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

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Summary

- The armor layer protects the finer bed subsurface from erosion, but when dislodged during high flow events it can release fine sediment enriched in Phosphorus (P) and Organic Carbon (OC).
- **Hysteresis and seasonal variations** in particulate and soluble reactive phosphorus (PP and SRP) and in particulate and dissolved organic carbon (POC and DOC) could be **controlled by armor layer motion**
- By monitoring summer monsoon and snowmelt flows and conducting field experiments in a mountain stream in NM, our preliminary results suggest that the **quantity of fine sediment in the riverbed is related to local hyporheic flux and near-bed flow velocity**.
- Particulate constituents such as POC, PP and suspended sediment (SS) often show clockwise hysteresis, whereas DOC tend to show counter-clockwise hysteresis, suggesting them **coming from different sources.**
- We are currently investigating these sources and constraining the exact timing of armor layer motion in each event.

Methods

Study Site: La Jara Creek,
Valles Caldera National Preserve, NM

1. Capturing Hysteresis:

Turbidity and fDOM*
Collected using a YSI EXO2 Sonde

Water samples (SS, SRP, PP, DOC & POC)
Stage-triggered portable ISCO samplers

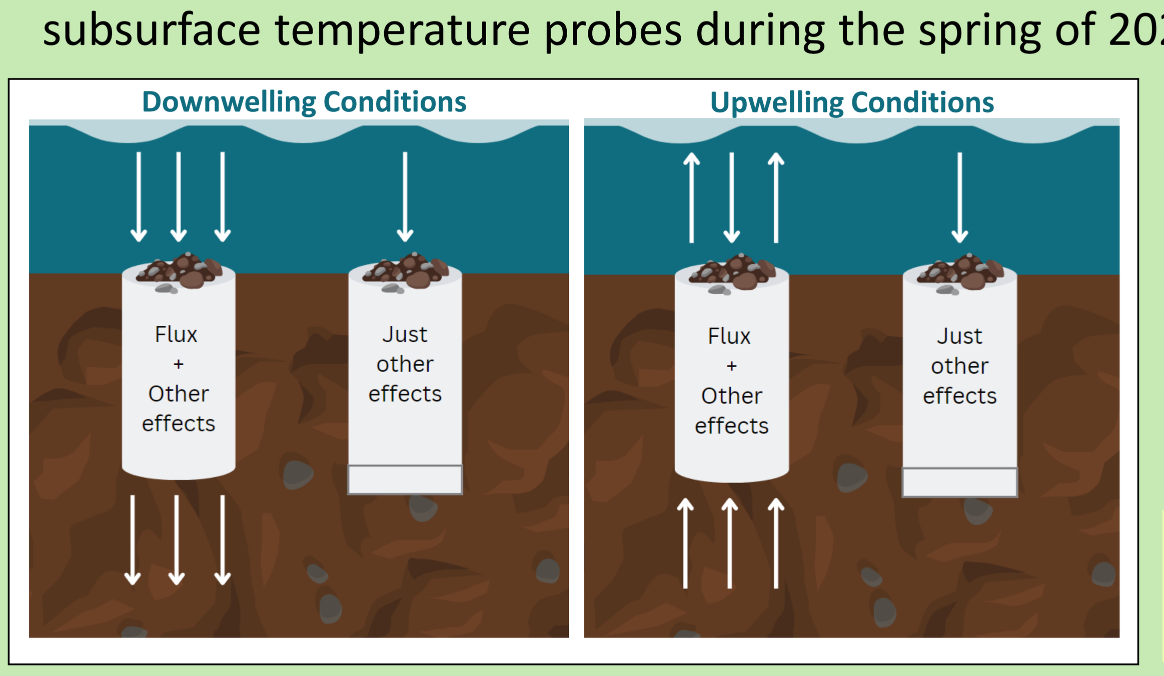
Flow depth and Discharge
Pressure transducers in stilling wells

* Fluorescent dissolved organic matter – a reliable proxy for DOC

Laboratory Procedures
SS – Laser diffraction method (LISST portable XR)
POC – Eurovector elemental analyzer coupled to an Isoprime IRMS
DOC – OI Analytical Aurora 1030 TOC Analyzer
SRP & PP – SpectraMax M2e

