Protecting Salmon from Stormwater: Green Infrastructure and Source Controls

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Boeing

SAM Stormwater Action Monitoring

Urban stormwater runoff is toxic to coho salmon

Adult spawners

Alevin

Juveniles

Urban road runoff: All die within 24 h of exposure

Puget Sound
Starts Here

Permeable Pavement

Types of Green Stormwater Infrastructure?

GSI Tool	How It Works
Bioretention	SOAKS IN, SLOWS, CLEANS
Rain Gardens	SOAKS IN, SLOWS, CLEANS
Stormwater Cisterns	SLOWS, STORES + REUSES
Dispersion	SLOWS, SOAKS IN
Dry Well/ Infiltration Trench	SLOWS, SOAKS IN
Biofiltration	SLOWS, CLEANS

GSI Tool	How It Works
Permeable Paving	SOAKS IN
Green Roofs	SLOWS, EVAPORATES
Depaving	SLOWS, SOAKS IN
Tree Canopy	SLOWS, EVAPORATES
Compost & Mulch	SLOWS, SOAKS IN

Photo Courtesy of Sustainable Seattle

GSI in Seattle (2015): 2025 Implementation Strategy

Testing bioretention effectiveness to prevent toxicity

Well water (4 hr)

All 4 fish alive at 24 hr

Unfiltered stormwater (4 hr)

0 of 4 fish alive at 24 hr

Filtered stormwater (4 hr)

