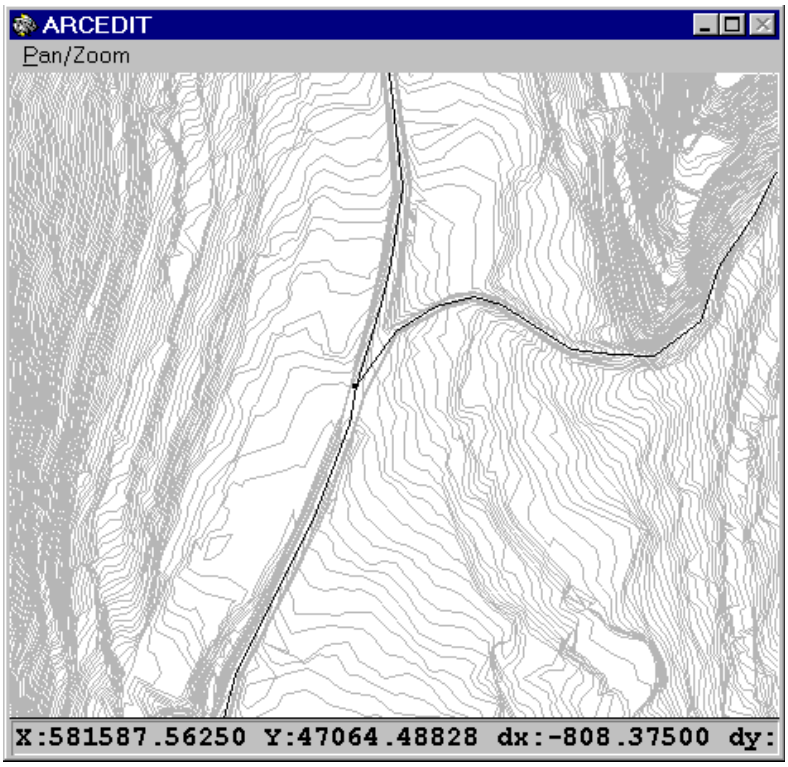


Figure 5.6 Main Channel Invert Coverage

Adding Reaches to an Existing Network

Adding a new reach to an existing river and reach network requires that a reach be split. To split a reach, select the reach and choose the **SPLIT** arc option from the *Edit Tool* palette. Cross-hairs will appear for the user to select the location to break the reach. Press the left mouse button when the location is selected. The user will then be prompted to edit the reach names of the two reaches and the selection cross-hairs will appear over the editing window. Select the first reach and edit or accept the *Reach Name* and press **OK**. Use the cross-hairs to select the second reach and edit or

accept the *Reach Name*. Pressing **Cancel** will keep the current names, as will pressing **OK** without making any edits.

Adding Tributaries to an Existing Network

After a reach is split, add a new reach using the **ADD ARC** option. Enter the *River Name* and *Reach Name* at the window prompt. To check that the node of the new reach lies on top the node of the downstream reach, zoom into the junction. If the nodes are not aligned, the nodes can be snapped together by moving the new reach or moving the end node of the new reach. The latter is suggested. Select the new reach and choose the **MOVEV** (move vertex) button from the editing palette. Select the TO node with the cross-hairs and press the left mouse button. Select the FROM node of the downstream reach and press the left mouse button. Note that if the snapping tolerance had been greater than the separation of the nodes, the nodes would have snapped on top of each other as the new reach was created.

Merge Reaches in an Existing Network

To merge two reaches into a single reach, they must share a node. In other words, the downstream node of the upstream river (TO node) must coincide with the upstream node (FROM node) of the downstream river. To verify that two nodes are coincident, zoom into the nodes' location and move one of the nodes on top of the other while the SNAPPING option is ON.

Select the two reaches to be joined and choose the **UNSPLIT** option from the *Edit Tools* palette. One reach will be drawn to the screen (only two nodes, instead of three) and the Name Stream Network window will appear. Enter the name of the newly formed reach and select **OK**. Pressing **Cancel** will keep the names displayed.

Main Channel Banks Coverage

The Main Channel Banks Coverage is a line coverage which indicates the separation between the main channel and the overbanks and is used to determine the main channel bank stations on the cross sections. *The Main*

Channel Banks Coverage is optional. To indicate bank positioning, use the **ADD ARC** option from the *Edit Tool* palette and draw the position of the bank stations for *both sides* of *each river*.

The bank lines may be broken and may cross where tributaries join a river reach. If two parallel bank lines are indicated (i.e., two broken bank lines overlap), the bank stationing farthest from the river will be used. Orientation of the bank station lines is not important. The Main Channel Banks Coverage is shown in Figure 5.7, along with the main channel.

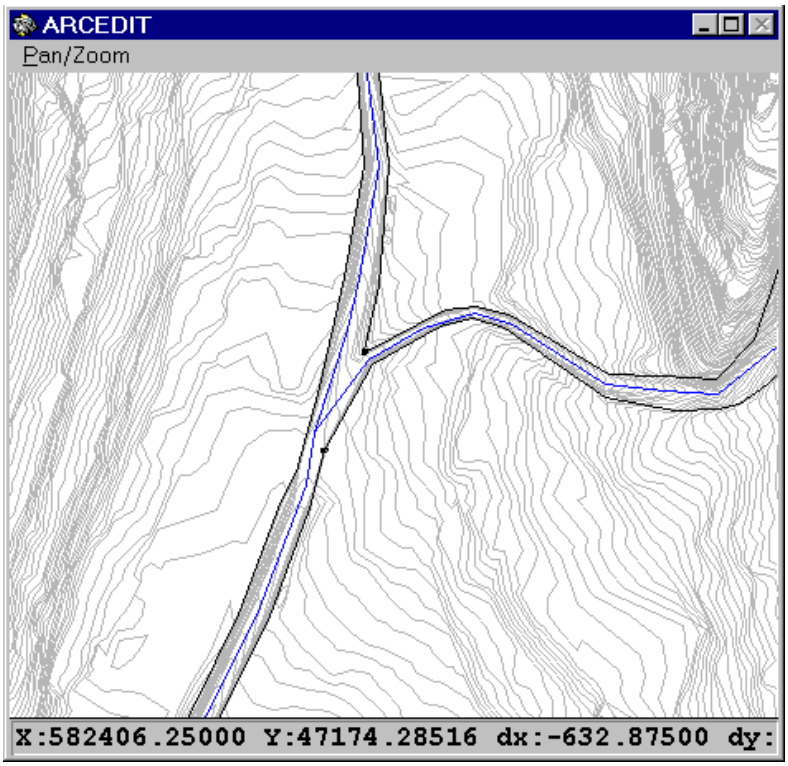


Figure 5.7 Main Channel Banks Coverage

Flow Paths Coverage

The Flow Paths Coverage is used to determined the downstream reach lengths between cross sections in the left overbank, main channel, and right overbank. *The Flow Paths Coverage is optional.*

The coverage is created by using the **ADD ARC** option to draw the hydraulic flow paths in the left overbank, main channel, and right overbank. If the Main Channel Invert Coverage already exists, the main channel flow path will be copied into the Overbank Flow Path Coverage and, therefore, will not need to be created. The three flow paths lines should not cross, cross each cross section cut line exactly once, and be drawn in the direction of flow (i.e., the TO node downstream of the FROM node). The Overbank Flow Path Coverage is shown in Figure 5.8.

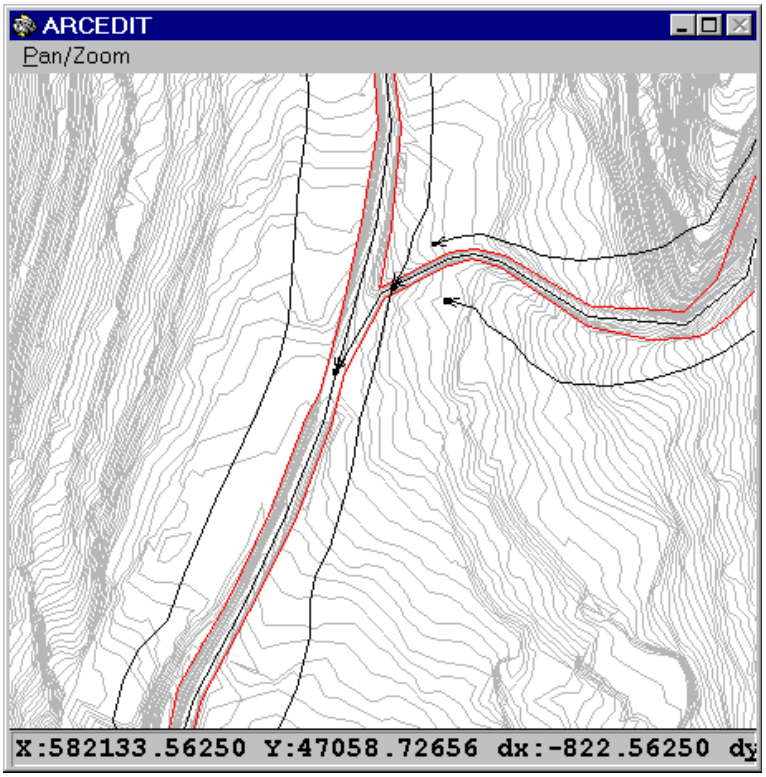


Figure 5.8 Over Bank Flow Path Coverage

Cross Section Cut Lines Coverage

The location, position, and expanse of channel cross sections is represented by the Cross Section Cut Lines Coverage. The cross section cut lines are used to extract the station and elevation data from the digital terrain model.

To draw a cross section cut line choose the **ADD ARC** option from the

editing pallete. Press the right mouse button to place the FROM node and draw the cut line to the TO node. Press the right mouse button to end the cut line. Cross section cut lines are constructed with the FROM node at the edge of the left overbank to the TO node at the edge of the right overbank. Vertices may be placed between the FROM and TO node using the left mouse button so that the cut line may be dog-legged perpendicular to the direction of flow. A cut line should cross a reach line exactly once, and should not cross another cut line.

The orientation of cut lines may be checked using the **ARROWS** option on the *Edit Tools* palette. When pressed, the ARROWS option places an arrow at the TO node pointing in the direction the arc was created. The Cross Section Cut Line Coverage is shown in Figure 5.9 with the ARROWS option turned on. If the cut line was constructed in the incorrect direction, use the **FLIP** option to reverse the FROM and TO node. The FLIP option may be used on one or many arcs.

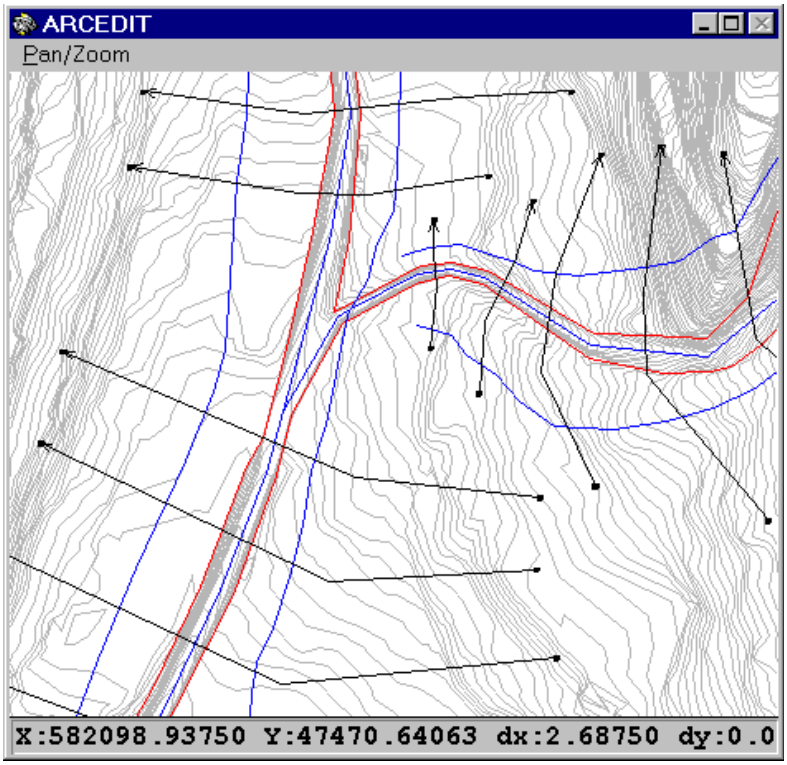


Figure 5.9 Cross Section Cut Line Coverage

Creating the HEC-RAS Import File

To create the HEC-RAS Import File, select **Create RAS Import File** from the **RASPrep** menu on the project manager. This will invoke a window with input fields for the four RAS Coverages as shown in Figure 5.10. The user must have specified the Digital Terrain Model, a Main Channel Invert Coverage, and a Cross Section Cut Line Coverage from the project manager before attempting to create the import file. The input fields for the Main Channel Bank Stations Coverage and Overbank Flow Paths Coverage may be left blank.

