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BASINS 4.0 – HARNESSING THE POWER OF GIS WITHOUT BEING CONSTRAINED BY IT

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ABSTRACT

EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) is a multipurpose environmental analysis system designed for use by regional, state, and local agencies in performing watershed and water quality-based studies. This system makes it possible to quickly assess large amounts of point source and nonpoint source data in a format that is easy to use and understand. Installed on a personal computer, BASINS allows the user to assess water quality at selected stream sites or throughout an entire watershed. This invaluable tool integrates environmental data, analytical tools, and modeling programs to support development of cost-effective approaches to watershed management and environmental protection, including TMDLs.

The latest release of BASINS is version 3.1. Like previous releases, BASINS 3.1 contains a suite of GIS-based tools and operates in a GIS environment, using the GIS interface as the front end of the user interface. During the development of BASINS 3.1 significant functionality was identified as not requiring GIS, and so this functionality was developed independently of the GIS customization environment. Keeping only those tools that truly are dependent upon GIS in the GIS customization environment provided a migration path for future enhancements to the system.

Release 4.0 of BASINS is currently under development. For this new release BASINS is undergoing significant restructuring. One of the major challenges in the development of BASINS 4.0 is the accommodation of different GIS software platforms, while removing the current proprietary GIS software as prerequisite to the use of BASINS. A new software product in BASINS 4.0 ties all of the BASINS components together through a single software component not based upon any proprietary GIS package. This new software component is known as the BASINS System Application.

The BASINS 4.0 System Application provides the user interface to access all of the existing BASINS components and more. The System Application identifies which of the supported GIS packages are available on the user's computer, and will thus indicate the GIS-based functionality available to the user. This design provides a migration path from one version of GIS software to

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another. The underlying software architecture provides a clear separation between interface components and GIS functions. This separation provides a future migration path for using core GIS functions from other GIS packages or for accommodating future updates to the already-supported GIS packages.

KEYWORDS

BASINS, Geographic Information Systems, Watershed Modeling, Software

BASINS 3.1 – ENHANCEMENTS WITH AN EYE TO THE FUTURE

The latest release of BASINS is version 3.1. Like previous releases, BASINS 3.1 contains a suite of GIS-based tools and operates in a GIS environment, using the GIS interface as the front end of the user interface. A number of factors resulted in a need to re-package the entire BASINS system as this new release. Since the release of BASINS 3.0 in June of 2001, incremental enhancements have been made to various components. The most significant of the changes to the BASINS system is a shift in data distribution. With vast amounts of data available on the World Wide Web, the static picture of data on CDs is no longer adequate. The new BASINS release takes advantage of the power of Internet connections to provide much more dynamic data to the users.

In addition to providing dynamically updated data, one very significant shift in the GIS realm influenced the development of this incremental release of BASINS. BASINS 3.0 was dependent upon proprietary software from Environmental Systems Research Institute (ESRI), as most of the interface is built using the scripting components of ArcView 3.x. Since ESRI is changing the customization environment for its latest release of desktop GIS software (now known as ArcGIS), the development team has observed that BASINS system components will be most reusable in future releases of the application if components evolve away from use of proprietary software tools. The core GIS functionality was separated from the rest of the BASINS system components, leading to a smoother evolution to the latest GIS platform without abandoning users of previous versions.

Other needs identified by the BASINS team were met in this incremental release.
Users had noted that it was difficult to move a BASINS project from one computer to another, because each project contains a large number of files distributed throughout a directory structure. Users also noted that archiving projects is important, especially when the BASINS system is being used in a particularly high-stakes situation, with reproducibility and defensibility taking on major importance. Another need identified by the BASINS team was a clearer identity for the BASINS system. The structure of BASINS 3.0 was such that the user would run a number of different programs under different situations, which led to confusion about what exactly defines the BASINS system. These and other needs were addressed in this incremental release of BASINS. The enhancements in BASINS 3.1 particularly related to GIS are described below.

Web-Based Data Extractor

BASINS 3.1 is released unencumbered by the extensive BASINS data holdings. Instead of releasing a CD set for each EPA region, the core BASINS system CD does not include the BASINS data. Instead a BASINS user sets up a new BASINS project using the BASINS data holdings accessed by a new software component through the World Wide Web. The selection of the study area is conducted through a GIS interface, but the actual downloading and extracting of the data is done outside the GIS environment.

