Oklahoma Clean Lakes & Watersheds Association (OCLWA)
Session C1: BST & Contaminants
Stillwater, OK
Apr 4, 2018

STEP ONE FOR WATER REUSE: ESTABLISH BASELINE CONCENTRATIONS FOR COMPOUNDS OF EMERGING CONCERN (CEC) IN SURFACE WATER SUPPLY SYSTEMS

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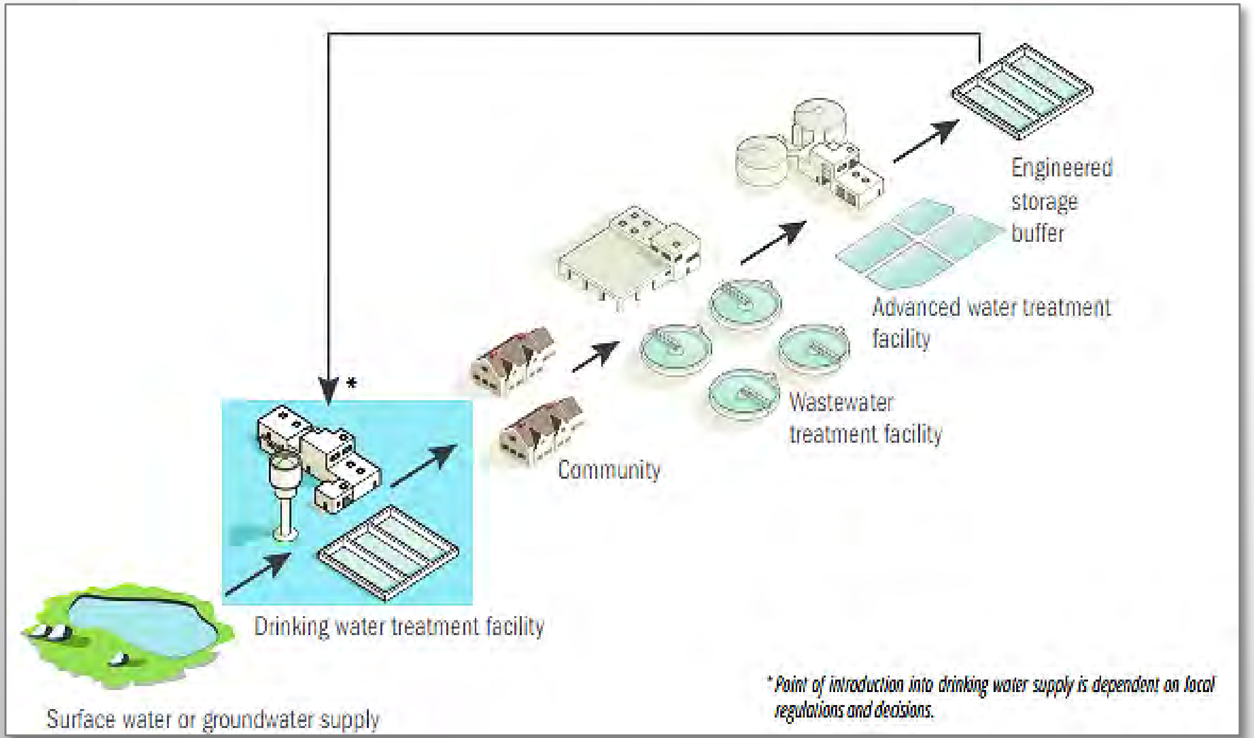
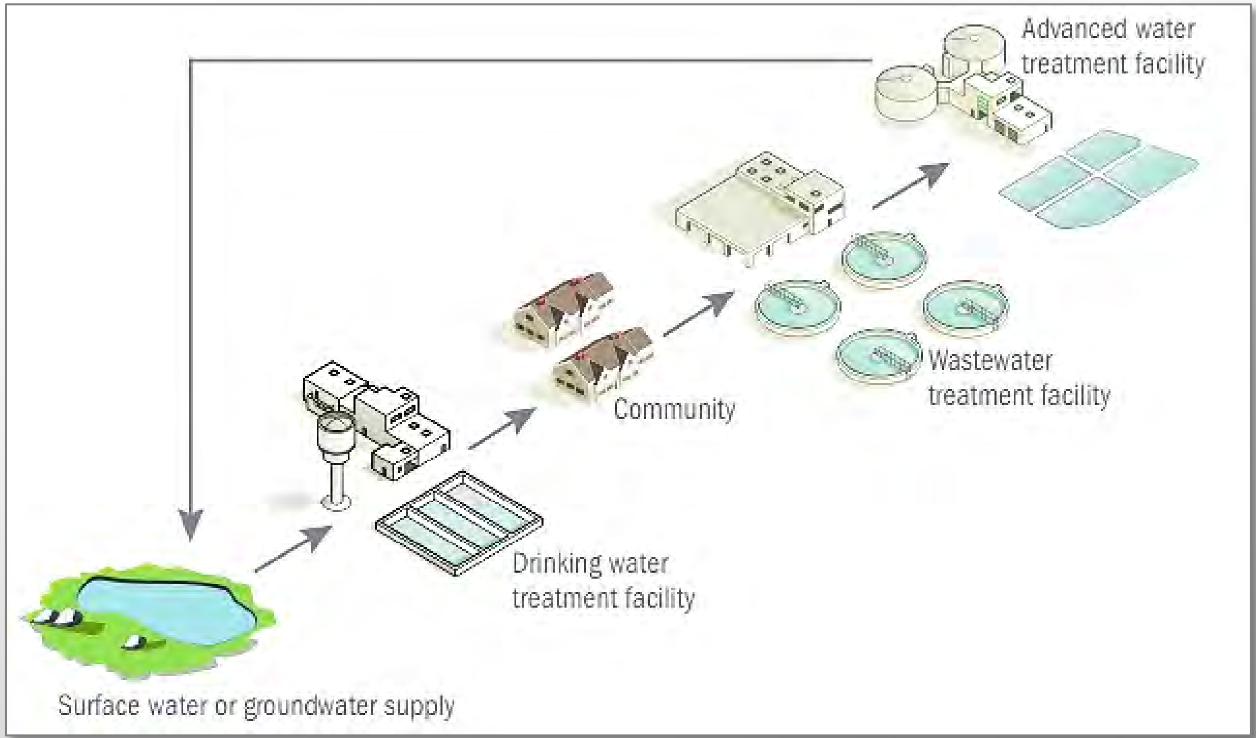
OKLAHOMA GEOLOGICAL SURVEY OGS 1908

Demand >>> Supply = Augment with Reuse

Direct Potable Reuse



Indirect Potable Reuse



(AWWA, 2016)

Major Public Concern: Compounds of Emerging Concern (CEC)

CEC are chemical solutes potentially found in surface waters at trace levels, ng/L, that may have an impact on aquatic and animal life (US EPA 2015)

- Over 84,000 chemicals in use today as inventoried by US EPA under the Toxic Substances Control Act (TSCA)

- Approximately 700 new chemicals added each year to the US EPA inventory

Categories of CEC (Murray et al., 2010)

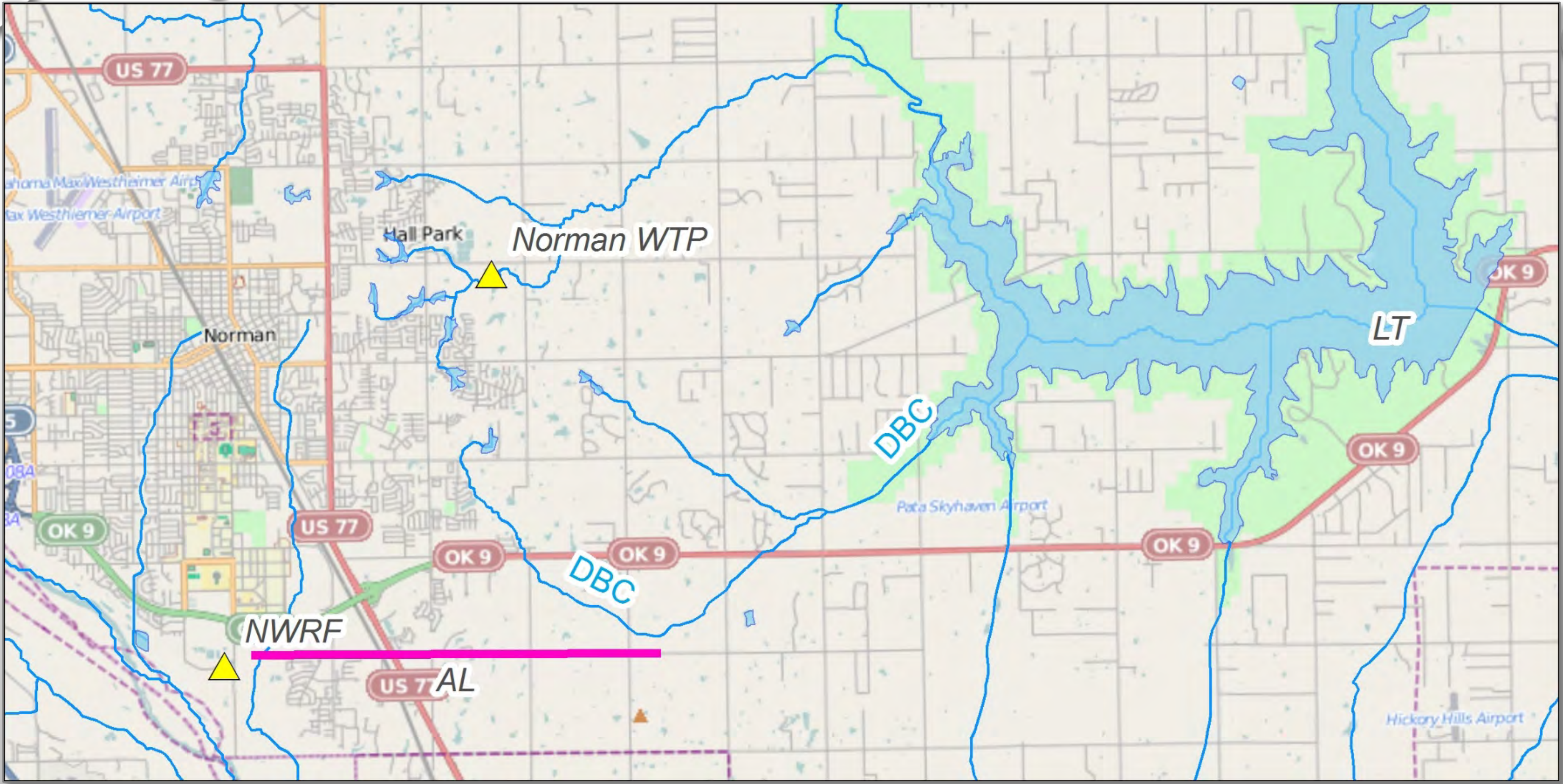
Pesticides

Pharmaceuticals and Personal Care Products (PPCPs)