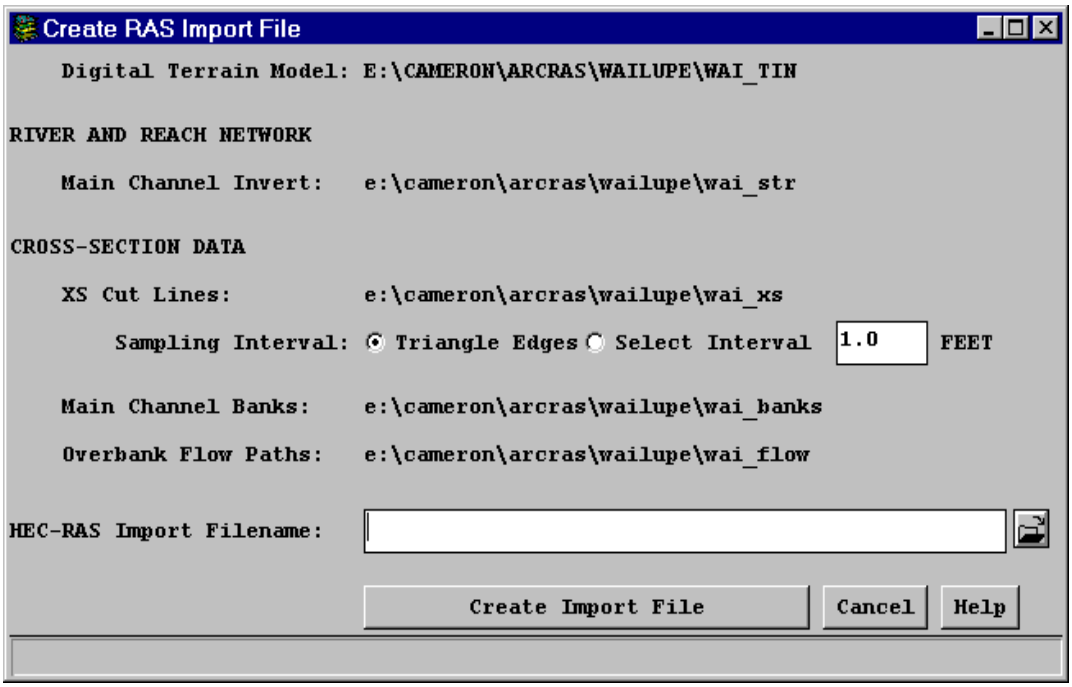


Figure 5.10 Create RAS Import File window

Select the sampling interval method. The sampling method indicates where the station and elevation data for cross sections will occur. The default method (*Triangle Edges*) samples the land-surface elevation at the edge of each triangle in the TIN. Choosing *Select Interval* allows the user to specify a uniform distance between cross-section stations. The units used for the sampling are read from the DTM.

Enter the filename for the import file. The extension *.geo* will be added to the filename. The user is not allowed to change the extension. Press

Create Import File when finished. **Cancel** dismisses the window and returns the user to the project manager.

Once the **Create Import File** button is pressed, the attributes of the RAS Coverages will be checked for missing data. Progress updates will be displayed in the Create RAS Import File status window shown in Figure 5.11.

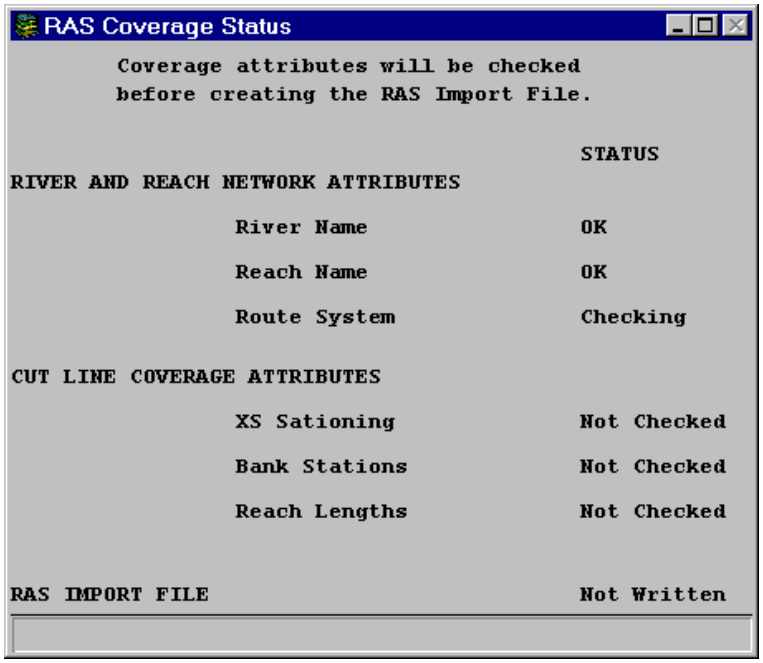


Figure 5.11 RAS Coverage Status window

Coverage Checking

Before the RAS Import File is created, the RAS Coverages will be checked. As the coverages are checked, geometric attribute data will be added or updated to the Cross Section Cut Line Coverage. The window shown in Figure 5.11 will update to indicate the progress of the coverage checking procedures. The status messages that are updated to the window and their meaning are listed below. If any of the coverages were not correctly created by the user, the checking procedure will be stopped and the user informed of the missing coverage data.

Message	Meaning
Not Checked	The corresponding attribute has not been checked.
Checking	The corresponding attribute is being checked.
OK	The coverage attribute was checked and the appropriate coverage data is present.
Updating	The attribute data is being updated.
Unmodified	The coverage attributes present were not updated since last attempt to create a RAS Import File.
No Stations	The Main Channel Banks Coverage is not present.
No Reaches	The Overbank Flow Paths Coverage is not present.
Not Written	The RAS Import File has not been written.
Writing	The RAS Import File is being written.

River and Reach Network Attributes

The river and reach network attributes are checked first. The checking procedure looks to see that the Main Channel Invert Coverage has a *River* and *Reach Name* for each reach in the coverage. Specifically, the checking procedure looks to see that the arc attribute table (AAT) for the Main Channel Invert Coverage contains the stream and reach items and that the items are not blank. STR_NAME and RCH_NAME are the default name created when the Main Channel Invert Coverage is create in the edit environment. *Reach uniqueness is not checked*; therefore, it is recommended that the user check the reach names prior to attempting to create the RAS Import File. If the *River* and *Reach Names* are not present, the checking procedure will be aborted and the user will be informed to edit the invert coverage river and reach names.

Cross section stationing is determined by dynamic segmentation of the Main Channel Invert Coverage. If this Route System is not present, windows will direct the user to create one based on the lengths of the river

arcs. Two ARC/INFO tables are created named as the Main Channel Invert Coverage name followed by .SECHECSTR and .RATHECSTR. If the Route System is already present, the user will be given the choice to update the tables.

Cut Line Coverage Attributes

After the river and reach network attributes are checked, items are added to the Cross Section Cut Line Coverage without user input. The user will only be prompted to update the tables, if the geometric attribute data are already present.

Cross section stationing data are added to the STATION item. If the STATION item does not exist, it will be added.

Bank station data are contained by the items BANK1 and BANK2 (left and right, respectively). Bank Stations will not be added if the Main Channel Banks Coverage has not been specified. BANK1 and BANK2 are optional items.

Reach length data are contained by RL1, RL2, RL3 (left bank, main channel, and right overbank, respectively). Reach lengths will not be added if the Flow Paths Coverage has not been specified. RL1, RL2, and RL3 are optional items.

C H A P T E R 6

Viewing HEC-RAS Water Surface Profiles

HEC-GeoRAS facilitates the import of water surface profile data exported from HEC-RAS results. Inundation area and depth are calculated during the import process and may be mapped using HEC-GeoRAS. Mapping options allow the user to view the extent of inundation for multiple profile data and determine the depth of inundation for a given event.

Mapping functions are performed in ARCPLOT.

Chapter 6 discusses the options for viewing exported HEC-RAS water surface profile data.

Contents

- Importing an HEC-RAS Export File
- Inundation mapping
- Printing map results

Importing an HEC-RAS Export File

Water surface profile results exported from HEC-RAS are imported by selecting **Import RAS Export File** from the **RASPost** menu on the project manager. The window shown in Figure 6.1 will be invoked, allowing the user to select the file to be imported. Right clicking over the input box will allow the user to select from a popup list any file with the *.gis* extension in the current directory, while pressing the button to the right of the input field will invoke a file browser.

After selecting the import file, enter the name of a new cross section coverage to create. The new cross section coverage will contain the geometric data *from the RAS results.* Water surface elevations from the user selected water surface profiles will be added to the new cross section coverage during the import process.

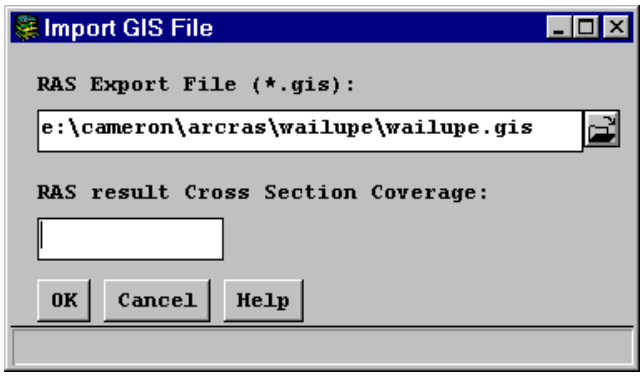


Figure 6.1 Import RAS Export File window

Pressing **OK** invokes the window shown in Figure 6.2 and allows the user to select the water surface profile data to process. The window also allows the user to select the grid-cell resolution of the depth grid that will be created. Pressing **OK** will create an inundation coverage and depth grid for each water surface profile selected and dismiss the windows.

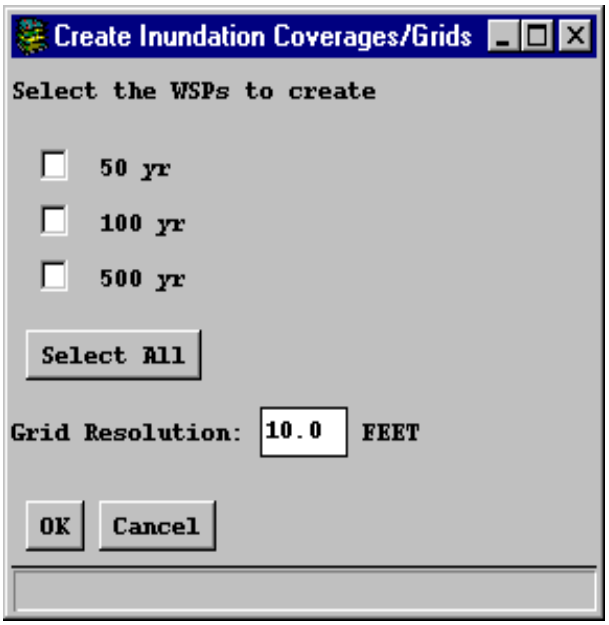


Figure 6.2 Create Inundation Coverages/Grids window

Two coverages will be created for each profile: a polygon coverage having the prefix *f_* and a depth grid having the prefix *d_*, followed by the water surface profile name. A water surface TIN having the prefix *t_* will be created but will be deleted after the water surface coverages have been

created. Underscores will replace any blanks in the water surface profile names. The coverages are created in the current workspace. The files *wsp.menu*, *wsp_draw.menu*, and *tempindex9999* will also be created in the current directory during this process. If the files already exist, they will be overwritten.

Profile names must be 11 characters or less. Inundation coverages will not be created for profiles with name longer than 11 characters.

Inundation Mapping

To view the coverages created, select **Inundation Mapping** from the **RASPost** menu. The Inundation Mapping window will be displayed along with a display window. The display window may be sized to the user's preference.

Mapping options are performed in ARCPLOT.

Inundation Mapping Menu

The Inundation Mapping window is organized by function. At the top of the mapping window are the File and Help menus. The upper portion of the window allows the user to select the coverages and corresponding colors to be displayed. The lower part of the menu provides the user with display window options. The Inundation Mapping window is shown in Figure 6.3.

File menu options include the Command Line, Print and Exit options, while the Help menu provides online help for users.

Command Line: Allows the user to issue commands at the Arc Plot prompt. Type &RETURN to return to the user interface.

Print: Print provides options for printing inundation map results.

Exit: Exit dismisses the mapping window and display and quits ARCPLOT. The user is returned to the project manger.

Help: Provides an ascii help file for mapping coverages.

ArcDoc: Provides access to the ARC/INFO help system.

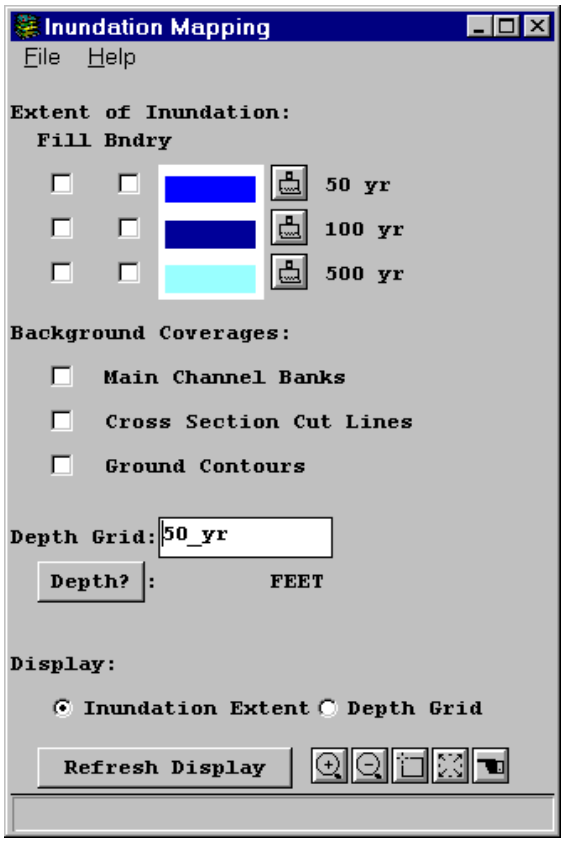


Figure 6.3 Inundation Mapping window

Coverage Display Options

Coverage display options allow the user to select the inundation extent coverages, background coverages, and the depth grid to be displayed. Inundation polygons and depths grids cannot be displayed at the same time. The extent of inundation may be viewed as a filled polygon or as a boundary polygon by selecting *Fill* or *Bndry*, respectively. These options may be mixed and matched as desired.

