USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

TECHNICAL PROPOSAL

1.Title: Investigation of Optimum Sample Number and Timing for Determining Pollution Loads

2.Focus Categories: WQ, NPP, HYDROL, NU

3.Keywords: Pollutants, Water Quality, Nutrients, Water Quality Modeling

4.Duration (month/year to month/year): September 1, 1998 to August 31, 1999

5.Federal Funds: $75,847 $75,847 $none

(Total) (Direct) (Indirect)

6.Non-Federal Funds: $151,694 $100,955 $50,739

(Total) (Direct) (Indirect)

7.Principal investigator's name(s) and university:

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8. Congressional district of university where the research is to be conducted: Third

9. Statement of critical regional water problem:

Accurate measurements of pollution loads in streams is critical for determining the impacts of non-point source (NPS) pollution in the Arkansas and Southeast U.S. Regions. Many researchers are currently attempting to determine these impacts. There are, however, few consistent rules or guidelines for determining the best sampling technique to be used. The ideal technique is to continuously measure stream flow and the concentration of the pollutants of interest (typically solids and nutrients). Pollutant loads may then be calculated with a high degree of precision and accuracy. If flow measurements are available in real time and an automatic sampler can be properly programmed, then flow-weighted composites can be collected. However, these techniques are often not realistic due to economic and/or technical restraints.

The solution to water sampling for determining pollution loads is frequently to continuously monitor flow and intermittently collect water samples. Pollutant loads are then calculated by assuming a uniform pollutant concentration between samples. Many researchers have identified possible sources of errors using this technique particularly during storm runoff events when the concentrations may change rapidly between samples (Richards and Holloway, 1987; Lowrance and Leonard, 1988). These errors may occur because the samples were not close enough together to detect fluctuations in the concentrations (Lathrop, 1986) or because the samples were not taken during the critical portion of a hydrograph (Baker, 1988). Research has shown that different pollutants may reach their peaks at different times during a storm and they may or may not be directly related to the flow (Montgomery and Kennedy, 1986). Inadequate sampling times can cause load calculations to either over or under estimate the actual value. Any errors in measuring pollution loads makes determining trends in water quality very difficult (Baker, 1988). Figure 1 is an example of the type of data set that this project has generated in it's first year. It shows the Illinois River stage as well as baseflow concentrations at the beginning of a small storm (average of last three baseflow grab sample concentrations), pollutant concentration variation during the storm (first 24 samples every 30 minutes and second 24 samples every 60 minutes), and baseflow concentrations after the storm (average of the next three grab sample concentrations).

10. <u>Statement of results or benefits</u>:

Sampling was begun on November 1, 1997 to investigate the optimum sample number and timing on the Illinois River in Arkansas. That original project will result in a database of approximately 650 discrete samples with 6 different water quality parameters covering baseflow conditions as well as 8 storm events at one site and 2 storm events at a second site. Due to the high costs of intense sampling, the original scope was limited to a minimum, particularly with respect to the second site. Many of the comments and reviews received for that proposal pointed out both that there were insufficient samples at the second site for adequate comparison and that the statistical analysis would greatly benefit from sampling additional storms especially in subsequent years. This proposed continuation of the project will address those concerns by sampling an additional 4 storm events at each site, providing an additional 550 discrete samples.

This database will be unique in its sampling intensity and range of coverage and will be a valuable resource for data analysis. The three flow conditions: baseflow, rising stormflow and falling stormflow, will be sampled and compared separately. Statistical methods will be used to compare the data sets with various subsets of the data to determine the optimum number and timing of samples required to determine pollutant loads with high confidence and low bias. This study will be unique since the sampling scheme will be designed to take many more samples during each portion of a hydrograph than would normally be economically feasible, giving enough data points for statistical analysis techniques to be effective for optimizing sampling numbers and strategies. Figure 2 is a preliminary example of the type of statistical analysis that will be performed on the data. It compares the total load calculated for all parameters for the storm shown in figure 1 using all of the measured concentrations, to the loads recalculated after removing every other one , every three out of four and every seven out of eight of the measured concentrations (all subsets are calculated using each of the possible combinations).

The proposed continuation of this project will greatly enhance the ability to determine the differences between sampling sites by increasing the number of storms sampled at both sites, particularly at the second site. This will give the statistical analysis techniques greater ability to determine the effect of stream order on optimum sample number. In addition, due to the abnormally dry weather in the fall of 1997 (only two small storms were sampled at the first site and none at the second), the effect of seasonality on the chemographs will be difficult to determine without additional sampling. The information gained will allow water quality investigators to design sampling schemes for their particular sites and conditions that use only enough samples to adequately characterize pollutant loads and concentrations, saving time and money. It will also increase the precision and accuracy of the load calculations, making assessments of improvements from Best Management Practices from year to year more reliable and assisting in setting more accurate TMDL limits. It will also provide criteria for accepting or rejecting a data set for a particular storm based on sample numbers or timing, saving significant analysis costs. The sampling sites chosen have been and are expected to be of intense interest to the states of Arkansas and Oklahoma with important decisions being based on the calculated pollutant loads. The information gained in this project will greatly facilitate the ability to calculate these loads accurately. The authors have been in contact with and intend to share results with USGS researchers in Wisconsin who are working on similar research. The results of this research will be useful in all parts of the country for optimizing sampling strategies.