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Supplemental Material

Supplementary text

Figure S1. Daily mean discharge records since 1990 for the (A) upper unregulated watershed and (B) lower river downstream of both Mud Mountain Dam and the Buckley Diversion structure. Figure is an enlargement of data presented in Figure 3A, B to allow better comparison over primary period of repeat topographic analyses.

Figure S2. Grain size distributions of White River sub-surface bed material and comparisons with bed load samples. (A) Median (D50) and 84th percentile (D84) particle sizes for sub-surface bed material samples in the White River. All samples collected summer of 2018. (B) Cumulative percent finer for bed load material collected by Nelson (1979) near Vkm 48, just upstream of the Mud Mountain Dam impoundment pool and co-located with USGS gage 12097850. (C) Cumulative percent finer for bed load material collected by Czuba et al. (2012b) at Vkm 10.5 and co-located with USGS gage 12100490.

Figure S3. Location of gages and repeat cross sections in the Mud Mountain Dam (MMD) area. (A) Topography of MMD (2011 lidar) and location of repeat cross sections used in Figure 7B. Orange-colored range lines indicate areas where data was not regularly available prior to 1974, and were not included in estimates of valley-floor storage change from 1960-2011. (B) Vertical channel change in the upper extent of the impoundment pool near Vkm 47, based on either gage analysis (USGS 12097850) or repeat cross sections.

Figure S4. Short-term relations between Mud Mountain Dam (MMD) operations and downstream channel response. (A) Pool elevation of MMD (USGS gage 12098000) from 1973-74 and (B) 1995-98. Horizontal dashed line marks 279 meter pool elevation, the approximate limit below which coarse sediment is able to exit the reservoir. (C) Discharge immediately downstream of MMD (USGS 12098500) from 1973-74 and (D) 1995-98. (E) Change in stage-discharge relation at USGS 12098500, two kilometers downstream of MMD, from 1973-74 and (F) 1995-98. (G) Changes in discharge-normalized Froude number at USGS 12098500 from 1973-74 and (H) 1995-98. Vertical dashed lines highlight instances where low pool elevations and outflow discharges above base flow result in abrupt downstream aggradation and channel smoothing (increasing Froude number). Incision and coarsening is associated with high outflow discharges and high pool elevations.

Figure S5. Changes in stage discharge relations in the lower Puyallup River (USGS 12101500).

Supplementary materials for "Coarse sediment dynamics in a large glaciated watershed: Holocene disturbance and storage transfers dictate contemporary channel change"

Scott Anderson and Kristin Jaeger

Supplementary text

Long-term discharge records

Combinations of discontinuous but comparable gage records and regressions with nearby gages were used to create continuous discharge records for the White River, representative of conditions at USGS 12097000, draining a 560 km^2 basin in the unregulated upper watershed, and for conditions in the Fan Reach at USGS 12100500, draining a 1,235 km^2 basin subject to regulation by Mud Mountain Dam and the Buckley Diversion.

Direct records for the upper White River at USGS 12097000 cover from 1929 to 1975. This record was extended to the present based on regressions of daily discharge with USGS gages on the Cowlitz River at Packwood (14226500) and the Carbon River near Fairfax (USGS 12094000), which drain major glaciers on the east and north aspects of Mount Rainier, respectively. Regressions were split seasonally to cover periods over which discharge is typically dominated by rain fall (Oct-Mar), snow melt (Apr-Jun), or glacier melt run-off (Jul-Sept). Regression predictions from the Carbon and Cowlitz River gages were averaged to produce final estimates of daily discharge at USGS 12097000 from 1975 to 2018.