To select the color for the extent of inundation coverages, press the button beside the profile name. A color palette will be displayed. If the user dismisses the palette before choosing a color, no color will be assigned to the coverage.

Selection of the depth grid is performed by right clicking in the input field or typing the exact name. A right click will result in a popup list from which the depth grid may be selected. Pressing the **Depth?** button will allow the user to interactively determine the water depth at a given

location. The water depth and corresponding units will be displayed to the right of the button. Use the cross-hairs and left click to select the location; right click to exit.

Background coverages may be displayed with the inundation coverages by selecting the corresponding check box. The Ground Contours, Main Channel Bank Stations, and Main Channel Invert coverages are the available background coverages, at this time. Background coverages will be displayed behind the inundation polygons but in front of the depth grid. Inundation mapping for exported water surfaces is shown in Figure 6.4.

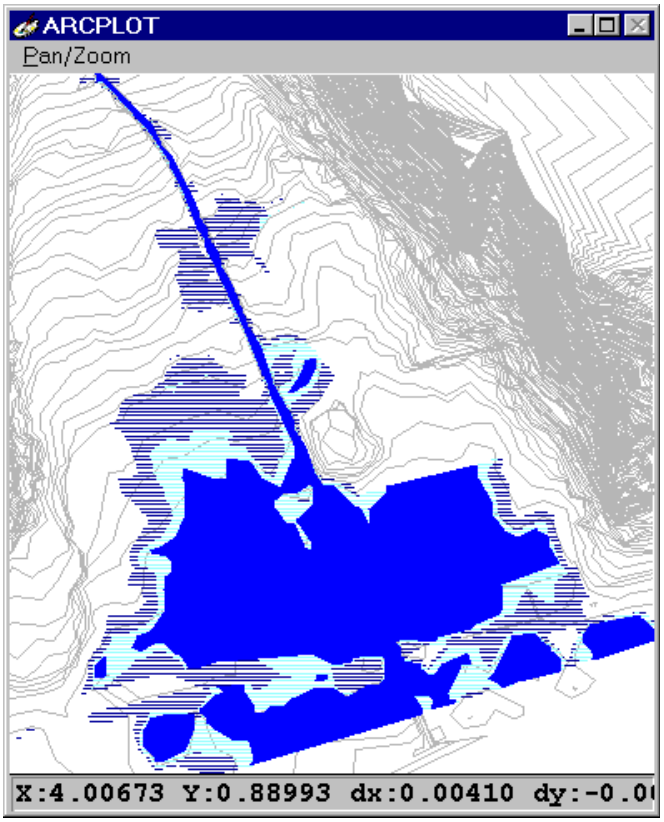


Figure 6.4 Inundation polygons

Window Display Options

Window display options allow the user to update the content of the display window. The *Display:* ○*Poly* ○*Grid* choice determines whether the inundation polygons or depth grid will be drawn to the display window. The polygons and depth grid may not be displayed simultaneously. The remaining display buttons are discussed below.

Refresh Display: Refreshes the display window with the selected coverage and display choice options.

ZoomIn: Zooms into the center of the window by a factor of 2. Use the left mouse button to select the location to zoomin to. Right click when finished zooming.

ZoomOut: Zooms out of the center of the window by a factor of 2. Use the left mouse button to select the location to zoom to. Right click when finished zooming.

ZoomExtent: Allows the user to specify the extent of the view using cross-hairs to select opposite corners.

FullView: Displays the entire extent of the coverage.

Pan: Allows the user to pan through the image without changing the scale of the view. Use the left mouse button to select the location to pan to. Right click when finished panning.

For each option, a left click perform the operation and a right click quits.

Printing Map Results

Map results displayed in the Inundation Mapping window may be modified and printed from the Print Map window. To access the Print Map window show in Figure 6.5, select **Print** from the **File** menu on the Inundation Mapping window.

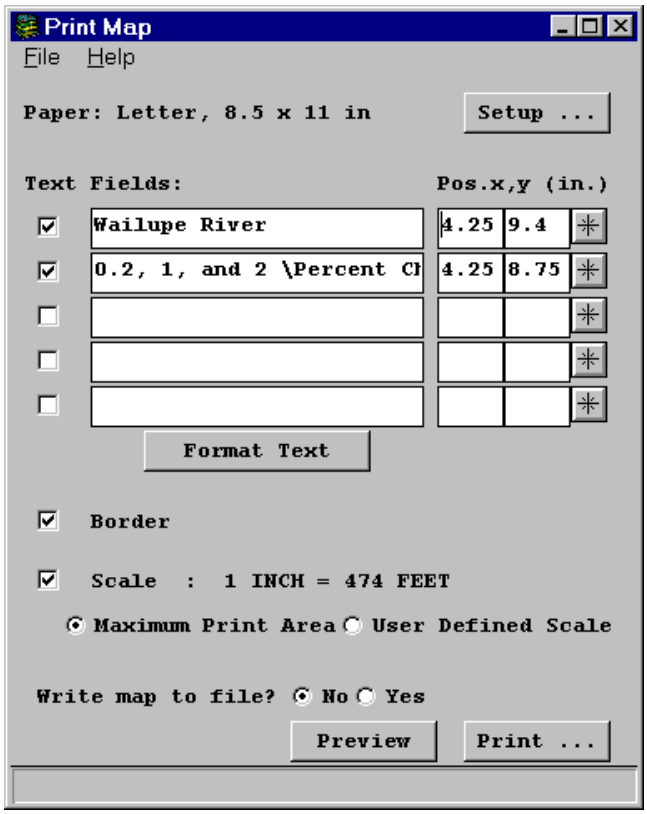


Figure 6.5 Print Map window

At the top of the Print Map window is a menu bar with the File and Help menus. The remainder of the menu is dedicated to modifying the page and presentation of the inundation map for printing.

The File menu options include Preview, Print, Command Line, and Exit, while the Help menu options provides access to online help.

Preview: Displays the entire page as it will be printed. Shown in Figure 6.6 is an inundation map displayed using the preview option.

Print: Writes the map to a file and brings up the ARC/INFO printing interface to print the map file.

Command Line: Allows the user to issue commands at the ARCPLOT prompt. Type &RETURN to return to the user interface. *Only experienced ARC/INFO users should use this option.*

Exit: Dismisses the Print Map window and returns control to the Inundation Mapping window.

Help: Displays a help file specific to the printing options

ArcDoc: Accesses the ARC/INFO online help system.

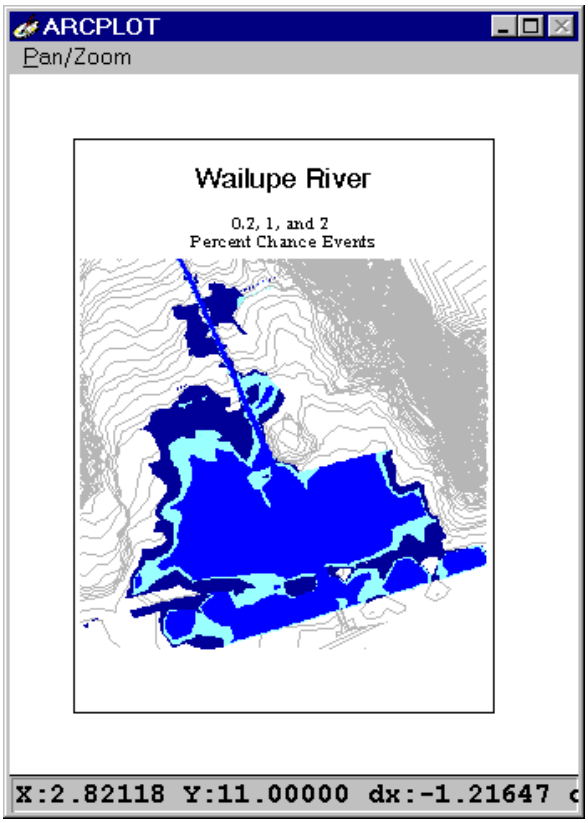


Figure 6.6 Preview of an inundation map

Options provided to the user for modifying the page presentation include the capabilities for selecting the page and page setup; displaying and formatting text; displaying a border; and specifying and displaying the map scale. Viewing a map presentation before printing a map is performed using the **Preview**, while the **Print** option writes the map to a file and accesses the ARC/INFO printing interface.

Page Setup

The type of paper currently selected for printing is displayed near the top of the Print Map window in the *Paper* field. To the right of the *Paper* field is the **Setup** button. Pressing the **Setup** button accesses the Page Setup window shown in Figure 6.7. The Page Setup window allows the

user to identify the *Paper* and *Orientation* and specify the *Page Margins* and *Internal Margins*.

Paper size options are provided for standard sizes. The user may select from the standard paper sizes listed by clicking the right mouse button while the cursor is over the *Paper* input box. The default paper size is Letter, 8.5 x 11 in.

Paper Standard	Size
Letter	8.5 x 11 in
Legal	8.5 x 14 in
B	11 x 17 in
C	17 x 22 in
D	22 x 34 in
E	34 x 44 in
F	44 x 68 in

Orientation choices are *Portrait* and *Landscape*. *Portrait* specifies that the first dimension listed after the name is the width of the paper while *Landscape* specifies that the second dimension is the paper width. *Portrait* is the default paper orientation.

Page Margins indicate where the *Border* will be drawn, if so desired. The margins are be specified in inches from the papers edge. One inch *Page Margins* are the default.

Internal Margins determine the area available for the map to be displayed. The margins are specified in inches inside of the *Page Margins*. The default margins are 1.0 inch from the top page margin and 0.1 inch from the remaining edges.

The **OK** button applies the Page Setup setting and dismisses the window. **Cancel** dismisses the window without changing the setup.

Text

Text options allow the user to enter five labels and specify the format and location of the text displayed. The *Text Fields* on the Print Map window

allow the user to type in the labels for the map. To enter a label, select a text field using the left mouse button and begin typing. Text with percent signs (%) on each side is not allowed, while backward slashes (\) will result in the text continuing on the next line, much like a carriage return. The corresponding checkboxes to the left of the *Text Fields* determine which text will be displayed when the **Preview** and **Print** option are used.

The position of the text may be specified by entering the coordinates manually or by pressing the  button and selecting the text placement with the cross-hairs provided. The positioning of the text in relation to the cross-hairs placement depends upon the justification setting for the text field.

To format a text field press the **Format Text** button. The window shown in Figure 6.8 will be displayed. The label text will be displayed on the left portion of the window with the formatting value displayed in corresponding fields to the right.

To select a *Font*, press the right mouse button over a selected font field to invoke the list of available fonts, or type in the entire name into the field. At this time, Courier, Helvetica, Palacio (Palantino), and Times fonts are available in normal, italic, bold, and bold italic. Helvetica is the default.

Font Size may be specified by typing in the desired size. Press the carriage return after entering the size. Size 16 pt font is the default.

Justification refers to the alignment of the label in relation to the cross-

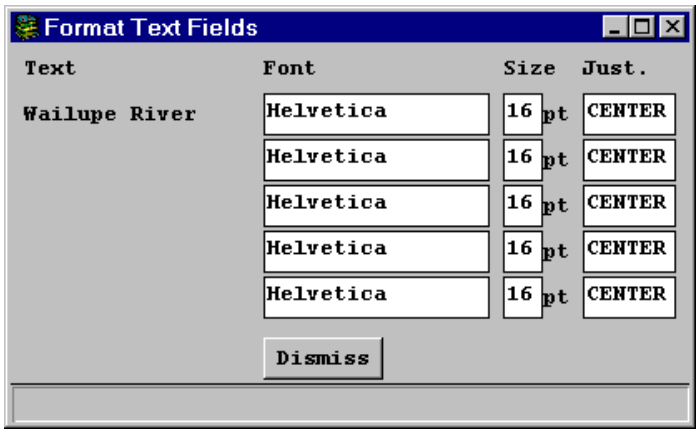


Figure 6.8 Text formatting window

hair position described earlier. LEFT, CENTER, and RIGHT justification choices are available. LEFT justification means that the bottom left-hand corner of the label will be located at the coordinate position shown on the Print Map window, while CENTER means the text will be centered above the position specified, and RIGHT means that the right-hand bottom corner of the label will be located at the position specified. Right click over the *Just.* field to invoke a popup list or type in the justification choice as listed above.

OK closes the Format Text Fields window, keeping any changes made.

Border

To display a border when using **Preview** and **Print** select the corresponding checkbox. The border will be drawn in black at the *Page Margins* specified using **Page Setup**.

Map Scale

To display the map scale on the printed map, select the corresponding checkbox. The map scale will be printed at the bottom left-hand corner, just below the border. The *Maximum Print Area* choice is used to print the map using the entire display area as determined from the *Internal Margins*. The *User Defined Scale* provides the user with a response window for entering a specific scale. The scale is defined as 1 inch to *X map units*, where *X* is the scale and *map units* are determined from the DTM. The display area is reduced to fit the longest side of the map.

Preview

To preview the map before printing, use the **Preview** option from the **File** menu. During preview, the map displayed from the Inundation Mapping window will be shown along with any items that have the corresponding checkbox checked.

To change the map displayed during preview, select **Exit** from the **File** menu to return to the Inundation Mapping window. From the Inundation Mapping window the user may adjust the map view as desired, before returning to the Print Map window.

Print

To print the map, select **Print** from the **File** menu. This will write the map to a file before accessing the ARC/INFO printing interface. If the user wishes to save the map to a file, select the *Yes* choice for *Write map to file?*. Otherwise, a temporary file *tempprintfile.gra* will be used to print the map.

From the printing interface select the file to print and printer **Driver** (Window NT) or printer (UNIX) and press **Print**. When finished printing press **Quit**, to return to the Print Map window.

To print from UNIX, a print queue file must be setup.

Exit

To exit from the Print Map window, select **Exit** from the **File** menu. The user will be returned to the Inundation Mapping window.

