

R2D_Bed

Bed Topography File Editor

User's Manual

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1.0 INTRODUCTION TO R2D_Bed

1.1 Background

R2D_Bed is a utility program intended for use with the River2D river modelling system. R2D_Bed is an interactive and graphical bed topography file editor. The normal modelling process would involve creating a preliminary bed topography file (text) from the raw field data, then editing and refining it using R2D_Bed. The resulting bed topography file is used in R2D_Mesh to develop a computational discretization. River2D is then used to solve for the water depths and velocities. Finally, the River2D habitat module is used to visualize and interpret the results and perform PHABSIM type fish habitat analysis. An iterative approach at various stages, including modification of the bed topography, is usual.

1.2 Features Overview

Accurate representation of the physical features of the river channel bed is probably the most crucial factor in successful river flow modelling. In addition to accurate and extensive field data, judgement and experience are necessary to connect the scattered data points into a digital surface representation. The River2D model family is based on the Triangulated Irregular Network (TIN) methodology, including breaklines, for spatial interpolation of nodal parameters. The nodal values are usually measured points, but the breakline locations are judgemental. R2D_Bed allows interactive setting and deleting of breakline segments.

The relevant physical characteristics of the channel bed necessary for flow modelling are the bed elevation and the bed roughness height. R2D_Bed allows these values to be edited on an individual point basis or over irregular polygonal regions. R2D_Bed is also useful for editing channel index files, with channel index replacing roughness height as the second nodal parameter.

R2D_Bed also allows default computational boundaries to be specified and edited. These boundaries may also be set at the mesh

generation stage in R2D_Mesh, but may need to be repeated with each new mesh.

As with any editor type utility, the use of R2D_Bed may vary from large data set input, major modification, or minor refinement. The interactive nature of the program allows a flexible approach to data manipulation. Various visualization facilities are available, including plots of node locations, breakline and boundary segments, triangulation, as well as contour and colour fill plots of the bed elevation and roughness. In most cases, the effect of changes to underlying data values can be observed immediately.

1.3 Program Status

Version 1.24 of R2D_Bed has not been extensively tested as yet. While each function works correctly on its own, not all possible combinations and sequences of commands has been tried. In addition, only a few data files have been considered. Further still, no undo features are available. It is advisable to save often, as modifications are made.

2.0 BED TOPOGRAPHY FILE DESCRIPTION

2.1 General

Input to, and output from, R2D_Bed model is in the form of bed topography files, usually indicated with a .bed filename extension. These files are also input to the R2D_Mesh finite element mesh generator program.

There are two slightly different .bed file formats used by R2D_Bed. The first uses brackets to implicitly group nodes into breakline or boundary specification. This format is convenient for using a text editor to make modifications to the file.

The second format lists nodes, breakline segments, and boundary segments separately and explicitly. While R2D_Bed will read either format, it will output only in the explicit format. It is therefore advisable to work on a copy of a bracket formatted file, rather than the original. Once in the explicit format, the file is difficult to interpret in a text editor. R2D_Mesh will read either format.

In explicit format, the basic structure of the file is a list of nodes (one per line), followed by a list of breakline segments (one per line) and finally by a list of boundary segments (one per line). The boundaries between the sections are indicated in the file with a period "." character, often incorporated into a comment such as "no more nodes."

In implicit format, breaklines and boundaries are specified in the same section as the nodes. Thus, the only period "." character required is at the end of the file. In this case, brackets are used to identify the nature of those nodes listed (whether it is an open or closed boundary or breakline). Therefore, sequence is unimportant and it is not necessary to group segments of a certain type.

Note that it is also possible to mix both formats. For example, a file that is chiefly in implicit format might have several breakline segments identified in a short section following the main file.

These breaklines would then need to be formatted according to the explicit rules.

The specifics of the bed file format are explained in detail in the sections that follow. A sample bed file called `BedNotes.bed` is provided in Appendix A. This file can also be downloaded from the River2D website.

2.1.1 Comments

The `.bed` file may contain any number of comments as long as the comments do not contain numerical digits, periods, or any form of brackets. Also, no comments should appear within the set of numbers defining a node, breakline segment, or boundary segment. Blank lines are treated as comments and ignored as well.

2.1.2 Node Specification

A single node is represented by a line in the `.bed` file and consists of a point number (integer), x-coordinate (floating point number), y-coordinate (floating point number), bed elevation (floating point number), bed roughness height (floating point number), and an optional code (up to twenty alphanumeric characters), all separated by any number of spaces or tabs. An example of the node format is shown below. Ordinary plain text output (tab or space delimited) from a text editor, word processor, or spreadsheet is entirely suitable (remember to use Save As Text, as appropriate). The end of the list of data points should be indicated with a period (which may be part of a comment, such as "end of data points.").

n	x	y	z	k	Code
101	1000	1000	105.6	0.5	OutsideSW
102	1450	1000	105.6	0.5	OutsideSE
103	1000	1200	105.7	0.5	OutsideNW
104	1250	1300	105.6	0.5	OutsideN
105	1450	1300	105.7	0.5	OutsideNE

The node numbers assigned to the nodes are important only in terms of providing a reference for explicit breakline and boundary segments. Care should be taken to insure that node numbers are not

duplicated. On output, node numbers may be different than when input, but will be unique.

2.1.3 Breaklines – Implicit Format

The first, and simplest, method of defining breaklines is to enclose the points forming the breakline in brackets. Curved brackets "(...)" indicate an "open" breakline, which starts at the first point and ends at the last point. An example from an actual .bed file is shown below. The brackets need not be on separate lines, but this helps organize the file and makes it easier to read and edit. The only requirement is the open bracket precedes the number of the first node and the closing bracket follows the roughness of the last point.

```
( Top of NW ridge
n      x          y          z          k          Code
161    1060.0     1090.0     100.1     0.15     NTHL1
162    1130.0     1110.0     99.9      0.15     NTHL2
163    1190.0     1160.0     99.7      0.15     NTHL3
164    1250.0     1200.0     99.1      0.15     NTHL4
165    1310.0     1215.0     98.7      0.15     NTHL5
166    1390.0     1180.0     99.6      0.15     NTHL6
)
```

Square brackets, "[...]", indicate a closed breakline, which starts and ends at the same point like a polygon. The closing point (same as the starting point) should not be entered a second time.

2.1.4 Breaklines – Explicit Format

The second method of designating breaklines is to explicitly specify the segments forming the breakline. After the period signifying the end of the data point specifications, these segments can be entered. Each one consists of a segment number (integer) and the numbers (integers) of the two points at the ends of the segment. An example of this format is shown below. These points must have been previously entered either as individual points or as part of another breakline (using brackets). When all desired segments have been entered, the explicit breakline section is terminated with a period. Comments are allowed in this section of

the data file as in the data point section. The explicit segment method of specifying breaklines allows more complex topologies than simple open and closed paths.

