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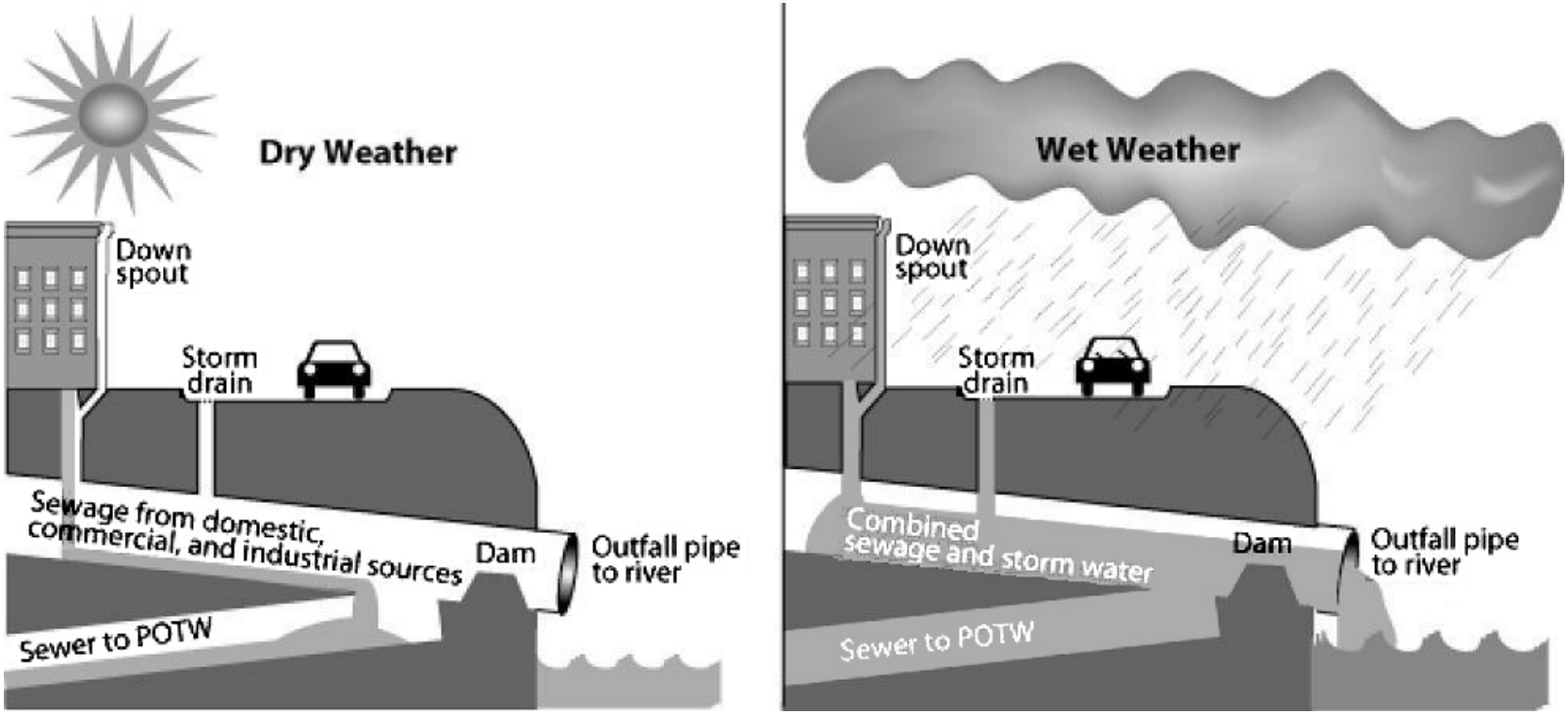
Ecosystem services from urban places

Bill Shuster, *USEPA-ORD*

Why are we here? The CSO Cycle



Caveats: complex hydraulics, dynamic system capacity, dry weather overflows are possible…

The Clean Water Act and Cities

How do we articulate the CWA (CSO rules) and allow for Green Infrastructure features?

- Consent orders
- Long-term control plan
- "Sticker-shock"
- Gray-Green management
- Decentralization

Sustainable Sanitary

Ecosystem services

- Ecosystem services are benefits that are rendered to humans by natural or otherwise functioning ecosystems
- Check out the Millennium Ecosystem Assessment reports

From urban soils:

- Regulating: SW management by infiltration
- Supporting: Soil formation, plant-available soil water
- Provisioning: carbon and nutrient cycling, clean water, timber
- Cultural: improve on aesthetic circumstances

Urban Soils as a basis for GI

- We are asking urban soils to do more
- Use actual field hydrologic measurements to front-load GI applications for success
- Reveal soil ecosystem services that substitute for scarce financial capital (*cost of long-term control plan*), and take the heat off of ageing infrastructure (*green-gray, infrastructure restoration*)

Urban Soils as a basis for GI

- A great deal of city acreage has been left vacant from demolition as blight control
- Disturbance history affects layering of urban soils
- Changes in layering predict changes in hydrologic functions
- Field measurements help us understand changes and what urban soils offer
- May minimize risk of unintended consequences (e.g., return flow), maximize ecosystem services

Consequences of going “data-free”

