High-Frequency Sensing of Specific Conductance to Understand Solute Transport Mechanisms During Storm Events in Johnson County, KS

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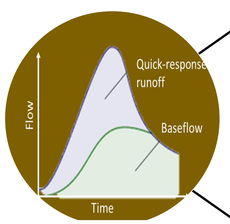
Introduction

Increasing freshwater salinity is considered a major water quality issue in Kansas due to its harmful consequences including degradation of drinking water and biodiversity reduction. Urbanization accelerates this process by altering the hydrologic pathways of solute delivery to streams and adding new sources such as wastewater treatment facility discharges and road-salt application during winter snow. Therefore, making effective decisions to mitigate freshwater salinization requires an understanding of how anthropogenic disturbances affect salt dilution and flushing dynamics as well as the relative contribution of surface (typically lower salinity) vs subsurface (typically higher salinity) flow.

In this study, we used high-frequency 15-minute specific conductance (proxy for freshwater salinity) data from 2002 to 2014 across five watersheds in rapidly urbanizing Johnson County to address these questions. We performed hysteresis analysis (the changing relationship between discharge and specific conductance) to identify the location of solute sources and used hydrograph separation methods to quantify the different components of streamflow during storm events.

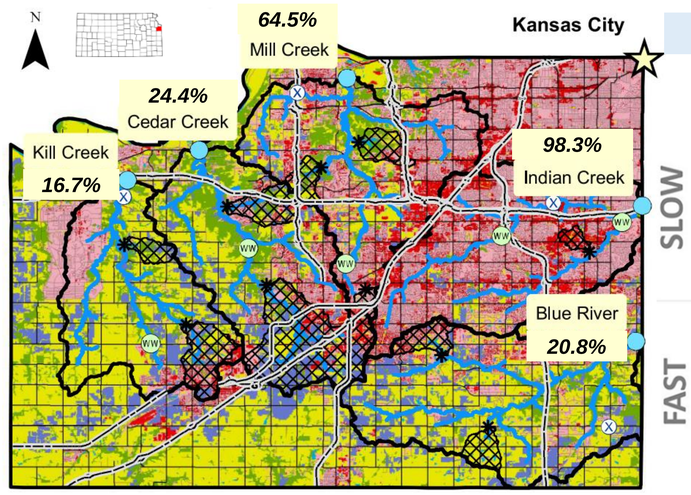
Research Objectives

Sense how salt **dilution** and **flushing** vary as a function of **land use**. Use this information to identify active source zones and mechanisms of solute transport



Quantify the contribution of ***new*** water vs ***old*** water in five watersheds. Investigate how urbanization impacts the relative contribution of *old* vs *new* water.

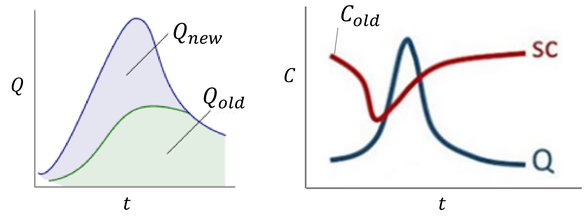
Study Site and Methods



Two-Component Hydrograph Separation

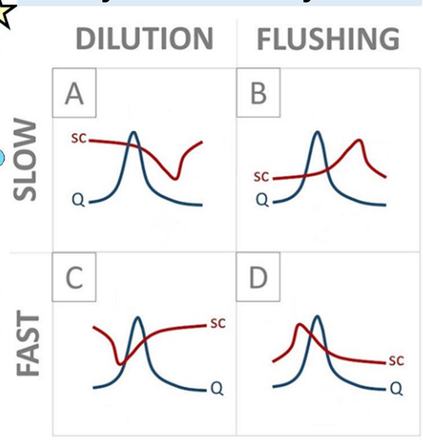
$$Q_{stream} = Q_{new} + Q_{old}$$

$$Q_{stream}C_{stream} = Q_{new}C_{new} + Q_{old}C_{old}$$



$$\boldsymbol{Q_{old} = Q_{stream}[(C_{new} - C_{stream})/(C_{new} - C_{old})]}$$