101	132	141
102	146	119
103	130	156

no more breakline segments.

2.1.5 Boundaries – Implicit Format

Curly brackets, "{...}", are used to delineate default computational boundaries. Like the square brackets, they delimit the points that make up a polygon. Any number of boundary polygons may be defined with the following restrictions. The first polygon represents the outer boundary, enclosing the overall area to be modelled. It must be defined with the points proceeding in a **counter-clockwise** fashion around the polygon. The subsequent polygons represent internal boundaries which are being excluded from the modelled domain, such as islands. These polygons must be defined with the points proceeding in a **clockwise** fashion. The reason for the direction switch is that the program interprets the area to the left of any boundary segment (defined by two points) to be "inside" the domain. The internal polygons must be wholly enclosed within the outer polygon. Finally, boundary polygons must not intersect themselves or with each other. Boundaries need not be defined in the .bed file and may be easily overridden (if desired) in the mesh generation process if they are defined.

Boundaries designated with the curly bracket notation are also assumed to be breaklines. Here is an example of an implicitly defined boundary.

```
{ Crest of island bank note clockwise for internal boundary
210 1205.0 1140.0 102.1 0.50 ITOB1
209 1220.0 1160.0 102.2 0.50 ITOB2
208 1250.0 1175.0 102.2 0.50 ITOB3
207 1290.0 1170.0 102.1 0.50 ITOB4
206 1335.0 1160.0 102.2 0.50 ITOB5
205 1320.0 1144.0 102.6 0.50 ITOB6
204 1295.0 1125.0 102.3 0.50 ITOB7
```

```

203  1260.0  1110.0  102.1  0.50  ITOB8
202  1218.0  1105.0  102.1  0.50  ITOB9
201  1201.0  1120.0  102.2  0.50  ITOB10
}
```

2.1.6 Boundaries – Explicit Format

Explicit boundary segments are specified in the last section of the bed topography file in a similar way to breakline segments. The only difference is that, in addition to the three integers, specifically a segment number and two node numbers, an additional integer and floating point number are required. These represent a boundary condition code and value. The simplest condition is code = 0 and value = 0.0, representing a "wall" or "no-flow" boundary. These can be changed at later stages using the mesh generator program.

The organization of the explicit boundary segments is important. The order of definition should trace the polygons just as the implicit definition does. Explicit boundaries are not considered to be breaklines.

The boundary segment section of the file may be terminated with a period, but this is not required. An example of an explicit boundary is shown below.

```

1      12      13      0      0
2      13      14      0      0
3      14      15      0      0
4      15      16      0      0
5      16      17      0      0
6      17      18      0      0
7      18      19      0      0
8      19      20      0      0
9      20      21      0      0
10     21      22      0      0
11     22      23      0      0
12     23      24      0      0
13     24      25      0      0
14     25      26      0      0
15     26      27      0      0
16     27      28      0      0
17     28      29      0      0
18     29      30      0      0
19     30      31      0      0
```


20	31	32	0	0
21	32	33	0	0
22	33	12	0	0

no more boundary segments

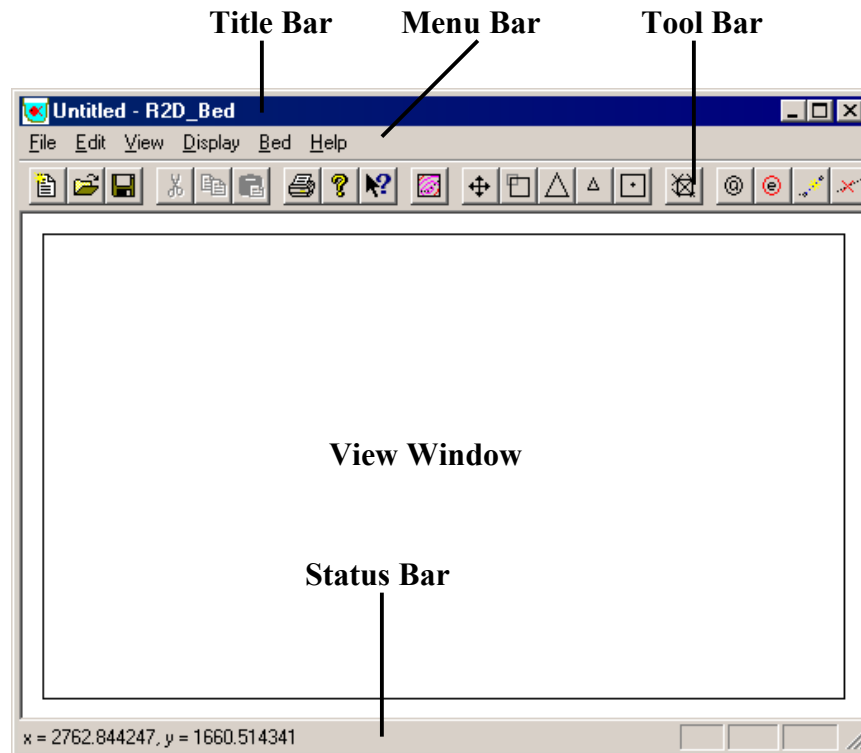
3.0 COMMAND REFERENCE

3.1 General

The operation of R2D_Bed is normally to input a starting .bed file, perform modifications, including importing additional files, then saving the result as a final .bed file. The user interaction is focused on a single window containing a map of the plan coverage area where the bed topography features are displayed in different ways. The appearance and the main features of R2D_Bed are shown in Figure 1.

All commands and operations are executed with a combination of menu commands and mouse selections on the map. Some of the most commonly used menu commands have short-cut icons available on the toolbar. The toolbar icons also indicate the status of various operations and the current mouse selection mode.

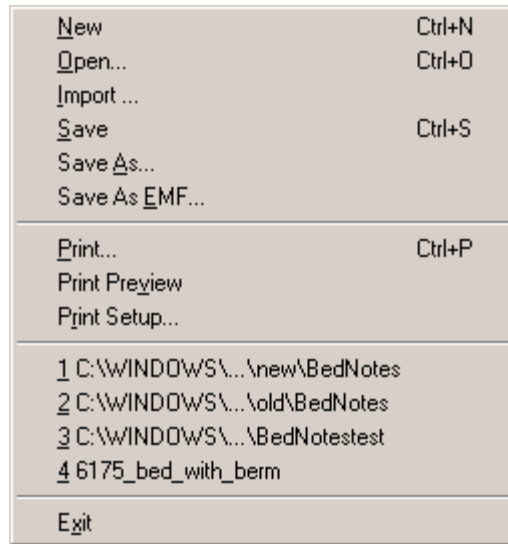
Figure 1: The elements of the R2D_Bed screen.