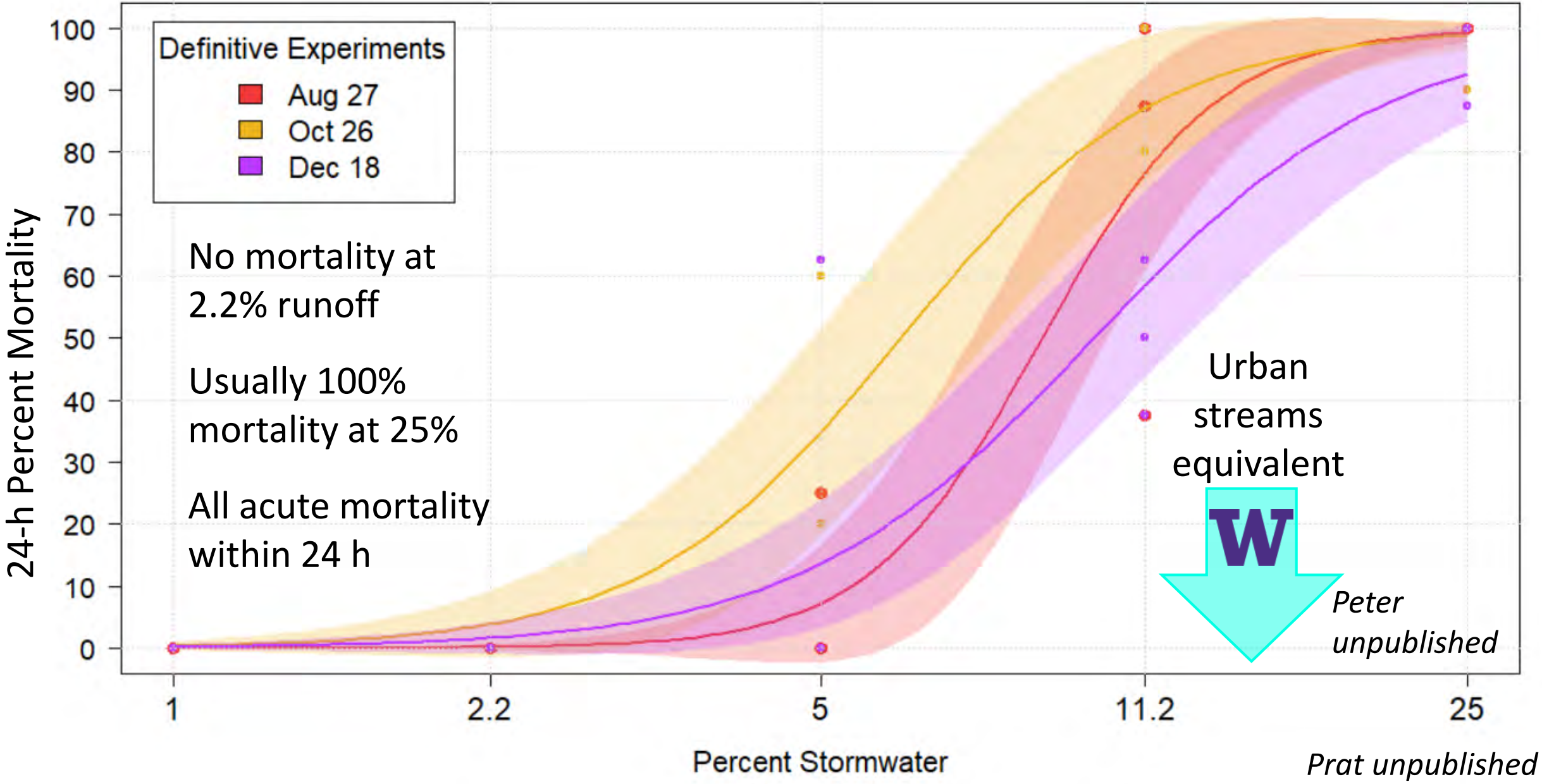
All 4 fish alive at 24 hr

Prevents acute mortality in spawners, juveniles, and alevin

Spromberg et al. 2016. J. Applied Ecology

Videos: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.12534

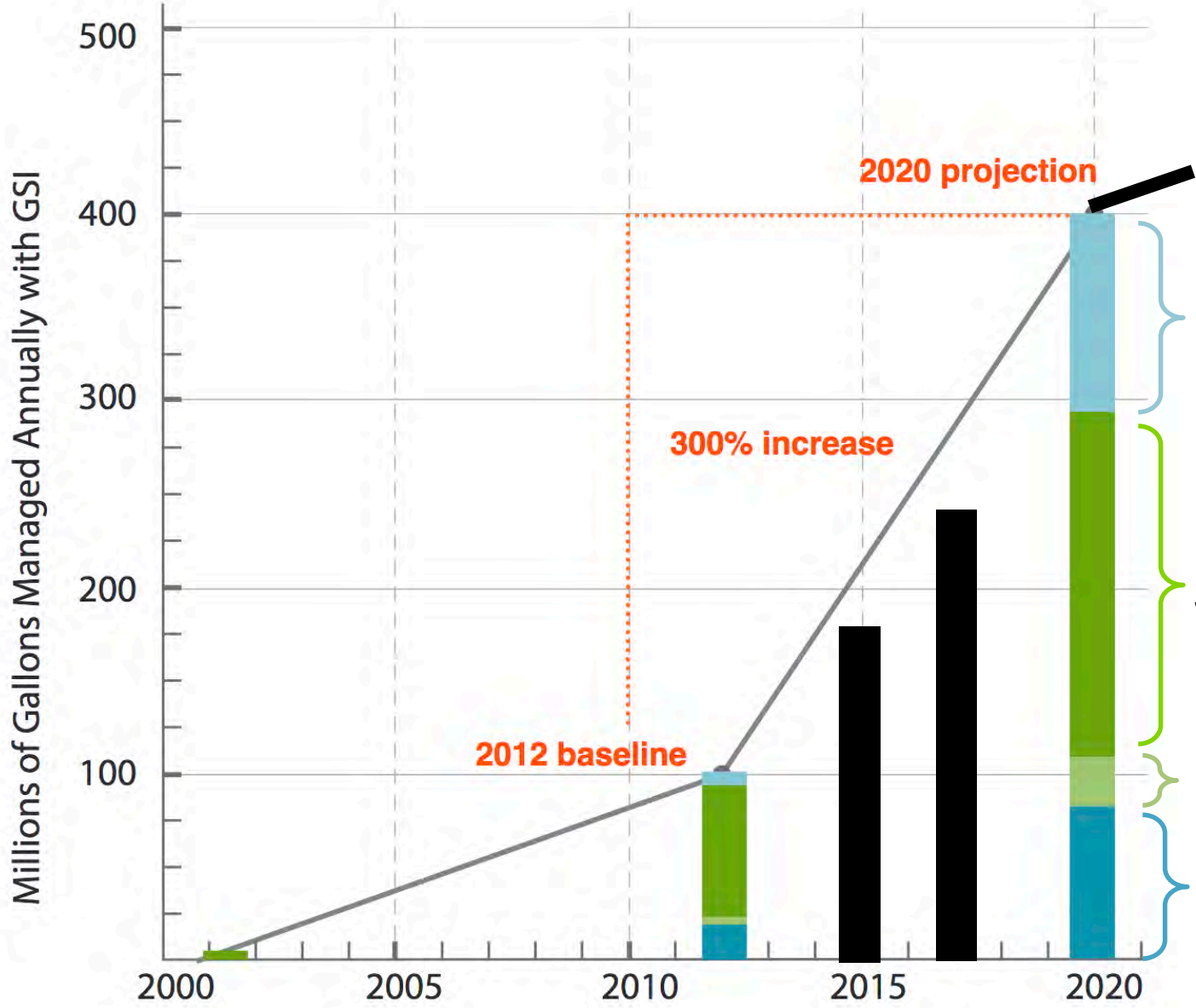
Dilutions of Stormwater Runoff from SR-520