Urban Soil Assessments

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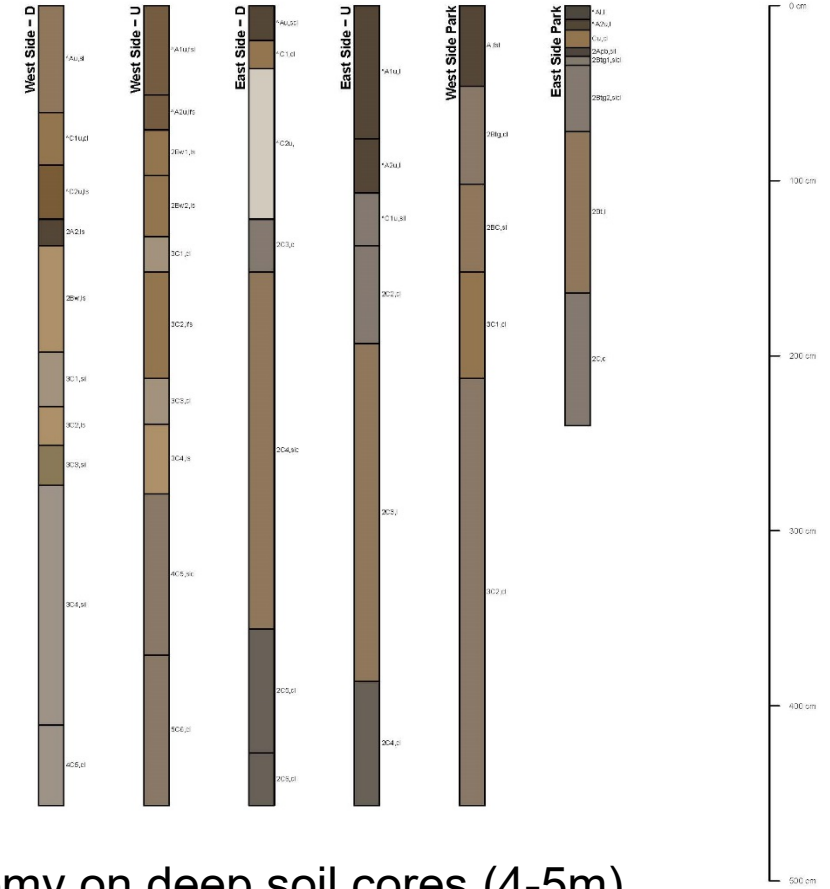
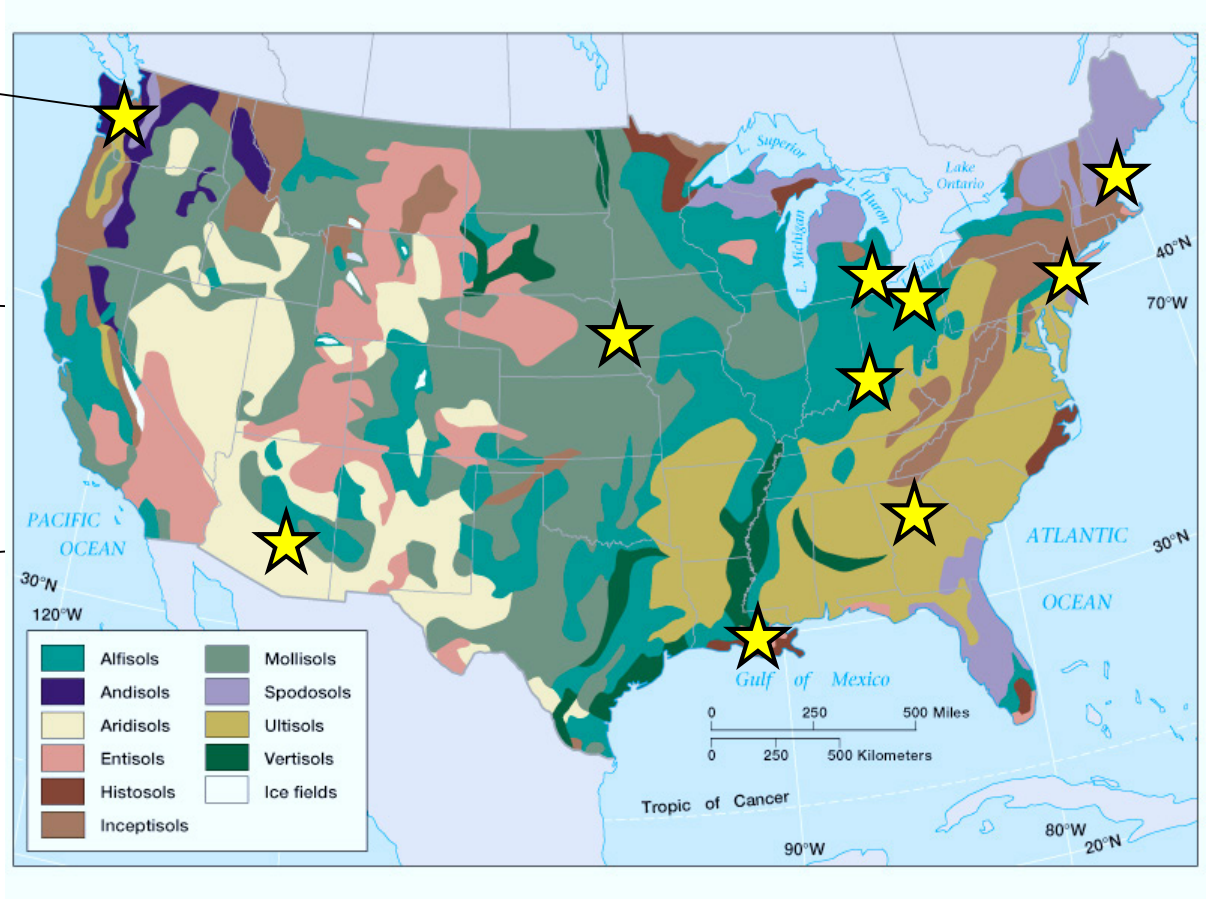


Field data (soil taxonomy on deep soil cores (4-5m), infiltration, drainage, canopy cover, penetration resistance, agronomic measures) provide a minimum dataset for planning and implementing green infrastructure