3.2 File Menu

The File menu contains the commands for basic input and output of the .bed files. Most of these commands operate as normal for a standard Windows program as shown in Figure 2. The only different commands available are the Import... and Save As EMF... commands.

Figure 2: The R2D_Bed File Menu.



3.2.1 Open...

The standard Windows file open dialog is presented with the filter set to files with a .bed extension. When an appropriate file is selected and the OK button is pressed, the .bed file will be read in. Information from any previous .bed file open will be deleted (from the program's memory, the original file will be unaffected).

3.2.2 Import ...

The import command behaves exactly like the open command, except that all nodes, breakline segments, and boundary segments read in from the chosen file are appended to the data already displayed. Thus this command can be used to increase the area of coverage, combine data from different sources, or to separate boundary or breakline data from the mass of nodes.

3.2.3 Save As EMF...

This command allows the user to save the current view to an Enhanced Windows Metafile. This file format saves the view in a vector-based format which is excellent for presentation purposes. Currently, the EMF's generated by this command can be imported into any Microsoft® Office application that accepts image files.

3.2.4 Print ...

The print command will cause the current map display to be redrawn to the indicated printing device. Due to differences in the page proportions to the screen proportions, typically more area (possibly blank) will be printed than appears on the display. Using the print preview command will allow assessment of the proportions of the printed result.

3.2.5 Recent Documents

The four most recent .bed files will be listed here for convenience. Selecting one of them will open it as if it had been selected using the Open command.

3.3 Edit Menu

The edit is present but no functions are implemented as yet. The menu items and corresponding toolbar icons are thus deactivated.

3.4 View Menu

3.4.1 Toolbar

This command simply toggles the toolbar at the top of the map window on and off.

3.4.2 Status Bar

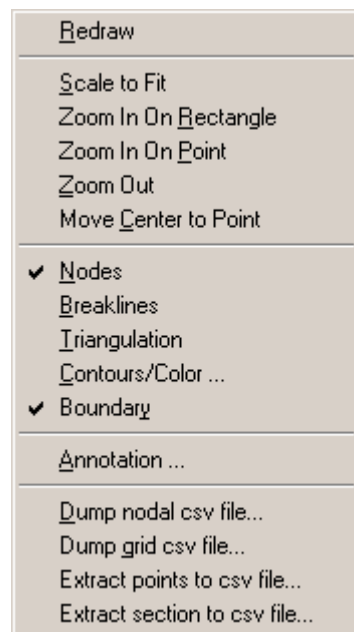
This command toggles the status bar at the bottom of the map window on and off. When R2D_Bed is first started, the status bar is blank. When a .bed file is read in, the status bar will indicate the x and y coordinates of the position of the mouse pointer. When the

mouse pointer is located in the interior of a valid triangulated TIN, the interpolated bed elevation of that point is also indicated. Among other uses, this is valuable to interpret contour line values.

3.5 Display Menu - Map Scale Commands

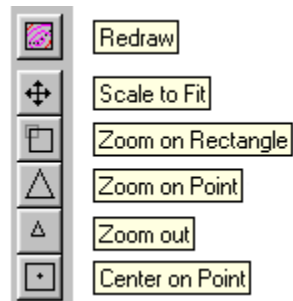
The Display Menu, presented in Figure 3, controls the presentation of the bed topography data on the map window. The first group of commands concerns the areal extent of the display, with scale and panning functions. The second group of commands concerns presentation of the bed topography data.

Figure 3: The R2D_Bed Display Menu.



All of the Display menu commands are available while performing bed editing operations. For example, while defining a breakline sequence, the map can be zoomed in for fine work in a congested area, then zoomed back out. Centering on a point can be used to pan across a highly magnified region. All of the Map Scale commands can also be accessed through the toolbar. Figure 4 presents the Display Menu commands that have short-cut icons on the toolbar.

Figure 4: The Display Menu toolbar icons.



3.5.1 Scale to Fit

The Scale to Fit command fits the entire extent of the bed data into the window with a small margin around the edge. The scale is isotropic so that the map will be undistorted. The x or y extent may therefore govern. To get the best use of window "real estate", the window proportions should be similar to the area covered by the .bed data.

3.5.2 Zoom in on Point

After selecting the Zoom in on Point Command, select any point on the map by clicking on it. The scale will double and the centre will shift to the selected point.

3.5.3 Zoom in on Rectangle

Select a rectangle by pressing the mouse button down at one corner, drag the cursor to the opposite corner, holding the button, then releasing the button. The selected rectangle will be fitted to the display window. Due to the isotropic scaling, more area than was selected may be displayed in one direction or the other.

3.5.4 Zoom Out

Selecting the Zoom Out Command causes the map scale to be halved, so that the map displays twice the extent in both directions. The centre point remains the same.

3.5.5 Move Center to Point

To pan a zoomed in view, use the Center on Point command. The point selected by clicking the mouse will become the new centre point. The scale remains unchanged.

The “panning” command is also available using the keyboard. The arrow keys have been mapped as follows in the R2D_Bed environment:

⇐ key: shift the display to left
⇒ key: shift the display to the right
↑ key: shift the display up
↓ key: shift the display down

Letter keys on the other side of the keyboard have also been mapped with “panning”:

A key: shift the display to left
D key: shift the display to the right
W key: shift the display up
S key: shift the display down

3.6 Display Menu - Data Presentation Commands

Most of these commands are simple toggles. Repeated selection will cause the selection to alternate between on and off. If the current status is on, a check mark will appear beside the command on the menu.

3.6.1 Nodes

All node locations will be displayed as small black open circles. Nodal display is on, by default. The current node is shown as a red circle. A node marked for deletion is drawn with a red "X" drawn over it.

