A NEW METHOD FOR ESTIMATING SUSPENDED SEDIMENT LOAD AND ITS APPLICATION TO THE REGULATED SOUTH SASKATCHEWAN RIVER

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Abstract: The determination of suspended sediment loads that are both accurate and precise is a continuing problem facing fluvial geomorphologists, engineers and riparian managers. Faced with only intermittent measurements of suspended sediment concentration (*C*), many researchers have utilized least squares regression to determine a log-log rating relationship between coincident values of *C* and water discharge (*Q*) measured at intervals ranging from days to several weeks. Continuous data for *C* are then modeled using (relatively) high frequency measurements of *Q*. The suspended sediment load is then estimated as the product *CQ*. Unfortunately, a large number of factors may introduce error into load estimates derived from rating curves, potentially leading to incorrect interpretation and understanding.

In this paper, an enhanced new method for estimating suspended sediment loads that allows the propagation of uncertainty associated with potential sources of error in measurements of *C* and *Q* is detailed. Uncertainties associated with discharge records, such as variations in the stage-discharge curve and rounding error, are propagated through the simulation by perturbing within the possible bounds of *Q*. LOcally-WEighted Scatter plot Smoother (LOWESS) relationships allow each perturbed ln *Q*-value to be transformed to an estimated value of ln *C*. The resulting estimate of ln *C* and its local standard deviation allow for Monte Carlo simulation of a possible value of ln *C* for the river discharge on that day. Each simulated value of ln *C* is then transformed into real space, and multiplied by the corresponding discharge. This procedure is undertaken for each day within a calendar year, and then repeated for each year within a 250-run Monte Carlo framework. The entire procedure allows uncertainties inherent both in discharge measurement and in suspended-sediment rating curves to propagate through to estimates of annual loads.

The new method has been applied to a reach of the South Saskatchewan River, Saskatchewan, Canada, in order to study the impact of Gardiner Dam, a 64 m-high and 4.8 km-wide earth fill dam. It impounds about 9.36×10^9 m^3 of water to form the 225 km-long Lake Diefenbaker. A reservoir of this size can be expected to have a 100% sediment trapping efficiency and this is borne out by the available data. Pre-closure (1911-1965), the median annual load 140 km downstream of the dam was 3,704,000 tonnes; post-closure (1968–2003), this reduced by 93% to 248,500 tonnes. 262 km upstream of the dam, the median annual load for the period 1917–2003 was 8,922,580 tonnes. Using annual load estimates from this location, and assuming a mean deposit density of 911 kg m^{-3}, it is estimated herein that 1.66×10^8 m^3 of reservoir volume was lost between 1966 and 1980 (90% confidence limits 1.35–2.06 × 10^8 m^3). This compares to a value of 1.27×10^8 m^3 derived from a series of repeated cross-sections. It is hypothesized that this discrepancy is caused by error in the assumed deposit density, error in the earliest surveys or a cross-section spacing (mean ≈ 7.3 km) that was too large to sufficiently capture morphological change.