How Much Green Stormwater Infrastructure?

6-fold dilution?

Green Stormwater Infrastructure in Seattle



GOAL: 700 million gallons by 2025

Projects required by stormwater code

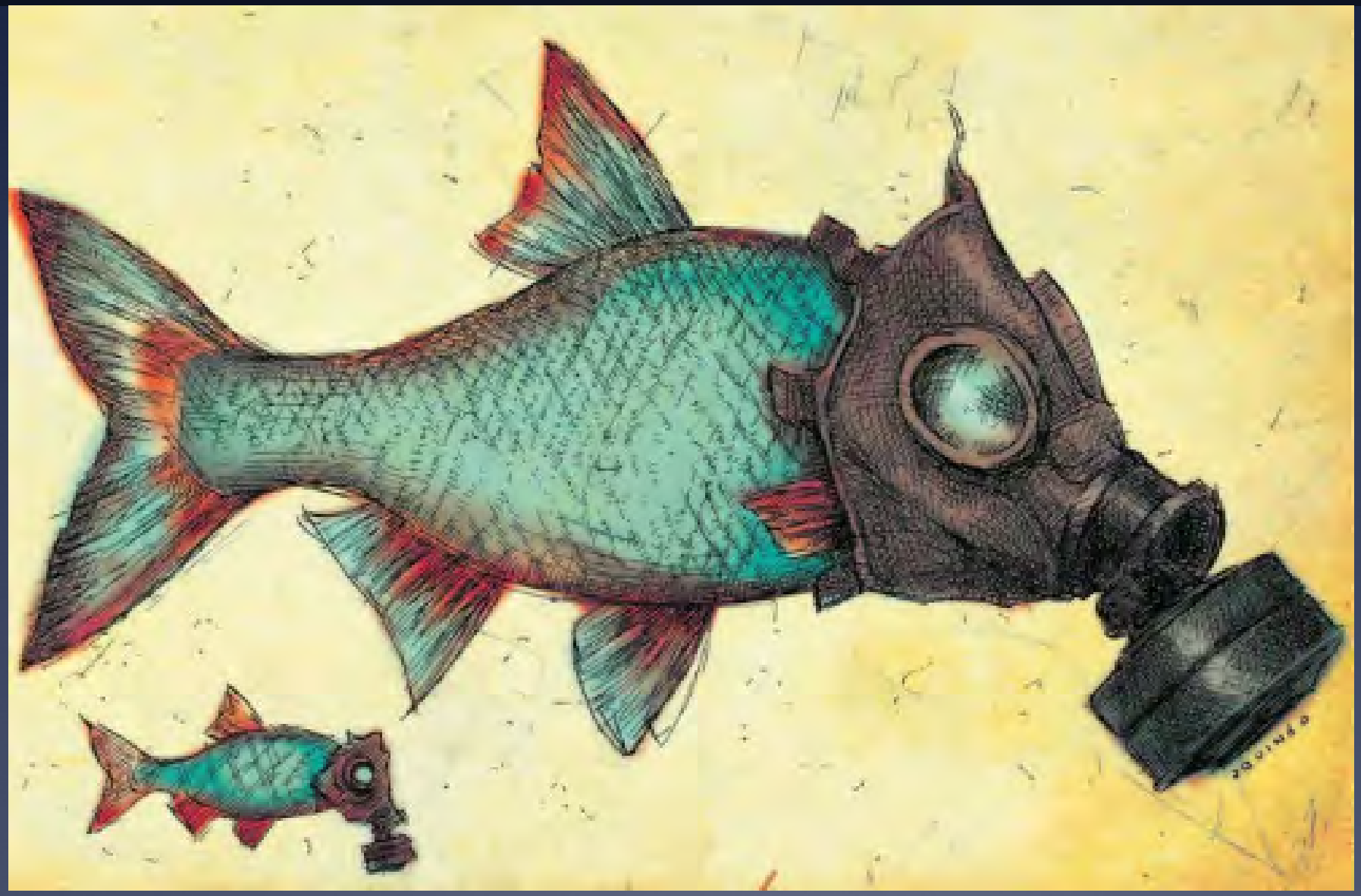
Retrofits paid by SPU or King County Wastewater Treatment Division

