Bed Load Research International Cooperative – BRIC

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Abstract

A Bed load Research International Cooperative – BRIC – has been formed as a web-based global organization for research that will provide a better understanding of bed load processes and improved means for estimating bed load discharge. The BRIC is a non-profit group of researchers, practitioners, resource managers et al. interested in acquisition and use of bed load data for research and/or for application in studies or management of river systems. Thus, it is by and for the international bed load-research community. The BRIC website consists of four components in addition to external links: i) A membership entry form and membership database; ii) bibliographic citations and related information; iii) bed load research venues; and iv) an under-construction portal to bed load data. The three functional components are fully searchable by keyword and other criteria. The strength of the BRIC is its membership. Those interested in the BRIC concept are invited to join and participate in the BRIC free-of-charge.

Keywords: Bed load, research, bibliography, research venue, database

INTRODUCTION

World-wide needs for fluvial sediment data continue to increase with the realization of the ubiquitous influence that sediment has on the environment. “Clean sediment” –sediment without consideration for adsorbed chemical or biological constituents – is listed as the third most prevalent impairment of U.S. streams (U.S. Environmental Protection Agency, 2007). The other top-four-listed impairments – mercury, pathogens, and metals – have strong positive correlation to concentrations of fine-grained fluvial sediments. For example, physical, chemical, and biological damages attributable to fluvial sediment in North America alone are now estimated to be between $20 billion and $50 billion annually (Pimental et al., 1995; Osterkamp et al., 1998; 2004).

Of the following four categories—suspended sediment, bed material, bed topography, and bed load—considerable technical progress in the acquisition of accurate data collected in an inexpensive and safe manner, has been achieved in all but the bed load category. Bed load is the most complex component of fluvial-sediment transport processes requiring quantification. This is due to a combination of factors related to the spatially and temporally variable nature of the bed load-transport process, and limitations of samplers, sampling techniques, and resources available to collect quantifiably accurate bed load data. Progress in knowledge about bed load-transport processes is retarded for want of more reliable, accurate, and temporally dense bed load datasets.

There are many factors and obstacles that impinge on our ability to measure – and particularly monitor – bed load discharge accurately. These include not only the highly variable nature of the bed load-transport process and equipment and methodology deficiencies, but also logistical and safety issues. These arise as a consequence of needs to determine:

1. bed load discharge under unstable bed conditions (aggradation or degradation) (figure 1), but also under equilibrium conditions;
2. bed load discharge under supply- or transport-limited conditions (Bravo-Espinosa, et al., 2003; Gray and Simões, in press);
3. bed load discharge in sand-bed, gravel-bed, and mixed-bed systems;
4. bed load fluxes entering reservoirs, lakes, floodplains and coastal outlets;
5. scour characteristics at bridge piers, abutments, and other in-stream structures;
6. the extent of variation of bed load discharge and particle-size distribution due to varying land use;
7. reliable relations between bed load discharge and explanatory variables, such as water discharge; and
8. the nature of bed load processes and bed activity.

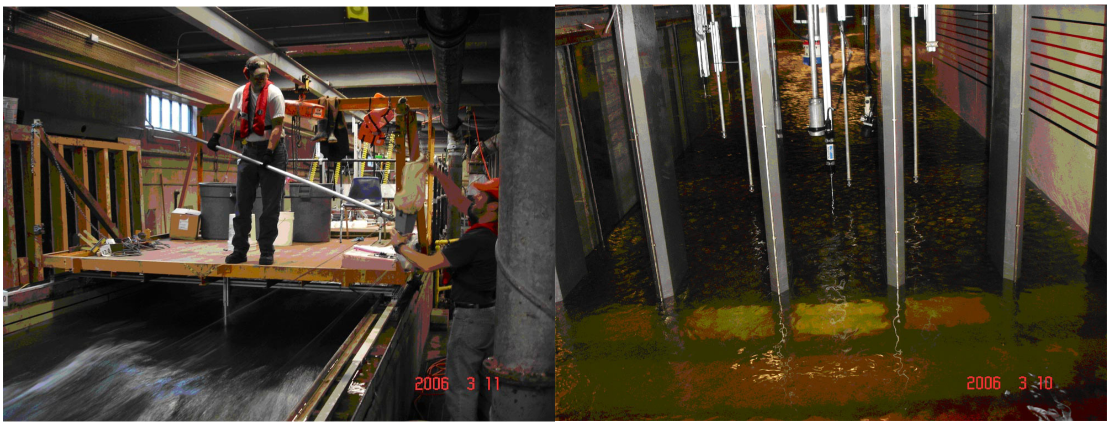

Figure 1. The BRIC research venue at the St. Anthony Falls Laboratory Main Flume, Minneapolis, Minnesota, USA. Downstream view collecting bed load samples with a pressure-difference bed load sampler (a). View upstream showing the cross-flume slot for collecting sediment to be automatically weighed in real time (b).

