STUDYING SURROGATES TO ESTIMATE SUSPENDED SEDIMENT CONCENTRATIONS IN THE MISSOURI RIVER AT NEBRASKA CITY, NE

Extended Abstract

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Fluvial sediments have various effects on river systems including adverse consequences for aquatic life, recreation, navigation, and reservoir storage capacity. Quantifying sediment transport is important in order to determine long-term trends in sediment transport, to understand the various effects from fluvial sediments, and to implement processes for minimizing adverse consequences. Traditionally, streamflow has been used as a surrogate to estimate instantaneous suspended sediment concentrations (SSC) and to compute sediment loads. However, streamflow alone may not be a reliable method for estimating SSC at locations that are effected by regulated flow, that have sediment inputs from a variety of sources, or have episodic sediment transport events which occur during a constant streamflow (Wood and Teasdale, 2013). Alternately, graphical methods for computing continuous concentration curves rely on interpretation supported by a subjective understanding of factors, often site-specific and undocumented, influencing sediment transport (Porterfield, 1972). To account for these factors, new techniques for using surrogates to estimate SSC are being developed and further study is needed refine these methodologies. The U.S. Geological Survey (USGS) has been studying three sediment surrogate methods at the Missouri River at Nebraska City, NE, streamgage.

The Missouri River at Nebraska City, NE, is a large river site, drainage area of 410,000 mi^2, and provides a unique study location with multiple and vastly different sediment sources. Sediment originates from the upper Missouri River with low SSC due to multiple dams, from the upper Platte River with Rocky Mountain snowmelt and lower Platte River alluvial sand, from runoff from the Loess Hills in Western Iowa with highly erodible aeolian silt soils, and from other local tributaries with agricultural runoff. This USGS streamgage, established in 1929 and operated in cooperation with the U.S. Army Corps of Engineers, is maintained by the USGS Iowa Water Science Center (IA WSC). Crews visit the site twice per week to collect measurements of streamflow and depth-integrated cross-sectional averaged SSC samples. Real-time streamflow data are computed from an established relation between stage, which is monitored real-time, and discharge which is updated routinely based on the streamflow measurements. Daily suspended sediment loads since 1957 have been computed by the USGS IA WSC using graphical methods for continuous concentration curves based on the sample results and daily streamflow, which is based on stage (Koltun and others, 2006). Averaged cross-section SSC samples since 1957 have ranged from approximately 100 milligrams per liter (mg/L) to 3,000 mg/L. Periodic analyses of the percent fine-grain material (less than 0.0625 mm) that is present in the SSC samples indicate material can vary spatially in the cross-section of the river and also vary temporally. The percent of fine-grain material ranges from less than 10 percent to over 90 percent (U.S. Geological Survey, 2014). Additional data collection for studying new surrogates at this location started in 2013 and is planned to continue through 2015 to include a variety of streamflow conditions. The additional data collection includes the installation of surrogate devices and more frequent analyses of the percent fine-grain material present in the SSC samples.

Three surrogate methods are being studied at the USGS streamgage on the Missouri River at Nebraska City, NE. These methods use turbidity, acoustic backscatter, and laser diffraction to develop a relation, by ordinary least-squares (OLS) regression, between SSC and the individual surrogate parameter. The dataset for each model is comprised of the cross-sectional averaged SSC samples and the corresponding recorded or computed surrogate values. The surrogate devices are mounted near the west bank in an area of uniform flow during a wide range of streamflow conditions. The Turbidity method uses turbidity data that are measured in formazine backscatter ratio units (FBRU) which has a broad operating range due to the data being calculated from infrared light at two backscatter angles. The turbidity data are recorded every 15 minutes by a data logger. The second method uses acoustic backscatter (ABS) measured by an acoustic Doppler velocity meter (ADVM) as a surrogate for SSC. Three ADVMs deployed at the site measure ABS recorded by a data logger every 15 minutes from each device. Two ADVMs have a frequency of 1500 kilohertz (kHz) and one ADVM has a frequency of 500 kHz. The 1500 kHz ADVMs are configured to determine if different measurement settings affect ABS during the same SSC conditions. The 500 kHz ADVM is installed to determine if model results at this site can be improved with a lower frequency. The third surrogate method uses laser diffraction technology to collect a volumetric measurement of SSC and of particle size distribution (PSD) divided into several size ranges. Water is pumped from the river for a short duration at one-hour intervals into a sample chamber where a laser is emitted through the sample volume. Logged every hour, volumetric SSC and PSD are measured depending on how the laser is diffracted through the sample volume. In addition to individual parameter models for SSC, combinations of some methods will also be used to assess models for SSC during varying particle size conditions. Combined models will determine if the different frequencies of ADVM data and the laser diffraction data for PSD together provide a better model for SSC at a site with such varying sediment sizes.

The use of surrogates at the Missouri River at Nebraska City, NE, streamgage, will provide significantly more data on sediment transport due to the frequency of the recording interval by each device. Rather than two cross-sectional averaged SSC samples per week, these surrogate methods can provide SSC information as often as data are recorded. The varying presence of fine-grain material at this site will also help refine methodologies to adjust for this condition. The results from this study will be used to identify the method that provides the best estimates for SSC in the Missouri River at Nebraska City, NE, and the applicability for use at similar locations.

REFERENCES

Koltun, G.F., Eberle, M, Gray, J.R., and Glysson, G.D., User's Manual for the Graphical Constituent Loading Analysis System (GCLAS), U.S. Geological Survey Techniques and Methods 4-C1, 51 p.

Porterfield, George, 1972, Computations of fluvial-sediment discharge. U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chap. C3, 66 p.

U.S. Geological Survey, 2014, U.S. Geological Survey National Water Information System, accessed October 31, 2014, at *http:waterdata.usgs.gov/nwis*.

Wood, M.S., and Teasdale, G.N., 2013, Use of surrogate technologies to estimate suspended sediment in the Clearwater River, Idaho, and Snake River, Washington, 2008-10: U.S. Geological Survey Scientific Investigations Report 2013-5052, 30 p.