2001-483-363

Habitat Modeling Tool for Instream Flow Project

By Venkatesh Merwade and David R. Maidment

Submitted to the Texas Water Development Board
In fulfillment of Grant # 2001-483-363

October 2001

Center for Research in Water Resources
J. J. Pickle Research Campus
University of Texas at Austin
Austin TX 78712 – 4497

Habitat Modeling Tool for Instream Flow Project

By Venkatesh Merwade and David R. Maidment

October 2001

Table of Contents

Chapter one: Introduction

1.1 Introduction

The Center for Research in Water Resources (CRWR) and the Texas Water Development Board (TWDB) have a mutual interest in the development of GIS tools to solve water resources problems. The TWDB has a continuing need for better tools to complete engineering tasks related to water resources including fish habitat modeling for Instream Flow studies. Instream flow is the minimum flow necessary to maintain species habitat in streams. When flow is diverted from a stream, it affects the species habitat and it is necessary to know how the diversion of flow, or a change in flow due to other reasons, affects the habitat in the streams. TWDB has in-house capabilities to do habitat modeling for instream flow studies using a 2D hydrodynamic model, Surface Water Management System and ArcView 3.2. Since the latest GIS software, ArcGIS, has more capabilities for customization and development of tools as compared to ArcView 3.2, TWDB wishes to upgrade its current methodology for Habitat Modeling using ArcGIS with some additional functionality.

1.2 Background

As instream flow is the minimum flow necessary to maintain species habitat in streams, it is necessary to know, how different flowrates affect species habitat in streams. For example, how much flow can be diverted from a stream into a reservoir without affecting the species habitat? In order to answer this question a procedure is developed to model the habitat species using GIS. Hydrodynamic conditions in streams play a major role in determining the species habitat. Thus, there are two components involved in the process of modeling species habitat namely, hydrodynamic modeling and habitat modeling using GIS. The hydrodynamic modeling requires bathymetric data of the stream and the habitat modeling requires a criterion that will define the type of species depending on the velocity and depth at any location in the stream. The hydrodynamic modeling process begins with the collection of bathymetric data, which is done using a Echosounder (instrument that records depth) and Global Positioning System (GPS). Thus, the Echosounder records the depth and GPS gives the geographic location (latitude, longitude) of the point at which the depth is recorded. The bathymetric data is then used to run hydrodynamic simulations using a 2D Hydrodynamic Model, Surface Water Modeling System (SMS). The model is run for different flows to get the velocity and depth at different points located at the intersection of 1m x 1m mesh. Thus the hydrodynamic simulations produce data for different points along the stream that have velocity and depth as its attributes besides other attributes including the spatial attributes. These points can be projected in GIS as a shape file.

In hydrodynamic modeling, two different habitats are modeled, MesoHabitat and MicroHabitat. The MesoHabitat species are classified into six different types namely, Deep Pool, Medium Pool, Shallow Pool, Run, Slow Ruffle, and Fast Ruffle. MicroHabitat species are classified usually into ten types by collecting number of fish samples at random locations along with the measurement of velocity and depth at those locations. These ten types of MicroHabitat species are named as Group One, Group Two and so on. The criteria for the classification of the species and other details are beyond the scope of this report and are therefore not included in this report. The final product of this biological study is a table as shown in Appendix A, which specifies different species and a range of velocities and depths that are required for their habitat at 50% confidence interval. Thus the GIS tool that is developed in the present study models

the species habitat by using the results from SMS as well as from the biological study. Since the habitat model is developed to work with the raster data, the first step involves converting the point data obtained from SMS into velocity and depth grids. Then using the habitat table, the GIS tool picks up only those points form the grids that satisfy the depth and velocity criteria for a particular species and display the results in map.

1.3 Objectives and Study area

The objectives of current research are

- Learn how to customize ArcGIS using Visual Basic, to work with raster data using the Spatial Analyst extension

- Development of user friendly and more secure interfaces so that this tool is easy to use for people who are new to ArcGIS

- finally, to apply the ArcGIS Habitat Modeling Tool to the study area

The study site is a stretch of Guadalupe River near Seguin, Texas as shown in the following Figure 1.1,
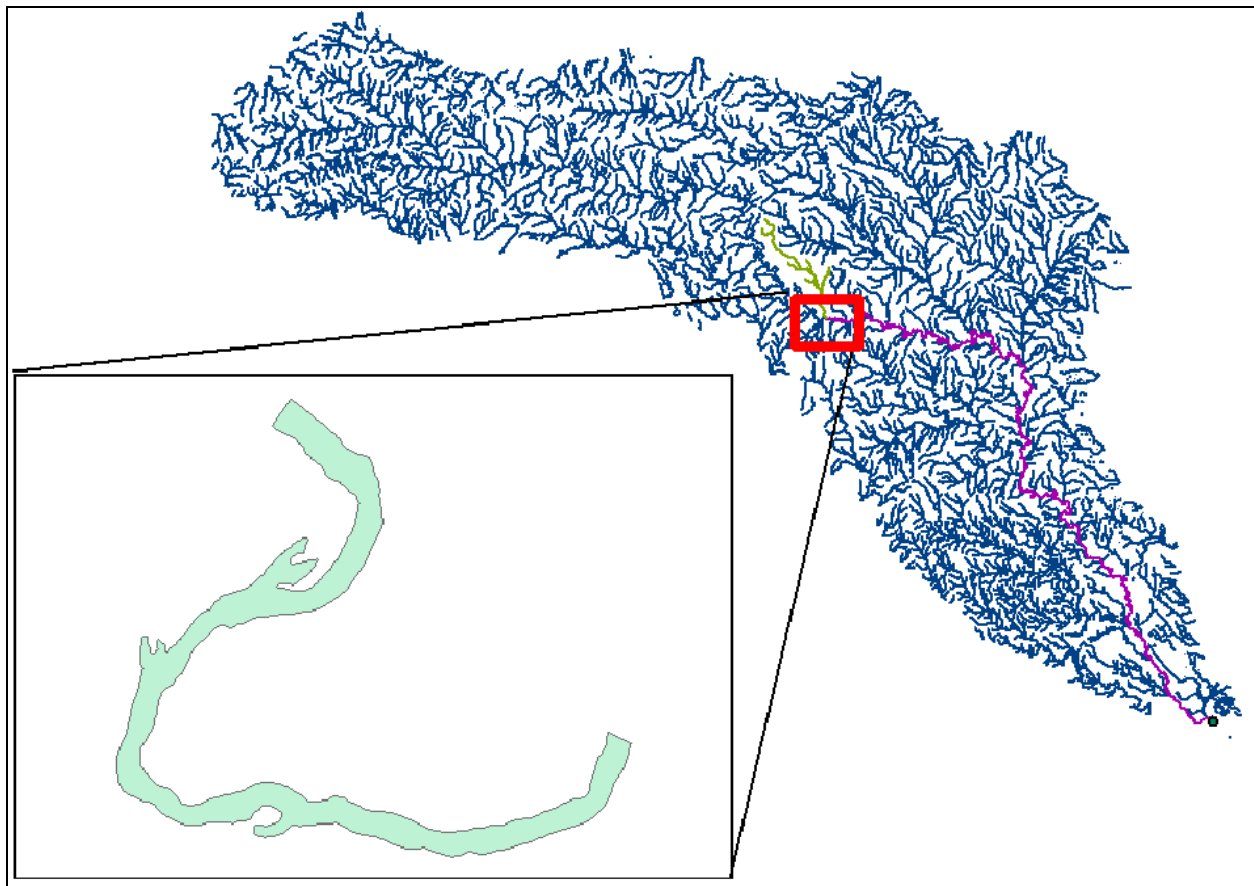

Figure 1.1: Study Site (a stretch of Guadalupe River)

The data supplied by TWDB for the study site and results from the SMS of that site (velocity and depth grid), are used in this study.

1.3 About this report

This report presents the ArcGIS Habitat Modeling Tool, different options available with the tool and functionality of each option. All the functionalities are explained with corresponding screen shots. Keeping in mind the need of potential users of the tool, the report is formulated in such a way that it can also be used as a user manual to apply the tool for habitat modeling. The report is divided into four chapters, the second chapter deals exclusively with the habitat modeling tool and the third chapter deals with Texas Rainfall Runoff Model (TxRR). The third chapter deals only with the new interface that has been developed for the TxRR and it is continuation of the earlier report submitted by CRWR in April 2001 (Perales et al., 2001) The fourth chapter contains conclusions from the current research work. This report is also accompanied by a CD that contains the Habitat Modeling Tool and a folder named Habitat. The habitat folder contains an ArcGIS file named sample.mxd, along with the data to use the tool. In order to run the tool, the user has to copy the habitat folder on c:\ as shown in Figure 1.2, and open sample.mxd file. The procedure to use the tool is explained in subsequent chapters.
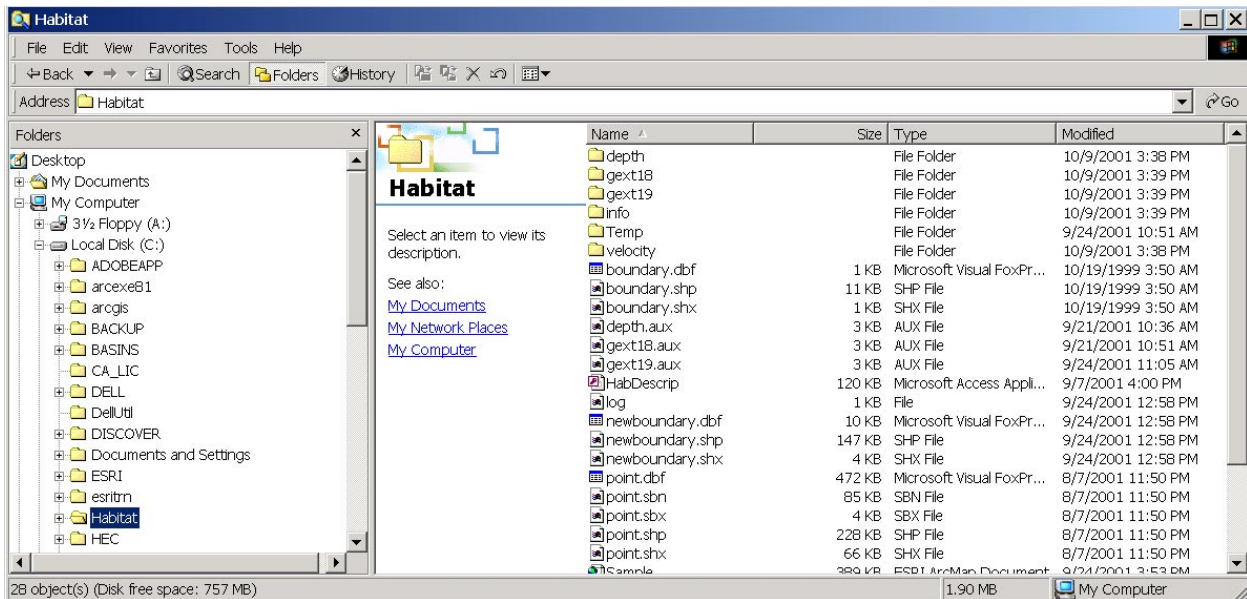

