US Army Corps
of Engineers
Hydrologic Engineering Center

HEC-GeoEFM

A Spatial Accessory for HEC-EFM (Ecosystem Functions Model)

User's Manual

Version 1.0
June 2011

Approved for Public Release. Distribution Unlimited.

CPD-80b

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Department of Defense, Executive Services and Communications Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
June 2011	Computer Program Documentation	

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
HEC-GeoEFM: A Spatial Accessory for HEC-EFM (Ecosystem Functions Model) User's Manual Version 1.0	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) John Hickey	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5F. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
US Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA 95616-4687	CPD-80b
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/ MONITOR'S ACRONYM(S)
	11. SPONSOR/ MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Also, see HEC-EFM Quick Start Guide, CPD-80a, and HEC-EFM User's Manual, CPD-80.

14. ABSTRACT

The Ecosystem Functions Model (HEC-EFM) is a planning tool that aids in analyzing ecosystem response to changes in flow regime. EFM analyses involve: 1) statistical analyses of relationships between hydrology and ecology, 2) hydraulic modeling, and 3) use of Geographic Information Systems (GIS) to display results and other relevant spatial data. Through this process, study teams visualize and define existing ecologic conditions, highlight promising restoration sites, and assess and rank water management alternatives according to predicted changes in different aspects of the ecosystem.

HEC-GeoEFM is a software tool developed to support spatial analyses commonly used during applications of the EFM. GeoEFM is programmed as an extension for ArcMap and offers the following capabilities for users planning ecosystem restoration or water management scenarios: 1) management of spatial data sets, 2) computation and comparisons of habitat areas, and 3) assessment of the habitat connectivity.

15. SUBJECT TERMS
HEC-GeoEFM, HEC-EFM, Ecosystem Functions Model, ecosystem modeling, ecosystem restoration, time series analysis, hydraulic modeling, Geographic Information Systems, river and wetland flow regimes, ecological relationships

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER
Unclassified	Unclassified	Unclassified	Unlimited	30	

HEC-GeoEFM

A Spatial Accessory for HEC-EFM (Ecosystem Functions Model)

User's Manual

Version 1.0
June 2011

US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

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

CPD-80b

HEC-GeoEFM, User's Manual

2011. This Hydrologic Engineering Center (HEC) documentation was developed with U.S. Federal Government resources and is therefore in the public domain. It may be used, copied, distributed, or redistributed freely. However, it is requested that HEC be given appropriate acknowledgment in any subsequent use of this work.

Use of the software described by this document is controlled by certain terms and conditions. The user must acknowledge and agree to be bound by the terms and conditions of usage before the software can be installed or used. For reference, a copy of the terms and conditions of usage are included in Chapter 7 of this document so that they may be examined before obtaining and loading the software. The software described by this document can be downloaded for free from our internet site (www.hec.usace.army.mil).

This document contains references to product names that are trademarks or registered trademarks of their respective owners. Use of specific product names does not imply official or unofficial endorsement. Product names are used solely for the purpose of identifying products available in the public market place.

Microsoft and *Windows* are registered trademarks of Microsoft Corp.

ArcGIS, ArcMap, ArcView, ArcInfo, Spatial Analyst, and *3D Analyst* are registered trademarks of ESRI, Inc.

Table of Contents

Foreword……ii

Chapters

1 Introduction 1-1

2 EFM and GeoEFM 2-1

3 GeoEFM: Installation and Construct 3-1

4 GeoEFM: Project Management 4-1

5 GeoEFM: Application 5-1
5.1 Managing Spatial Layers (Managers) 5-1
5.1.1 Standard Views 5-2
5.1.2 Combo Views 5-3
5.1.3 Custom Views 5-4
5.2 Navigating GeoEFM Projects (View Finder) 5-5
5.3 Computing Habitat Areas (Tabulate Tool) 5-6
5.4 Analyzing Habitat Connectivity (Patch Analysis Tool) 5-8
5.5 User Support (Help Menu) 5-10

6 Conclusions 6-1

7 Terms and Conditions for Use 7-1

Foreword

HEC-GeoEFM works with HEC-EFM and HEC-EFM Plotter to help users assess the ecological implications of water resource decisions. GeoEFM focuses on spatial questions such as: How much habitat is generated by a particular water management strategy or configuration of river channels and wetlands? Which species would be helped or hurt by implementation of new management practices? Where is the habitat? Are different habitat areas connected? Where does it make sense to protect or restore habitat?

GeoEFM was developed through a partnership between the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers and the Environmental Systems Research Institute, Inc. (ESRI). Development was initiated as part of an ongoing cooperative research and development agreement between those organizations in recognition of both the power of GIS and the importance of ecological considerations in water systems.

Mr. John Hickey, HEC, Water Resource Systems Division, designed the software and managed its development. Dr. Amit Sinha, ESRI, contributed to design and performed the programming. Dr. Dean Djokic, ESRI, helped manage the project and leads ESRI participation in the cooperative agreement between HEC and ESRI. Dr. Tom Evans, HEC, leads HEC participation in the cooperative agreement between HEC and ESRI. Mr. Matt McPherson was Chief of the Water Resource Systems Division and Mr. Chris Dunn was Director of HEC at the time of completion and public release of GeoEFM 1.0.

HEC is a division of the Institute for Water Resources, U.S. Army Corps of Engineers.

CHAPTER 1

Introduction

GeoEFM is a software tool developed to support spatial analyses commonly used during applications of the Ecosystem Functions Model (HEC-EFM). GeoEFM is programmed as an extension for ArcMap. Use of GeoEFM requires a user license for ArcView 9.3 or 9.3.1. Spatial Analyst and 3D Analyst extensions for ArcMap must also be installed and activated.

GeoEFM provides three primary capabilities for users planning ecosystem restoration or water management scenarios: 1) management of spatial data sets, 2) computation and comparisons of habitat areas, and 3) assessment of the habitat connectivity.

This user's manual provides an overview of GeoEFM and illustrates how the software is applied. Many figures in this document show a GeoEFM project being built and used to assess ecosystem conditions for the Rolling River, which is the fictional river also used in the demonstration project and user guidance for EFM. Please refer to the EFM Quick Start Guide (USACE 2009) for background about the hydrologic and ecologic scenarios described herein. The reference for that document follows:

U.S. Army Corps of Engineers (USACE) 2009. HEC-EFM: Ecosystem Functions Model - Quick Start Guide. CPD-80a. Hydrologic Engineering Center, Davis, CA.

The text in this manual has been formatted to help readers keep track of the different types of information presented. *Italics* are used to identify *software features* that are available through the user interfaces of GeoEFM. <u>Underlines</u> are used to identify model <u>input data</u>, which includes the names of flow regimes and relationships used in the demonstration project. **Bold** is used to highlight **key information** for individual sections of text.

CHAPTER 2

EFM and GeoEFM

The process of applying EFM involves three basic phases: statistical analyses, river hydraulics modeling, and spatial analyses (Figure 1). Most user interfaces in EFM support the statistical phase where users identify the water management scenarios ("flow regimes") and the aspects of the ecosystem ("relationships") to be investigated. Results from the statistical phase are then input to hydraulic models that generate layers of water depth, velocity, and inundation, which are then used in Geographic Information Systems (GIS) to investigate spatial criteria and results for the flow regimes and relationships.

