

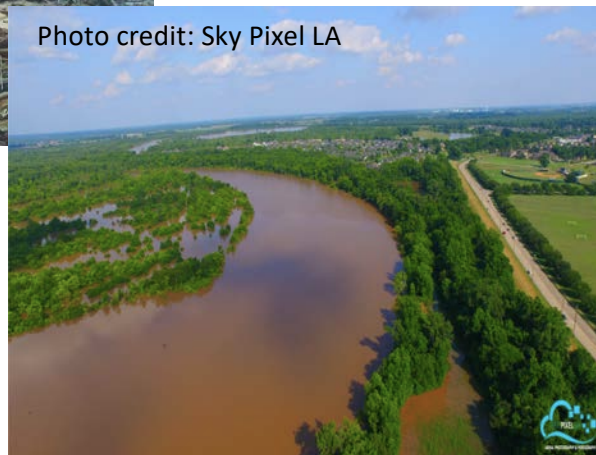
Interacting Influence of Log Jams and Branching Channels on Stream-Groundwater Exchange



Audrey H. Sawyer, Karl Wilhelmsen, Anna Marshall, Xiaolang Zhang, Christian Roumelis, Kamini Singha, and Ellen Wohl

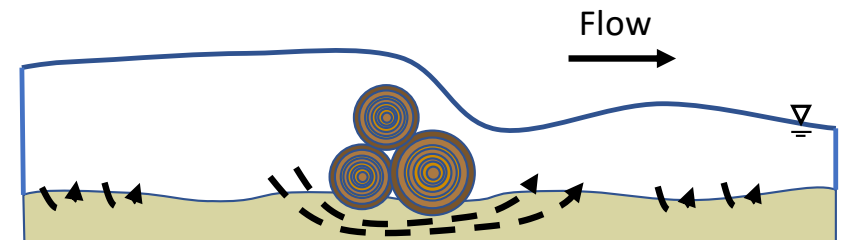


Log jams form naturally and are removed as part of watershed management



Why does it matter?

Jams influence many stream processes....



Jams and channel complexity go hand-in-hand



Bank incision



Branching channels

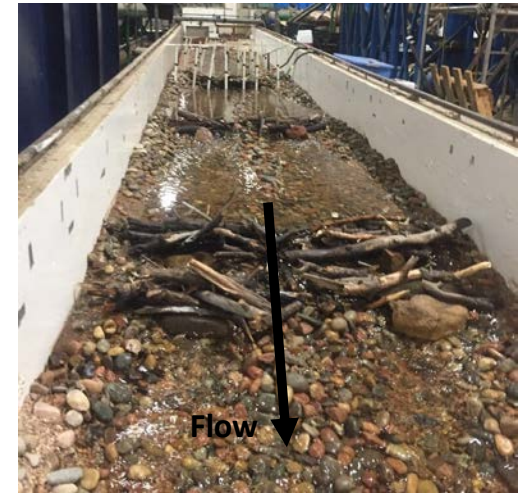
We asked...

- 1) How do jams and multiple channel threads both influence surface water-groundwater exchange?
- 2) What are the potential impacts on stream water quality?

Approach: flume experiments and numerical models

Flume and model setup

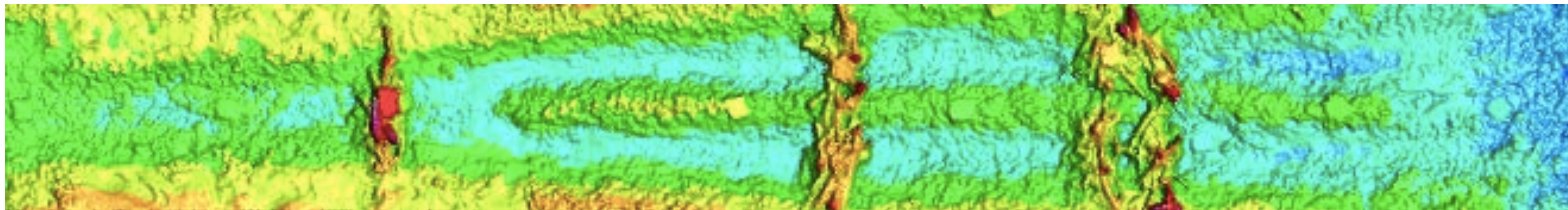
- 9 m long flume, 1.2 m wide, 0.2 m deep
- Three jams versus none
- Three flow rates: 1.42 L/s , 4.25 L/s , 8.50 L/s
- Coupled surface water and groundwater flow models



