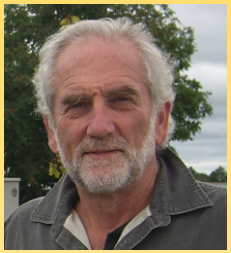
Pollution of Drinking Water Aquifers due to Infiltration

UNIVERSITY OF MINNESOTA
Driven to Discover℠

John S. Gulliver, Peter T. Weiss, John L. Nieber and Caleb Arika


1. Are there groundwater quality impacts of infiltration?
2. What are we doing to investigate the potential impacts?
3. Conclusions



Department of Civil Engineering
Environmental · Geomechanical · Structures · Mechanics and Physics · Transportation · Water Resources

Water Quality of Runoff

- Maestre and Pitt (2005) investigated the results of 3757 NPDES runoff records from municipalities
- Median Dissolved Values /National Drinking Water Std

– Zinc	51 µg/L	None
– Copper	8 µg/L	1,300 µg/L
– Cadmium	0.5 µg/L	5 µg/L
– Chromium	2 µg/L	100 µg/L
– Lead	3 µg/L	15 µg/L
– Nitrates	0.6 mg/L	10 mg/L
– Ammonia	0.4 mg/L	None
– Oil and grease	4 mg/L	None

Water Quality of Runoff

- However, there are extremes in the water quality of runoff (Maestre and Pitt, 2005)
- Median Dissolved Values /Coefficient Of Variation

– Zinc	51 µg/L	4.6
– Copper	8 µg/L	2.2
– Cadmium	0.5 µg/L	4.4
– Chromium	2 µg/L	1.5
– Lead	3 µg/L	1.9
– Nitrate/Nitrite	0.6 mg/L	2.0
– Ammonia	0.4 mg/L	3.5
– Oil and grease	4 mg/L	4.5

Water Quality - Chloride

- Not tracked by NPDES
- Difficult to treat
- Novotny and Stefan say that 2/3 of the road salt stays in the Twin Cities basin

Vermont Transportation Department

- TMDLs for Chloride in the Shingle Creek Watershed- GW-surface water influence?
- MDL = 250 mg/L

Water Quality - Viruses

- Problem in groundwater.
  - 46% of Minnesota relies on non-disinfected groundwater for drinking (Mark Borchardt, USDA-ARS).
  - 22% of acute gastrointestinal illness was from contaminated groundwater.
- Believed to be caused by septic systems and leaks in sanitary sewers.
- Does stormwater infiltration play a role?

Source Viruses in Runoff

www.winnipeg.ca

Source Viruses in Runoff

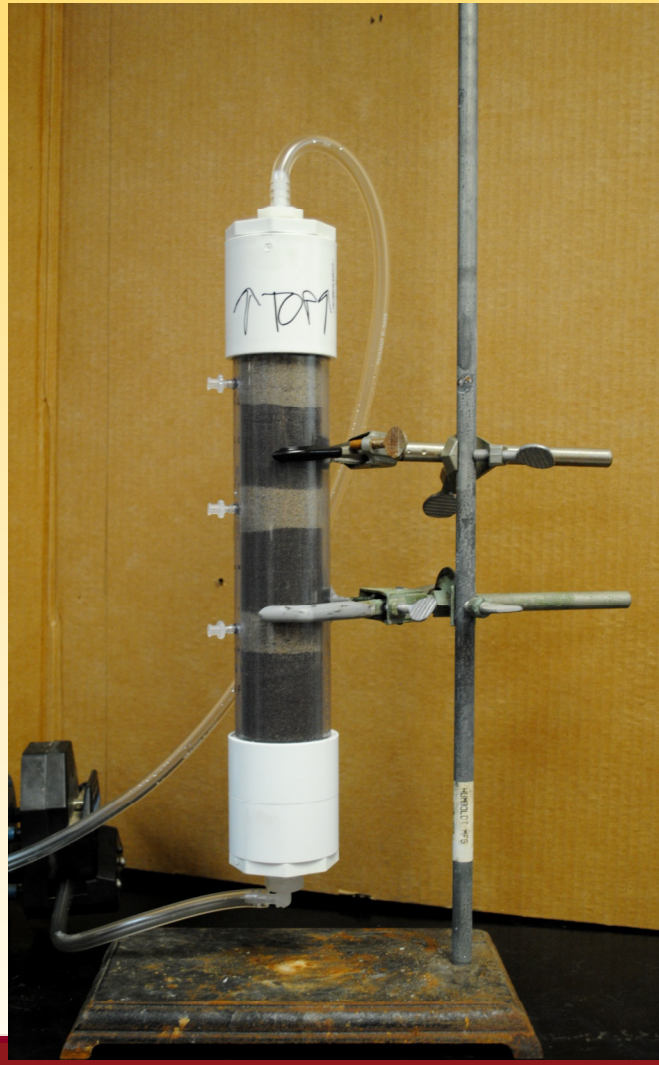
What are we doing to investigate the potential impacts?

- Surface infiltration with organic compounds in the soil
  - Rain Gardens
  - Infiltration basins
  - Swales
  - Infiltration trenches?
  - Pervious pavement?