2. Fine Sediment Deposition

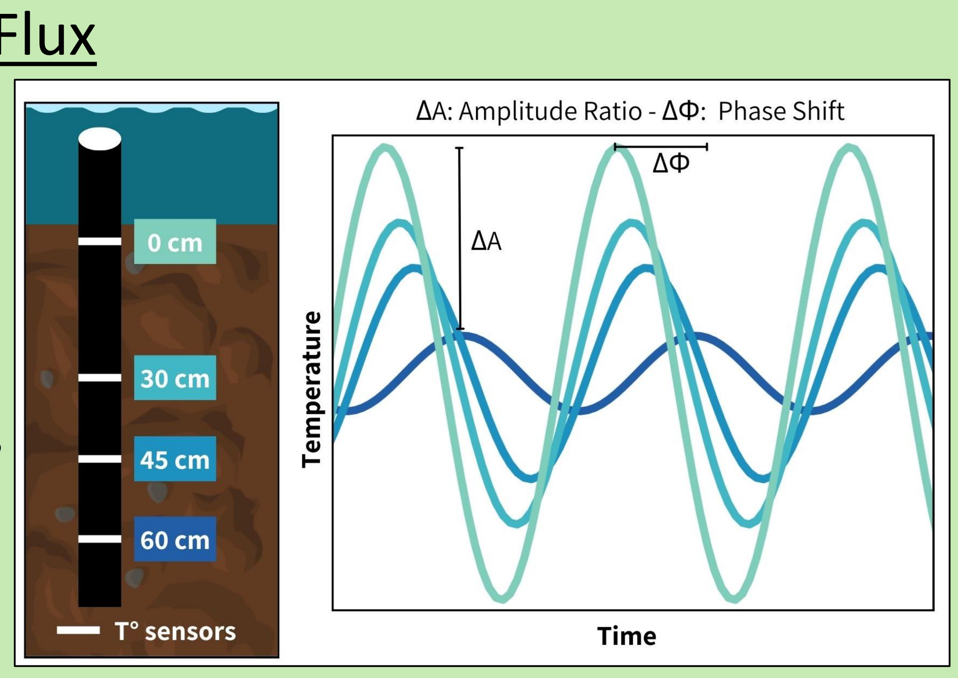
Sediment traps with open and closed bottoms were installed next to subsurface temperature probes during the spring of 2023



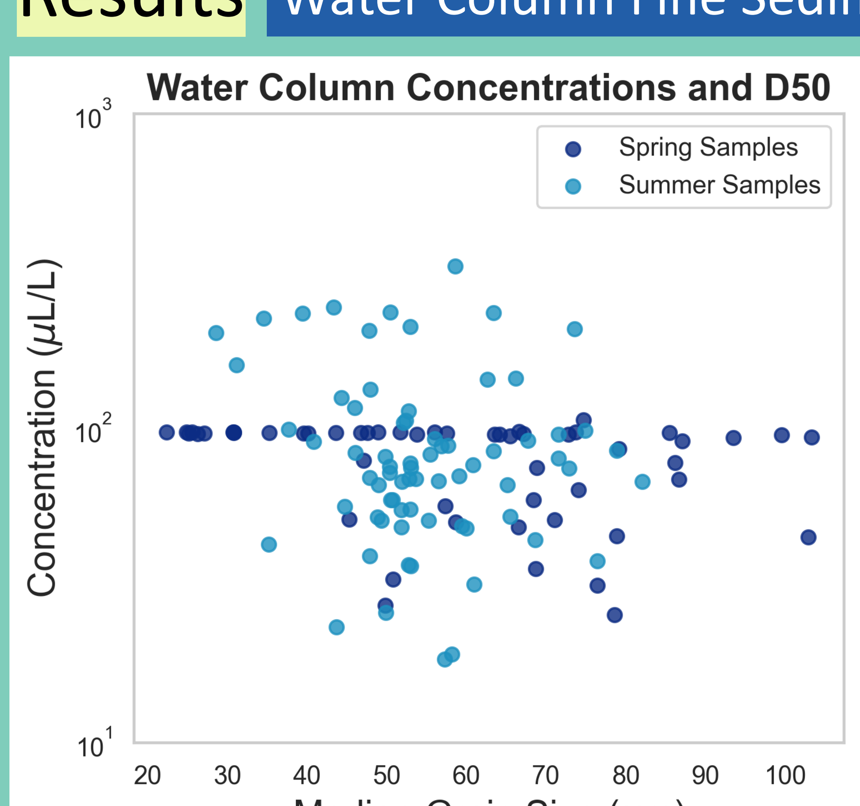
Other deposition effects:
- settling velocity
- stream turbulence effects

3. Computing Hyporheic Flux

Through diel substrate water temperature fluctuations, we can solve the vertical flux from the 1D advection-diffusion equation using *ΔA and ΔΦ*. Temperature-monitoring probes were installed at the locations of each basket group to estimate local hyporheic flux.