In creating a new BASINS project, the user opens BASINS and chooses to create a new BASINS project. Doing so invokes a GIS interface displaying the 48 contiguous United States, the counties within those states, and the 8-digit hydrologic units or HUCs (Figure 1).

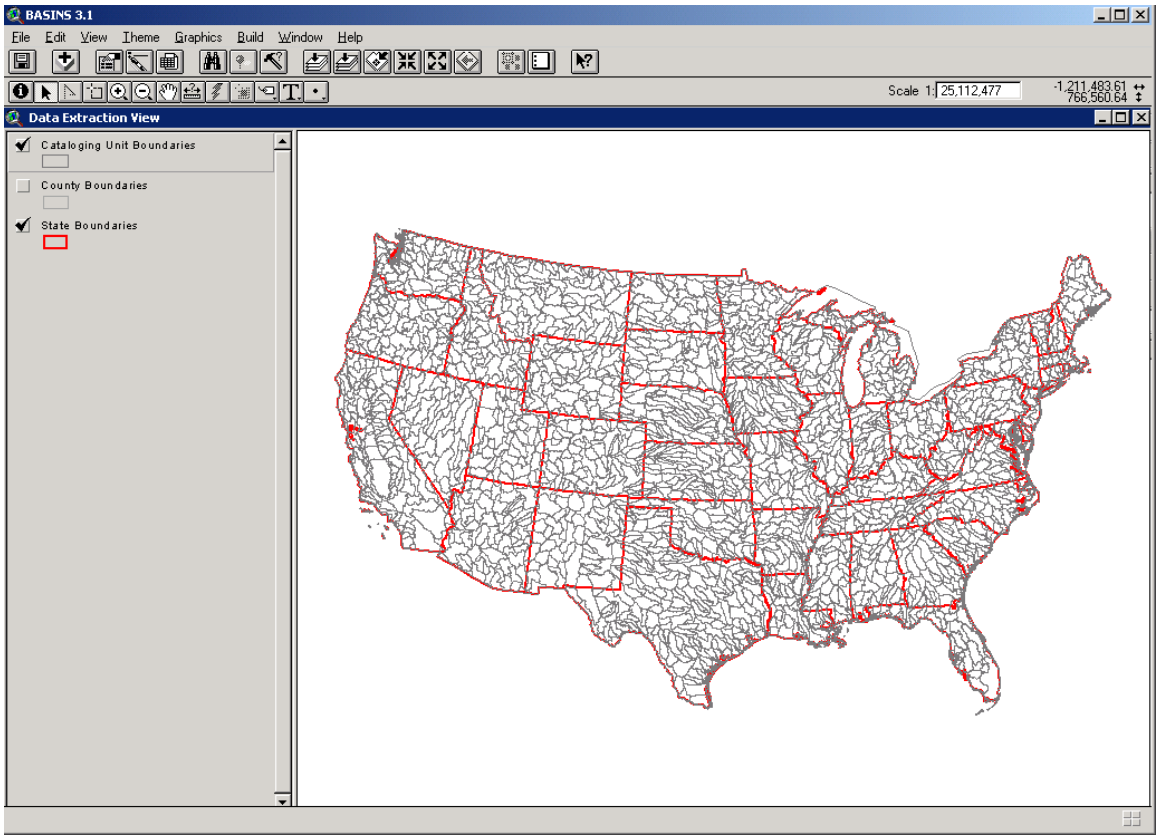

Figure 1: The BASINS 3.1 Data Extractor

From this interface a user may, using the standard ArcView map tools, zoom to any portion of the map and select a region of interest. That region may be one or more HUCs, counties, or states. To create the new BASINS project, the user selects a particular menu item in the interface. BASINS then prompts for the name of a project folder to create and the project name. The user is also prompted for a map projection to use for that project.

At this point, the ArcView interface invokes a new tool, known as the Web Data Download tool. Program control leaves the ArcView interface at this point, as the remainder of the Data Extraction process is not dependent upon proprietary GIS software. The Web Data Download

tool (Figure 2) finds the appropriate data from among the core BASINS data holdings and downloads that data.