Bed load monitoring in essentially all environmental settings, but especially in gravel and mixed gravel/sand bedded streams, is complicated by the nature of bed load-transport processes. Bed load occurs close to and in contact with the river bed, and the channel is typically the principal source of sediment. Almost without exception, the nature of bed load movement necessitates deployment of samplers that contact the bed, or of slot samplers arrayed within the bed. Both types of devices suffer from an assortment of issues that can result in substantial and largely unquantifiable uncertainties in bed load-rate measurements (e.g., Vericat et al., 2006). For devices that collect a physical sample, difficulties include but are not limited to:

1. the need to have personnel present at the site continuously, or at least periodically, during bed load transport, thus usually resulting in a temporally sparse dataset;
2. the use of measuring techniques that are laborious, time consuming, relatively expensive, potentially dependent on the skill and knowledge of the operator, and in some cases, hazardous;
3. the presence of a physical sampler on the bed, which may alter the very process that is intended to be measured;
4. a variety of sampling errors (representativeness, repeatability, bias, precision) dependent on hydraulic and sampling efficiency, bed load size and shape, sampler stability issues, and issues related to sampler deployment – all exacerbated by typically large spatial and temporal variations of bed load discharge; and
5. the broad range of particles sizes that may be transported as bed load.

There is a need for indirect monitoring devices, however, they have yet to be adequately evaluated by acceptable calibration procedures, although such laboratory and field evaluations are taking place with increasing frequency at some of the research venues listed in the Bed load Research International Cooperative (BRIC; 2007) website (Table 1).

Advances in bed load-surrogate technologies mostly based on acoustic principles show promise for applications in continuous bed load monitoring. Instruments based on acoustic (Taniguchi et al., 1992; Rickenmann, 1997; Barton et al., 2006; Bogen et al., 2003, Rennie and Villard, 2004, Rennie et al., 2002, Gaeuman and Rennie, 2006, Abraham and Kuhnle, 2006) and other principles do not require routine collection of a physical sample and provide a time series of data heretofore operationally unavailable, except perhaps for data provided by real-time weighing slot samplers. Additionally, these techniques may enable derivation of reliable estimates of uncertainties associated with the bed load-transport measurements. Such experimental instruments need to be brought to maturation and calibrated against reliable "ground truth," and traditional manual and slot samplers.

Within this context, developing capabilities to monitor bed load discharges more economically, accurately and safely, and with a substantially greater data density such as with time-series data on intervals of fractions of a day, should encourage additional scientists to work in this field.

THE BED LOAD RESEARCH INTERNATIONAL COOPERATIVE

The Bed load Research International Cooperative (Laronne and Gray, 2005) sponsored by the National Center for Earth-surface Dynamics, Ben Gurion University of the Negev, International Research and Training Centre for Erosion and Sedimentation, International Association of Hydrological Sciences, and U.S. Geological Survey, was formed in 2004 in recognition that progress in bed load measurement and research would benefit from a concerted and collaborative effort within the world's bed load-research and -monitoring community. The BRIC is a web-based, global organization for research that will provide a better understanding of bed load processes and improved means for determining characteristics of bed load transport.

The BRIC is a non-profit group of researchers, practitioners, resource managers et al. interested in acquisition and use of bed load data for research and for application in studies or management of river systems. The BRIC is by and for the international research community. The BRIC membership represents a wide range of disciplines with expertise in fields including sedimentology and fluvial geomorphology, hydraulic engineering, fluid mechanics, forestry, agriculture, aquatic ecology, and fisheries services. Membership is open to scientists from other disciplines that traditionally have not been associated with studies of bed load processes, such as remote sensing, physics, geophysics, and mechanical engineering. Other than possession of interest and expertise, there are no limitations to BRIC membership. Although making bed load data available for use by others is not a prerequisite for BRIC membership, such data sharing is a fundamental strength of the BRIC concept.

The BRIC represents a focal point for expertise germane to bed load research and serves as a central source of information of common interest to its members and the scientific community at large. Members are encouraged to share information on advances in bed load sampling methods, bed load databases and research findings once these have been published.

