Project Title

Green River Suspended Sediment Monitoring

Bureau of Reclamation Agreement Number:

R17PG0047

Project/Grant Period:
Start date: 10/1/2016
End date: 9/30/2021
Reporting period end date: 9/30/2021, extended through April 2022 for the Final Report.
Is this the final report? Yes __ No X

Principal Investigator:

David J. Topping
Research Hydrologist
USGS Grand Canyon Monitoring & Research Center
2255 North Gemini Drive
Flagstaff, AZ 86001
Phone: (928) 556-7396
Fax: (928) 556-7100
Email: dtopping@usgs.gov

Abstract:

The purpose of this project is to collect and analyze suspended-sediment data to help the Program better understand geomorphic processes that form and maintain habitats important to Colorado pikeminnow and razorback suckers in the Green River, including connected backwaters, side channels, and flooded bottomlands. The Recovery Program is interested in: (1) quantifying changes in sediment storage in the Jensen-Ouray segment of the Green River as a function of the magnitude and timing of inputs of sediment and water; and (2) quantifying the streamflows required to export the sediment delivered to this segment to maintain/improve habitat. For this purpose, this project collects high- temporal-resolution suspended-sediment data using multi-frequency acoustics, calibrated pump samples, and conventional EWI measurements near the USGS gages on the Green River near Jensen and at Ouray, UT, and uses these data to construct mass-balance silt- and-clay and sand budgets.

Study Schedule:

Collection of sediment-transport data for this project began at both Green River sites in FY 2017. These sites will continue to be visited by field staff multiple times each year through FY 2023 for equipment maintenance, collection of suspended-sediment samples for the calibration and verification of acoustical sediment-transport data, and for tracking bedform migration to estimate the bedload component of total sediment transport.

Relationship to RIPRAP:

General Recovery Program Support Action Plan I. Provide and Protect Instream Flows

Accomplishment of FY 2021 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

During FY 2021, 15-minute, two-frequency acoustical suspended-sediment measurements were made at the Green River above Jensen, UT, station (located just downstream from the Split Mountain Campground in Dinosaur National Monument) and the Green River above Ouray, UT, station (located at the fish observation deck in the Ouray National Wildlife Refuge). These stations are located upstream from the USGS gages near Jensen, UT (#09261000) and at Ouray, UT (#09272400), respectively. In addition to the acoustical measurements, 49 calibrated-pump suspended-sediment samples were collected at the above Jensen station and 25 calibrated-pump suspended- sediment samples were collected at the above Ouray station, and 3 EWI measurements (measurements made using depth-integrating samplers deployed across the entire cross section) were made at the above Jensen station and 3 EWI measurements were made at the above Ouray station. Roughly 2/3 of the pump and EWI physical suspended-sediment samples have been processed through the GCMRC sediment laboratory for concentration and grain size; the remainder will be processed through the laboratory before the end of January 2022.

Both sites were visited multiple times FY 2021 for operation and maintenance purposes, including visits to collect suspended-sediment samples used for calibration and verification of the acoustical and pump-sampler data. The above Jensen station was visited 4 times and the above Ouray station was visited 4 times. EWI and bed-sediment measurements were made at each station during 3 of these visits. Previously, during FY 2019, we finalized the relations used to estimate sand bedload at the Ouray station on the basis of the suspended-sand load and discharge. These relations were developed from paired EWI and bedform-tracking measurements made during 6 site visits in FY 2017–2018 and have been programmed into our website to provide continuous estimations of sand bedload. In addition, 27 historical cross sections from 1993–1995 were resurveyed in October 2020 to document long-term topographic changes in the Jensen to Ouray segment.

Based on analyses of the data we collected during FY 2017–2020, net deposition or erosion of sand in the Jensen to Ouray segment during annual floods appears to be controlled by systematic inter-annual changes in the upstream sand supply and not directly by the discharge of water. The upstream sand supply in this segment (at the above Jensen station), in turn, appears to be controlled by the interaction of Flaming Gorge dam releases with Yampa River streamflow. This modulation of the upstream sand supply depends on the duration of higher discharges within the Flaming Gorge dam releases and not on the peak discharge of these releases. Net deposition of sand in the Jensen to Ouray segment occurred during one annual flood (2019). During the 2019 flood, the duration of higher discharges within the Flaming Gorge dam releases was short and the duration of higher discharge within the annual flood of the Yampa River was long (Figure 1). Consequently, the upstream sand supply was enriched during this flood, as evidenced by the much higher concentrations of suspended sand at Jensen than at Ouray (Figure 2a). Conversely, the greatest net erosion of sand from this segment occurred during the 2017 annual flood, when the duration of higher discharges within the Flaming Gorge dam releases was