Photos

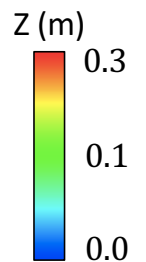


Digital
Elevation
Model

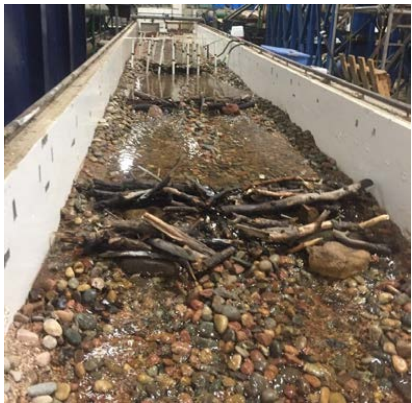
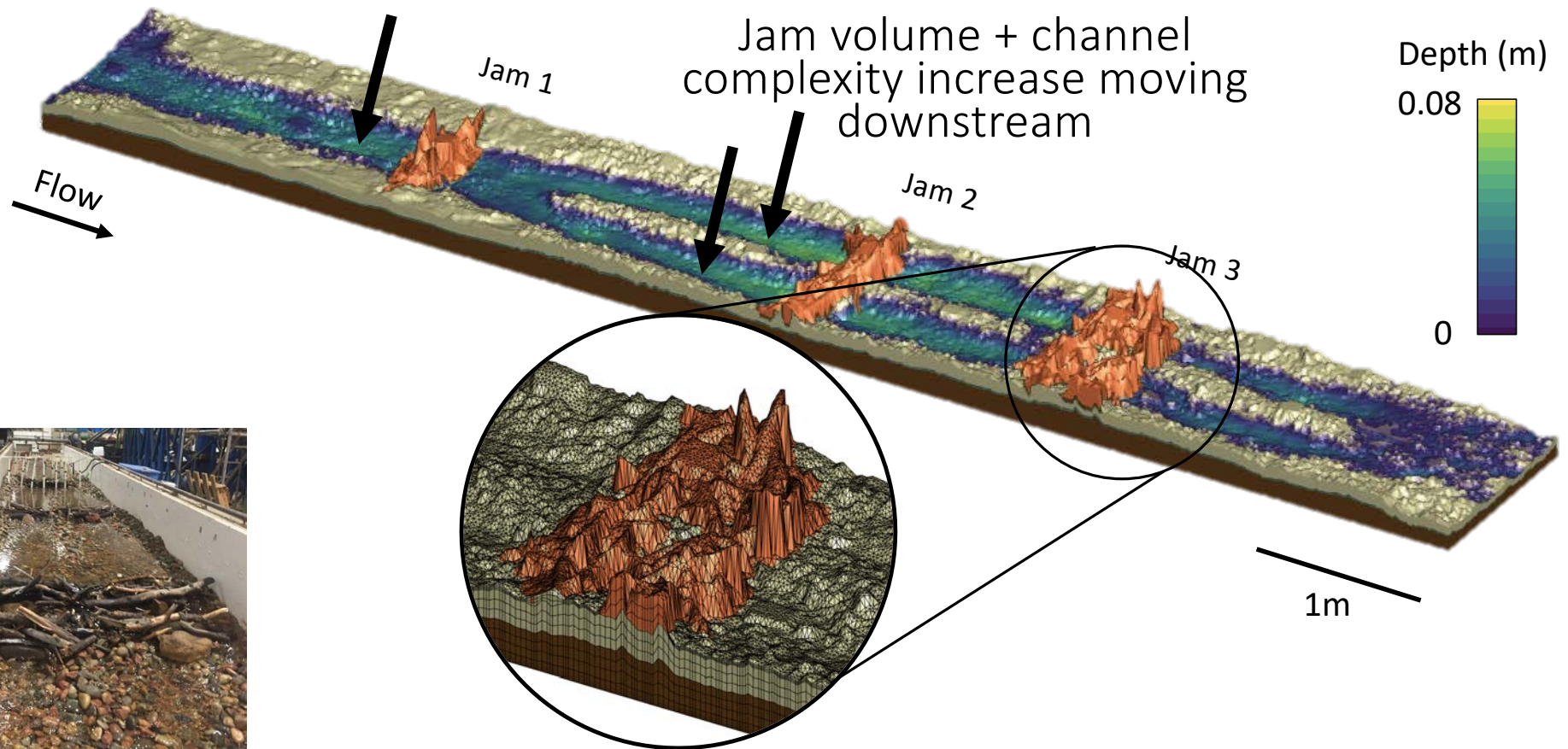