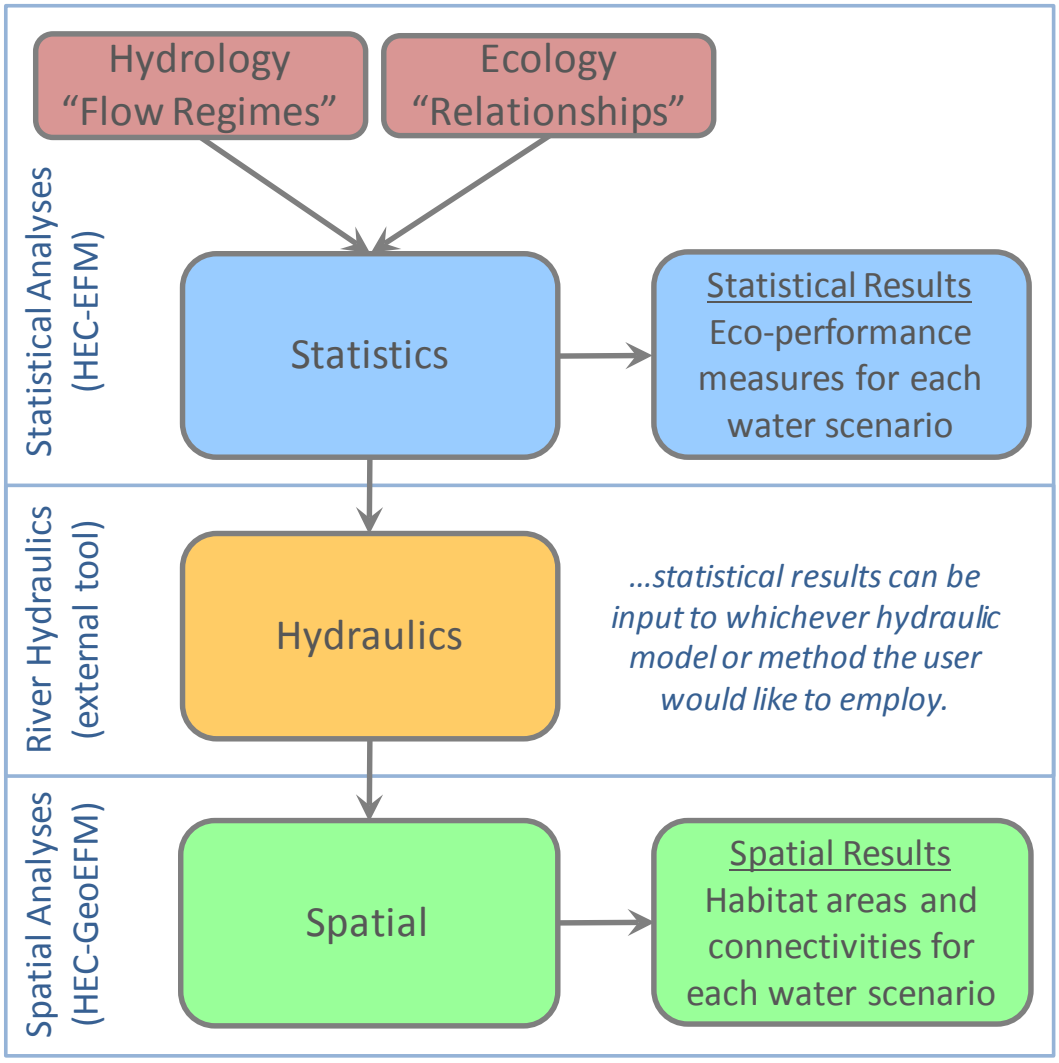

Figure 1. Statistical, hydraulic, and spatial phases of the EFM process. GeoEFM is used in the spatial analyses phase to investigate habitat areas and habitat connectivity produced by different water management scenarios.

"Flow regime" and "relationship" are terms that appear frequently in this manual. An EFM "flow regime" is defined as two concurrent daily time series that reflect conditions for a study area. Typically, the two series are mean flows and mean stages of a water body. Multiple flow regimes can be activated for consideration in a single analysis, but only one may be identified as the reference, which is the flow regime that all other active flow regimes will be compared to when considering model outputs.

"Relationships" are links between characteristics of flow regimes and elements of the ecosystem. Individual relationships are defined by the user via combinations of statistical criteria (seasonality, flow duration, rate of change, and flow frequencies) and geographical criteria (suitable ranges of water depth and velocity). Statistical criteria are considered in the first phase of the EFM process. Geographical criteria are considered in the last.

As GeoEFM is used in the last phase (spatial analyses), much of the structure for data and modeling will already have been determined before beginning work with GeoEFM. It is important to remember that due to this sequence **information such as names of flow regimes and relationships are always passed from EFM to GeoEFM**.

For more information about EFM use and terminology, please refer to the user guidance for that software or visit HEC's webpage (www.hec.usace.army.mil).

CHAPTER 3

GeoEFM: Installation and Construct

GeoEFM is a toolbar in ArcGIS 9.3 and 9.3.1 for Windows. It is used with an ArcView level license. Spatial Analyst and 3D Analyst extensions must be installed and activated. There is also a software component, the Water Utilities Application Framework, which provides functions that are required for use of GeoEFM. The Water Utilities Application Framework is installed, verified, or updated as needed by the GeoEFM installer.

After installation, the GeoEFM toolbar can be activated via right clicking on the toolbar area of the ArcMap interface and selecting the "HEC-GeoEFM" option (Figure 2).

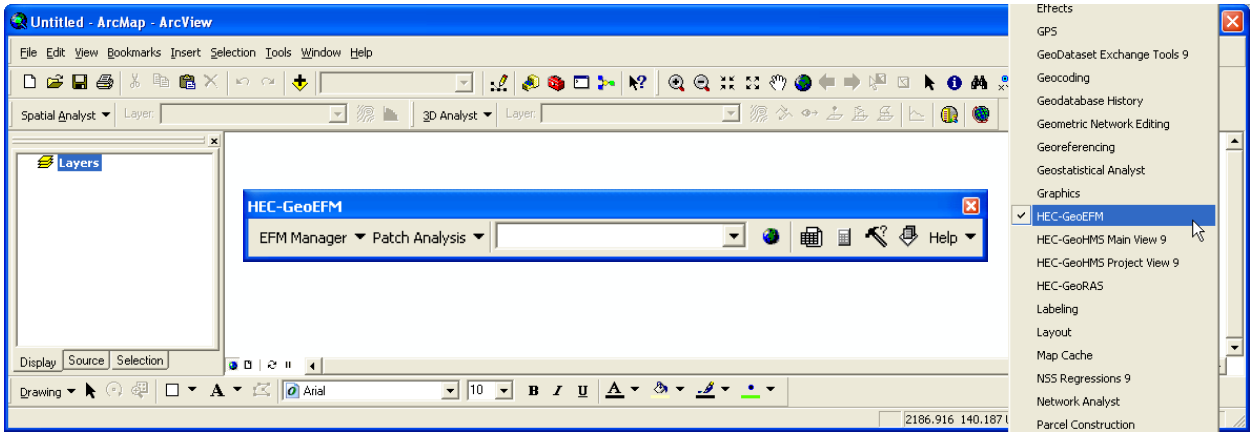

Figure 2. Activating the GeoEFM toolbar.

Typically, GeoEFM applications begin with layers generated during the hydraulic modeling phase of the EFM process as well as other relevant data such as maps of land use, soils, and vegetation. The GeoEFM toolbar (Figure 3) can then be used to organize these layers per the flow regime-relationship structure already established in the EFM project (via the *EFM Manager* menu), navigate this structure (via *View Selector*), compute habitat areas (via *Tabulate*), and assess habitat connectivity (via the *Patch Analysis* tool).

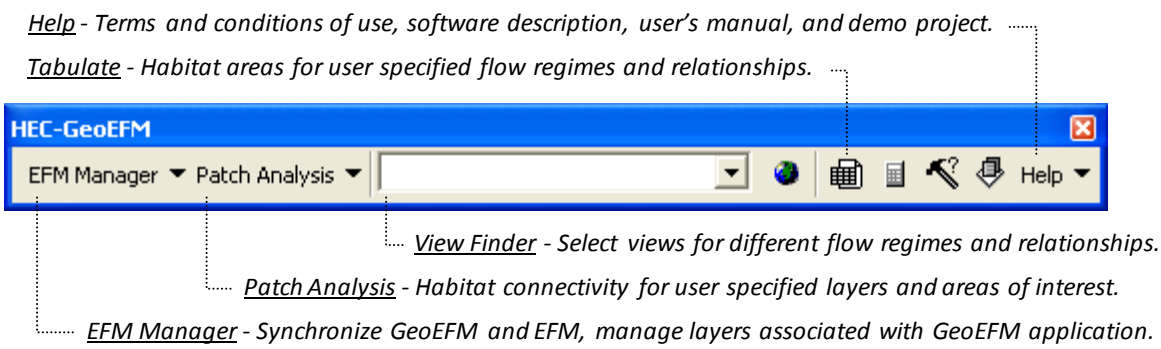

Figure 3. Key components of the GeoEFM toolbar.

CHAPTER 4

GeoEFM: Project Management

A GeoEFM project is simply an ArcMap document and geodatabase (i.e., "ProjectName.mxd" and "ProjectName.mdb" files, respectively) associated with an EFM project, such that ArcMap can access, interpret, and store information from EFM for use in GIS.

Data and project structure are passed from EFM to GeoEFM. This is done through the *EFM Manager – Synchronize Project* menu option. The first time *Synchronize Project* is selected for a new GeoEFM project, the user will be prompted to identify the EFM project to be associated with the GeoEFM project (Figure 4).

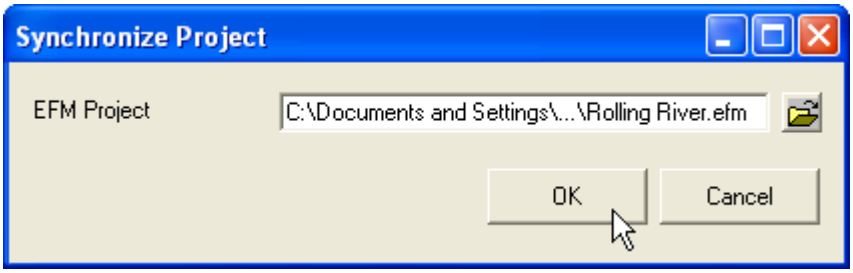

Figure 4. Initial synchronization of an EFM project.

When the *OK* button is clicked, the file and path names of that EFM project are saved as part of the GeoEFM project and **the following information is passed from EFM to GeoEFM: flow regime names and integer identifiers, relationship names and integer identifiers, tag names, and combo relationship names and integer identifiers.** In EFM, integer identifiers are assigned to flow regimes and relationships when those are first created. The integer does not change as the flow regime or relationship is renamed and is never reused over the life of the EFM project.