3.6.2 Breaklines

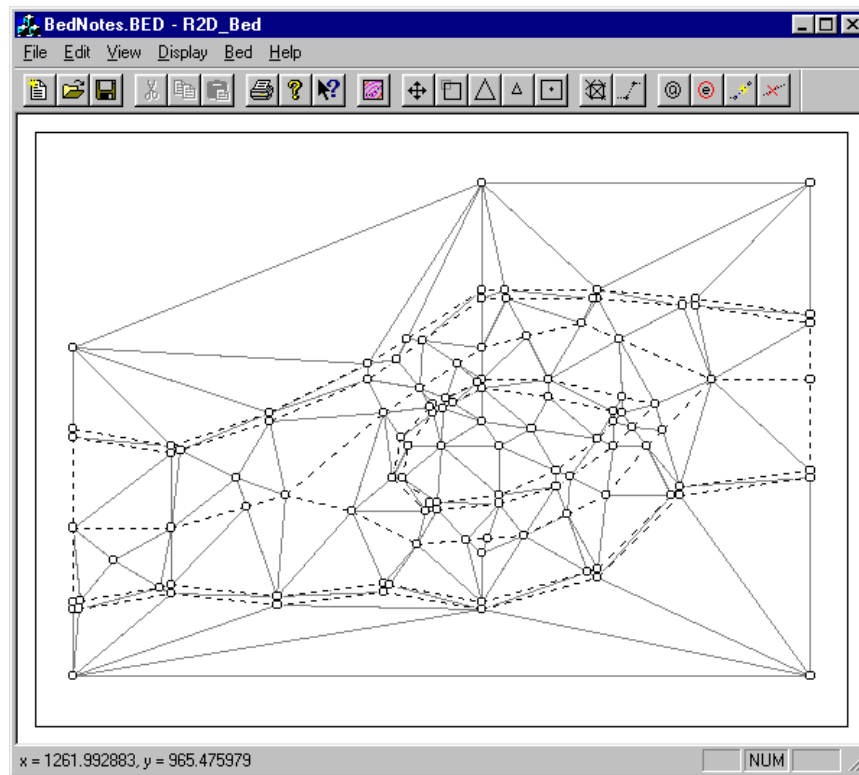
If set to on, all current breaklines will be displayed as black dashed lines. A breakline segment (line between two nodes) which is

marked for deletion will have a red "X" drawn over its midpoint. The breakline display option is off by default, but is automatically turned on when a breakline operation (define new breakline, delete breakline) is invoked.

3.6.3 Triangulation

This option displays the TIN triangles as thin, solid black lines. At all triangle vertices a node is present. This option is useful to see where breaklines might improve the spatial representation. In Figure 5, a sample .bed file is presented with the triangulation, breaklines, and nodes displayed.

Figure 5: A sample .bed file with nodes, breaklines and triangulation displayed.

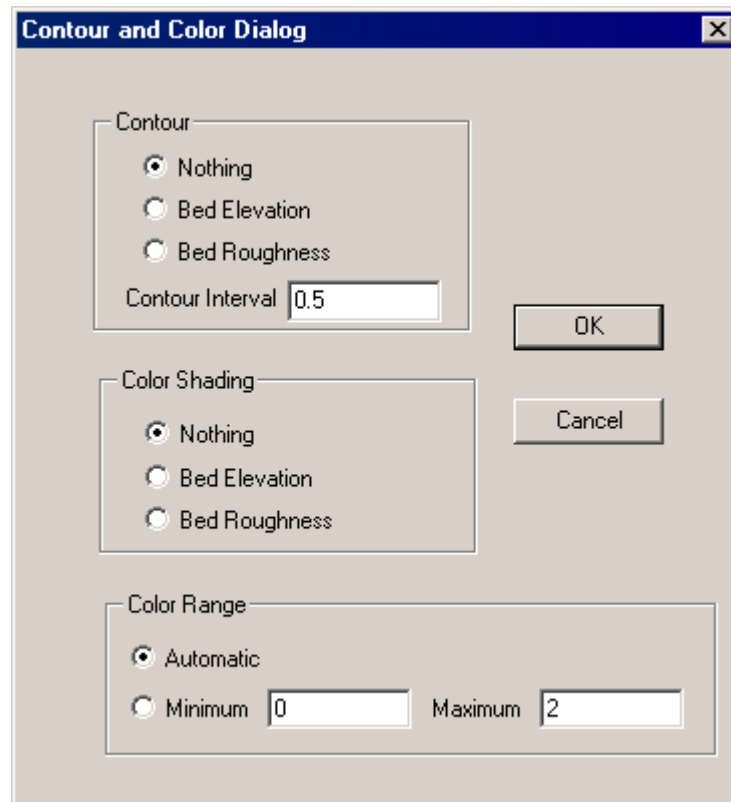


3.6.4 Contours/Colour

The Contours/Colour menu command allows the display of a contour map and/or a colour fill diagram. The parameter displayed is either the bed elevation or the bed roughness. The dialog box is

used to set the parameter for each type of drawing as shown in Figure 6. Note that the TIN must have been previously triangulated for either of these displays to work.

Figure 6: The Contour and Colour dialog box.



The contour map takes the contour interval as an input parameter. The map will be drawn with contour lines starting at the lowest even multiple of this interval and on up to the highest value present in the TIN. A sample bed elevation contour map generated by R2D_Bed is presented in Figure 7.

The colour fill display scales 14 fixed colours in a spectrum between blue (lowest) and red (highest) to represent the full range of the parameter present in the TIN. A sample bed elevation colour diagram is shown in Figure 8.

Figure 7: A sample bed elevation contour map.

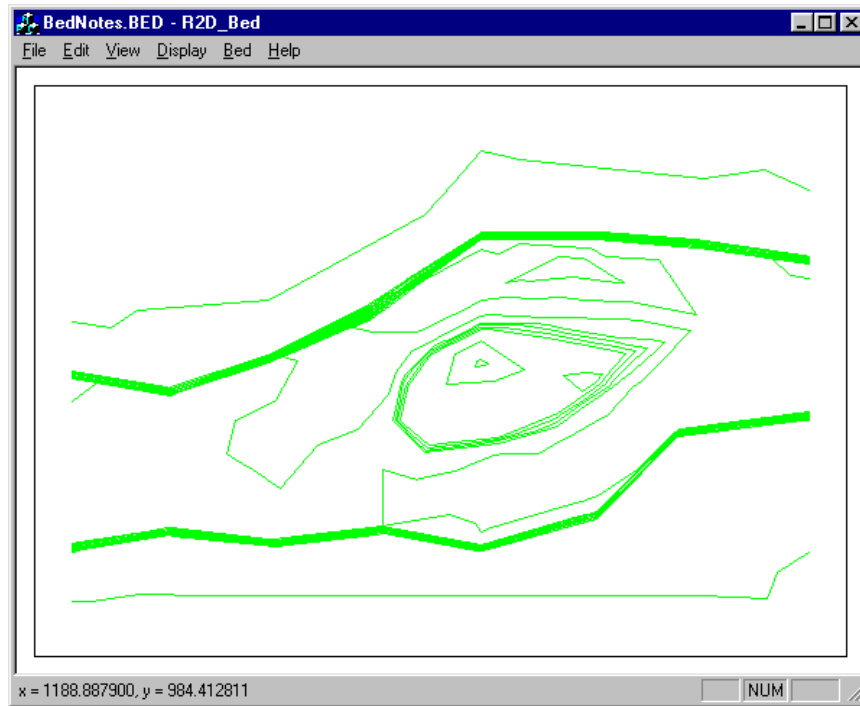
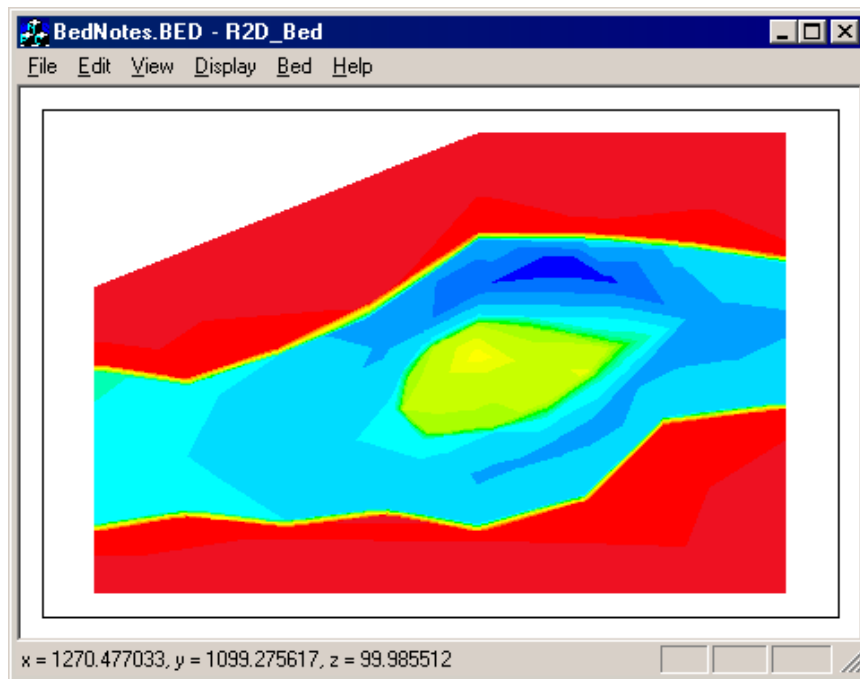