Cover 10/12 major soil orders

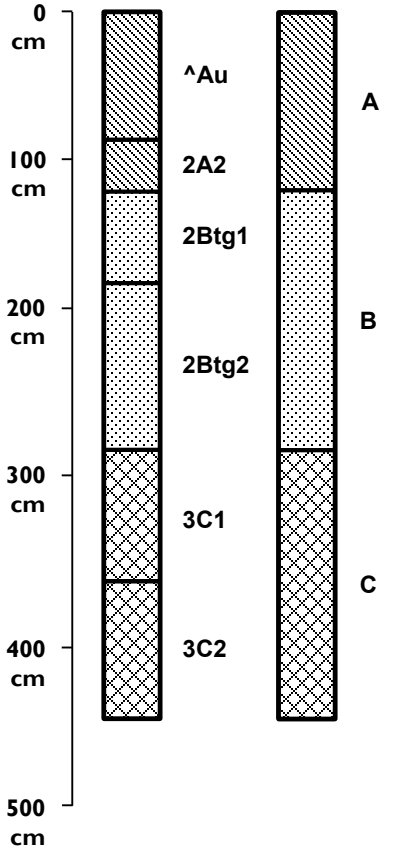


Urban Soil Assessments

Basic - Urban soils are not assessed for many urban centers, GI target areas suffer from poor data support

Practical - Hydrologic suitability of urban soils for a broad range of ecosystem services

Response - Develop observed dataset of paired pre -, post-urban; *field hydropedological data*



Urban and reference soil profiles

Compared to reference profiles (A-B-C), urbanized soil profiles were:

- ✓ More variety in layering – *affects hydraulics-hydrology!*
- ✓ Missing B horizons,
- ✓ …had deeper A, shallower C horizons,
- ✓ …and that overall, the *A-C sequence was predominant*

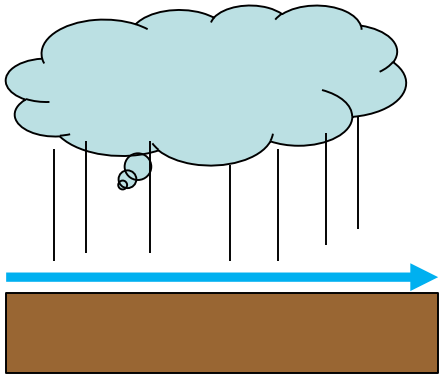
City	Urban profiles	Soil series	"Pre – urban" Reference profiles
Cleveland	72	9	28
Total (all 12 cities)	332	75	181

Herrmann, Schifman, Shuster; 2018, *Widespread loss of intermediate soil horizons in urban landscapes. In revision, Proc. Natl. Acad. Sci.*

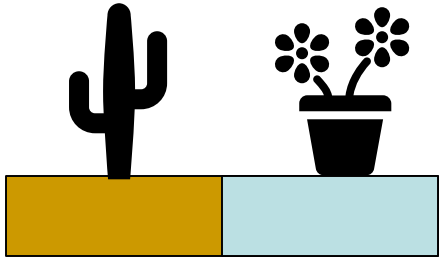
Concept and approach

Target ecosystem services:

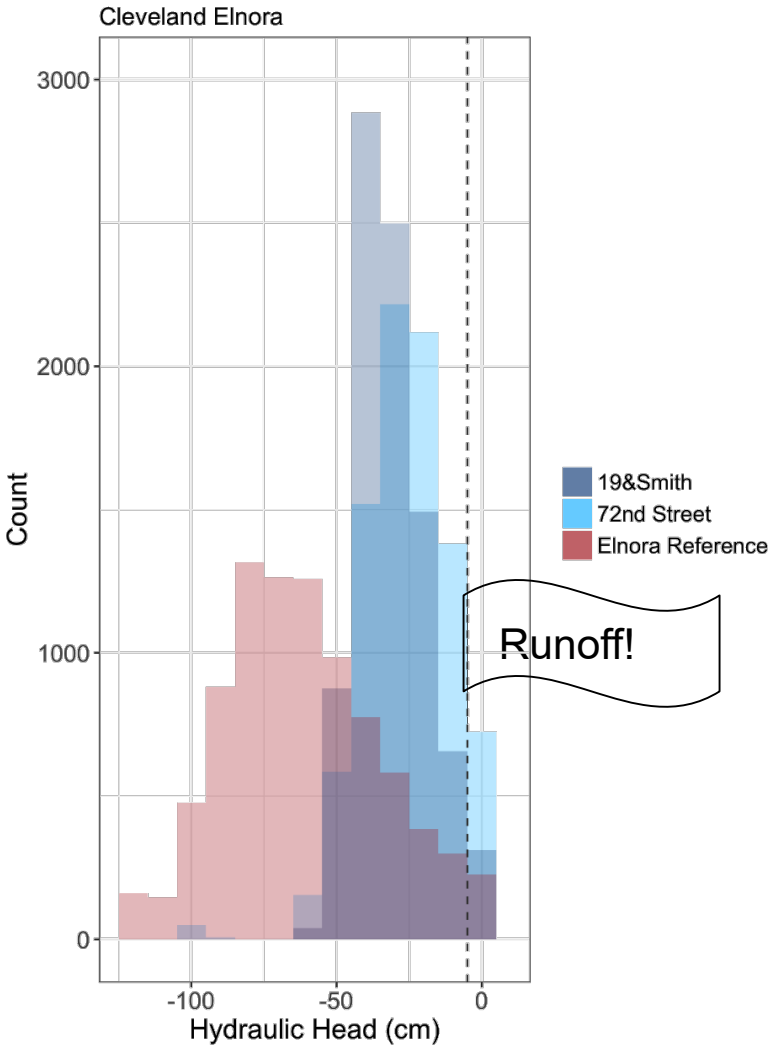
Regulating: *Runoff Formation:* how often does the soil surface saturate?