C H A P T E R 7

Example Application

This chapter provides an example application of how to integrate ARC/INFO data sets with HEC-RAS using HEC-GeoRAS. The user is taken through a step by step procedure of how to develop an HEC-RAS Import File and view water surface profile data exported from HEC-RAS.

To perform the steps taken in the example application, the user must have an existing DTM of the river system to be modeled. Chapters 4-6 provide a more detailed discussion of the steps performed in the example.

Contents

Starting a New Project

Start up ARC/INFO and change directories to the workspace containing your DTM. To change workspaces use the WORKSPACE function just as you would using *cd* at the UNIX or DOS prompt. Type **georas**. The project manager window, shown in Figure 7.1 will appear.

Begin a new project by selecting **New Project** from the **File** menu on the

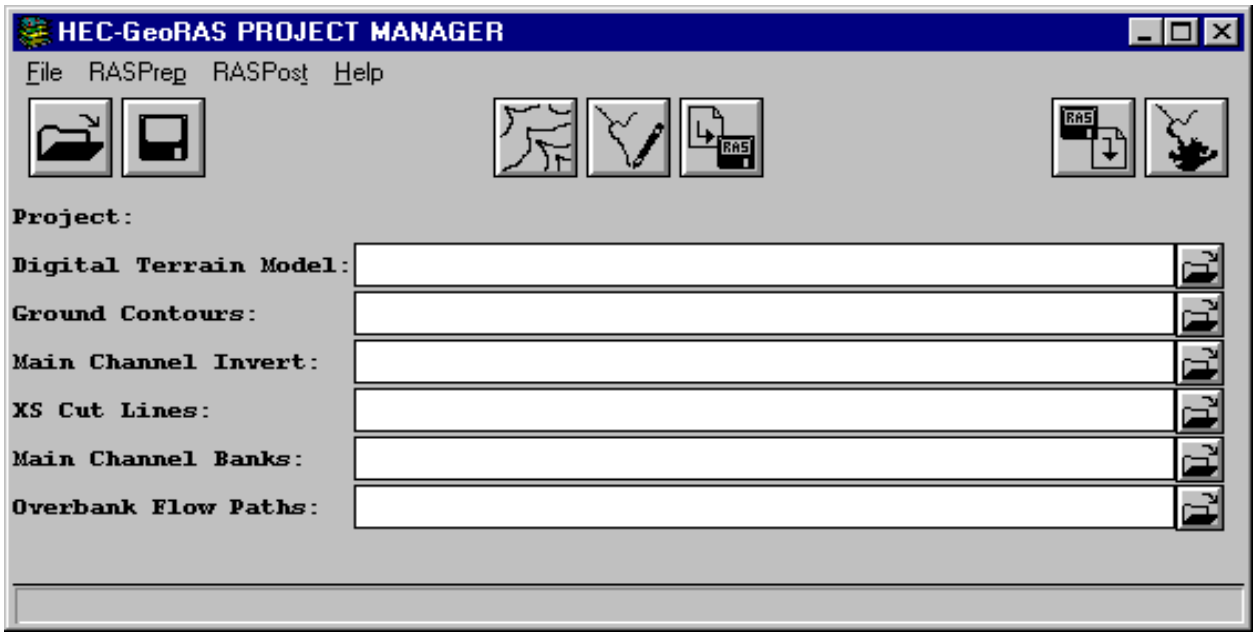


Figure 7.1 HEC-GeoRAS Project Manager window

project manager. Enter the name of the new project in the response window and press **OK**. The name of the project will be displayed in the *Project* field on the project manager.

Select the DTM using the browser or tight click over the *Digital Terrain Model* field. From the popup list, select the desired DTM with a left click.

Creating a Contour Coverage

A contour coverage must be created next. It will be used to help you create the RAS Coverages later. Press the **Create Contour Coverage** button on the project manager window. The window shown in Figure 7.2 is invoked (except the *Contour Coverage* field will be blank).

Enter the *Contour Coverage* name and a *Contour Interval* and press **Create Contour Coverage**. Processing of the Contour Coverage will take a few minutes, depending on the contouring interval and number of

points defining the DTM. After the coverage is created, you will be returned to the project manager. The name of the Contour Coverage created will be listed in the corresponding input field.

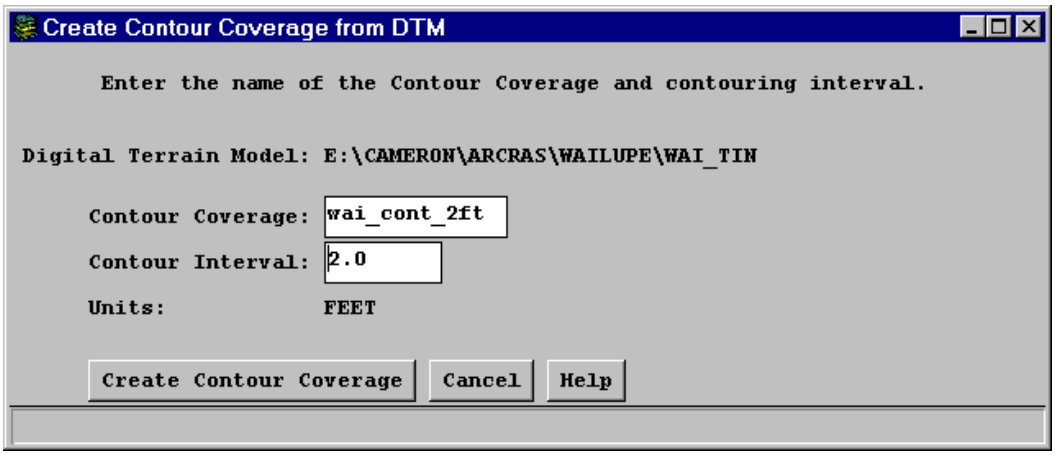


Figure 7.2 Create Contour Coverage window

Create RAS Coverages

Access the coverage editing environment by pressing the **Create/Edit RAS Coverages** button on the project manager window. It will take a few seconds for the editing environment to come up as ARCEDIT loads. The Edit RAS Coverages window, shown in Figure 7.3, will at last appear with an editing window. Resize the window as desired.

At this time, the editing window is blank. Select the *Ground Contours* checkbox on the Edit Ras Coverages window and press **Refresh Display**. The contours will be drawn in gray to the editing window.

The Edit RAS Coverages window and editing window will be used in concert to create four coverages; Main Channel Invert, Main Channel Banks, Overbank Flow Paths, and Cross Section Cut Lines. The Main Channel Banks and Overbank Flow Paths coverages are optional but will be created in this example for completeness.

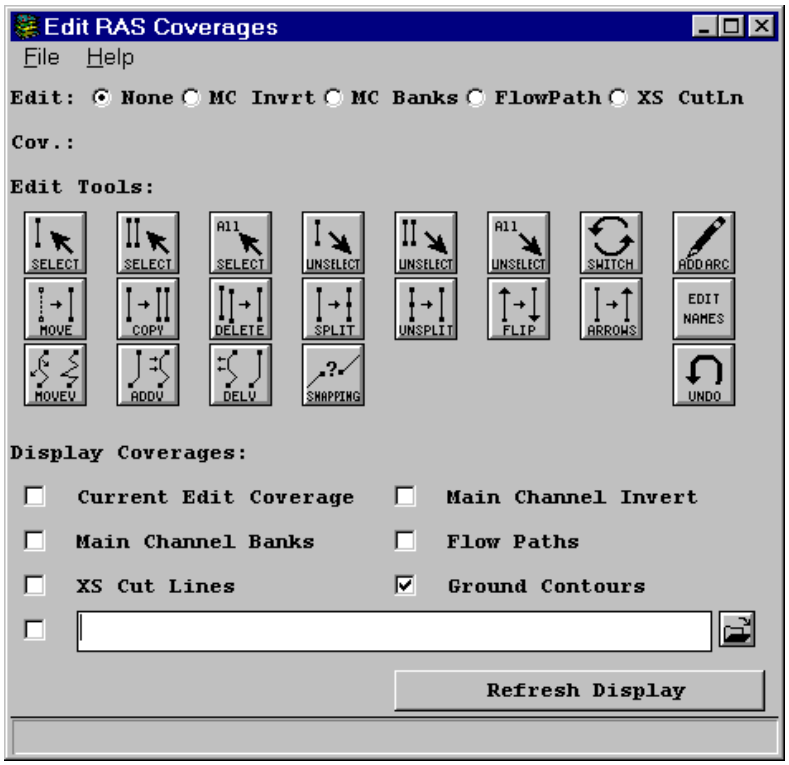


Figure 7.3 Edit RAS Coverages window

Main Channel Invert Coverage

As dictated by the Contour Coverage delineation, we are going to create the two rivers, three reach system shown in Figure 7.4. Select the **MC Invrt** choice on the top of the Edit RAS Coverages window. Draw the main channel invert by performing the following steps:

1. From the **Pan/Zoom** menu select **Extent.** Use the left mouse button to select opposite corners in the uppermost portion of the river system to zoom into.

2. Press the **ADD ARC** button on the *Edit Tools* pallete.

3. Move the mouse pointer to the upstream most point of the first river and press the right mouse button to place the FROM node. Begin moving downstream using the left mouse button to add vertices along the reach. As you run out of editing window space, select **Pan** from the **Pan/Zoom** menu and left click in the direction

you wish to pan (wherever the mouse is when you click will become the new center of the editing window). When you get to the end of a reach, right click to place the TO node.

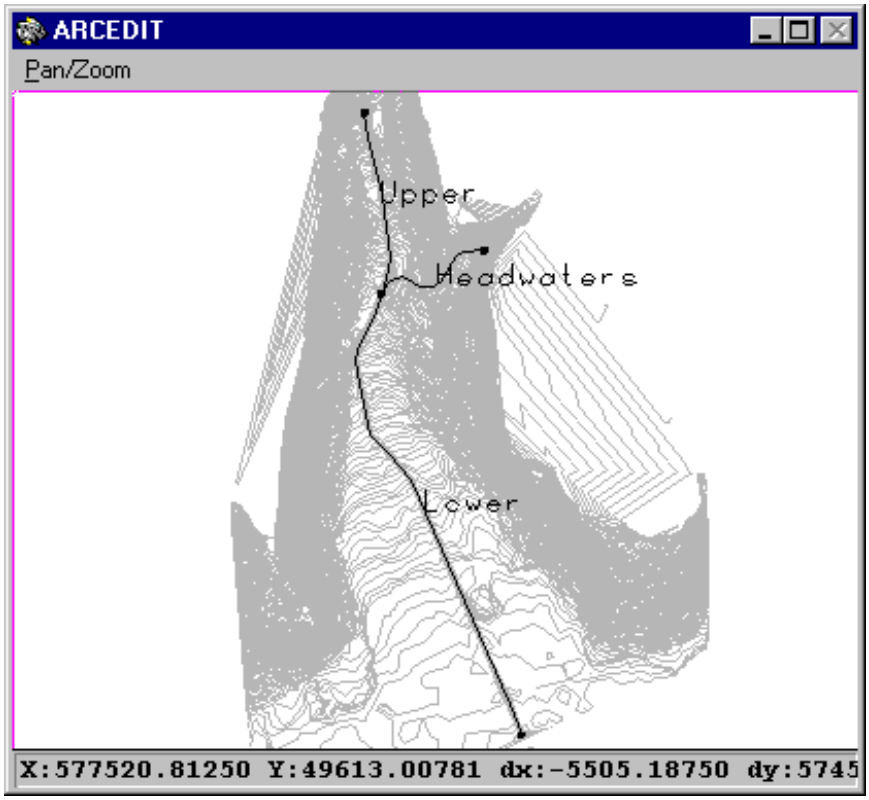


Figure 7.4 River and reach network

4. Once a reach is drawn, a window will prompt you to enter an identifier for the *River Name* and *Reach Name*. Each name is limited to 16 characters, and all reach names for the same river must be unique. In this example, the Wailupe River has two reaches named ***Upper*** and ***Lower*** and the tributary Kului Gorge has one reach named ***Headwaters***.

5. Repeat steps 2-4 for each reach. Be sure that the FROM node of the "lower" reach is coincident with the TO node of the "upper" reaches. Zoom into each junction to check.

Several options are available from the *Edit Tools* palette to more completely delineate the river network. After coarsely delineating the stream network, use the add, move, and delete vertex options to fine tune each reach. Lastly, use the **EDIT NAMES** button to double check that

each *Reach Name* is unique. Go to the **File** menu of the Edit RAS Coverages window and select **Save.**

Main Channel Banks Coverage

The next step is to establish the location of the main channel bank stations. Select the **MC Banks** choice from the top of the Edit RAS Coverages window. This will clear the Main Channel Invert Coverage from the editing window. Select the *Main Channel Invert* checkbox from the *Display Coverages* portion of the edit window and press **Refresh Display**. This will redraw the main channel to the editing window in blue.