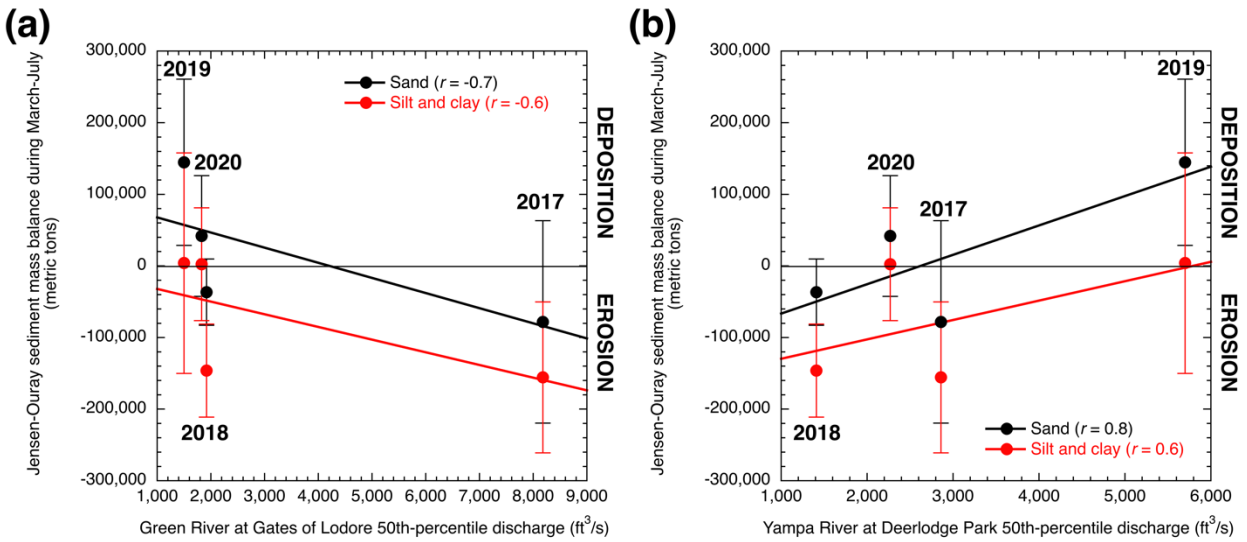


Figure 1. Mass balance of sand and of silt & clay in the Jensen–Ouray segment during March–July of each year plotted as a function of the March–July 50th-percentile discharge at **(a)** the Green River at the Gates of Lodore and **(b)** the Yampa River at Deerlodge Park. Least-squares linear regressions with correlation coefficients (*r*) shown. Positive values of the sediment mass balance indicate net deposition during the March–July period of the annual flood; negative values of the sediment mass balance indicate net erosion during this period. The median (50th-percentile) discharge during March–July is used as a proxy for the duration of higher discharges during the annual flood.