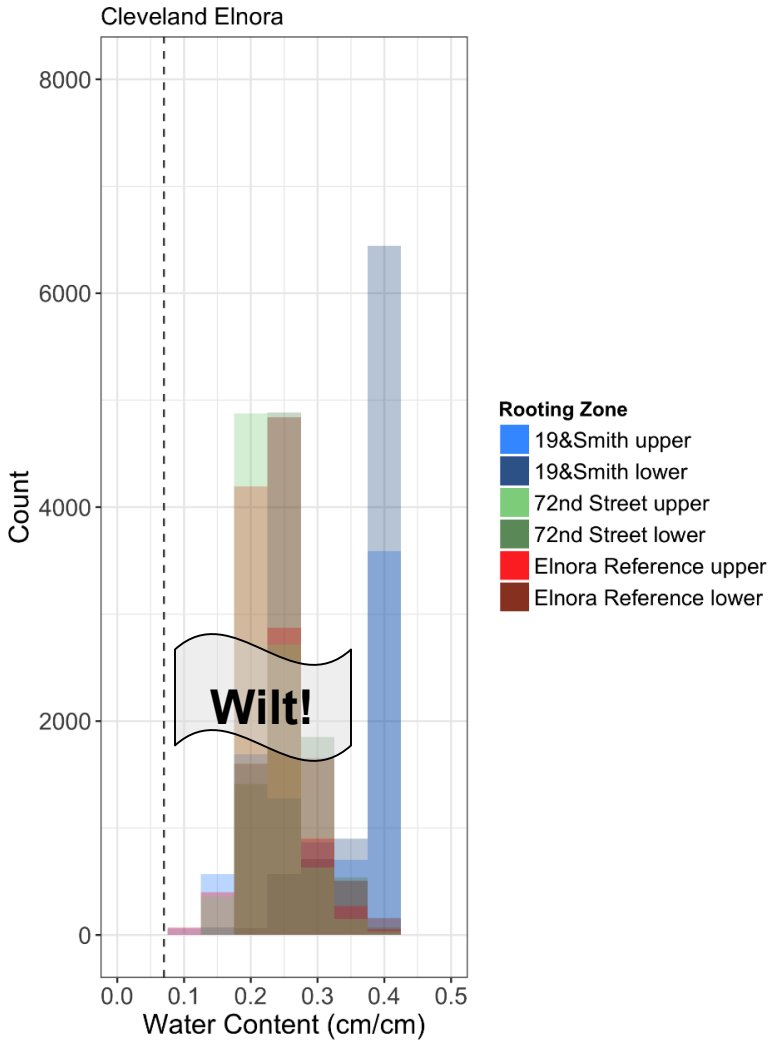


Supporting: *Plant Growth:* do we have sufficient moisture in the rooting zone to support vegetation?



Soil ecosystem services – how often do we get these?





Available land for water management

- When these soils *don't produce runoff*, they offer detention capacity as passive, infiltrative green infrastructure that is decentralized across our urban centers
- These results help us understand how to "count" green infrastructure toward Clean Water Act consent orders, and overall effective waste/storm water management



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Passive GI

- Vacant-lots are well-integrated into the urban fabric (Decentralized)
- Serve as passive green infrastructure to absorb rainfall, prevent runoff formation, and regulate return flow into sewer collection system (Gray-Green management)

Application (Shifting Gears): what does demolition have to do with water?

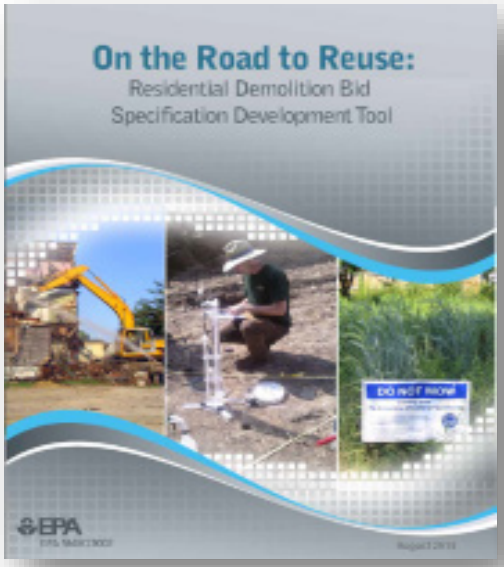
- Demolition leaves behind vacant land
- Vacant land is a new landscape made up of soils, debris, and vegetation
- These vacant lots might take in water when it rains (infiltration), or these same lots may produce runoff
- Our assessments across the United States indicate that vacant lots generally produce runoff
- This is the result of how the vacant lot is backfilled and finished

Let's use the demolition process as a first step toward restoration

On the Road to Reuse:

Residential Demolition

Bid Specification Development Tool



Can we improve the demolition process?

- One of the recommendations is to use a sandy loam soil for backfill
- This gives us some permeability, but also a good foundation for vegetation
- Yet, we all know that sourcing soil is problematic
- It's not only supply and demand, but also the qualities of these backfill soils that are important

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Detroit MI

- Vacant landscapes have become a large proportion of the total land area in many US cities, e.g., Detroit
- Demolition drives land use change in Detroit
- Over 23.4 square miles of the Detroit MI is vacant land, and that's 16.8 percent of its total land area

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Where do we find soil?

(for thousands of demolitions per year!)

Mid-Michigan Crushing Recycling (MMCR) Facility…

Crushed + Native subsoils

- MMCR 1.5” 60/40 backfill soil is a skeletal fine sandy loam
- Backfill with this soil material has emerged as a best practice
- High potential for compaction
- A 1’ “silt loam blanket” is placed on top of this backfill to prepare the site for revegetation (turfgrass)