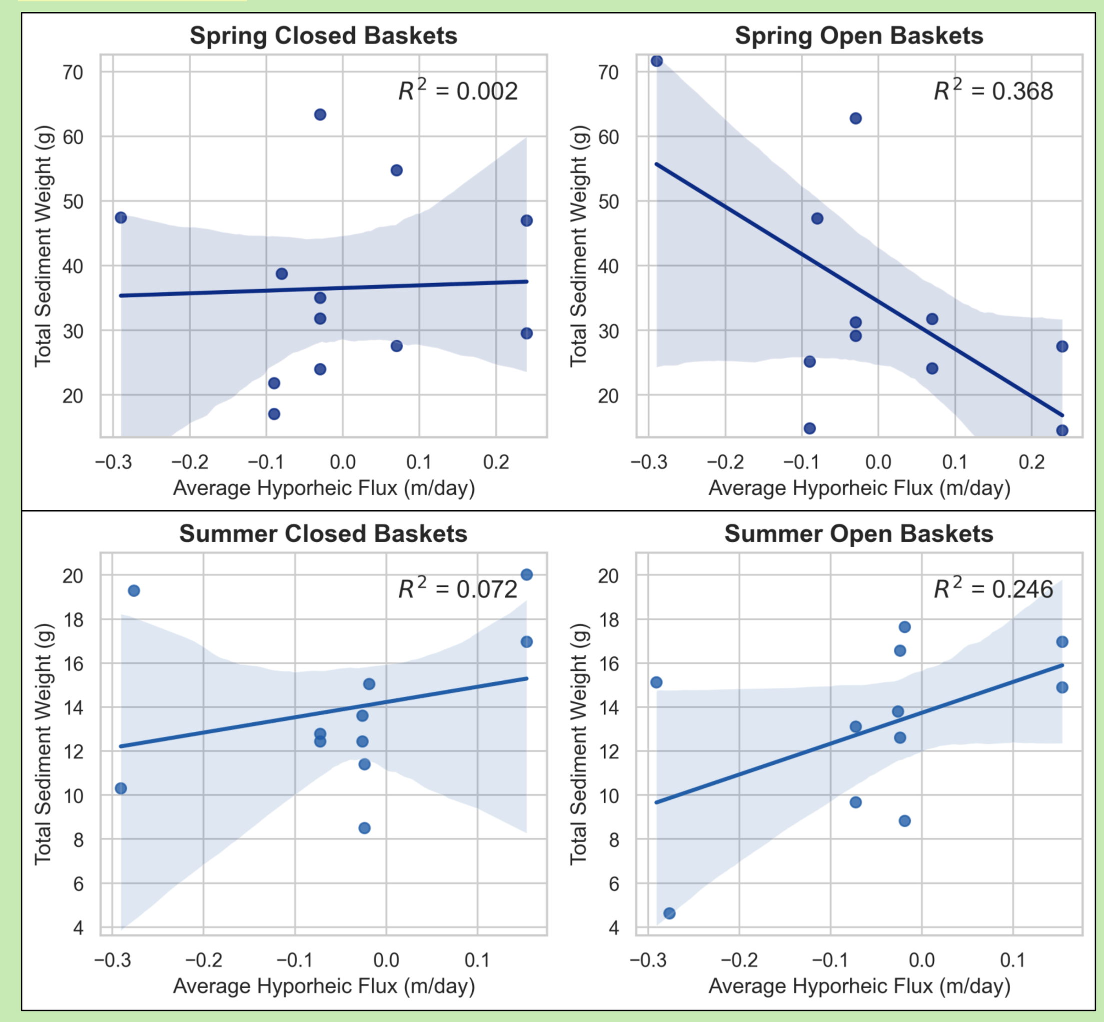
Results — Water Column Fine Sediment Concentrations and D_{50}



- **Summer high flow events** displayed a wider range of concentrations and **higher peak concentrations on average** than the spring event concentrations.
- **Spring high flow events** have a wider range of D50's and a **coarser grain size distribution on average** compared to the summer samples.