Figure 1.2: Location of Habitat folder on c:\

Chapter Two: Habitat Modeling Tool

2.1 Introduction to Habitat Modeling Tool (HMT)

The Habitat Modeling Tool is developed in Visual Basic using ESRI Object library and is compiled as Dynamic Link Library (DLL). Some Visual Basic terms are explained in Appendix A to help the reader to understand the terminology used in this report. The ESRI object library allows the user to use all the interfaces that are used to run an ArcGIS application. Thus the HMT uses, besides other interfaces, the Spatial Analyst interface to work with grid data. The TWDB_Habitat_m.dll has three functionalities embedded in it and they are

1. Raster analysis
2. Micro and MesoHabitat analysis
3. Delete Grid

Raster Analysis

The raster analysis functionality is developed to perform some initial analysis with the point data and produce the velocity and depth grid. The raster analysis tool uses one point layer, which contains all the points with velocity and depth, besides other data, as its attributes and one polygon layer which cover the area of interest. The raster analysis tool can be used to produce grid for any single attribute of the point layer. This grid is then clipped for the area of interest using the polygon layer. This tool is explained in detail in later sections.

ID	Species	Sp Code	50% MinD	50% MaxD	50% MinV	50% MaxV
1	Group 1	Group 1	1.5	2.7	1.5	2.9
2	Group 2	Group 2	0.9	1.7	0.9	2.3
3	Group 3	Group 3	0.5	1.2	0.6	2
4	Group 4	Group 4	0.6	1.2	1.6	2.3
5	Group 5	Group 5	1.8	4.6	0.3	1.6
6	Group 6	Group 6	4.3	6.5	0.5	0.9
7	Group 7	Group 7	1.5	3.3	0.1	1.2
8	Group 8	Group 8	1.1	10	0.01	0.9
9	Group 9	Group 9	0.5	2.1	0.4	1.6
10	Group 10	Group 10	0.3	1.5	0.01	0.8

Table 2.1: Classification of MicroHabitat species for different velocities and depths.

50% MinD = Minimum depth with 50% confidence interval
50% MaxD = Maximum depth with 50% confidence interval
50% MinV = Minimum velocity with 50% confidence interval
50% MaxV = Maximum velocity with 50% confidence interval

Micro and Meso Habitat Analysis

This tool calculates the MesoHabitat and MicroHabitat grids using the velocity and depth grids. The working of this tool is similar to the tool developed by Mark Wentzel in Avenue to work with ArcView 3.2. As explained earlier, the MesoHabitat species are classified into six types by using the velocity and depth information at different locations in the stream. The MicroHabitat analysis is carried out based on a table shown in Table 2.1, that specifies maximum and minimum velocities and depths for different species. The user has to specify the type of species, and the program queries the table, and finds out the range of velocities and depths for that particular species. Then using the velocity and depth grid, the program selects only those cells that satisfy the velocity and depth criterion. This tool is explained in detail in later sections.

Delete Grid

This is a general tool that is used to delete the intermediate grids that are produced during the species habitat analysis. This tool is explained in detail in later sections.

2.2 Working with the Habitat Modeling Tool

In order to work with the tool, it has to be registered with ArcMap and the procedure for registering the DLL is explained in subsequent section.

Registering the DLL

The habitat modeling code is compiled into a DLL and is named as **TWDB_Habitat_m.dll.** To register the DLL, start ArcMap and choose Customize from the Tools menu. Once clicked on customize, the window as shown in Figure 2.1 appears.
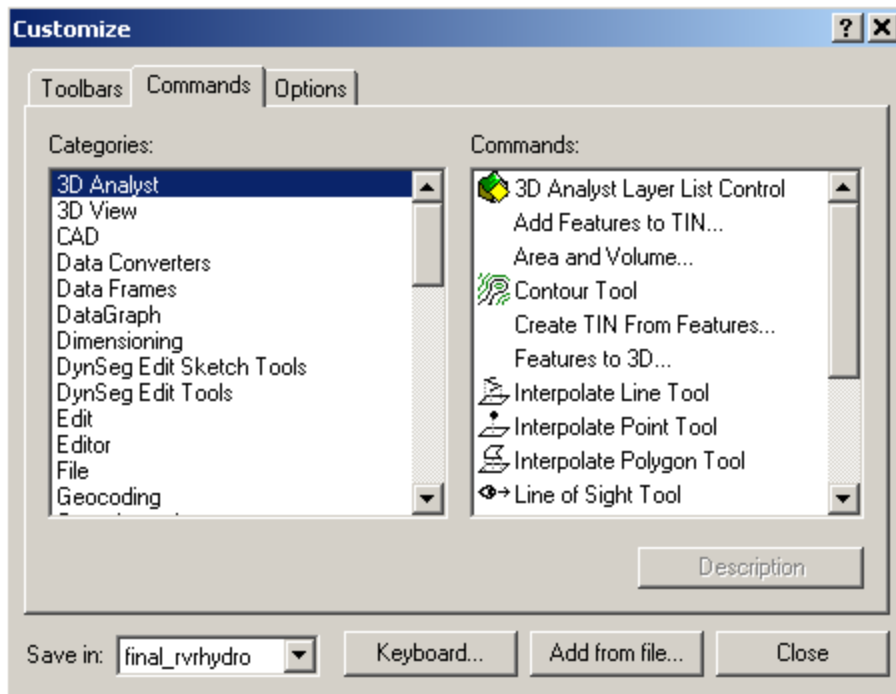
Figure 2.1: Customize window in ArcMap

In the Save in Combo Box, there are two options available. The customization can either be saved in the working file or it can be save in normal.mxt. If it is saved in the working file then the tool is available only within that file and if it is saved in normal.mxt then the tool becomes available to all the files opened in ArcMap.
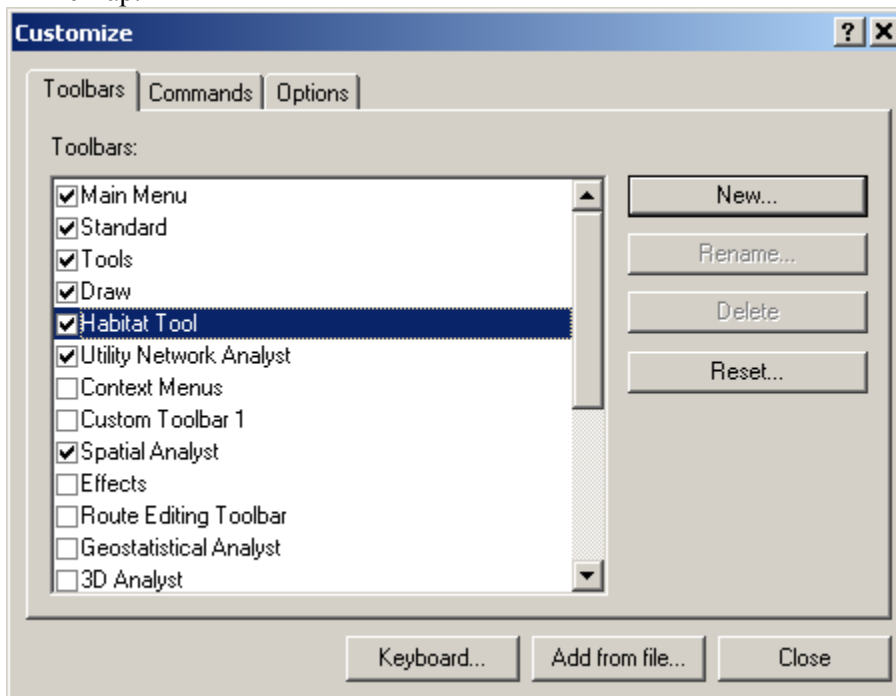
Figure 2.2: Customize window in ArcMap after registering the TWDB_habitat_m.dll

Once this is done then click Add from file. Browse to the compiled DLL, TWDB_Habitat_m.dll, and click Open. The Added Objects dialog shows what components were added. Click OK. Then in Toolbars category, a toolbar named Habitat Tool appears as shown in Figure 2.2. Click on the new toolbar and it appears on the screen as shown in Figure 2.3.
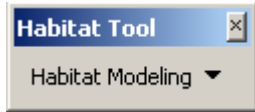

Figure 2.3: Habitat Modeling Toolbar

Drag this new toolbar to the existing main toolbar and it is available to work. There are three options available under the Habitat Modeling menu namely, Raster Analysis, Micro and MesoHabitat, and Delete Grid as shown in Figure 2.4.
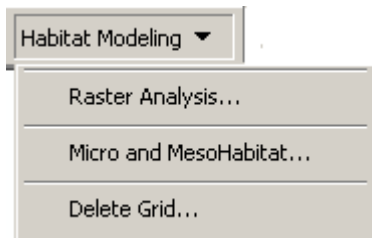

Figure 2.4: Options available with Habitat Modeling Toolbar

Each of these options is discussed in detail in the following sections.

