# Report for 2003TX87B: Coupling Modular Hydrologic Models with GIS

- Conference Proceedings:
  - Goodall, J. L. and D. R. Maidment (2004). Representation of Spatial and Temporal Data in ArcGIS. AWRA 2004 Spring Specialty Conference: GIS and Water Resources III, Nashville, NC.
  - Goodall, J. L. and T. Whiteaker (2003). Water Quality Modeling in GIS. GIS Hydro 2003: Preconference to the ESRI International User's Conference, San Diego, CA.
  - Sorenson, J. K., J. L. Goodall, D.R. Maidment. (2004). Arc Hydro Time Series Framework for Defining Hydroperiod Inundation. AWRA 2004 Spring Specialty Conference: GIS and Water Resources III, Nashville, NC.
  - Zoun, R., D. R. Maidment, J.L. Goodall. (2003). GIS as a Tool for Assisting TMDL Development. Twenty-Third Annual ESRI International User Conference, San Diego, CA.

Report Follows

# Coupling Modular Hydrologic Models with Geographic Information Systems

## PROGRESS REPORT

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## RESEARCH RELATED ACTIVITIES

The objective of this project was to investigate using dynamic linked library (DLL) files as a method for linking processing routines with spatial and temporal data stored in geographic information systems (GIS). DLL files can contain legacy and original code written in any COM-compliant language and can be accessed through any COM-compliant language. This means, for example, code written in Fortran can be called from a Macro written in Visual Basic of Applications in ArcGIS.

This concept was tested with two test cases: (1) estimating the non-point source fecal coliform loading to Galveston Bay, Texas and (2) estimating the point and non-point source nitrogen loading along the Guadalupe River, Texas using the USGS SPARROW model regression equations(2003; Zoun, Maidment et al. 2003). Both of these test cases used a tool developed at the Center for Research in Water Resources (CRWR) for processing an Arc Hydro Schematic Network. Background on Schematic Network Processing can be found on the web at the following URL:

http://www.crwr.utexas.edu/gis/gishydro03/Schematics/SchematicNetwork.htm.

The first test case (Figure 1) included subroutines stored in a DLL file that estimated in-stream decay as a first-order chemical reaction, and the each bay's concentration using CFSTR (Constant flow stirred tank reactor) assumptions. The estimated long term bay concentrations matched observed concentrations in each bay segment.

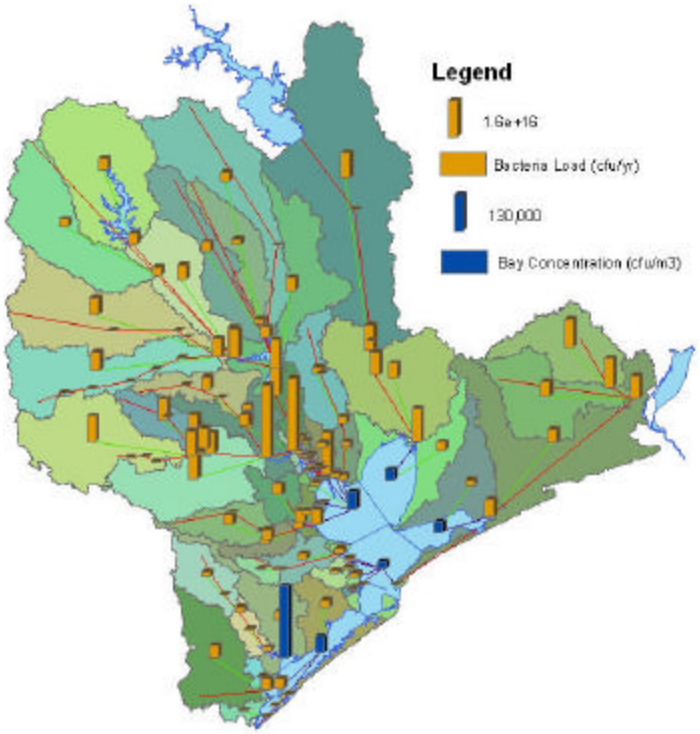


Figure 1 – Case Study 1 estimated non-point fecal coliform bacteria delivered to Galveston Bay

The second test case used the USGS SPARROW (SPAtial Referenced Regression on Watershed Attributes) model to estimate land-to-river decay and in-stream decay processes. Functions to estimate the non-point source loading within each watershed and the in-stream decay for each river reach were stored in a DLL file and used in conjunction with the Schematic Network Processing tool to estimate non-point and point source loadings for

