Report for 2001AR3641B: Critical Evaluation of TMDL Data Requirements for Agricultural Watersheds

- Water Resources Research Institute Reports:
  - Chaubey, I., A.S. Cotter, T.A. Costello, M.A. Nelson, and T.S. Soerens. 2002. Quantification of runoff and nutrient load prediction uncertainity due to GIS data resolution. Proceedings of the AWRC Annual Conference (In Press).
- Conference Proceedings:
  - Cotter, A.S., I. Chaubey, T.A. Costello, M.A. Nelson, and T.S. Soerens. 2002. TMDL Data Requirements for Agricultural Watersheds. Proc. Total Maximum Daily Load (TMDL): Environmental Regulations Conference. ASAE, St. Joseph, Mo. Pg. 408-415.
- Articles in Refereed Scientific Journals:
  - A.S. Cotter, I. Chaubey, T.A. Costello, M.A. Nelson, and T.S. Soerens. 2001. Effect of DEM data resolution on SWAT output uncertainty. J. Hydrologic Processes. In Review.

Report Follows:

Problem and Research Objectives:

Nonpoint source transport of nutrients, sediment and pathogens from agriculturally dominated watersheds is a major concern in Arkansas. There is ample evidence to suggest that excess land application of animal manure and row crop agriculture have led to surface and ground water pollution. Runoff losses of nutrients and sediment have resulted in excess algal blooms, eutrophication and turbidity of lakes and streams. The 303(d) list of Arkansas identifies sedimentation, mercury and nutrients as top three pollutants of concern affecting more than 70% of total impaired water bodies in the state. Currently, a total of 39 water bodies representing more than 1300 miles of streams/rivers/shorelines and more than 7100 acres of lakes/estuaries are impaired with sediment, nutrients, and pathogens in Arkansas. The Clean Water Act of US EPA requires the states to establish Total Maximum Daily Load (TMDL) for the pollutants and watersheds of concern. The TMDL program is identified as the method to resolve continuing water quality problems, including polluted runoff from nonpoint sources.

Water quality models are frequently used to estimate NPS pollutant loads from watersheds and to predict stream response to various pollutant loading scenarios. Models are also used to estimate TMDLs from point and nonpoint sources that will result in desired optimum water quality improvement with minimum TMDL implementation cost. Because intensive monitoring of watersheds is very expensive, it is important that model estimates of effectiveness of various Best Management Practices (BMPs) are accurate so that costly mistakes of developing inaccurate, or sometimes, unattainable water quality goals can be avoided.

The Research Need:

A critical evaluation of currently available water quality models is needed before they can be used to develop TMDLs for agricultural watersheds in Arkansas. Currently, several NPS models are being used to develop TMDLs in other states. None of these models have been extensively validated/tested for watersheds in Arkansas. Because the accuracy of model prediction is directly dependent upon how well the model works in certain land use, soil, and hydrologic conditions, it is important to validate these models using the data obtained from watersheds in Arkansas. Accuracy of model prediction is also dependent upon accuracy of input data. A TMDL developed by a water quality model cannot be expected to be accurate if the model inputs were not accurate. It is imperative that spatial and temporal input data requirements of such models are evaluated so that effective watershed monitoring plans can be developed.

This project evaluates currently available water quality models for TMDL development in Arkansas and to determine the optimum-scale of temporal and spatial input data required to accurately develop TMDL for agricultural watersheds. No such comprehensive validation has been done in Arkansas. The models are evaluated using data obtained from Lincoln Lake watershed. This watershed has been extensively monitored for over a decade and very high quality data are available to critically evaluate

TMDL model needs. This project addresses a very critical need of the state agencies and will give valuable information to State and Federal agencies, and other groups involved with developing and implementing TMDL process decisions.

Methodology:

This study was carried out in two phases. First the SWAT model was calibrated for the Lincoln Lake watershed, located in western Washington County in Northwest Arkansas. The drainage area of the watershed is 3240 ha. Major land uses within the watershed are pasture (55%) and mixed forests (39%). Animal production is prevalent, in the form of numerous poultry and beef operations located in the watershed. Second, the output accuracy for each input GIS data resolution was evaluated. Acceptable resolution scales had greater than 90% accuracy in watershed response prediction.

Principal Findings and Significance:

Input DEM data resolution affected SWAT model predictions by affecting total area of the delineated watershed, predicted stream network, and sub-basin classification. Results of this study showed that input DEM resolution had the most significant impact on the SWAT model output. The optimum GIS data resolution to achieve 90% prediction accuracy depended upon the output of interest and ranged from 30m – 200 m. When modeling stream flow with the SWAT model, resolution of input DEM should be ≤ 200m. Land use and soil resolution had no impact on flow predictions. When modeling sediment, resolution of DEM and soil should be ≤ 30m, and ≤ 300 m, respectively. Land use resolution had no impact on sediment predictions. The minimum DEM, soil, and land use resolutions needed to reduce model uncertainty less than 10% are 30m, 150m, and 200m, respectively.