Raster Analysis

Raster analysis option comes with a basic functionality that is needed to perform, before running the Habitat Modeling analysis. It is used to interpolate the point data to create the velocity and depth grid. In order to run this interface the map should contain at least one point layer and one polygon layer. The point layer is used to interpolate the point data and create a grid. The grid is then clipped to the selected polygon to get a grid only for the area enclosed by the polygon. So basically, the polygon is the boundary of the point layer. Once the Habitat folder from the CD is copied in c:\, the point and polygon layer can be added from c:\Habitat\Point.shp and c:\habitat\boundary.shp respectively as shown in Figure 2.5.
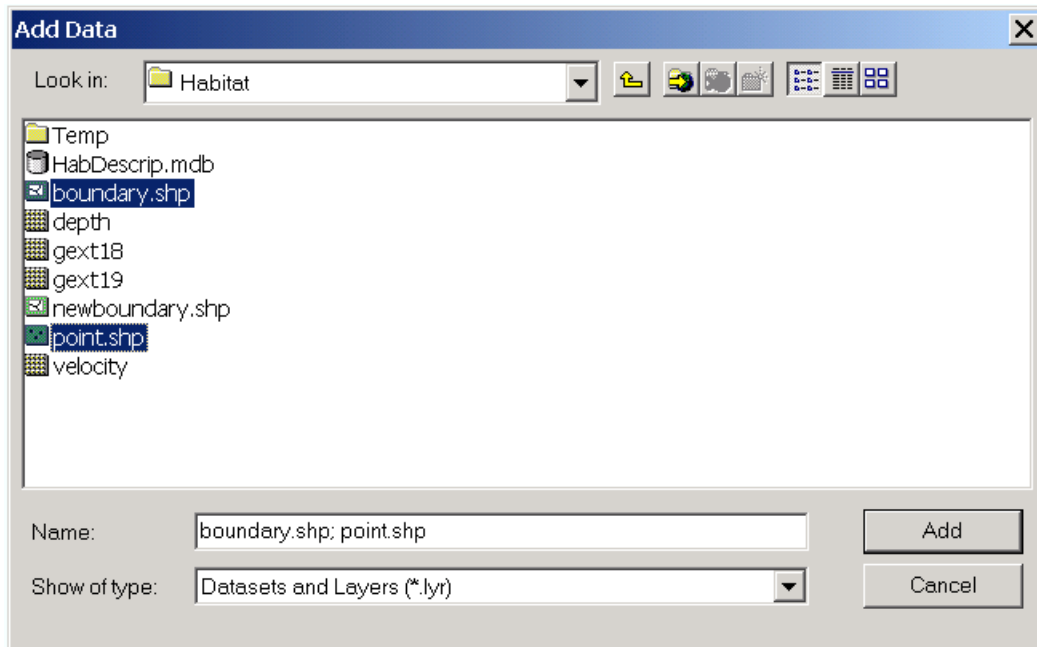
Figure 2.5: Add Data dialog box in ArcMap

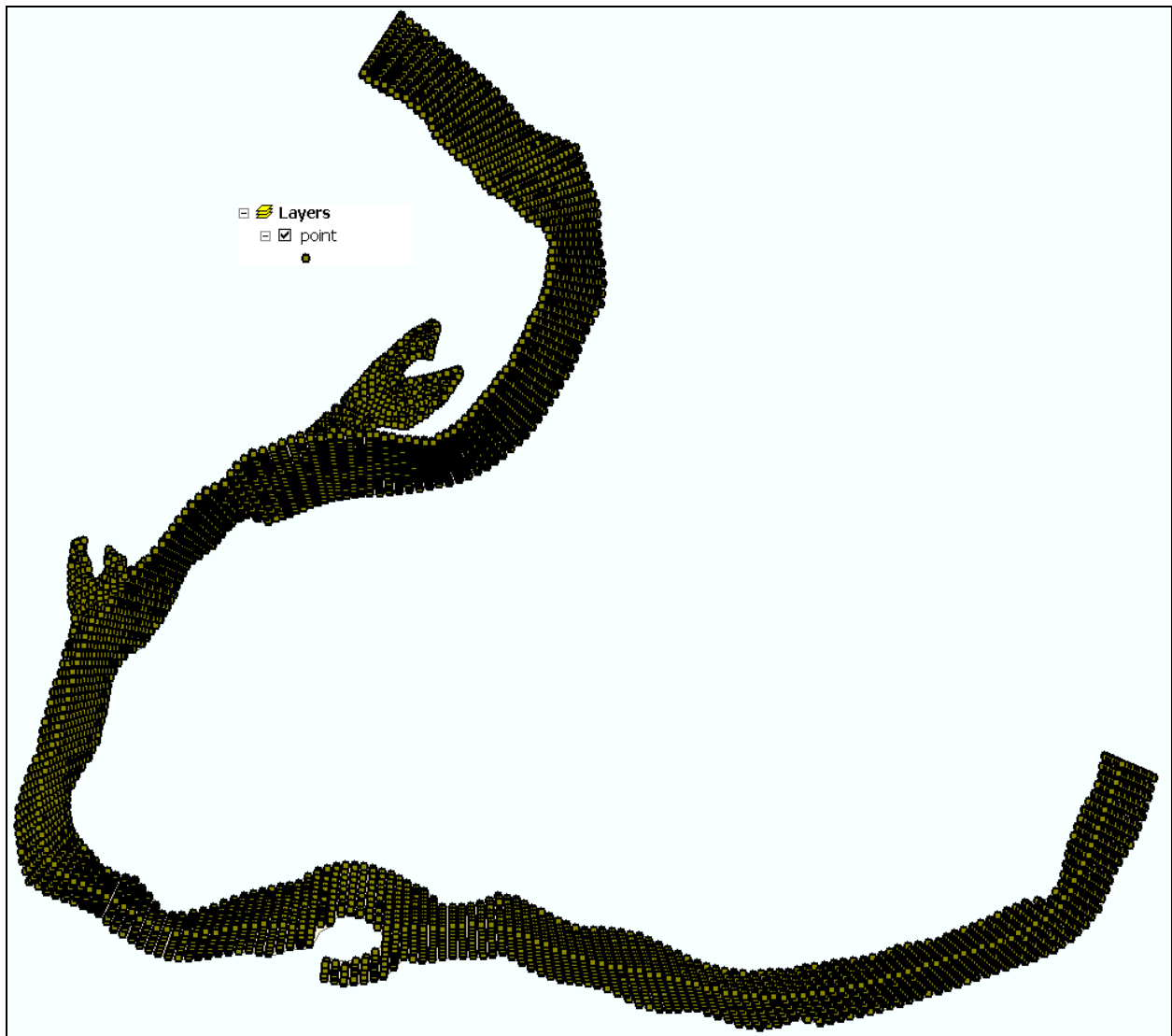The ArcMap view after the addition of point layer, point.shp is shown in Figure 2.6.

Figure 2.6: ArcMap view with point.shp

The ArcMap view after addition of polygon layer, boundary.shp is shown in Figure 2.7 and the Raster Analysis interface is shown in Figure 2.8.

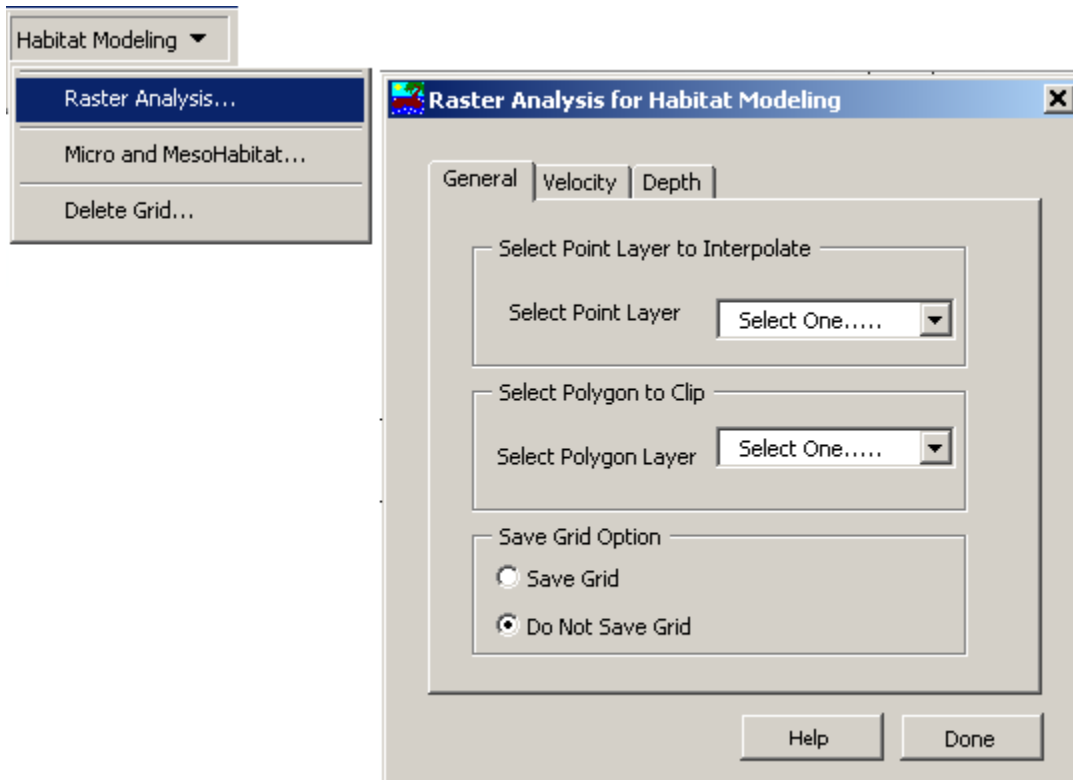Figure 2.7: ArcMap view with boundary.shp

