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Mark N Landers, PhD, P.E., D.WRE
U.S. Geological Survey, OSW
Chief, Federal Interagency Sedimentation Project
678-924-6616 (office); water.usgs.gov/fisp
1770 Corporate Drive, Suite 500, Norcross, GA 30093

RE: Effect of Mesh Size on Bedload Sampler Performance Study

Dr. Landers,

In accordance with our discussions, Colorado State University (CSU) is pleased to present the following proposal for your consideration. It is our understanding that you wish to conduct a flume study designed to quantify the effect of varying mesh size on commonly used bedload samplers. The CSU team has both the experience and facilities required to conduct an effective and efficient study to meet the project's purpose.

1. Introduction

1.1 Backgound

Handheld bedload samplers consist of a metal body to which a relatively fine-meshed net bag (typically a 0.25 to 0.5 mm mesh width) is attached that collects the sediment. The samplers were designed mainly for sand bedload but are used in gravel-bed streams as well. Fine-meshed bags fill quickly in gravel-bed streams, and users attach bags of different mesh sizes to let sand pass the sampler and focus on the gravel load. However, the velocity of water flow through a bedload sampler is affected by the mesh width of the attached sampler bag (O'Leary and Beschta 1981; Bunte and Swingle 2003, 2009; Bunte et al. 2012, 2015; Bunte 2015), and those velocity differences would cause bags of different mesh widths to collect different amounts of sediment (apart from the mesh width's control of the particle sizes retained in the net).

Another issue facing users in forested catchments is the transport of organic debris (e.g., algae, pine needles and leave fragments) within the water column. The debris clogs the net's pores. This reduces the water throughflow rate which, again, reduces the amount of sediment collected in the sampler. This study uses flume measurements to quantify how the velocity of water flow through a bedload sampler is affected by various mesh widths of the attached sampler bag as well as by parts of the nets being blocked by organic debris.

1.2 Overview of flume experiments

Flow velocity fields are to be measured in a 4-ft wide flume at the Hydraulics Lab in the Engineering Research Center of Colorado State University with three handheld bedload samplers under the following conditions:

- 3 bedload samplers (BL-84, Elwha, and TR2) placed directly on the bare flume bed
- with 2 different nets (BL-84) and 3 different nets attached (Elwha, TR2)
- for parts of the nets blocked off to water flow to mimic and test the effect of net clogging
- at three depth-averaged flow velocities of 1, 2.5, and 4 ft/s for all three samplers while ensuring that flow depth are maintained at least 4 times the sampler height
- at 9 verticals for each test run: 5 verticals inside or in front of the sampler nozzle and 4 verticals left and right near the outside of the nozzle walls.

Table 1 summarizes the proposed test matrix.

1.3 Obtaining samplers, nets, and netting material

After initial contacts have been made by the Federal Interagency Sedimentation Project (FISP) with persons who can loan handheld versions of the bedload samplers to be tested (e.g., John Pitlick, Smokey Pitman, John Gray and/or Kurt Spicer), CSU will contact the persons to arrange borrowing of the samplers.

Precision netting with mesh sizes to be tested but not currently available on loan with the samplers or not comparable because of different closures at the net ends (e.g., cinched with cam strap vs. sewn shut) need to be purchased. It is the understanding of CSU that required netting will be purchased by the USGS and provided to the laboratory.

Table 1: Test matrix

Test configuration		No sampler Velocity (f/s)			BL-84 (3"x 3") Velocity (f/s)			Elwha (8" x 4") Velocity (f/s)			TR2 (12" x 6") Velocity (f/s)			# of Runs
		1	2.5	4	1	2.5	4	1	2.5	4	1	2.5	4	
		X	X	X										3
Total:														3
Flume runs to evaluate the effects of nets with various mesh widths														
BL-84	no net				X	X	X							3
	0.25 mm				X	X	X							3
	0.5 mm				X	X	X							3
Elwha	No net							X	X	X				3
	0.5 mm							X	X	X				3
	1 mm							X	X	X				3
	2 mm							X	X	X				3
TR2	No net										X	X	X	3
	0.5 mm										X	X	X	3
	1 mm										X	X	X	3
	2 mm										X	X	X	3
Total:														33
Flume runs to evaluate the effects of mesh clogging for various mesh widths														
BL-84	0.25 mm				X	X	X							3
	0.5 mm				X	X	X							3
Elwha	0.5 mm							X	X	X				3
	1 mm							X	X	X				3
	2 mm							X	X	X				3
TR2	0.5 mm										X	X	X	3
	1 mm										X	X	X	3
	2 mm										X	X	X	3
Total:														24
Grand total:														**60**

2. Test set-ups

2.1 Flume

Testing will be conducted in a 4-ft wide flume at the Hydraulics Lab in Engineering Research Center of Colorado State University. While bedload samplers are typically deployed on sandy-gravelly stream-beds, the tests are run on a smooth (i.e., metal) flume bottom. This minimizes disturbances of the near-bottom flow from a rough bed and allows us to concentrate on an evaluation of how different mesh-sized nets affect the flow velocity right in front of the sampler.

2.2 Measurements of flow velocity

Flow velocities will be measured using a Nortek Acoustic Doppler Velocimeter (ADV) available at the ERC. An ADV has several advantages over pitot tubes that were employed in related studies decades ago. ADVs are a more accurate device for detailed flow velocity measurements at the sampler entrance to study how different nets affect the hydraulic efficiency of pressure-difference bedload samplers. ADVs provide a mean velocity over an extended sampling time and a time record of velocity fluctuations from which to compute Reynolds stress. An ADV can measure the flow field near the outside nozzle walls to compare flow going into the sampler vs. flow passing around the sampler especially when fine or clogged mesh reduces a sampler's hydraulic efficiency.