Industrials

Other

City of Norman – Top Rated Plan for Water Augmentation



WTP = (drinking) Water Treatment Plant NWRF = Norman Water Reclamation Facility

AL = Augmentation Line DBC = Dave Blue Creek

LT = Lake Thunderbird

Project Objectives

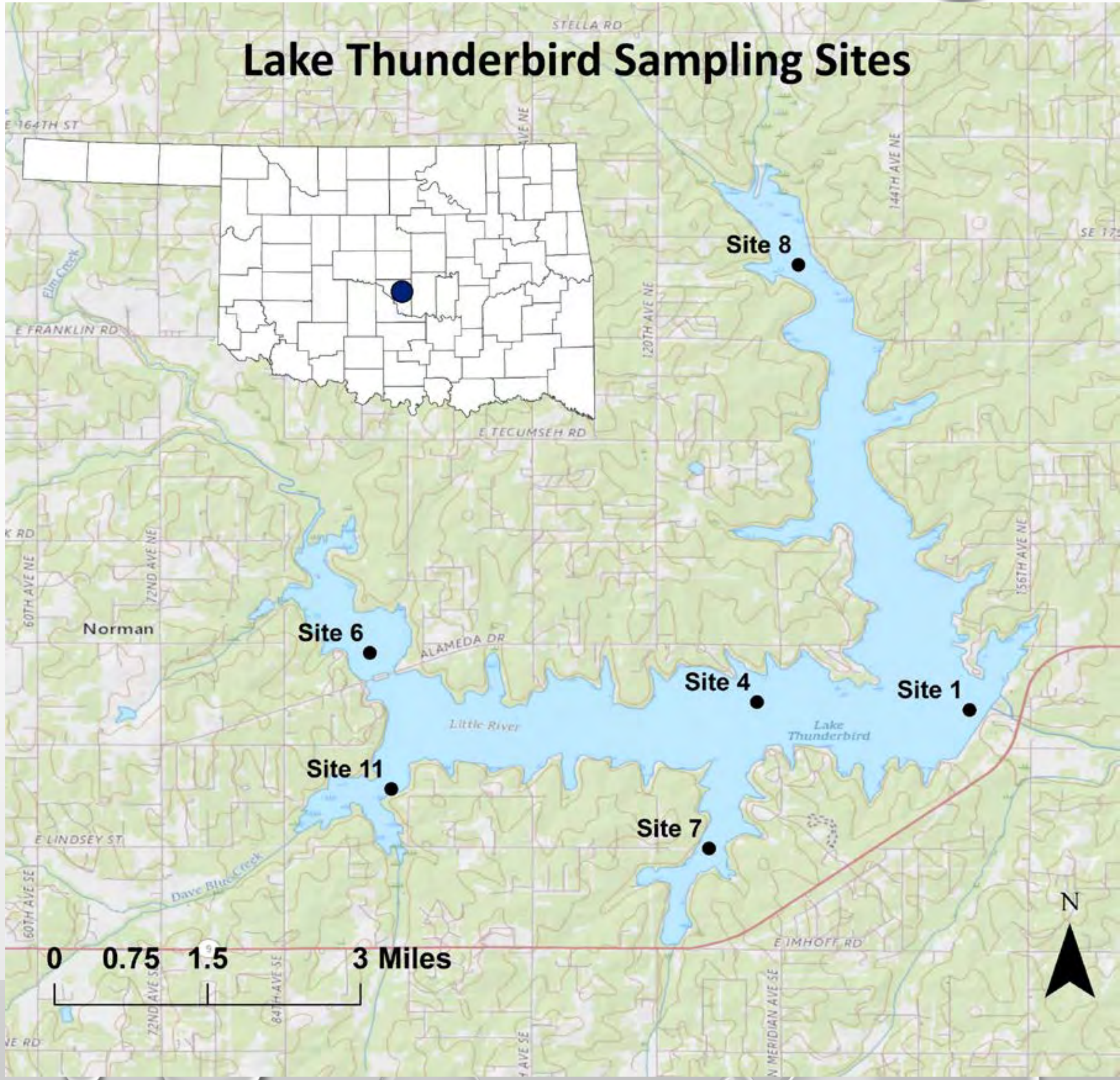
Measure CEC concentrations in Lake Thunderbird, Norman, OK

- Evaluate seasonal variations
- Compare to established health standards

Assess potential sources of CEC from Lake Thunderbird sub-watersheds using land use and a loading factor index model

Methods: Collect Water Samples

- Locations consistent with OWRB water quality studies
- Sampled in Jun 2016 (Summer), Oct 2016 (Fall), Jan 2017 (Winter), Apr 2017 (Spring)
- Kemmerer 1.2 L stainless steel, Teflon-ended water sampler
- Composite samples of 1/3, 2/3, and 3/3 depth



Acknowledgement to:
Central Oklahoma Master Conservancy District (COMCD) for funding the research project

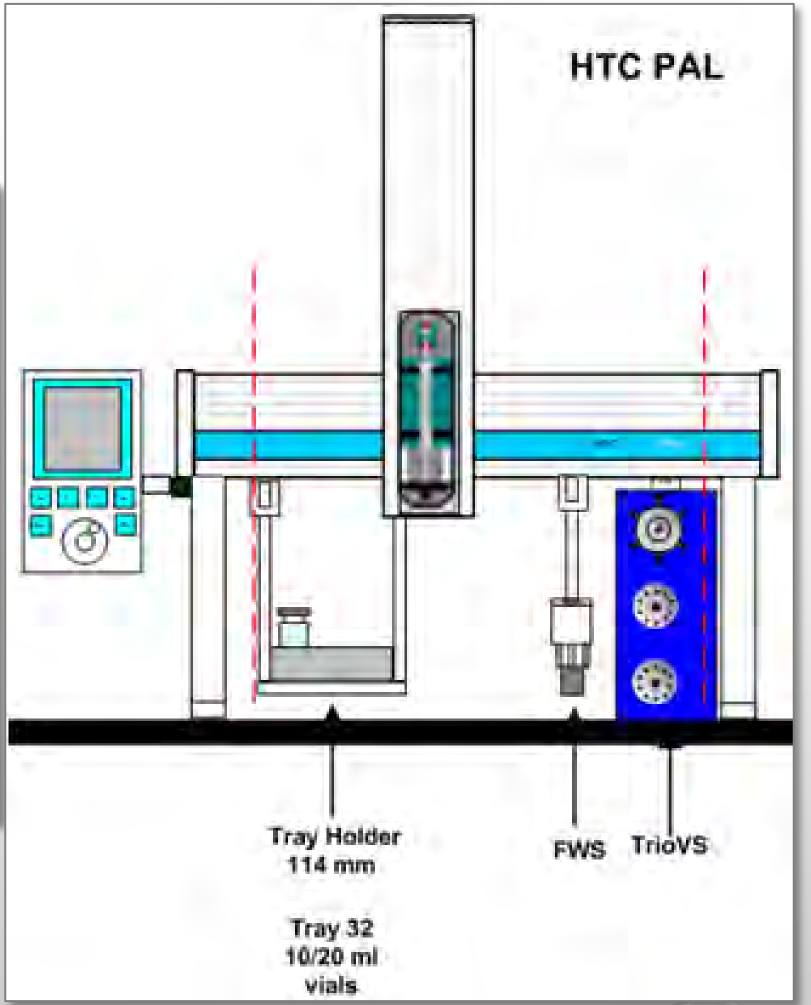
Methods: Measure Field Parameters

YSI 6920 multi-parameter water quality sonde

- Point sampling at 2/3 depth
- Measured
  - Temperature
  - pH
  - ORP
  - DO
  - Specific conductance
  - TDS
  - Salinity
  - Chlorophyll

Acknowledgement to Dr. Robert Nairn's CREW lab

Methods: Analyze for CEC



Eurofins Eaton Analytical (EEA), Monrovia, CA

- 98 analytes
- SPE-LC/MS/MS method
- Equipment blank and blind duplicate
- All seasons

Univ of Arizona WEST

- 43 analytes
- UHPLC-MS/MS method
- Equipment blank and blind duplicate
- Winter and Spring

113 unique analytes

Acknowledgement of:
Ashley Horton, current MS student
Ella Walker, former Research Associate