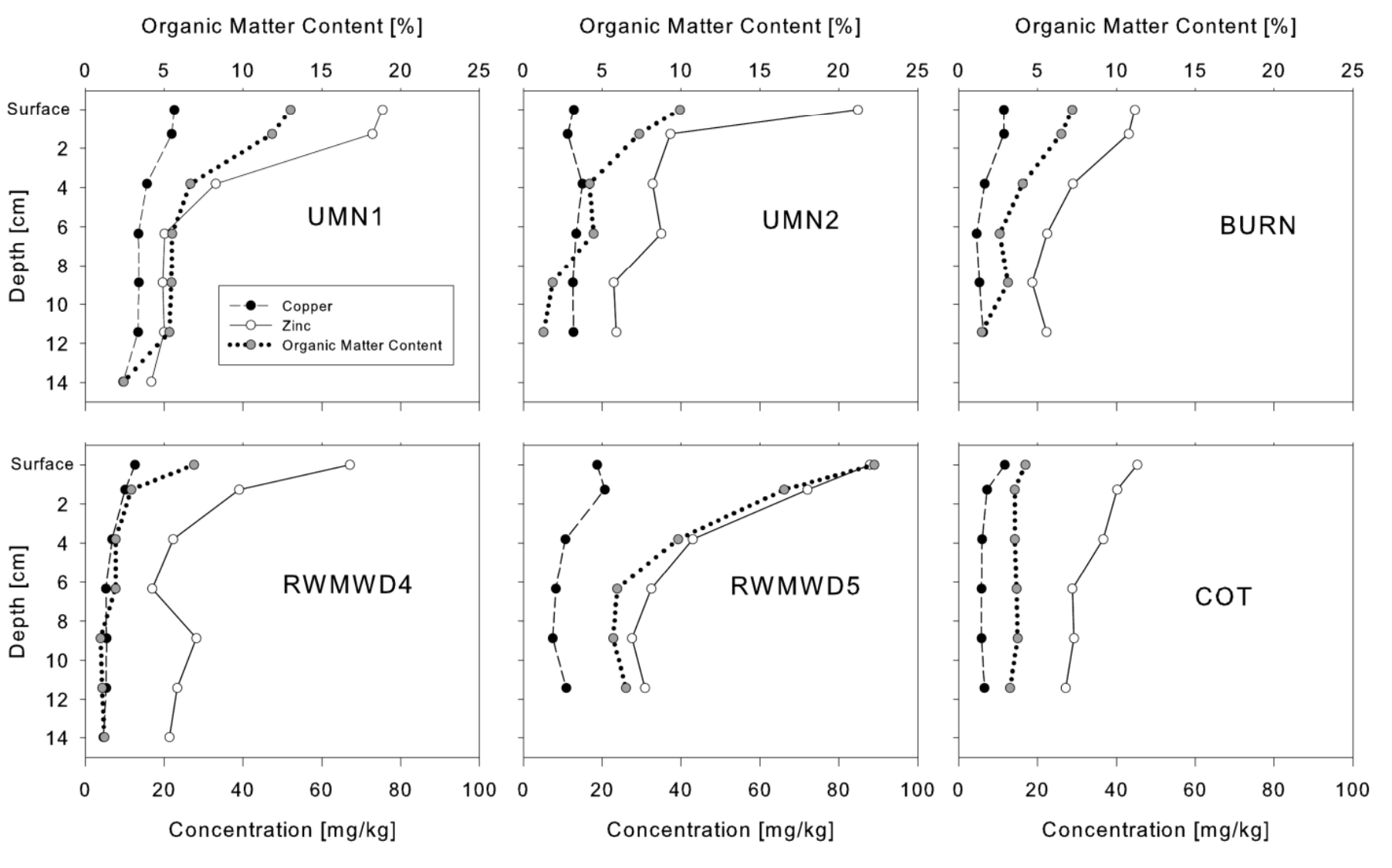
Column Studies with Rain Garden Media

Assume a rain garden made of 70/30 sand and compost by volume

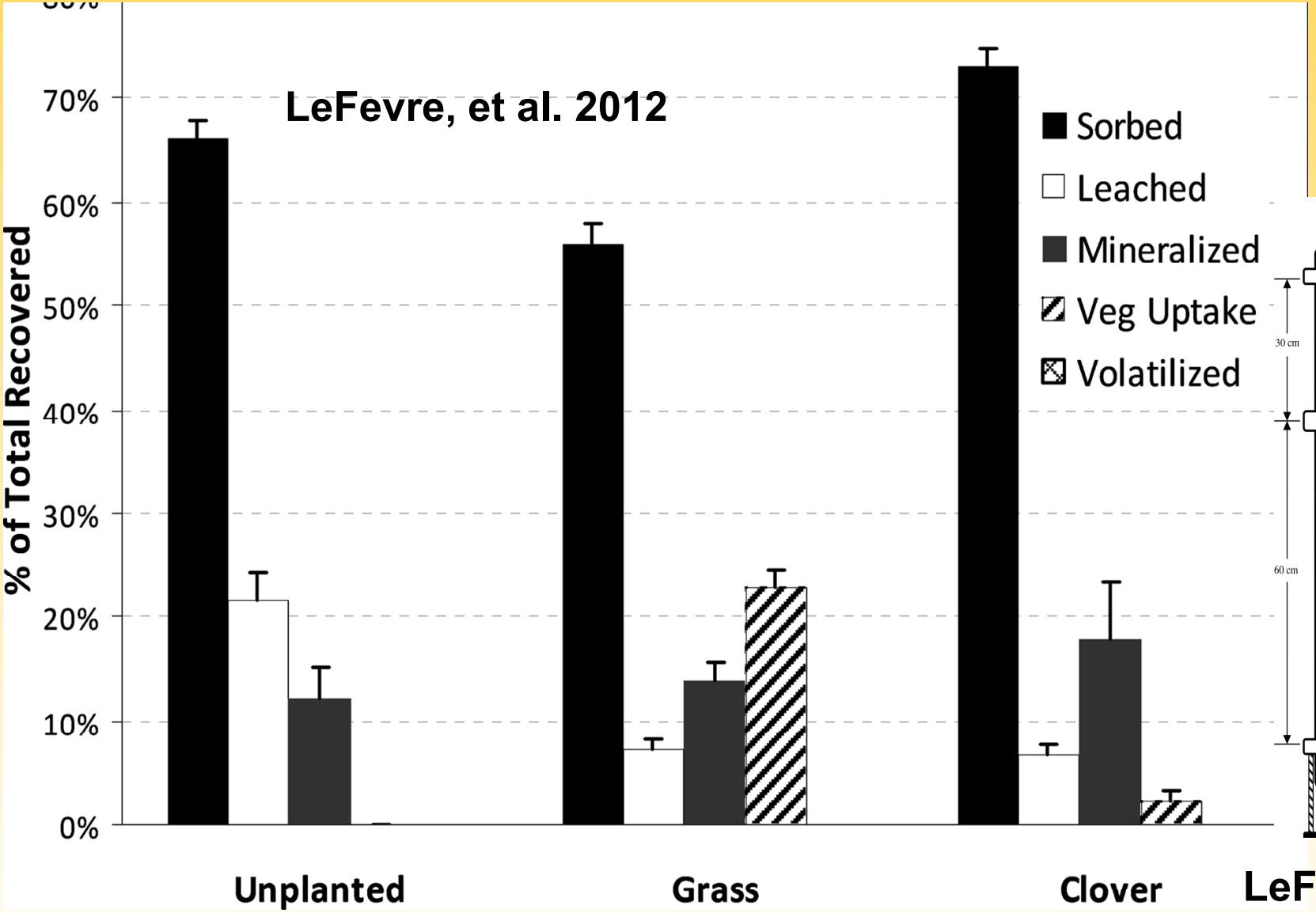
- Depth of Water Treated at 6" depth
  - Cadmium: 507 m
  - Zinc: 935 m
- Time to breakthrough
  - Cadmium: 79 years
  - Zinc: 145 years

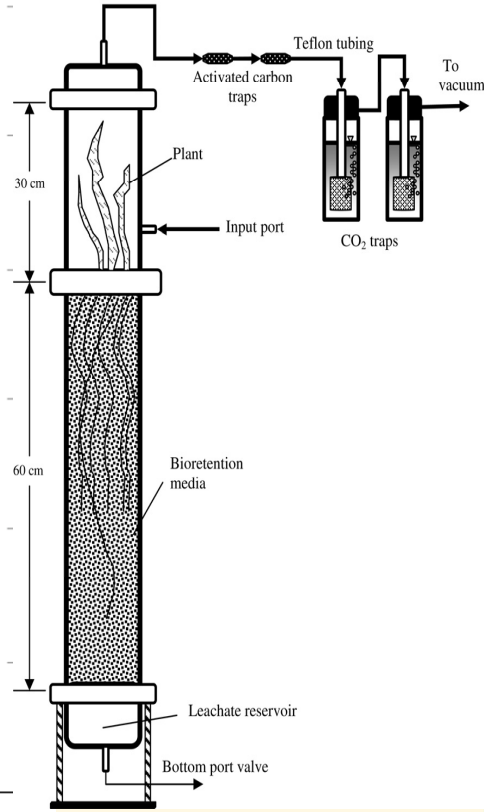


Metal Retention by Rain Gardens



Column Studies
Retention of Hydrocarbons





LeFevre, et al. 2012

Organic material and surface infiltration

- Particulates and bacteria are filtered.
- Organic material in the soil has a great capacity to adsorb metals and petroleum hydrocarbons.
- Bacteria near plant roots will degrade hydrocarbons.

Organic material and surface infiltration

- Nitrate will be released by degrading organic materials.
- Chloride will pass through.
- Viruses will pass through.
- **We need to consider chlorides and nitrates in the groundwater. Viruses? Disinfection**