BRIC Objectives

The BRIC provides an organizational forum and framework for the international community to address issues of bed load transport, which will be defined by the membership. Topics of considerable interest and immediate urgency include:

1. Determining *bed load-monitoring needs* under varying fluvial environments. This includes accuracy criteria for bed load samplers. A range of criteria based on bed type and flow condition may be necessary. These needs could reconsider manual sampling methodologies by comparing commonly used methods for deploying bed load samplers, including use of staylines and tetherlines. These needs could also address temporal and spatial aspects of bed load-discharge monitoring, as well as those related to sediment supply with respect to the monitored cross section or reach.
2. Aiding in the *development of novel (surrogate) devices for the monitoring of bed load*. These include samplers, traps, and especially indirect monitoring techniques using sensors, be they in situ or remote sensing, as well as *calibration of devices* in flumes and under prototype conditions. A key goal is to provide continuous (time-series) measurements of bed load. To this end, the BRIC-sponsored, "International Bed load-Surrogate Monitoring Workshop" was held at the St. Anthony Falls Laboratory, Minneapolis, Minnesota, USA, in April 2007 (http://www.nced.umn.edu/BRIC_2007.html).
3. Identify *existing infrastructure* and *programs* that could support field or laboratory testing of surrogate technologies. This is a fundamental need, as measurements made by surrogate devices will by and large only be as reliable as the ground-truth data against which they must be calibrated.
4. Aiding in the *dissemination of information* on the design, deployment, and use of bed load-monitoring devices through the data clearinghouse and other less formal mechanisms. As a first stage, the BRIC will seek to gather this information to be published as an up-to-date and on-line manual that may be updated periodically. Members will be invited to contribute as coauthors to this manual (see item 2 above).
5. Compiling information describing a bed load-discharge *database* of rivers in various hydrologic and sedimentologic regimes. The database, which will probably be distributed, will be available publicly at no cost, and will eventually set standards of storage criteria and data quality; and
6. Providing a *vision* of bed load-data needs and comparing that vision to worldwide on-going efforts in bed load research and monitoring; identifying gaps between the vision and on-going efforts, and encouraging research to fill those gaps.

BRIC Website Components

The BRIC website (http://bed loadresearch.org/) includes three interactive components and a fourth that will soon be interactive, along with selected internet links. The four components are:

1. Membership list: Membership entries include name and contact information, the member's URL if available, and keywords describing each member's expertise, experience, responsibility, and/or interests, and an optional biography. The membership database is searchable by name, contact information, or keyword.
2. Bibliographic Citations: Bibliographic citations include title, authorship, source (publication outlet), year published, a link to the report if available on-line, and keywords describing the report. The database can be searched on each of these entries.
3. Research Venues: Facilities and opportunities to perform bed load research are listed by devices that are used to provide calibrations (ground truth) and devices to be calibrated; the composition of the research venue bed; the location of the venue, and the individual(s) that might be contacted if there is interest obtaining more information or to collaborate. Each of these entries is searchable. Figure 2 shows photographs of two research venues listed on the BRIC venues website. A large number of bed load calibration venues are presently or will soon be active (Table 1; Figs. 1, 2).
4. Bed load and Ancillary Data: This component, which is under construction, will in the short-term list available bed load databases and provide ancillary information in the database, including information on accessibility of the database. Eventually it is anticipated that the distributed database will be rendered searchable. This component will also list any available data-collection and –analysis protocols used to produce the data.

Figure 2. BRIC research venues at (a) The Eshtemoa river site with 5 independent Reid-type slots samplers: The samplers will soon be utilized to calibrate an acoustic bed load monitoring system; (b) The Erlenbach site in the Swiss Alps where piezoelectric and, lately, acoustic bed load monitoring has been undertaken for many years. Each plate independently records collisions generated by bed load transport. The seasonal pond in the background has been used for calibration; (c) The Ashi-arait-tani bed load calibration site in the volcanic Hodaka Mountains, Central Japanese Alps. The pipe hydrophone (red circle) is located at the lower end of a supercritical flume, immediately upstream of the large, Reid-type slot sampler; (d) Plant view of 3 Birkbeck pit samplers in the Inglabaga site, the Ribera Salada River (NE Spain). Photograph was taken after July and August 2006 floods (see Batalla et al. in this issue). Flow direction is from top to bottom. The samplers will soon be utilized to calibrate an acoustic bed load monitoring system and to assess bed load sampling accuracy of Helley Smith samplers (76- and 152-mm intakes).

FUTURE OF THE BRIC

The Bed load Research International Cooperative (BRIC; **http://bed loadresearch.org/),** is by and for the International bed load research community. Its ultimate success is predicated on its active membership. If you are interested in the BRIC concept, please join the BRIC.