With each subsequent *Synchronize Project* command, GeoEFM retrieves the latest saved version of those data from its parent EFM project. Any changes, including adding, renaming, or deleting flow regimes and relationships, must be performed and saved in EFM and then updated in GeoEFM through a *Synchronize Project* command. When GeoEFM successfully retrieves data from its parent EFM project a message will be provided for acknowledgement by the user (Figure 5).

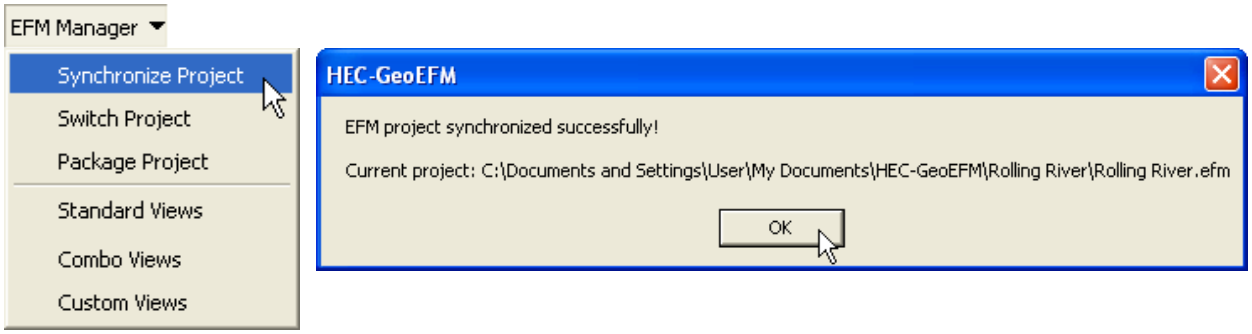

Figure 5. Synchronizing an EFM project.

The *EFM Manager – Switch Project* menu option allows users to redirect a GeoEFM application to a new parent EFM project (Figure 6). This command should be used with caution. It is intended to allow update of connections between GeoEFM and EFM where the EFM project has been either moved (to a new computer location) or renamed (to reflect a change in content or status). However, GeoEFM performs a "switch" according only to the integer identifiers of flow regimes and relationships. Any Views and associated settings that are not an exact identifier match between old and new EFM projects will be removed. The file and path name of the current EFM parent project is provided as the default in the *Switch Project* interface.

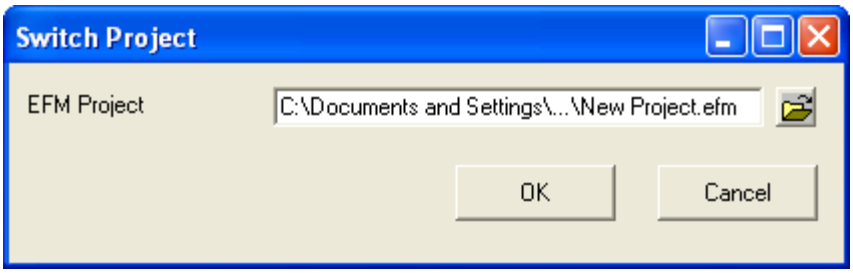

Figure 6. Switching an EFM project.

The *EFM Manager – Package Project* menu option is designed to allow users to quickly organize and compress the spatial data associated with an application of GeoEFM. There are several packaging options (Figure 7), including "full project", which packages all associated data, and "Select flow regimes and relationships…", which allows users to choose particular pairing(s) of flow regimes and relationships for packaging. Be aware that the *Package Project* feature has not been tested thoroughly in the current version of GeoEFM.

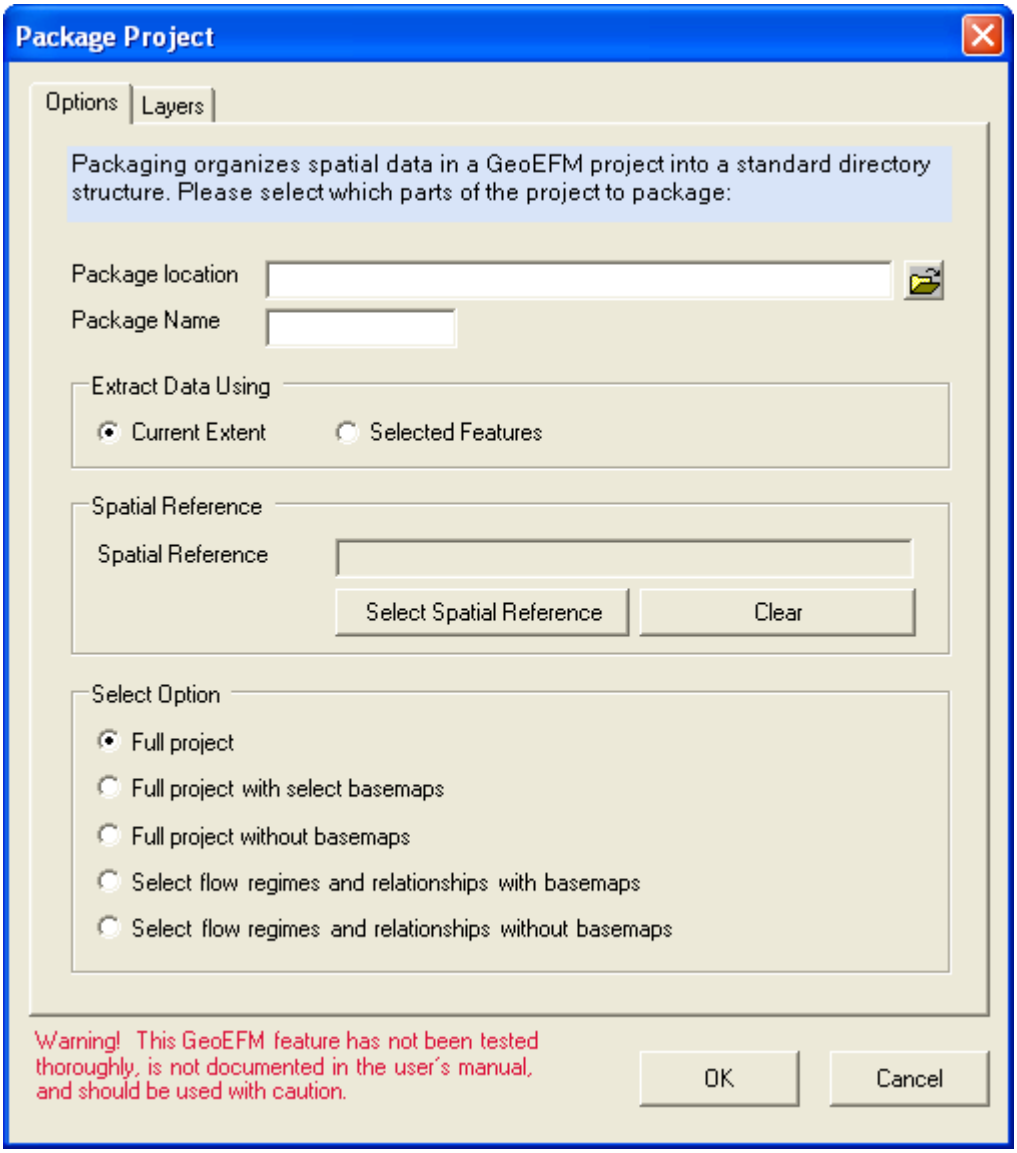

Figure 7. Package project interface supports selective packaging of layers in GeoEFM projects.

Flow regime and relationship names imported from EFM create a structure for GeoEFM applications. Essentially **each pairing of flow regime and relationship acts as a placeholder for a "data frame"**. In ArcMap, a data frame is the fundamental map element of a GIS project – it defines geographic extent, coordinate system, and display properties for the map layers that belong to that data frame. GeoEFM can be used to create data frames, add layers to them, and analyze ecosystem responses generated by different water management scenarios or restoration designs.

CHAPTER 5

GeoEFM: Application

In addition to the data and structure obtained from the EFM project, GeoEFM applications typically begin with layers generated during the hydraulic modeling phase of the EFM process as well as other relevant data such as maps of land use, soils, and vegetation. These spatial data may be added to the GeoEFM project through the standard *Add Data* mechanisms available in ArcMap or ArcCatalog. Figure 8 shows a GeoEFM project that has been synchronized with an EFM application and has data added to the default "Layers" data frame (statistical results from EFM, which were subsequently used in hydraulic modeling to generate the corresponding layers, are also shown).