Post-demolition assessments

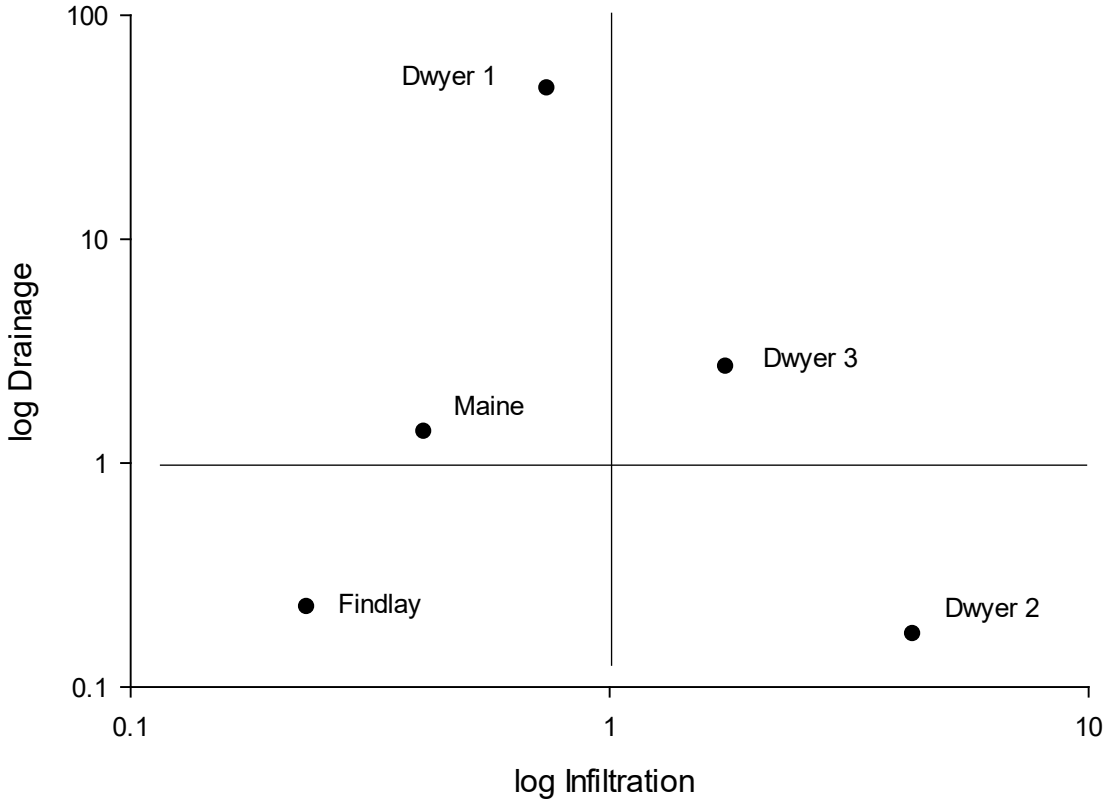
- In September 2016, my team and I made measurements on a limited sampling of recent demolitions on the East Side of Detroit MI
- The vacant lots that we studied were backfilled with soil material generated by Mid-Michigan Crushing & Recycling

Overview

- Neighbors were categorically pleased with the removal of blighted structures
- This put an end to the arson, squatting, and other issues associated with these houses; there is some evidence of increased value of the remaining homes (+14%; City of Detroit, 2017)
- On the other hand, neighbors indicated that, post-demolition, they had unwittingly traded blight for a different kind of abandonment (*blight lite*)

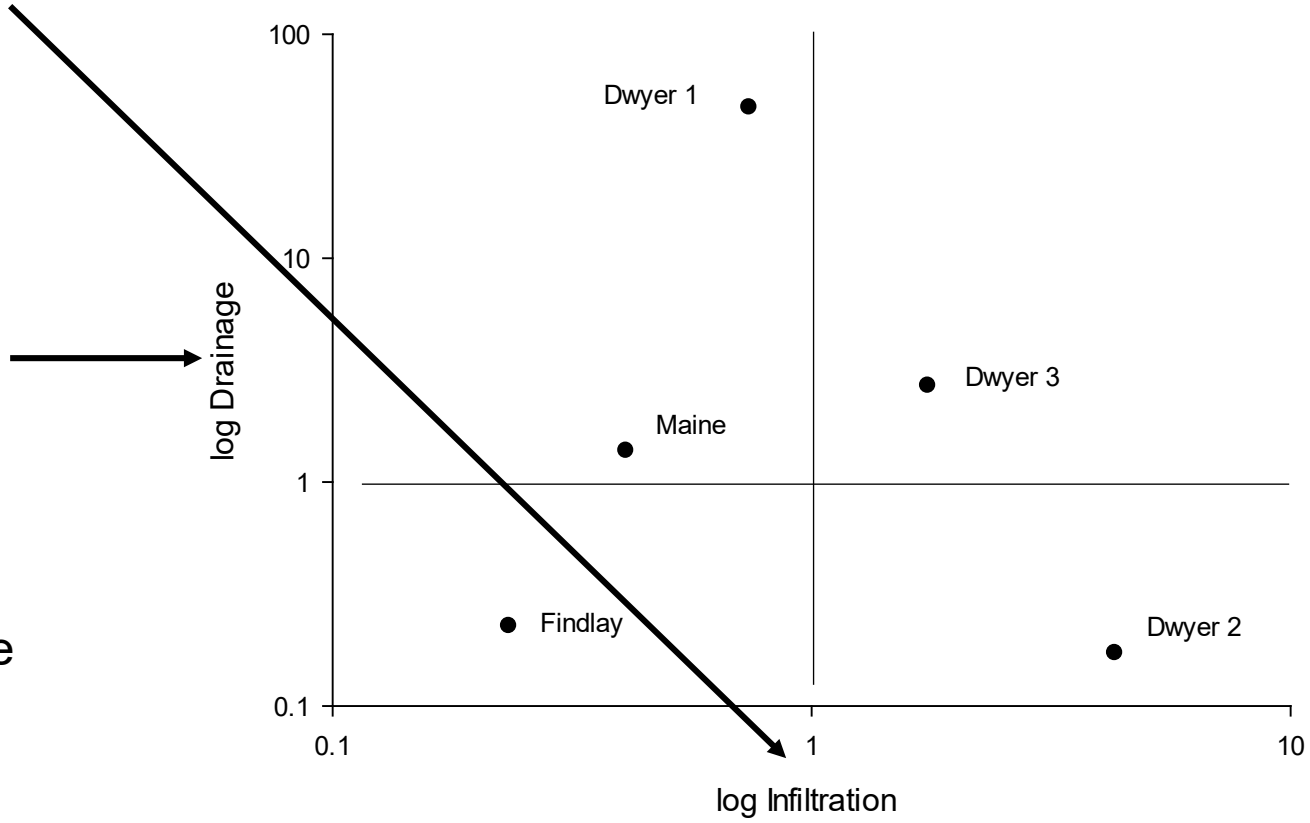
A way to visualize how water does (or does not) move through vacant lots