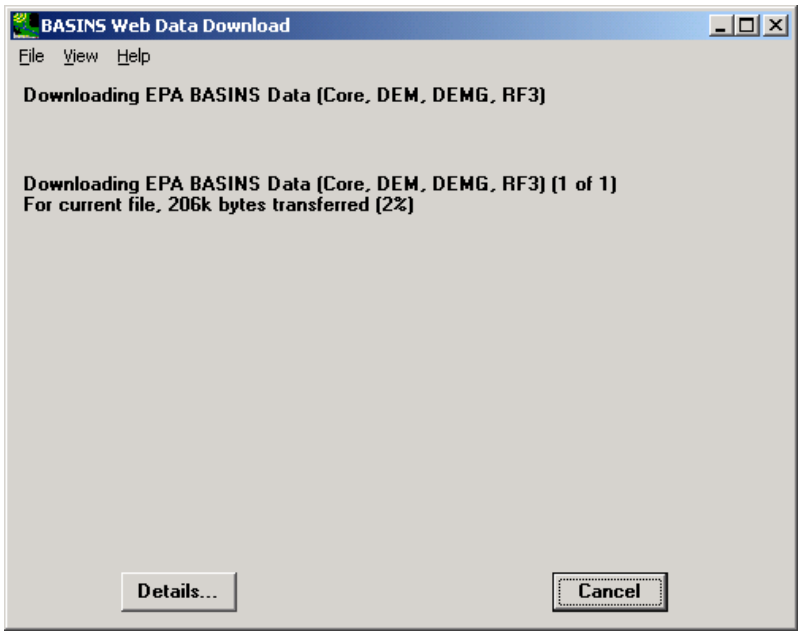

Figure 2: Downloading the BASINS Core Data

Once the BASINS data are downloaded, they are extracted and projected to the user specified map projection. Once the projection change is accomplished, the new project file (the ArcView .apr file) is automatically built.

BASINS 3.1 Web Data Download Tool

A new Web Data Download tool in BASINS 3.1 allows the user to add additional data to the BASINS project from a variety of data sources. Since data available on the web are not static, this tool allows a user to check for more recent data and update the BASINS project data as appropriate. The Web Data Download tool is accessed through a menu option within the BASINS GIS interface (Figure 3). The tool itself is the same separate executable program used in the Data Extraction process, which again is not dependent upon any GIS package.

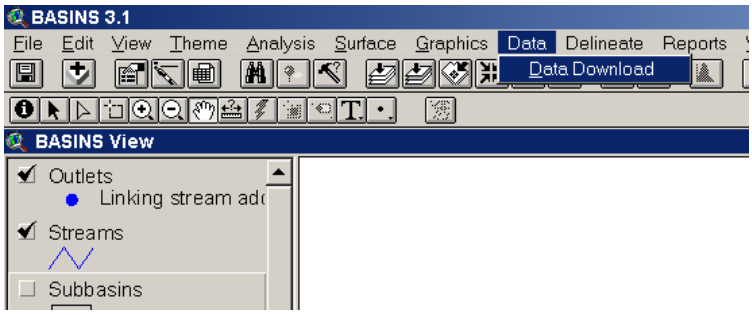

Figure 3: Invoking the Web Data Download tool

When the Web Data Download tool is started, a window appears listing all of the available data types that the tool may add or update. The list of data types is determined at run-time, so this list may expand as new data-type components are created (Figure 4).

