TESTING LASER-BASED SENSORS FOR CONTINUOUS, IN-SITU MONITORING OF SUSPENDED SEDIMENT IN THE COLORADO RIVER, GRAND CANYON, ARIZONA

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ABSTRACT

Overview: The Grand Canyon Monitoring and Research Center (GCMRC) was established in 1995, following completion of a major environmental impact statement on operations of Glen Canyon Dam (DOI, 1995). The GCMRC supports the Glen Canyon Dam adaptive management program (AMP) by providing research and monitoring information on a variety of resources associated with the Colorado River ecosystem within Glen Canyon National Recreation Area and Grand Canyon National Park. Resources of special concern include native fishes, cultural and recreational resources, as well as fine-grained sediment deposits located along channel margins of the river. Owing to the ecosystem's supply-limited sediment- transport behavior (Rubin et al., 1998; Topping et al., 2000a), intensive monitoring of fine sediment below Glen Canyon Dam is an AMP requirement for environmental management of the Colorado River ecosystem. One objective of the GCMRC's monitoring program is measurement of the ecosystem's monthly sand mass balance between influx from tributaries and efflux downstream in the main channel.

Daily or near-daily measurement of suspended-sand concentration and grain-size using standard suspended-sediment sampling methods is currently required to estimate monthly sand flux between the dam and upper Lake Mead. The current program is logistically complicated, costly and provides limited spatial and temporal resolution. In-situ, laser-based sensors are being investigated as one alternative method for measuring sand export to Lake Mead.

Results of 2001 LISST Testing: Initial point data collected at a fixed-depth, near-shore site were obtained by averaging 16 measurements at 2-minute intervals during a 24-hour deployment starting at 16:00 on July 19, 2001. The data were collected using a LISST-100 "Type-B" sensor (Laser In-Situ Scattering and Transmissometry). The Type-B is a laser-diffraction based sensor designed to detect suspended particles over a size range of 1.3-250 microns. The LISST can also determine suspended concentrations over a variable range, depending on grain size and the instrument's adjustable sample-path length. The standard sample path of the LISST-100 is a cylindrical volume with a diameter of 6 mm and a length of 50 mm. Additional description of this technology is reported by Agrawal and Pottsmith (2001). The LISST-100 used during the July test was previously evaluated under laboratory and field conditions and its performance was reported by Gartner et al. (2001). The 720 LISST point measurements collected at the Grand Canyon gage in July 2001, compare very well with cross-sectionally integrated suspended-sand and silt and clay data obtained from 13 samples collected at a cableway near the test site using a D-77 bag sampler. During the test, fluctuating releases from Glen Canyon Dam ranged from about 9,000 to 17,000 cubic feet per second; a typical diurnal summer pattern of discharge related to hydropower generation at the dam. In addition to accurately tracking the sand concentration, the LISST-100 also recorded the physically expected increase in sand-concentration variance with increasing flow, with peak values ranging up to 150 mg/l (Figure 1). As predicted, concentrations of silt and clay obtained by the LISST were much less variable and ranged from about 50 to 100 mg/l (Figure 2). It is worth noting that the highest concentrations of fines occurred during the daily minimum discharge, which at this location occurs at night when conventional sampling does not occur. The LISST also provided median grain size data for sand that closely matched sand sizes obtained using the D-77 sampler (Figure 3).

A second field test was implemented from September 2001 to February 2002, to explore performance characteristics of three different LISST instruments during longer, continuous deployments. Our preliminary results from the fall through winter 2002 testing, indicate that in-situ, laser-based sensors can provide continuous data with appropriate maintenance, albeit under a limited range of grain-sizes and concentrations.

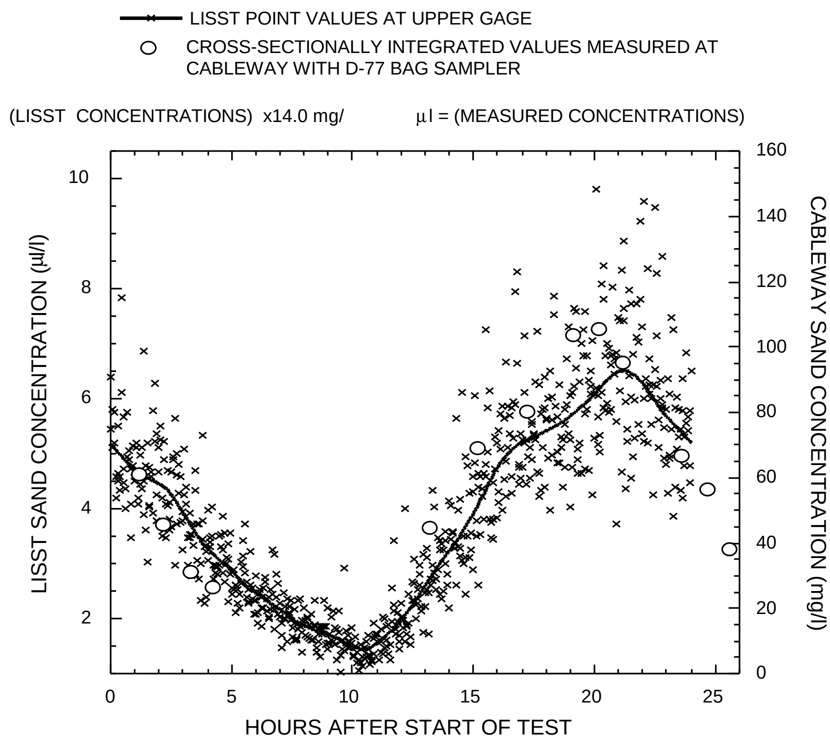

Figure 1. Comparison of sand concentrations measured at Grand Canyon using LISST-100 and the D-77 bag sampler.