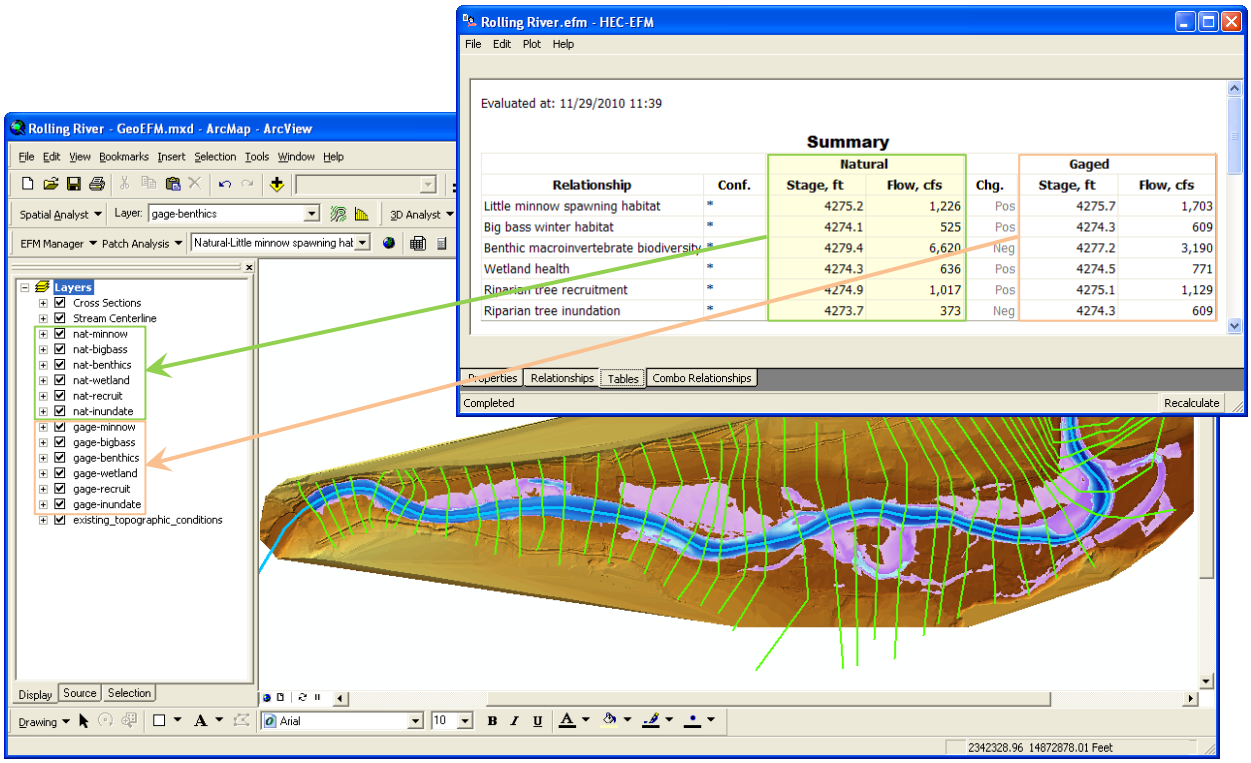

Figure 8. New GeoEFM project with connections to EFM statistical results.

5.1 Managing Spatial Layers (Managers)

The next step in a GeoEFM project is to organize the spatial layers per the structure obtained from the EFM project. Adhering to that structure is advantageous because it will ultimately facilitate the use of GIS functions for groups of spatial layers (e.g., apply a fish spawning criteria to depth grids for multiple water management scenarios) and enable comparisons of habitat areas for user selected flow regimes and relationships.

In GeoEFM, sets of "views" are built per the structure obtained from the EFM project. Each "view" is a data frame. There are three types of views: *Standard, Combo, and Custom*. *Standard Views* and *Combo Views* correspond directly to different parts of the EFM structure. In fact, placeholders for all possible *Standard* and *Combo Views* are made when the EFM and GeoEFM projects are synchronized.

5.1.1 Standard Views

Standard Views are used as workspace for pairings of flow regimes and relationships. When the *EFM Manager – Standard Views* menu option is selected, the *Manage Standard Views* interface activates and allows users to assign layers from the Source View to the Destination Standard View. Layers are assigned to the data frame associated with the Destination Standard View (Figure 9). If that data frame does not exist when layers are assigned, it will be created automatically by GeoEFM.

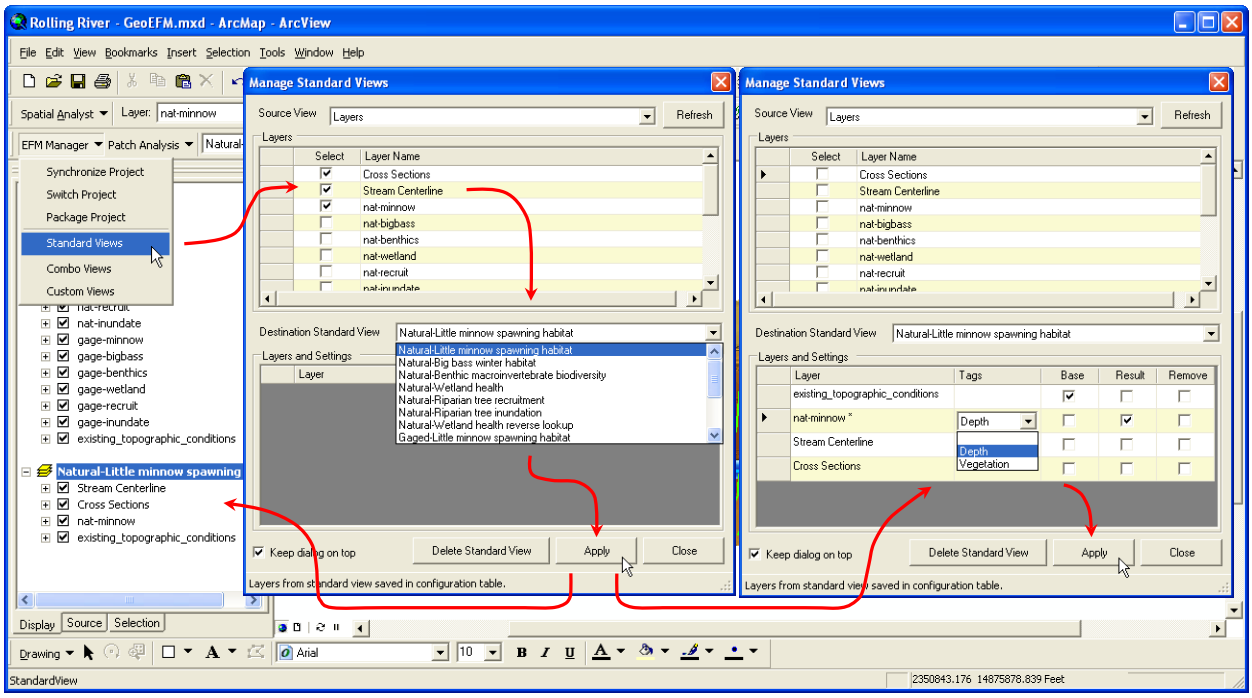

Figure 9. Creating and managing Standard Views in GeoEFM.

The Source View list includes all data frame names in the GeoEFM project. The Destination Standard View list includes all pairings of flow regime and relationships. The Source and Destination View selections are controlled by the user through dropdown text boxes. When layers are selected in the Source for addition to the Destination, the user must click the *Apply* button to actually add those layers. Clicking the *Close* button will deactivate the interface without assigning selected layers or saving any unapplied settings. Clicking the *Delete Standard View* button removes the data frame and all associated layers and settings for the *Destination Standard View* selected at the time of the delete command. It does not remove that selection from the list of Standard Views because the flow regime - relationship pairings are determined by the parent EFM application and must be managed at that level.

After the data frame for a Standard View is created, the user can specify *Tags*, *Base*, and *Result* settings for individual data layers. There is also a setting option for *Remove*, which, if selected when the Apply button is clicked, will remove that layer and its settings from the layer list and associated data frame.

In the current version of GeoEFM, *Tags* simply indicate that a relationship has a geographical requirement that could be used to further define which spatial areas meet all of the criteria needed for suitable habitat. For example, the Little minnow spawning habitat relationship has *Tags* called "Depth" and "Vegetation" (Figure 9). The ecological meaning of these tags is that, in addition to the statistical criteria considered by EFM, suitable spawning habitat for Little minnows is also characterized by a particular range of water depth (0 to 3 feet) and the presence of aquatic vegetation (USACE 2009). Future versions of GeoEFM will allow users to actually perform the geographic queries for individual tags. That is, based on the relationship, tag, and criteria specified by the user, GeoEFM will find the areas that meet those criteria for all flow regimes.

The *Base* setting allows users to designate layers as base maps. Bulky layers, in terms of memory requirements, are often stored in shared databases in order to limit memory use on individual computers. The *EFM Manager – Package Project* feature offers users the choice of whether or not to include layers designated as base maps when packaging GeoEFM applications.

The *Result* setting identifies the layer whose area meets all criteria for the relationship and flow regime being considered. There can be only one "results layer" per *Standard View*. The Tabulate feature discussed later herein queries results layers when computing and reporting total habitat areas for different flow regime - relationship pairings.