Figure 2.8: Raster Analysis Interface

The Raster Analysis interface is a multipage interface with three pages in it namely, General, Velocity and Depth. The general page has three functionalities namely, selection of point layer, selection of polygon layer and save option. The user has to select the point layer (point.shp) to be interpolated from the select point layer combo box. This Combo Box does not appear, if there is no point layer present in the current map. The select polygon layer is used to select the necessary polygon layer (boundary.shp) for the selected grid. Again this Combo Box does not appear, if there is no polygon layer present in the map. After selecting the point layer, polygon layer and save option, click on the velocity page. The velocity page is shown in Figure 2.9.
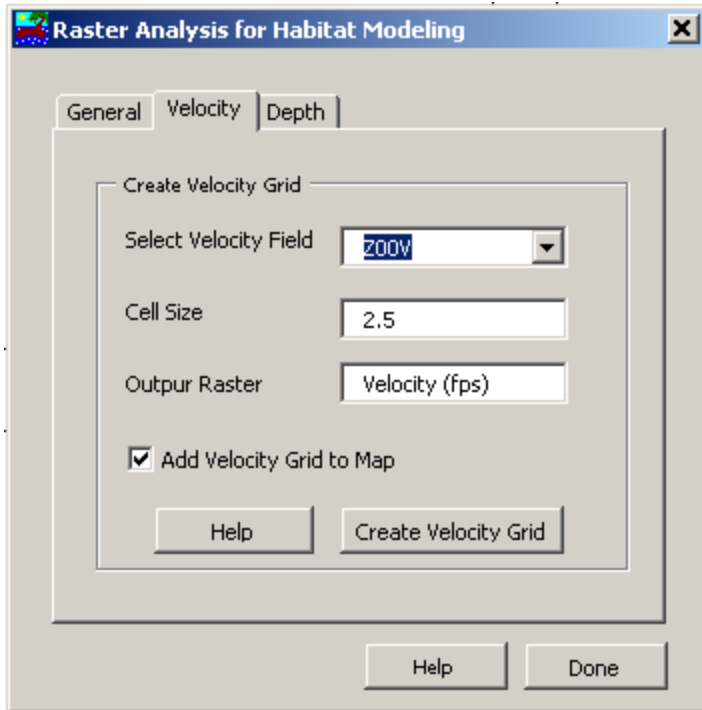
Figure 2.9: Velocity page in Raster Analysis Interface

The velocity page contains one Combo Box and two Text Boxes. The Combo Box is for selecting the attribute of the point layer, selected in general page that is interpolated to get the velocity grid. In other words, an attribute that represents velocity has to be selected. Cell size is the size of cells of the output grid. Output raster is the name of the output grid. It is important to know that this is not the name of the file, but just a name as it appears in the table of content window in ArcMap. It is recommended not to change this name, Velocity (fps), as this will be explained later in the Habitat Modeling interface. If the Add Velocity Grid to Map box is not checked then the raster is not added to the map and it is saved as c:\Habitat\temp\ raster** . Here, ** represents a number. All the analysis is done only after Create Velocity Button is pressed and the velocity grid as shown in Figure 2.10 is added in ArcMap.
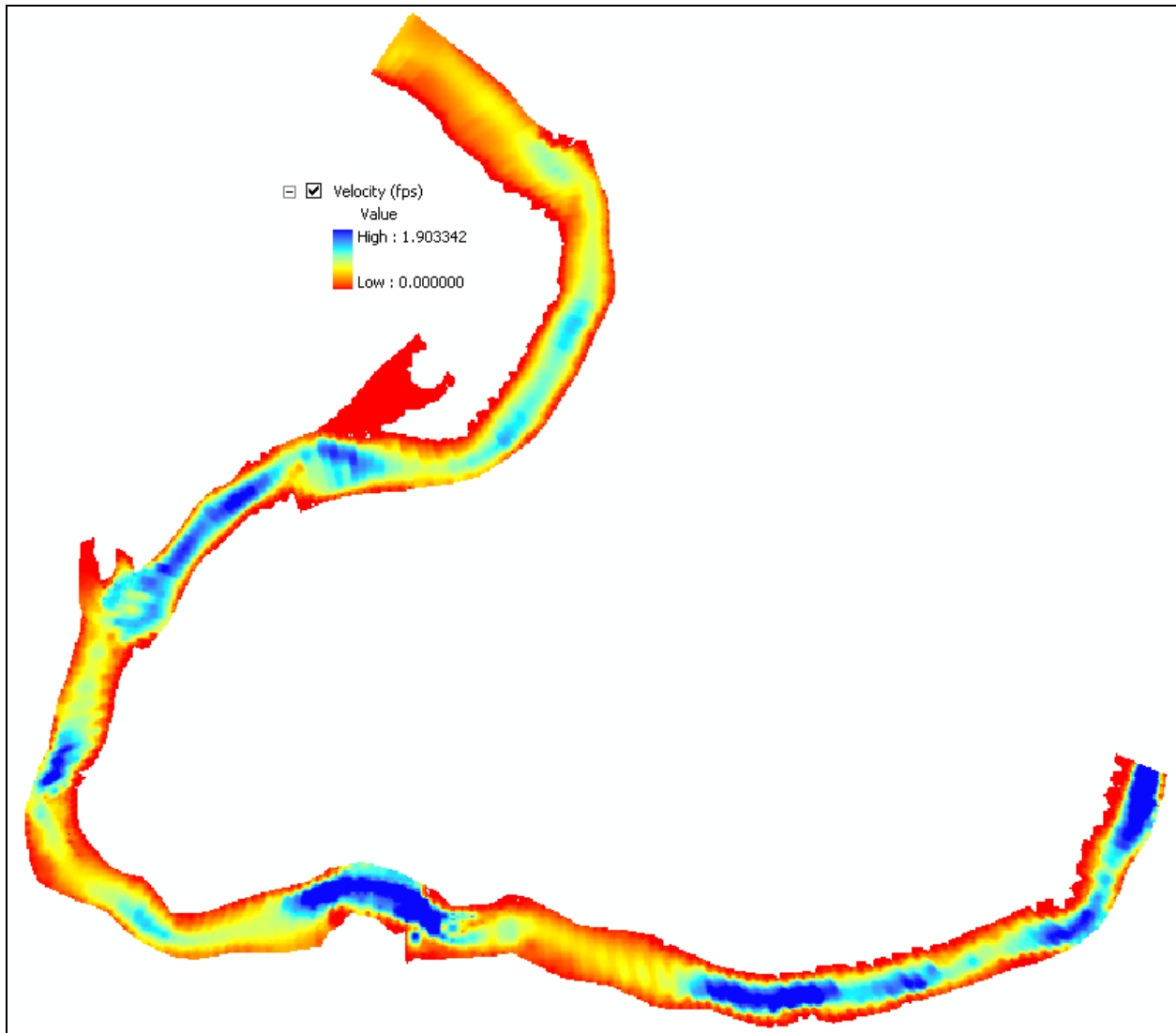
Figure 2.10: Velocity grid in ArcMap

The Depth page is shown in Figure 2.11. All the setup for this page is similar to that of velocity page. The only difference is the selection of depth field from the Combo Box and the name of output raster. Again it is recommended to not to change the output raster name and if the add depth grid to map is not checked, the raster is not added to the map and it is saved as c:\Habitat\temp\raster**. The ArcMap view after the depth grid is added is as shown in Figure 2.12.