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Table 1. Bed load calibration venues: recently, presently and soon to be active.

type of bed	location	direct monitoring device	calibrated surrogate device	country [1]	email
gravel					
	river	H-S sampler with 76-mm square nozzle[2] (HS-3") & VUV sampler[3]	Acoustic Doppler Current Profiler (ADCP)	Canada	crennie@genie.uottawa.ca
		BfG sampler[4]	microphone beneath plate	Germany & Luxenbourg	krein@lippmann.lu
		portable traps[5]	H-S 3"	USA	kbunte@engr.colostate.edu
		H-S 3" with ground plate	H-S 3"	USA	kbunte@engr.colostate.edu
gravel					
	flume	trap + digital imaging	magnetic detector	Canada	*mhassan@geog.ubc.ca*
		weighing each particle	microphone beneath plate	Germany	krein@lippmann.lu
		recording pit	*In situ* trap 3"	USA	*kbunte@engr.colostate.edu*
sandy gravel					
	river	Birkbeck pit sampler	hydrophone plates + H-S 6"[6]	Austria	helmut.habersack@boku.ac.at
		5 independent Birkbeck samplers	hydrophone plates	Israel	john@bgu.ac.il
		seasonally emptied pits	24 ultrasonic + 15 pressure transducers	Italy	marioaristide.lenzi@unipd.it
		seasonally emptied pit trap	ultrasonic sensors	Italy	g.callegari@isafom.cnr.it
		total bed load device	passive acoustic pipe hydrophone	Japan	mizuyama@kais.kyoto-u.ac.jp
		Birkbeck pit sampler	passive acoustic pipe hydrophone	Japan	mizuyama@kais.kyoto-u.ac.jp
		trommel sampler	passive acoustic pipe hydrophone	Japan	yamashita.shintaro@sumicon.co.jp
		fixed-rod H-S	*Clampton* acoustic sensor	Norway	jbo@nve.no
		Mülhofer	*Clampton* acoustic sensor	Norway	jbo@nve.no
		post-flood emptied pit	acoustic sensor	Poland	wfroehlich@pro.onet.pl
		3 Birkbeck pit samplers	H-S + Acoustic hydrophones	Spain	rbatalla@macs.udl.es
		H-S 6"	H-S 3"	Spain	rbatalla@macs.udl.es
		seasonally emptied pit	hydrophone plates	Switzerland	rickenmann@wsl.ch
		Birkbeck pit sampler	magnetic bridge	UK	d.sear@soton.ac.uk
		TR-2 on controlled floods	passive acoustic hydrophone	USA	sling@geosc.psu.edu

Table 1 continued

type of bed	location	direct monitoring device	calibrated surrogate device	country [1]	email
sandy gravel					
	flume	direct bucket sampling of all the solid discharge	microphone beneath plate	Japan	*sawai@civ.setsunan.ac.jp*
		direct bucket sampling of all the solid discharge	passive acoustic pipe hydrophone	Japan	*mizuyama@kais.kyoto-u.ac.jp*
		recording pit	acoustic sensor	Norway	*jbo@nve.no*
		recording pit	BLH-84[7], H-S 3", ADCP, TR-2"[8], sonar Elwha[9], [10]	USA	*marrx003@umn.edu*
		pit trap + digital video	ADCP	USA	*crennie@genie.uottawa.ca*
gravelly sand					
	river	modified H-S + Modified Birkbeck pit	passive acoustic hydrophone	USA	*rkuhnle@msa-oxford.ars.usda.gov*
		modified Birkbeck pit	soon acoustic sensor	USA	*jlewis01@fs.fed.us*
gravelly sand					
	flume	recording pit	BLH-84, H-S 3", ADCP, TR-2", sonar Elwha	USA	*marrx003@umn.edu*
sand					
	river	H-S 3"		Canada	*crennie@genie.uottawa.ca*

[1] See BRIC site (www.bed loadresearch.org) for more information (e.g. contact person).
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[4] BfG: Sampler developed by German Federal Inst. Hydrol.. Wieprecht, S.; Dittrich, A.; Koll, K. (2002): Optimisation and calibration of the BfG bed load sampler. Abstract, EGS 27th General Assembly, Nice, France.
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[6] Helley-Smith sampler with 152-mm square nozzle
[7] BLH-84: Sampler developed by the US Geological Survey (http://fisp.wes.army.mil/Catalog_Page_US_BLH-84.htm)
[8] TR-2": Toutle River type-2 nozzle (1.4-flare ratio). Nozzle width is 12" by 6".
[9] Sonar Elwha: 8" by 4" nozzle version of TR-2.
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