Combined sewer overflows create novel concentration-discharge hysteresis patterns in urban streams

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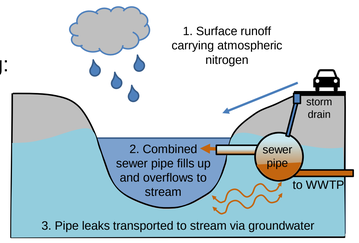
INTRODUCTION

- Concentration-discharge (c-Q) hysteresis is a common method to differentiate among watershed transport mechanisms, in which flushing of riparian soil nutrient sources and dilution of upland sources show different patterns.
- However, c-Q relationships are more complicated in urban areas due to additional flowpaths to streams including:
  1. storm drains that rapidly convey surface water,
  2. combined sewer overflows (CSOs) that directly input domestic wastewater, and
  3. groundwater-borne leakage from buried sewer pipes.



STUDY AREA & METHODS

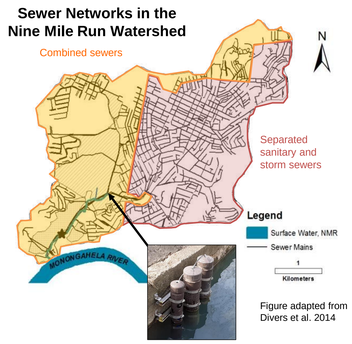
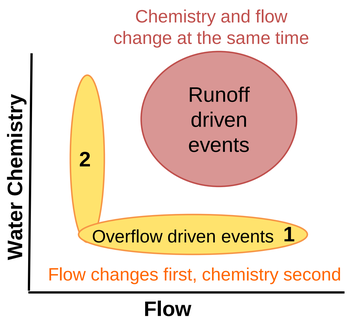


Figure adapted from Divers et al. 2014

- The Nine Mile Run watershed near Pittsburgh, PA has 38% imperviousness, fully buried headwaters, and a major sewer main buried alongside the stream channel.
- The stream is extremely flashy and order-of-magnitude changes in discharge are not uncommon within 15-minute sensing intervals.
- 15-minute water chemistry and flow data was collected with a SUNA, YSI EXO_2 Sonde, and pressure transducer.
- Grab samples from two storm events were collected with an ISCO autosampler and analyzed for concentrations of major anions (NO_3^-, NO_2^-, F^-, Cl^-, SO_4^{3-}) and stable nitrate and water isotopes.

RESULTS

- Event-by-event differences precipitation intensity and geography determine the relationship between water chemistry and discharge (flow) in a storm.
- Storms focused on the eastern (served by sanitary sewers) part of the watershed have hydrographs that can be chemically distinguished into three components: 1) road runoff, 2) activation of overflows, and 3) groundwater flushing.
- Storms focused on the western (served by combined sewers) have rapid discharge changes, dilution, followed by increases in nitrate and other anion concentrations.



DISCUSSION

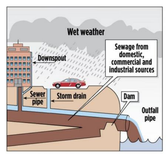
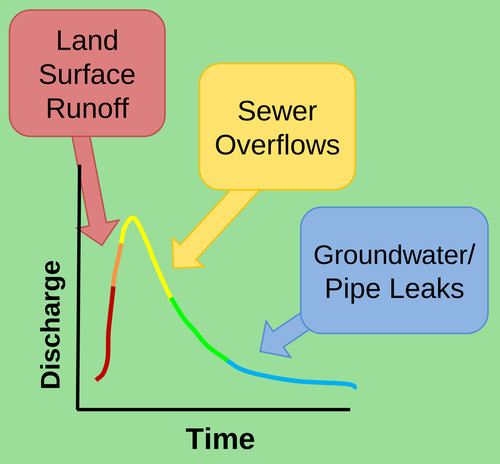


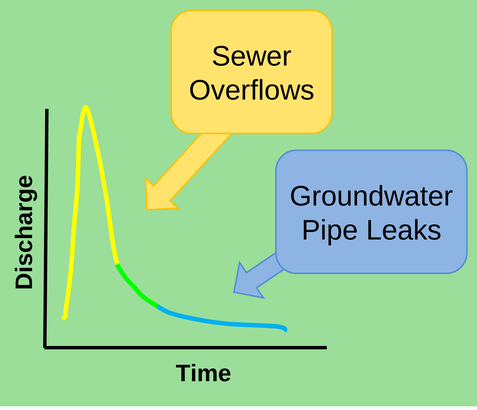
Figure from StormwaterONE.com

- In overflow-driven storms, water from landscape runoff does not reach the stream until the in-pipe overflow threshold is reached (by which point runoff water is already mixed with sewage in the pipe).
- In both types of events, post-storm increases in nutrients and anions are likely a delayed transfer of sewage leaks from full capacity pipes (sanitary or combined) that are carried by groundwater to the stream at the tail end of the storm event.