1m

Flow



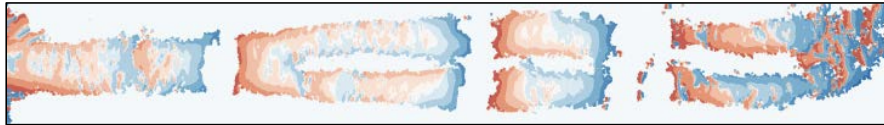
HydroGeoSphere Models



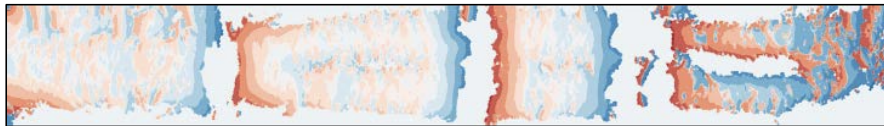
Hyporheic Exchange Fluxes

Flux with Jams

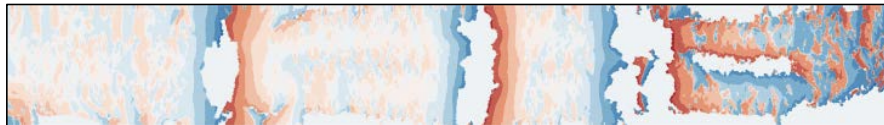
Low flow



Medium flow



High flow

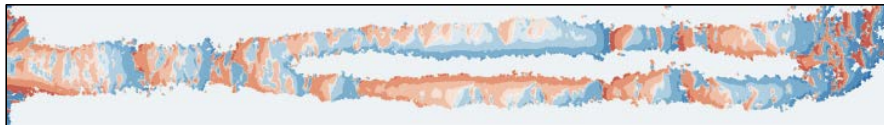


Flux without Jams

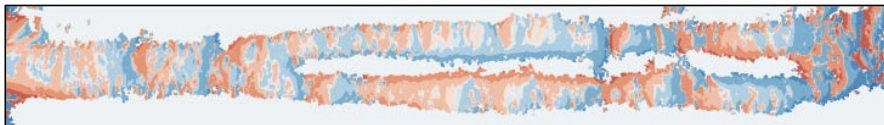
Flow

1m

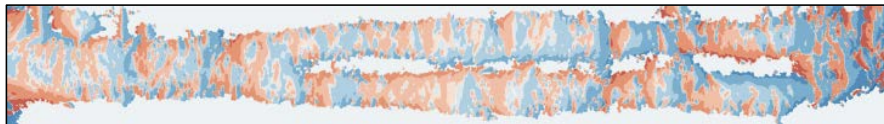
Low flow



Medium flow

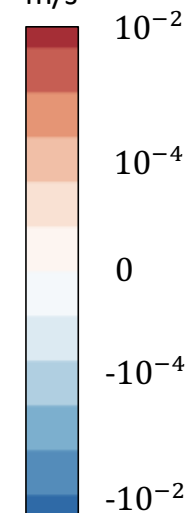


High flow



With jams, streambed area also expands (hyporheic zone grows in 3D)