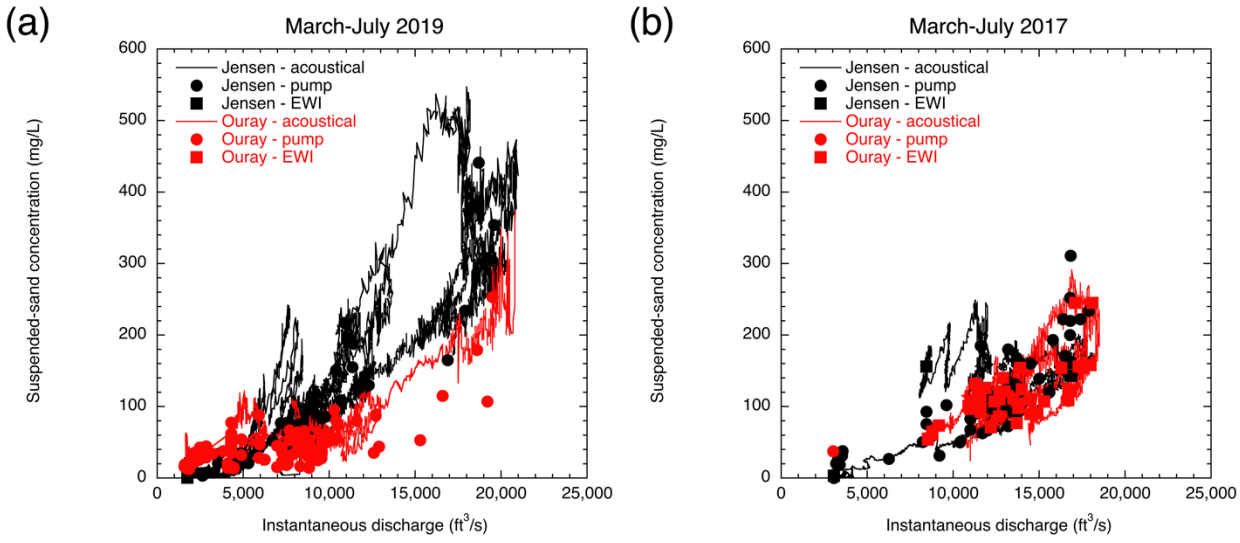
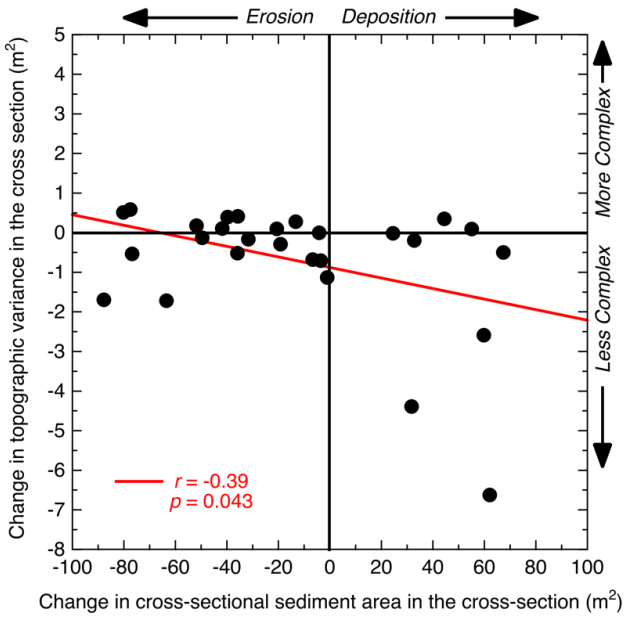


Figure 2. Suspended-sand concentration plotted as a function of the instantaneous discharge of water during **(a)** March–July 2017 and **(b)** March–July 2019 at Green River above Jensen, UT, and the Green River above Ouray, UT, stations. Different measurement types indicated.

long and the duration of higher discharge within the annual flood of the Yampa River was relatively short (Figure 1). Consequently, the upstream sand supply was depleted during this flood, as evidenced by the comparatively low concentrations of suspended sand at Jensen over most of March-July (Figure 2b). The change in sand mass in the Jensen to Ouray segment was smaller during the annual floods in 2018 and 2020, which had intermediate durations of higher discharge from the dam and the Yampa River. Although a similar dependence of the silt-and-clay mass balance in this segment on the relative durations of higher discharge within the Flaming Gorge dam releases and the annual flood of the Yampa River was observed, this relation is less certain than that for sand. We will be redoing these analyses to include the FY 2021 data as soon as we finish processing the FY 2021 sediment samples through our laboratory; these analyses of the FY 2017–2021 data will be included in our Final Report to be submitted to the Program in March 2022.

Increased channel complexity is associated with increased lower-velocity backwater and side-channel habitat for native fish. We hypothesize that net erosion of sediment from the Jensen–Ouray segment of the middle Green River corresponds to an increase in channel complexity and conversely that net sediment deposition corresponds to a decrease in channel complexity and fish habitat. During 2017–2021, we used continuous sediment-transport monitoring (results described in previous paragraph) and repeat surveys of cross sections to test this hypothesis. Resurvey of 27 cross sections in the Jensen–Ouray segment last surveyed in the mid-1990s provides limited support for our hypothesis. Among these cross sections, the correlation between deposition and channel complexity, expressed through the variance in cross-section topography, is negative, consistent with our hypothesis, but also weak (Figure 3). Greater variance in cross-section topography indicates a rougher, irregular channel bed characterized by greater elevation differences between the thalweg(s) and bars. Greater topographic variance thus corresponds to greater bar-associated lower-velocity backwater habitat. Although we found little relation between cross-section complexity and erosion, there is a tendency for deposition to be associated with smoother, less-complex topography among the resurveyed cross sections. Thus, maintenance or improvement of fish habitat likely requires conveyance of sediment through or erosion of sediment from the Jensen–Ouray segment, not net deposition of sediment in this segment. Therefore, positive mass-balance sand budgets for the Jensen–Ouray (that is, Uintah Basin) segment at our website (https://www.gcmrc.gov/discharge_qw_sediment/), as in 2019, likely indicate degradation of fish habitat, whereas neutral (2018, 2020) to negative (2017) mass-balance sand budgets likely indicate maintenance or improvement of fish habitat.

