WHY ARE CONTINUOUS IN-STREAM TURBIDITY DATA NEEDED TO CHARACTERIZE SEDIMENT TRANSPORT AND SOURCES? AN EXAMPLE FROM THE LITTLE ARKANSAS RIVER, KANSAS

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Abstract An in-stream water-quality monitoring system developed by the U.S. Geological Survey in Kansas provides continuous real-time computations of concentrations and loads for sediment, major ions, selected nutrients and metals, atrazine, and indicator bacteria, and uncertainty and probability of exceeding criteria (http://nrtwq.usgs.gov/ks/). Examples of data collected from the Little Arkansas River, south-central Kansas, are used to compare traditional computations using streamflow to in-stream turbidity computations of suspended-sediment concentration (SSC) and load (SSL). These examples illustrate the use of using hourly flux computations to evaluate sediment transport variability among individual storm runoff events.

From 1999-2009, continuous turbidity and streamflow data from the Little Arkansas River were used to compute SSC and SSL. Based on these data, the following conclusions were made:

1. Streamflow only explained about 72 percent of the variability in SSC. Turbidity explained 94 percent of the variability in SSC.
2. Hourly streamflow varied from less than 1 to about 15,000 cubic feet per second (a factor of about 10,000). Annual flows varied by about a factor of 10.
3. Hourly SSCs varied from about 1 to 2,000 milligrams per liter.
4. The hourly SSL varied by a factor of 100,000, while annual SSL only varied by a factor of 100.
5. The largest single storm each year produced 15- 63 percent of the annual SSL in 0.03 to 0.19 percent of the time.
6. The total SSL of all storms (average of 18 per year) was 62 to 99 percent of the annual SSL and occurred in less than 2 percent of the time.
7. Streamflow-computed annual sediment loads were larger than those computed using turbidity and may have overestimated SSL by much as 40 percent.

Hysteresis between hourly SSC and streamflow varied between individual storm runoff events. Potential causes of hysteresis include changes in hydraulic carrying capacity and sediment sources. Clockwise hysteresis (an increase in SSC or turbidity corresponding with an increase in streamflow followed by a decrease in SSC or turbidity corresponding with continued increase in streamflow) has been demonstrated by many researchers and used to infer supply limitation or a depletion of available sediment from the streambed, channel, or areas near the channel. Counterclockwise hysteresis can occur when sediment is derived from sources that are more distant from the stream (overland flow or tributary inflow) or channel wasting. In 2007, geochemical-fingerprinting analysis of bed sediment in the Little Arkansas River for nutrients and cesium-137 demonstrated that the geochemical signature of streambed sediments after a series of large runoff events were similar to those of stream bank deposits. Generally,

geochemical fingerprinting and clockwise hysteresis during the largest runoff events in the Little Arkansas River illustrate that exhaustion of supply was more pronounced with successive events.

Despite implementation of practices to control sediment transport, a historical comparison of annual SSL determined for the Little Arkansas River using traditional methods indicated that annual sediment transport and yield had changed little in the past 50 years. These results indicated that the uncertainty in streamflow-based regressions were too large to detect all but the largest changes in sediment transport. Time- and spatially-dense data collection with high accuracy likely are required over a long period to detect and quantify changes in sediment transport because of large variability in hydrology and sediment sources. Variability of individual storm runoff event loads and yields and hydrology are described best using continuous SSC data computed from turbidity data.