Hysteresis Analysis

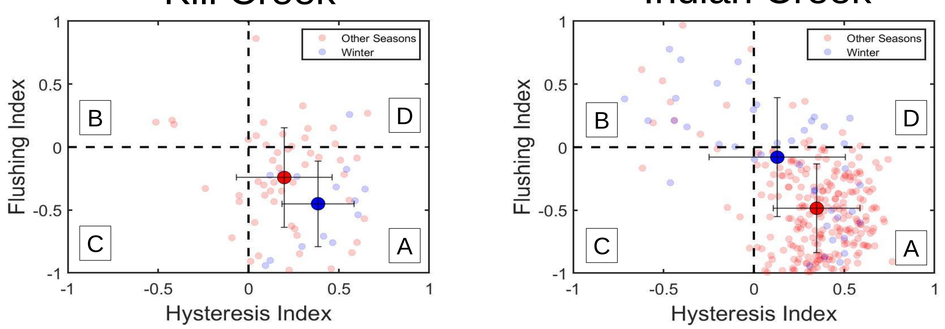


Lakoba et al. (2020)

828 storms with discharge and conductivity identified!

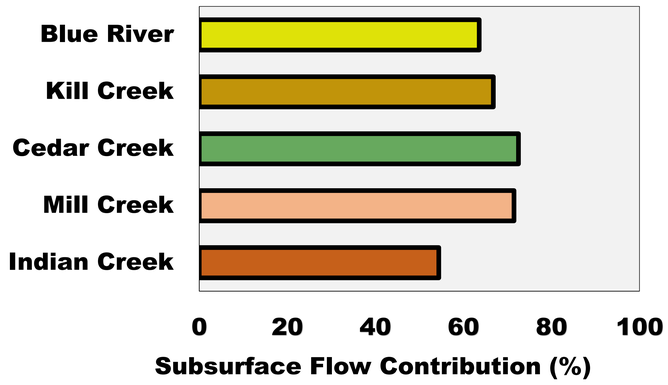
Each storm classified as (A), (B), (C), or (D) using Hysteresis and Flushing Indices!

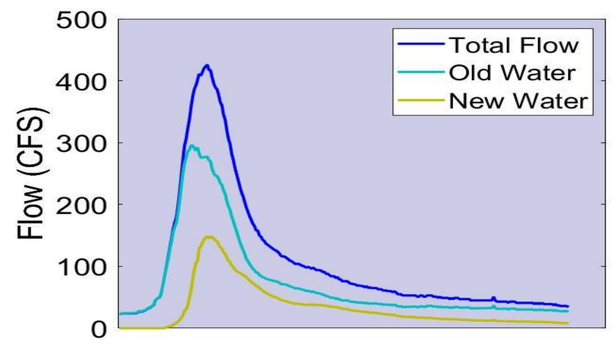
Hysteresis Analysis Results



- Clockwise diluting pattern is dominant across all watersheds indicating **fast** response of solutes and consistent **source limitation** in Johnson County.
- Winter storm events are more likely to increase salinity of the streams in urban watersheds (**road-salt and deicing agents**)

Hydrograph Separation





- Baseflow has higher a contribution to the stormflow, even in the most urban watershed!
- *New* water contributions **lag** the increase in discharge → flushing of *old* water first!
- ✓ Rapid mobilization of water stored in near stream soils or storm water drainage networks?
- ✓ Flood waves of baseflow water displaced by runoff?

<u>Three-component hydrograph separation is required</u>

Conclusion

The primary source of solutes in Johnson County's streams is located near the stream channel and is rapidly mobilized and depleted during storm events. However, salt becomes transport-limited during winter in urban watersheds due to road-deicing.

(1) Rasmussen, T., & Gatotho, J. Water-Quality Variability and Constituent Transport in Streams of Johnson County, Kansas. **(2)** Lakoba, V., Wind, L., DeVilbiss, S., Lofton, M., Bretz, K., Weinheimer, A., ... & Hession, W. C. (2020). Salt Dilution and Flushing Dynamics of an Impaired Agricultural–Urban Stream. ACS ES&T Water, 1(2), 407-416.. **(3)** Lloyd, C. E. M., Freer, J. E., Johnes, P. J., & Collins, A. L. (2016). Using hysteresis analysis of high-resolution water quality monitoring data, including uncertainty, to infer controls on nutrient and sediment transfer in catchments. Science of the Total Environment, 543, 388-404.