Results: Detections of Benchmark Pesticides

Atrazine

- Herbicide
- Half life = > 200 days

  (U.S. Department of Health, 2003)
- Did not exceed health standards

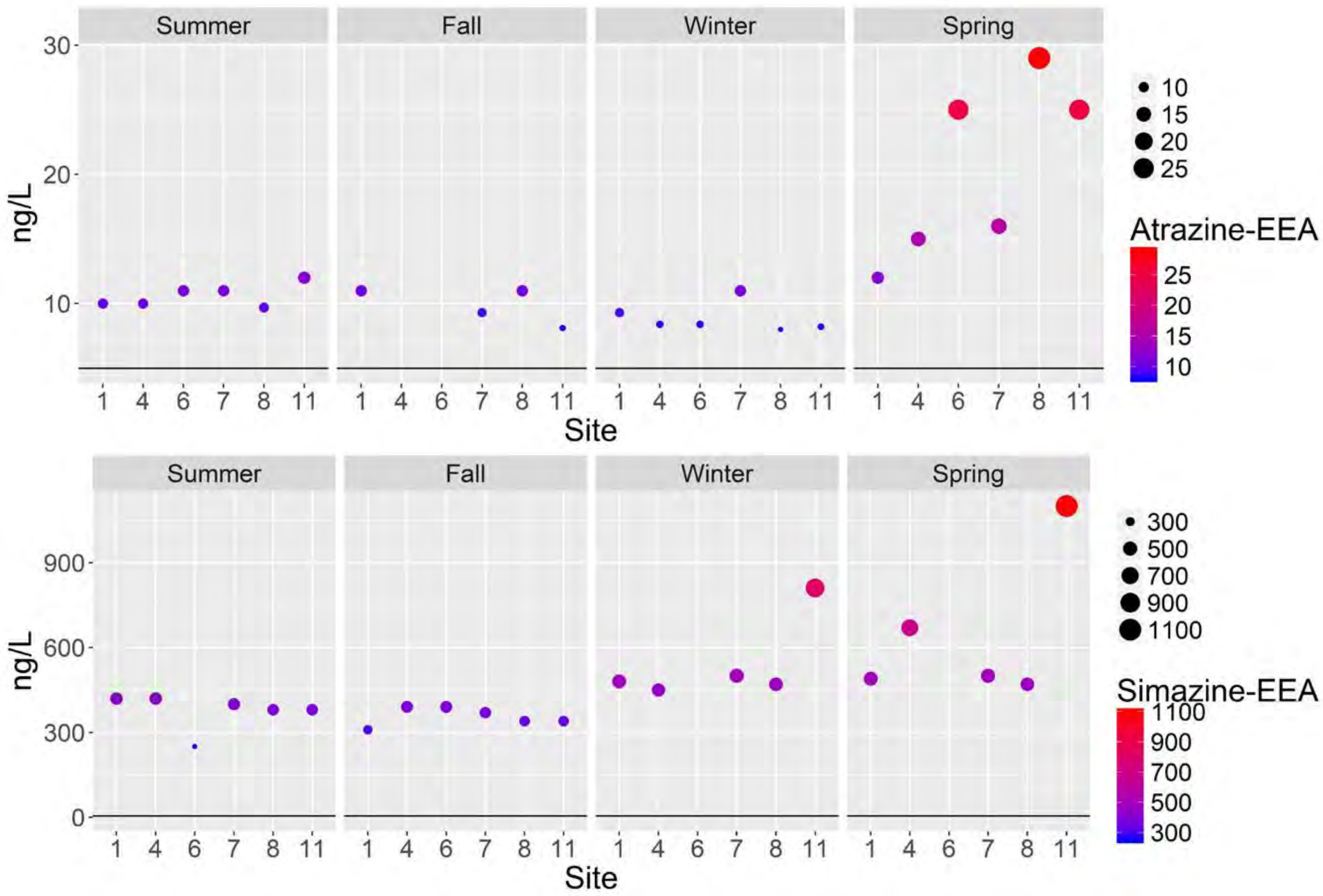
  (EPA, 2017)

Simazine

- Herbicide
- Half life = 145 days

  (Environmental Monitoring Branch, 2004)
- Did not exceed health standards

  (EPA, 2017)



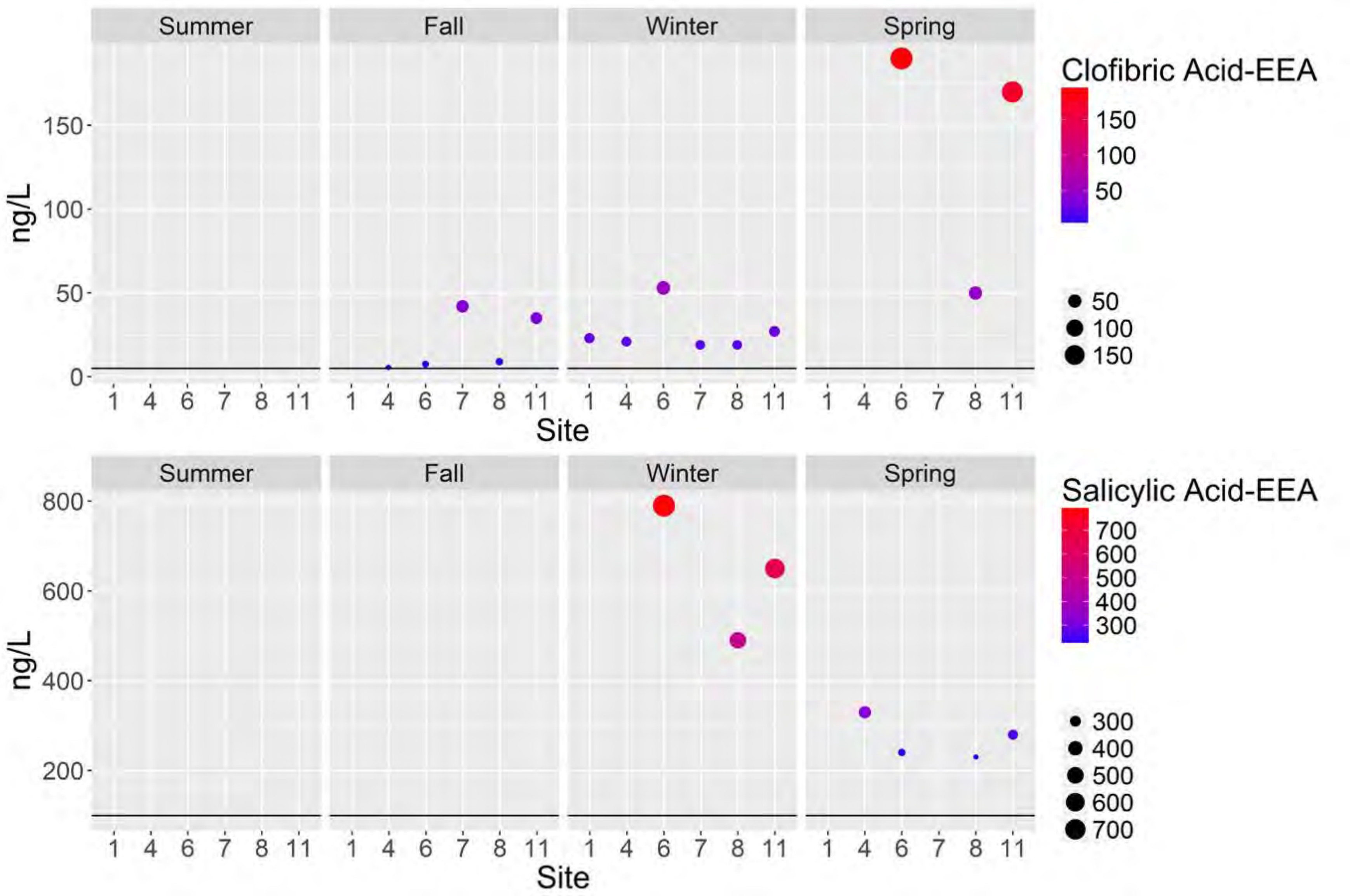
Results: Detections of Benchmark PPCPs

Clofibric Acid

- Lipid regulator and herbicide
- Half life = 2 days
  (Kunkel and Radke, 2011)
- No available health standards

Salicylic Acid

- Phenolic acid
- Half life = not available
- No available health standards



Results: Detections of Benchmark Other Compounds

Acesulfame-K

- Artificial sweetener
- Half life = 7 - 9 days

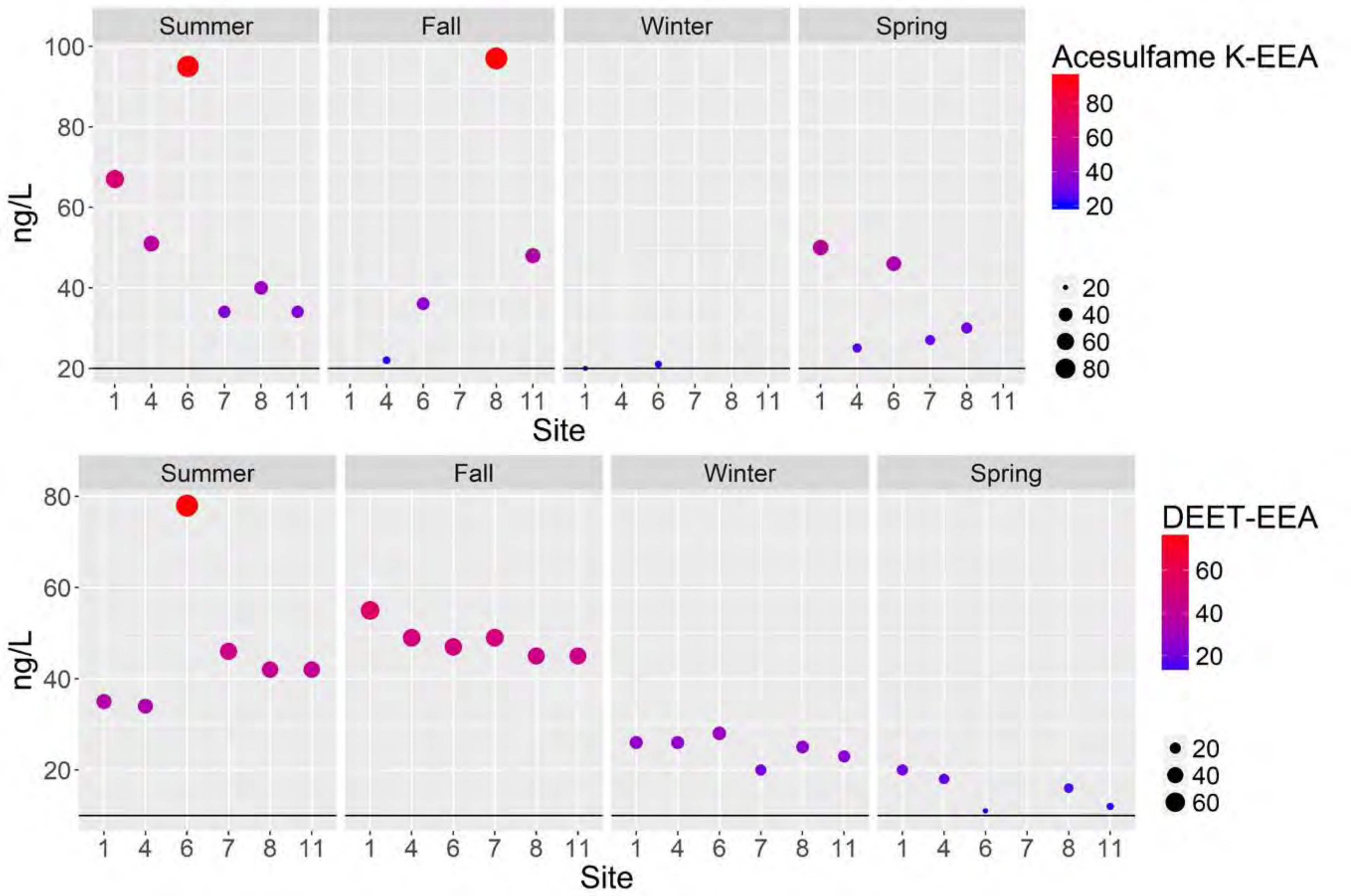
  (Gan et al., 2014)
- No available health standards