Underground Infiltration

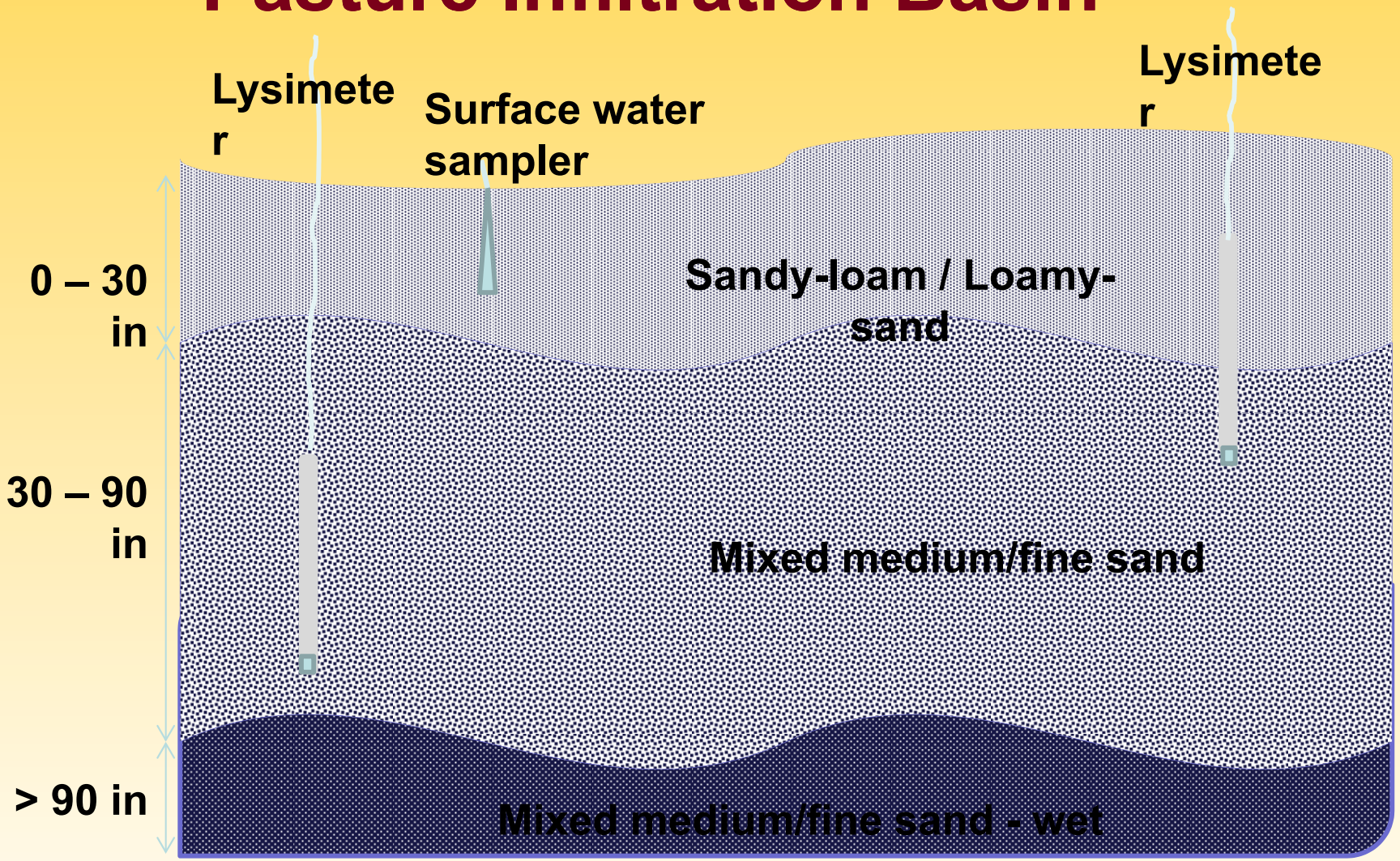
Underground Vaults and Permeable Pavement

- Not much research
- **Need to consider all compounds of interest**
  - Nitrate
  - Chloride
  - Metals
  - Petroleum hydrocarbons

Current Research - Monitoring

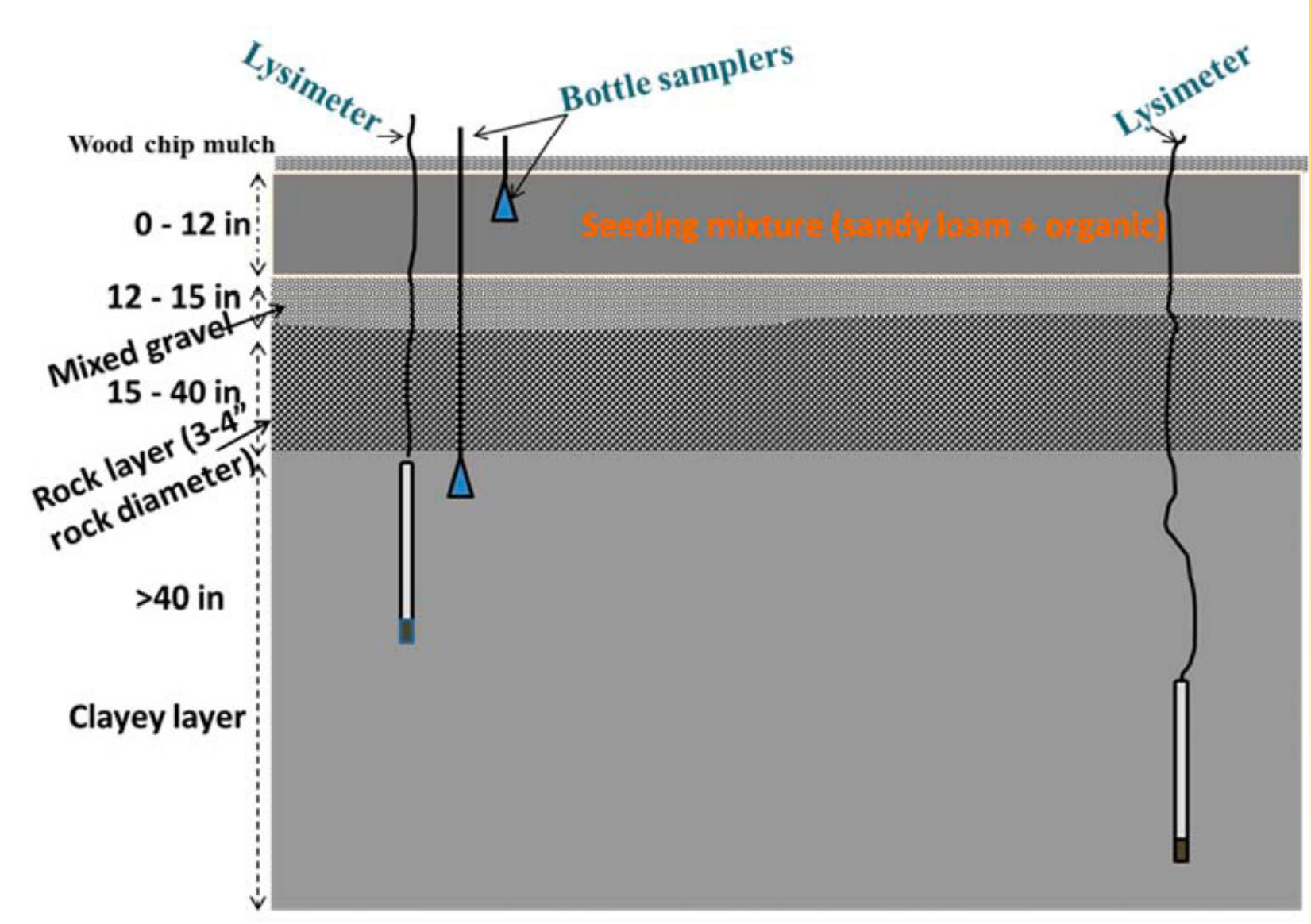
- Infiltration Basin – 5 bottle samplers placed at the surface and 7 Lysimeters placed at depth.
- Rain Garden – 5 bottle samplers placed to sample surface water and 3 Lysimeters placed at depth.
- Underground Chamber – 10 Sumps placed above (4) and below (6) underground vault
- Measuring metals, nitrates, chlorides and petroleum hydrocarbons

