USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Assessing the hydrologic and geomorphic impacts of land use change in urbanizing watersheds, Indianapolis.

Duration: March 1, 1999 through March 1, 2000

FY 1999 federal funds: $25,000

FY 1999 non-federal funds: $59,288

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Congressional district of university performing research: 7

Overall Context

A wide range of city, county and state-level agencies and organizations are involved in work that generates scientific and technical questions concerning water resources that their staff are not trained to answer. For example a planning department might develop a new need for a new water resources impact model, or a mayor's office might need to find out about the latest research in wetland hydrology to drive new policy directions. In theory there are a wide range of federal and state sources for some of this information and advice, but in practice many departments and agencies either are unaware of these, or do not make use of them for a variety of political, historical or other reasons.

The faculty and students of the universities provide a vast intellectual resource that is underutilized by city, county and state-level agencies and organizations. The universities are typically held in high regard, and can provide objective research and analysis, as well as access to people knowledgeable about the newest work and thinking in water resources. However, there is typically a lack of contact between the universities and these agencies and organizations, despite the fact that these agencies and organizations include large numbers of university graduates.

The goal of this proposal is to provide specific research in to the hydrologic and geomorphic impacts of urban development in Indianapolis, and this is described in more detail below. However, the broader context of this effort is that this research will integrate with and complement efforts being undertaken to provide specific research needs of the City of Indianapolis, and is of considerable interest not only to the City's watershed management team, but also the County Soil and Water Conservation District and a grass roots environmental group, the Indian Creek Watershed Alliance (ICWA). Because of this, the project will provide a demonstration of the way in which university water resources research can fruitfully respond to the information needs of grass roots, city, county and state-level agencies and organizations. Thus a larger goal of the project

is to demonstrate and facilitate water resources research focused on important information and knowledge needs of the citizens and government organizations of the State of Indiana.

Research Project Background

Purdue faculty, staff and students are currently working with the City of Indianapolis' inter-departmental Watershed Management Teams. Purdue's Department of Earth and Atmospheric Sciences was approached by the City of Indianapolis' watershed team coordinator initially because of their interest in finding out more about a land use change impact assessment model we are developing. Faculty and student willingness to present information on the model, and to sit in on watershed team meetings as a way of providing additional scientific advice, has led to the beginning of an expanded relationship with city groups. This includes providing research that is of value to the scientific research community, but is also motivated by the need to solve specific problems in the Indianapolis area.

The work proposed here is an outgrowth of this process. As is the case for many other communities, the City of Indianapolis is struggling to deal with environmental impacts asociated with urban sprawl. The range of issues surrounding urban sprawl have been highlighted in recent speeches and policy statements by individuals and groups such as Vice-President Gore, national environmental and farm organizations, and local level politicians and grass-roots organizations. The particular focus of the research proposed here are the impacts of land use change and development in disturbing the hydrologic and sediment load characteristics of streams. Although much has been written in general about the hydrologic and geomorphic impacts of land use change, very little research has been directed towards developing tools that can be used to evaluate both impacts and proposed management options, making use only of readily available data. Although there have been considerable advances in understanding the details of the physical processes that operate in hydrologic and geomorphic disturbance, these have led to the development of highly complex models that require input data that are rarely available (both in terms of the parameters needed, and the spatial and temporal resolution of the data).

Over the past 8 years we have progressively developed a model, called L-THIA (Long-Term Hydrologic Impact Assessment), that makes use of readily available data for land use, soils and climate to assess the impact of past and proposed future land use change. A proto-type web-based version of this method can be found at http://danpatch.ecn.purdue.edu/~napra/LTHIA/. L-THIA has as its core a daily simulation of runoff for the local 30-year climate record, using a distributed rainfall-runoff model, and is able to deal with a wide range of soils and land use conditions. Recent work has added nonpoint source pollution loadings to the model. However, it is important to note that the input data are restricted to the types of information that a local planning agency, soil and water conservation district, or engineer would have easy access to. This of course raises a number of issues with respect to model reliability, problems of spatial and temporal resolution, and model sensitivity. These issues have been addressed progressively for LTHIA in a series of graduate theses:

Keith McClintock (MS, 1993): Assessing and managing the impacts of development and land use change on sediment and water supplied to a wetland: Hudson Township, Summit County, Ohio. Matt Grove (MS, 1997): Development of a GIS model for assessing the long-term hydrologic impact of land use change. Marie Minner (MS, 1998): Sensitivity analysis and advanced applications of L-THIA. Budhendra Bhaduri (Ph.D., 1998): A GIS-based model to assess the long-term impacts of land use change on hydrology and nonpoint source pollution.