Figure 2.11: Depth page in Raster Analysis Interface
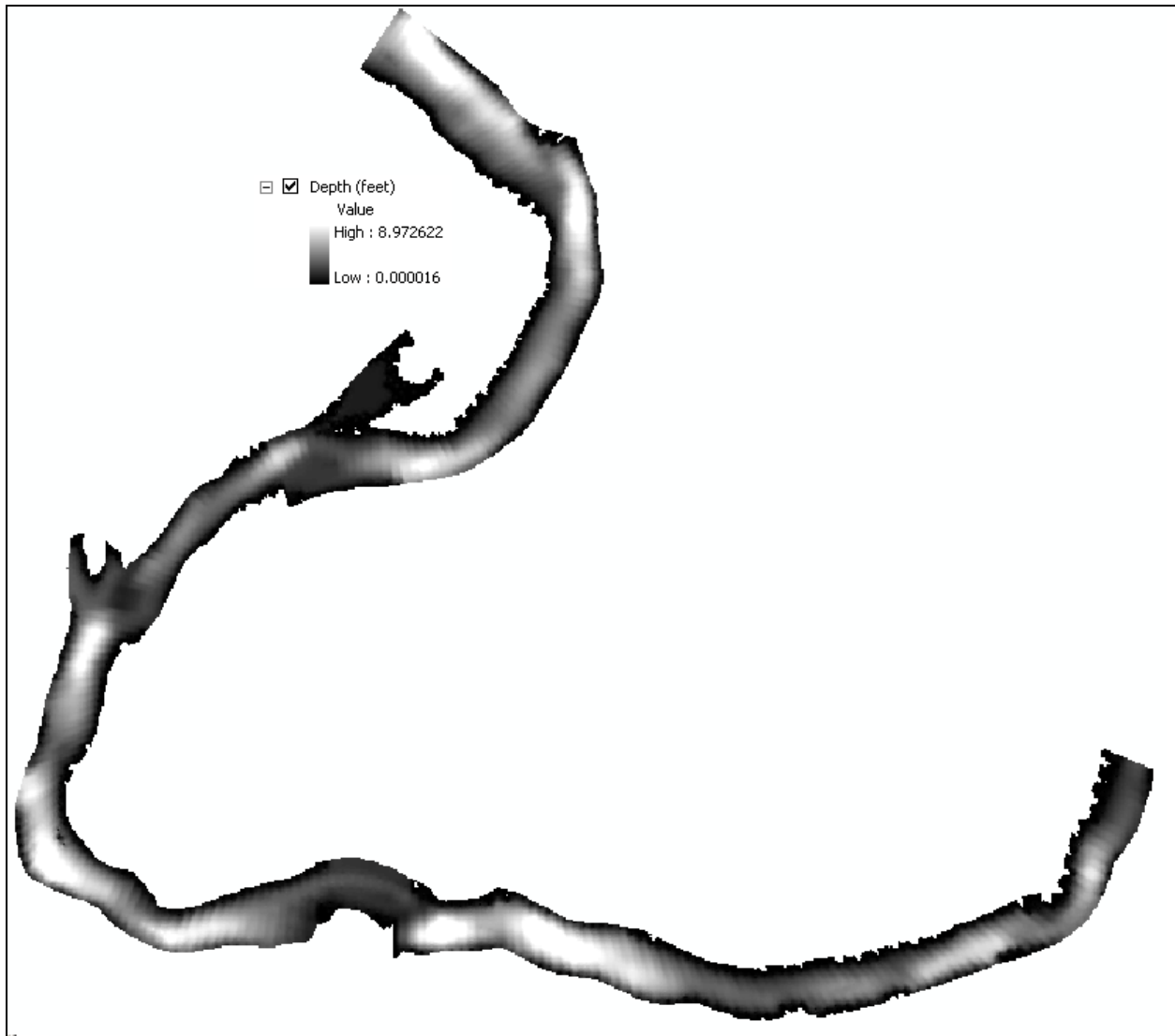
Figure 2.12: Depth grid in ArcMap

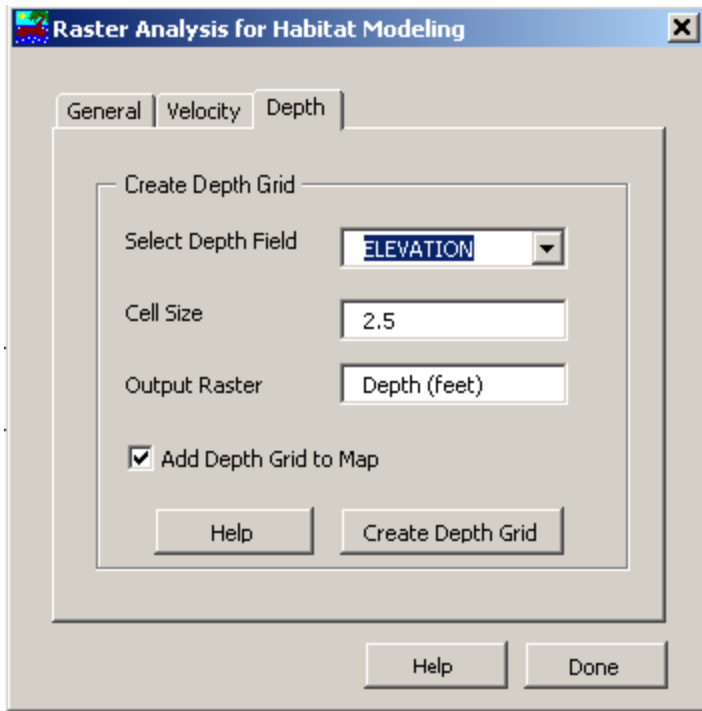If the Save Grid option is selected in the general page, then a Dialog Box as shown in Figure 2.13 appears and the user can select the output path and the name of the output grid. If the Save Grid option is not selected, all the grids are saved by default in c:\Habitat\temp with raster** name. It is advised to save the outputs every time otherwise it is difficult to find the output in c:\Habitat\temp, because during the calculations a number of grids are created and saved in c:\Habitat\temp with raster** name and it is difficult to find out which is the final one. If it is not saved, then it is always easy to find the name and path of the final output from the grid properties in ArcMap. This is done by right clicking on the grid name in the table of content window. When all the analysis is done the interface window is closed by clicking on the Done button.
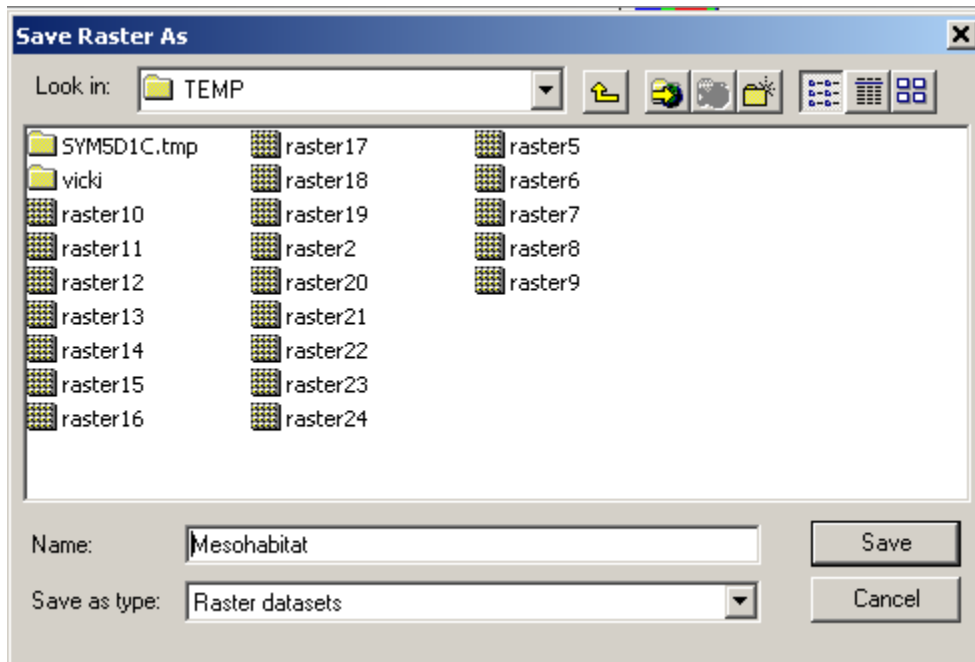
Figure 2.13: Save Raster As dialog box in ArcMap

Micro and Meso Habitat Analysis

This interface is used to get the MesoHabitat and MicroHabitat grid. This interface works only when the map contains only one velocity grid with Velocity (fps) as its name and only one depth grid with Depth (feet) as its name. The map can contain more than one velocity or depth grid, but they should not have the names, velocity (fps) and depth (feet), for the velocity and depth grid respectively. If there are multiple grids present in the map with the same name the interface will work on the first grid by default.
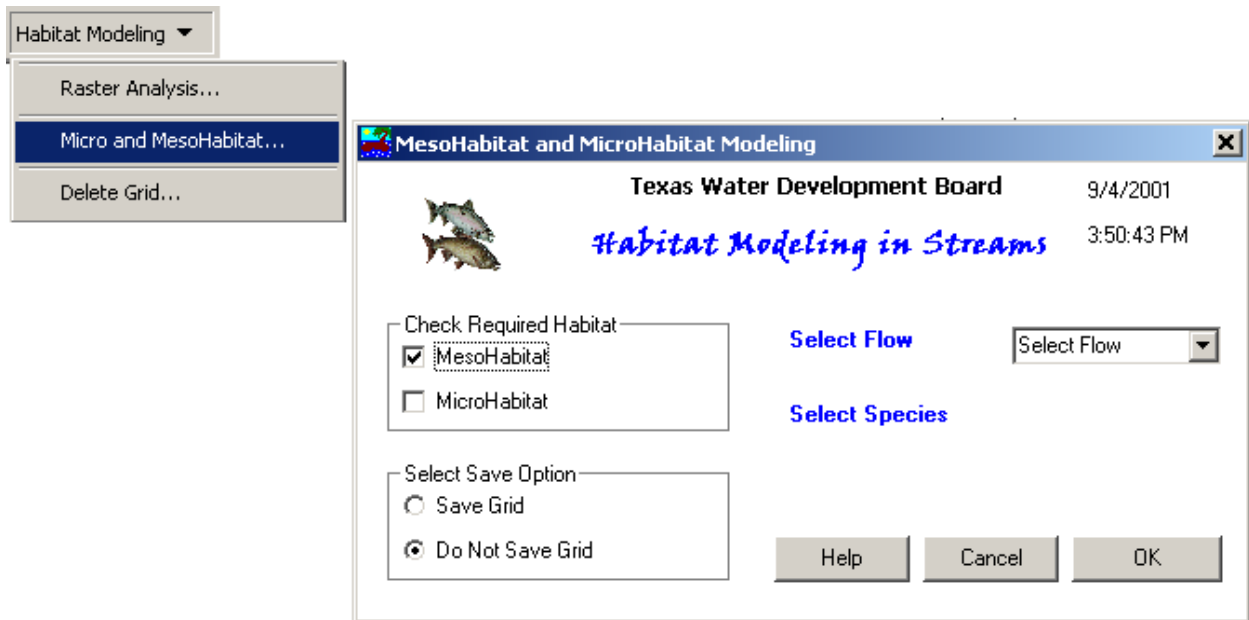
Figure 2.14: MesoHabitat and MicroHabitat Modeling interface