Lysimeter Installation – Sheep's Pasture Infiltration Basin

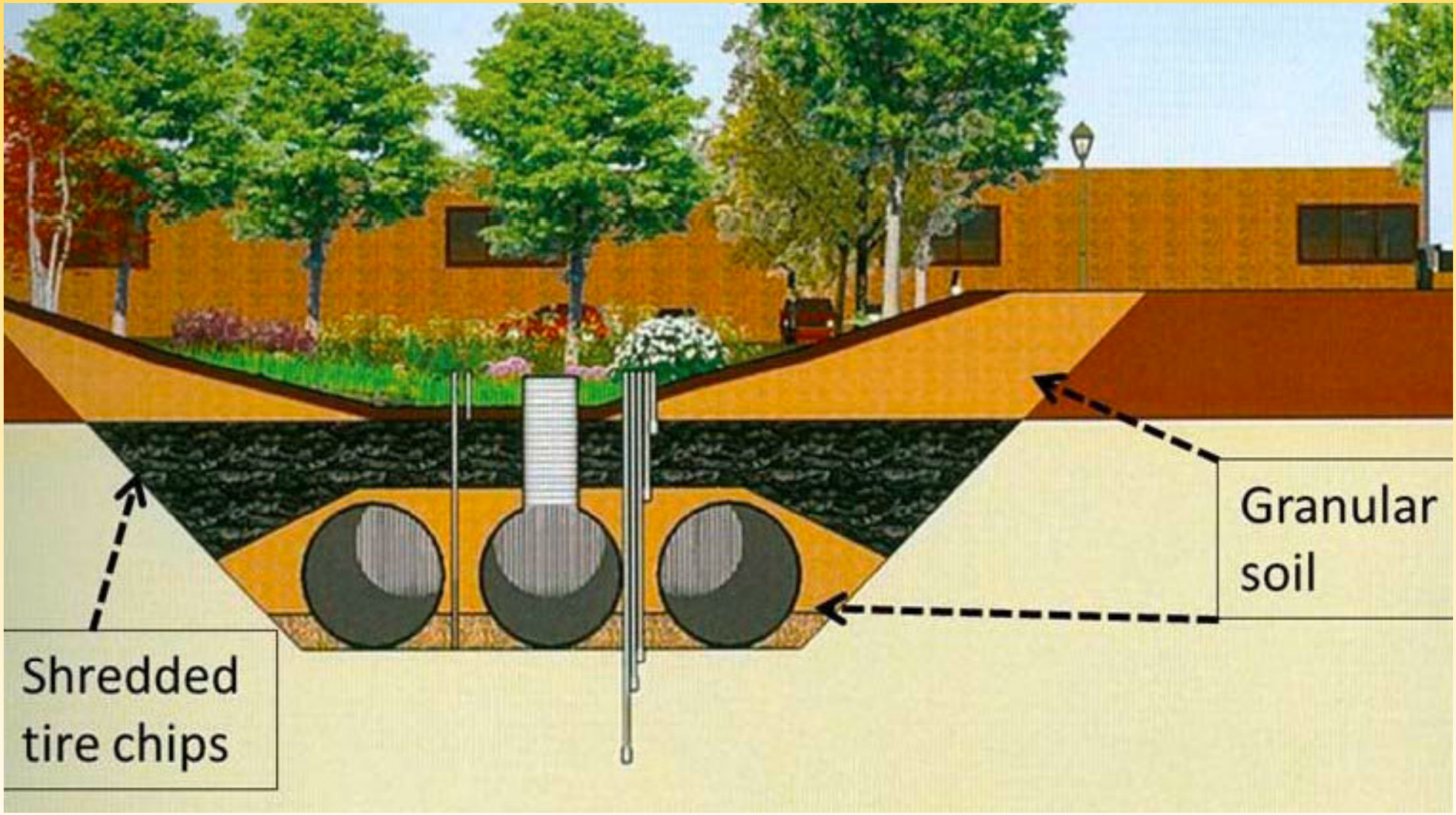


Hamline-Midway Rain Garden