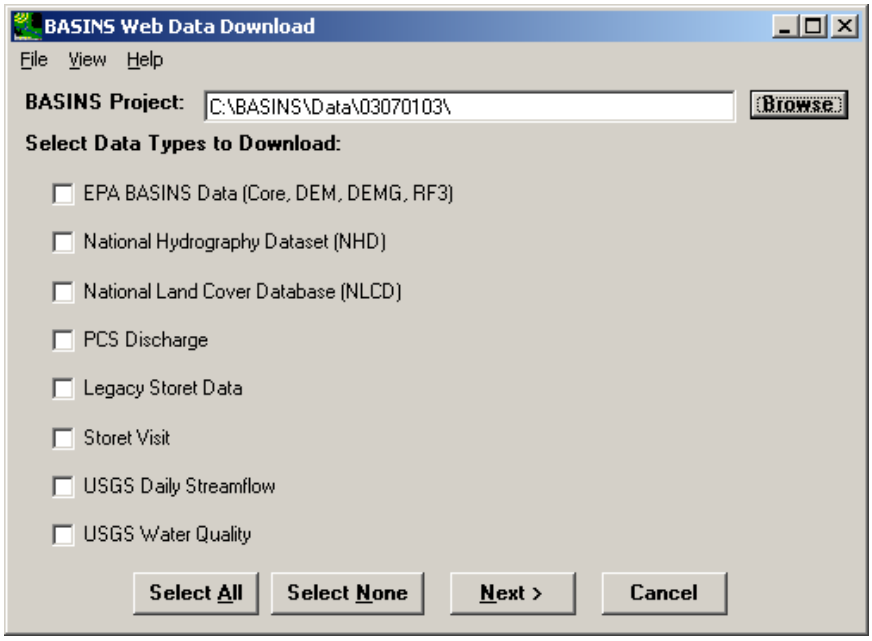

Figure 4: Web Data Download Window

The user chooses as many of the data types as desired, and the tool accesses the specified data through the World Wide Web and adds the data to the BASINS project.

A key feature of BASINS Web Data Download's architecture is the separation of each data type into individual components. Thus, for each data type available for downloading, there is a unique Dynamic Link Library (DLL). This greatly enhances the ability to maintain the entire Web Data Download program. If a data type's web storage is changed such that the code also requires changing, only the DLL for that data type will need to be updated and distributed, not the whole Web Data Download program.

This tool provides great flexibility in pulling data from a variety of sources. Instead of distributing all BASINS data through a specially compiled BASINS data holding, the data can be retrieved from the source of the data directly. This design makes the BASINS system easier and less expensive to maintain, since it eliminates having another copy of each dataset in the BASINS data holdings. In addition, updates to the data are available as soon as the agency producing the data makes the update available, making the most updated data available directly to the user.

Since the Web Data Download tool is not tied to ArcView, it has the inherent flexibility to migrate to future versions of BASINS.

BASINS 3.1 Archive and Restore Tool

A BASINS project consists of a multitude of files, including GIS data layers, tables, and model input and output files. The Archive and Restore Tool, created for BASINS 3.1, provides a means to easily archive the current state of a BASINS project and restore it at a later time. The project can be restored on the same or another computer, and it may be restored under the same or a different name.

The Archive and Restore tool is accessed through an ArcView extension. A menu option within the BASINS GIS interface provides the means to invoke this tool. Like the Web Data Download tool, the tool itself is a separate executable program.

When the Archive and Restore tool is invoked, a window appears giving the user options to archive a project, restore a project, view and compare archives, and build a new BASINS project (Figure 5). The View/Compare option is useful for seeing and understanding the differences between various archived projects. These differences may be seen as a list of files with differences or, for map layers, viewed on a map with differences highlighted. The Build function is a utility included so that the user may build a new BASINS project from an existing BASINS core data set.