m/s

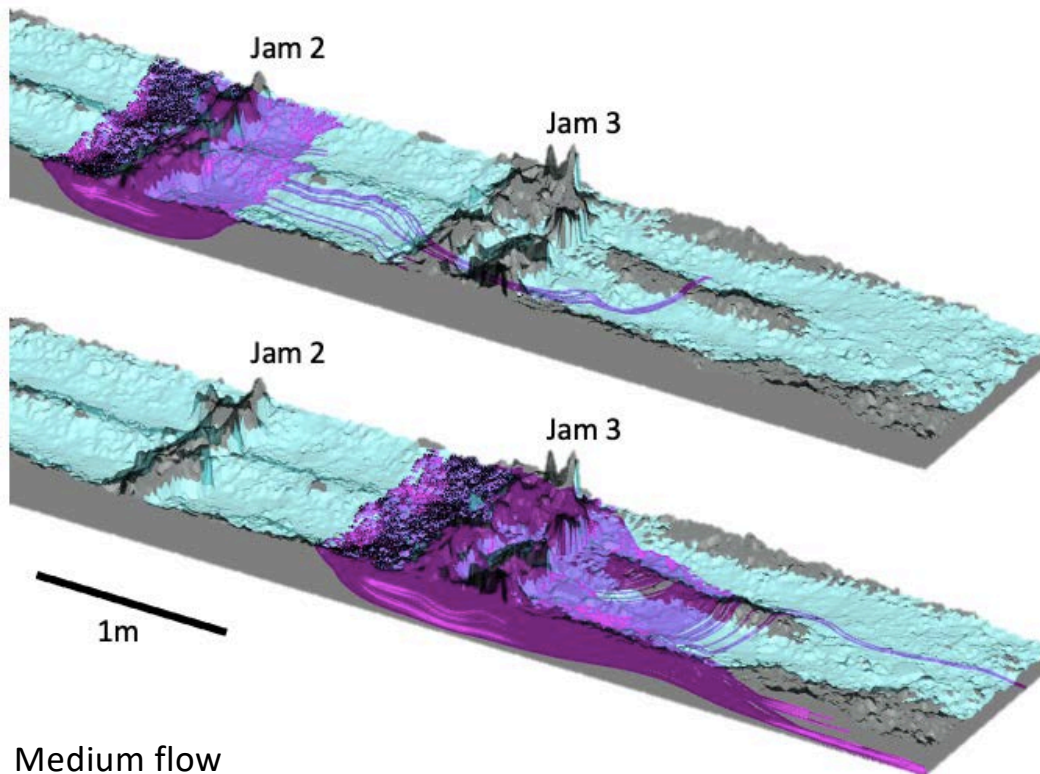


upwelling



downwelling

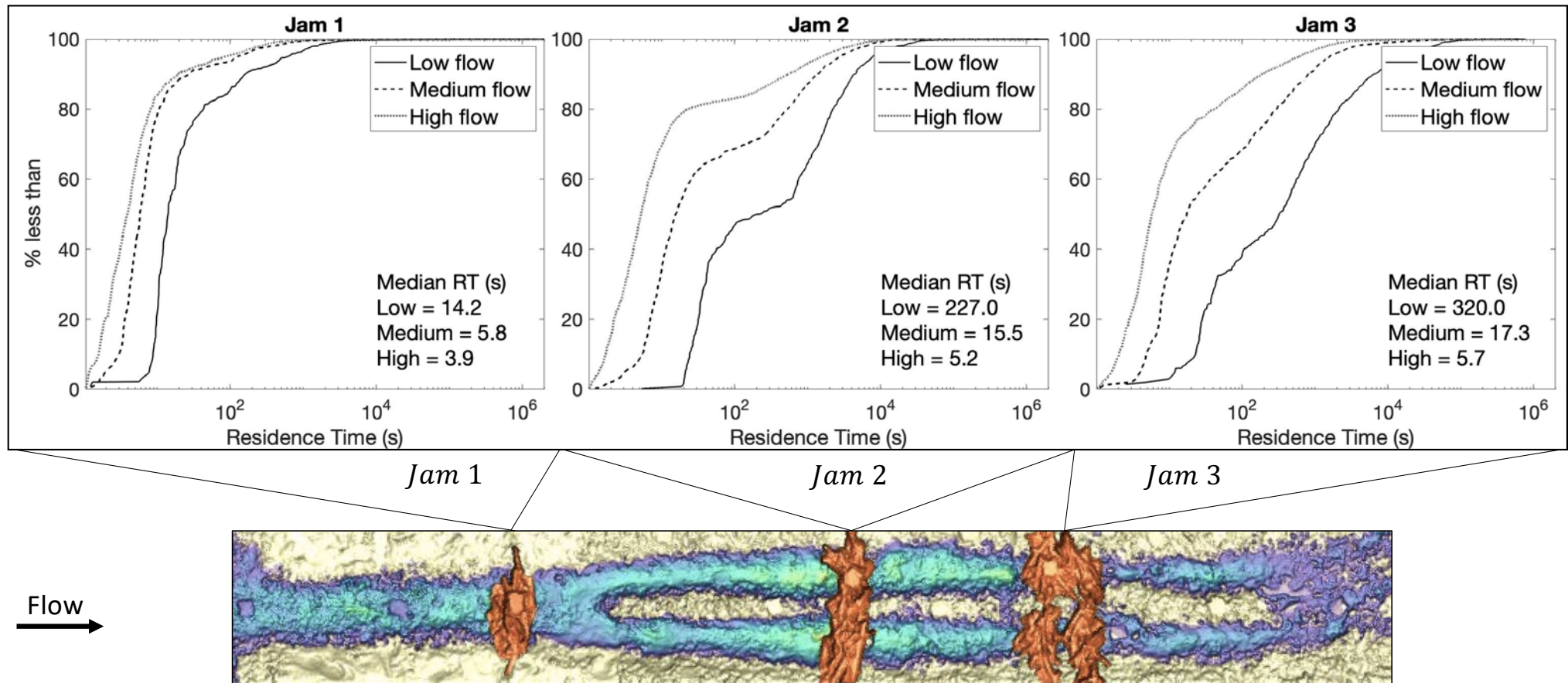
Hyporheic flow paths and residence times