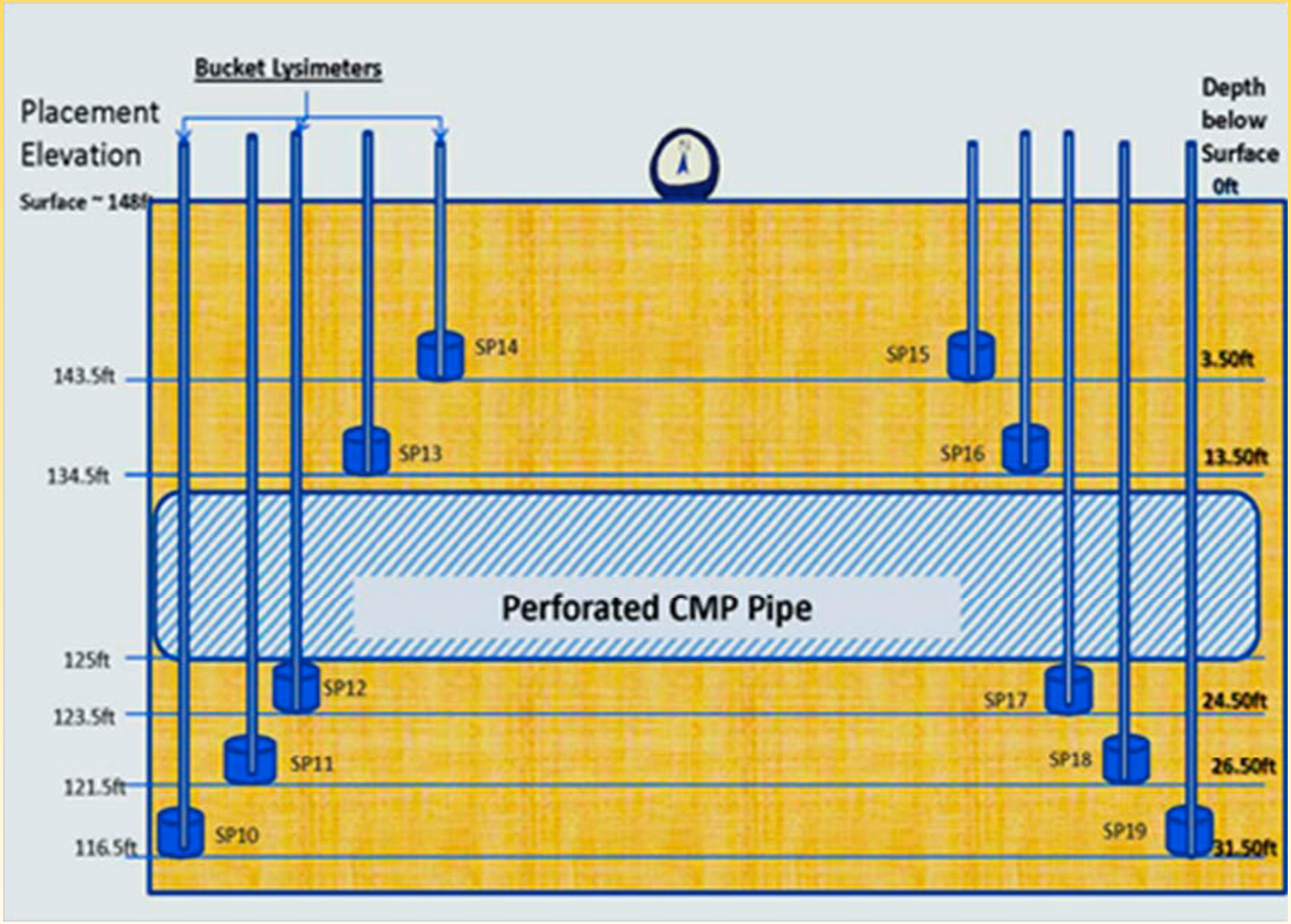
Hamline-Midway Rain Garden



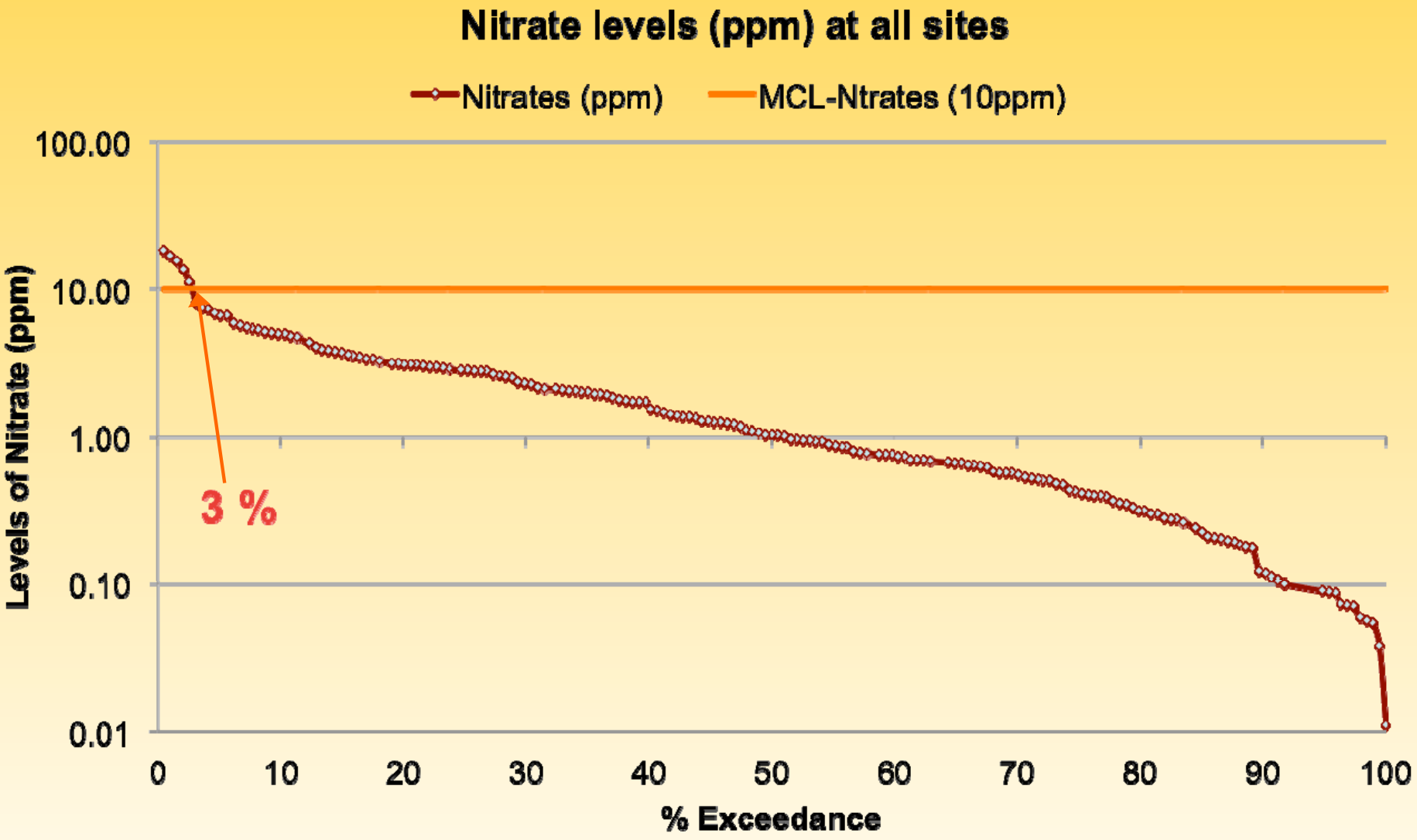