Figure 8: A sample bed elevation colour diagram.



3.6.5 Boundary

If the boundary display option is set, then the boundary segments will be highlighted as red dashed lines. This option is on by default.

3.6.6 Annotation...

The annotation Command brings up a dialog box with various options as shown in Figure 9. A diagram title may be specified. The x and y axes may be annotated with bounding box coordinates. A legend indicating the name of the displayed parameter, the horizontal scale, and a colour table is also available. While useful for final prints, these options take a significant proportion of the screen space. A sample .bed file with the all possible annotations displayed is presented in Figure 10.

Figure 9: The Annotation Options dialog box.

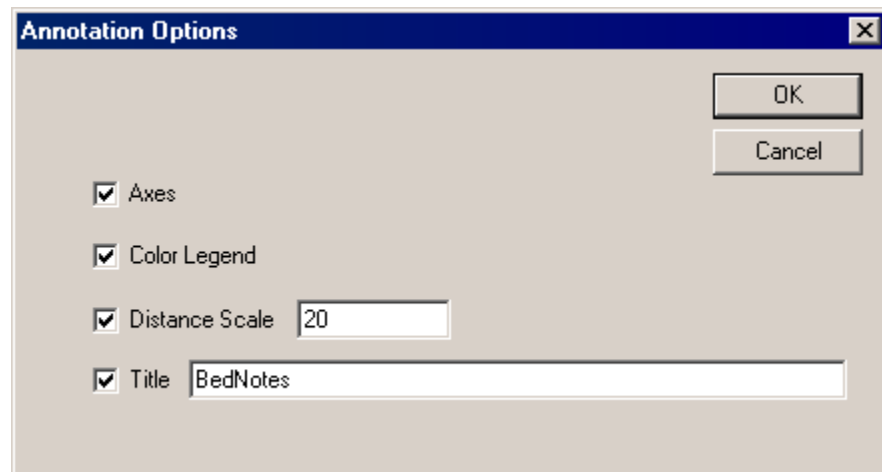
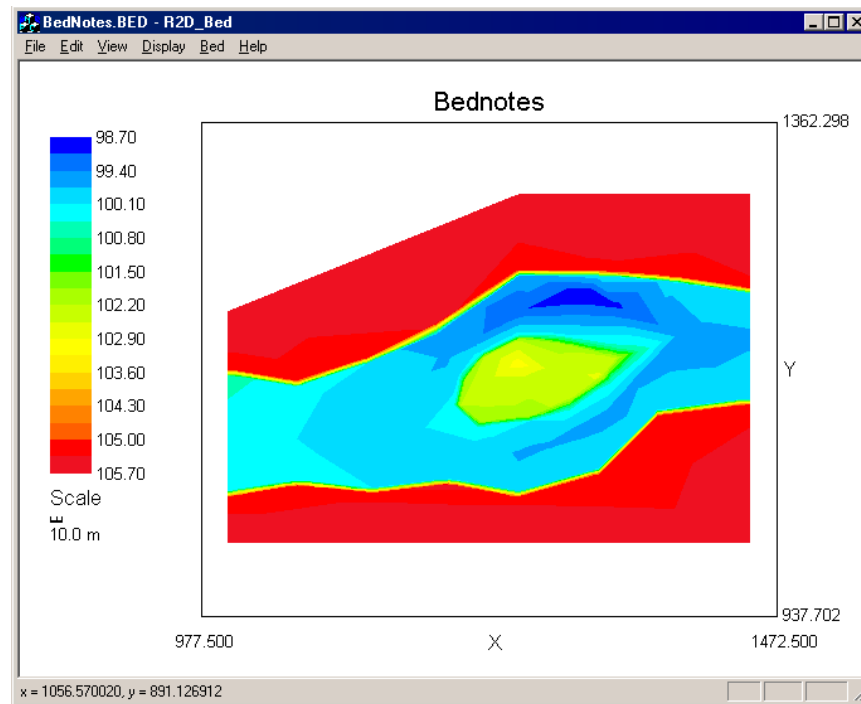


Figure 10: The appearance of R2D_Bed display annotations.



3.7 Display Menu – csv File Output Commands

3.7.1 Display -> Dump nodal csv file...

The Dump nodal csv file command is an optional output from the R2d_bed. There is one line in the csv file for every node in the mesh. Each line contains the node number, the x coordinate, the y coordinate, the bed elevation and the bed roughness for that particular node, delimited by commas. The .csv form of output is convenient for further processing of the results in a spreadsheet or GIS program.

3.7.2 Display -> Dump grid csv file...

The Dump grid csv file command is similar to the dump nodal csv file command except that the points are set on a grid. The file format is identical with one line in the csv file for point in the grid. A dialog box prompts the user for the coordinates of the area to be gridded in terms of the lower left (x1, y1) and top right (x2, y2) values. The default values are set to be just outside the domain of

the actual mesh points. Any point on the grid which is not "inside" the mesh will have negative node number and a zero parameter value assigned to both the bed elevation and the bed roughness. The point spacing value is the grid increment in both directions. The grid will start with lines at x_1 and y_1 and extend to the last grid line which is less than x_2 and y_2 .