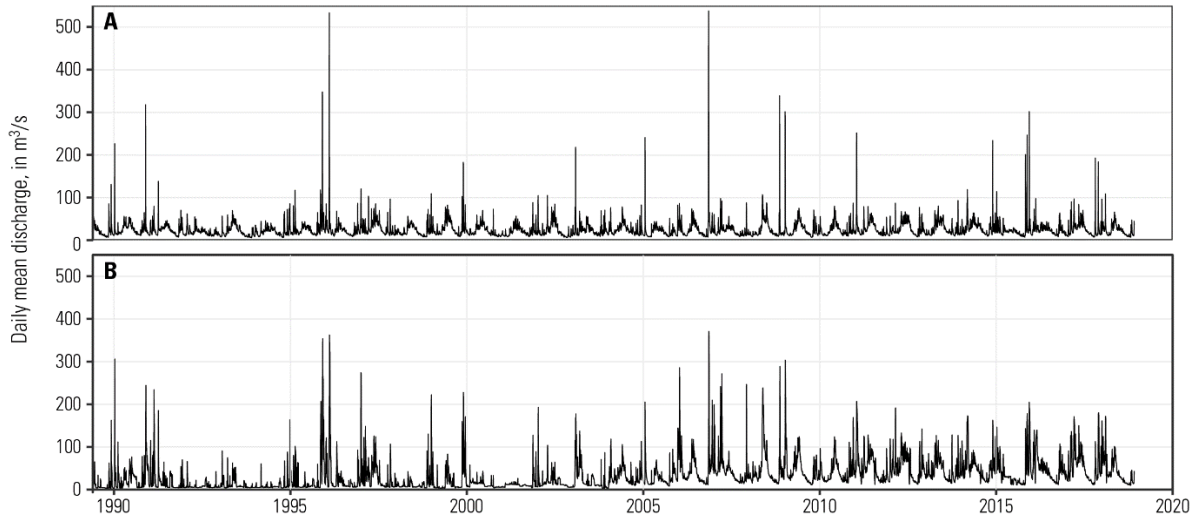
Records for the Fan Reach were primarily based on three gages operated at various times in the reach, including USGS 12100500 (1945-71), USGS 12100496 (1987-2009) and USGS 12100490 (2010-2018). The period from 1977-1986 was spliced in from records at USGS 12100000, immediately downstream of the Buckley Diversion, after application of a simple scaling multiplier of 1.1, estimated through linear regression during periods of overlap with the three downstream gages. No records were available from 1972-76, or prior to 1945.

Grain size samples

Grain size distributions along the White River were characterized based on bulk sieving of sub-surface material. The sub-surface was sampled on the basis that is more likely comparable to the grain size of the aggregate bed load flux and, by definition, defines that caliber of material exchanged as bed material. To the degree possible, sample sites were located near the apex of recently-active gravel bars in areas with uniform hydraulics. Two bulk samples, separated by several hundred meters of downstream distance, were collected at each site.

Bulk samples were collected by first removing the surface layer to the approximate depth of the D90, after which approximately 200 kilograms of sediment was removed from a roughly circular area to a depth of 50 cm. Material coarser than eight millimeters in diameter was sieved and weighed in the field, while a split of the < 8 mm material was taken and was lab-sieved at 2 and 0.5 mm breaks.

