Proposal Title: Verification of New Technology to Reduce Solids Stratification Bias in Urban Runoff Sampling

Project Chief: Bill Selbig

Project Chief Location: USGS, Wisconsin Water Science Center, Middleton, WI

Proposed Start Date: January, 2011 **Proposed End Date:** June, 2013

Relation to FISP Goals

Collection of representative stormwater-quality samples in urban runoff can be difficult due to large sources of variability, both temporal and spatial. Use of automated water-quality samplers has vastly improved the way water- resources professionals collect samples in these environments, but the stratification of solids by particle size in a flowing water column may result in biased concentration data collected from urban conveyances, both in the past and present. Millions of dollars are spent annually by environmental managers, engineering consultants, manufacturers of proprietary stormwater treatment devices and others to mitigate, control, and prevent stormwater pollution in our nation's waterways. Accurate concentration data is vital to their decision-making process. Therefore, the location of a sampler intake can be critical depending on the degree of stratification in the storm sewer pipe.

Recognition of autosampler inefficiencies has led to new advancements in sampling technology. Smith (2002) developed a hydrostatic-mixer assembly used to artificially provide agitation in the flow path to produce a sample representing the average concentration of suspended sediment. Quality- control data showed an even distribution (by mass) of particles less than 62 µm throughout the water column but particles greater than 62 µm tended to be concentrated near the bottom of the pipe. Kayhanian and others (2005) suggested designing a new autosampler system that uses a float system to place the intake at the midpoint of a flow path. DeGroot and others (2009) designed an intake manifold that adjusts itself to the depth of flow in the pipe by use of a fin. Although this device showed promising results for accurately collecting sand-sized particles in a small- diameter pipe, an alternate mechanism would be necessary for pipes larger than 24 inches in diameter (DeGroot and others, 2009). These ideas mark the genesis of new technologies to improve the way a stormwater-quality sample is acquired by use of autosamplers.

To address the concern of stratification of solids in urban stormwater, the USGS has developed a new prototype Depth-Integrated Sample Arm (DISA). The DISA is designed to integrate with existing autosampler configurations for collection of stormwater-quality samples of urban runoff in a storm sewer. Use of the DISA facilitates collection of stormwater-quality samples from a single or multiple point(s) in the water column. Integrating samples from the entire water column, rather than from a single, fixed point, can result in a more accurate representation of stormwater-borne solids. In a recent study, the DISA and a fixed-point sampling method were used to collect samples of urban runoff (Selbig and Bannerman, 2010, in review). Results from the two methods were compared on the basis of concentrations of suspended sediment, organic content, and particle- size distributions. Concentrations of suspended sediment in runoff were statistically greater using a fixed- rather than multi-point collection system. Median suspended-sediment concentrations measured at the fixed location were approximately double those collected using the DISA. This relationship was consistent across a range of concentrations and was duplicated at two different study locations. In general, concentrations and size distributions of suspended sediment decreased with increasing vertical distance from the storm- sewer invert. Coarser particles tended to dominate the distribution of solids near the storm- sewer invert as discharge increased. In contrast to concentration and particle size, organic material was, to some extent, homogenously distributed throughout the water column, likely the result of its low specific density, which allows for thorough mixing in less turbulent water.

Results of this study have potential benefits to federal, state, and local agencies, consulting firms, research laboratories, and universities with responsibilities for collecting and disseminating accurate stormwater-quality concentration data. Water resources professionals responsible for interpretation of stormwater-quality concentration data such as trend detection, modeling, evaluation of Best Management Practices (BMPs), and site characterization will benefit from the reduced bias and improved precision of stormwater-quality concentration data offered by this study.

Technical Merit and Context

Although evidence of stratification of both sediment concentration and particle size was found in field-collected data, comparison of these data to a known quantity was unfeasible. Therefore, comparisons between the DISA and a fixed-point sampler can only illustrate the differences between each sampling method but cannot make inferences as to which method is more accurate. Research similar to what has already been done in the field was recently duplicated in a controlled laboratory setting where concentrations and distributions of sediment can be compared to a known quantity across a range of flow conditions.

Phase I of this study was to statistically quantify the precision and bias errors of sediment concentrations and distributions for the DISA and fixed-point sample collection methods. Colorado State University's (CSU) hydraulics facility served as host for this effort.

Phase II of this study will focus on summarizing data collected as part of Phase I into a peer-reviewed journal article. The paper would be submitted to the journal *Water Environment Research* and would serve as a follow-up to the soon-to-be-published field data summary (Selbig and Bannerman, in review).

Phase III will determine if changes to the sampling configuration of the DISA would provide more accurate results. For example, currently the DISA is set up to take a sub-sample at three locations in the water column. The first is located near the bottom of a storm sewer, the second at 30% of the water depth, and the third at 60% of the water depth. Phase III of this study will focus on additional research needed to determine the following:

- If three sub-samples vertically spaced across the water column is too many or too few;
- If the percentage of the water depth for each sub-sample should be increased or decreased;

- If sampling the entire water column would be more or less accurate than at discrete points. This configuration would require modification to the DISA assembly and controls.

Data collected from Phase III will be summarized into a USGS series publication or peer-reviewed journal. Additional research during Phase III would focus on miniaturizing the DISA assembly as a means to collect samples from conduits with a diameter as small as 12 inches.

Field-collected data comparing the DISA and fixed-point samplers has already been summarized and submitted as a research paper to the journal *Water Environment Research* and is currently in review (Selbig and Bannerman, 2010, in review). Phases II and III will build upon the conclusions made in Selbig and Bannerman (2010) and will thus be submitted to *Water Environment Research* as an addendum or separate research paper in 2012-2013. Furthermore, study results will be presented at one or more professional conferences.

Proposed Budget and Timeline

Funds requested from FISP for the successful completion of this study totals $65,000. This amount will be used primarily for salary, travel expenses and publication fees. It will also be used to purchase necessary equipment and supplies to modify the DISA to fit smaller diameter pipers. The duration of the project is estimated to be 3 years. A breakdown of funding by year would be $25,000, $25,000, and $15,000 in years 2011, 2012, and 2013, respectively.

The total project cost is estimated to be $115,000. The Wisconsin Department of Natural Resources and U.S. Geological Survey will contribute approximately $35,000 and $15,000, respectively. The USGS will also provide all equipment necessary to operate the DISA, collect water-quality samples, and measure particle size distribution.

CSU’s hydraulics facility is open for general use during summer months. It is anticipated the time needed to complete testing of the DISA will require approximately one week. Data will then be analyzed and summarized in a peer-review journal. Table 1 shows major milestones chronologically for this study.

Table 1. Chronological timeline of anticipated milestones.

Milestone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						2011						
1. Report preparation for Phase I research	■	■	■	■	■							
2. Submittal of report to journal for review						■						
						2012						
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
3. Conduct experiments at CSU hydraulics facility									■			
4. Data analysis										■	■	■
						2013						
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
5. Report preparation for Phase III data	■	■	■	■	■							
6. Submittal of report for review						■						

Partners

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