Impacts of streambed dynamics on nutrient and fine sediment transport in mountain rivers

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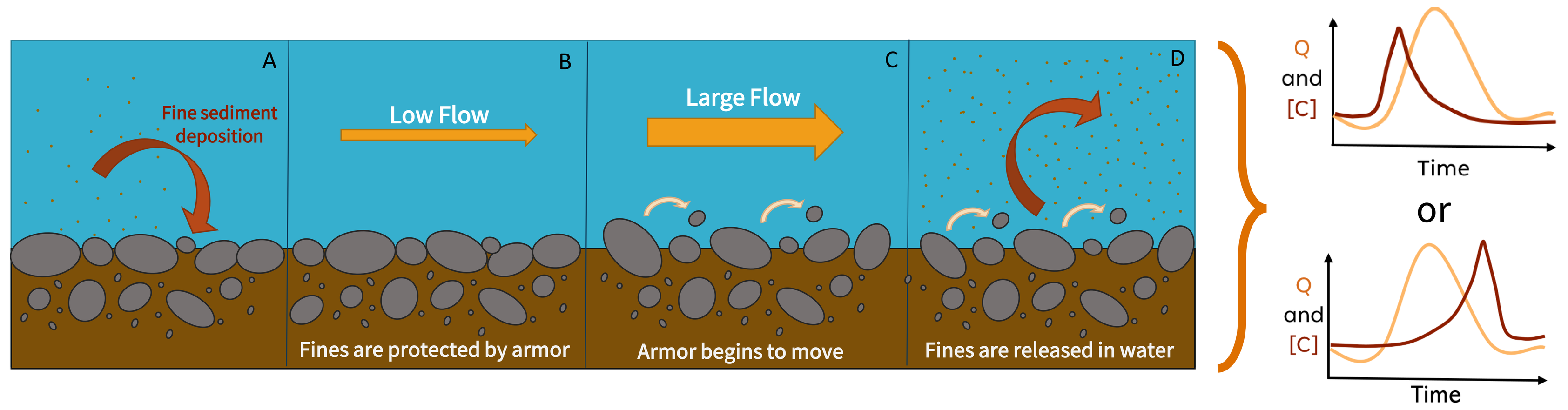
Background

- Rivers typically have an armor layer of coarse sediment that protects the finer subsurface from erosion.
- Armor layer motion during high magnitude flows could release subsurface fine sediments that are enriched in Phosphorus (P) and Particulate Organic Carbon (POC).



- Hysteresis in POC, soluble reactive phosphorus (SRP), particulate phosphorus (PP), and suspended sediment (SS) may therefore be partly controlled by armor layer motion.

Methods

- Study Site: La Jara Creek

- An armored tributary of the East Fork Jemez River in the Valles Caldera National Preserve in New Mexico.
- Channel characteristics: - Slope: 8-10%
  - Width: 1 m

- Data were collected during high flow events in **summer of 2021 and 2022**
- Equipment is in two reaches:
  - Upwelling
  - Downwelling
- Fieldwork still ongoing during spring and summer 2023

- Measurements

Water samples (SS, SRP, POC & PP)
Collected through stage-triggered **portable ISCO samplers**

Turbidity
These measurements were obtained with a **YSI EXO2 Sonde**

Flow depth and Discharge
Obtained through **pressure transducers** installed in stilling wells

Laboratory Procedures
SS – Laser diffraction method (LISST portable XR)
POC – Eurovector elemental analyzer coupled to an Isoprime IRMS
SRP & PP – SpectraMax M2e

- Armor layer movement

RFID tracer particles and Hydrophones
Particle sizes & distances — Particle sizes & timing

Size Class (mm)
128
90
64
45
32

- Tracer particle locations were recorded **before** and **after** each high flow event.
- Transported distances were computed through the **triangulation method** using fixed reference points
- Hydrophone data is still being processed (no results yet)

- Field Experiments

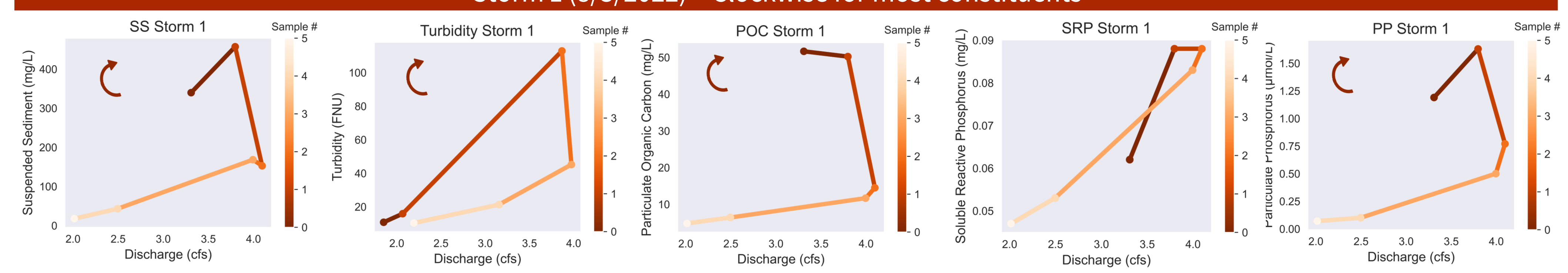
- Artificial pulse floods – Backed up and released water. Continuous water samples and RFID tracer movement was recorded
- Manually removed armor – No flow manipulation, no hysteresis