- This is a "stoplight" approach to visualizing how water moves into and through vacant lots
- Measured in the City of Detroit, not estimates!
- Note log scale



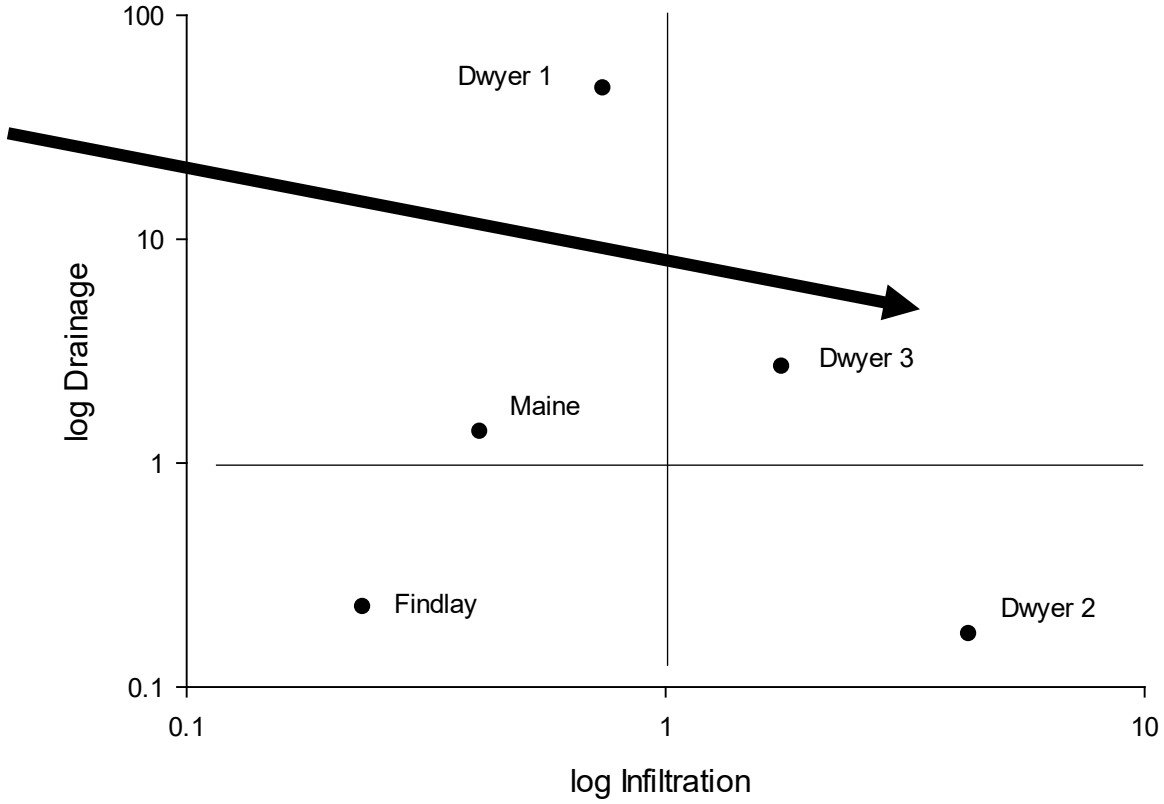
A way to visualize how water does or does not move through vacant lots

- Infiltration is the process of water moving from the surface into the soil
- Drainage is rate at which water resitributes
- 1 cm/hr is used as the threshold rate



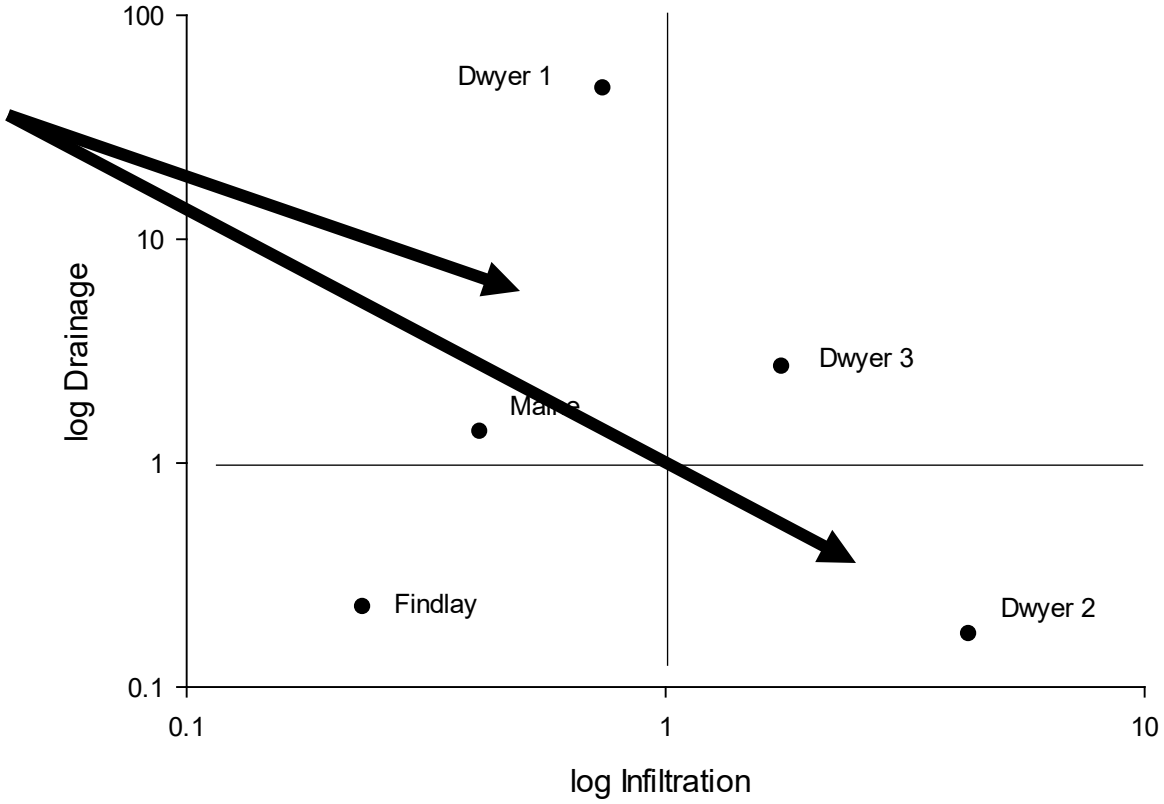
A way to visualize how water does or does not move through vacant lots

- The green area represents vacant lots where water moves into the soils and then drains well. We'd like to see this condition everywhere.