3.7.3 Display -> Extract points to csv file...

The Extract points to csv file command is similar to the dump nodal csv file command except that the points are already defined in an existing .csv file. The input file format is identical to the output format of any of the .csv file options. This allows one to compare different meshes of the same area. A dialog box prompts the user for the input .csv file and then for the output .csv file.

3.7.4 Display -> Extract section to csv file...

The Extract section to csv file command is similar to the dump grid csv file command except that the points are set on a line defined by two endpoints. The file format is identical with one line in the csv file for point along the line. A dialog box prompts the user for the coordinates of the start (x_1, y_1) and end (x_2, y_2) points. Any point on the line which is not "inside" the mesh will have negative node number and a zero parameter value assigned to both the bed elevation and the bed roughness. The point spacing value is the increment spacing along the line. The set of points will start with a point at x_1 and y_1 and extend to the last incremented point before the end point is reached. The line may be defined in any direction. The endpoints need not be within the mesh.

3.8 Bed Menu Commands

The commands available under the Bed Menu, shown in Figure 11, allow the editing of the bed topography data. These commands allow basic triangulation and adding and edit nodes as well as defining and deleting breaklines. Boundary loops may also be cleared and set. Some of the Bed Menu commands are also accessible through short-cut icons on the toolbar, as shown in Figure 12.

Figure 11: The R2D Bed Bed Menu

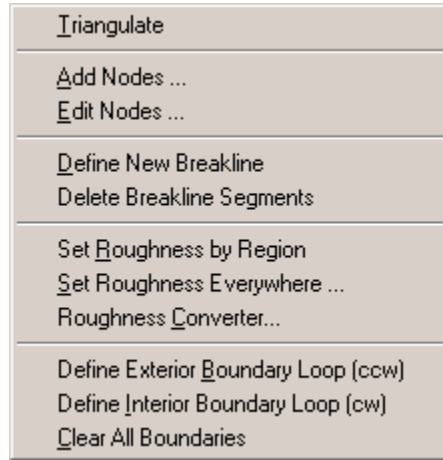
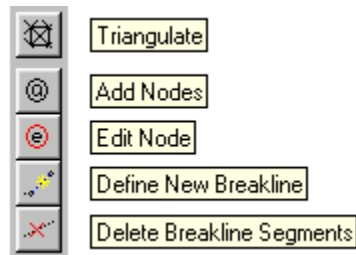


Figure 12: The Bed Menu toolbar icons.



3.8.1 Triangulate

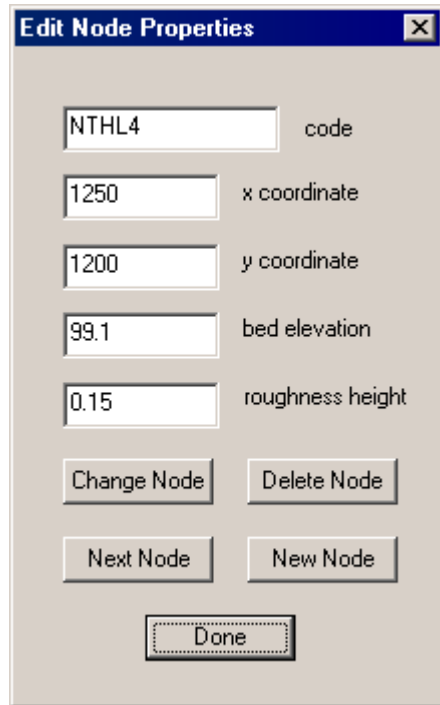
The Triangulate command clears the existing triangulation, performs a new triangulation on the node set and then incorporates the defined breaklines.

3.8.2 Add Nodes


The Add Nodes Command sets the mouse to the add nodes mode. At every point subsequently selected by the clicking the mouse, a new node will be generated. After the first node is generated, the edit node dialog box will be displayed, if it is not already on the screen. This dialog box, shown in Figure 13, allows the numerical properties of the newly generated node to be changed, including the precise position. The new node is generated with a default elevation and roughness which will both likely need to be reset.

Since the code is optional, it is not given any default name or value.

Figure 13: The Edit Node Properties dialog box.



3.8.3 Edit Nodes

The Edit Nodes Command sets the mouse to the edit nodes mode. At every point subsequently selected by clicking the mouse, the closest node will be selected. After the first node is selected, the edit node dialog box, shown in Figure 13, will be displayed, if it is not already on the screen. This dialog allows the numerical properties of the selected node to be changed. Changes take effect either when the Change Node button is clicked or when another node is selected on the map, as well as when the dialog box is closed (either by clicking the Done Button or the  box).

Through this command, it is possible to change the coordinates, bed elevation, roughness height, and the code of various nodes.

Changes to nodal properties take effect immediately but will not affect the contour/colour display until the display is redrawn, usually with a new contour/colour command.

Moving a node by changing its coordinates may cause a problem if the nodes are triangulated. If the new location moves the node across a triangle boundary, the triangulation will be corrupted and the program may hang while trying to track the mouse cursor.

3.8.4 Define New Breakline

Selecting this command starts a new breakline sequence. Breaklines can be defined in either the add nodes or edit nodes modes. The former adds new nodes as the breakline is set and the latter uses the closest existing nodes to establish the breakline. In either case, the first mouse click identifies the starting node. Subsequent mouse clicks will each cause a breakline segment to be drawn between the previous node and the newly selected node.

The breakline is incorporated into the triangulation immediately. The new breakline is first drawn as a blue dashed line. After it has been incorporated it will be redrawn as a black dashed line. Note that other breaklines may be affected (nodes inserted).

To change from using new nodes to existing nodes or vice-versa, simply select the appropriate Add Nodes / Edit Nodes command.

To start a new breakline (new starting point), reselect the Define Breakline Command.

To turn off the breakline definition, select the Delete Breakline Command twice.

3.8.5 Delete Breakline Segments

Selecting the Delete Breakline Segment puts the mouse pointer in delete breakline segment mode. Subsequent mouse clicks will mark the closest breakline segment for deletion. These breaklines will disappear when the Triangulation command is selected.

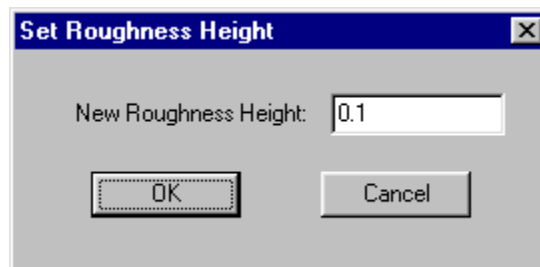
To turn breakline deletion mode off, select the Delete Breakline command again or select another command.