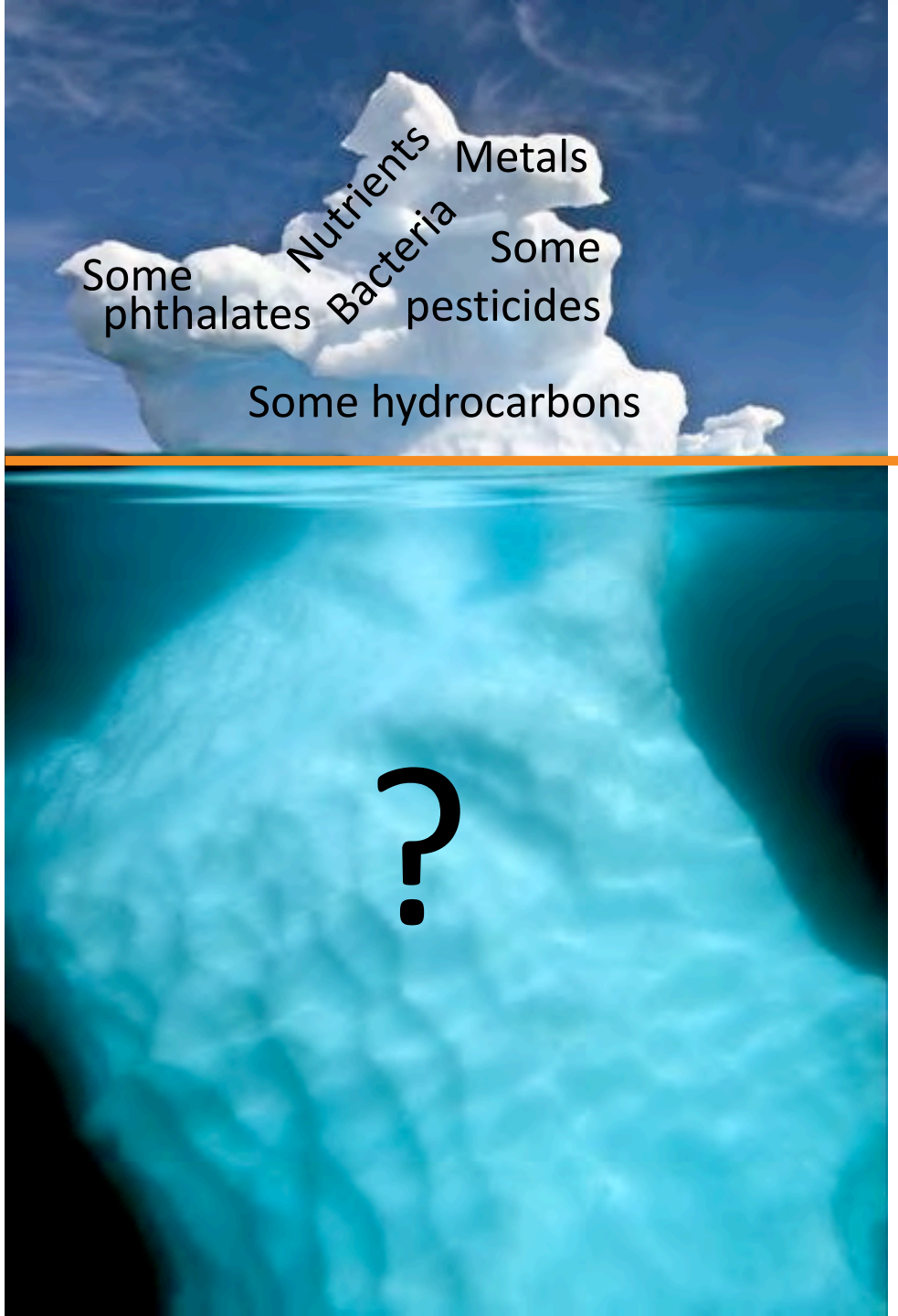
Retrofits incentivized

Other

GSI in Seattle (2015): 2025 Implementation Strategy

Solutions to stormwater pollution: Source Control





The chemistry of stormwater runoff

Thousands of unique chemicals are present in urban road runoff

Du et al. 2017. Env. Sci. Processes and Impacts

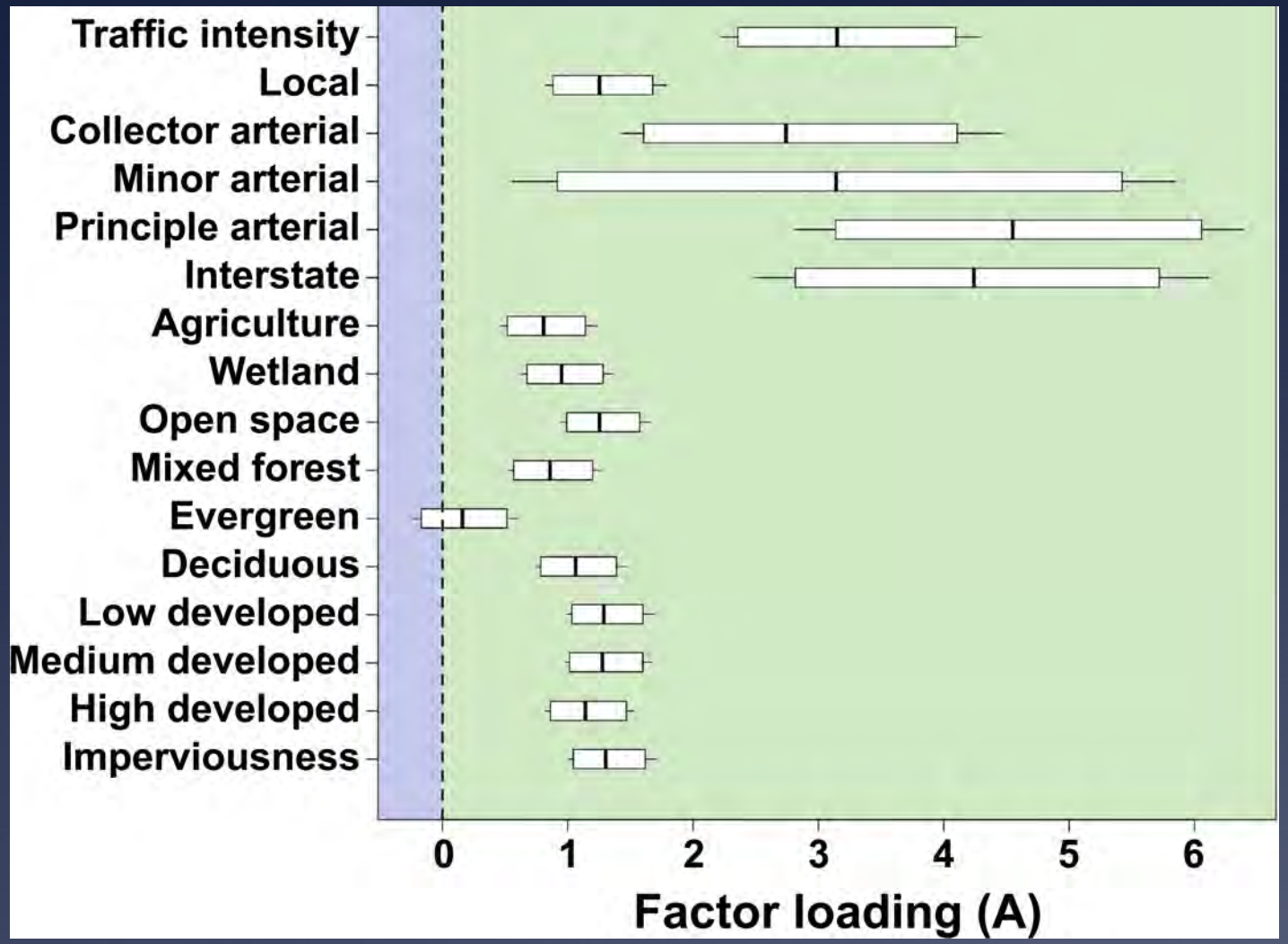
Relatively few of them are identified

Peter et al. 2018. ES&T

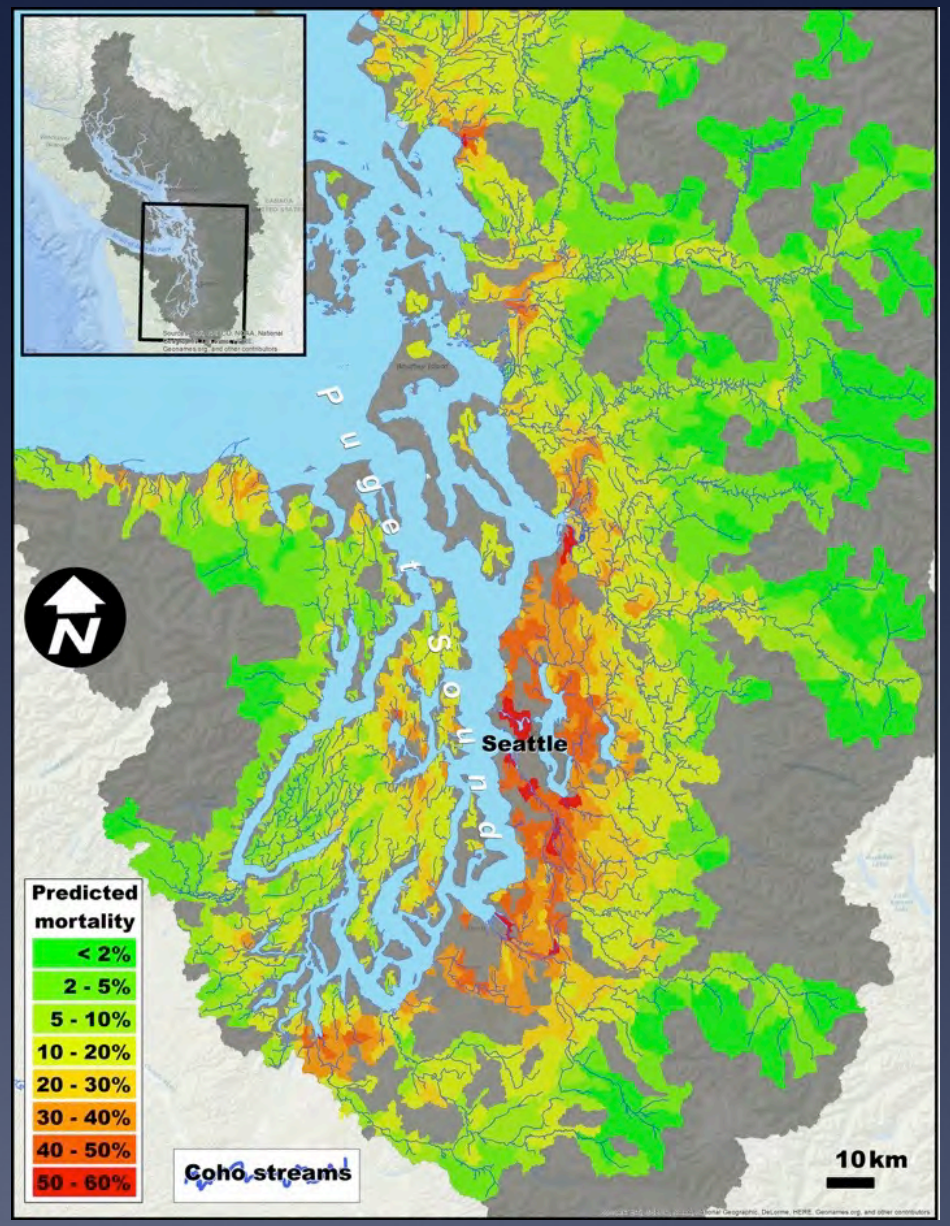
The chemicals that we know don't appear to cause the observed toxicity

Spromberg et al. 2016. J. Appl. Ecol.