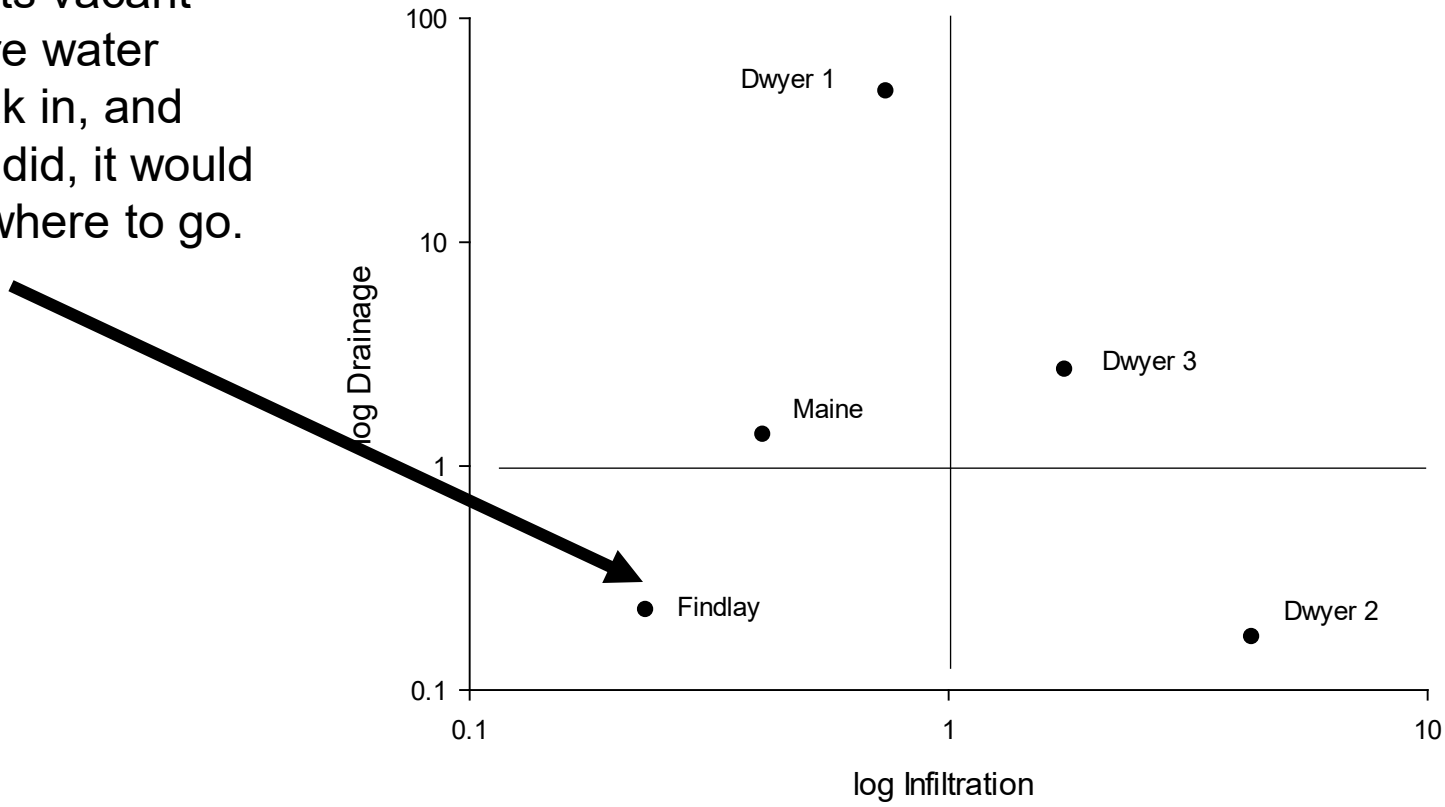
A way to visualize how water does or does not move through vacant lots

- The orange or yellow areas (caution) represent vacant lots where either infiltration OR drainage is not acceptable



A way to visualize how water does or does not move through vacant lots

- The red area (stop) represents vacant lots where water can't soak in, and even if it did, it would have nowhere to go.



Detroit, East side, Findlay St.

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Maine St.