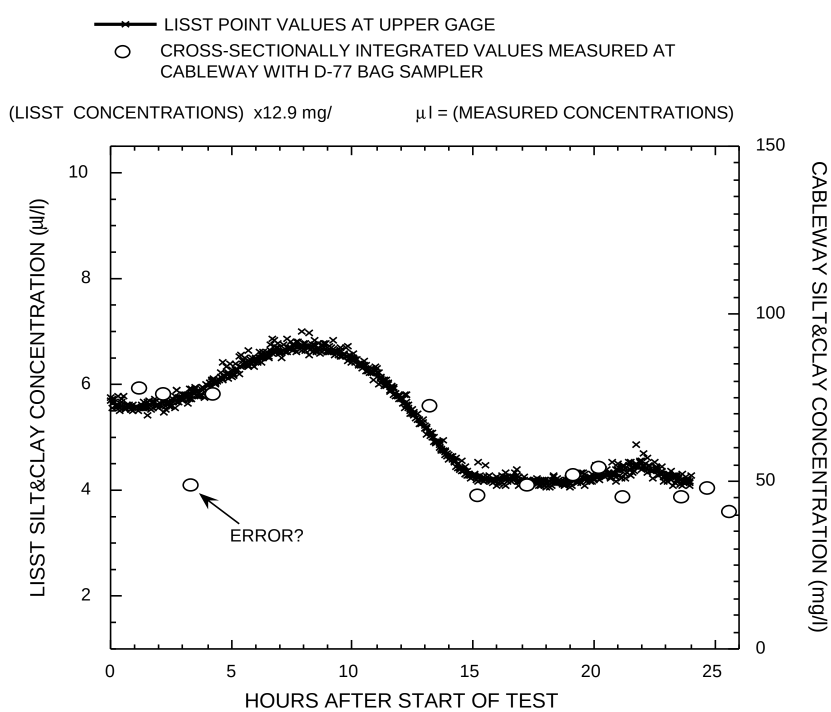

Figure 2. Comparison of fines measured at Grand Canyon using LISST-100 and the D-77 bag sampler.

<u>Monitoring Sediment Supply Conditions Using LISST and *Beta*</u>: Our previous work has shown that suspended-sediment concentration and grain-size data can be used to back-calculate grain size of sediment on the bed upstream (Rubin and Topping, 2001). The *beta* value, derived by the above method, is a surrogate for how enriched a river segment is in fine sediment, and thus provides an indirect, reach-integrated measure of a river's sediment mass balance (in non-armored conditions). The approach can also be applied to other sediment transport environments. Preliminary results suggest that LISST data will be suitable for calculating *beta* at higher spatial and temporal resolutions than those that are presently obtained using conventional suspended-sediment sampling methods.

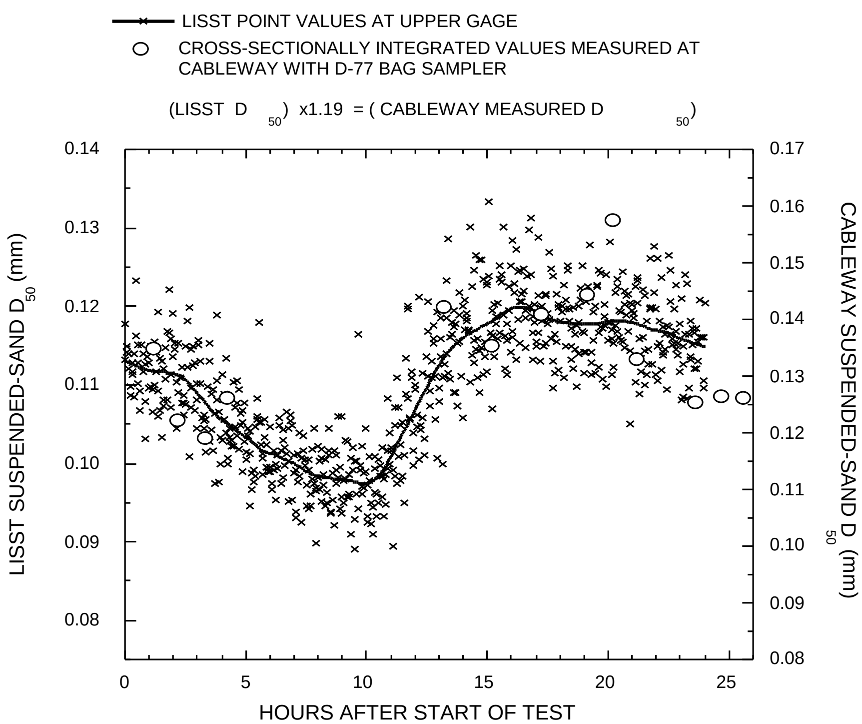

Figure 3. Comparison of median grain size of sand measured at Grand Canyon using LISST-100 and the D-77 bag sampler.

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