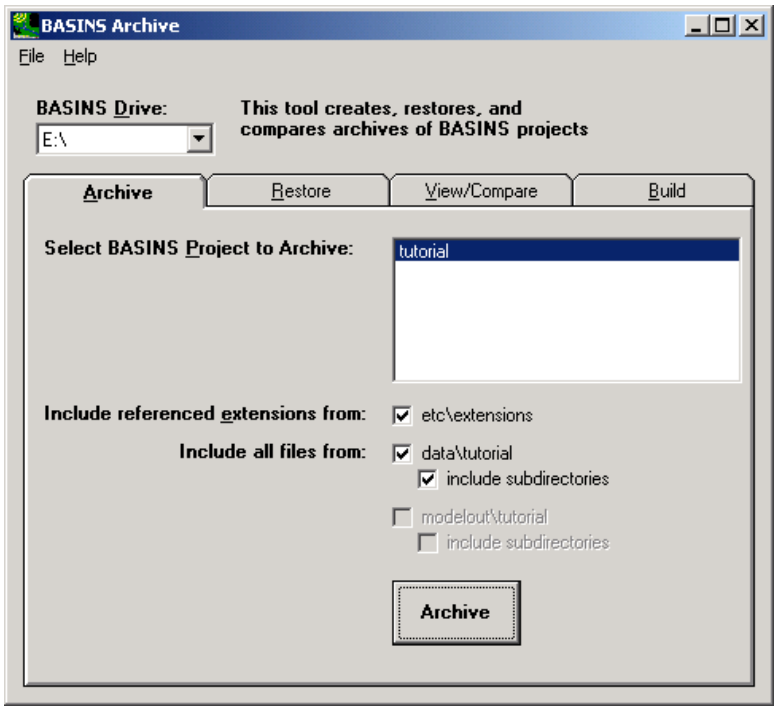

Figure 5: The Archive and Restore Tool

As BASINS projects, with their associated model scenarios, get more and more complex, the Archive and Restore tool is useful for keeping precise records of the BASINS application process. The software architecture of this tool allows for easy migration from BASINS 3.1 to later releases of BASINS.

BASINS 4.0 – A MAJOR MIGRATION

The design of the BASINS 3.1 components lends itself to a more significant restructuring in the next release, to be known as BASINS 4.0. One of the major challenges in the development of BASINS 4.0 is the accommodation of both ArcView 3.x and ArcGIS 8 as GIS analysis tools, while removing ArcView software as prerequisite to the use of BASINS. A new software product in BASINS 4.0 ties all of the BASINS components together through a single software component not based upon any proprietary software package. This new software component is known as the BASINS System Application.

The BASINS 4.0 System Application encompasses all of the existing BASINS components and more into a single new interface. As in BASINS 3.1, independent access to individual components is still available, but these components are tied together into one interface. The System Application identifies which (if any) GIS software products are available on the user's computer, and thus indicates the GIS-based functionality available to the user. This design provides a migration path from the ArcView 3.x components to the ArcView 8.x components.

The dominant graphical feature within the BASINS 4.0 System Application is an interactive map of the United States (Figure 6). The map shows 8-digit HUC boundaries along with state and county boundaries, highlighting those 8-digit HUCs where BASINS projects exist on the user's computer. Selecting a particular HUC (or in some cases an existing project within a HUC) allows the user to proceed into any of the BASINS components. This map does not use any proprietary mapping tools, so this application does not require any run-time licensing.