Supplementary figures



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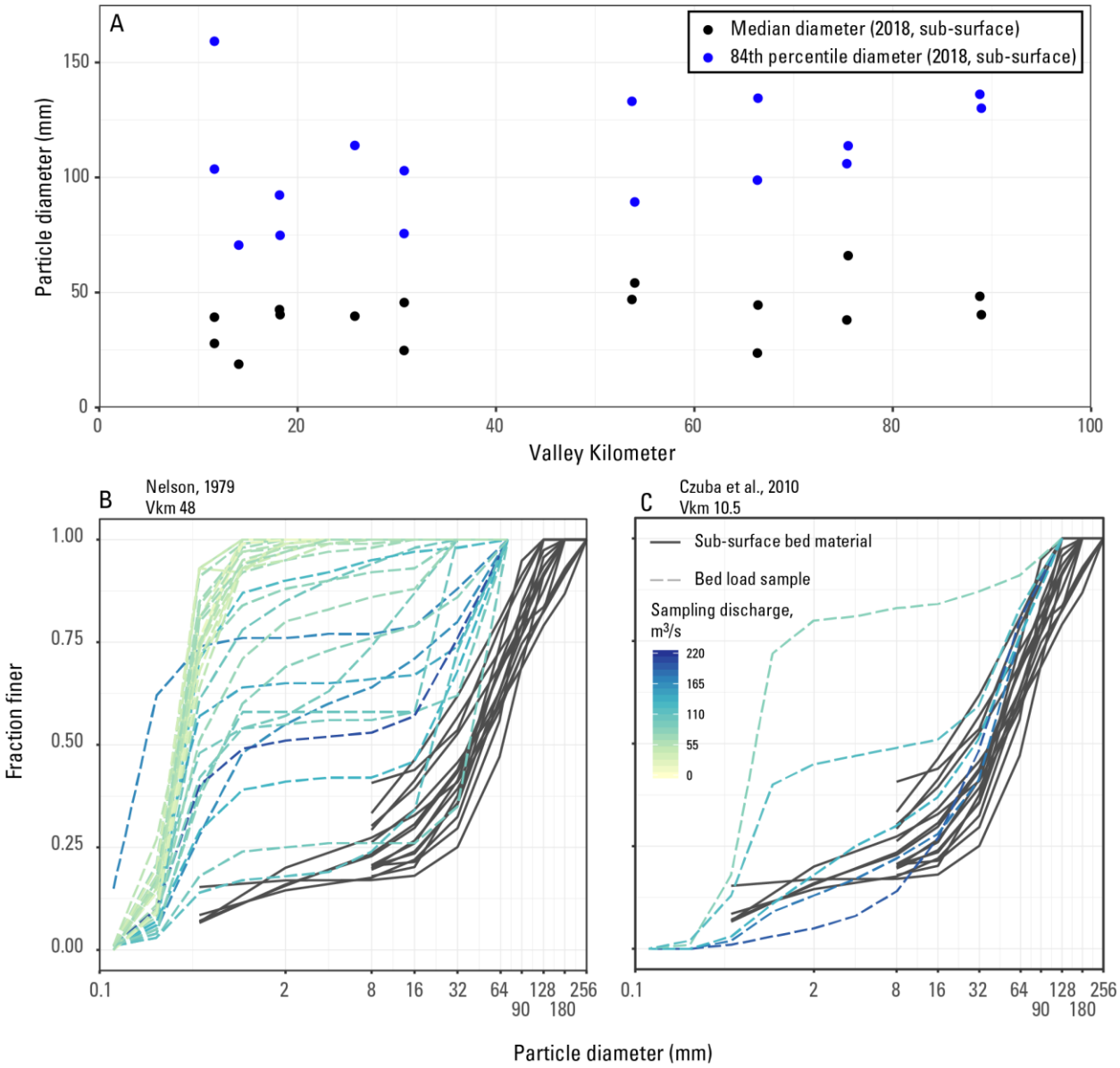