DEET

- Insect repellant
- Half life = 5 - 15 days

  (ECHA, 2010)
- Did not exceed health standards

  (MDH, 2013)



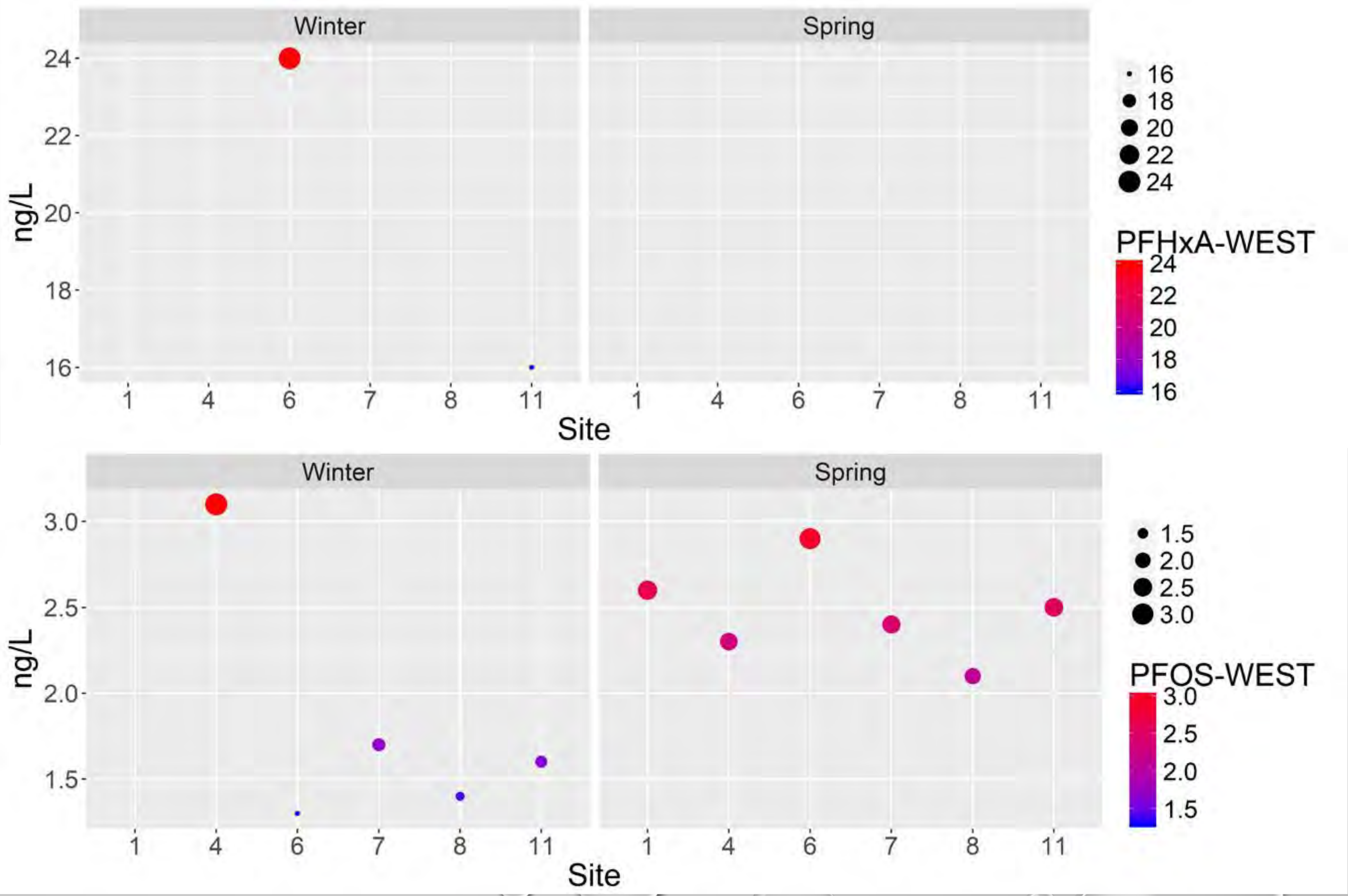
Results: Detections of Benchmark Industrials

PFHxA

- Surfactant
- Half life = not available
- No available health standards

PFOS

- Surfactant
- Half life = 3.3 years
  (Worley et al., 2017)
- Did not exceed health standards
  (MPCA, 2008)

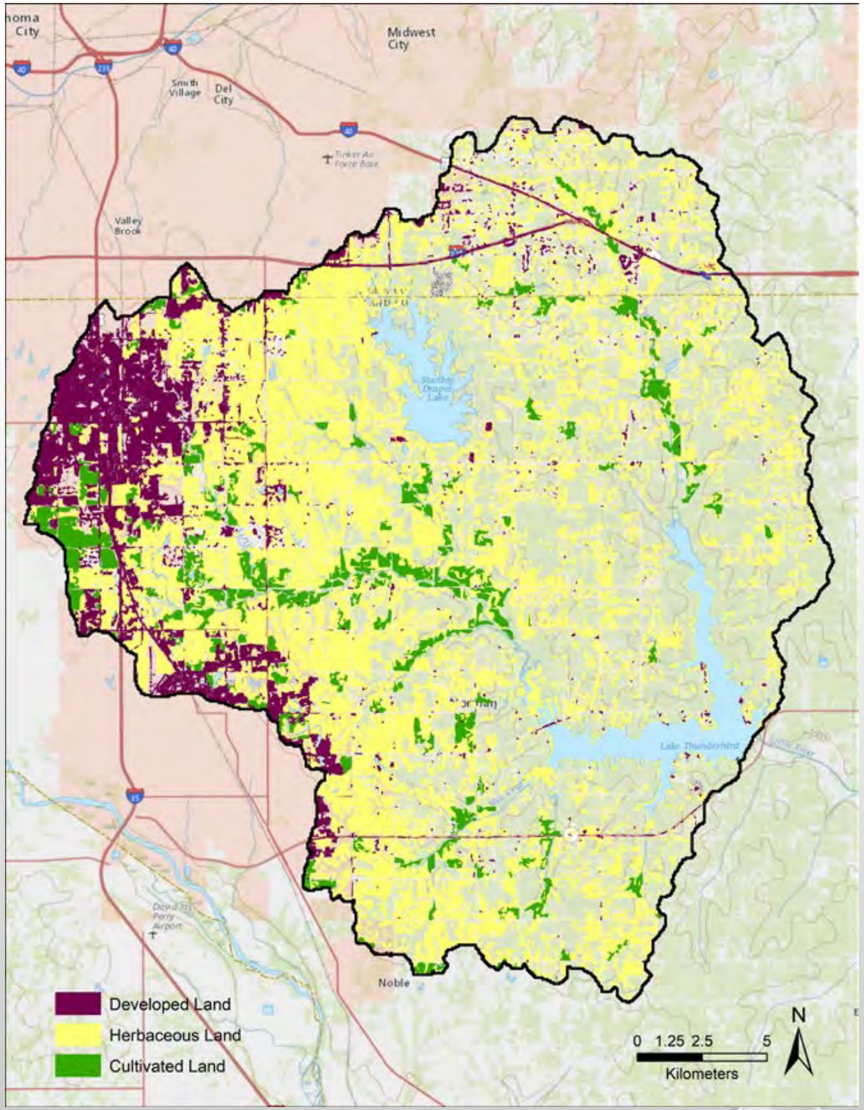


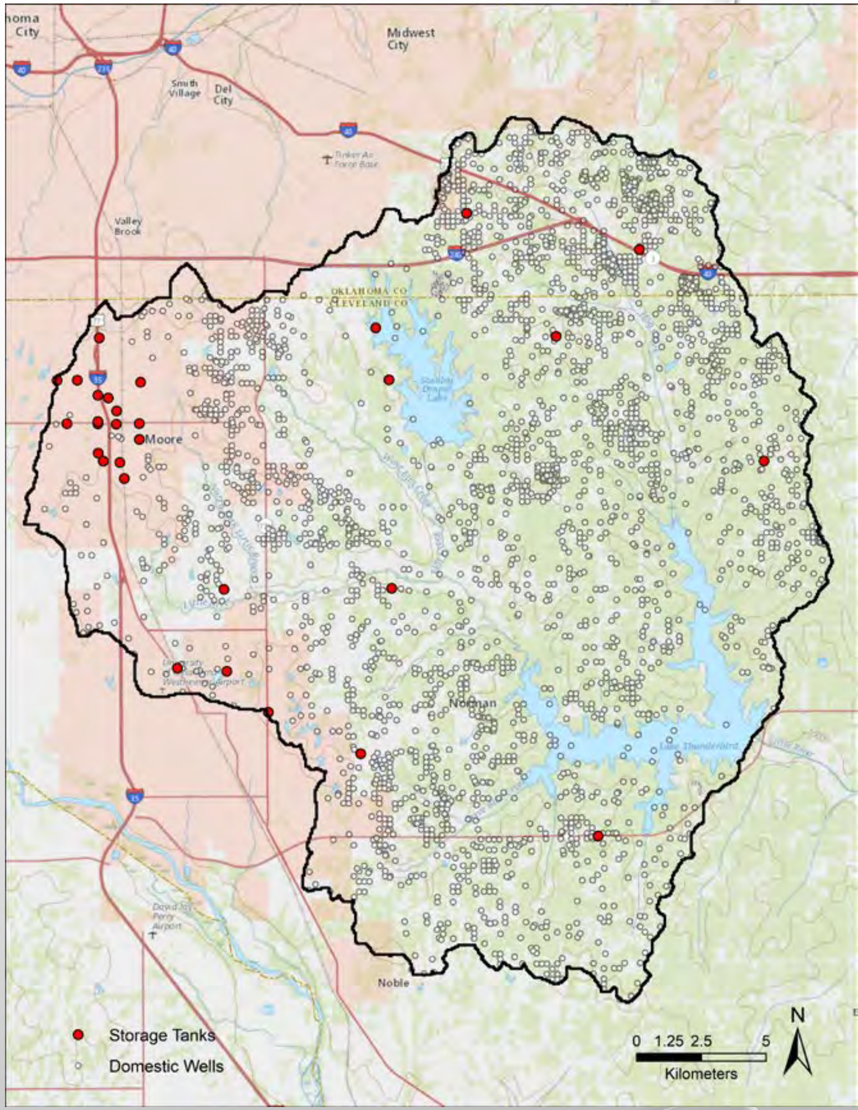
Methods: Hypothesize Potential Sources of CEC w/ a Loading Model