5.1.2 Combo Views

In EFM, combo relationships are used to detail how two or more relationships are grouped to represent a single ecosystem dynamic. In GeoEFM, combo relationships are treated much the same as regular relationships with one exception. As a tag indicates a geographical criteria for a relationship, the *Tags* setting is not relevant for combo relationships (geographical criteria are applied for each individual relationship) and has been replaced by the *Combo* setting (Figure 10).

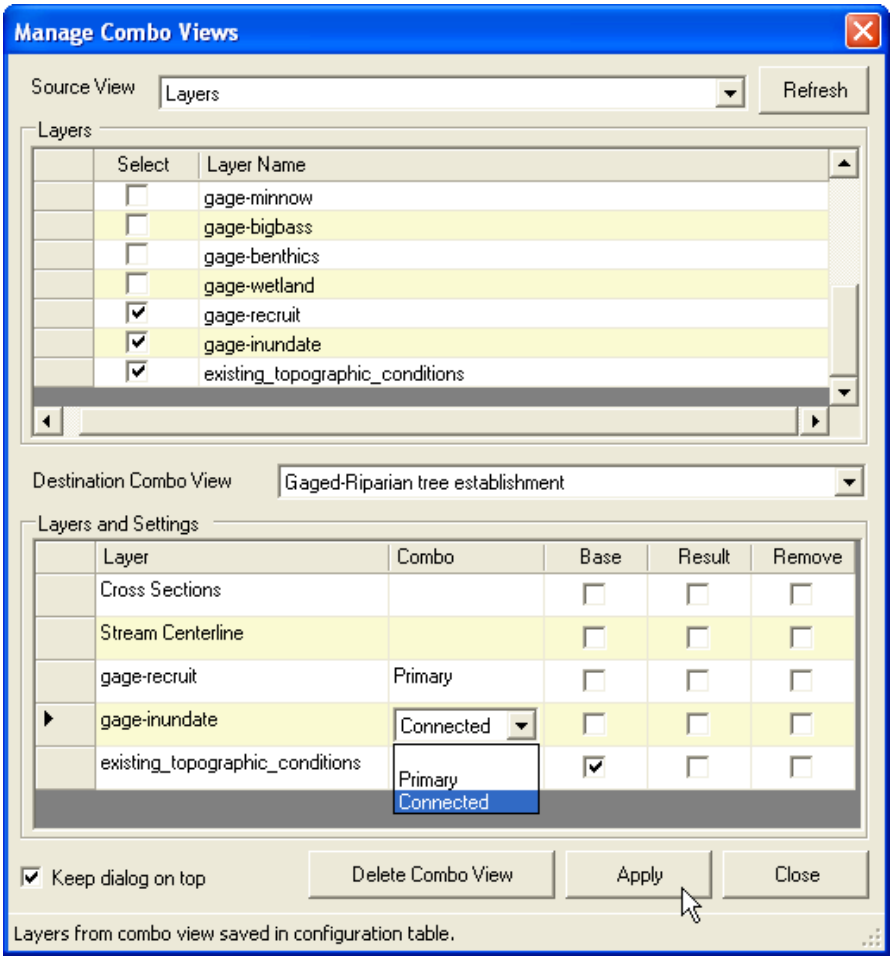

Figure 10. Creating and managing Combo Views in GeoEFM.

The *Combo* setting allows users to identify layers as "Primary" or "Connected". Only one layer per *Combo View* can be designated as primary; multiple layers can be designated as connected. Primary and connected layers are typically results layers for the regular relationships being grouped to represent the combo relationship. The primary layer serves as the starting point. Connected layers are then used to alter the primary layer via GIS functions such as clip or intersect to create a results layer for the combo relationship.

For example, the Riparian tree establishment combo relationship uses layers from both the Riparian tree recruitment and the Riparian tree inundation relationships. The recruitment layer is designated as primary and the inundation layer as connected, with the logic that to generate a layer of Riparian tree establishment areas start with areas suitable for seedlings to begin to grow (recruitment) and then remove areas where potential seedlings would be drowned (inundation). All other buttons and settings in the *Manage Combo Views* interface behave as described above for their counterparts in the Standard Views manager.

5.1.3 Custom Views

Users can create *Custom Views* to perform comparisons of different water management scenarios, analyze data, or simply as workspace to do whatever GIS efforts are needed for the

project. The only difference between a *Custom View* and a generic data frame in ArcMap is that Custom Views, while not part of the EFM structure, are part of the GeoEFM project and can therefore be managed through the *EFM Manager – Package Project* menu option and the *View Finder* feature, which is described later in this manual.

To create a Custom View, enter a name in the text box to the far right of the Custom View dropdown list and click the *Add View* button (Figure 11). The name, which must be unique in the project, will be added to the list of *Custom Views*. Any layers selected in the *Source View* will also be associated with the new *Custom View* at that time. Subsequent additions can be done by selecting those layers and clicking the *Apply* button.

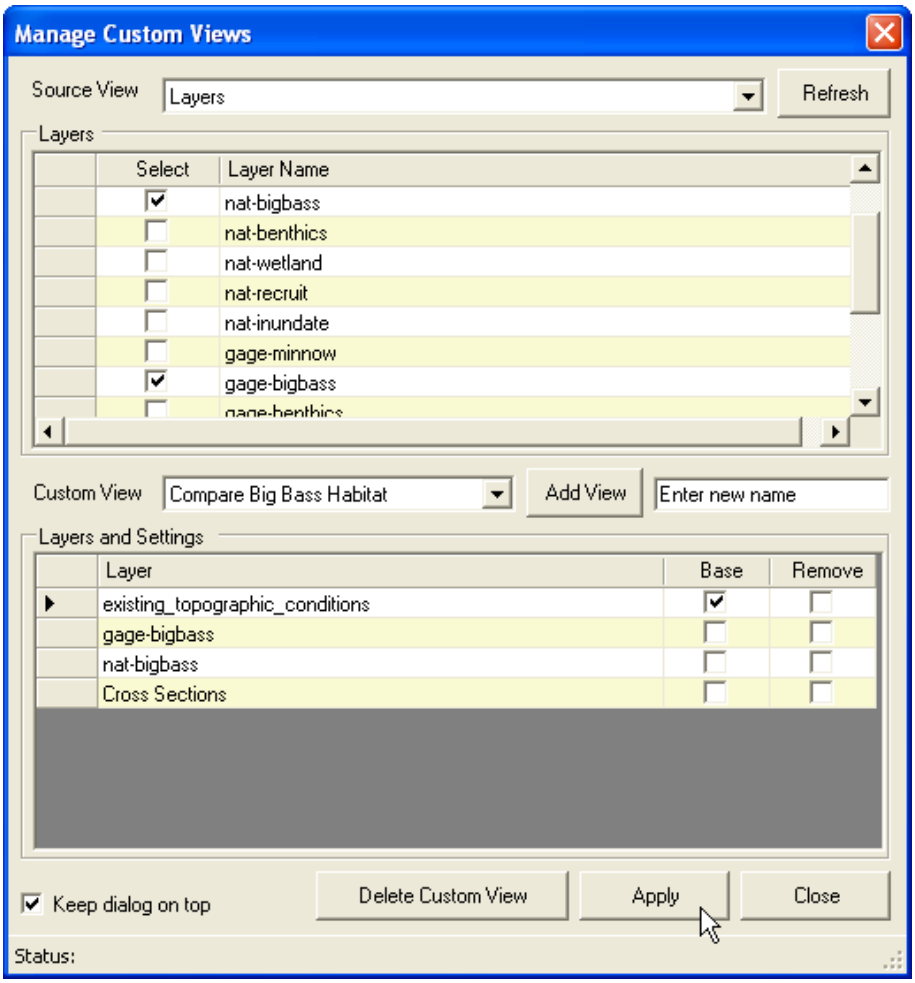

Figure 11. Creating and managing Custom Views in GeoEFM.

5.2 Navigating GeoEFM Projects (View Finder)

The *View Finder* is a simple feature that allows users to switch between views associated with a GeoEFM project. This includes all Standard, Combo, and Custom Views. Functionally, this feature performs the same action as right clicking on a data frame and selecting the Activate menu option in ArcMap.

To use the *View Finder*, select the desired view from the dropdown list on the GeoEFM toolbar and click the *Show View* button, which has a globe icon and is located directly to the right of the dropdown list. Figure 12 shows the first step in the process of switching from the Gaged-Little minnow spawning habitat *Standard View* to the Natural-Riparian tree establishment *Combo View*.