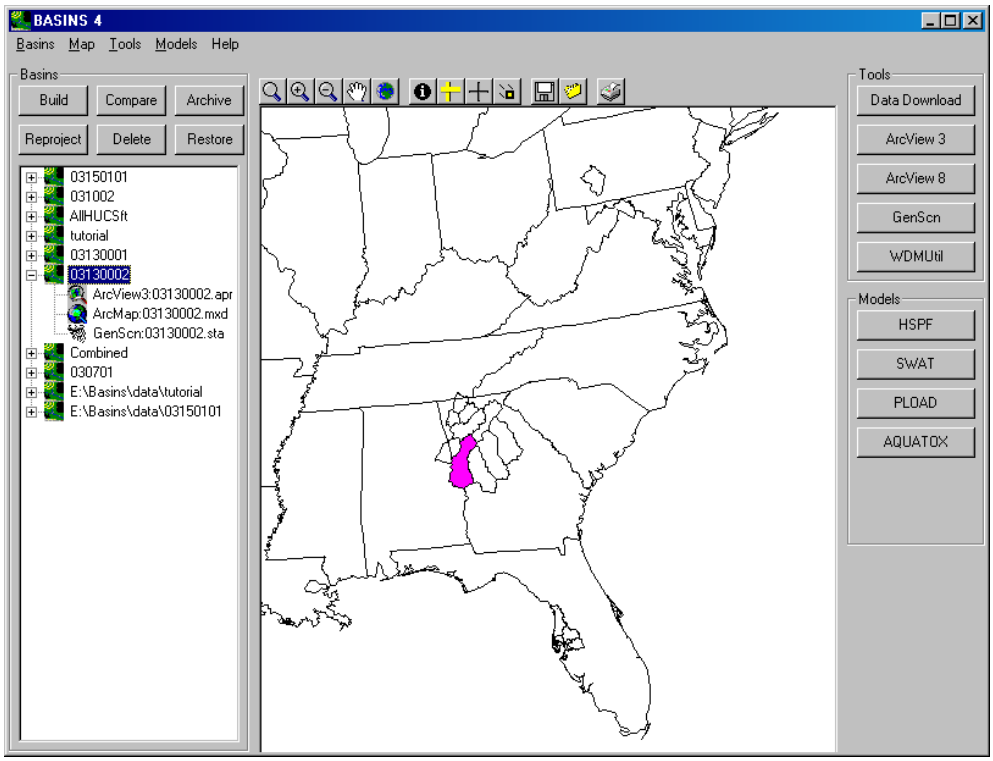

Figure 6: The BASINS 4.0 System Application

A key advantage to this approach is the removal of ArcView 3.x as a prerequisite to the use of BASINS, while allowing its continued use. The BASINS system is available with limited GIS functionality to a user without either ArcView 3 or ArcGIS. All of the functionality from the BASINS 3 ArcView interface is still available, while components for ArcGIS are being developed and rolled out to the user community. Specific BASINS functionality requires prerequisite GIS products, just as Spatial Analyst is indicated as prerequisite to some functions of BASINS 3.

To the left of the map is a list of the current BASINS datasets, or watersheds, on the user's computer, with the projects within those watersheds. Projects may include the BASINS .apr for ArcView 3.x, the .mxd for ArcView 8.x, the GenScn .sta file, or any model input sequence. To the right of the map are frames containing command buttons. These frames are populated at run-time based upon the software available on the user's computer. Buttons may include 'ArcView 3', 'ArcView 8', or both, depending upon the software installed.

Class Architecture

The GIS extension architecture, integral to BASINS since version 3.0, allows for the addition of other models without re-releasing the core software. A similarly extensible architecture allows tools and models to be added at runtime for BASINS 4.0.

A BASINS 4.0 tool or model implements a generic interface defined through a Visual Basic class. Each tool or model has its own class. Code specific to the tool resides in the class along with standard properties and methods used by the BASINS System Application and other components. Tools are discovered at runtime, which allows tools to be added or updated independent of the BASINS core system.

Similarly, a Visual Basic class implements an interface to the BASINS Watershed. This class is used to hold information about each watershed. When the BASINS System Application is started, the BASINS Watersheds on a system are inventoried and the class is built for each watershed. This information is displayed in the System Application and passed to a BASINS Tool when it is invoked.

This flexible class-based architecture is especially important for the BASINS system, which combines dynamic data sources with a suite of models. The data continually evolve, as do the models as different agencies or organizations continually enhance and refine these tools. The software architecture of BASINS 4.0 provides the flexibility needed to keep BASINS always at the leading edge of watershed assessment systems.

The BASINS 4.0 ArcMap Toolbar

One of the most significant enhancements in BASINS 4.0 is the support for ArcGIS 8. A custom GIS interface for BASINS is available in ArcGIS through a toolbar in ArcMap. The BASINS Toolbar (Figure 7) contains menus for accessing the suite of BASINS GIS functions.