3.8.6 Set Roughness by Region

The bed roughness height for an irregular polygonal region can be set through this command. The points selected are not existing nor new created nodes, regardless of the add nodes or edit nodes setting. The first point selected with a mouse click will be displayed with a highlighted spot to make it easier to identify when closing the last segment. The points must be selected proceeding in a **counter-clockwise** direction around the polygon. Clicking near the starting point will close the polygon and bring up a dialog box requesting the roughness value. At this stage a value can be provided in the Set Roughness Height dialog box, as shown in Figure 14, which will be assigned to all nodes in the polygon, or the whole operation can be cancelled.

Note that scaling operations can be performed during the polygon definition, but no other data editing operations can be started until the boundary is closed.

Figure 14: The Set Roughness Height dialog box.



3.8.7 Set Roughness Everywhere

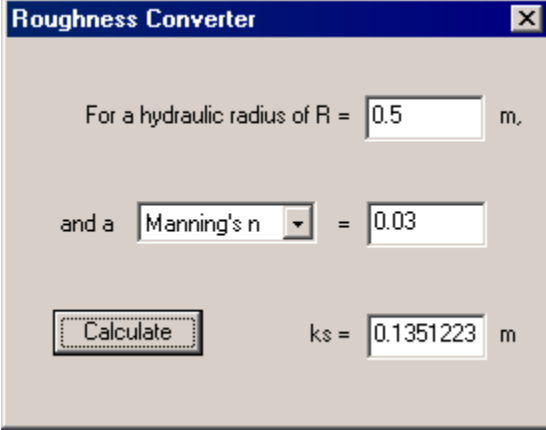
The set roughness Everywhere Command brings up the dialog box shown in Figure 14 to provide a global roughness value for the whole domain. This option is useful for setting a default or background roughness. Then local modifications using the region setting can be made.

3.8.8 Roughness Converter...

This command opens the Roughness Converter as shown in Figure 15. For a given hydraulic radius, R , the Roughness Converter will convert Manning's n to effective roughness height, k_s , or vice versa.

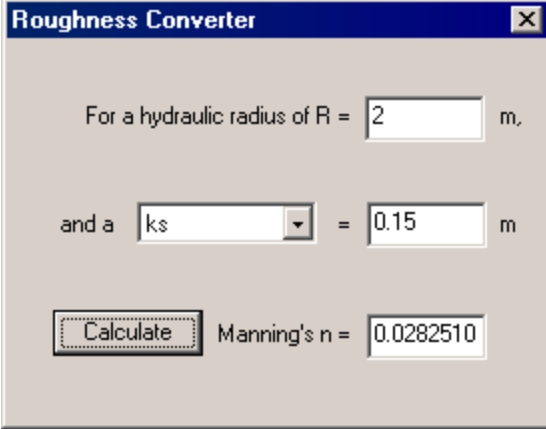
Figure 15: The Roughness Converter

Calculating k_s ...



The screenshot shows a dialog box titled "Roughness Converter" with a close button (X) in the top right corner. The text inside reads: "For a hydraulic radius of R = 0.5 m," where "0.5" is in a text input field. Below this, it says "and a Manning's n" with a dropdown menu showing "Manning's n" and a value of "0.03" in a text input field. At the bottom left is a "Calculate" button. To the right of the button, the result is displayed as "ks = 0.1351223 m", where "0.1351223" is in a text input field.

Calculating Manning's n ...



The screenshot shows a dialog box titled "Roughness Converter" with a close button (X) in the top right corner. The text inside reads: "For a hydraulic radius of R = 2 m," where "2" is in a text input field. Below this, it says "and a ks" with a dropdown menu showing "ks" and a value of "0.15" in a text input field. At the bottom left is a "Calculate" button. To the right of the button, the result is displayed as "Manning's n = 0.0282510", where "0.0282510" is in a text input field.

When calculating roughness, the program uses

$$n = \frac{R^{1/6}}{2.5\sqrt{g} \ln\left(\frac{12R}{k_s}\right)} \quad (1)$$

to evaluate Manning's n and

$$k_s = \frac{12R}{e^m} \quad (2)$$

to evaluate k_s where m is

$$m = \frac{R^{1/6}}{2.5n\sqrt{g}} \quad (3)$$

For 2D open channel flow, the hydraulic radius is can be approximated by the depth of flow to the free surface, that is

$$R = \frac{A}{P} \cong H \quad (4)$$

where A is the cross sectional area of the channel and P is the wetted perimeter of the channel at A .

3.8.9 Define Exterior Boundary Loop (ccw)

This command allows the definition of an outside bounding loop. The loop must be defined by selecting existing nodes in order in a counter-clockwise direction (inside the boundary is to the left of each new segment). The loop is closed and the command is finished when the starting node is selected for the second time.

3.8.10 Define Interior Boundary (cw)

An interior boundary loop is defined in the same manner as an exterior loop. The only difference is that the loop is defined in a clockwise order. The active area is still to left of each newly defined segment, however.

3.8.11 Clear All Boundaries

The Clear All Boundaries Command will delete all boundary definitions. Deleting individual loops or edit segments is supported at this time. To fix an error, it may be necessary to delete all boundaries and start over. Save often.

APPENDIX A

BedNotes.bed

This file is an example of a bed topography description file for use with the RiverTwoD set of programs. It illustrates a typical river modeling situation with flow splitting around an island which may be submerged at high discharges.

When this file is opened, possibly edited, and then saved in the Bed program, all comments, brackets, and formatting will be lost. The saved bed file will be simply a list of nodes and then boundary segments. The node numbers will be different but the twenty character code will be retained.

Comments may appear anywhere in this file except within the numbers defining a particular node or segment. The comments may not include numerals, minus signs, or periods. Notice that there are no periods at the end of these sentences.

Each point or node is defined with a number, x coordinate, y coordinate, bed elevation, bed roughness height and an optional user defined code. The fields should be separated by spaces or tabs and must all be on one line.

The node number may be set arbitrarily but be changed by the program. The purpose of these numbers is to provide references for any breakline segments defined independently (after all nodes have been defined).

The optional code may be up to twenty alphanumeric characters and will be retained with the node. It may be changed by the user in the edit node dialog box in the Bed program.

The first few points describe the high ground outside of the river channel. It is important to have topographic points outside the expected computational boundary to allow interpolation at the boundary.

n	x	y	z	k	Code
101	995.0	1000.0	105.6	0.50	OutsideSW
102	1455.0	1000.0	105.6	0.50	OutsideSE
103	995.0	1200.0	105.7	0.50	OutsideNW
104	1250.0	1300.0	105.6	0.50	OutsideN
105	1455.0	1300.0	105.7	0.50	OutsideNE

The next group of points represent the top of the bank of the river channel.