Average:	Spring	Summer
Concentration (μL/L)	80.51	95.00
Median Grain Size (μm)	59.56	54.65

Results — Spring and Summer Fine Sediment Deposition



The sediment traps demonstrated that the **total captured sediment weight was higher for the spring samples.**

Preliminarily, we also found that the spring sediment particle size distribution (PSD) is coarser than the summer sediment PSD

Total deposited **sediment weight correlates better for the open traps** than for the closed traps for both seasons. The slope is different for spring (negative) and summer (positive).

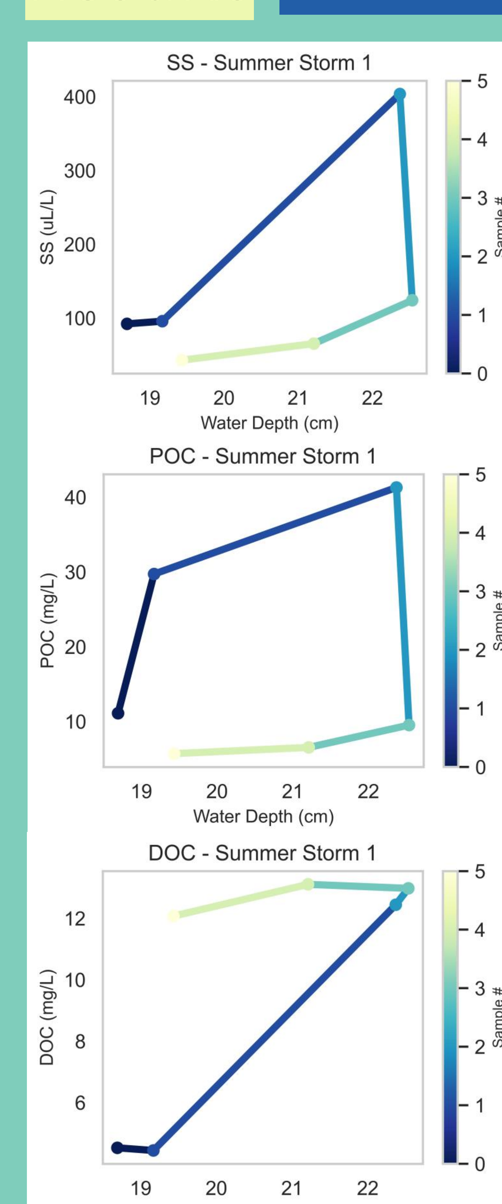
To further understand this trend, other deposition effects such as **horizontal velocity** (obtained through AVD measurements) and **Turbulence Kinetic Energy (TKE)** were used to compute multivariate regressions to explain deposited sediment weights

Preliminary results show that **hyporheic flux and TKE can potentially explain the amount of deposited sediment in open traps**. Closed traps showed little to no relation with these variables.

Settling velocities are yet to be added to this analysis

Regression Variables:		Hyporheic Flux, Horizontal Velocity and TKE		Hyporheic Flux and Horizontal Velocity		Hyporheic Flux and TKE	
Type of traps:		CLOSED	OPEN	CLOSED	OPEN	CLOSED	OPEN
R^2 values	R^2	0.413	0.791	0.375	0.677	0.310	0.791
	Adjusted R^2	0.192	0.702	0.236	0.597	0.156	0.739
Coefficients	Hyp. Flux	19.621	-6.556	9.708	-67.069	28.416	-5.177
	Hor. Vel.	13.139	0.693	18.505	21.704	-	-
	TKE	22.304	67.457	-	-	47.032	69.052
P values	Hyp. Flux	0.524	0.865	0.711	0.024	0.355	0.845
	Hor. Vel.	0.270	0.958	0.046	0.025	-	-
	TKE	0.493	0.092	-	-	0.076	0.004

Results — Seasonal Constituent Hysteresis



Particulates tend to have CW hysteresis and DISSOLVED CCW in summer
Particles still have CW in spring, but also CW for DOC

Further work

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