Beacon Bluff Underground Infiltration Chamber



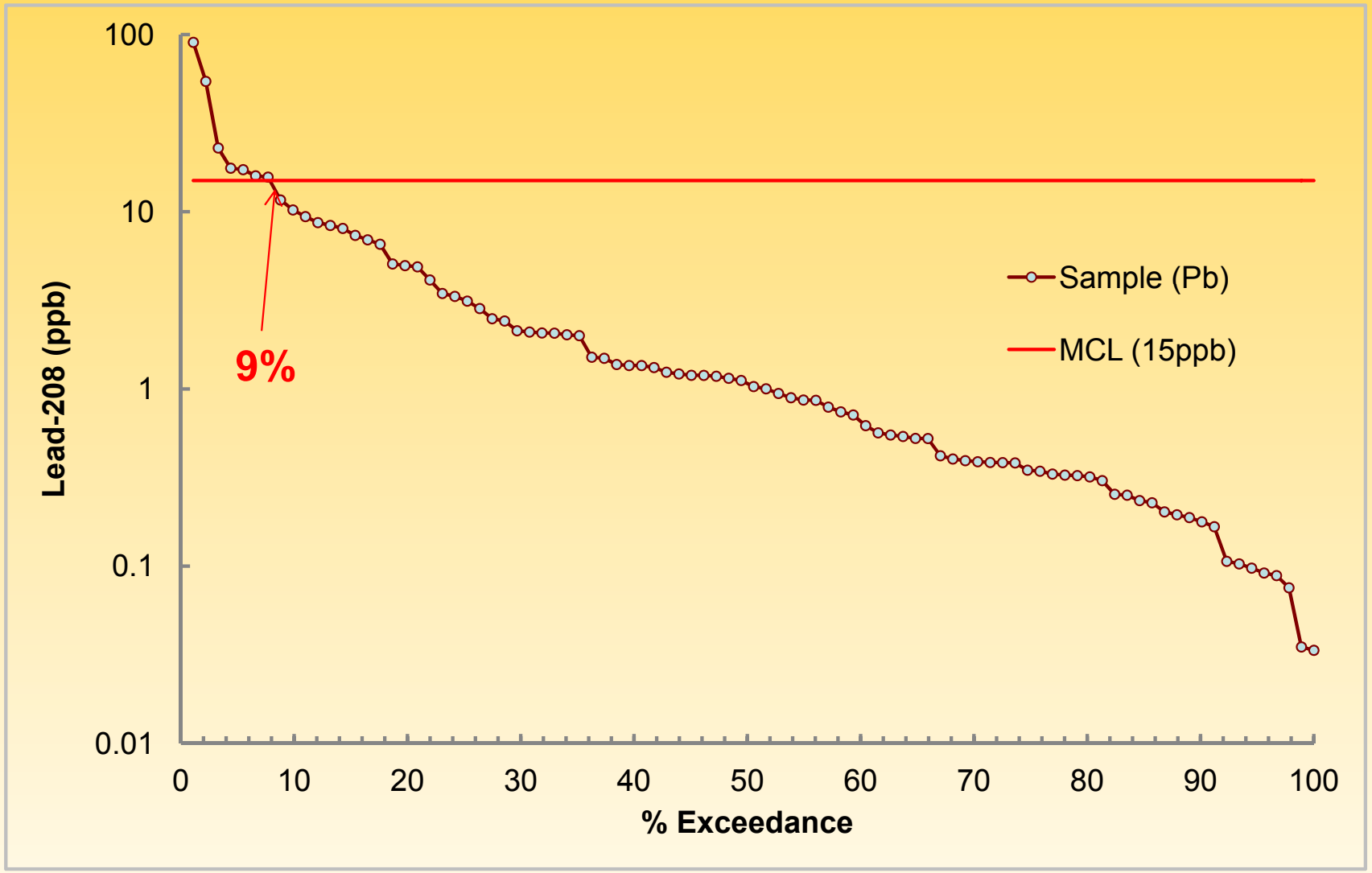
Beacon Bluff Underground Infiltration Chamber