Contributing Factors



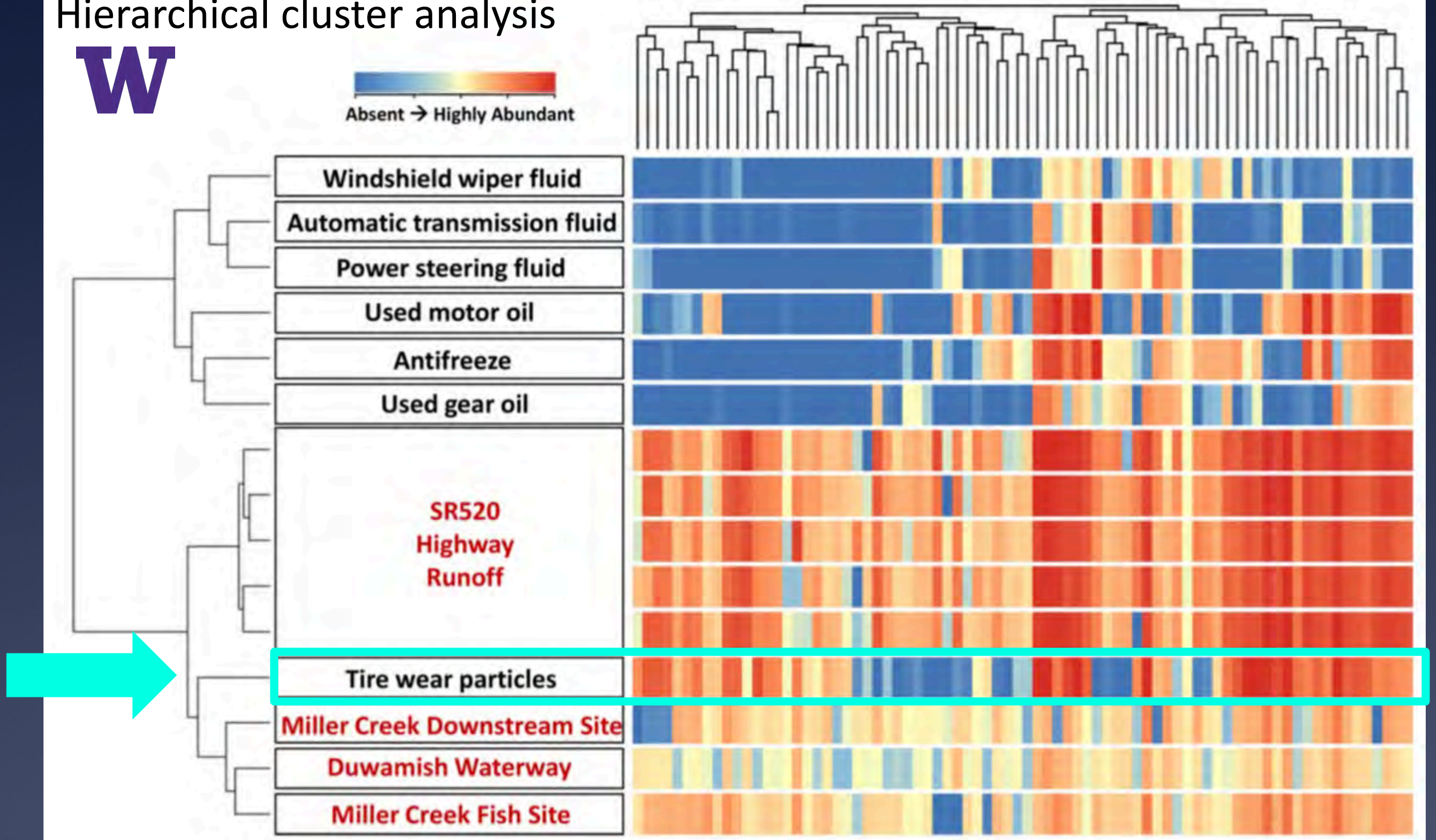
Predictive Mapping



Increasing PSM →

Feist et al. 2017. Ecol Applications

Hierarchical cluster analysis

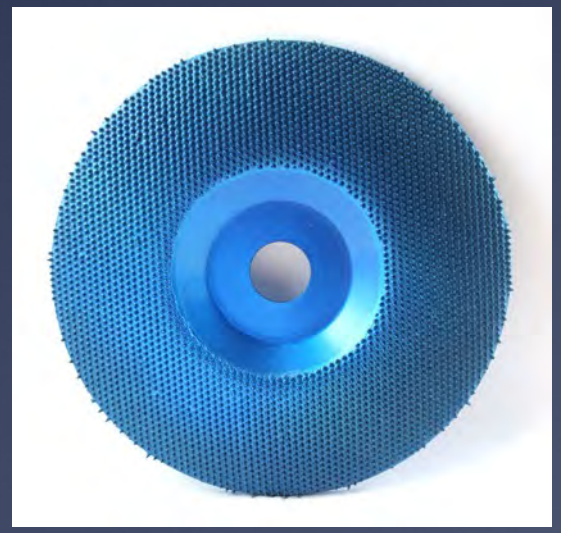


Peter et al. 2018. ES&T

Are tire particles an important source of toxicity?

Generating Tire Powder for Testing

- Graduate students
- Electric planer
- Carbide grinding disk
- Respirators
- VOC filter

