Report for 2001IA1542B: Modeling, GIS, and Technology Transfer in Support of TMDL Development and Implementation in Iowa

There are no reported publications resulting from this project.

Report Follows:

Project Rationale and Significance:

Under the provisions of the federal Clean Water Act (CWA) Section 303(d), states (herein referred to the collection of states, territories, and authorized tribes) are required to identify water bodies and stream segments that are impaired from point and nonpoint pollution sources. To improve the water quality problems in these water bodies, total maximum daily loads (TMDLs), defined as "the sum of the individual waste load allocations for point sources and load allocations from nonpoint sources and natural backgrounds" (40 CFR 130.2) are to be developed. TMDLs form the basis for developing best management practices for stream water quality restoration and play a key role in stakeholder involvement in watershed management and watershed restoration strategies. All stages in the TMDL development process requires sound science and the ability to translate complex data and information into a coherent and concise package so that agencies and stakeholders can understand the issues and be able to evaluate alternative remedial options.

The basis for TMDL development rests on a wide range of factors, including source water assessments, expected ability to meet the TMDL limits, terrestrial and aquatic ecosystem modeling and monitoring, and resource economics. Although the Environmental Protection Agency (EPA) has provided a compendium of tools and models to aid in the TMDL development and implementation plan, the reliability of these models for general applications remain questionable. There remain considerable gaps between models developed for the prediction of point and nonpoint source pollution and those that can be used to support TMDL analysis and development. Indeed, many in the agriculture and water resource communities have expressed concerns over the lack of science behind the TMDL modeling and planning process. For example, former Secretary of Agriculture, Dan Glickman and many others have expressed concern over the TMDL program. Specifically, Mr. Glickman stated, *"the USDA is concerned about the science being used in assessing and attributing the effects of nonpoint source pollution. These models have a high degree of uncertainty and there are gaps in the data regarding what is natural background pollution versus what is caused by human activity.*" Given these uncertainties, there is critical need for an objective evaluation and refinement of existing models and tools used in TMDL development as well as a concise demonstration of how these models can be used to establish quantitative measures of the relationship between pollutant sources and water quality impacts. Equally critical is the need for effective information dissemination, training, and stakeholder engagement programs that build capacity for effective and technically defensible implementation of TMDLs.

The problems faced in developing TMDLs vary widely across water quality issues and problems. Iowa, like many states, currently needs to develop TMDLs for nearly 49 watersheds and 157 affected streams; efficient and equitable development of TMDL requires a sound scientific and technical base and appropriate tools not currently available. Successful water quality management in the U.S. has always depended on applying good science and on the efficacy of modeling techniques. This project will undertake a comprehensive review of models, recommend modifications to models as appropriate, assess existing data sources for Iowa and develop a database for model application, and refine and apply the SWAT model to assessing sediment, nutrients, pesticides, and microbial pathogen impairment related to TMDLs.

Objectives of the Research Project:

This research is structured to provide enhanced decision support for TMDL analysis by: (a) critically evaluating existing terrestrial and aquatic models and TMDL planning tools to insure that they are based on sound science and are used in a sound manner; (b) providing tools for estimating waste loads associated with biological pollutants under different watershed conditions and management practices; (c) developing objective criteria for choosing among models, data sources, and implementation plans based on the priorities of all stakeholders; and (d) demonstrating the use of integrated models for assessing the potential ecological benefits of TMDL implementation at the watershed scale. As outlined in the original proposal, the specific project objectives are:

- To undertake a science-based evaluation of existing models for their use in TMDL development and implementation and suggest areas for future refinements.

- To integrate algorithms developed for waterborne pathogens (specifically bacteria) into the SWAT biophysical model to facilitate use in development of nutrients and microbial TMDLs in tiled drained watersheds in Iowa.

- To assess the potential ecological and water quality benefits of TMDL implementation in an agriculturally dominated watershed in Iowa to serve as a case study.

The overarching goal of the project is to enhance the effectiveness of watershed water quality management efforts and improve the scientific basis and computer models for TMDL development and implementation. The products from this research should increase the likelihood of acceptance of the TMDL process by regulators and stakeholders, and help assure that the entire TMDL development process meets the desired water quality goals.

Progress Made Thus Far:

The project is proceeding well, with considerable progress made in the development of the primary project deliverables. Specifically, the research is progressing in three interrelated phases. In Phase I, we conducted a rigorous, science-based evaluation of existing terrestrial and aquatic ecosystem models that are available or recommended for use in developing TMDL loads and waste-loads. Under this phase, two activities were accomplished. First, a detailed review of the procedures and methodologies used by the states, tribes and territories within the U.S. to develop TMDLs was conducted. The objective of this review was to compare or contrast differences in TMDL methodology, modeling techniques, and implementation strategies. The second activity involved a critical, process-level, science-based evaluation of the terrestrial/in-stream response models used for TMDL development. In Phase II of the project, constitutive equations (algorithms) that govern the movement of microbial pathogens—including the fecal coliform bacteria group—were developed for inclusion into the SWAT biophysical model. Currently we are under Phase III of the project, which involves a rigorous demonstration of the utility of the enhanced SWAT modeling system for TMDL development and using the modeling system to explore the ecological benefits of TMDL implementation within an agriculturally dominated watershed.

Under the Phase III project plan, we have assembled relevant input parameters to support SWAT modeling or water quality conditions in the Upper Maquoketa River watershed. Observed flow and transport parameters have also been assembled for critical evaluation of model reliability. The Upper Maquoketa River watershed is located within the Counties of Buchanan, Clayton, Delaware, and Fayette in northeast Iowa. With a total drainage area of 15,890 ha or 39,248 acres, the watershed land use consists of 78.7% agricultural (i.e., 40.3% corn, 27.2% soybean, and 11.2% oats/hay/alfalfa), 10.5% pasture, and 8.8% forest. Monitoring activities within the watershed consist of flow measurements at four sites and water quality sampling at same sites. Among other constituents, these water quality samples are analyzed for nitrate-nitrogen (N), kjedahl-N, ammonium-N, total phosphorus (P), ortho-P, chemical oxygen demand, and total suspended solids. In this project, data on nitrate and bacterial concentrations and flow will be used to establish the TMDL waste-load numeric criteria. The various tasks under this phase of the project are being conducted with assistance from Dr. Baker and Dr. Kanwar. A research associate, Marius Aqua, was also hired to help in data assemble and data quality checks.

In addition to the tasks described above, our Year 2 activities also involve process-level evaluation of the microbial fate and transport component in the SWAT model. From this evaluation, a more robust modeling component for developing numeric standards for microbial pathogens will emerge, providing much needed analytical tool for predicting movement of not only total and fecal coliform bacteria, but also other pathogens that may be present in land-applied animal manure and sewage.

Future Project Activities:

The project elements that remain to be accomplished will involve application of the modified SWAT model to the Upper Maquoketa River watershed. Here we will conduct model simulation runs, assess the reliability of the model, and suggest techniques for evaluating model uncertainty and error propagation. In addition to model verification and reliability assessment, the Year 2 activities will also include the application of modified SWAT modeling environment in assessing the ecological and water quality benefits of the TMDL program in the watershed. This activity will concentrate on the Upper Maquoketa watershed where continuous water quality (including bacterial) monitoring has been underway for quite a number of years. The lessons learned from this modeling process will form the basis for transferring methods to other watersheds. Technology transfer activities will involve demonstration of the modeling system to personnel at state or federal resource agencies. Upon completion of the Year 2 activities, we will submit a final report that details the project elements, modeling system, deliverables, and accomplishments to ISWRRI and prepare manuscripts for journal publication.