The MesoHabitat and MicroHabitat Modeling interface has three main parts, the first one is for selecting the habitat type, the second one is for grid save option and the third, which is important is for selection of flow and the type of species to be queried. It is recommended to select only one habitat at a time, either MesoHabitat or MicroHabitat. The interface does not work with both the habitat types selected. In Figure 2.14 the Combo Box for selecting the species does not appear, because it shows up only when the MicroHabitat box is checked. The interface with MicroHabitat box checked is shown in Figure 2.15. Another important thing to remember with this interface is that, it looks for a Microsoft access file named HabDescrib.mdb in c:\Habitat\ directory and this file, HabDescrib.mdb, should contain a table, HabitatDescrip, in it.
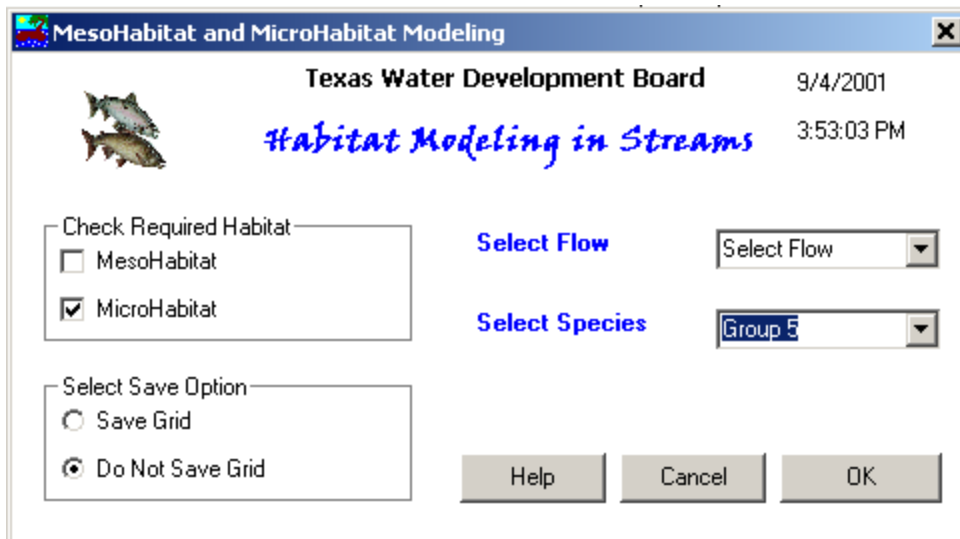
Figure 2.15: MesoHabitat and MicroHabitat Modeling Interface for MicroHabitat analysis

This interface is very easy to operate. For MesoHabitat analysis, after selecting the habitat type and the Save Option, click OK and the MesoHabitat grid as shown in Figure 2.16 is added to the map.
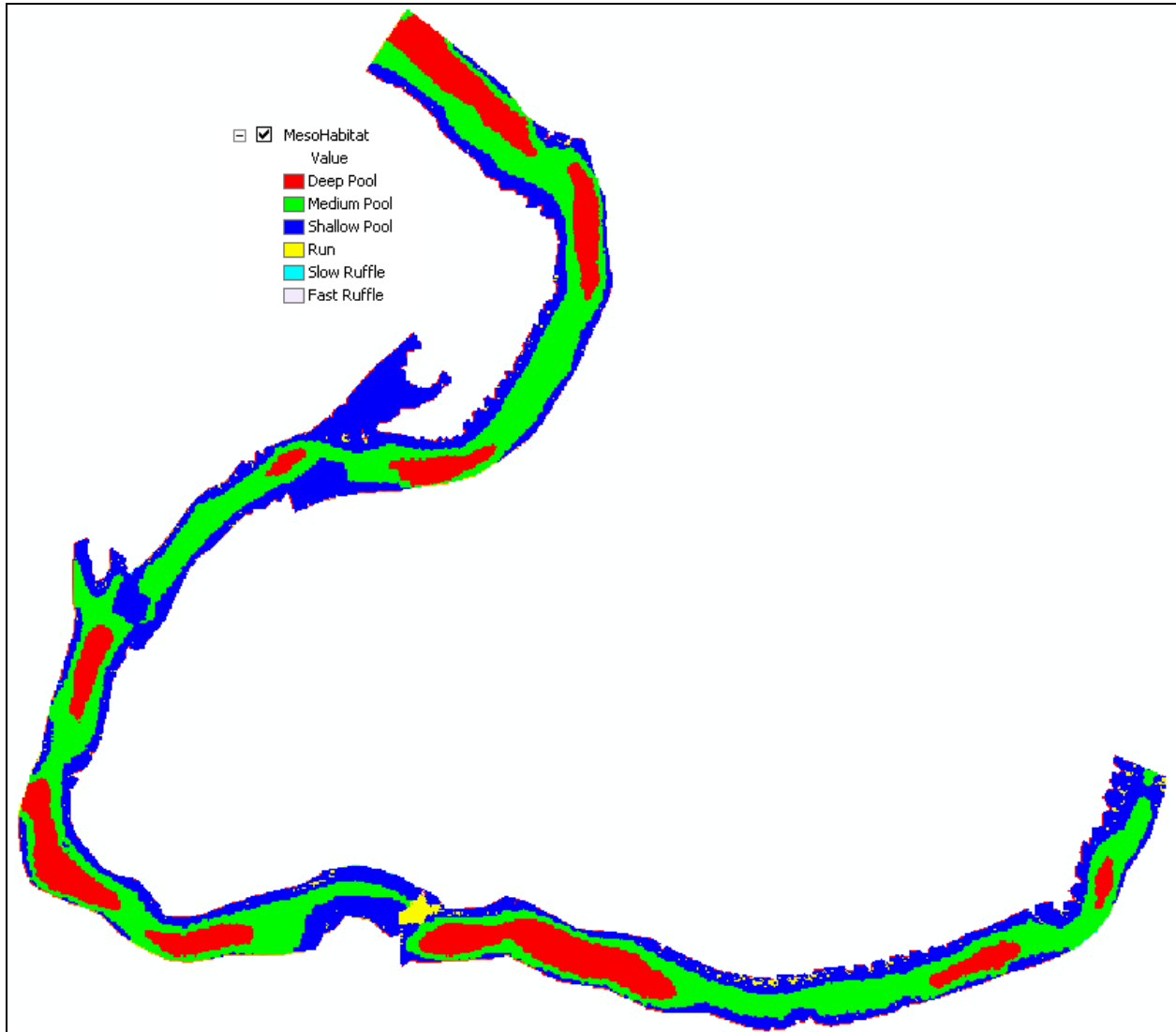
Figure 2.16: ArcMap view with MesoHabitat grid