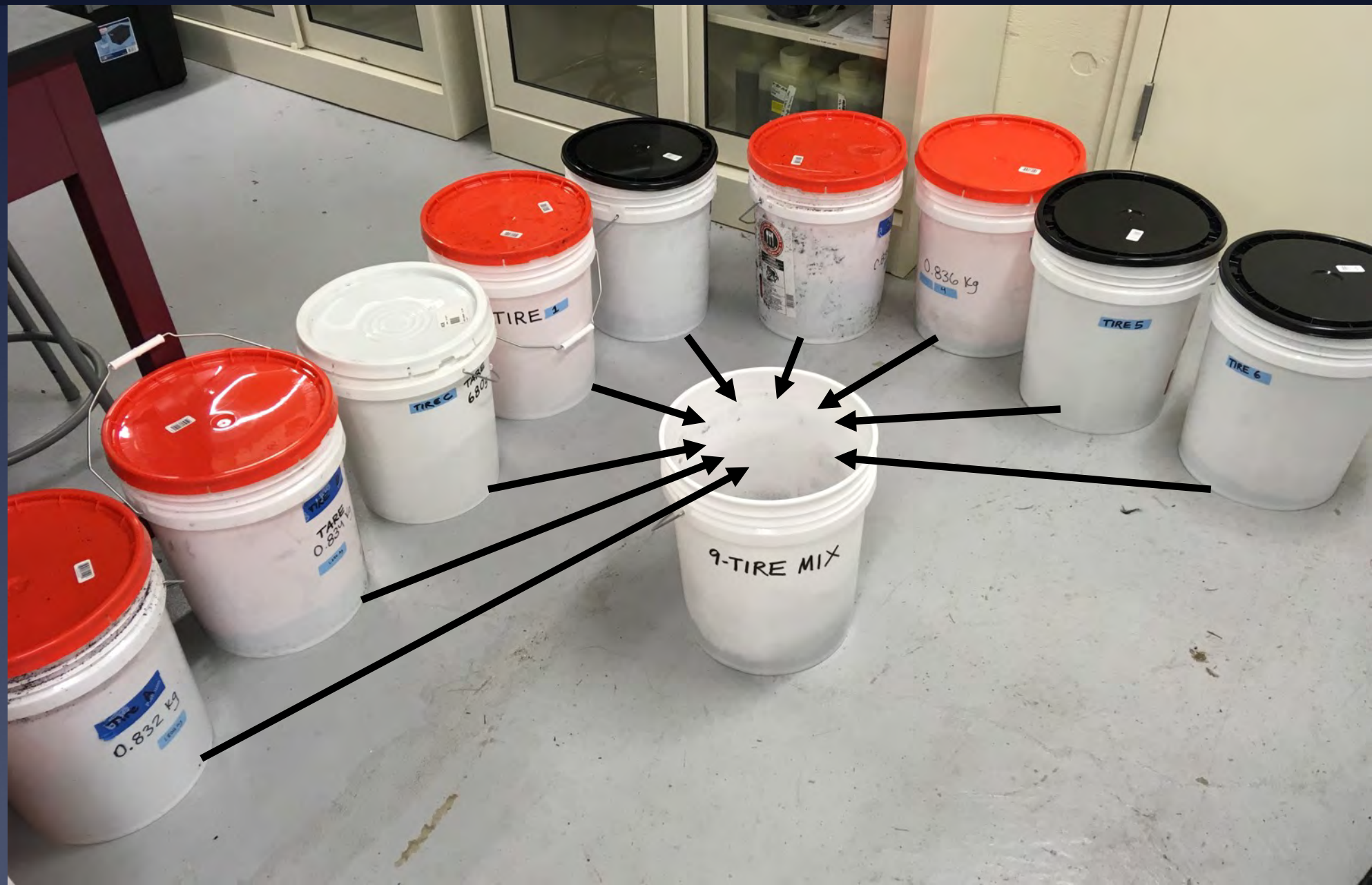


Generating 9-Tire Powder Mix for Testing

<u>9 Tires</u>
7 used
2 new

Ground to powder

Combined in equal-weights



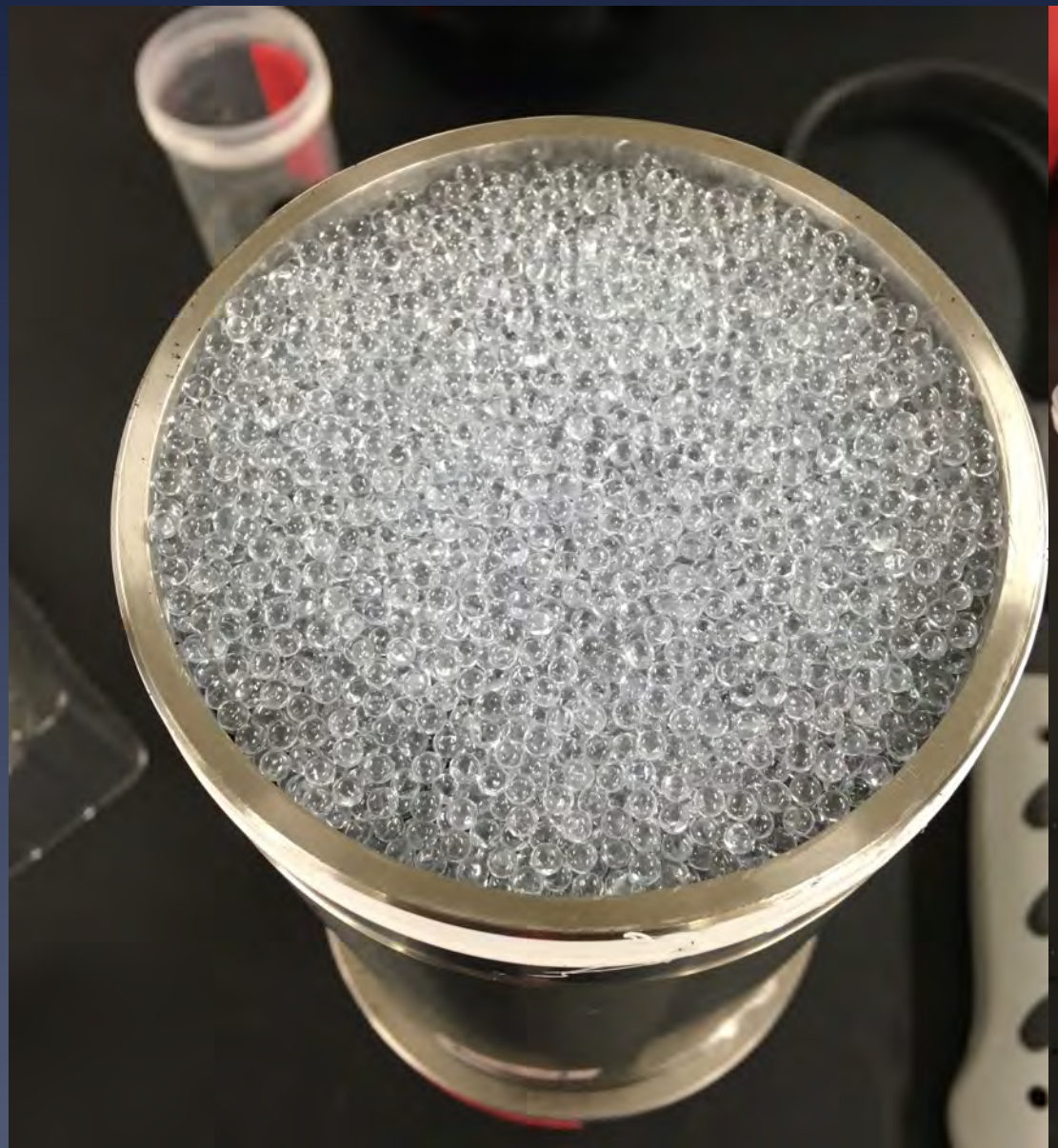
Tire Leachate Fractionation Studies

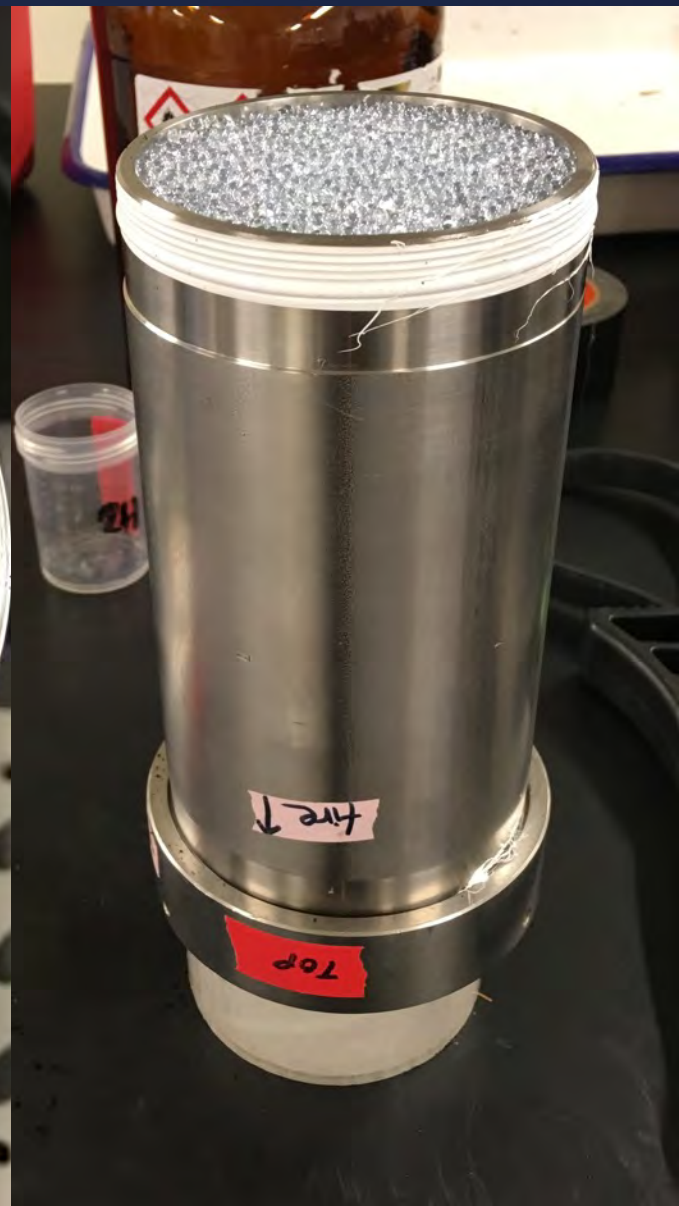
Do tire chemicals affect coho?

Are coho uniquely sensitive?