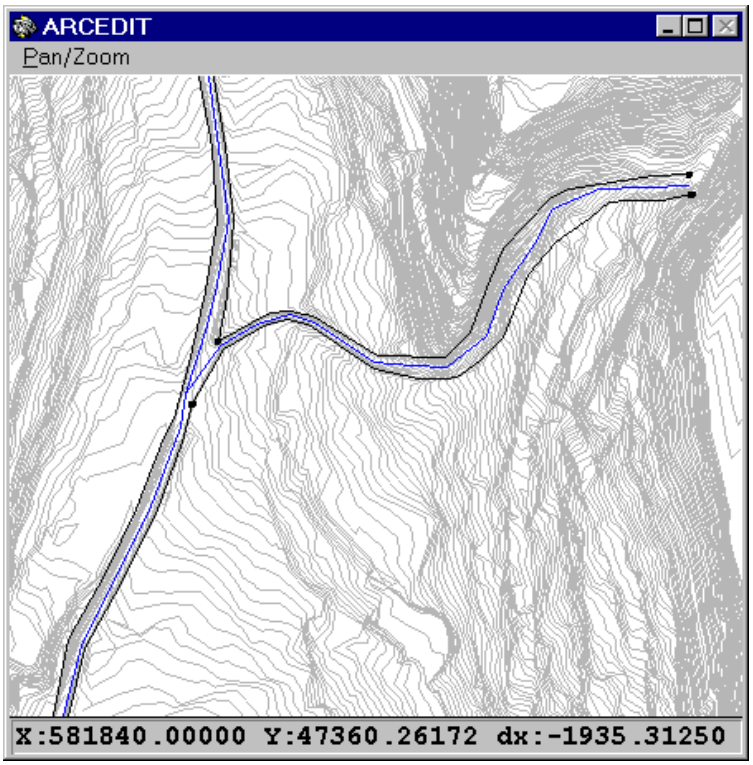


Figure 7.5 Main Channel Banks Coverage

Establish the bank station locations by using the **ADD ARC** option. Use a right click to drop the beginning node and use the left mouse button to add vertices as you draw the location of the bank stations along one side of one river. At the end of the river, right click the mouse to place the end

node. Establish bank station location lines for each side of each river using the ADD ARC option, as shown in Figure 7.5. After the bank station locations have been defined, go to the **File** menu and select **Save**.

It is okay for bank station lines of a tributary to overlap with those of the main river.

Overbank Flow Paths Coverage

Now construct the Overbank Flow Paths Coverage, as shown in Figure 7.6. Select the **FlowPath** choice from the Edit RAS Coverages window. The flow path for the main channel will be copied from the Main Channel Invert Coverage, leaving only the flow paths in the overbanks to be constructed.

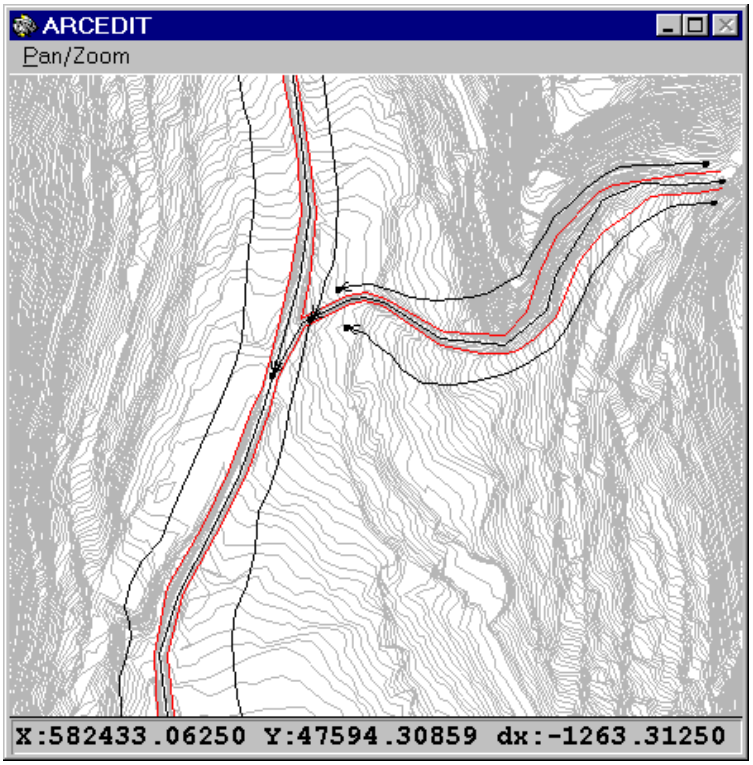


Figure 7.6 Overbank Flow Paths Coverage

Press the **ADD ARC** button and add the flow paths for the left and right overbank. Use the right mouse button to begin the flow path at the upstream end and continue downstream using the left mouse button to add

vertices. Use the right mouse button again to end the flow path. To quit drawing paths, press Ctrl + right mouse button. Use the **ARROWS** option to check that the flow paths point downstream. After you have finished all edits to the coverage, go to the **File** menu and select **Save**.

The overbank flow paths should be drawn to indicate the center of mass for overbank flow during larger flow events. The flow path coverage will be used for determining downstream reach lengths between cross sections. It is okay for flow paths from tributaries to intersect with those of the main stem.

Cross Section Cut Lines Coverage

The last coverage you need to create is the Cross Section Cut Line Coverage. Select the **Cut Line** choice from the Edit RAS Coverages window. Select the checkboxes for the *Main Channel Invert, Main Channel Bank Stations, Overbank Flow Paths,* and *Ground Contours* and press **Refresh Display**.

Cross section cut lines are created from the left overbank to the right overbank when looking downstream. Press the **ADD ARC** button to begin drawing the cut lines. Position the mouse pointer on the left edge of the left overbank and press the right mouse button to place the FROM node. Draw the cross section cut line across the floodplain using the left mouse button to dog-leg the cut line perpendicular to the flow path lines. Use the right mouse button to place the TO node at the end of the cut line. Continue adding cross section cut lines using the **Pan/Zoom** menu options to change views. Press Ctrl + right mouse button to finish adding cut lines. The Cross Section Cut Line coverage is shown in Figure 7.7 along with the main channel flow paths and bank stationing.

To copy a cross section, go to the Edit Tools palette and press the **SELECT ONE** option (SELECT MANY may be used, as well, if you want to copy many cross sections). Using the cross-hairs that appear, to select the cross section cut line to copy. Press the **COPY** button and select the location to copy the cut line using the cross-hairs. Press the left mouse button, and the cut line will be copied. The copied cross section cut line will be drawn in magenta to the screen.

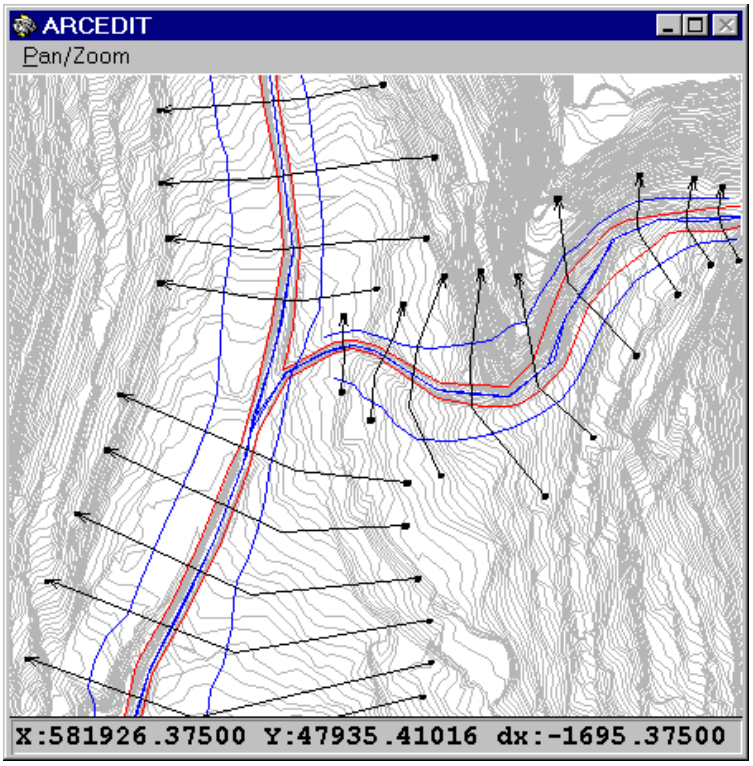


Figure 7.7 Cross Section Cut Line Coverage

Move the cut line to the desired location using the **MOVE** option. Press the **MOVE** button, and use the pointer that appears to move the cut line to the exact location. Use the vertex options to reshape the cross section cut line.

Lastly, use the **ARROWS** option to double check the cross section cut lines were created from the left overbank to the right overbank. If any cut line is oriented backwards, select the cut line using the **SELECT ONE** option and press the **FLIP** button on the *Edit Tools* palette. When finished editing and checking the cut lines, go to the **File** menu and select **Save**.

When finished creating the four RAS Coverages, select **Exit** from the **File** menu to quit from the Edit Coverage window.

Creating a HEC-RAS Import File

Now that the RAS Coverages have been created, you are ready to create the RAS Import File. Press the **Create RAS Import File** button on the project manager. The window shown in Figure 7.8 will appear. Enter the name of the import file to create and press the **Create Import File** button. The status window shown in Figure 7.9 will appear and be updated as the attribute data for the RAS Coverages is checked.

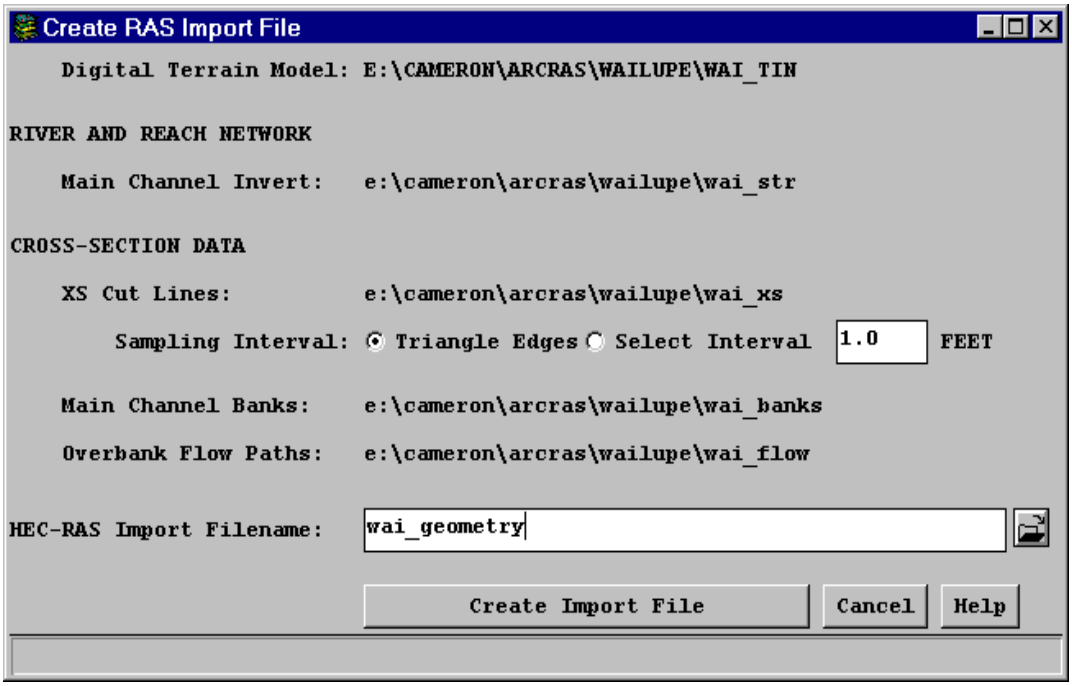


Figure 7.8 Create RAS Import File window

Because the route system for the river network does not exist, you will be prompted to establish river stationing. The editing display window will appear with the Main Channel Invert Coverage displayed. One of the rivers will be displayed in green and a message window will prompt you to select the downstream most point in the reach. Select the downstream most point with the cross-hairs and press the left mouse button. Next, a window will allow you to enter the river station for that location. Zero is the default. Enter the river stationing and press **OK**. This procedure is repeated for each river.

After the RAS Import File has been created, a message window will appear informing you the file has been successfully created. Press **OK** to dismiss the window.

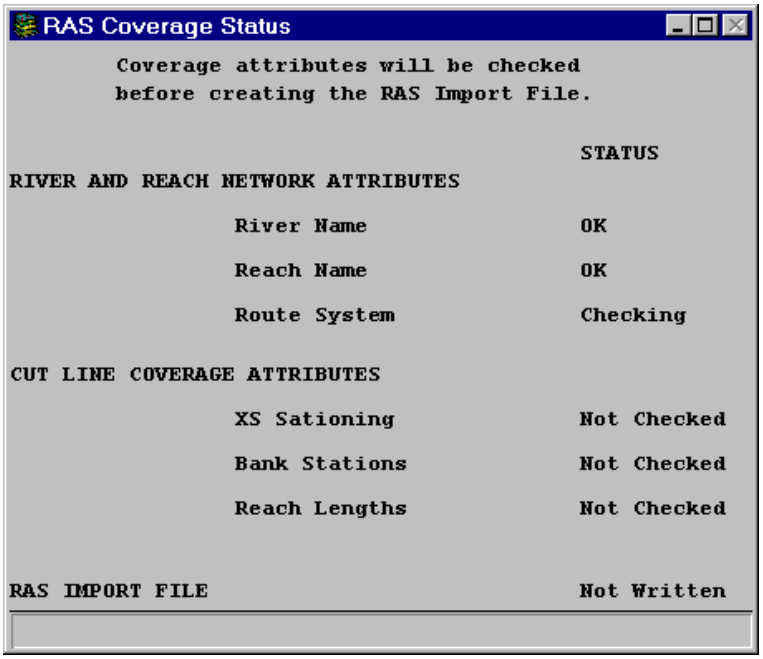


Figure 7.9 RAS Coverage Status window

Running RAS

To use HEC-RAS in concert with the GIS, perform the following steps:

1. Import the the RAS Import File into HEC-RAS from the Geometric Data Editor.

2. Complete the following hydraulic data: roughness coefficients, expansion and contraction coefficients, and hydraulic structure data. For a more complete discussion on importing geometric data refer to the HEC-RAS User's Manual, Chapter 13.

3. Run simulations in HEC-RAS and review the output.

4. Export the water surface profile results back to the GIS. For a more complete discussion on exporting GIS data refer to the HEC-RAS User's Manual, Chapter 13.