In flashy urban streams, storm events can be characterized as **runoff-driven** or **sewer overflow driven** based on spatial variation in rainfall that activate different **pipe tributary networks.**

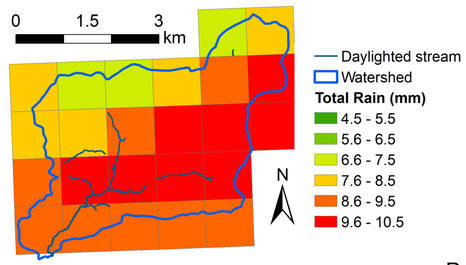
Runoff–driven events: Three water and solute sources, each having a distinct chemical signature, contribute sequentially to discharge in a storm event.





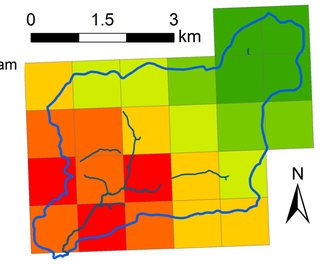
Overflow-driven events: Flashier hydrograph with no runoff signal, followed by a stronger sewage signal from groundwater-transported sewer pipe leaks

Runoff-Driven Event
June 10, 2019

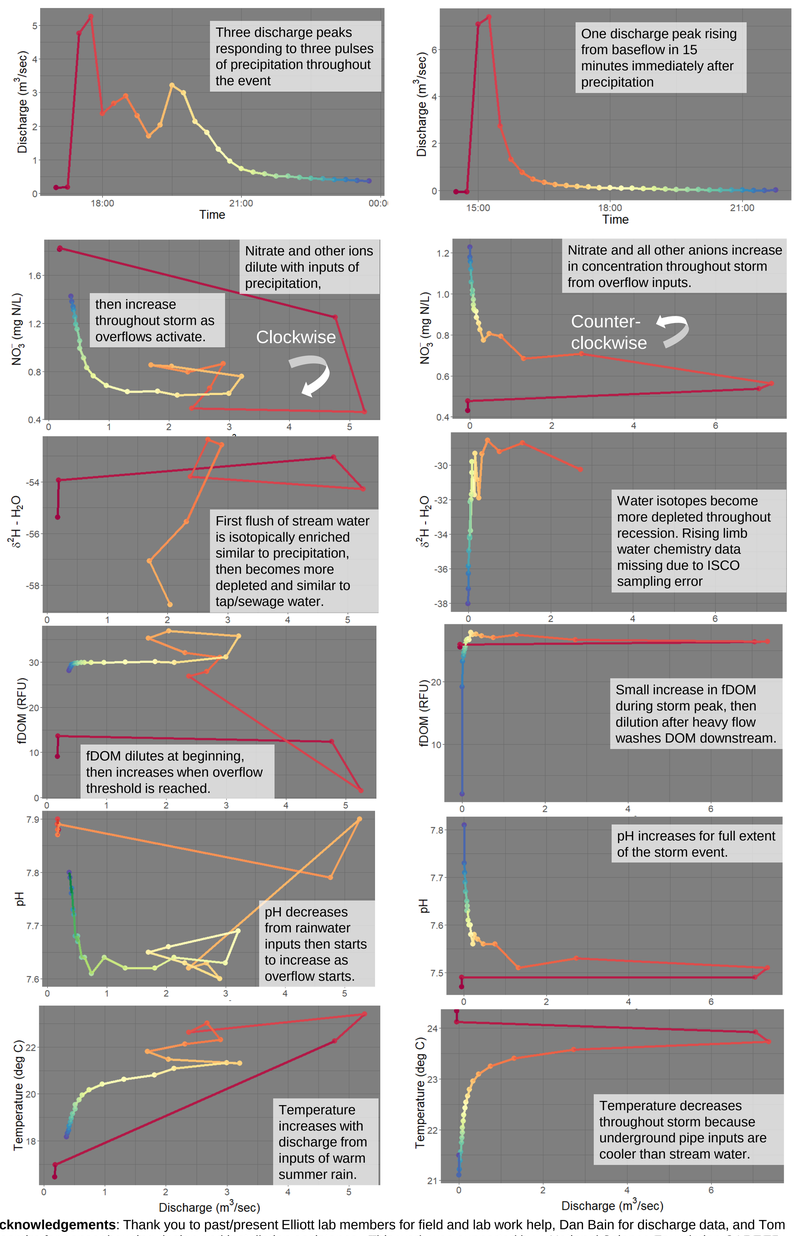


Precip duration = 4 hours
214 mm total
Previous storm 10 days prior

Overflow-Driven Event
Aug 22, 2019



Precip duration = 1 hour
178 mm total
Previous storm 1 day prior



Acknowledgements: Thank you to past/present Elliott lab members for field and lab work help, Dan Bain for discharge data, and Tom Gasmire for sensor housing design and installation assistance. This work was supported by a National Science Foundation CAREER award (Grant No. 1253000) to E.M.Elliott, an Andrew Mellon Pre-doctoral Fellowship from the University of Pittsburgh to R. Forgrave, and from funding by the Heinz Endowments for the Pittsburgh Water Collaboratory.