Coefficients:

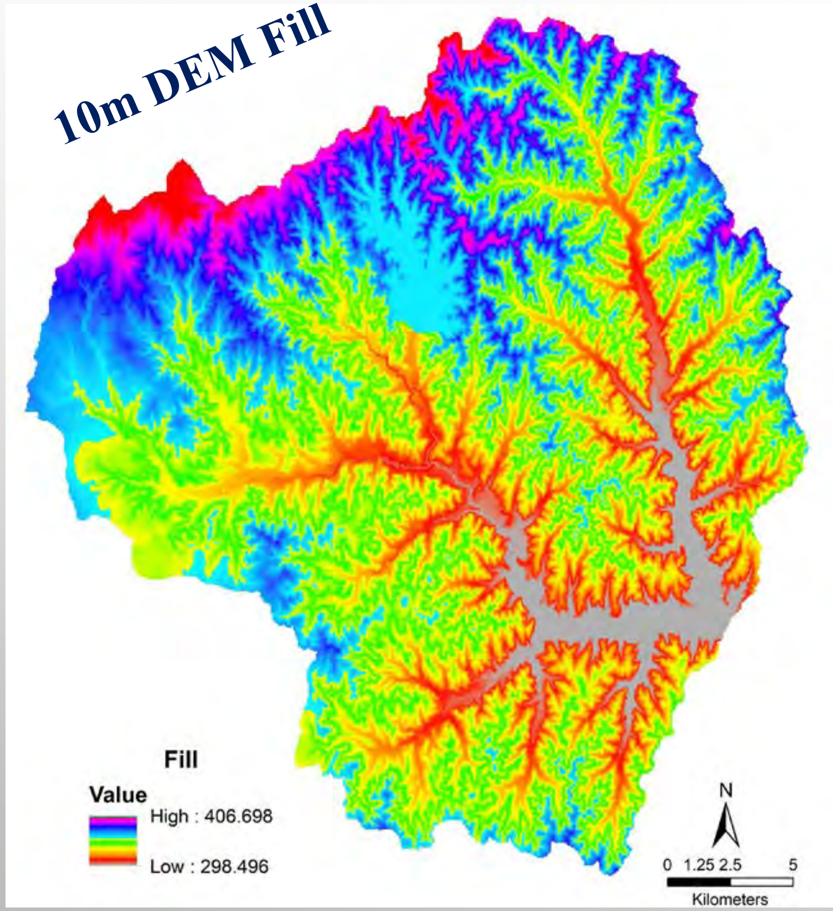
- ST = # of in use storage tanks per acre
- DW = # of domestic wells per acre (proxy for Septic Systems)
- D = proportion of developed land use
- C = proportion of cultivated land use
- H = proportion of herbaceous land

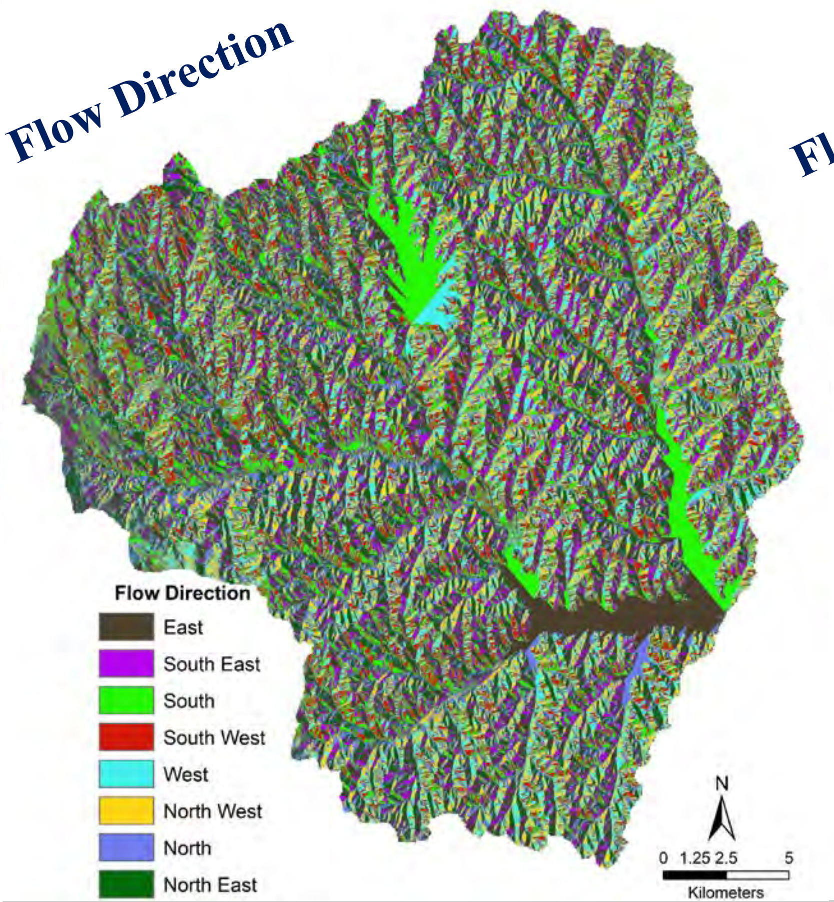
Industrial = ST + DW + D + C
Pesticide = C + D + H
PPCP = DW + D + C
Other = DW + D