Importing a HEC-RAS Export File

To begin the import procedure press the **Import RAS Export File** button from the project manager. The window shown in Figure 7.10 will appear allowing you to browse for the GIS file. Select the file to import and enter the name of a new coverage to be created. The new coverage will contain cross-section attribute data along with water surface elevations at each cross section for each profile. Press **OK** to continue.

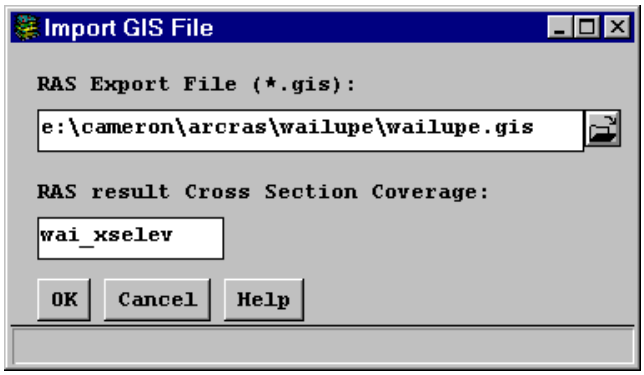


Figure 7.10 Import GIS File window

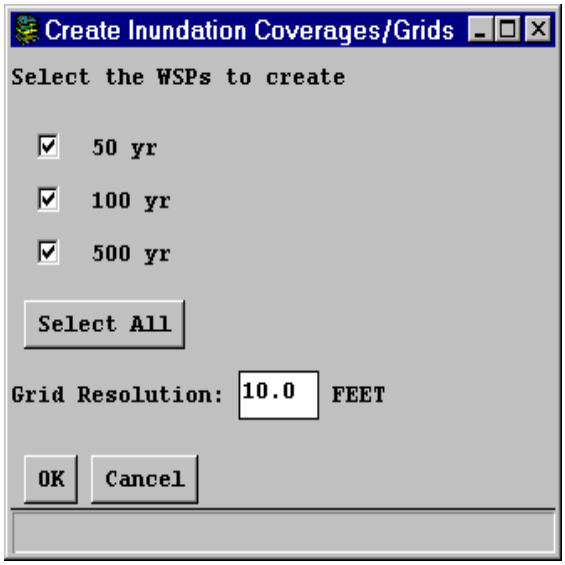


Figure 7.11 Water surface profile selection window

Pressing **OK** from the Import GIS File window will invoke a the Create Inundation Coverages/Grids shown in Figure 7.11. Select the checkboxes corresponding to the water surface profiles you wish to view and enter the resolution for the depth grid(s). Press **OK** to begin creating the water surface coverages from the exported water surface profile data.

You will be notified upon successfully creating the water surface profile coverages. Press **OK** from the message window continue.

Inundation Mapping

The next step is to view the extent and depth of floodplain inundation. Press the Inundation Mapping button on the project manager. The window shown in Figure 7.12 will appear along with a display window.

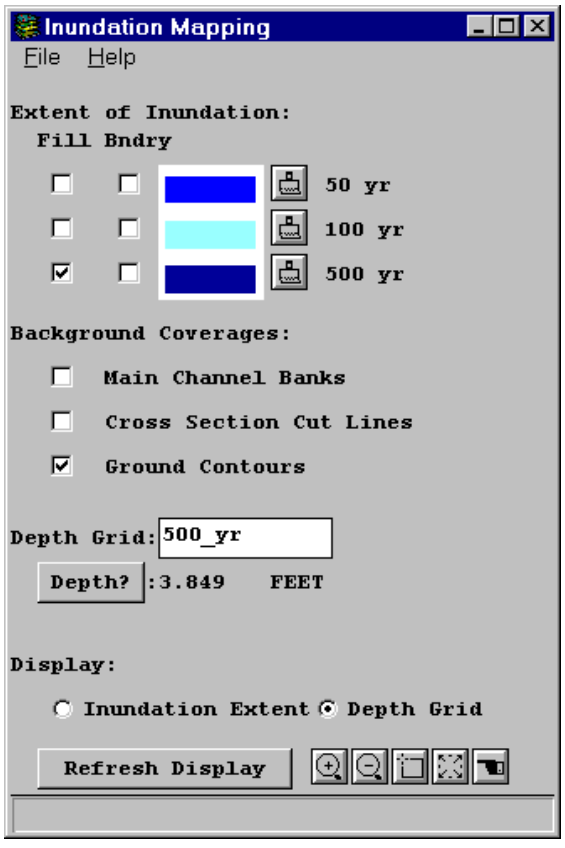


Figure 7.12 Inundation Mapping window

Select the checkbox that corresponds to the event, ground contours, and other background coverage(s) you wish to view and press the **Refresh Display** button. Shown in Figure 7.13 is a water surface flood extent polygon displayed over the *Ground Contours*.

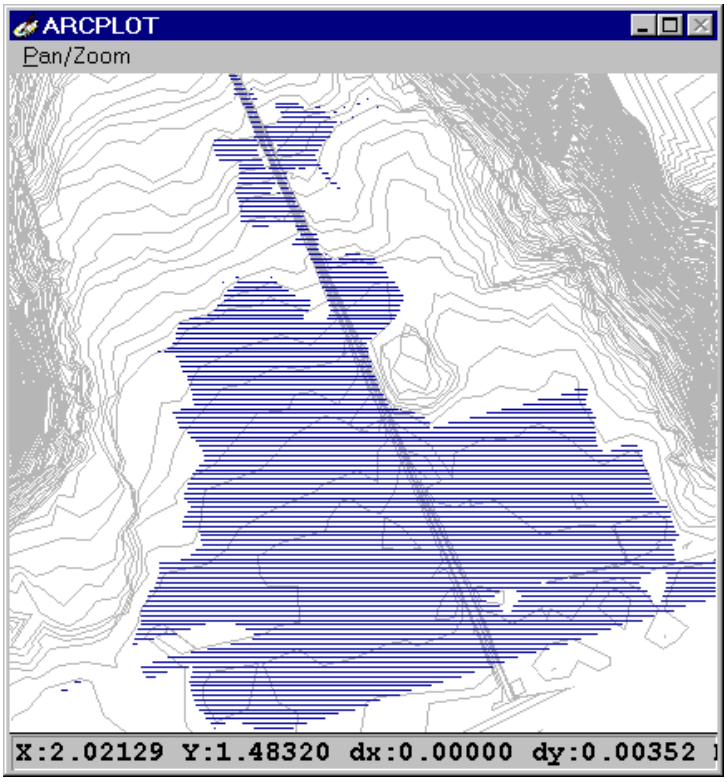


Figure 7-13 Water surface extent polygon coverage

Next, select the depth grid that corresponds to the water surface you just viewed. Right click over the *Depth Grid* input field and a list of available grids will appear from which to choose. (You can also type the name of the grid in the field.) Select the depth grid and press **OK**. To view the depth grid, choose *Depth Grid* from the *Display* option and press the **Refresh Display** button. As shown in Figure 7.14, a blue-scaled grid will be displayed, this time with the contours on top. Darker blue indicates greater inundation depths.

Press the **Depth?** button to find out the depth of inundation at key locations. Cross-hairs will appear that allow you to left click at points over the grid. The depth at those points will be shown to the right of the **Depth?** button. Right click when finished determining depths.

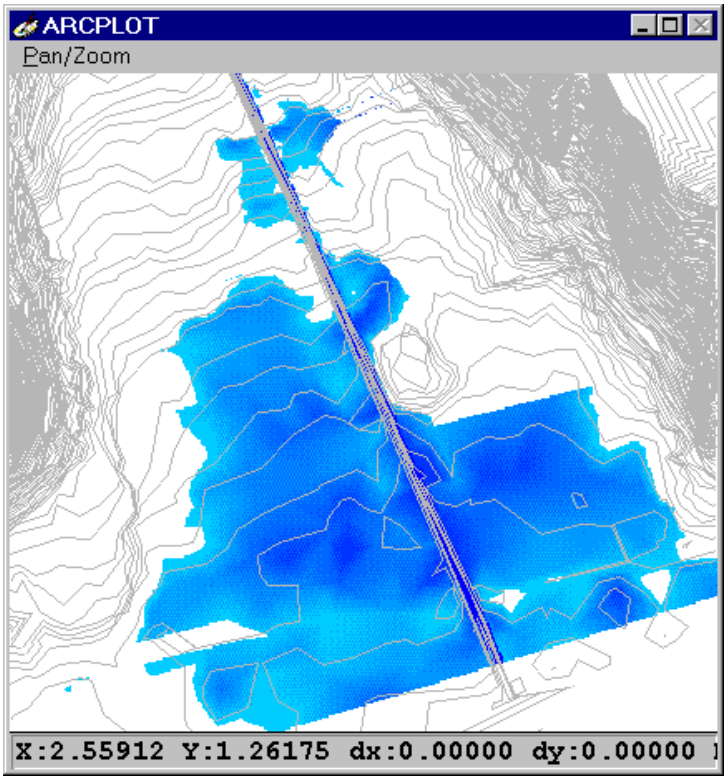


Figure 7.14 Shaded depth grid of floodplain inundation

Printing Map Results

Prepare the view you wish to print using the display options on the Inundation Mapping window. From the **File** menu select **Print**. The Print Map window shown in Figure 7.15 will be invoked, although the text fields will be blank.

Select the *Border* checkbox and press the **Preview** button. The page, as it will be printed will be drawn to the display window. If the you wish to change the inundation map, select **Exit** from the **File** menu. You will be returned to the inundation mapping window to change the view.

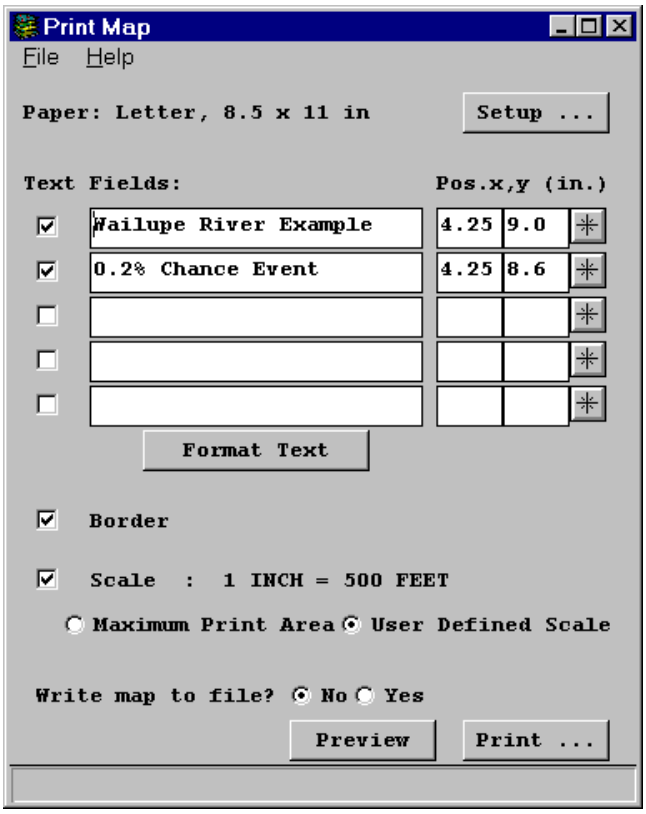


Figure 7.15 Print Map window

Select the desired page size, and margins using the **Setup** button to activate the Page Setup window. To change the page size, right click over the *Page Size* field to invoke a select list. After leaving the Page Setup window, press the **Preview** button to see the changes made to the page setup.

Add a title to the map by typing in one of the text fields. Use the cross-hairs to position the text on the map, or enter the page coordinates manually. Press the **Preview** button to see how the text looks. To format the text use the **Format Text** button located beneath the text input fields.

Before printing, select the scale of the map. To print the map scale on the map, select the map scale checkbox. Use the **Preview** option to see how your map will look at the new scale. An example map is shown in Figure 7.16.

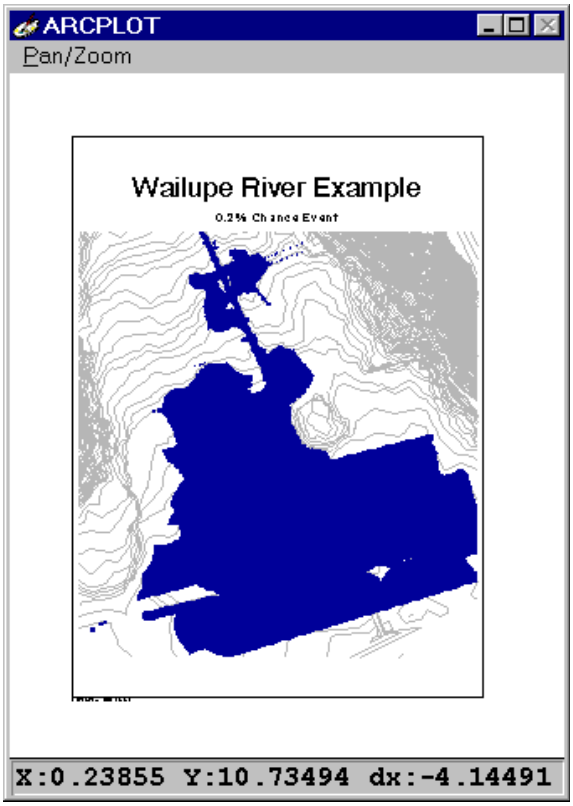


Figure 7.16 Preview of inundation map

When satisfied with your inundation map press the **Print** button. If you elected to write the map to a file, your map will be written to the filename specified. Otherwise, a temporary file will be created. The ARC/INFO print interface will then be invoked.

