RECLAMATION
Managing Water in the West
Bureau of Reclamation, Technical Service Center
Robert C. Hilldale and Timothy J. Randle

Surrogate Bed Load Measurement on the Elwha River

National Center for Physical Acoustics, University of Mississippi
Jim Chambers, Brian Carpenter, Bradley Goodwiller & Daniel Kleinert

Problem Statement

Reclamation has been charged with monitoring coarse sediment that will be evacuated from two reservoirs behind Elwha and Glines Canyon dams (see below) during and after dam removal. Significant accumulations of bed load in the river downstream of the dams can affect safe channel capacity and can cause the channel to avulse.

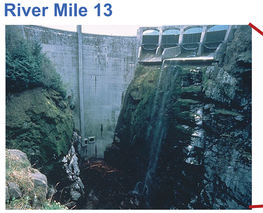
A continuous bed load monitoring system is needed to measure bed load flux and expand the current knowledge of how coarse sediment is transported.

Project Area

The Elwha River begins in the Olympic Mountains in Washington, USA and flows north into the Strait of Juan de Fuca.

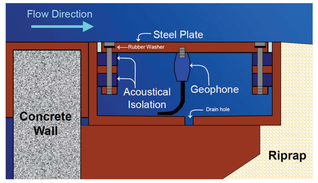
Elwha Dam (1913)
River Mile 5

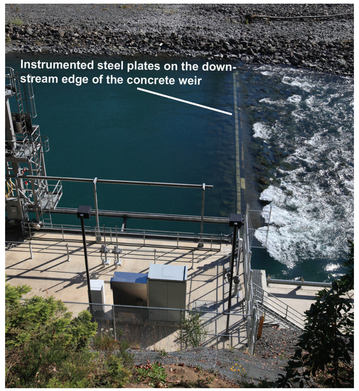
Glines Canyon Dam (1927)
River Mile 13



The Solution

A series of **bed load impact plates** (below) have been installed across the channel at a location downstream of both dams (River Mile 3). 72 stainless steel plates are instrumented with either a geophone or an accelerometer (10^3 – 10^4 Hz). Bed load flux will be continuously monitored with this system.

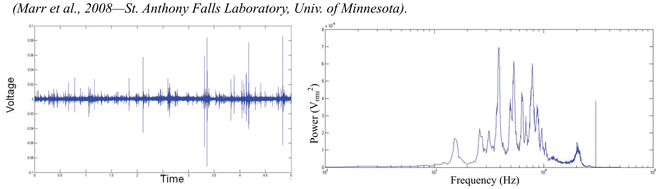




Laboratory Testing

Testing was performed at St. Anthony Falls Laboratory to determine correlations between impacts of gravel on the instrumented steel plates and sediment flux. A separate lab calibration was obtained for geophones and accelerometers, providing sediment flux measured with the impact plate system.

Spectral Analysis of gravel strikes generating power on a stainless steel plate instrumented with an accelerometer (Marr et al., 2008—St. Anthony Falls Laboratory, Univ. of Minnesota).



Methodology

For the **accelerometer measurements**, 5 samples are averaged using rms and a linear weighting mode. Bohman time-domain window is applied to each time signal and the power spectral density is obtained. Lastly, the FFT of the time signal is computed to generate 4 frequency bands. From here, a relationship between mean sediment flux vs. mean total power resulting from gravel impact can be created.

In the **geophone measurements**, the number of peaks are compiled for 3 voltage thresholds. A 3-element array is compiled and divided by the sample time to produce a mean count rate for the voltage range. At this point, a plot can be constructed to show sediment transport rate vs. mean count rate.

Field Calibration

In order to obtain a proper field correlation between signals from the instrumented plates and bed load transport, an in situ calibration will be performed. Calibration will be accomplished in summer 2012 by deploying a pressure difference sampler (TR-2 or something similar) from a tethered raft positioned over or near the steel plates. Unit bed load flux will be obtained using the physical samples enabling calibration at several locations across the channel.

The objective of the field calibration is to yield correlations between unit bed load flux and either; the number of counts indicated by the geophone or, total power generated by the accelerometer over the four frequency bands. Unit bed load flux will be obtained at each plate across the entire channel.

Laboratory Research and Development of Bedload Impact-Plate Sensors
J.D.G. Marr, S.R. Johnson, C.R. Ellis, T.J. Randle, and R.C. Hilldale

Continuous Surrogate Bedload Measurement on the Elwha River Following Dam Removal
Timothy J. Randle, M.S., P.E., D.WRE; Robert C. Hilldale, M.S., P.E.; Jeffrey D.G. Marr, M.S.; Sara R. Johnson

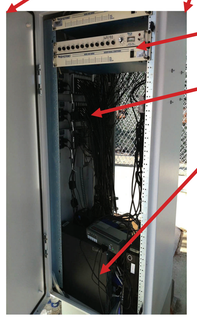
Presented at the 33rd IAHR Congress, Vancouver, WA, Aug. 6—17, 2009

Funding has been provided by the Federal Interagency Sedimentation Project (FISP) and Reclamation's Science and Technology research program, grant #0115.

Data Acquisition Installation

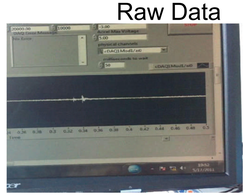
All wiring from the instrumented plates was routed to an instrumentation box atop a water intake structure (below, viewed from river left). There is over 15,000 feet of wiring in the system.

The Data Acquisition System (DAQ) was designed, tested, and installed by the National Center for Physical Acoustics at Univ. of MS. The DAQ System is controlled using a LabView program created by **Brian Carpenter**. The software allows for remote access of data and control of the data collection. Data is sampled at 20 kHz for 90 seconds simultaneously across all channels, streamed to the A/D module, and the processed data is saved.



Instrumentation Box

Raw Data



Vibration impact from gravel (8-16mm) on an accelerometer plate

Testing the response of each instrumented plate following the construction of the plate system, wiring, installation of computer hardware and data acquisition system.