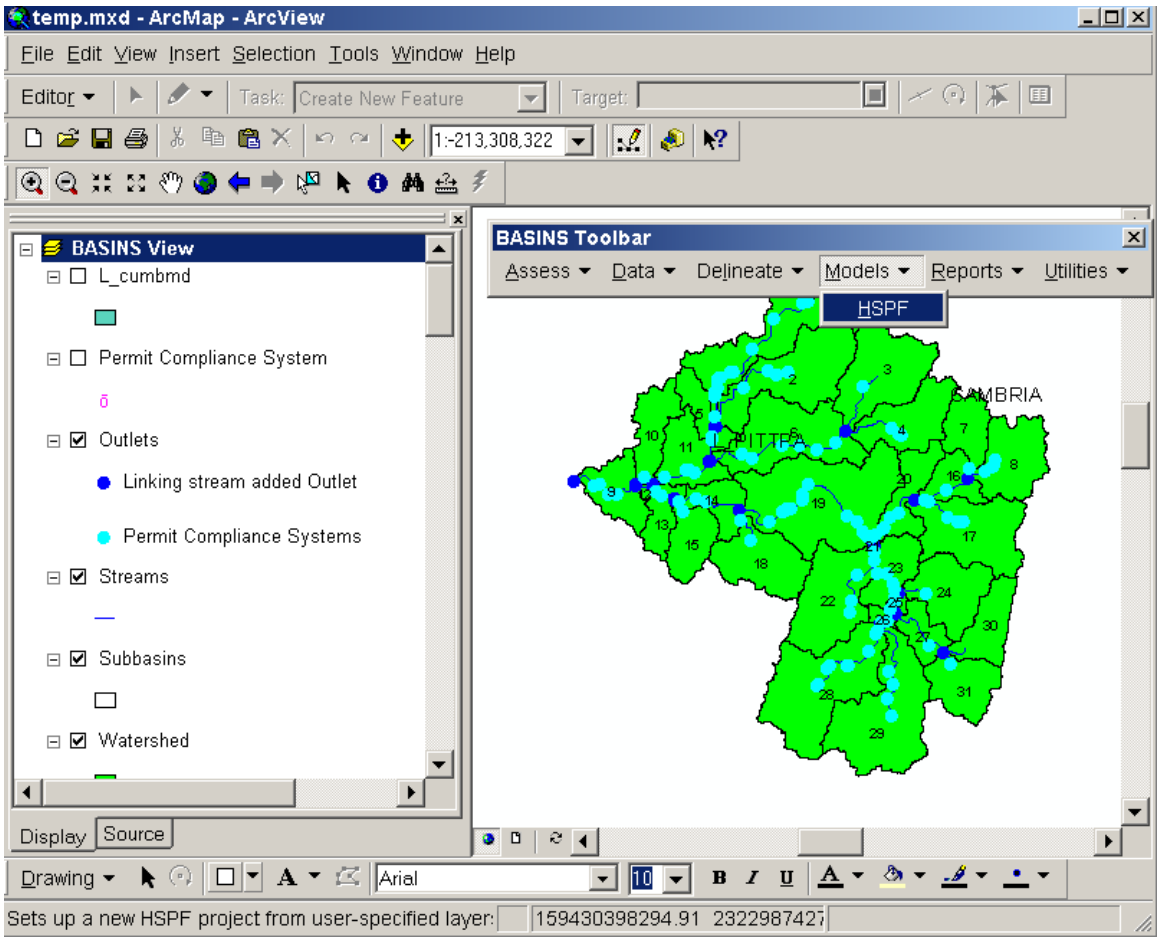

Figure 7: The BASINS Toolbar in ArcMap

The software underlying each menu option in the BASINS toolbar is packaged as a separate DLL, providing flexibility in the structure of the toolbar, as well as expandability as other tools or models are added in the future. Each menu option invokes a tool developed in a COM-compliant programming language, using ESRI's ArcObjects for GIS functions. All of the tools and models share a common component for interacting with ArcObjects. This design enforces a clear separation between tool components and GIS functions. This separation will help accommodate future updates to ESRI's ArcObjects since only one component would need to be updated. BASINS could even be enhanced to not use ESRI products at all, as this design even provides a clear migration path for using core GIS functions from other GIS packages.

CONCLUSIONS

During the development of BASINS 3.1 significant functionality was identified as not requiring GIS, and so this functionality was developed independently of the GIS customization environment. Keeping only those tools that truly are dependent upon GIS in the GIS customization environment provided a migration path for development of BASINS 4.0. One of the major challenges in the development of BASINS 4.0 is the accommodation of different GIS software platforms, while removing the current proprietary GIS software as prerequisite to the

use of BASINS. A new software product in BASINS 4.0 ties all of the BASINS components together through a single software component not based upon any proprietary GIS package. This System Application identifies which of the supported GIS packages are available on the user's computer, and thus indicates the GIS-based functionality available to the user. The underlying software architecture provides a clear separation between interface components and GIS functions. This separation provides a future migration path for using core GIS functions from other GIS packages or for accommodating future updates to the already-supported GIS packages. Most importantly it provides a transition from ArcView 3 to ArcGIS 8, allowing BASINS to harness the power of GIS without being constrained by it.

REFERENCES

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), Version 3.0 User's Manual: U. S. Environmental Protection Agency, EPA-823-C-01-001, Office of Water, Washington DC.