Experiments were to isolate the effects of armor layer on nutrient and fine sediment concentrations in the water column

Results

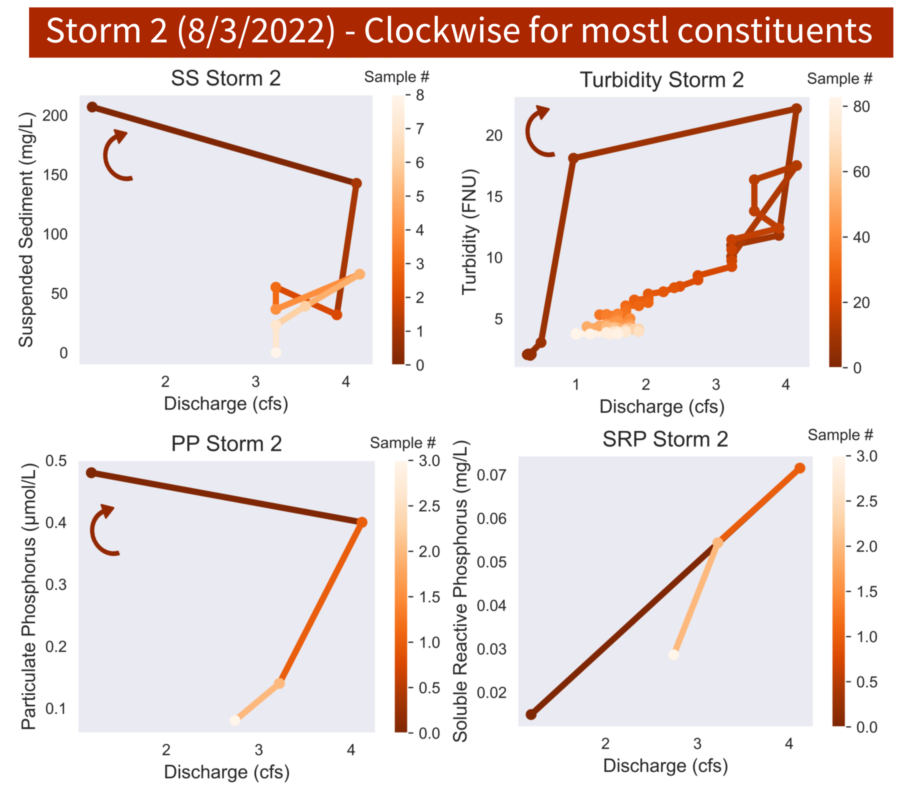
- Only 3 storms have occurred during the study period: One storm occurred in 2021 and two occurred in 2022
- Hysteresis plots from the downwelling reach are displayed, but both reaches showed the same pattern type