The cross-section resurveys suggest slight net erosion of sediment from the Jensen–Ouray segment but also a slight decrease in channel complexity since the mid-1990s. 70% of the cross sections eroded, mainly by channel widening (bank erosion), whereas 30% of the cross sections gained sediment, mainly by bed aggradation. Despite the net erosion detected among the 27 cross sections and because of the only weak correlation shown in Figure 2, the average tendency has been for the cross sections to become slightly less complex. However, this average tendency toward channel simplification owes largely to sediment deposition at only 3 of the 27 cross sections, thus suggesting only highly localized degradation of fish habitat since the 1990s. In our Final Report, we will be combining our above results with hydrologic analysis of streamflow in the Jensen to Ouray segment over the last 30 years. We will then know the likelihood of whether the 2017 annual flood resulted in improved native-fish habitat in the Jensen to Ouray segment whereas the 2019 annual flood resulted in degraded native-fish habitat in this segment.



In summary, the mass balance of sediment in the Jensen to Ouray segment is not controlled by the peak discharge of the annual flood in this segment nor by the peak discharge of Flaming Gorge Dam releases. The peak discharge of the 2017 annual flood near Jensen, 18,300 ft^3/s, was actually slightly smaller than the 20,900 ft^3/s peak discharge of the 2019 flood. Similarly, the peak discharge of the 2017 dam release measured at Gates of Lodore, 8,720 ft^3/s, was also slightly smaller than the 8,910 ft^3/s peak discharge of the 2019 dam release. Net sediment erosion occurred during the smaller 2017 flood, whereas net sediment deposition occurred during the larger 2019 flood. Thus, depending on the degree to which changes in fish habitat are related to the mass balance of sediment in this segment, the amount and quality of fish habitat may be unrelated to peak flood discharge. Instead, changes in fish habitat may be controlled by the changes in the upstream sediment supply that are driven by the interaction of Flaming Gorge dam releases with Yampa River streamflow.

Recommendations:

We recommend that our study be continued for a sufficient number of years so that we can collect data during enough years with differing hydrologic and sediment conditions to see if the results described in the previous section are universal. Of the first 5 years of our study for which we have completed data processing, we have only three years in which we detected changes in the sediment mass balance in the Jensen to Ouray segment (2020 was indeterminate with respect to changes in the mass of sand and changes in the mass of silt and clay). Although the hydrologic-sediment relations during the four years of our study strongly suggest that the relative durations of higher flows within Flaming Gorge dam releases and within the Yampa River annual flood are the key to managing for improved fish habitat in the Jensen to Ouray reach, we only have a sample size of 3. In addition, we recommend that the 27 cross sections that we resurveyed in October 2020 (previously surveyed in the mid-1990s) be resurveyed again before the termination of our study, and that our study continue long enough to make this resurvey meaningful for comparing against our flux-based sediment budgets. Given that our study has been

extended through FY 2023, we would ideally resurvey these cross sections again in late 2023 or later if we are funded for another extension beyond 2023.

Project Status:

Ongoing

FY 2021 Budget Status
Funds Provided: $40,612.93
Funds Expended: $40,612.93
Difference: -0-
Percent of the FY 2021 work completed, and projected costs to complete: 90%, zero costs required to complete last 10%
Recovery Program funds spent for publication charges: -0-

Status of Data Submission

All data processed to date have been posted to our website, where data can be plotted and downloaded, and mass-balance sediment budgets can be constructed and viewed. This website can be accessed at: https://www.gcmrc.gov/discharge_qw_sediment/.

Signed:

David J. Topping
Principal Investigator Date: January 12, 2022