In case of MicroHabitat analysis, the select species Combo Box shows up and the user then has to select the species too. All the species types that are included in this combo box are read from the HabDescrib.mdb file. The required format for this file is explained in Appendix B. Once the species type is specified, click OK and the MicroHabitat grid as shown in Figure 2.17 is added to the map. Figure 2.17 shows MicroHabitat grid for Group 7 species. If the save grid option is not selected all the output grids are saved as temporary grids in c:\habitat\temp. By default all the results, the final MesoHabitat and MicroHabitat grid, are added to the map.
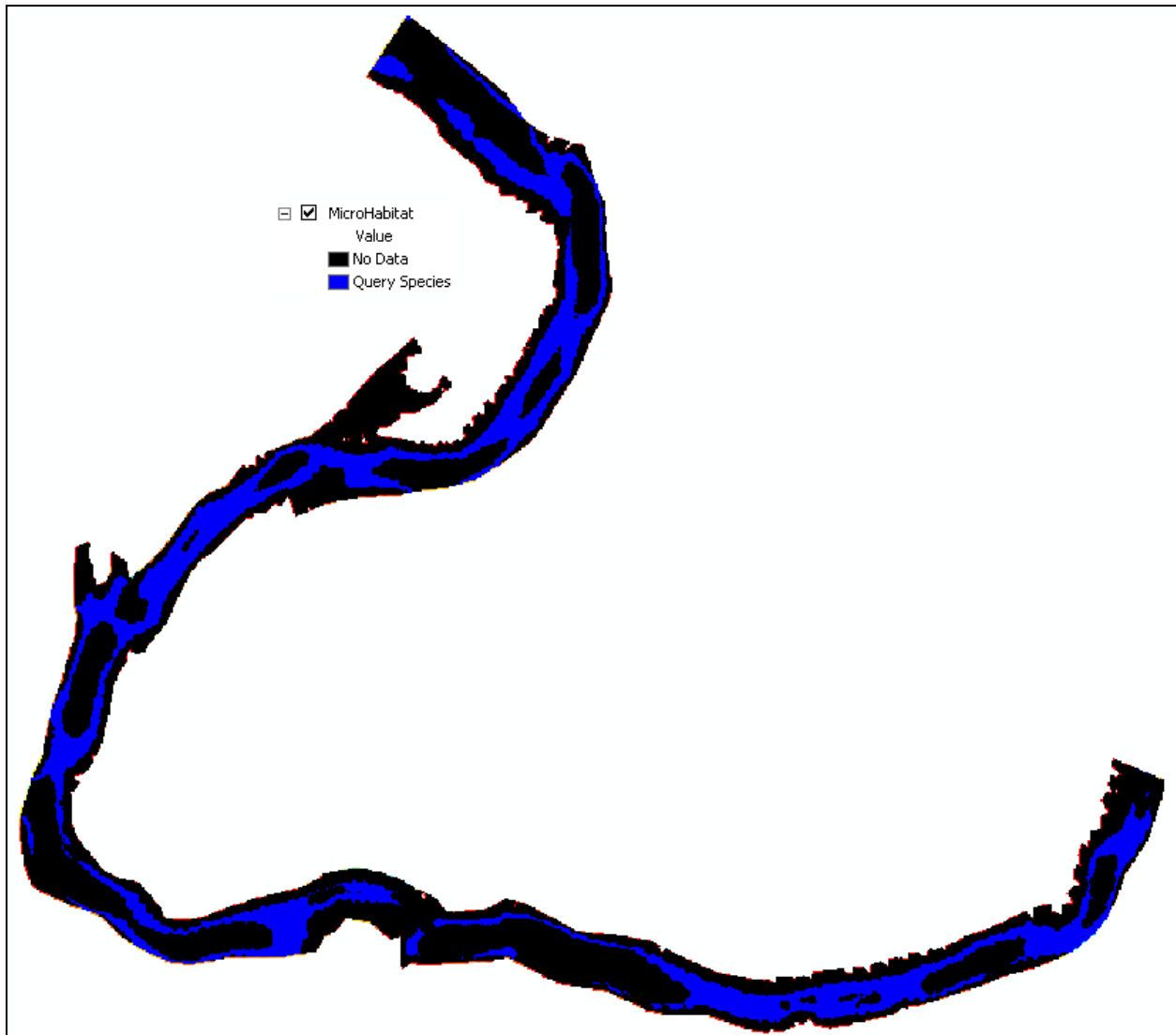
Figure 2.17: ArcMap view with MicroHabitat grid for species Group 7

The flow Combo Box is not in operation yet, but the program works without it. The methodology about how to take the flow into account is not yet defined by TWDB and will be accommodated later.

As explained earlier, if the Save Grid option is not selected all the grids are saved as temporary grids in c:\habitat\temp with raster** as their name. And if the save grid option is selected then a window as shown in Figure 2.13 appears and the user can then select the output path and the grid name.

2.2.4 Delete Grid
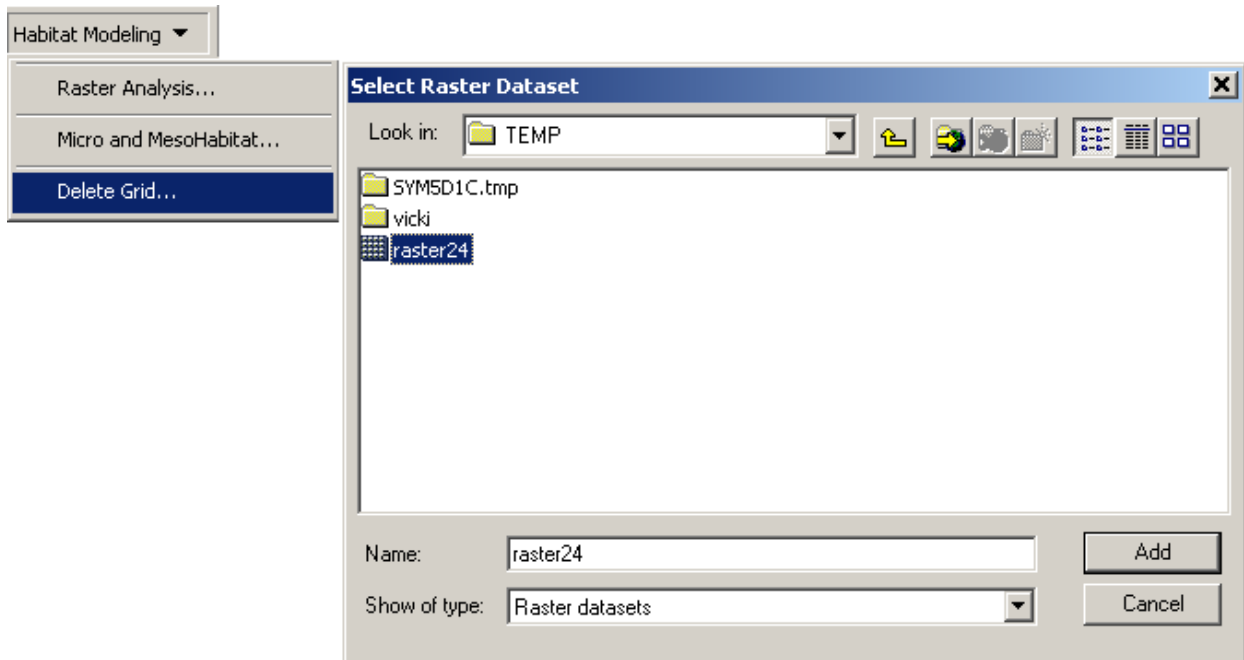
Figure 2.18: Dialog Box for deleting grids

As the name suggests, this button is used for deleting grids. All ESRI grids are saved in a particular format, which saves the data in two or three different folders. For example, when a grid is saved as "Temporary" in c:\Habitat\temp, then one folder with name Temporary appears in c:\Habitat\temp and some other files for this grid are saved in c:\Habitat\temp\info and these files are not visible with Microsoft windows explorer. Thus, if it is required to delete a grid, it is not advisable to delete it from the windows explorer, because all the files related to that folder will not be deleted. This, Delete Grid, option allows to delete the grid in an appropriate way. It uses the "Kill" command of ArcInfo workstation and deletes all the necessary files and folders thus deleting the grid completely. Once this option is clicked a Dialog Box as shown in Figure 2.18 appears. Then the user has to browse the grid and press the add button and the grid is "Killed"!

Chapter Three: Texas Rainfall Runoff Model (TxRR)

The detailed description of TxRR can be found out in TWDB's TxRR manual (Matsumoto, 1992). Here, only the working of new interface for the TxRR is explained. The new interface incorporates all the three old interfaces into a single interface and makes the operation more seamless. As shown in Figure 3.1, the main interface of TxRR has three buttons on it. The new TxRR interface is a visual basic program compiled into an executable file (.exe) and it has to be placed in c:\TxRR. The first step is to create the input data to run the main TxRR (DOS) program. After the Input Data button is pushed, then input data window as shown in Figure 3.2 appears where the user supplies all the necessary input data to run the model.
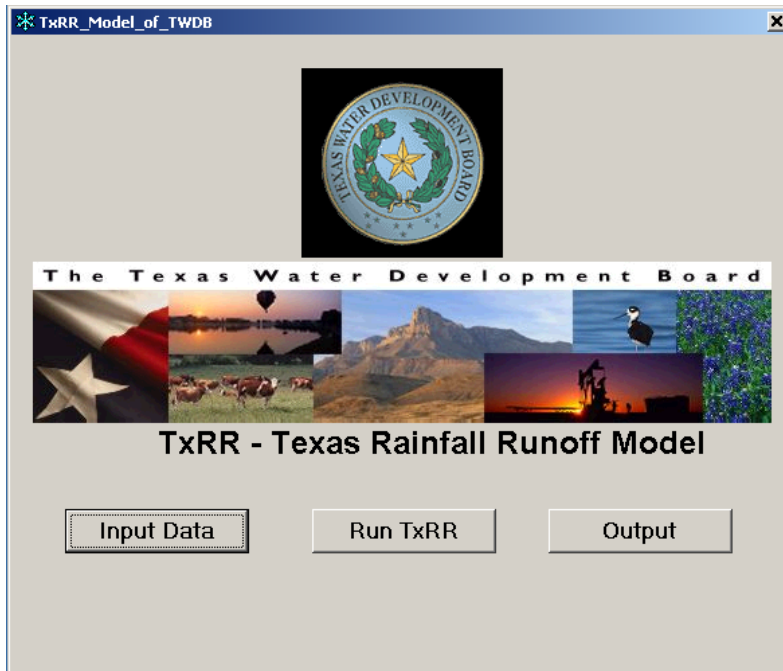
Figure 3.1: TxRR Interface