Storm 1 (8/3/2022) – Clockwise for most constituents

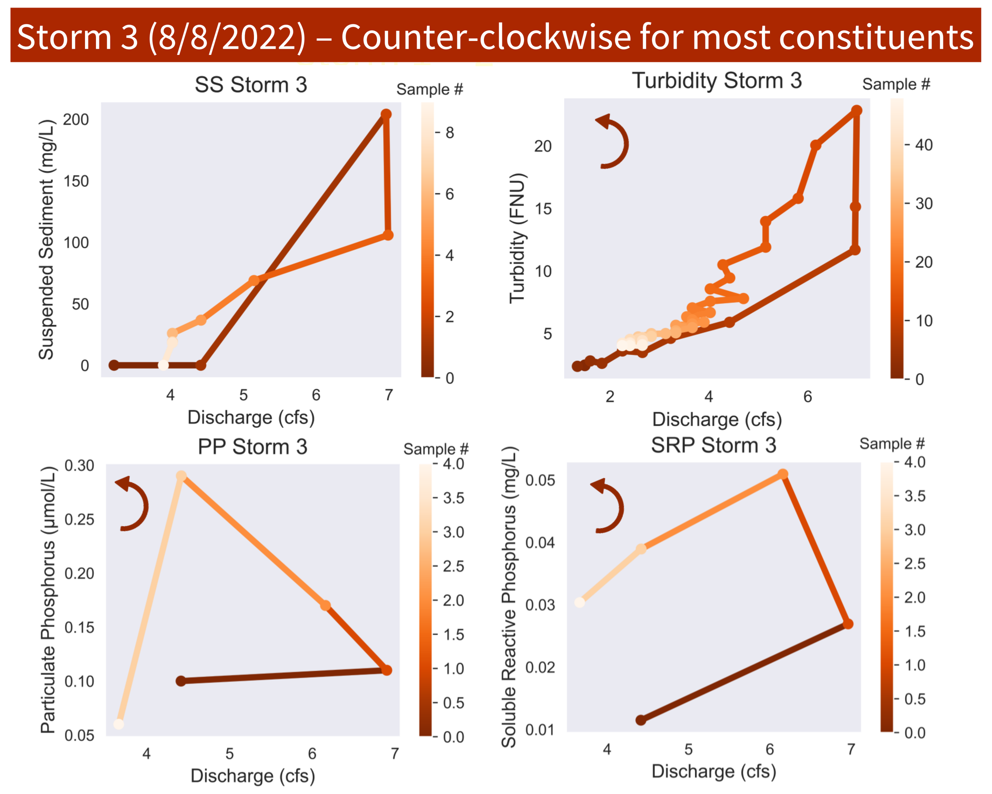


Note: Currently, this is the only storm we have POC data for, we will the rest this summer (2023)

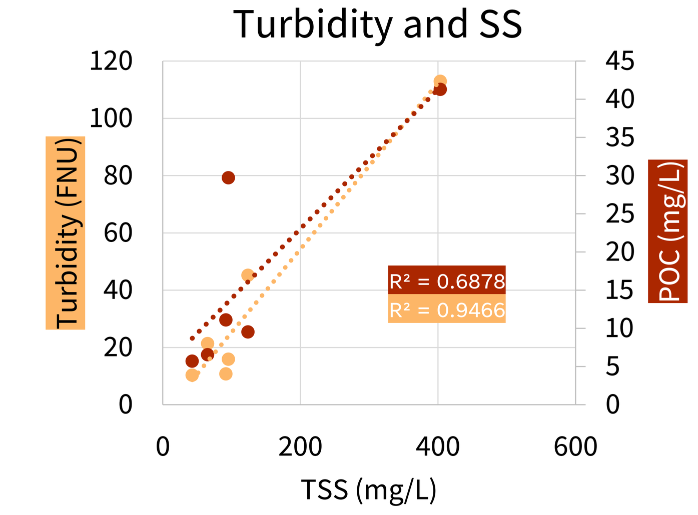
Storm 2 (8/3/2022) - Clockwise for mostl constituents



Storm 3 (8/8/2022) – Counter-clockwise for most constituents



Correlation between POC, Turbidity and SS



Both POC and the turbidity measurements correlate well with SS

- The **average value of all released constituents was higher in the downwelling reach**. Same for peak values of POC and SS, but not for PP and SRP.

Notes: 1) This comparison is only available for storm 1, since all subsequent storms only have information on the downwelling reach.
2) The values seem to be similar between the upwelling and downwelling reaches within the standard error of the mean, but we need further storm data and actual bed concentrations to further prove this statement

Average concentrations for storm 1:		
Constituent	Upwelling	Downwelling
SS (mg/L)	137.246 ± 54.4	196.498 ± 69.9
SRP (mg/L)	0.0625 ± 0.008	0.07 ± 0.008
PP (µmol/L)	0.443 ± 0.248	0.71 ± 0.252
POC (mg/L)	17.31 ± 5.99	23.22 ± 8.87

Peak concentrations for storm 1:		
Constituent	Upwelling	Downwelling
SS (mg/L)	403.52	457.12
SRP (mg/L)	0.09	0.088
PP (µmol/L)	1.66	1.63
POC (mg/L)	41.28	51.66

- **RFID tracer particles:** The river armor was displaced for each storm. The percent of bed that moved for each size class was considerably higher for storm 1 and 2 compared to storm 3, which could partly explain their differing hysteresis patterns.

STORM 1		
Size Class	Percent of bed that moved (%)	Average moved Distance (cm)
128	0.00	0
90	28.57	19.67
64	60.00	30.33
45	57.14	56.29
32	71.43	27.50

STORM 2		
Size Class	Percent of bed that moved (%)	Average moved Distance (cm)
128	0.00	0
90	66.67	19.89
64	43.75	21.88
45	61.90	46.93
32	48.72	36.93

STORM 3		
Size Class	Percent of bed that moved (%)	Average moved Distance (cm)
128	0.00	0.00
90	33.33	18.45
64	25.00	93.63
45	19.05	40.70
32	33.33	43.02

- **Field Experiments:** The artificial flood experiments showed consistent clockwise hysteresis for both SS and PP, but differing patterns for SRP. Further analysis is still being conducted as well as processing of POC samples.

Key Findings and current work

- Our results demonstrate how **the amount of armor layer movement could impact the hysteresis patterns of released constituents**.
- We are yet to determine if the timing of armor layer movement is an important factor. This will be done through the hydrophone data.
- Preliminarily, we found that **downwelling reaches can potentially release higher SS and nutrient concentrations during high flow events.** This is further being explored through riverbed sediment nutrient concentration comparisons in both reaches.
- We are conducting more field seasons during 2023 as well as the processing of POC samples.

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