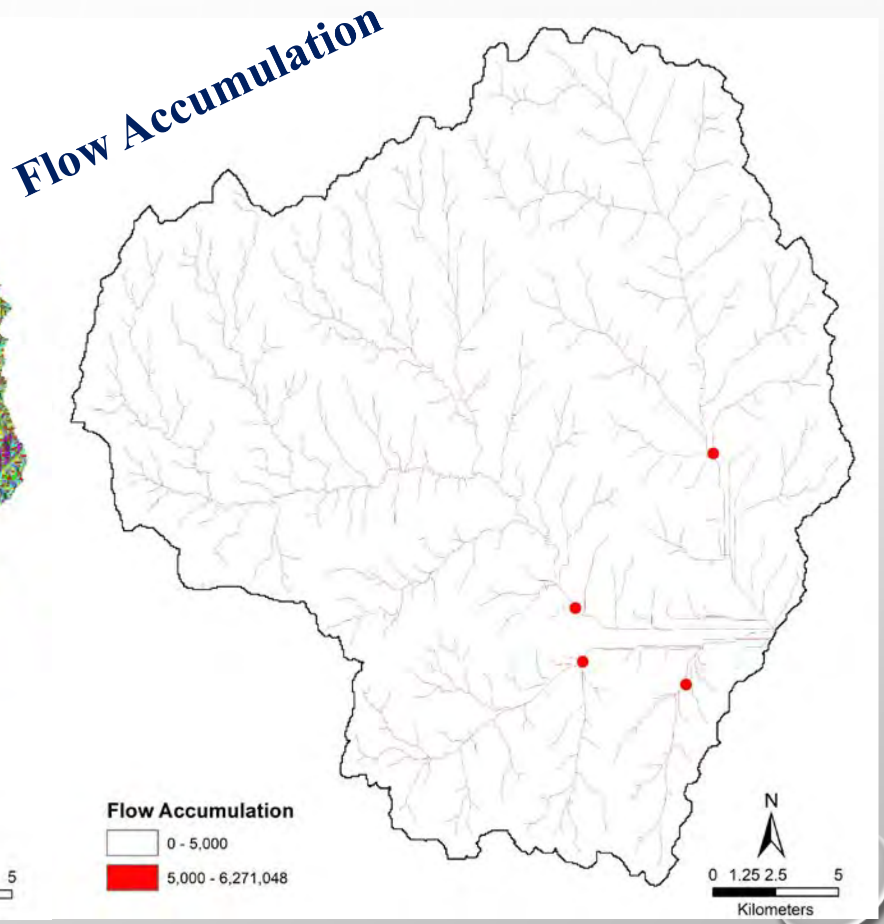




Methods: Sub-Watershed Delineation

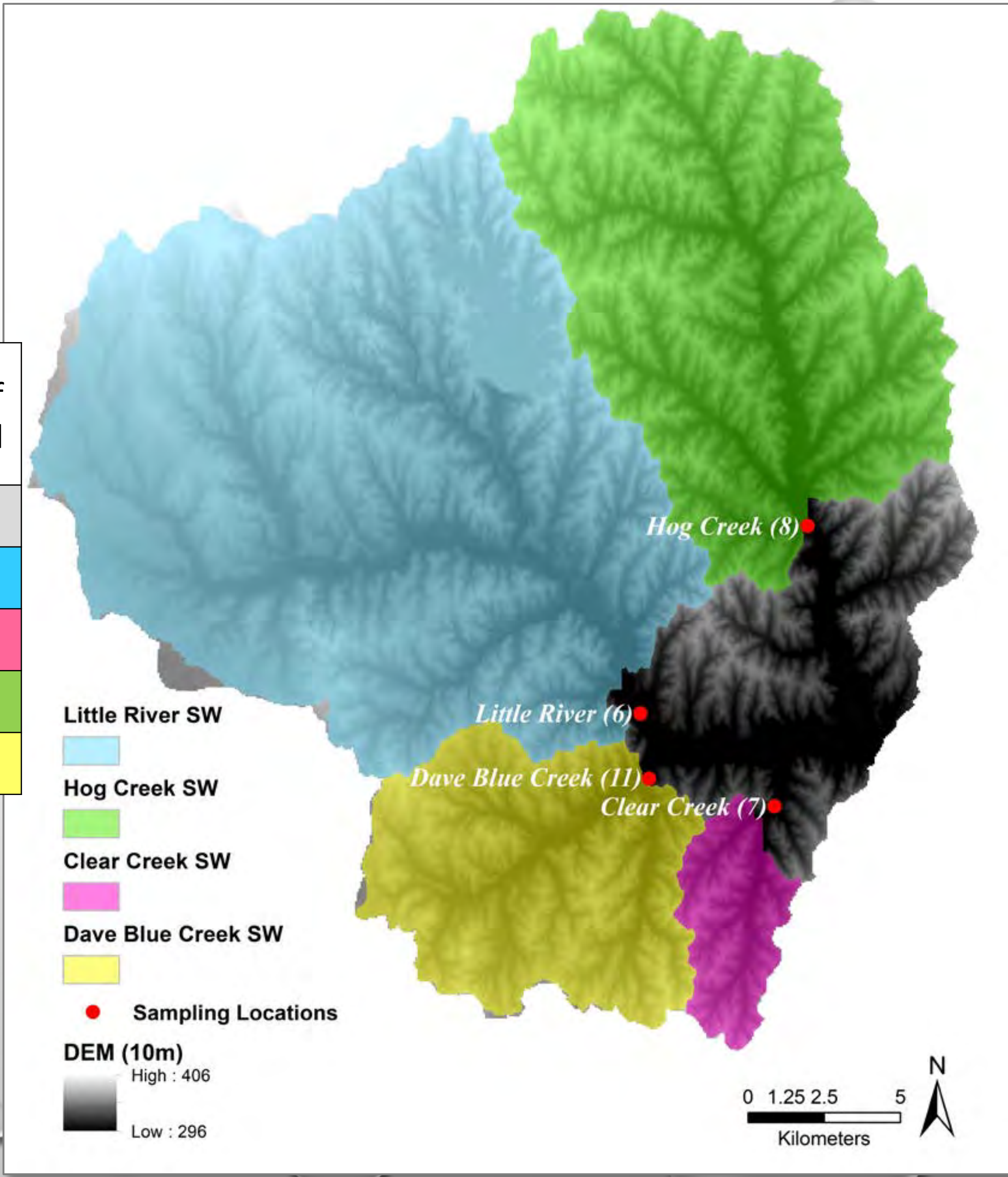




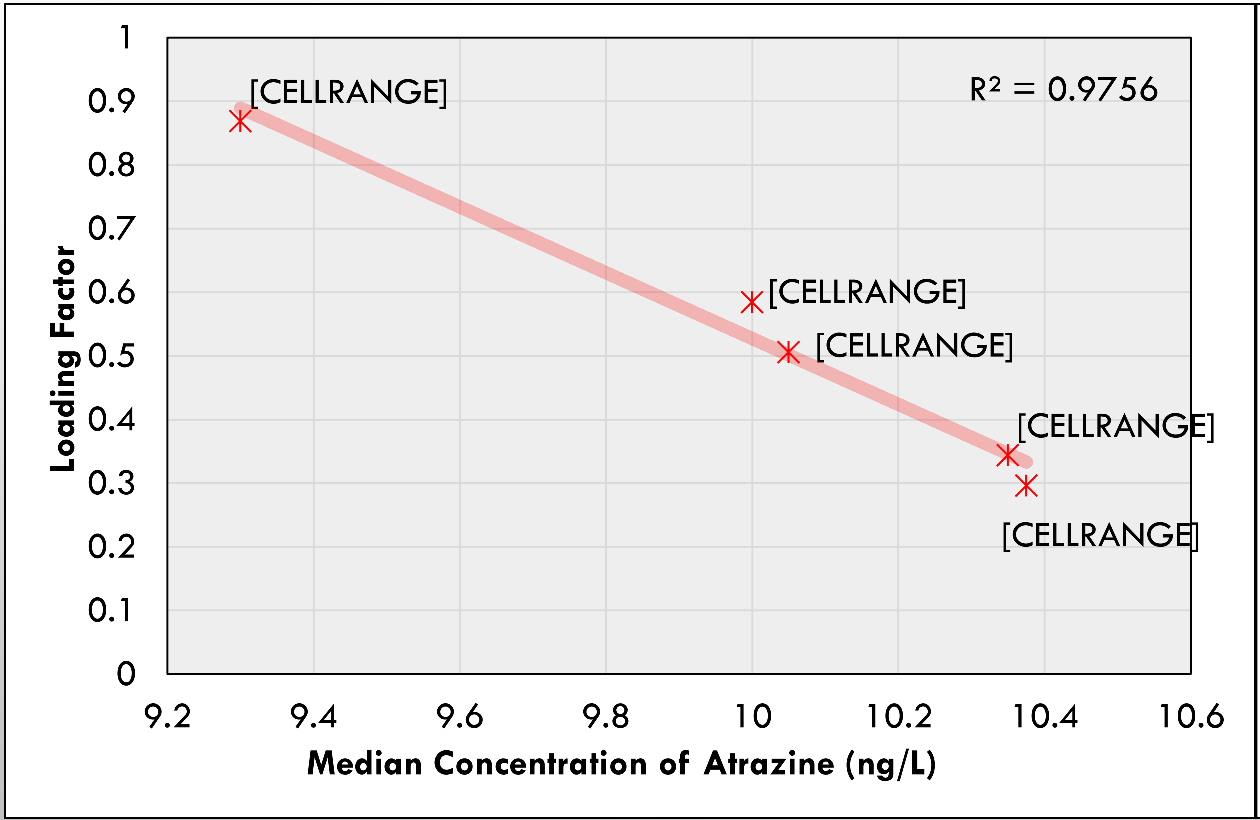


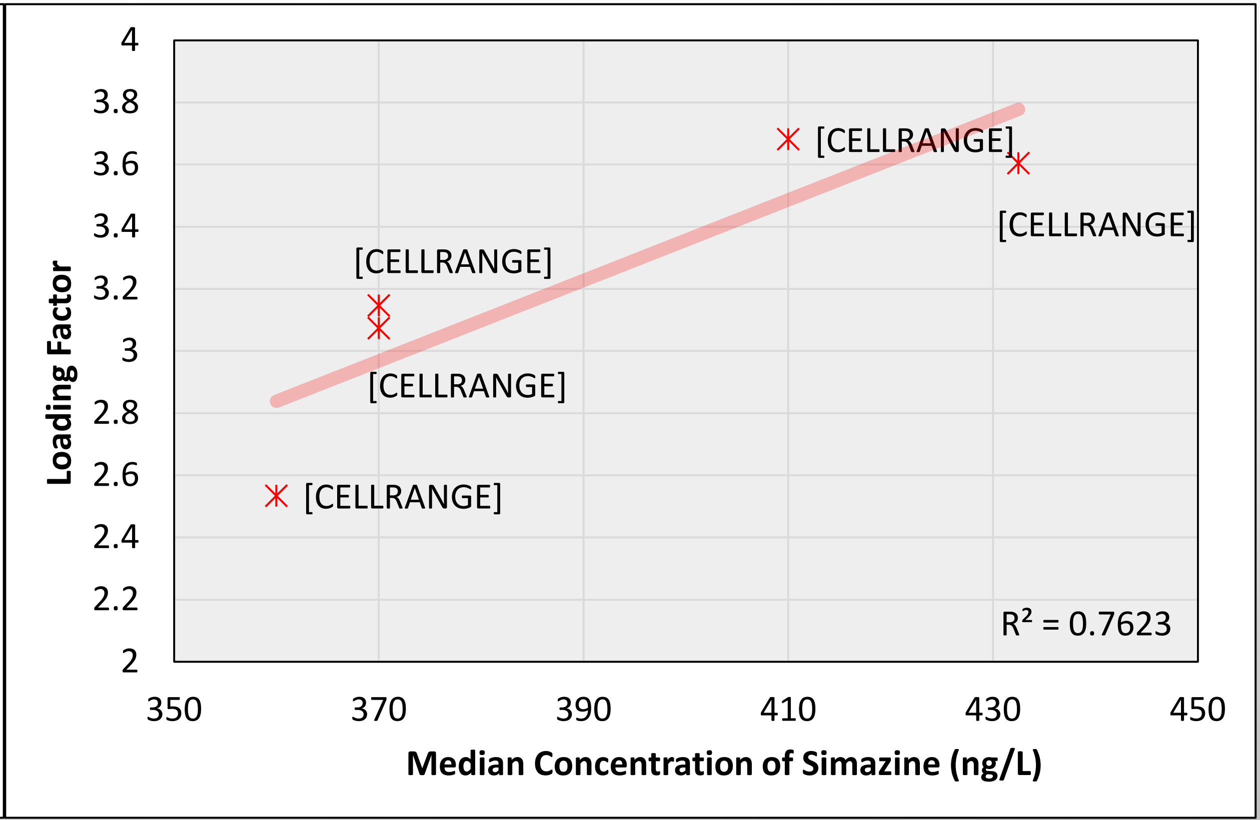
Results: Sub-Watersheds and Land Use Factors

Name	Area (Acre)	LST (in use)/Acre	Domestic Wells/Acre	Fraction of Herbaceous	Fraction of Cultivated	Fraction of Developed
Entire Watershed	165465.41	0.00048	0.022	0.368	0.054	0.079
Little River SW	74878.95	0.00077	0.013	0.431	0.082	0.141
Clear SW	5145.96	0.00058	0.015	0.396	0.022	0.006
Hog SW	43230.52	0.00030	0.039	0.311	0.032	0.025
Dave Blue SW	20136.78	0.00000	0.024	0.437	0.054	0.024