The velocity field will be measured across a flume transect with 9 verticals and 5 points per vertical: 5 verticals are placed in front of the sampler nozzle (at 25, 50, 75, as well as at approx., 5 and 95% of the sampler nozzle width and at 2 verticals each along the outside nozzle walls). Measurements will be made as close as possible to the front of the sampler entrance, approximately 1 inch upstream. Velocity measurements in front of the nozzle are more indicative of the sampler's sediment collection properties than measurements inside the nozzle because once a sediment particle has entered the nozzle it will not rest there but pass into the net.

2.3 Open Flume measurements with no sampler present

Without a sampler present in the flume, velocity profiles will be measured across the center part of a 4-ft wide flume transect at the respective testing locations for the various samplers to be placed in the flume in the subsequent runs. Those velocities will be the

baseline values against which velocities measured later with the samplers present will be compared.

2.4 Measurements with three bedload samplers and different nets attached

The sampler to be tested is fastened in the center of the 4-ft flume. The first run measures the flow velocity field right in front to the sampler while no net is attached. In subsequent runs, the flow field will be re-measured with nets of various mesh sizes attached to the sampler. Finally, parts of the nets will be made impermeable to flow to mimic and test the effect of net clogging by organic debris.

2.5 Flume runs to test sampler bag clogging

Clogging of the sampler net by organic material—either by periphyton washed off the rocks or organic material from streamside forest (pine cones and scales, leaves, twigs etc.)—is ubiquitous in gravel-bed streams and may quickly clog the sampler net which decreases sampling efficiency as sampling time progresses. Longer sampling times are desirable for representatively collecting the largest, infrequently moving particles that may contribute a large portion to the sample mass (hence increasing sampling efficiency), whereas the progressive clogging of the net with organic material decreases hydraulic and sampling efficiency over time. While analyzing the temporal patterns of those effects would be quite useful, it is proposed to consider an endpoint of the clogging effect and perform several tests during which part of the net will be made impermeable to mimic clogging by organic debris. Making a known portion of the net surface impermeable to flow (e.g., by applying a wax coating) allows quantification of the amount or degree of clogging more accurately than would be by adding to the nets specified amounts of organic debris (e.g., saw dust) that scale with the respective sampler bag volumes.

3. Project Personnel

Dr. Christopher I. Thornton, Director of CSU's Hydraulics Laboratory and Research Center, will serve as the Principal Investigator of the study. He will supervise the CSU team, coordinate the operation of the test facility and assist in the evaluation of test results. Dr. Kristin Bunte, research scientist, Dept. of Civil and Environmental Engineering, will serve as the Co-PI. She will coordinate the procurement of all samplers and nets, manage the collection and interpretation of project data and prepare the final report. CSU graduate and undergraduate students will provide appropriately skilled laboratory technician services throughout the proposed test program.

4. Project Costs

The estimated costs to perform the proposed scope of work are presented in Table 2. All costs include normal University Indirect Costs and are on a lump sum basis. A detailed itemization of costs can be provided upon request.

Table 2. Summary of Project Costs

Project Costs	
PERSONNEL SALARIES	
Academic Faculty:	$6,939
Fringe Rate	$1,763
Administrative Professional:	$15,892
Fringe	$4,037
Student Hourly:	$7,280
Fringe	$44
TOTAL SALARY:	$30,111
TOTAL FRINGE:	$5,844
TOTAL PERSONNEL:	**$35,955**
MATERIALS AND SUPPLIES	**$3,750**
OTHER DIRECT COSTS	
Equipment Use Fees:	$2,325
Other:	$1,100
TOTAL OTHER DIRECT:	**$3,425**
TOTAL DIRECT COSTS:	**$43,130**
Facilities & Administrative:	**$7,548**
TOTAL:	**$50,678**

Additional tests may be added at any time during the program with costs to be negotiated prior to testing.

4. Project Schedule

University regulations require that all contractual agreements be in place prior to the commencement of any work. Contract language and payment schedules are negotiated through the Office of Sponsored Programs and Colorado State University.

Upon finalization of a contract, it is anticipated that initial project organization and collection of samplers and nets will take approximately two (2) weeks. Conducting the sixty (60) tests summarized in Table 1 will require approximately six (6) weeks to complete. Tests will be sequenced to provide optimization of model results and therefore data interpretation and analysis will be concurrent with proposed testing. Report

preparation and project deliverables will require approximately three (3) weeks from the completion of the final test.

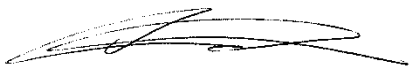
5. Summary

Colorado State University proposes to assist the United States Geologic Survey in assessing the effect of mesh size on three (3) bedload samplers. A suite of sixty (60) tests will be conducted in a four (4) foot wide flume as outlined in Table 1. Three dimensional velocity data will be collected and used to quantify variations in flow conditions as a function of sampler mesh size and potential clogging.

The proposed effort will require approximately three (3) months to complete, with a total project cost of $50,678. Work may begin as early as 15 JAN 2016. Additional tests may be conducted with scope and cost to be negotiated. Upon completion of the final test series, a project report will be prepared and delivered. In addition, video and photographs of non-professional quality will be delivered upon completion of testing, so as to aid documentation of results.

Colorado State University is pleased to provide this quotation for your consideration. We currently have the facility, staff and expertise available to conduct this study. Costs quoted in this proposal are valid through 31 January, 2016. Do not hesitate to contact me at 970-491-8394 if you have questions or comments as to the scope of work or costs. I look forward to hearing from you.

Sincerely,



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