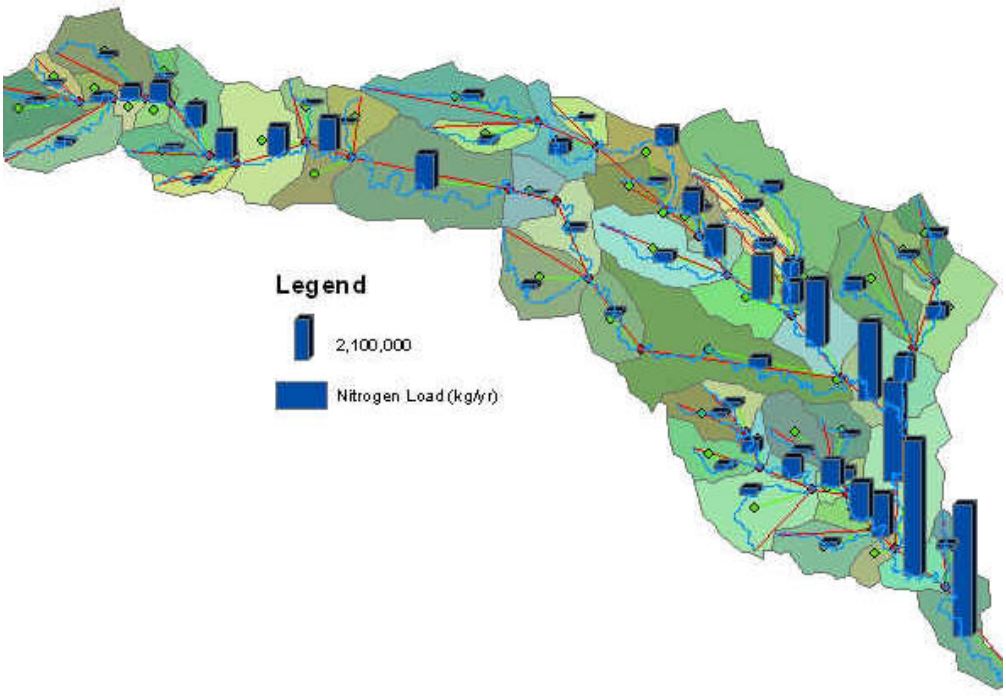


Figure – Case Study 2 estimated point and non-point nitrogen loading along the Guadalupe River.

Both test cases were to estimate the long-term loading (kg/yr) and did not account for seasonal variability. This is in part because geographic information systems are not particular strong at dealing with temporal data. Recent research at CRWR has focused on developing a framework for storing time series and spatiotemporal data in a GIS database(Goodall and Maidment 2004; Sorenson, Goodall et al. 2004). This research is necessary for establishing the foundation for integrating geospatial data common in GIS with time series data common in many industry standard water resources simulation models.

Following are the publications resulting from this research:

## WHAT WE HAVE LEARNED

We have learned through this research that storing modular simulation functions and subroutines in DLL files provides a powerful means for linking processing routines with geospatial data in GIS. A major benefit is that the routines written in a DLL file can be accessed through many software systems. One can write generic, modular functions and routines in a DLL file that can be accessed through Macro routines in Excel or GIS. The functions in the DLL file can be used in Excel just as predefined functions. The same functions in the same DLL can be used in GIS to estimate non-point source pollutant load. This suggests the possibility of sharing processing routines as freely as sharing data. The key to making this happen is clear documentation of the functions and subroutines and for the functions and subroutines to be developed in a generic manner that accepts universal data types (numeric, character, arrays, etc.).

We have also learned through this research that a major obstacle to water resources analysis in GIS is extending GIS to include time series and spatiotemporal data. Without a formalized methodology for incorporating time into GIS, dynamic water resources processing routines, such as those used by the Army Corps of Engineering Hydrologic Engineering Center (HEC) models, can not be used in GIS. Time series measured at a gage must be linked to the geospatial location of the gage; flood inundation polygons must be temporally referenced so that one can visualize a dynamic flood event; rain measured by NEXRAD and stored as rasters must be stored in a time-indexed series.

## PROGRESS ON FUNDS EXPENDATURE

The remaining balance for the research funds is $2,081.76. The main purchase thus far has been for a laptop computer ($1,930.34). The remaining money is being allocated to attend a conference where the final results of this research project will be presented. The exact conference is yet to be determined.

## PROGRESS ON GRADUATE DEGREE PROGRAM

I am in my third year of graduate school. I received my master's degree in civil engineering from the University of Texas in May of 2003. In August of 2003 I successfully passed the Ph.D. qualifying exam and in January 2004 was accepted as a Ph.D. candidate. The final steps in obtaining my degree are to propose and defend a dissertation. I have completed a first draft of the dissertation proposal and am making revisions suggested by my supervising professor, Dr. David Maidment. The anticipated proposal defense date is March 12, 2004 and the anticipated dissertation defense date is the summer of 2005.

## ADDITIONAL FUNDING RELATED TO THIS PROJECT

This project has not yet directly led to any additional funding.