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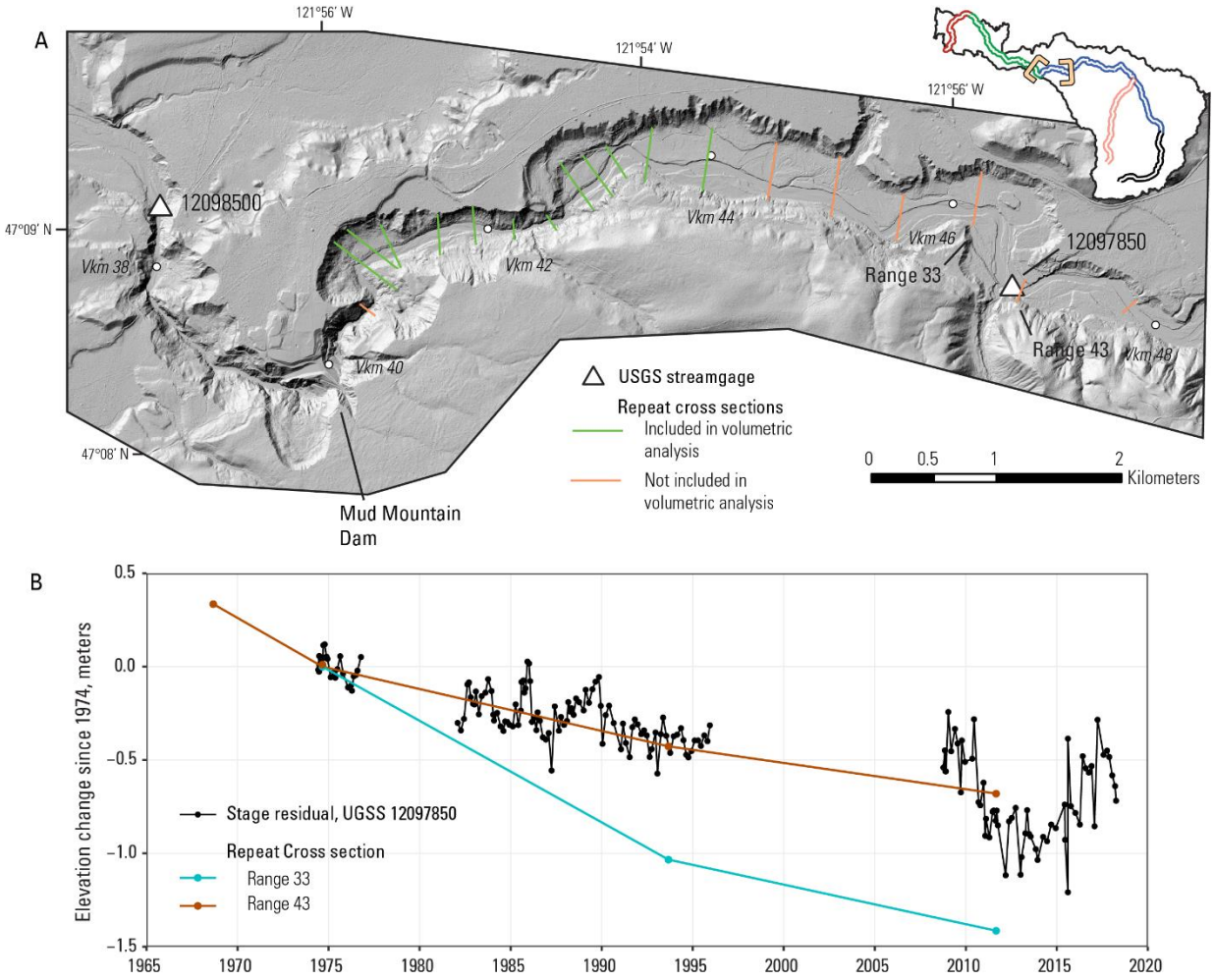