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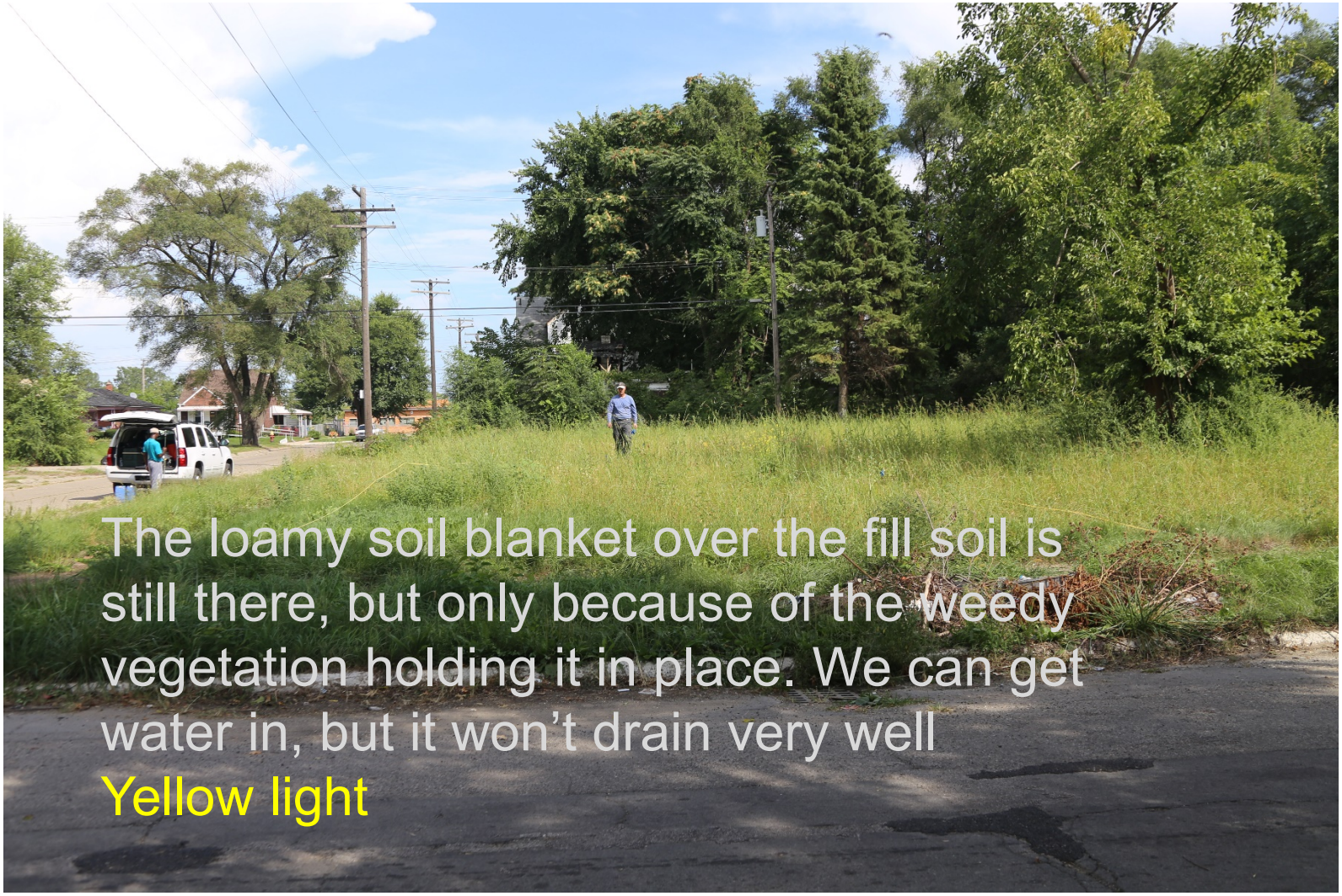
Dwyer 2



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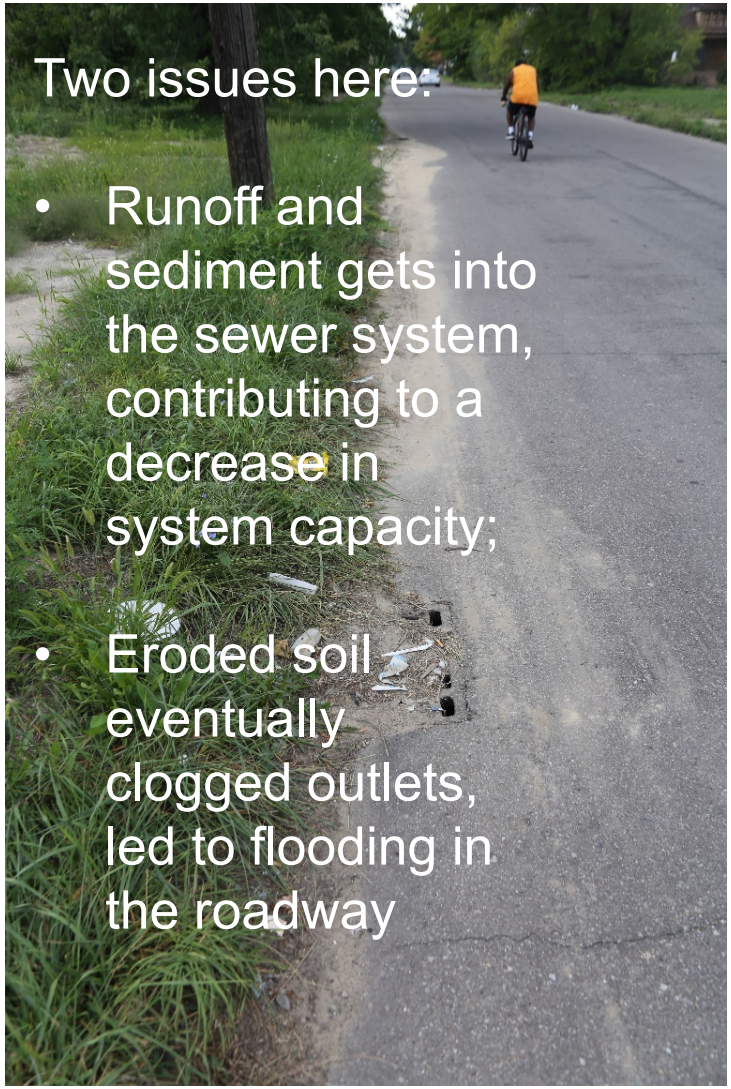
Dwyer 3

Consequences of runoff production



Demolition

- Keep in mind that the vast majority of vacant lots are the outcome of a standard demolition process with minimal attention paid to environmental performance and sustainability outcomes
- That's a lot of unmanaged land mass, and a lot of impact on neighborhoods and the sewer system
- Based on our observations, older than newer Detroit vacant lots may be more functional as passive GI due to better backfill



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Conclusions

- Think about the vast number of local geotechnical and well-log borings and their accompanying data
- Through an intentional assessment process, we have a new appreciation for the role that urban soils can play in the urban water cycle
- This type of data and its application can promote front-loading urban redevelopment as ecosystem service - producing, passive green infrastructure



Thank you for your time

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