Proposal Title: Sound localization for Sediment-Generated Noise (SGN) measurement

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Proposed Project Duration: 12 Months

1-Year Funding Request: $20,350

1. **Relation to FISP goals** – SGN is a surrogate bed-load monitoring methodology with the potential to allow economical, continuous measurement of coarse bed load in streams using passive acoustics. While the magnitude of recorded sound has been shown to be well-correlated with bed load transport (e.g. Thorne, 1985 and 1986; Barton, 2006), substantial work is still needed before the technique is ready for wide-spread deployment. Continued development of SGN methodology is well-aligned with the FISP goals of improving technology for sediment measurement and development of indirect methods for measuring sediment transport.

2. **Scientific Merit and Relevance –** Past efforts to develop Sediment-Generated Noise (SGN) as a surrogate bed load monitoring technology have revealed that little information on underwater sound propagation in natural stream channels is currently available. Most of the work on acoustic propagation that has been done in shallow water that is directly relevant to SGN deployment has been in support of bioacoustics research, where the lack of shallow, freshwater acoustic research has been noted (e.g. Forrest et al., 1993; Forrest, 1994; Amoser & Ladich, 2010; Johnson, Rice, & Richardson, 2014). Our recent efforts to address the basic processes of SGN have further highlighted the importance of understanding sound propagation in natural stream channels. A previous laboratory-based study that was funded by the FISP revealed sound propagation dependencies on bed roughness, while also demonstrating the need to pursue further sound propagation research in stream channels rather than laboratory flumes. In partnership with the National Center for Physical Acoustics, the Bureau of Reclamation, and Colorado State University, preliminary measurements of sound propagation in both a snow-melt driven, natural gravel-bed stream (Halfmoon Creek, CO) and a shallow sand/gravel bed stream (Goodwin Creek, MS) were conducted in May-June 2015. These measurements provide an initial step towards the goal of the proposed work, but revealed many new questions relevant to SGN development. Two key problems highlighted by this preliminary work were the variable acoustic environments created by stream geometry and the production of flow-induced noise around the hydrophone. This project will address the source area problem by attempting to map detected SGN signals from the stream bed in real-time through the development of a 2-D phased hydrophone array to locate the sound sources spatially. Such a device would provide information in larger mobile bed applications of the spatial distribution of bed movement as well as a de facto measurement of the source region for SGN signals. Empirically mapping the acoustic source region would aid the development of calibration relations for SGN deployments on larger rivers.

3**. Methodology –** Two-dimenional phased arrays have been used in aeroacoustics research for aircraft applications such as the localization of sound sources on an airframe. Similar work has been done at the National Center for Physical Acoustics for localization of turbulent sound sources in jet noise research in wind tunnels. This project would adapt acoustic array technology from existing numerical acoustic models to design an array for SGN application. We proposed to to contract with CRAFT Tech, Inc., a computational fluid dynamics company maintaining a permanent research collaboration with the NCPA, to produce a prototype array design using models already developed for work at NCPA. Using the design provided by CRAFT Tech we would then construct a prototype array and field test it for verification of sound localization capability in tank and/or pond settings.

4. **Timeline, budget (Feasibility), and partners** -

Budget:

The salaries of the researchers working on the project are covered by other funds and will not be charged to this study.

Travel for NSL personnel to present results at conference:	$1,500
Modeling for Array Design and Characterization:	$10,000
Supplies for array prototype and experiments:	$7,000
Overhead (10%):	$1,850
Total:	$20,350

Partners:

Dr. Daniel Wren, USDA-ARS, National Sedimentation Lab, Oxford, MS
Dr. Roger A. Kuhnle, USDA-ARS, National Sedimentation Lab, Oxford, MS
Brian Carpenter, National Center for Physical Acoustics, University of MS
Bradley Goodwiller, National Center for Physical Acoustics, University of MS
Dr. Nathan Murray, National Center for Physical Acoustics, University of MS
Dr. Praveen Panickar, CRAFT Tech, Inc., Oxford, MS

References:

Amoser, S., & Ladich, F. (2010). Year-round variability of ambient noise in temperate freshwater habitats and its implications for fishes. *Aquatic Sciences*, *72*(3), 371–378. http://doi.org/10.1007/s00027-010-0136-9

Barton, J.S., (2006). Passive acoustic monitoring of bedload in mountain streams: University Park, PA, The Pennsylvania State University, Ph.D., 107 p.

Forrest, T. G. (1994). From sender to receiver: propagation and environmental effects on acoustic signals. Amer. Zool., 34:644-654.

Forrest, T. G., Miller, G. L., and Zagar, J. R. (1993). Sound propagation in shallow water: Implications for acoustic communication by aquatic animals. Bioacoustics 4:259-270.

Johnson, M. F., Rice, S. P., & Richardson, J. (2014). Animal perception in gravel-bed rivers: scales of sensing and environmental controls on sensory information. *Canadian Journal of Fisheries and Aquatic Sciences*, *71*(6), 945–957. http://doi.org/10.1139/cjfas-2013-0474

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

Thorne, P. D., (1986). Laboratory and marine measurements on the acoustic detection of sediment transport. J. Acoust. Soc. Am., 80(3): 899-910.

Urick, R. J., (1975) Principles of underwater sound. McGraw Hill, New York.