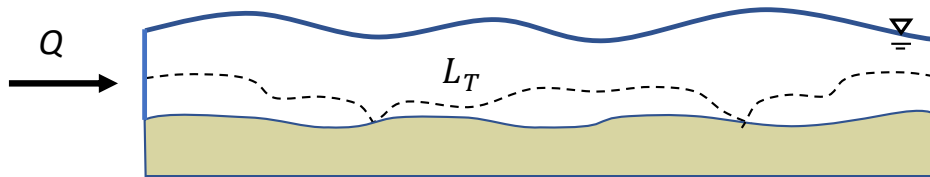
Long scales of exchange develop between complex jams...

...and between jams, bars, and multiple channel threads

More complex jams/channels drive complex hyporheic transport



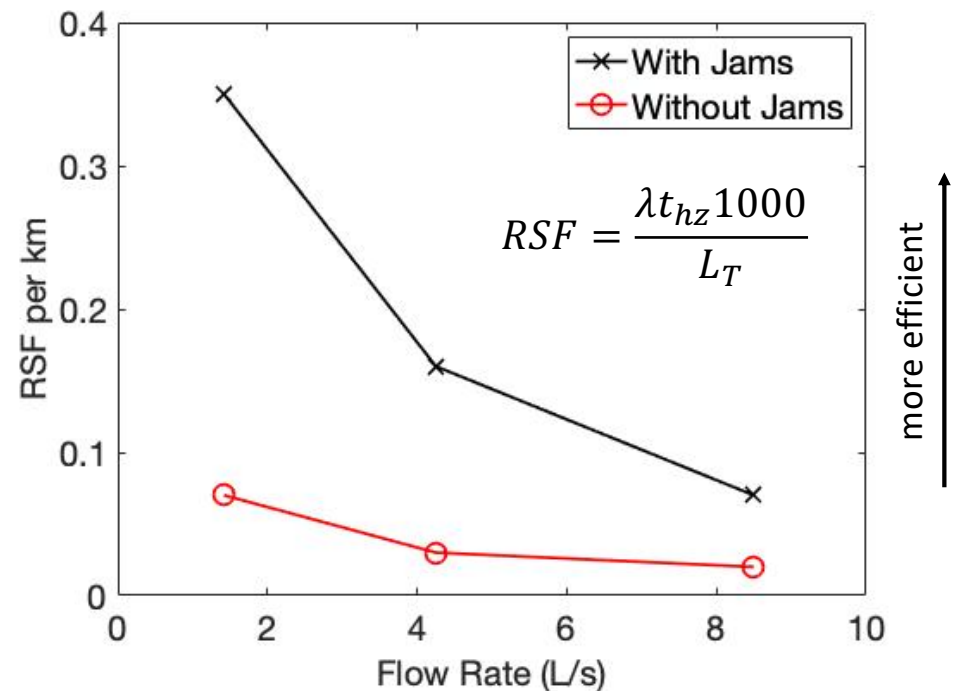
Implications for water quality



$$L_T = \frac{Q}{q_{swi}A} L_f$$

- Turnover Length (L_T)
 - Average length in stream a solute travels before entering hyporheic zone
 - With Jams: 2.0 – 2.8 meters
 - Without Jams: 44.2 – 229.6 meters