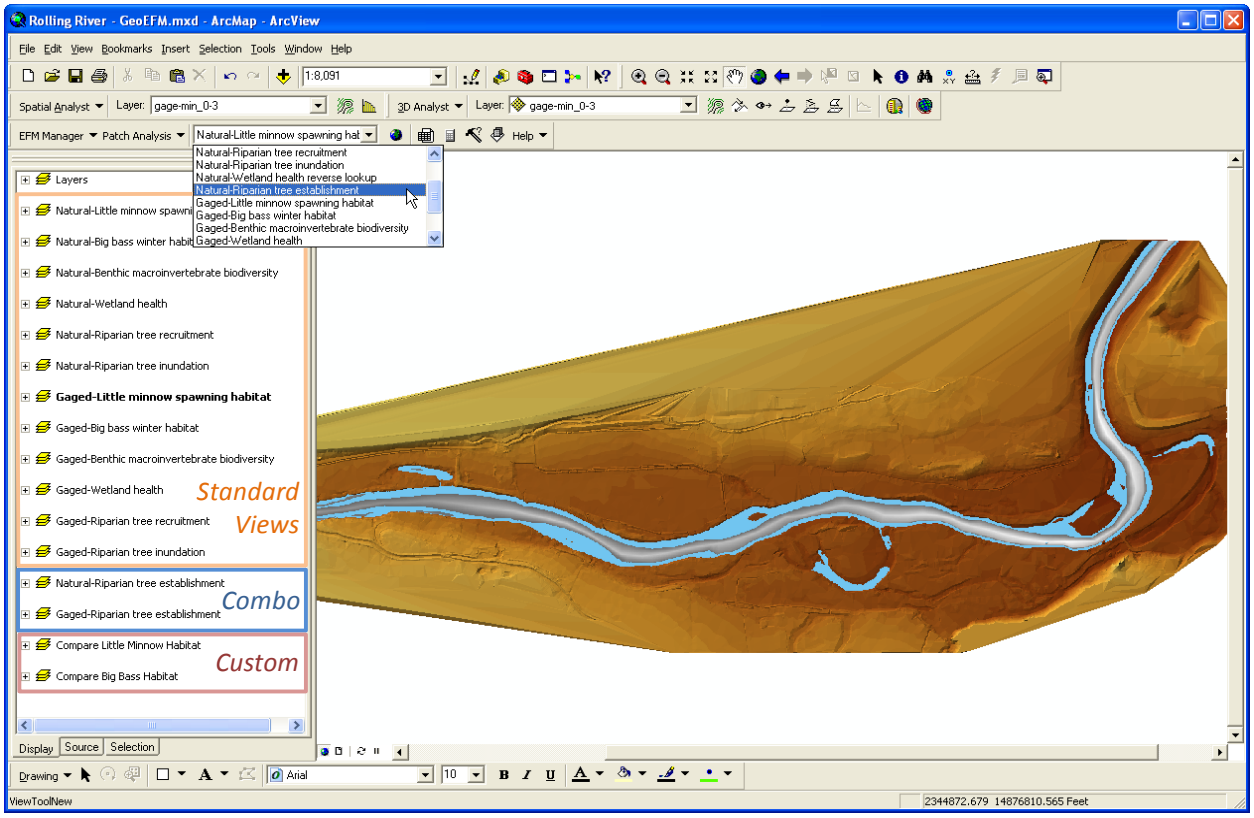

Figure 12. Using the View Finder in GeoEFM to toggle between different project views.

5.3 Computing Habitat Areas (Tabulate Tool)

The *Tabulate* tool allows users to compute, report, and archive total habitat areas. Options are provided for selecting the desired flow regimes and relationships, output units, mode of comparison for multiple flow regimes, and the file and path names for the report to be generated by GeoEFM (Figure 13).

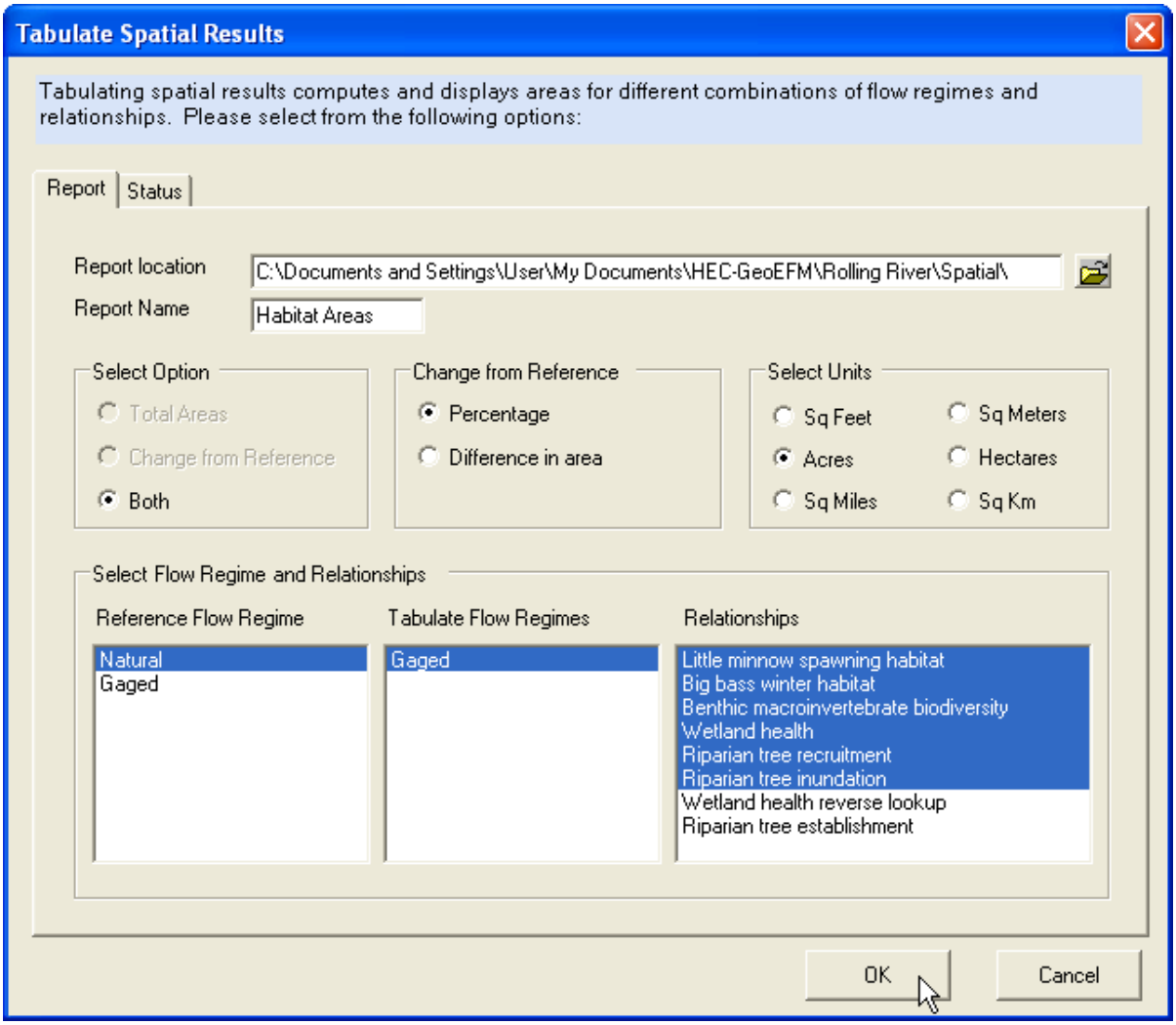

Figure 13. Options and settings for the Tabulate Spatial Results interface in GeoEFM.

As in EFM, only one flow regime may be selected as the reference. Habitat areas generated by any other flow regimes highlighted for analysis will be compared to habitat areas generated by this reference in accordance with the *Change from Reference* setting in the *Tabulate* interface. When the *Ok* button is clicked, **GeoEFM assesses area for the result layer of each flow regime - relationship pairing selected for tabulation**. A "ReportName.xml" file is generated that can be opened in web browsers and other software (Figure 14).

Summary

	Natural	Gaged	
Relationship	**Area, Acres**	**Area, Acres**	**Change, %**
Benthic macroinvertebrate biodiversity	78.06	45.3	-42.0
Riparian tree inundation	28.04	30.77	9.7
Riparian tree recruitment	34.41	35.31	2.6
Wetland health	31.02	32.24	3.9
Big bass winter habitat	29.91	30.77	2.9
Little minnow spawning habitat	21.67	17.19	-20.7

Figure 14. Habitat areas for select pairings of flow regimes and relationships.

The *Status Tab* details progress as output is generated and provides warning messages if any problems are encountered. Please note that **GeoEFM will not compute and report habitat areas unless all required results layers are identified and have defined spatial references.** Use the *ArcToolbox – Data Management Tools – Projections and Transformations – Define Projection* feature to assign the appropriate projections.

5.4 Analyzing Habitat Connectivity (Patch Analysis Tool)

In GeoEFM, habitat connectivity is analyzed for individual pairings of flow regime and relationship. Connectivity is considered for areas of interest known as Search Polygons. Creating a search polygon layer is the first of several steps required to apply the *Patch Analysis* tool.

Search polygon layers can be created, adopted from other views, or populated with polygons from existing layers. Figure 15 shows the process for creating a new search polygon layer entitled Demo_Search_Polygons through the *Patch Analysis - Create Search Polygon Layer* menu option and then drawing search polygons through the *Trace* and *Split* tools in the *Manage Search Polygons* interface. There is no known limit to the number of search polygons that GeoEFM can consider. Also, search polygons do not need to intersect with or encompass the habitat being considered.

