Proposal Title: Laboratory and Field Measurement of Bed Load using Self-Generated-Noise (SGN)

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Proposed start date, end date: January, 2013 – December, 2013.

Relation to FISP goals: Conventional measurements of bed load are difficult, time consuming, often of unknown accuracy, and expensive. Consequently, data on the rate of bed load transport of most streams is lacking. This project seeks to make improvements to the technology used to convert the sound generated by gravel in transport to rates of bed load through laboratory and field experiments. Measurements of the sound generated during gravel motion will be made in the hydraulic laboratory at the National Sedimentation Laboratory, Oxford, MS under controlled conditions. These laboratory results will inform the design of and data interpretations resulting from a field test in a natural channel within the Walnut Gulch Experimental Watershed to measure and evaluate SGN in comparison with conventional sediment measurement methods.

Scientific Merit and Relevance: The approach of this study is to combine field and laboratory efforts to yield an improvement in the use of SGN for bed load measurement. The work of Thorne (1985, 1986) demonstrated the feasibility of using SGN field data to calculate bed load. This study will add data collected in the laboratory using towed rocks under a range of velocities known to occur for grains moving as bed load (Nino and Garcia, 1994a, b). In addition, bed load data collected under natural transport conditions with conventional measurement methods at Walnut Gulch will provide a unique basis of comparison. Measurements will be compared to a similar study in progress for the USBR by two of the cooperators at the Trinity River, CA.

Methodology:

<u>Laboratory experiments</u>

The laboratory experiments will consist of still water experiments over which grains are towed at prescribed velocities and concentrations over unmoving substrates. The reason for this simplified set-up is that the variable number of grains moving, their velocity, and extraneous noises caused by turbulent flow will be controlled and known in all experiments. The first two substrates will consist of the coarsest and finest fractions of the gravel present at Walnut Gulch. This will be followed by an unmoving substrate with a wider, more representative grain size distribution. Individual and groups of grains will be towed over the substrates at speeds ranging from 0.15 to 0.50 m/s, which are representative of measured grain velocities of bed load (Nino and Garcia., 1994a,b). The sounds generated from these grains will be recorded, and the characteristics of the sound (frequency and spectral pressure) will be related to the size of the grains, the velocity of the grains and the mass in transport. These experiments are planned to be completed before field data collection begins.

Field Experiment

SGN will be tested in a small headwater channel in the Lucky Hills subwatershed within the Walnut Gulch Experimental Watershed (WGEW). The WGEW is a 149-km^2 (58-mi^2) semiarid watershed in southeastern Arizona. Channels are ephemeral and almost all runoff and fluvial sediment transport occurs during summer months in response to high intensity convective rainstorms. The watershed has been instrumented to measure rainfall, runoff, and sediment since the 1950's.

The Lucky Hills area is actively eroding and sparsely vegetated. Channels are relatively steep and bed sediment is 'very poorly sorted' consisting of medium coarse sand with a small gravel fraction. Runoff at the outlet of a 9.1 ac subwatershed is measured with a 100 cfs supercritical flow, Santa-Rita style flume (Smith et al., 1982) and sediment is sampled with a depth integrated, "total load", traversing slot sampler (figure 1).

SGN instrumentation will be deployed in the flume approach reach in the natural channel. Acoustic measurements will be compared with sediment sampled and measured as described in the following paragraphs to assess the relation between acoustic energy and sediment transport under natural runoff conditions. Specific field protocols will be determined based on the results of the National Sedimentation Laboratory flume experiments and field site visits by project collaborators.

The runoff flume is instrumented with a traversing slot that normally is positioned out of the flow. When flow depth is greater than 0.06 m, the chain driven traversing slot travels at a uniform speed across the outlet of the flume and diverts a depth-integrated sample to evenly spaced, stationary slots below the flume exit. Samples are collected on a pre-defined time-step in two-liter sample bottles. Sediment concentrations are determined in the laboratory and are used to compute event sediment loads. The size of sampled sediment is limited by the physical dimensions of the slot.

In addition to the slot sediment sampler, a pit trap will be used to collect the entire load of coarse sediment transported during individual events. Sediment collected in the pit will be transported to the WGEW field headquarters where it will be dried, weighed, and sieved to characterize event sediment load and particle size distribution. Analysis of sediment collected during previous experiments (Nichols, 2003) indicates that particles as large as 64 mm are transported.

Approximately 2-6 flows can be expected during the July/Aug/Sep runoff season; however, the timing and magnitude are unpredictable. Thus, a student will be stationed at the field headquarters during the runoff season.

The field study location at Walnut Gulch offers the benefits of onsite housing as well as heavy equipment and laboratory support. In addition to the core instrumented field site at the proposed study site, infrastructure available at the Walnut Gulch Field Headquarters in Tombstone, AZ to support sediment research includes: welding and fabrication facilities, a Gilson sediment sieve (1

mm – 64 mm), laboratory for standard silt/clay/sand particle size analysis, a Bobcat with bucket, water trucks, and machine and electronics shop facilities.

Figure 1. LH103 flume, traversing slot sediment sampler, and pit trap.

Timeline, budget, and partners:

Timeline:

January- construct beds of gravel substrates for experiments in laboratory flume.

March- WGEW field visit and planning meeting to determine the best ways to deploy underwater microphones and recording equipment at the field site. NSL, NCPA, and ARS personnel to attend

July- acoustic sensor and pit trap will be deployed at WGEW.
July – September – field data collection

August – Runoff season field site visit by NSL and NCPA personnel (ARS personnel will be onsite)

October – December – data analysis and interpretation

Budget:
The salaries of the researchers working on the project from ARS in Tucson and Oxford and are covered by other funds and thus will not be charged to this study.

Travel: NSL personnel to Tucson, AZ two trips:	$3000
Equipment to conduct towing experiments:	$800

Student employee to run flume experiments:	$4,000
NCPA personnel (engineer) 1.5 wks, 2 trips to Tucson, AZ, two trips:	$7,000
Student employee to be stationed in Tombstone summer 2013:	$7,200
Onsite housing:	$1,500
Field supplies:	$1,000
Local travel expenses in support of field work:	$500
Overhead (17.2%)	$5,200
Total	$30,200

Partners:
Dr. James Chambers, National Center for Physical Acoustics, University of Mississippi; Oxford, MS,
Dr. Roger A. Kuhnle, USDA-ARS, National Sedimentation Lab, Oxford, MS; and
Dr. Mary H. Nichols, USDA-ARS, Southwest Watershed Research Center, Tucson, AZ.
Dr. Daniel G. Wren, USDA-ARS, National Sedimentation Lab, Oxford, MS

Deliverables:
A completion report will be provided to FISP including an assessment of the use of SGN technology for measuring transported sediment under field conditions. Improvements to and limitations of the technology will be identified.

References:
Nichols, M.H., 2003. Characteristics of transported sediment from small semiarid watersheds during thunderstorm generated runoff. Proc. ASAE Conf. Watershed Management to Meet Emerging TMDL Environmental Regulations, Nov. 8-12, Albuquerque, NM, pp. 130-135.

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Smith, R. E., Chery, D. L. Jr., Renard, K. G., and Gwinn, W. R., 1982. Supercritical flumes for measuring sediment-laden flow. USDA Tech. Bull. 1655.

Thorne, P. D., 1985. The measurement of acoustic noise generated by moving artificial sediments. J. Acoust. Soc. Am., 78(3): 1013-1023.

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