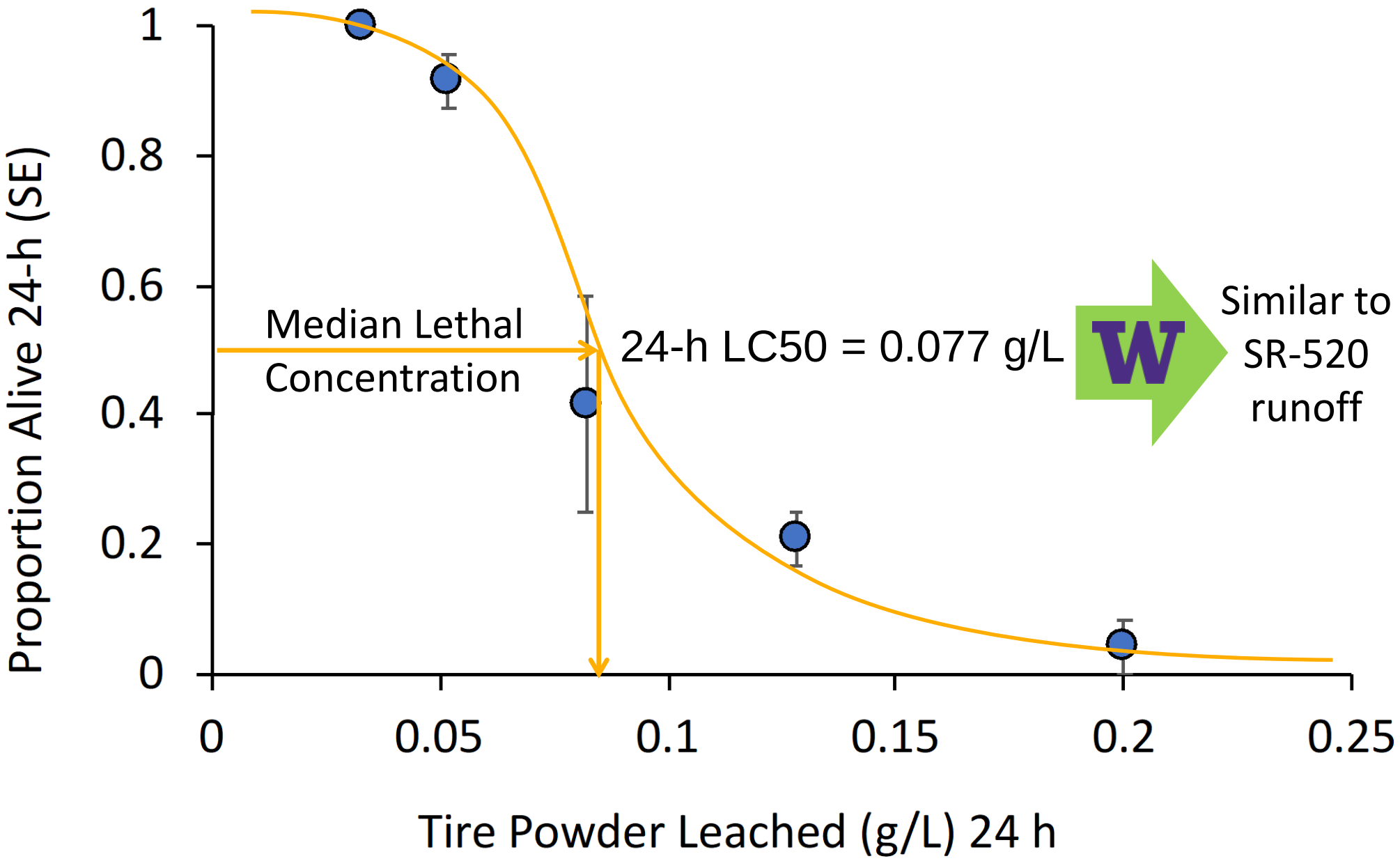
McIntyre et al. 2018. Env. Pollut.

What are the responsible toxicants?

