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Annual Sediment Budgets for Newly Formed Point Bars on Powder River, Montana, USA

John Moody and Robert Meade

U.S. Geological Survey, National Research Program, Boulder, Colorado, United States (jamoody@usgs.gov)

Morphodynamic processes have been monitored for 37 years on Powder River, a large, unregulated meandering river that drains an area of about 35,000 km2 in northeastern Wyoming and southeastern Montana, USA. Cross-sectional surveys of the channel and adjacent floodplains and terraces have been measured nearly annually (30 out of 37 years) by the U.S. Geological Survey (USGS) at 24 locations along 90 kilometers of the river. This long-term data set has provided insights into the natural morphological and sedimentary processes; and most recently, into the annual sediment budgets for three point bars that were created when an extreme flood in 1978 cut new channels across the necks of two former meander bends and radically shifted the location of a third bend. Because our cross-sectional surveys are generally made only once a year (during the low-flow period, usually September-October), we record only the net change in thickness of the annual deposition and erosion because some areas on a point bar may be scoured and refilled during multiple floods in a year.

Point-bar sediment budgets vary spatially as well as annually. The long-term average of the net annual sediment budgets during the post-1978 years (n=26 surveys) indicates that the average annual increment of new sediment deposited on the three point bars has been three to four times the average annual increment of old sediment eroded from the point bars. This annual deposition-to-erosion ratio has varied at one point bar from a minimum of 0.14 (1986) to maximum of 275 (1995). At the other two point-bar sites the ratio ranged from 0.18 (1991) to 265 (2008) and from 0.023 (1980) to 479 (1987). The lack of correlation from year to year or from one point bar to the next suggests the importance of differences in the planimetric configurations and hydraulic histories of each point bar in the evolutionary process.

All the deposited sediment we measured during an annual survey represents the same sediment year class, whereas the eroded sediment we measured is composed of different proportions of previous sediment year classes. An index of the preservation (completeness) of these sediment year classes was defined for each point-bar as the percent of the initial deposit (older than 10 years) that was still remaining in 2011. The average (n=20 surveys) completeness was 59, 81, and 64%, and in general, deposits had better chances for being preserved if they were deposited higher on the point bar surface, or if they were covered by new deposition in the following year. Net annual deposition correlated only weakly with annual peak water discharge, and we found no correlation between annual peak water discharge and the amount of sediment eroded from the point bars. These low correlations may be the result of our using only net deposition and erosion values, and not the total deposition and erosion. These results illustrate the dynamic nature of point bars that adds an important component to earlier uniform, lateral accretion models of point bars. This dynamic nature produces a range of vegetation year classes, and thus, a rich diverse habitat for terrestrial and aquatic populations.

This abstract has described one application of this unique long-term data set, and the authors will be pleased to provide the data set to anyone who might need long-term fluvial geomorphic data to address other research questions such as floodplain contaminant storage, river restoration, and environmental change.