The print interface for Windows NT differs from the UNIX interface. For Windows NT the following steps are required: (1) select the print *Driver* and press **Print** (if you did not elect to write the map to a file, the file *tempprintfile.gra* will be selected as the file to print); (2) choose the destination printer from the Windows NT print manager and press **Print**. For UNIX the following steps are required: (1) select the file to be printed (if you did not elect to write the map to a file, the file *tempprintfile.gra* will be selected as the file to print) and double click on the destination printer; (2) edit the page attributes if desired and press **Print**.

When finished printing, choose **Quit** from the ARC/INFO print interface and select **Exit** from the **File** menu on the Print Map window. You will be returned to the Inundation Mapping window.

Exiting HEC-GeoRAS

When finished viewing water surfaces return to the project manager by selecting **Exit** form the **File** menu. From the **File** menu on the HEC-GeoRAS Project Manager select **Exit**. Upon exiting, the user will always be asked to save the current project. The user will be returned to the Arc prompt.

A p p e n d i x A

References

Environmental Systems Research Institute, 1998. http://www.esri.com

Hydrologic Engineering Center, 1998. *HEC-RAS, River Analysis System, User's Manual*, U.S. Army Corps of Engineers, Davis, CA.

A p p e n d i x B

HEC-RAS Import/Export Files for Geospatial Data

At version 2.0, HEC-RAS has introduced three-dimensional (3D) geometry for the description of river networks and cross-sections. This capability makes it possible to import channel geometry from CADD or GIS programs without conversion from real-world coordinates to station-elevation descriptions for the cross-sections, as HEC-2 required. Similarly, water-surface elevations calculated at cross-sections can be exported to CADD or GIS programs, where they can be used to create model water surfaces for inundation mapping**.**

Supported HEC-RAS Data Exchange

Using a formatted ASCII text file, HEC-RAS will import a basic description of the channel geometry including:

- The structure of the stream network, as represented by interconnected reaches.
- The location and description of cross-sections.

Using the same file format, HEC-RAS can write a file exporting the results of a hydraulic model run to a CADD or GIS program. At a minimum, reported results include the locations of cross-sections and the calculated water-surface elevations at those cross-sections.

The Import/Export Data File Structure

This section gives general rules for the construction of an HEC-RAS geometric data import or export file. It is not necessary to understand all these rules to build an import file, but they may be useful when debugging failed imports. The rules given here are a portion of the definition of a general-purpose geometric data exchange format being developed at HEC for its NexGen model programs. **Note: These file formats are evolving, in that additional data types will be added, and some of the existing ones may be modified for future versions. If you are writing software to read and write these file formats, please keep in mind that you may need to modify your software to stay compatible with future versions**

of HEC-RAS.

Records and Keywords

The HEC-RAS geometric data import file is composed of records, which in turn are composed of keywords and values. All records must contain one keyword, and all keywords end with a colon (:). A record can also contain a value or a set of values following the keyword, i.e., after the colon. Spaces, tabs, or line ends can be placed between a keyword and values within a record.

A record that contains a keyword and no value marks the beginning or the end of a group of related records (for example, the record "BEGIN HEADER:" marks the beginning of the header section of a data file). A record that contains a keyword and a value assigns that value to the part of the model named by the keyword.

When a keyword is read, all spaces up to the colon are removed and all letters are capitalized. The keywords "Begin Header:", "Begin header:", and " Be GiNH eadEr:" are all equivalent to "BEGINHEADER:". For readability, keywords named in this manual will contain internal spaces.

Values

A record can assign a single value to a single variable, or multiple values to an array. Values can be integers, floating point numbers, text strings, or locations (X,Y,Z, label). A single value in an array of values is called an "element" of that array.

A **numerical value (integer or floating point)** cannot contain internal blanks. A floating point number can contain a decimal point; an integer cannot. Elements in an array of numerical values can be separated by commas, blanks, tabs, or line ends.

A **text string** can contain internal blanks, tabs, and commas, but cannot contain internal line ends. Elements in an array of text strings must be separated by line ends.

A **location** consists of three coordinate values and a label (X, Y, Z, label). The first two coordinates are planar, the third gives elevation. The coordinate values are floating point numbers, and the label can be any type of value (although the label can be restricted to a particular data type in a particular context). In certain contexts, the elevation value or the label may not be required. If a label is used, all three coordinate values must be given; the value "NULL" is valid for the elevation coordinate only. The coordinate values and the label can be separated by commas, blanks, or tabs, but a location cannot contain internal line ends. Elements in an array

of locations must be separated by line ends.

Data Groups

Records in the data file can be collected in two types of groups: objects and file sections. An object is a group of records that combine to describe an entity within the model, a cross-section for example. A file section is a logical or functional grouping of data, the file header, for example, is a section that contains a description of the whole file.

Objects and file sections begin and end with records that contain keywords, but no values. A file section starts with a record containing a keyword composed of the word "BEGIN" followed by the section name and a colon, and ends with a keyword composed of the word "END" followed by the section name and a colon. For example, records containing only the keywords "BEGIN HEADER:" and "END HEADER:" are used to start and end the header section of a file. An object starts with a record containing a keyword naming the object type and ends with a record containing the keyword "END:" only. For example, a cross-section object begins and ends with records containing the keywords "CROSS-SECTION:" and "END:" only.

Comments

Hash characters (#) are used to identify comments. When a hash character is encountered in the file, all data from the hash to the next line end are ignored. A line that begins with a hash is equivalent to a blank line.

HEC-RAS Channel Geometry Import File

HEC-RAS reads channel geometry from a text file composed of three data sections:

1. A header, containing descriptions that apply to all data in the file.
2. A description of the stream network, containing reach locations and connectivity.
3. A descriptions of the model cross-sections, containing their location on the stream network and data required to support the HEC-RAS model.

An example HEC-RAS Channel Geometry Import file and HEC-RAS model results export file is shown at the end of this appendix.

Header

The header is bounded by the records "BEGIN HEADER:" and "END HEADER:" and must contain a record to identify the units system used in the imported data set. The units system can be ENGLISH or METRIC.

```
BEGIN HEADER:
 UNITS: ENGLISH
END HEADER:
```

minimum import file header

Records that may be included in the header are listed in the Table B.1:

Table B.1

Keyword	Value Type	Value
UNITS:	string	ENGLISH or METRIC
PROFILES:	string array	List of profiles exported from HEC-RAS. Not used on import.
DTM TYPE:	string	type (e.g., TIN or raster)
DTM:	string	name of digital terrain model
STREAM LAYER:	string	name of stream layer in CADD or GIS
NUMBER OF REACHES	integer	number of hydraulic reaches contained in the file.
CROSS-SECTION LAYER:	string	name of cross-section layer in CADD or GIS
NUMBER OF CROSS-SECTIONS:	integer	number of cross sections in the file
MAP PROJECTION:	string	projection (coordinate) system used (e.g., STATEPLANE)
PROJECTION ZONE:	string	projection zone (if applicable, e.g., 5101)
DATUM:	string	reference datum for planar coordinates
VERTICAL DATUM:	string	reference datum for vertical coordinates

Stream Network

The stream network section is bounded by the records "BEGIN STREAM NETWORK:" and "END STREAM NETWORK:" and contains records describing reaches and reach endpoints. At a minimum, the stream network section must contain at least two endpoints and one reach. The minimum requirements for a stream network are shown below.

```
BEGIN STREAM NETWORK:
  ENDPOINT: 476132.66, 65291.86, 155.28, 1
  ENDPOINT: 478144.53, 64296.61, 123.72, 2

  REACH:
    STREAM ID: Below Springfield
    REACH ID: Blue River
    FROM POINT: 1
    TO POINT: 2
    CENTERLINE:
      476132.66, 65291.86, 155.28, 23.13
      476196.08, 65196.61, 154.47
       lines omitted
      478144.53, 64296.61, 123.72, 22.41
  END:
END STREAM NETWORK:
```

minimum import stream network section

A reach endpoint is represented by a record containing the keyword "ENDPOINT:" followed by four comma-delimited fields containing the endpoint's X,Y,Z coordinates and an integer ID.

A reach is represented by a multi-record object that begins with a record containing only the keyword "REACH:" and ends with a record containing only the keyword "END:." At a minimum, a reach object must contain records setting values for a stream ID, a reach ID, a FROM point, and a TO point. A reach's FROM and TO point IDs must match IDs for endpoints listed before the reach object in the file. The reach object must also contain an array of locations defining the stream centerline. This array begins with a record containing only the keyword "CENTERLINE:" and ends when any keyword is encountered. A location element in the array contains the X, Y, and Z coordinates of a point on the stream centerline, and the point's river station. In HEC-RAS, elevation and stationing are optional in the stream network definition. If a location element includes a station value, it must occupy the fourth field in the element. If the elevation is not known, the word "null" must take its place.

Station values are assumed to be in miles for data sets in English units,

and in kilometers for data sets in metric units. Stationing is used for indexing locations along reaches, and is not used to precisely locate objects in the model.

Records that may be included in a stream network section are listed in Table B.2:

Table B.2

Keyword	**Value Type**	**Value**
ENDPOINT:	location	coordinates and integer ID
REACH:	none	marks beginning of reach object
END:	none	marks end of reach object
The following records are required for a reach object.		
STREAM ID:	string	identifies reach's membership in stream
REACH ID:	string	unique ID for reach within stream
FROM POINT:	string	integer reference to upstream endpoint
TO POINT:	string	integer reference to downstream endpoint
CENTERLINE:	location array	array elements contain coordinates and (optionally) floating point station value.

Cross-Sections

The cross-section file section begins with a record containing the only the keyword "BEGIN CROSS-SECTIONS:" and ends with a record containing the only the keyword "END CROSS-SECTIONS:." A cross-section is represented by multi-record object beginning with a record containing only the keyword "CROSS-SECTION:" and ending with a record containing only the keyword "END:."

A cross-section object must include records identifying the stream, reach, and station value of the cross-section, a 2D cut line, and a series of 3D locations on the cross-section. Stationing is given in miles for data sets with plane units of feet and in kilometers for data sets with plane units of meters. A cut line is composed of the label "CUT LINE:" followed by an array of 2D locations. A cross-section polyline consists of the label "SURFACE LINE:" plus 3D coordinates written as comma-delimited X,Y,Z real-number triples, one triple to a line.

Records that may be included in the cross-section file section are listed in Table B.3:

Table B.3

Keyword	Value Type	Value
CROSS-SECTION:	none	marks beginning of cross-section object
END:	none	marks end of cross-section object
The following records are required for a cross-section object.		
STREAM ID:	string	identifiers for stream and reach where cross-section is located (must refer to existing streams and reaches in the model)
REACH ID:	string	
STATION:	floating point	relative position of cross-section on stream
CUT LINE:	location array	array elements contain 2D coordinates of cross sectione stike line
SURFACE LINE:	location array	array elements contain 3D coordinates of cross section points
The following records are optional for a cross-section object.		
BANK POSITIONS:	floating point (2 elements)	Fraction of length along cut line where main channel bank stations are located. (values 0.0 - 1.0)
REACH LENGTHS:	floating point (3 elements)	Distance along left overbank, center channel, and right overbank flow paths to next cross-section downstream (units are feet or meters).
WATER ELEVATION:	floating point array	Water surface elevation values. Used for export of model results. Not read on import.

HEC-RAS Model Results Export File

HEC-RAS exports model results to a text file using the same format as the data import file. The contents of the files, however, are not identical. The stream network section is not required for data export, and the surface line may be omitted from the cross-section objects. An example HEC-RAS model export file is shown at the end of this discussion. Model results are reported with the following elements (Table B.4), which are not required (and are not read) in the import file.

Table B.4

Keyword	Value Type	Value
The following record is optional in the Header section of the export file.		
PROFILE NAMES:	string array	name(s) of water surface profiles reported in the file. This record is required if more than one profile is reported.
The following record is required for each cross-section object.		
WATER ELEVATIONS:	floating point array	Elevation of water surface at the cross-section. The array must contain one value for each profile.
The following records make up a section defining a bounding polygon of the water surface limits.		
BEGIN BOUNDARIES:	none	Marks start of boundaries file section.
END BOUNDARIES:	none	Marks end of boundaries file section.
PROFILE LIMITS:	none	Marks start of an object defining the limits of a single water surface profile.
PROFILE ID:	string	Name of profile. This must match a name in the Profile Names record in the header.
POLYGON	location array	A series of 2D locations marking the limits of a water surface. A single profile limit can be merged from multiple polygons.

1. **Profile names can contain up to 11 characters for HEC-GeoRAS.** They must begin with a letter.

2. If no profile name is provided, only one water elevation will be written for each cross section.

Water Surface Bounding Polygon

In addition to a water surface elevation at each cross section (one for each profile), the HEC-RAS program sends a bounding polygon for each hydraulic reach in the model (the program outputs a new set of bounding polygons for each profile computed). The bounding polygon is used as an additional tool in assisting the GIS (or CADD) software to figure out the boundary of the water surface on top of the terrain.

In most cases, the bounding polygon will represent the outer limits of the

cross section data, and the actual intersection of the water surface with the terrain will be inside of the polygon. In this case, the GIS software will use the water surface elevations at each cross section and create a surface that extends out to the edges of the bounding polygon. That surface is then intersected with the terrain data, and the actual water limits are found as the location where the water depth is zero.

However, is some cases, the bounding polygon may not represent the extents of the cross-section data. For example, if there are levees represented in the HEC-RAS model, which limit the flow of water, then the bounding polygon will only extend out to the levees at each cross section. By doing this, when the information is sent to the GIS, the bounding polygon will prevent the GIS system from allowing water to show up on both sides of the levees.