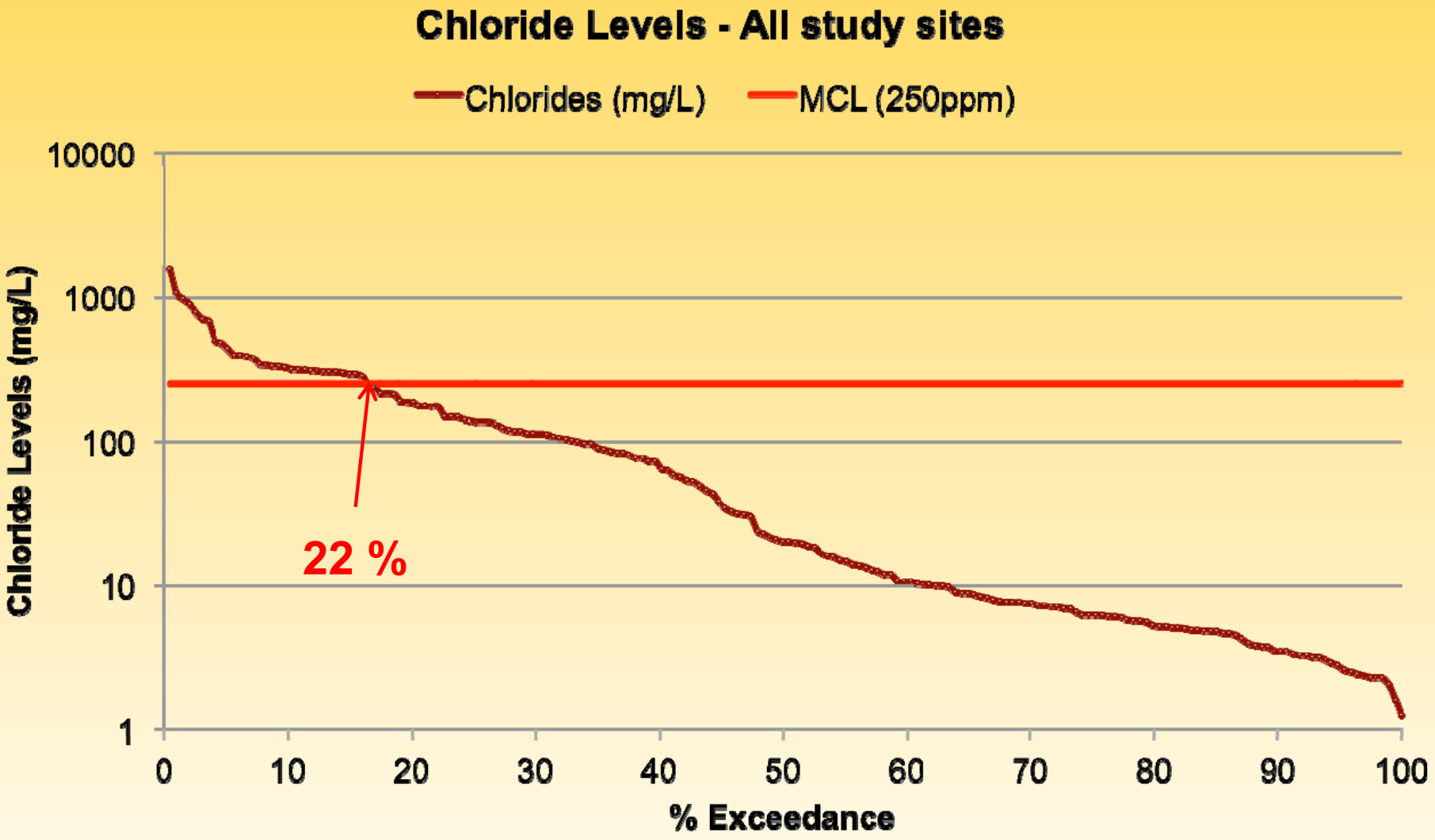
Nitrate Concentration – Three sites



Lead Concentration – Three Sites



Chloride Concentration – Three Sites



Conclusions

- Concentrations in stormwater are not high compared to drinking water standards
  - Local hot spots can occur
  - Intense storms => high concentrations
- Surface infiltration will likely retain metals and retain and degrade petroleum hydrocarbons
  - Nitrates and Chlorides are main concern
  - Possibly Viruses
- Underground infiltration needs to be studied
  - All compounds need to be considered

Thankyou!
Back to Mike Trojan!