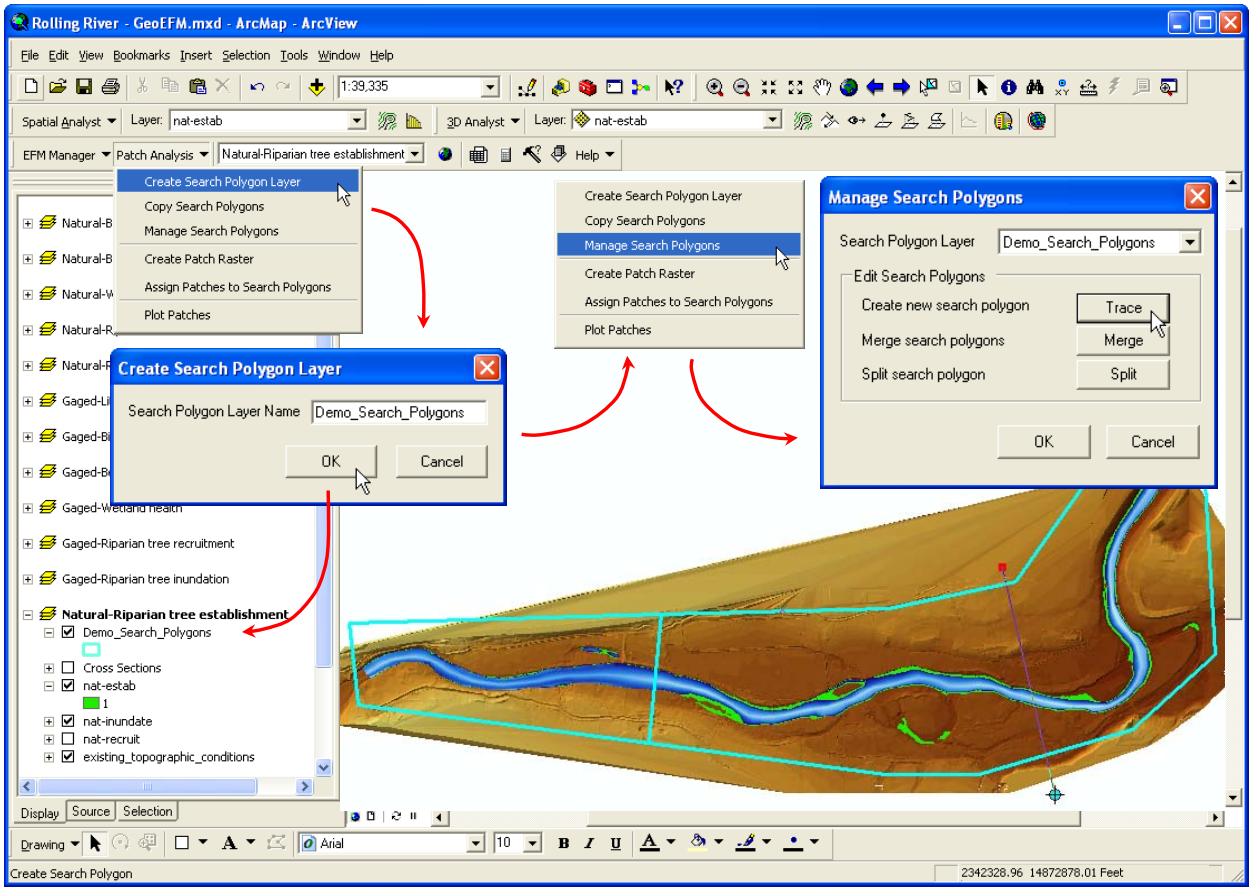

Figure 15. Creating and managing a search polygon layer for use in habitat connectivity analyses.

Once search polygons are established, the next step is to create a "patch raster", which is simply a raster data set whose data has been split into separate habitat areas known herein as "patches". A patch is defined as areas that share either a *Connected Edge* or a *Connected Point*. Figure 16 shows a patch raster for Riparian tree establishment that was generated using the *Connected Point* setting for defining patches. The small thumbnail image in the lower left corner of the figure shows a single patch (circled) that would have been split into two patches if the *Connected Edge* setting were used.

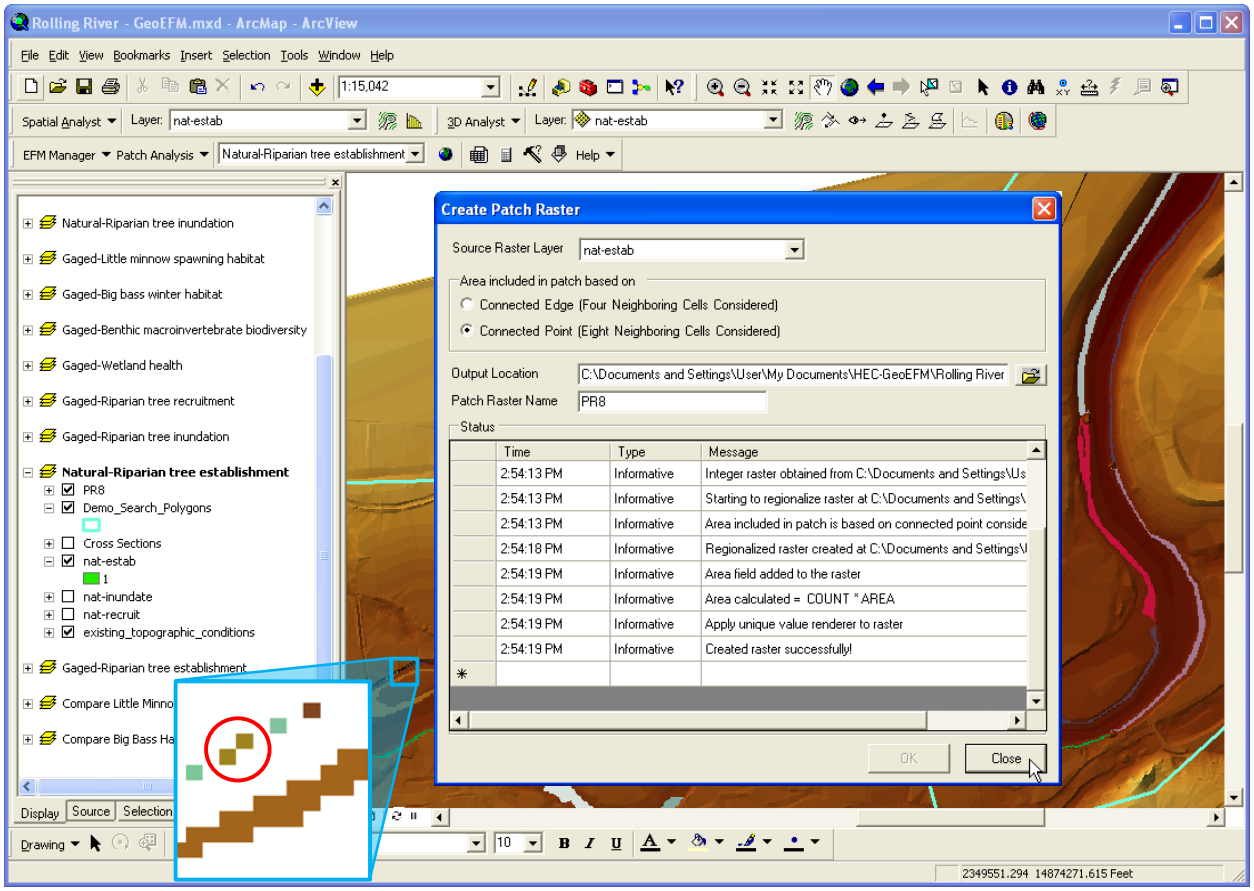

Figure 16. Creating a patch raster layer for use in habitat connectivity analyses.

Patches are then assigned to search polygons through the Assign Patches to Search Polygons menu option. Users are given the option of assigning patches by splitting patches at the search polygon boundaries or according to the search polygon that contains the most patch area. Figure 17 shows results of a patch analysis where the Riparian tree establishment patch raster was assigned to polygons in the Demo_Search_Polygon layer using the split at *Split at search polygon boundary and assign patch* method. Results were then displayed via the *Patch Analysis – Plot Patches* menu option and could be accessed through the attribute table of the generated "PR8_Split" layer.

Currently, connectivity can be assessed only for raster datasets.