In addition to levees, the bounding polygon is also used at hydraulic structures such as bridges, culverts, weirs, and spillways. For example, if all of the flow is going under a bridge, the bounding polygon is brought into the edges of the bridge opening along the road embankment on the upstream side, and then back out to the extent of the cross-section data on the downstream side. By doing this, the GIS will be able to show the contraction and expansion of the flow through the hydrualic structures, even if the hydraulic structures are not geometricaly represented in the GIS.

Another application of the bounding polygon is in FEMA floodway studies. When a floodway study is done, the first profile represents the existing conditions of the flood plain. The second and susequent profiles are run by encroaching on the floodplain until some target increase in water surface elevation is met. When the encroached profile is sent to the GIS, the bounding polygon is set to the limits of the encroachment for each cross section. This will allow the GIS to display the encroached water surface (floodway) over the terrrain, even though the water surface does not intersect the ground.

Import/Export Guidelines

The following rules apply to channel and cross-section import/export data.

Defining The Stream Network

1. The stream network is represented by a set of interconnected reaches. A stream is a set of one or more connected reaches that share a common stream ID.

2. A stream is composed of one or more reaches with the same stream ID, and each reach in a stream must have a unique reach ID. Every reach must be identified by a unique combination of stream and reach IDs.

3. Stream IDs and Reach IDs are alphanumeric strings up to 16 characters long. Reach endpoint IDs are integers.

4. Streams cannot contain parallel flow paths. (If three reaches connect at a node, only two can have the same stream ID.) This prevents ambiguity in stationing along a stream.

5. A reach is represented by an ordered series of 3D coordinates, and identified by a stream ID, a reach ID, and IDs for its endpoints.

6. A reach endpoint is represented by its 3D coordinates and identified by an integer ID.

7. Reaches are not allowed to cross, but can be connected at their endpoints (junctions) to form a network.

8. The normal direction of flow on a reach is indicated by the order of its endpoints. One point marks the upstream or "from" end of the reach, the other marks the downstream or "to" end of the reach.

Defining Cross-Sections

1. Each cross-section is defined by a series of 3D coordinates, and identified by a stream name and reach name (which must refer to an existing stream and reach) and a station, indicating the distance from the cross-section to the downstream end of the stream.

2. Stationing is given in miles for projects using English units and in kilometers for projects using metric units.

3. A cross-section line can cross a reach line exactly once, and cannot cross another cross-section line.

Results of a water surface calculation are exported in a file that contains cross-section locations in plane (2D) coordinates, water-surface elevations for the cross-sections, and boundary polygons for the reaches.

The Following Rules Apply to Water-Surface Export Data

1. A cross-section is represented by a water surface elevation and a series of 2D coordinates on the cross-section cut line. The full width of the cross-section is included.

2. One bounding polygon is created for each reach in the stream network, and for each profile.

3. A reach's bounding polygon is made up of the most upstream cross-section on the reach, the endpoints of all cross-sections on the reach, and the most upstream cross-sections of reaches downstream of the reach.

4. For purposes of defining bounding polygons *only*, the endpoints of a cross-section are adjusted to the edge of the water surface at the cross-section if the cross-section is part of a floodway, a leveed section of the reach, or the water extent is controlled by a hydraulic structure. This allows calculated water surfaces that are higher than the land surface to be reported back to the CADD or GIS program.

Sample HEC-RAS Geometry Import File

```
BEGIN HEADER:

  DTM TYPE: TIN
  DTM: /HEC63/USR1/EVANS/WAILUPE/WAI_TIN (TIN)
  STREAM LAYER: /HEC63/USR1/EVANS/WAILUPE/WAI_STR
  NUMBER OF REACHES: 3
  CROSS-SECTION LAYER: /HEC63/USR1/EVANS/WAILUPE/WAI_XS
  MAP PROJECTION: STATEPLANE
  PROJECTION ZONE: 5101
  DATUM: NAD27
  UNITS: ENGLISH

END HEADER:

BEGIN STREAM NETWORK:

  ENDPOINT:   582090.19,    49360.46,   220.17, 1
  ENDPOINT:   583638.69,    47559.38,   266.80, 2
  ENDPOINT:   582307.31,    46985.66,   112.84, 3
  ENDPOINT:   584128.44,    41274.97,    -3.41, 4

  REACH:
    STREAM ID: Kulai Gorge
    REACH ID: Headwaters
    FROM POINT: 2
    TO POINT: 3
    CENTERLINE:
      583638.69,    47559.38,  266.80,    0.33
  11 lines omitted
      582307.31,    46985.66,  112.84,    0.00
  END:

  REACH:
    STREAM ID: Wailupe
    REACH ID: Upper
    FROM POINT: 1
    TO POINT: 3
    CENTERLINE:
      582090.19,    49360.46,  220.17,    1.65
  14 lines omitted
      582307.31,    46985.66,  112.84,    1.19
  END:

  REACH:
    STREAM ID: Wailupe
    REACH ID: Lower
    FROM POINT: 3
    TO POINT: 4
    CENTERLINE:
      582307.31,     46985.66,   112.84,   1.19
  33 lines omitted
```

```
      584128.44,     41274.97,        -3.41,      0.00
  END:

END STREAM NETWORK:

BEGIN CROSS-SECTIONS:

  CROSS-SECTION:
    STREAM ID: Kulai
    REACH ID: Headwaters
    STATION: 0.312
    BANK POSITIONS:  0.5562,  0.6294
    REACH LENGTHS:   84.541,  89.110,  82.013
    CUT LINE:
      583613.16,     47441.98
      583567.80,     47529.68
      583558.73,     47575.04
      583567.80,     47638.55
    SURFACE LINE:
      583613.16,     47441.98,       309.69
  29 lines omitted
      583567.80,    47638.55,      278.10
  END:

6 Cross-Sections omitted

  CROSS-SECTION:
    STREAM ID: Kulai
    REACH ID: Headwaters
    STATION: 0.019
    BANK POSITIONS:  0.4454,  0.4799
    REACH LENGTHS:   187.942, 193.195, 163.246
    CUT LINE:
      582769.62,     46950.81
      582598.07,     46978.64
      581981.41,     47224.45
    SURFACE LINE:
      582769.62,    46950.81,      167.62
  78 lines omitted
      581981.41,    47224.45,      169.89
  END:

  CROSS-SECTION:
    STREAM ID: Wailupe
    REACH ID: Upper
    STATION: 1.629
    BANK POSITIONS:  0.4781,  0.5615
    REACH LENGTHS:   55.965,  53.626,  40.370
    CUT LINE:
      582159.78,     49259.60
      582013.48,     49223.76
    SURFACE LINE:
      582159.78,    49259.60,      235.49
  29 lines omitted
```

```
      582013.48,    49223.76,       241.78
   END:
```

7 Cross-Sections omitted

```
  CROSS-SECTION:
    STREAM ID: Wailupe
    REACH ID: Lower
    STATION: 1.183
    BANK POSITIONS:  0.5236,  0.5686
    REACH LENGTHS:   171.000, 164.796, 159.249
    CUT LINE:
      582723.17,     46846.45
      582426.44,     46878.92
      581953.51,     47082.99
    SURFACE LINE:
      582723.17,    46846.45,      161.92
  70 lines omitted
      581953.51,    47082.99,      165.01
  END:
```

23 Cross-Sections omitted

```
  CROSS-SECTION:
    STREAM ID: Wailupe
    REACH ID: Lower
    STATION: 0.037
    BANK POSITIONS:  0.5034,  0.5155
    REACH LENGTHS:   82.365,  192.982, 137.742
    CUT LINE:
      586214.12,     42127.92
      581980.99,     40806.06
    SURFACE LINE:
      586214.12,    42127.92,        4.01
  71 lines omitted
      581980.99,    40806.06,        6.39
  END:

END CROSS-SECTIONS:

FILE COMPLETE: 28 October 1996,  17:17
```

Sample HEC-RAS Geographic Data Export File

```
BEGIN HEADER:

# RAS output file created 29 Oct 96 16:36:41 Tuesday
# by HEC-RAS
  NUMBER OF REACHES: 3
  NUMBER OF CROSS-SECTIONS: 46
  NUMBER OF PROFILES: 2
  MAP PROJECTION: STATEPLANE
  PROJECTION ZONE: 5876
  DATUM: NAD27
  PLANE UNITS: FEET
  ELEVATION UNITS: FEET
  STATION UNITS: MILES
  PROFILE NAMES: PF#1, PF#2

END HEADER:

BEGIN CROSS-SECTIONS:

  CROSS-SECTION:
    WATER ELEVATIONS: 265.8189, 268.7436
    CUT LINE:
      583613.16,   47441.98
      583567.80,   47529.68
      583558.73,   47575.04
      583567.80,   47638.55
  END:

  CROSS-SECTION:
    WATER ELEVATIONS: 257.7377, 270.6435
    CUT LINE:
      583537.56,   47429.88
      583474.05,   47529.68
      583474.05,   47568.99
      583492.20,   47662.74
  END:
```

119 cross-sections omitted

```
  CROSS-SECTION:
    WATER ELEVATIONS: 5.964032, 6.43543
    CUT LINE:
      586202.53,   42188.21
      583941.76,   41483.75
      581932.30,   40961.43
  END:

  CROSS-SECTION:
    WATER ELEVATIONS: 5.662289, 6.12576
    CUT LINE:
      586214.12,   42127.92
```

```
      581980.99,  40806.06
  END:

END CROSS-SECTIONS:

BEGIN BOUNDS:

  PROFILE LIMITS:
    PROFILE ID:PF#1
    POLYGON:
      582013.48 , 49223.76
    63 lines omitted
      581819.14 , 49209.56

    POLYGON:
      581953.51 , 47082.99
    141 lines omitted
      581934.965 , 47008.78

    POLYGON:
      583567.8 , 47638.55
    43 lines omitted
      583530 , 47650.645
  END:

  PROFILE LIMITS:
    PROFILE ID:PF#2
    POLYGON
      582013.48 , 49223.76
    63 lines omitted
      581819.14 , 49209.56

    POLYGON:
      581953.51 , 47082.99
    141 lines omitted
      581934.965 , 47008.78

    POLYGON:
      583567.8 , 47638.55
    43 lines omitted
      583530 , 47650.645
  END:

END BOUNDS:

#FILE COMPLETE: 17 Jan 97 16:38:04 Friday
```

A p p e n d i x C

RAS Coverage Data Structure

Main Channel Invert

The Main Channel Invert Coverage is used to define the location of the river channel and to establish the river and reach network. River and reach names are defined by the user and written to the STR_NAME and RCH_NAME items, respectively. Coverage items written to the arc attribute table (AAT) are listed below.

Item	Type	Output	Description
Cover#	B	5	Generated by ARC/INFO
Cover-ID	B	5	Generated by ARC/INFO
LENGTH	F	18	Generated by ARC/INFO, length of cut line
STR_NAME	C	16	Created by HEC-GeoRAS, user defined value for river
RCH_NAME	C	16	Created by HEC-GeoRAS, user defined value for reach

Dynamic segmentation information for the Main Channel Invert Coverage is written to the route table .RATHECSTR and section table .SECHECSTR.

.RATHECSTR

Item	Type	Output	Description
HECSTR#	B	5	Generated by ARC/INFO
HECSTR-ID	B	5	Generated by ARC/INFO
STREAMID	C	16	Generated by ARC/INFO

.SECHECSTR

Item	Type	Output	Description
ROUTELINK#	B	5	Generated by ARC/INFO
ARCLINK#	B	5	Generated by ARC/INFO
HECSTR#	B	5	Generated by ARC/INFO
HECSTR-ID	B	5	Generated by ARC/INFO
T-MEAS	F	12	Generated by ARC/INFO
F-MEAS	F	12	Generated by ARC/INFO
T-POS	F	12	Generated by ARC/INFO
F-POS	F	12	Generated by ARC/INFO

Cross Section Cut Line

The Cross Section Cut Line Coverage is used to determine the location and expanse of each cross section. All attribute data are attached to this coverage in the AAT before the RAS Import File is written.

Item	Type	Output	Description
Cover#	B	5	Generated by ARC/INFO
Cover-ID	B	5	Generated by ARC/INFO

Item	Type	Output	Description
LENGTH	F	18	Generated by ARC/INFO, length of cut line
STR_NAME	C	16	Created by HEC-GeoRAS, user defined value for **river name**
RCH_NAME	C	16	Created by HEC-GeoRAS, user defined value for **reach name**
STATION	F	12	Created by HEC-GeoRAS, defines the **cross-section stationing**
BANK1	F	7	Created by HEC-GeoRAS, defines percent distance to **left bank station** along cut line from left end
BANK2	F	7	Created by HEC-GeoRAS, defines percent distance to **right bank station** along cut line from left end
RL1	F	12	Created by HEC-GeoRAS, defines downstream **reach length** for **left overbank**
RL2	F	12	Created by HEC-GeoRAS, defines downstream **reach length** for **main channel**
RL3	F	12	Created by HEC-GeoRAS, defines downstream **reach length** for **right overbank**

Main Channel Banks

The Main Channel Banks Coverage is used to determine bank station locations for each cross section. The following attributes are written to the Main Channel Banks AAT.

Item	Type	Output	Description
Cover#	B	5	Generated by ARC/INFO
Cover-ID	B	5	Generated by ARC/INFO
LENGTH	F	18	Generated by ARC/INFO, length of arc

Flow Paths

The Flow Path Coverage is used to determine downstream reach lengths for each cross section. The following attributes are written to the Flow Paths AAT.

Item	Type	Output	Description
Cover#	B	5	Generated by ARC/INFO
Cover-ID	B	5	Generated by ARC/INFO
LENGTH	F	18	Generated by ARC/INFO, length of arc
STR_NAME	C	16	Copied from the Main Channel Invert Coverage (if it exists) in HEC-GeoRAS
RCH_NAME	C	16	Copied from the Main Channel Invert Coverage (if it exists) in HEC-GeoRAS