Watershed Assessment Model Enhancements within the ArcGIS Environment

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Abstract

The Watershed Assessment Model (WAM) is a comprehensive GIS-based program that has been used extensively for numerous large and small scale hydrologic and water quality evaluations, including TMDLs (Bottcher and Hiscock, 2002). WAM is currently being migrated from ArcView 3.2 to the ArcGIS 9.2 and ArcHydro (Maidment, 2002) database environments. The presentation will summarize the functionality of WAM as well as highlighting the new graphical user interface (GUI) and ArcHydro features that will significantly improve initial model set up, scenario testing, and output analysis and presentation. Inclusion of the ArcHydro data schema will provide direct database compatibility with a number of the water resource agencies across the country.

Body

Introduction

The Watershed Assessment Model (WAM) is a comprehensive GIS-based program that has been used extensively for numerous large and small scale hydrologic and water quality evaluations, including analyzing impaired water bodies for the Environmental Protection Agency's Total Maximum Daily Load (TMDL) Program. WAM simulates source flows and loads from the various land use / soil combinations found in the watershed or parcel. The flows and loads reaching the stream network and the flows, loads, and stages throughout the stream network are also simulated. Total suspended solids, nitrogen and phosphorous species, and biological oxygen demand are also simulated throughout the system.

WAM is being used by numerous agencies including Natural Resource Conservation Service, US Environmental Protection Agency, Florida Department of Environmental Protection (FDEP), Florida Department of Agricultural Services, Southeastern Climate Consortium, National Institute of Water and Atmospheric Research Ltd / New Zealand, and numerous water management districts, counties, cities, and consultants. WAM is used extensively in Florida because of its ability to simulate both well-drained and high water table soils and to simulate complex hydrography, including looped stream systems with complex flow control structures.

WAM was originally developed by Soil & Water Technology, Inc., (SWET) in 1997 using ArcInfo. In 1998, it was migrated to ArcView 3. The ArcView version of WAM has many tools to assist in setting up the basin and for the end user to evaluate the current conditions and alternatives through a predefined set of best management practices

(BMPs). The input data sets are modified by the experts setting up WAM for a basin by changing values in ASCII files.

Objectives

With numerous users migrating to ArcGIS, the need to migrate WAM to ArcGIS became apparent. With the increased flexibility afforded by ArcGIS, the new WAM interface was designed to give the experts setting up the basin and the end-user far more ease and flexibility in examining and changing inputs parameters.

Therefore, the objective of this project is to migrate WAM from ArcView 3 to ArcGIS 9 and to provide the experts and the final users the ability to view and change the inputs through the GUI. WAM is being migrated from ArcView 3.2 to the ArcGIS by the Applications Programming Group at ESRI. Funding for this upgrade is being provided by Florida Department of Environmental Projection (FDEP).

User Needs Definition

SWET staff interviewed FDEP staff involved in the development of TMDLs. Because of the large quantity of TMDLs that need to be developed, tools to increase the speed of setting up a new basin were of key importance. These included the ability to easily incorporate data from other data sources and the ability to use base sets of data that have been set up for the entire state, such as a statewide soils feature class with corresponding tabular data.

Once the basin has been set up, additional tools to analyze alternatives were also discussed. This included that ability to apply BMPs and to analyze the temporal impacts, such as how long it will it will take for the BMPs to reach full effectiveness. Additional viewing options, such as mapping the differences between existing and alternative conditions were also noted.

Graphical User Interface (GUI)

The challenge to designing the new WAM GUI was to provide access to the detailed information needed by experts setting up the basin and the advanced users while at the same time having the interface useful for the more casual user. Several key design decisions were developed early in the design discussions to address this challenge.

Nomenclature

Developing a dataset nomenclature to define the various types and groupings of information was key to being able to design the GUI (see Figure 1).

Master Data Sets – Data sets provided as base information for the development of a new project are defined as “Master Data Sets”. These master data sets may be housed on servers for use by agency staff as the starting point for new projects. Master data sets would include all available data for defining a region, including soils, management, weather, service areas, etc.

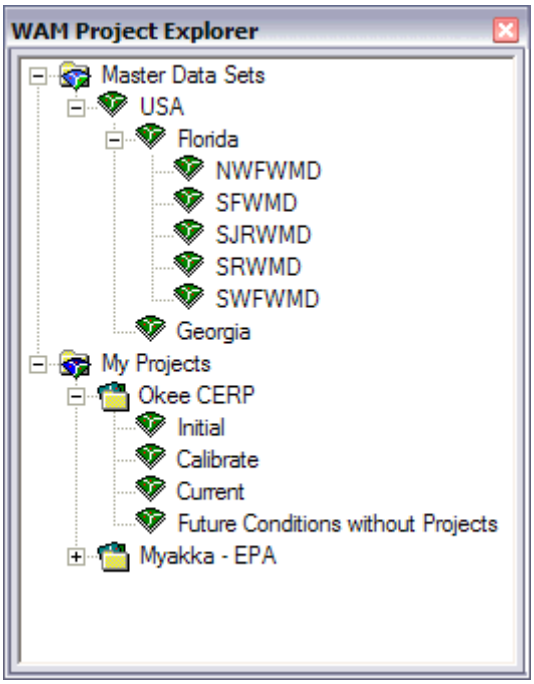

Figure 1. Master Data Sets and Projects with Scenarios

Project – The user creates a new project when they are working on a new region or for a different user. The master data sets are often used as the starting point for a new project. The user locates a master data set that covers their region of interest and creates the project based on this region.

Scenario – The user creates scenarios within a project. Each scenario contains a complete set of data defining the basin and its associated information. A new scenario is created by the user whenever they want to define a different set of conditions for a basin, such as BMP alternatives, historical conditions, etc.