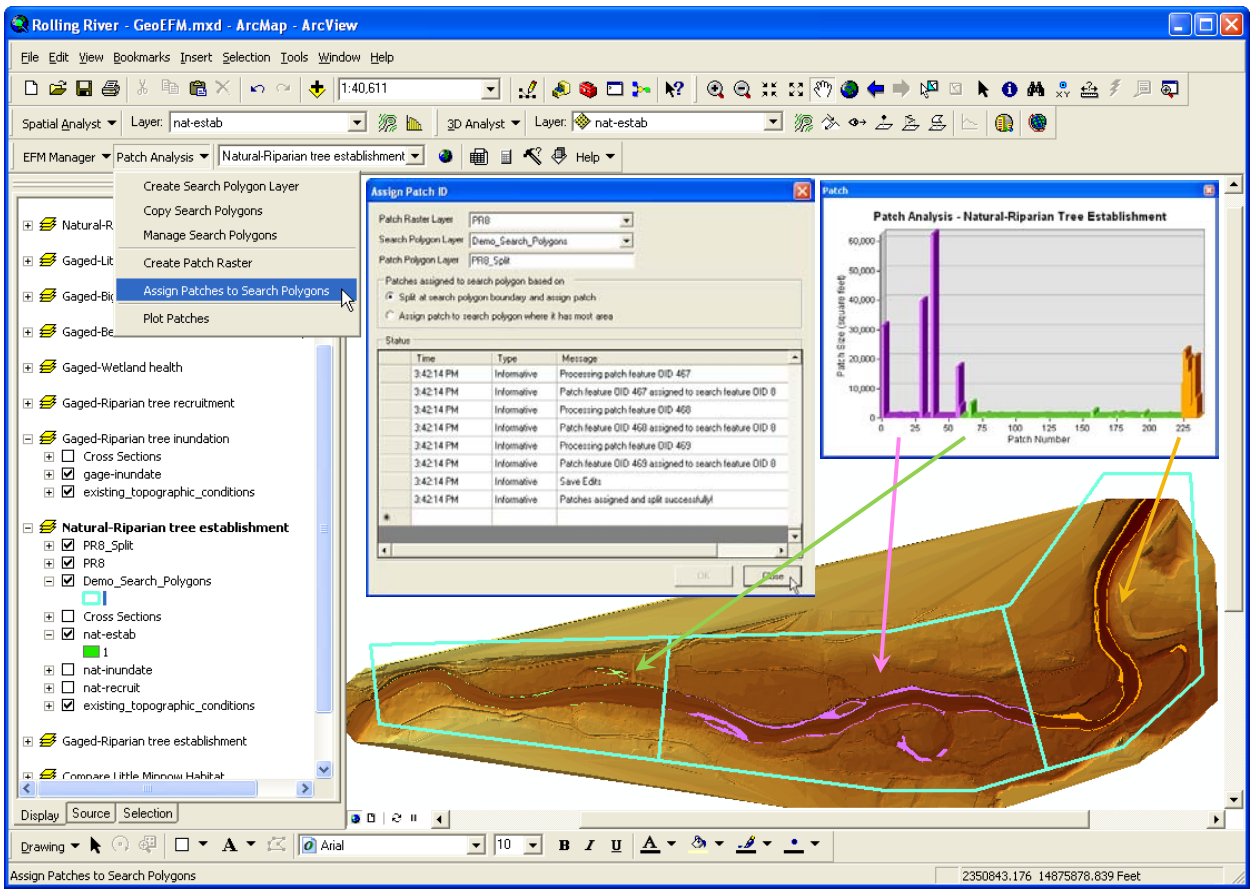

Figure 17. Assigning patches to search polygons in GeoEFM. Results of patch analysis plotted.

5.5 User Support (Help Menu)

The Help menu (Figure 18) provides access to the Rolling River demonstration project, GeoEFM user's manual, an information page that includes software version number, and a web link to the GeoEFM homepage.

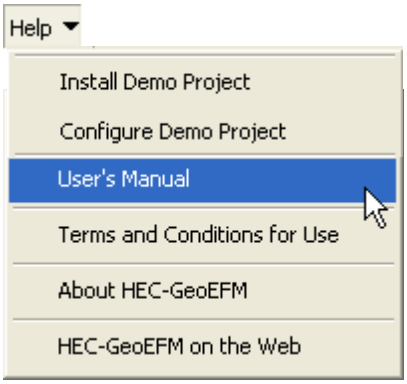

Figure 18. Help menu options for GeoEFM user support.

The demonstration project includes an EFM project, a river hydraulics model, and a GeoEFM project complete with all layers and data frames shown herein. **Accessing the demonstration project requires two steps.** First, the *Install Demo Project* menu option allows users to specify where project files will be placed on their computer. Then, the *Configure Demo Project* menu option must be used to update the locations of spatial data layers associated with the project.

The ArcMap document of the GeoEFM project is entitled "Rolling River - GeoEFM.mxd" and is located in a folder named "Spatial". When first opened, user's will need to do a *Switch Project* command to reconnect the GeoEFM project with its associated EFM project, "Rolling River.efm", which is located in the "Rolling River – GeoEFM" folder.

CHAPTER 6

Conclusions

GeoEFM is a partnered effort between HEC and the Environmental Systems Research Institute, Inc. (ESRI). Development was initiated as part of an ongoing cooperative research and development agreement between those organizations in recognition of both the power of GIS and the importance of ecological considerations in water systems.

The project management, habitat area, and habitat connectivity features of GeoEFM Version 1.0 are viewed as a good foundation for this software. Future development plans include raster splicing to map ecosystem functions over broad landscapes, habitat density measures for assessing habitat connectivity, calculators for considering spatial habitat preferences of biota and cumulative variables, incorporation of spatial hypothesis and confidence tracking, and incorporation of ecological indices based on habitat areas.

Anyone with other ideas for enhancing GeoEFM is encouraged to submit suggestions to the EFM team via email at hec.efm@usace.army.mil.

CHAPTER 7

Terms and Conditions for Use

Use of the program is governed by the terms and conditions for use. They limit what can be done with the program software, waive warranty, limit liability, and indemnify the developers and the United States government. The program cannot be used unless the terms and conditions for use are accepted; the full text is given below.

Terms and Conditions for Use

The United States Government, US Army Corps of Engineers, Hydrologic Engineering Center ("HEC") grants to the user the rights to install the geographical component of the Ecosystem Functions Model (HEC-GeoEFM) "the Software" (either from a disk copy obtained from HEC, a distributor or another user or by downloading it from a network) and to use, copy and/or distribute copies of the Software to other users, subject to the following Terms and Conditions for Use:

All copies of the Software received or reproduced by or for user pursuant to the authority of this Terms and Conditions for Use will be and remain the property of HEC.

User may reproduce and distribute the Software provided that the recipient agrees to the Terms and Conditions for Use noted herein.

HEC is solely responsible for the content of the Software. The Software may not be modified, abridged, decompiled, disassembled, un-obfuscated or reverse engineered. The user is solely responsible for the content, interactions, and effects of any and all amendments, if present, whether they be extension modules, language resource bundles, scripts or any other amendment.

The name "HEC-GeoEFM" must not be used to endorse or promote products derived from the Software. Products derived from the Software may not be called "HEC-GeoEFM" nor may any part of the "HEC-GeoEFM" name appear within the name of derived products.

No part of this Terms and Conditions for Use may be modified, deleted or obliterated from the Software.

No part of the Software may be exported or re-exported in contravention of U.S. export laws or regulations.

Waiver of Warranty

THE UNITED STATES GOVERNMENT AND ITS AGENCIES, OFFICIALS, REPRESENTATIVES, AND EMPLOYEES, INCLUDING ITS CONTRACTORS AND SUPPLIERS PROVIDE HEC-EFM \"AS IS,\" WITHOUT ANY WARRANTY OR CONDITION, EXPRESS, IMPLIED OR STATUTORY, AND SPECIFICALLY DISCLAIM ANY IMPLIED WARRANTIES OF TITLE, MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NON-INFRINGEMENT.

Depending on state law, the foregoing disclaimer may not apply to you, and you may also have other legal rights that vary from state to state.

Limitation of Liability

IN NO EVENT SHALL THE UNITED STATES GOVERNMENT AND ITS AGENCIES, OFFICIALS, REPRESENTATIVES, AND EMPLOYEES, INCLUDING ITS CONTRACTORS AND SUPPLIERS, BE LIABLE FOR LOST PROFITS OR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR IN CONNECTION WITH USE OF HEC-EFM REGARDLESS OF CAUSE, INCLUDING NEGLIGENCE.

THE UNITED STATES GOVERNMENT'S LIABILITY, AND THE LIABILITY OF ITS AGENCIES, OFFICIALS, REPRESENTATIVES, AND EMPLOYEES, INCLUDING ITS CONTRACTORS AND SUPPLIERS, TO YOU OR ANY THIRD PARTIES IN ANY CIRCUMSTANCE IS LIMITED TO THE REPLACEMENT OF CERTIFIED COPIES OF HEC-GEOEFM WITH IDENTIFIED ERRORS CORRECTED. Depending on state law, the above limitation or exclusion may not apply to you.

Indemnity

As a voluntary user of HEC-GeoEFM you agree to indemnify and hold the United States Government, and its agencies, officials, representatives, and employees, including its contractors and suppliers, harmless from any claim or demand, including reasonable attorneys' fees, made by any third party due to or arising out of your use of HEC-GeoEFM or breach of this Agreement or your violation of any law or the rights of a third party.

Assent

By using this program you voluntarily accept these terms and conditions. If you do not agree to these terms and conditions, uninstall the program and return any program materials to HEC (If you downloaded the program and do not have disk media, please delete all copies, and cease using the program.)