#185: Indirect Sediment Transport Measurement in the Upper White River on Mount Rainier

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A critical first step in managing a gravel and sand river through a populated area is measuring sediment transport rates to identify areas of persistent erosion or aggradation and trends in bed grain size distribution; to understand the relative influence of large and small flows over sediment mobility and bed exchange and long-term channel adjustment to external perturbations. In rivers transporting sediment sizes from silt to boulders, data collection necessarily includes multiple approaches, both direct and indirect. Sediment measurement efforts, and how collected data are used to understand and manage the river, are described for a river in the Cascade Mountains in Washington State.

The White River originates at Emmons Glacier on Mount Rainier and flows approximately 105 km downstream to a confluence with the Puyallup River and then another 16 km to Puget Sound. It is a wandering channel in that it has an irregularly sinuous planform with both meandering and braided reaches. Sediment eroded from Mt Rainier transports by debris flows, lahars, and atmospheric river driven floods. Mud Mountain Dam (MMD), the Corps' flood risk management reservoir, is located at RM 28. A fish trap and barrier is approximately 6 miles downstream of Mud Mountain Dam, at RM 24.8, where upstream migrating fish are collected and trucked to a release site upstream of MMD. Both MMD and the fish trap and barrier collect sediment during high flow events and that sediment is then flushed downstream at lower flows.

Bed surface and subsurface sediment sampling has been repeated throughout the river in recent decades, providing bed grain size distributions over time. Suspended sediment was measured in the 1970s and has since been calibrated to turbidity data. Estimates of the bedload sediment supply to MMD from the Upper White River come from sampling over 1974-1976 using a 3-inch Helley-Smith at RM 26. Further downstream, at RM 8, bedload sampling was undertaken in 2010 with an Elwha Sampler at RM 9. Direct bedload samples are limited due to the difficulties in data collection. Recent analyses have focused on indirect estimates of transport though bed volume change. Repeat LiDAR, aerial imagery, and Structure-from-Motion have been applied to develop hypotheses of on-going channel bed adjustment to a 1906 avulsion that lowered the channel between RM 11-6. A recent levee setback at RM 5 is being monitored for its impact on bed elevations and side channel deposition rates.

On-going work is focused on indirect sediment monitoring at the fish trap and barrier. Fine sediment in suspension and washload sediment pass the fish barrier continuously and can be estimated from continuous turbidity records. The larger suspended sediment and gravels transport downstream only when the flows exceed 4,000 cfs and the barrier gates are lowered. Reach bathymetry is measured using an ADCP after each flow event during which the barriers are lowered and bedload transport possible. Sequential data sets are differenced to estimate the minimum sediment transport volume past the barrier with each high flow and over each water year. Through this process, a minimum bedload transport rate through the White River can be determined by storm event and annually. During fall 2022, hydrophones were installed 850 feet (approx. 8 channel widths) downstream of the barrier to monitor gravel transport. The hydrophone signal from the events will be correlated to the measured bathymetric change over the barrier reach for that event. Hydrophone records will be analyzed to determine if the method can be used to determine sediment transport timing and volume in the White River.