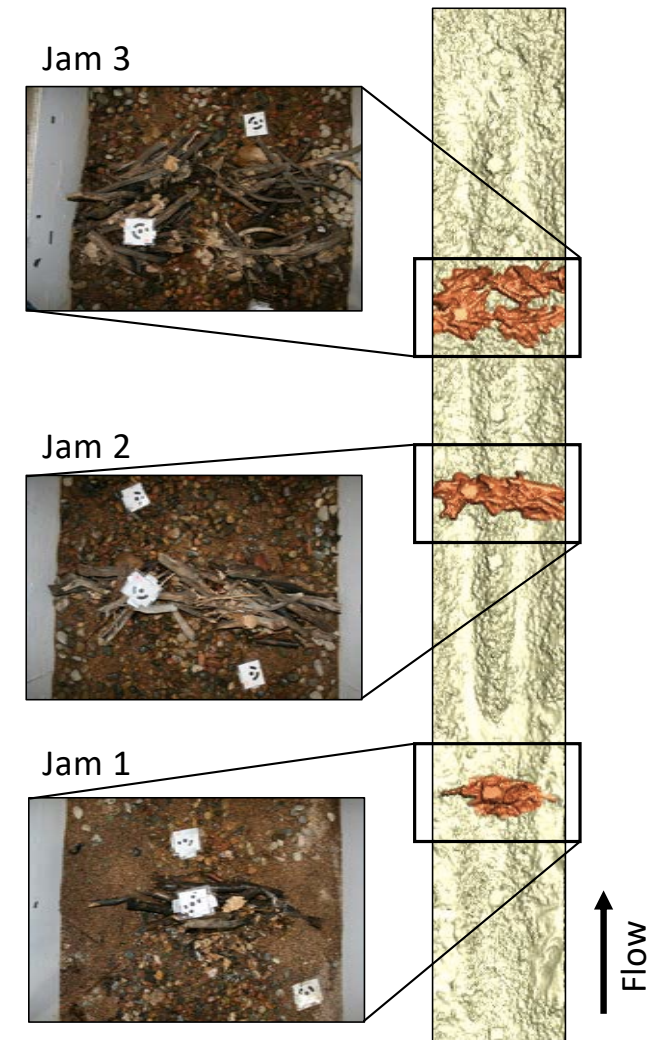
- Reaction Significance Factor (RSF): “Efficiency” of hyporheic zone at a given chemical process



To Recap:

- Jam structures:
 - Increase stream wetted area, creating pools
 - Increase exchange rate between surface and subsurface
- Greater jam and channel complexity:
 - Increases length scales and residence times of hyporheic flow
 - Creates multiple modes of flow
- Why does this matter for water quality?
 - More effective chemical processing within the hyporheic zone, especially at low flows

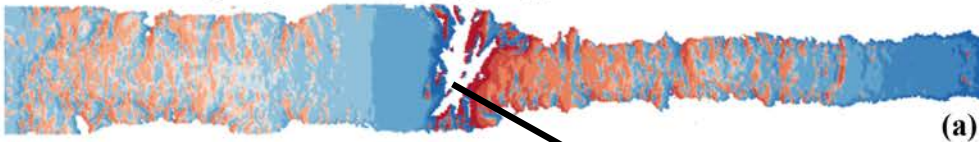
Wilhelmsen, K., Sawyer, A. H., Marshall, A., McFadden, S., Singha, K., & Wohl, E. (2021). Laboratory flume and numerical modeling experiments show log jams and branching channels increase hyporheic exchange. *Water Resources Research*, 57, e2021WR030299. <https://doi.org/10.1029/2021WR030299>



New experiments coming soon on jam porosity, abundance, and backwater interactions....

Marshall, A., Zhang, X., Sawyer, A.H., Wohl, E., & Singha, K. (in prep). Logjam Characteristics as Drivers of Transient Storage in River Systems.

Low flow, Low logjam permeability, Single logjam



High flow, Low logjam permeability, Single logjam



Low flow, High logjam permeability, Single logjam



High flow, High logjam permeability, Single logjam



Questions?

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- Sawyer McFadden for assistance with flume experiments
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