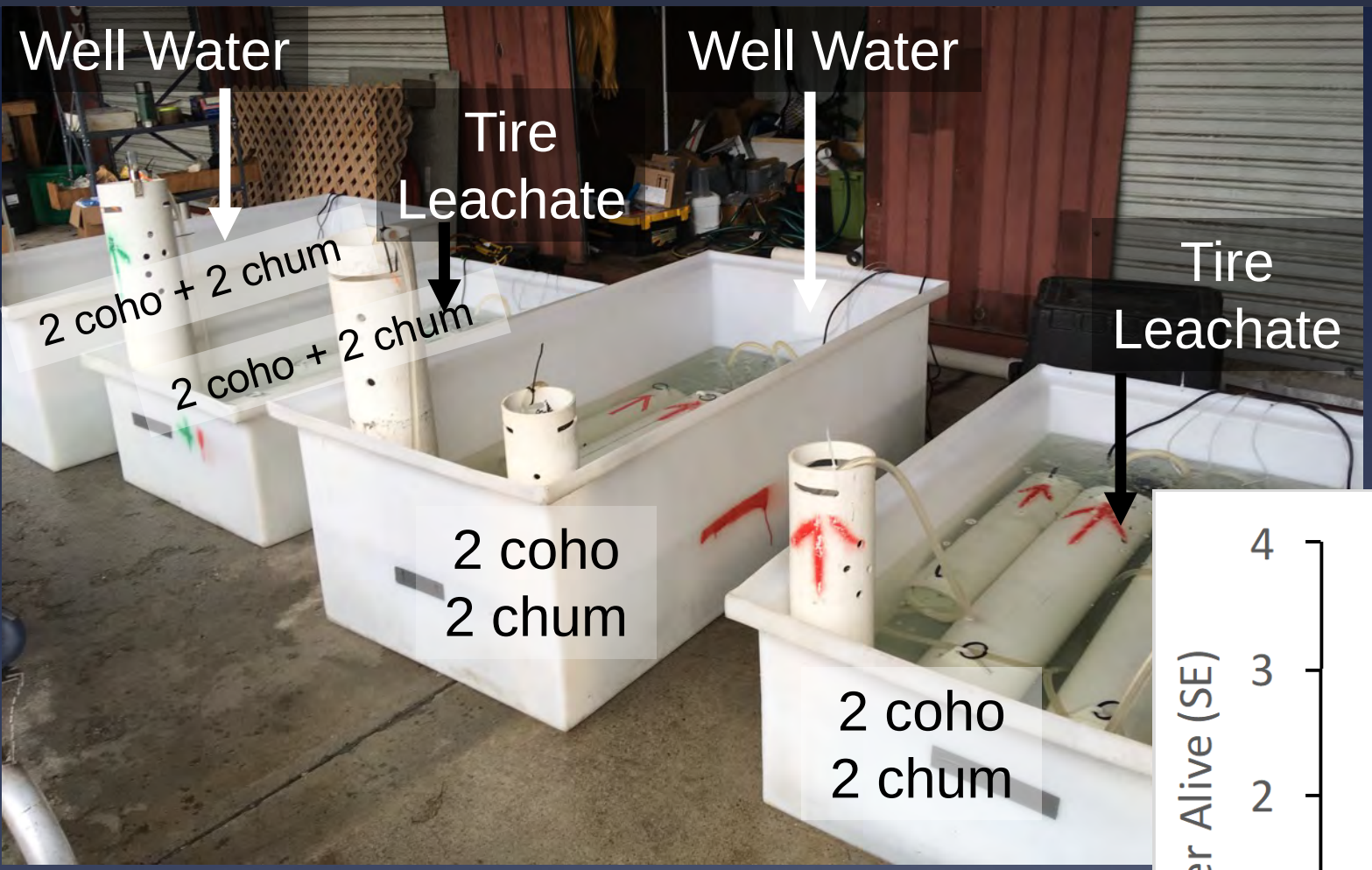




Tire leachate is acutely lethal to coho salmon

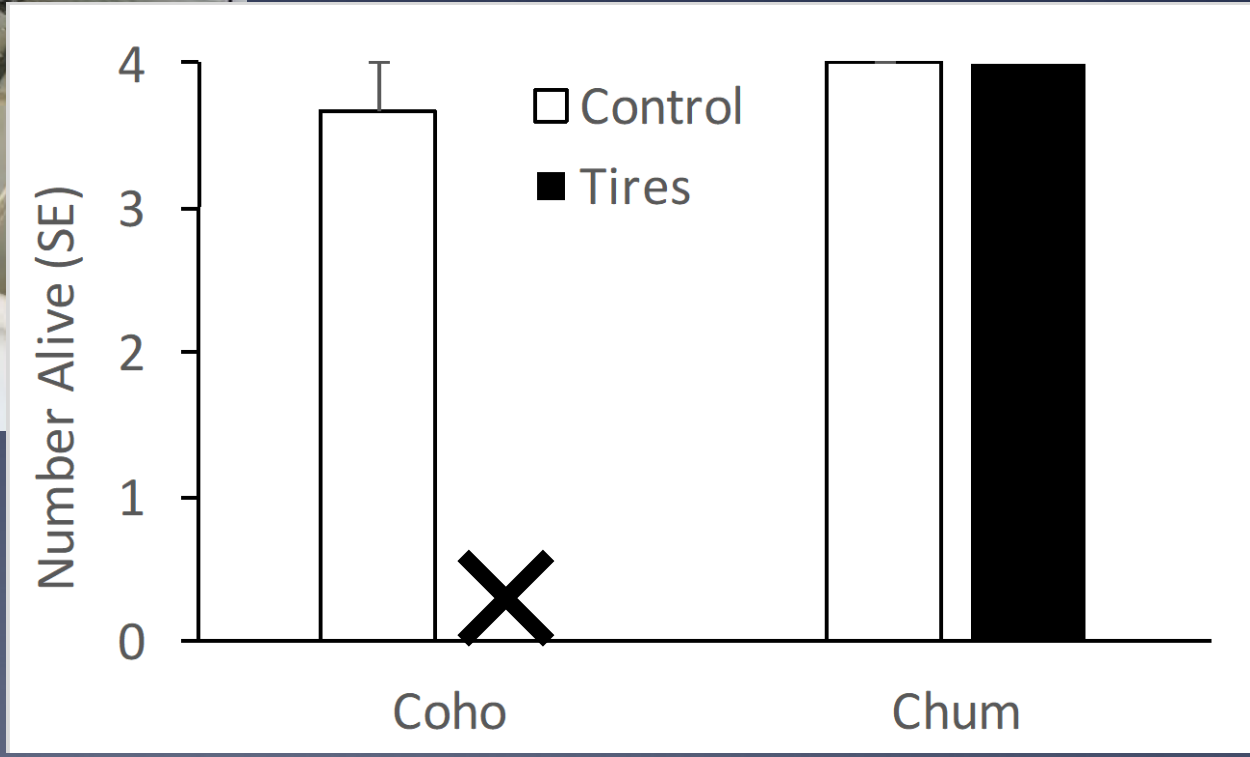


Do tire chemicals affect coho but not chum?



November 2017
Repeated 4x

Similar to runoff, chum were not affected



- Tire Leachate = 0.32 g/L (nominal)
- 24 h exposure
- Expect 100% mortality in coho

Tire Leachate Fractionation

Fractionation Method	Target Property	Result?	
Sand Filter	Particulates	✗	
Aeration	Volatility	✓	vigorous; 3 d
Chelation	Metals	✗	
Cation Exchange Resin	Cations	✗	
Heating	Thermal stability	✗	
Reverse phase chromatography	Polarity	✓	moderately polar

Ongoing work towards identifying responsible chemicals

Zhenyu Tian & Kathy Peter – postdocs with Dr. Ed Kolodziej at UW-Tacoma

Green Solutions and Source Control Summary

- Urban road runoff is acutely lethal to coho salmon
- Green stormwater infrastructure can prevent toxic impacts to coho (and other species)
- GSI retrofits are $$$$ (easier for new development)
- Source controls of stormwater pollutants should also be pursued
- Tire wear is a potentially important source of the contaminants that are killing coho

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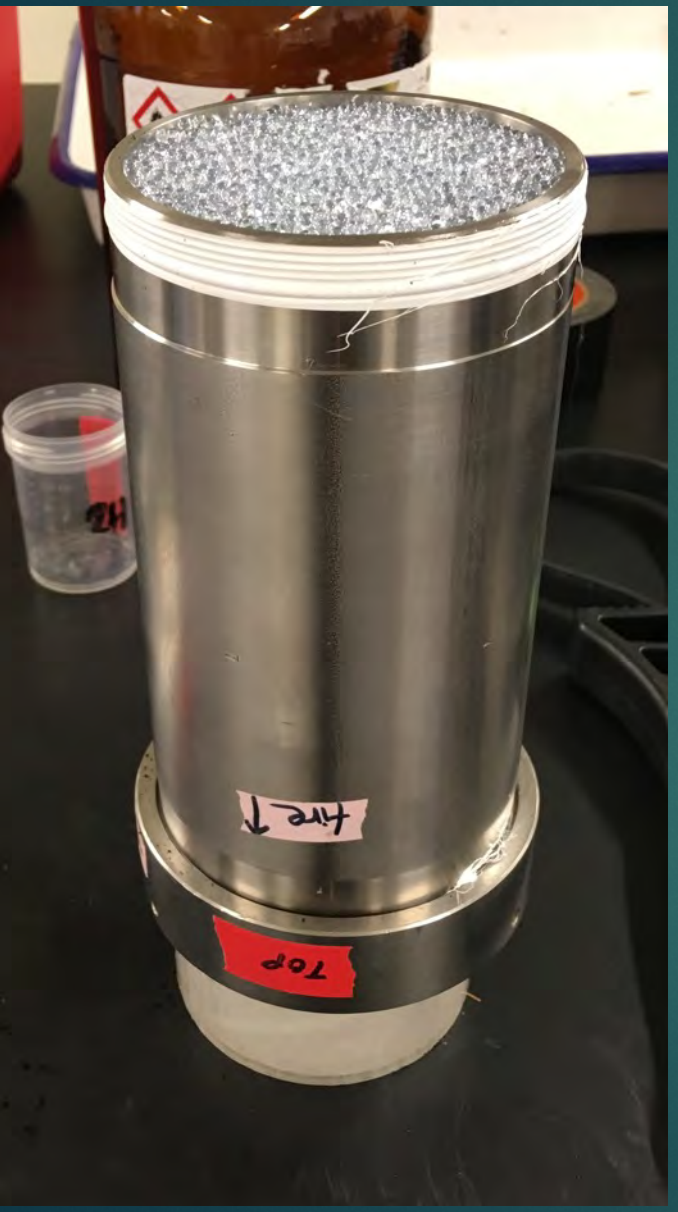
Tire Leachate Fractionation Studies



Leaching Methods

1. 9-tire mix
2. 1 g/L tire leachate
3. 0.5 L/min for 24 h

Screening Methods

1. Juvenile coho; 30 L
   5 fish/fraction; 24 h
2. Negative control
   (lab water)
3. Positive control
   (250 mg/L leachate)