As this is a convenient computational boundary the north and south top of bank lines are connected with downstream and upstream sections to form a closed loop which is oriented counterclockwise. The whole group of points is enclosed in curly brackets to indicate that this is the default computational boundary.

{ Start boundary definition

South top of bank

111	1000.0	1040.0	105.2	0.50	STOB1
112	1060.0	1050.0	105.1	0.50	STOB2
113	1125.0	1043.0	105.3	0.50	STOB3
114	1190.0	1051.0	105.4	0.50	STOB4
115	1250.0	1040.0	105.3	0.50	STOB5
116	1320.0	1060.0	105.1	0.50	STOB6
117	1370.0	1110.0	105.2	0.50	STOB7
118	1450.0	1120.0	105.3	0.50	STOB8

Outflow section

119	1450.0	1125.0	99.9	0.15	OUT1
120	1450.0	1180.0	99.7	0.15	OUT2
121	1450.0	1215.0	100.1	0.15	OUT3

North top of bank

122	1450.0	1220.0	105.3	0.50	NTOB1
123	1380.0	1230.0	105.2	0.50	NTOB2
124	1320.0	1235.0	105.3	0.50	NTOB3
125	1250.0	1235.0	105.2	0.50	NTOB4
126	1180.0	1190.0	105.4	0.50	NTOB5
127	1120.0	1160.0	105.1	0.50	NTOB6
128	1060.0	1140.0	105.2	0.50	NTOB7
129	1000.0	1150.0	105.2	0.50	NTOB8

Inflow section

130	1000.0	1145.0	100.6	0.15	IN1
131	1000.0	1090.0	100.2	0.15	IN2
132	1000.0	1045.0	100.4	0.15	IN3

} End boundary definition

The next two groups of points represent the bottom of the south and north river channel banks respectively. These are separate lines which mostly parallel the corresponding tops of bank. As these are not loops, they are grouped together with round brackets.

(south bottom of bank
141 1060.0 1055.0 100.2 0.15 SBOB1
142 1125.0 1048.0 100.1 0.15 SBOB2
143 1190.0 1056.0 100.0 0.15 SBOB3
144 1250.0 1045.0 100.1 0.15 SBOB4
145 1320.0 1065.0 100.1 0.15 SBOB5
146 1370.0 1115.0 99.9 0.15 SBOB6
)

(north bottom of bank
151 1380.0 1225.0 99.8 0.15 NBOB1
152 1320.0 1230.0 99.9 0.15 NBOB2
153 1250.0 1230.0 99.6 0.15 NBOB3
154 1180.0 1180.0 99.4 0.15 NBOB4
155 1120.0 1155.0 100.1 0.15 NBOB5
156 1060.0 1135.0 100.2 0.15 NBOB6
)

The next two groups of points define the river channel thalweg The first is complete and passes to the north side of the island The second is just the branch that passes to the south of the island Later, when additional breakline segments are defined these will be connected together and to the inflow and outflow sections

(north thalweg
161 1060.0 1090.0 100.1 0.15 NTHL1
162 1130.0 1110.0 99.9 0.15 NTHL2
163 1190.0 1160.0 99.7 0.15 NTHL3
164 1250.0 1200.0 99.1 0.15 NTHL4
165 1310.0 1215.0 98.7 0.15 NTHL5
166 1390.0 1180.0 99.6 0.15 NTHL6
)

(south thalweg
171 1170.0 1100.0 100.1 0.15 STHL1
172 1210.0 1080.0 99.9 0.15 STHL2
173 1275.0 1085.0 99.7 0.15 STHL3
174 1325.0 1110.0 99.6 0.15 STHL4
175 1350.0 1140.0 99.7 0.15 STHL5
)

The next two sets of points represent the island in the middle of the channel The first loop is the toe or bottom of the island bank Since this is a closed loop, square brackets are used to group the points

[Toe of island bank

181	1195.0	1120.0	100.2	0.15	IBOB1
182	1215.0	1100.0	100.4	0.15	IBOB2
183	1260.0	1105.0	100.1	0.15	IBOB3
184	1295.0	1115.0	100.3	0.15	IBOB4
185	1330.0	1140.0	100.5	0.15	IBOB5
186	1355.0	1165.0	100.7	0.15	IBOB6
187	1290.0	1180.0	100.1	0.15	IBOB7
188	1250.0	1180.0	100.2	0.15	IBOB8
189	1220.0	1165.0	100.2	0.15	IBOB9
190	1200.0	1145.0	100.1	0.15	IBOB10

]

The top of the island bank may or may not be considered a boundary The points are given in a clockwise circuit as appropriate for an internal boundary For a noflow boundary use curly brackets For no boundary at all use square brackets In the latter case flow over the top of the island will occur for high discharges or high downstream water surface elevations while it will be dry for low flow situations

{ Crest of island bank

210	1205.0	1140.0	102.1	0.50	ITOB1
209	1220.0	1160.0	102.2	0.50	ITOB2
208	1250.0	1175.0	102.2	0.50	ITOB3
207	1290.0	1170.0	102.1	0.50	ITOB4
206	1335.0	1160.0	102.2	0.50	ITOB5
205	1320.0	1144.0	102.6	0.50	ITOB6
204	1295.0	1125.0	102.3	0.50	ITOB7
203	1260.0	1110.0	102.1	0.50	ITOB8
202	1218.0	1105.0	102.1	0.50	ITOB9
201	1201.0	1120.0	102.2	0.50	ITOB10

}

Scattered points in the river channel

221	1025.0	1070.0	100.1	0.15	C1
222	1100.0	1120.0	100.0	0.15	C2
223	1250.0	1075.0	99.7	0.15	C3

Scattered points on the top of the island

231	1250.0	1155.0	103.1	0.50	I1
232	1280.0	1150.0	102.4	0.50	I2
233	1225.0	1140.0	102.4	0.50	I3
234	1260.0	1140.0	102.3	0.50	I4

The end of the list of nodes is indicated with a period, which may be part of a comment

no more nodes.

After the end of the node list, additional breakline segments can be defined. Each one has an identifying number and the numbers of the two nodes which define the segment. These nodes must have been defined previously somewhere in the node list, even as part of a breakline.

connect south bottom of bank to inflow and outflow sections

101 132 141

102 146 119

connect north bottom of bank to inflow and outflow sections

103 130 156

104 151 121

connect thalweg to inflow and outflow sections

105 131 161

106 166 120

connect south branch of thalweg to north

107 162 171

108 175 166

Another period is necessary to end the breakline segment list

no more breakline segments.