In the Input Data interface, the user is supposed to specify, besides other parameters, rainfall data file and gauged runoff data file. All these files should be stored in c:\Genalg\data\ folder. After the create input files is pressed, all the specified parameters and other data are stored in some text files that are stored in c:\TxRR folder. The user should make sure that, all the data is specified correctly and then press the Exit button. The next and most important part is to run the model by pressing Run TxRR button. Since TxRR is a DOS program placed in c:\TxRR\. It looks for all the input files in c:\TxRR directory and if everything is in place and in correct format, the program will run and the user should see a DOS window, as shown in Figure 3.3 for a while before it exits the program. One of the common mistakes that is usually made in running the program, is to specify the period incorrectly. It is advised to check the data contained in the input files. For example, if the rainfall is recorded only from the year 1990 to 1995, the program will not run if the user specifies the period from 1190 to 1996 or 1985 to 1990 etc.
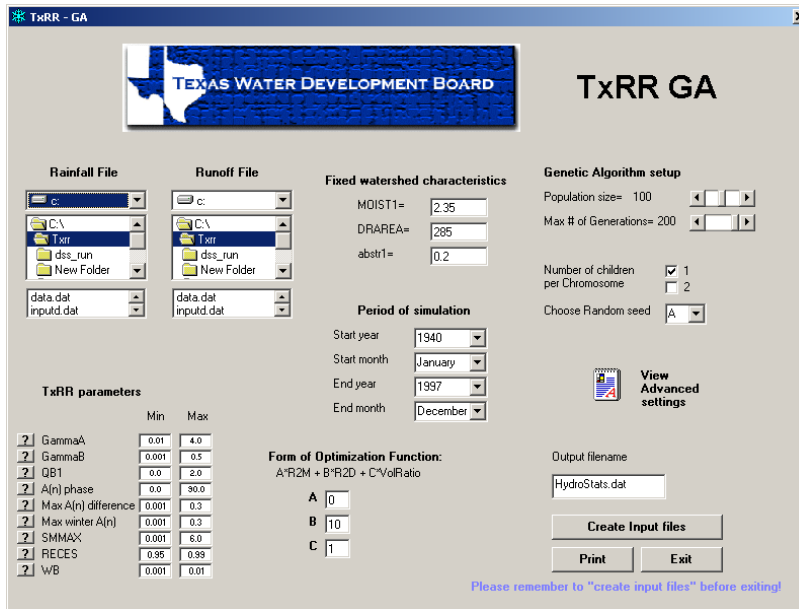
Figure 3.2: Interface for specifying the input parameters for TxRR
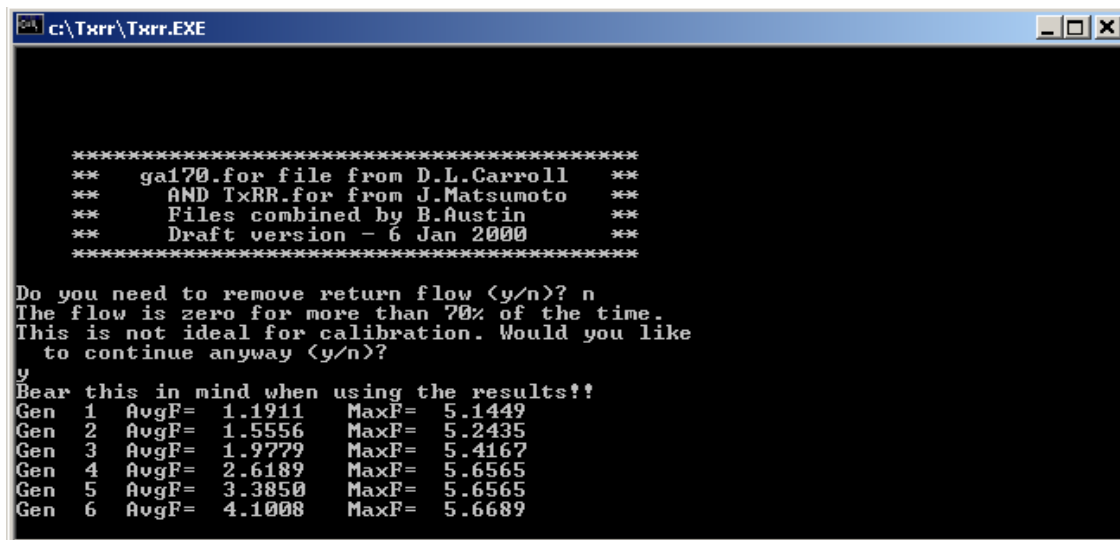
Figure 3.3: DOS window with TxRR in execution

Once the DOS program is executed, the final step is to see the output hydrograph. This is done by pressing the output button on the main window. Once this button is pressed an empty window, similar to Figure 3.4, appears without any graph on it.
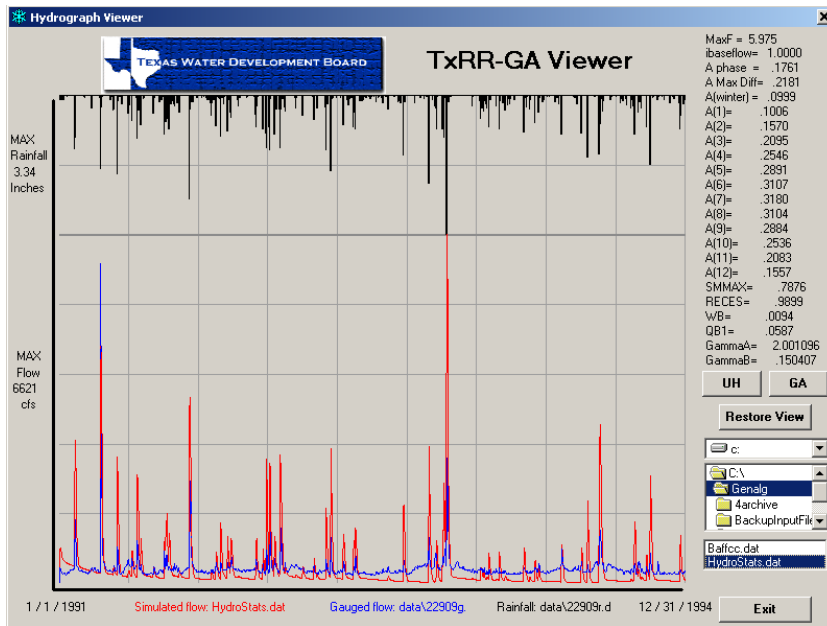
Figure 3.4: Hydrograph Viewer for TxRR

In order to see the hydrograph, the user has to map to the output file. The output file to be mapped is hydrostats.dat and it is stored in c:\txrr.

Chapter Four: Conclusions

The following conclusions can be drawn from the current research

- It is possible to model habitat species using ArcGIS and this offers flexibility and security in terms of customization using Visual Basic.

- Since ArcGIS uses Visual Basic for customization as opposed to Avenue by ArcView, it is very easy to add additional functionality to the tool if required.

- The earlier version of the tool in ArcView 3.2 creates a number of unnecessary temporary grids making it difficult to use the tool and visualize the results whereas the new tool is easy to apply and gives only the final results.

- The preliminary analysis, such as creation of grid from the point layer, required to model the habitat species was done manually with the old tool, but the new tool has functionality to do everything that is needed for modeling the species habitat.

- The new tool is more user friendly compared to the old tool and easy to apply with good error handling procedures.

- The new TxRR interface is easy to use with single interface and the user doesn't have to switch between DOS and Windows environment as with the old TxRR.

References:

- *Avenue Scripts developed by Mark Wentzel for Habitat Modeling (1999).* Texas Water Development Board.

- *ArcObjects Developer Help (2001)*. Environmental Systems Research Institute, http://arconline.esri.com/arcobjectsonline/

- *Developing a GIS-TxRR Model (2001).* Jerome Perales, Richard Gu, & David R. Maidment, Center for Research in Water Resources, University of Texas at Austin.

- *User's Manual for The TWDB's Rainfall-Runoff Model (1992).* Junji Matsumoto, Texas Water Development Board.

Appendix A:

Visual Basic Controls:

Visual Basic Form: A collection of one or more pages that behaves like a standard window or dialog box. A form contains controls for displaying and editing data. Forms can be contained within a form set.

Command Button Control: A control that is associated with a command. When you click the command button at run time, the command associated with the button executes.

Text Box Control: A control that allows you to enter or view text in a form. Typically, text boxes hold a single line of text, but it is possible to have multiple line of texts as well.

Combo Box Control: A control, similar to a list box and text box combined, in which you enter a value or select an item from a list.

CheckBox Control: A control that indicates whether an option is on or off. A checkmark appears in the box when it is selected.

OptionButton Control: An OptionButton control displays an option that can be turned on or off.

While OptionButton controls and CheckBox controls may appear to function similarly, there is an important difference: When a user selects an OptionButton, the other OptionButton controls in the same group are automatically unavailable. In contrast, any number of CheckBox controls can be selected.

Multipage Control: A MultiPage is a control that contains a collection of one or more pages. Each Page of a MultiPage is a form that contains its own controls, and as such, can have a unique layout. Typically, the pages in a MultiPage have tabs so the user can select the individual pages.

Appendix B

Format of HabDescrib.mdb

ID	Species	Sp Code	50% MinD	50% MaxD	50% MinV	50% MaxV
1	Group 1	Group 1	1.5	2.7	1.5	2.9
2	Group 2	Group 2	0.9	1.7	0.9	2.3
3	Group 3	Group 3	0.5	1.2	0.6	2
4	Group 4	Group 4	0.6	1.2	1.6	2.3
5	Group 5	Group 5	1.8	4.6	0.3	1.6
6	Group 6	Group 6	4.3	6.5	0.5	0.9
7	Group 7	Group 7	1.5	3.3	0.1	1.2
8	Group 8	Group 8	1.1	10	0.01	0.9
9	Group 9	Group 9	0.5	2.1	0.4	1.6
10	Group 10	Group 10	0.3	1.5	0.01	0.8

50% MinD = Minimum depth with 50% confidence interval
50% MaxD = Maximum depth with 50% confidence interval
50% MinV = Minimum velocity with 50% confidence interval
50% MaxV = Maximum velocity with 50% confidence interval