Default Values

Because of the very large number of inputs required to define a basin, it was decided that all inputs would have default tabular values provided by the experts. The users would then be able to adjust these values, as they see fit. Without these default values, the user would be faced with choosing values for thousands of inputs before they could begin their first simulation.

For example, when the user adds a polygon feature class for land use, each land use code would have associated tabular data, created by an expert, that would be used as the default attributes of that particular land use. If the land use code corresponded to low density residential housing, then the tabular data would contain information on the number of people per hectare, whether they are on septic tanks or central sewage, the amount of impervious land, the amount of irrigation and fertilization of the lawn that

occurs, etc. The user could then change these values, if desired, to better represent the management of this particular land use code globally or for an individual polygon.

Property Grid

Defining the inputs for a basin requires many levels of data. For example, land use includes management, type of wastewater treatment including service area, and detention/retention ponds. Management is made up of a calendar of management events, such as planting, irrigation, fertilization, harvest, etc. Fertilization is made up of fertilization dates, fertilizer type, application method, etc.

In order to allow the user to access the data at various levels of detail, the use of a property grid, similar to the one used by Microsoft Visual Studio and ESRI ArcSketch, was decided on (see Figure 2). The property grid has several attractive features. It is easily customized to the feature class that has been selected. Also, it is a well tested paradigm for grouping and editing disparate information.

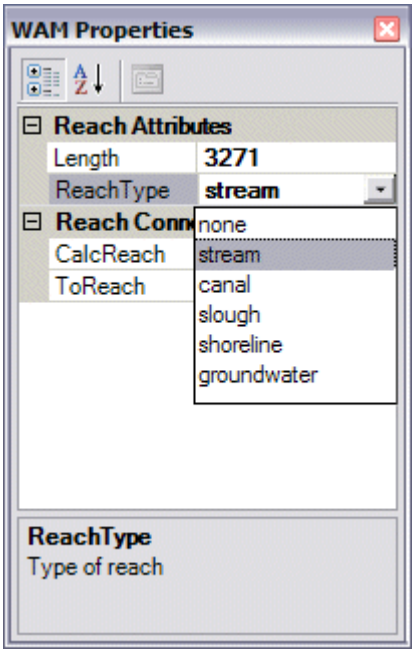

Figure 2. WAM Property Grid

Temporal Data Handling

Most basin models only deal with temporal weather data, such as rainfall and temperature, but neglect temporal data associated with land use changes over time. One of the key features in the new WAM GUI is its ability to incorporate both tabular and spatial temporal data. Each feature class has a date associated with it that denotes when the feature class becomes “active”. A “break point” approach was taken where this feature class is active until another feature class, representing the same type of data, has a date associated with it that is equal to the current date.

Presentation of Inputs and Simulation Results

In order to meet the needs of the user for displaying both inputs and results, several tools were developed in the GUI. The user is able to use standard ArcGIS tools to display maps of the various feature classes and their associated attributes. Tabular data can be displayed with various groupings, such as subbasin, land use, area of interest, etc. Time series data are exported to comma separated variable (CSV) files and are displayed using Excel. This approach was used in the ArcView 3.2 version of WAM and was popular with users because of their comfort with being able to perform various analyses with Excel. Multiple scenarios can also be compared, including the differences in inputs and output data. The use of NetCDF data to display temporal maps is currently being investigated.

Geodatabase Structure

The GUI and geodatabase structure were developed simultaneously because each one influenced decisions on the other.

ArcHydro

The decision to base the database schema on ArcHydro geodatabase designs was easy to make because of its current and growing acceptance by water management districts and other agencies. In Florida, South Florida, Southwest Florida, and St Johns River Water Management Districts are actively working on moving data into ArcHydro compliant databases. Having WAM able to make use of these data sets fits well into the concept of the "master data sets". Also, WAM is able to leverage much of the thinking and effort that has gone into the development of ArcHydro. ArcHydro provides a suite of tools that the WAM users can access to set up data sets.

Default and Scenario Data Sets

The importance of having default data was discussed above in the GUI design elements. The implication for the geodatabase design is that each type of data will have two sets of tables, default tables and scenario tables. Default tables contain the list of default data sets provided by the experts and possibly modified by the user. These tables are used to assign default attributes to features or to change the attributes of an existing feature. Scenario tables contain the tabular data attributes associated with each feature class. These are the data that will be used in the simulation of the basin.

Feature Class and Tabular Data Linkage

The attribute fields associated directly with each feature class were kept to a minimum, consisting only of a data characteristic ID. This ID links the feature class to the scenario table which contains the detailed information. Because of the many levels of data often associated with a feature class, the first tabular table often contains only an ID, name, description, and links to related tables.

GUI / Geodatabase to Model Linkages

Based on the experiences of the Applications Programming Group at ESRI in developing other GUIs, such as HEC-GeoRAS, the underlying simulation models are being loosely linked with the GUI / geodatabase using XML files and XSLT transformations. The GUI

extracts the appropriate information for a model run into an initial XML file. XSLT files are then used to transform the information into input files appropriate for the simulation models. After the simulation is completed, the output files are translated using XSLT files into XML files that are brought into the geodatabase ready to be displayed to the user.

Conclusions

The ArcGIS upgrade of WAM will provide the features requested by the users. These include compatibility with ArcGIS, ability to access all inputs from within the interface with better data quality control, more rapid set up of basins, ability to represent temporal data, and increased features for displaying results, including differences between scenarios.

The upgraded version is scheduled for completion by September 2006. Beta testing has been scheduled by water management districts for basins in north and south Florida shortly there after. A release version of WAM will be available Spring 2007. The WAM is freely available for download and use from the SWET website (www.swet.com) and from the EPA TMDL Toolbox website (www.epa.gov/athens/wwqtsc).

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