Results: Sub-Watershed Land-Use Loading vs. Pesticide Detections

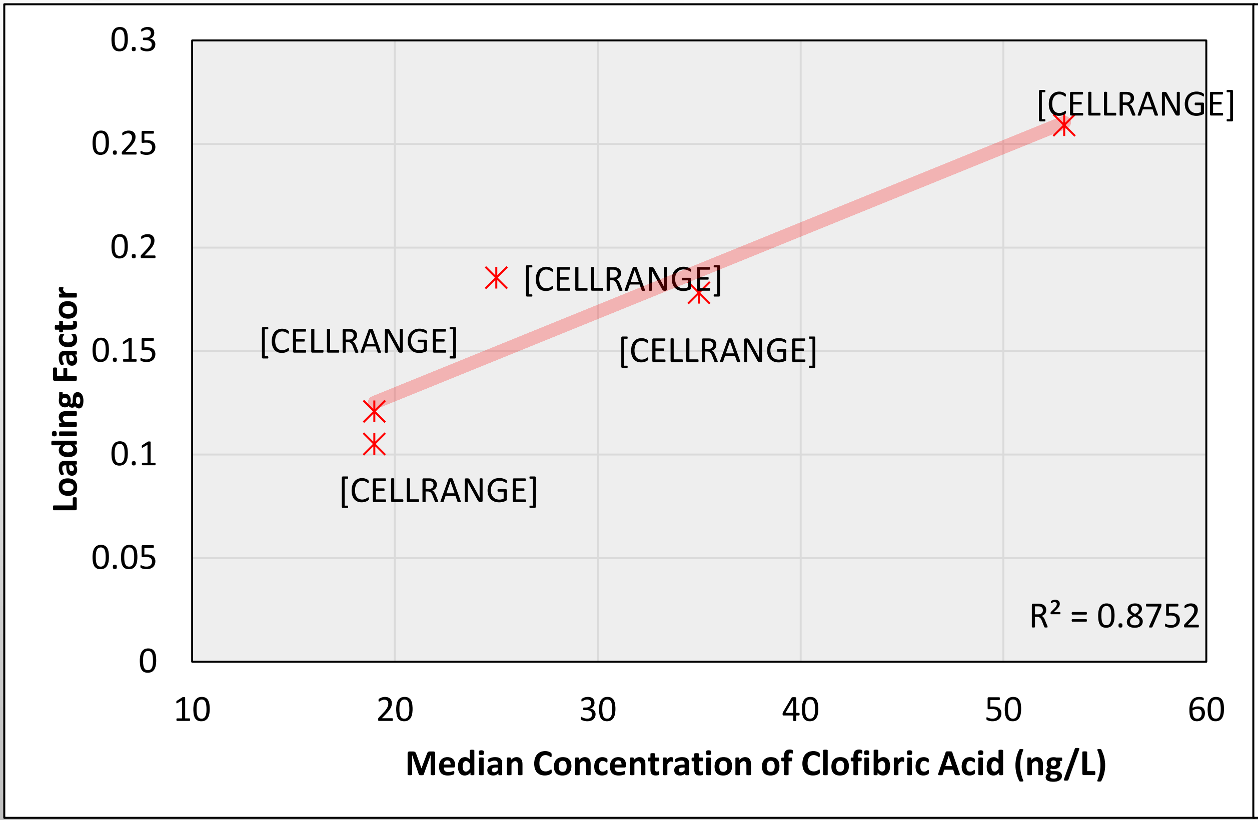


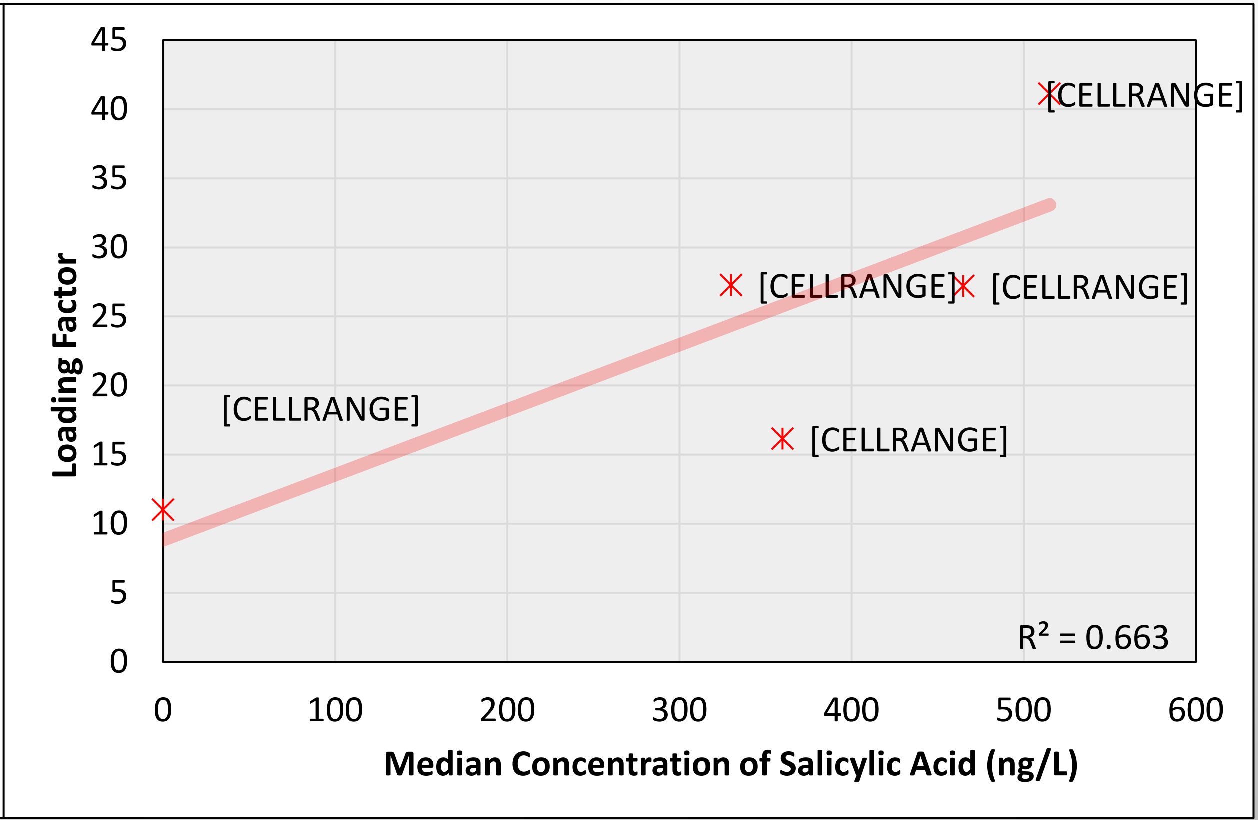


Atrazine = 4.8 C+2 D+0.45 H
R^2 = 0.9756

Simazine = 4.4 C + 0.01 D + 7.7 H
R^2 = 0.7623

Results: Sub-Watershed Land-Use Loading vs. PPCP Detections

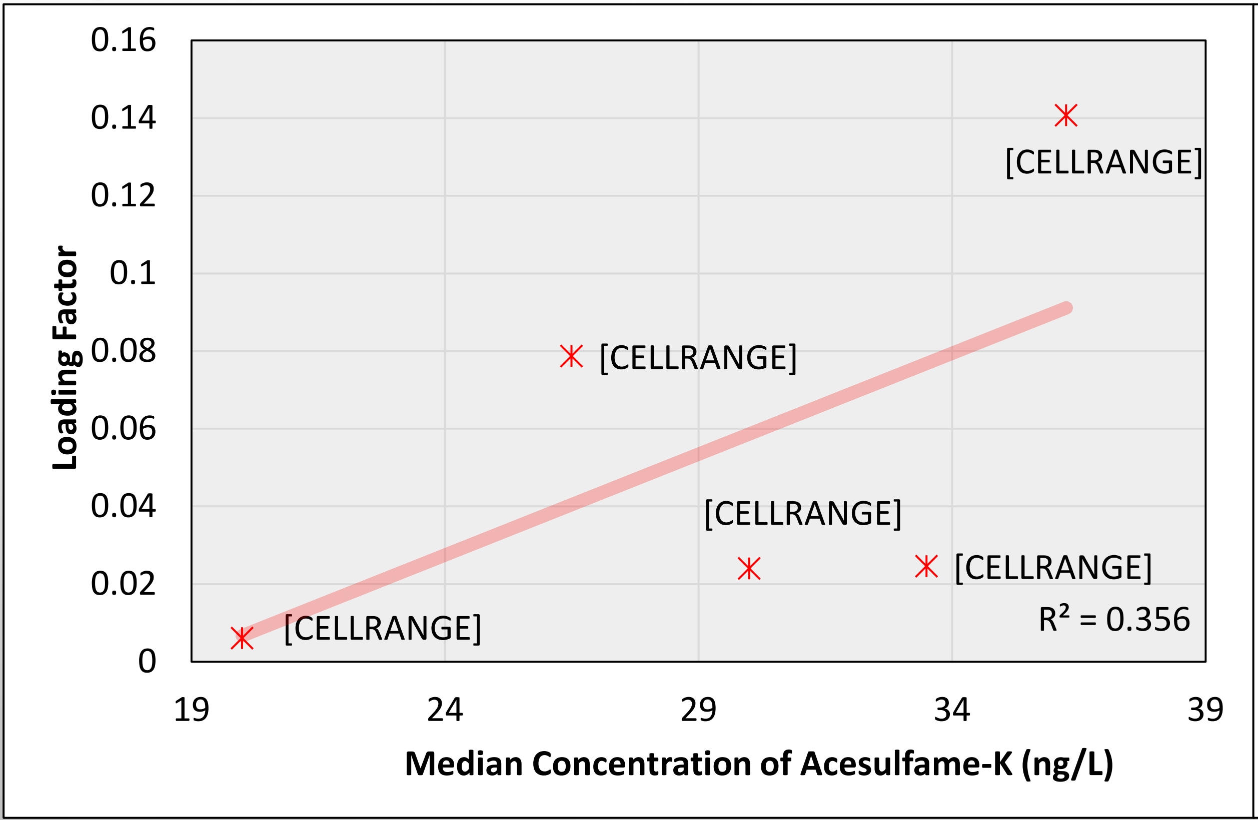


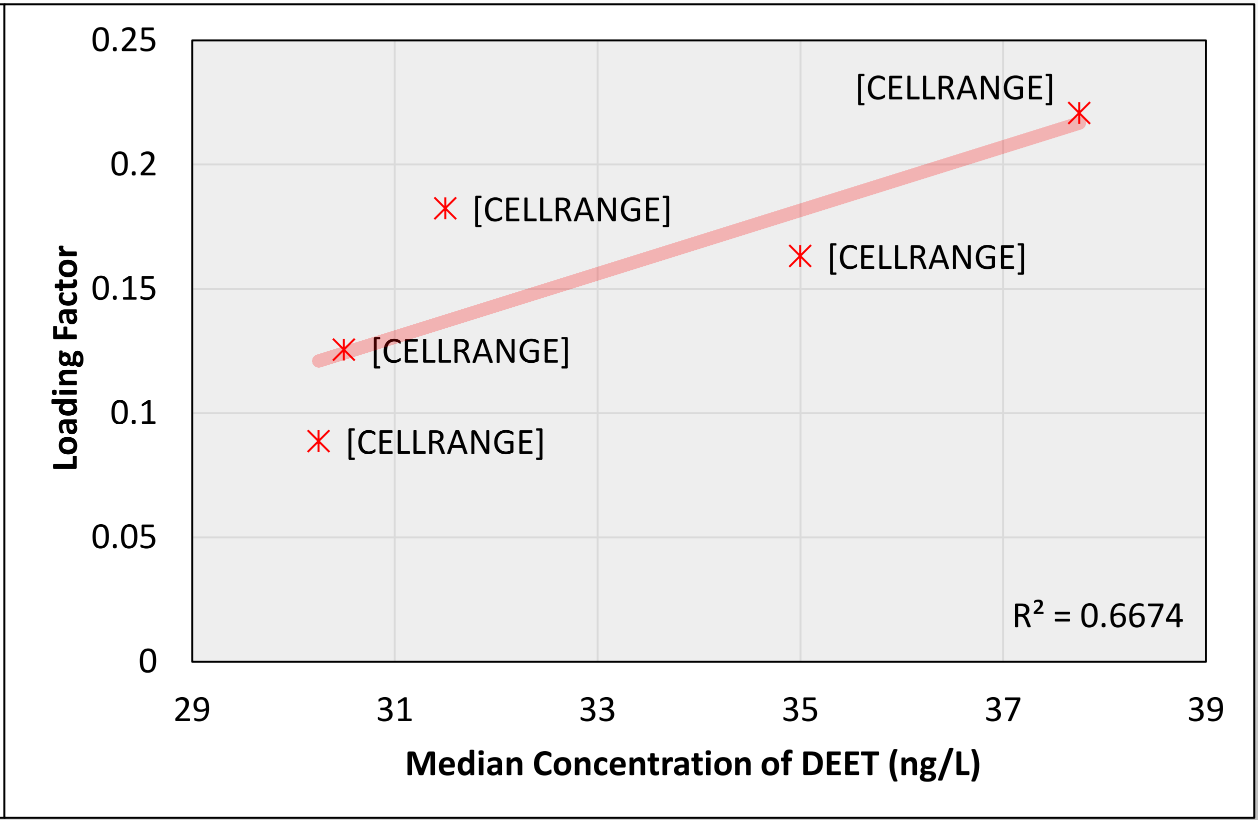


Clofibric Acid = 1 DW + 0.001 D + 3 C
R^2 = 0.8752

Salicylic Acid = 0.001 DW + 1 D + 500 C
R^2 = 0.6630

Results: Sub-Watershed Land-Use Loading vs. Other Detections

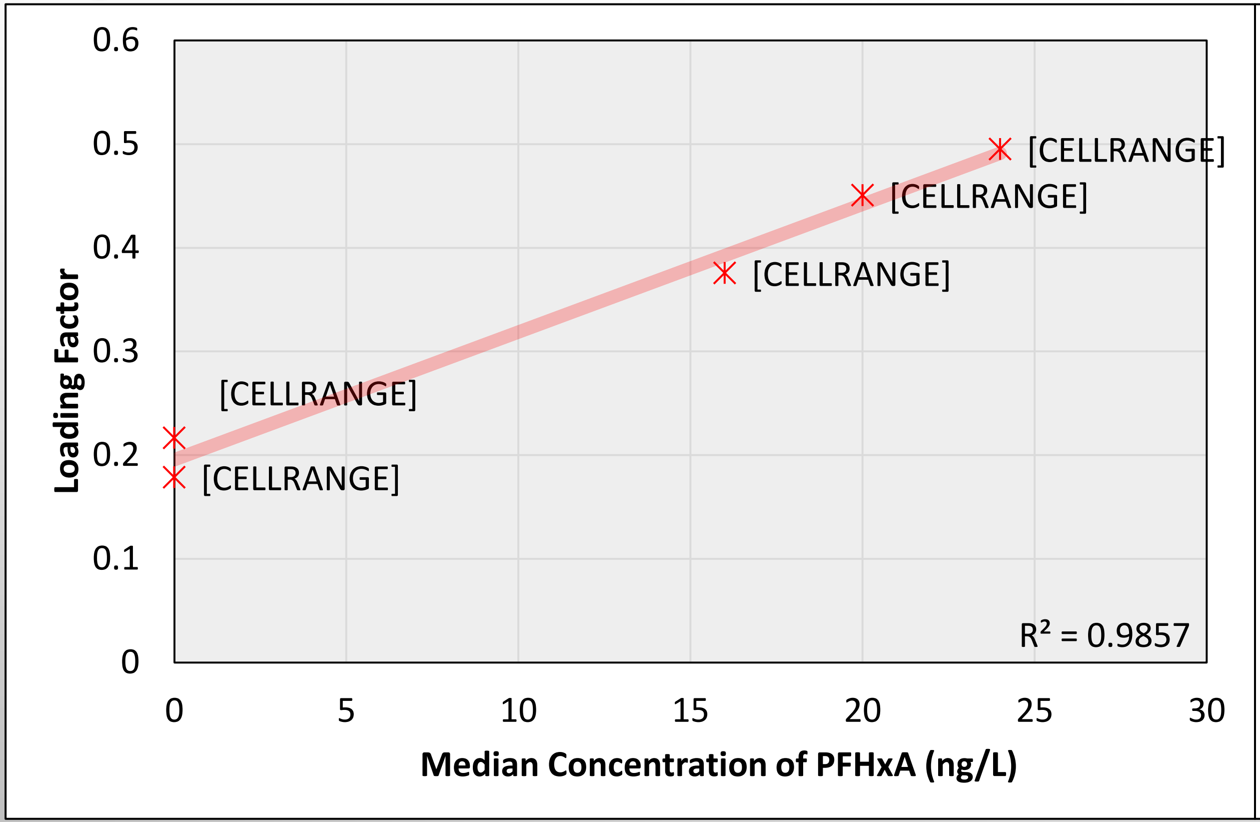


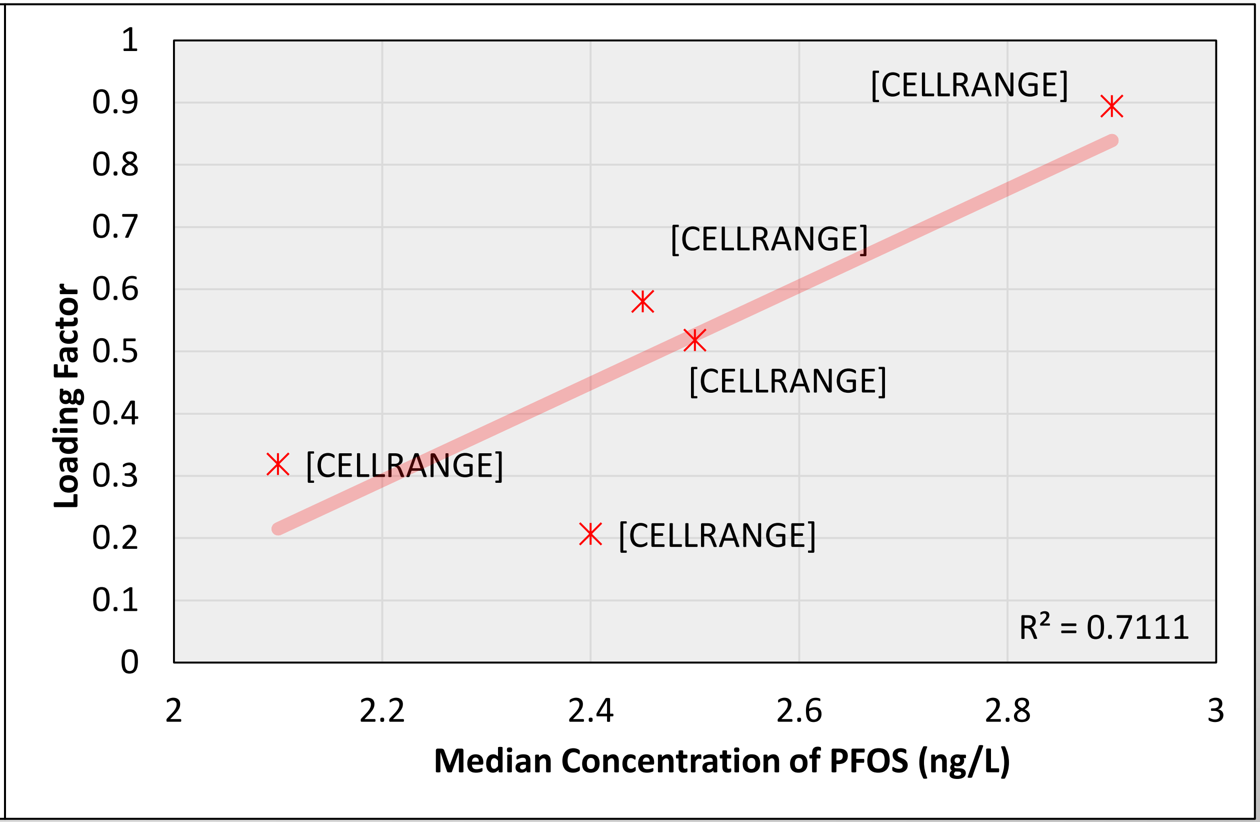


Acesulfame-K = 4 DW + 1.2 D
R^2 = 0.6674

DEET = 0.001 DW + 1 D
R^2 = 0.3560

Results: Sub-Watershed Land-Use Loading vs. Industrial Detections





PFHxA = 0.01 ST + 5 DW + 0.001 D + 4.7 C
R^2 = 0.9857

PFOS = 0.1 ST + 0.1 DW + 1.1 D + 9 C
R^2 = 0.7111

Summary: CEC & Wastewater Reuse in a Regional Water Supply System

- It will take years to **build public acceptance** for a reuse project
- Major **public concern** are PPCPs, specifically hormones
- CEC are present in all waters, **WE > WF > WS > WG > WT**
- Typical water reclamation facility with primary and **secondary clarifiers** will **reduce concentrations and remove a high percentage of CEC**
- Pesticides are present at highest concentrations in WS and WG, but **PPCPs are most toxic** at current environmental concentrations
- Human health standards are only established for a few CEC, continued **work to establish toxicity levels and health advisory levels**
- **Potable reuse of municipal wastewater is feasible and can be safe**

Stay tuned…study of Bartlesville, OK underway and will be presented in the future