Research Project Description

One limitation of the LTHIA approach as it is applied at present is the failure to include point sources of pollution. This makes it hard to compare model output with empirical data, because the model simply predicts the nonpoint source component of the pollutant load in the stream or river, whereas most empirical data include both point and non point sources. In the work proposed here we will develop an additional ability in the model to allow the user to enter data on point source pollution loadings to the watershed. In many urban areas there are monitoring data available from major point sources of pollution, as a result of regulatory requirements for data collection and reporting. We will develop the LTHIA model to allow for input of point source pollution loadings, with two goals. First, to allow better testing and verification of the model against observational data, and; 2, to allow model-based assessment of the relative roles of point and nonpoint sources in urban water quality degradation. This later capability will allow considerable flexibility in evaluating ways in which alternate management strategies will actually effect overall water quality. The City of Indianapolis has agreed to fund acquisition of relevant land use data, and basic LTHIA setup for a study area (this is part of the cost-share on the project), and this is the basis for the exapnsion to include point sources of pollution. In practical terms, the inclusion of point source pollution will involve expanding the program code to allow the user to enter time variant pollutant loadings at specified points in the watershed, which will then be added to the calculated nonpoint source pollution loadings during the daily simulation calculations. Where long-term daily data are available, these will be used. If long-term averages are available we will develop a scheme to allow the user either to select use of average values, or to control time-variant loadings around the average (eg seasonal or monthly variation).

In developing the research plan, we have identified sediment as a particularly important potential pollutant. However this is one area in which relevant local data for major sources are not widely available. Construction sites are widely believed to be responsible for enhanced sediment loadings in urbanizing watersheds, yet there is little actual empirical data available on sediment delivery to streams (as opposed to erosion rates at study plots on construction sites). Thus a second goal of the project is to collect empirical data in a study watershed (Figure 1) to address local rates of sediment delivery to streams from construction sites. This will involve installation of automated flow measurement and sample collection equipment (ISCO samplers) up and down stream of construction sites, with the goal of collecting flow and suspended sediment load data through to the end of the project (with an intent to continue monitoring beyond then if additional funds become available from other sources). Flow data will be collected at 15 minute intervals

using a calibrated level to flow conversion, and the samplers will be programmed to collect samples both at a regular interval for low flow conditions, and closely spaced samples during storm events, to allow us to characterize the total sediment load during each storm. Samples will be analyzed with respect to total sediment load and grain size distribution. ISCO samplers are already available for the project, and can be used at no cost to the grant. The difference between up and downstream sediment loads will allow us to provide sediment loadings from construction sites, comparable to other point source loadings available from monitoring of facilities such as factories and wastewater treatment plants.

Outcomes

The primary outcome of the research performed under this grant will be the development and testing of an expanded version of LTHIA which will include both nonpoint and point source loadings. The model will be tested in collaboration with the City of Indianapolis, which is funding the portion of the work that involves initial set up of LTHIA for Indianapolis watersheds. The project will make use of readily available data on point source contributions from traditional facilities (eg wastewater treatment plants), and will include development of new empirical data on the sediment load input from construction sites in a sample urbanizing study area. The LTHIA model is attracting increasing attention as an appropriate, user-friendly model for initial estimation of the impacts of future urban sprawl, and thus we anticipate wide interest in the expanded model both from the scientific community and real-world users. We would expect to publish at least two articles on this work in peer-reviewed scientific journals.

A secondary outcome of this work will be to demonstrate city-university collaboration in the development of research projects geared to the real information and research needs of government organizations. To make this more explicit, we will develop a web page for the project that will include space for government organizations within Indiana to post requests for information or research assistance. These requests will be forwarded to appropriate faculty at Purdue and other Universities across the state using the WRRC database. We have already assembled a group of faculty at Purdue interested in expanding the role of research in service of water resources management in Indiana, and they have committed a portion of their time to reviewing these research postings and developing expanded contacts with state and city organizations. This group of faculty includes Ron Turco (Agronomy, and Director, Environmental science and Engineering Institute), Bernie Engel (Agricultural and Biological Engineering, and Director, Center for Advanced Applications of GIS), Jane Frankenberger (Agricultural and Biological Engineering and Extension), Anne Spacie (Forestry and Natural Resources) and Guofan Shao (Forestry and Natural Resources). This group represents expertise in diverse areas of water resources, including watershed modeling, fluvial geomorphology, GIS, remote sensing, wellhead protection, stream ecology, wetlands and bioremediation.