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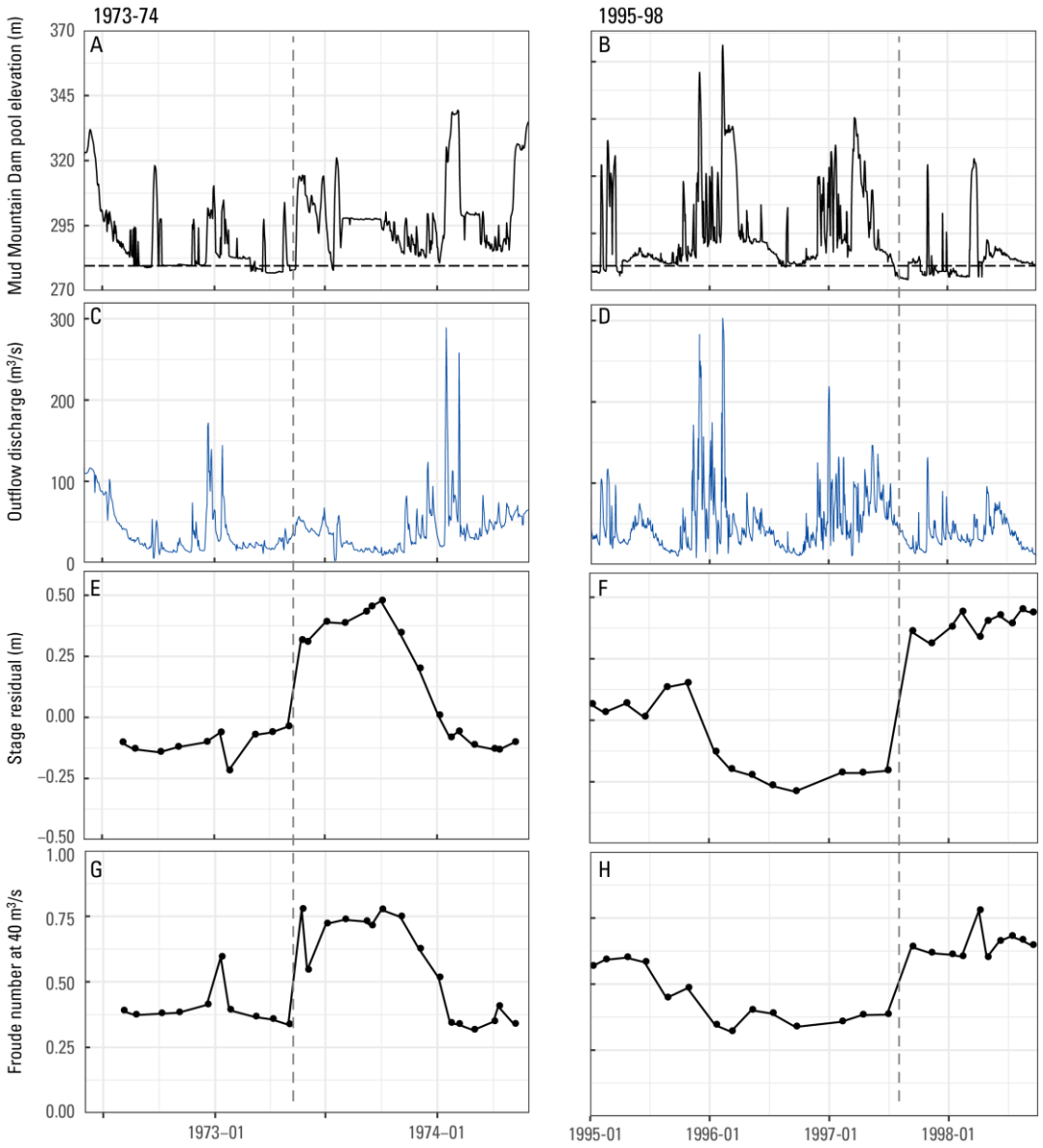

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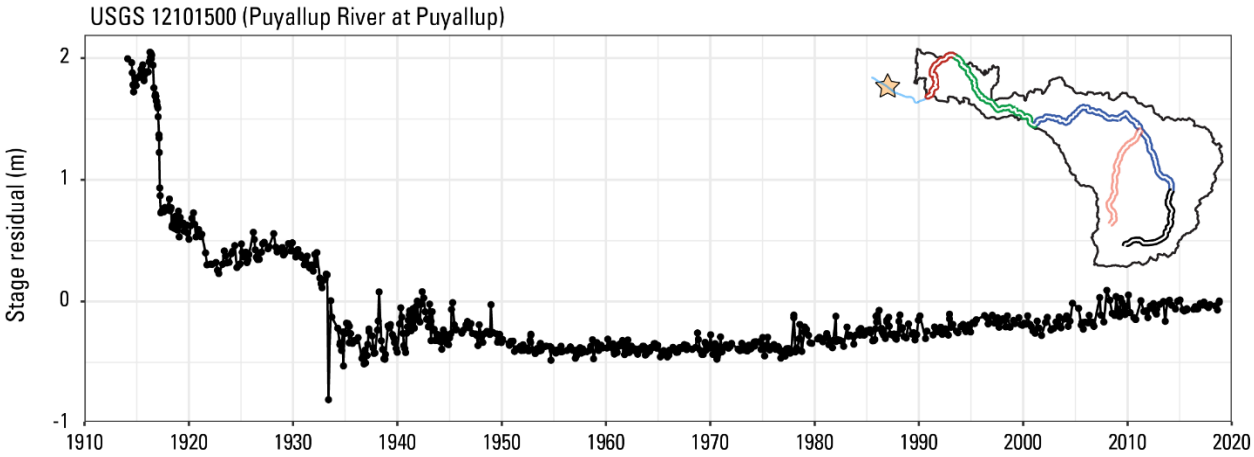

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