

Risk-based Prioritization of Contaminants of Emerging Concern Detected in Great Lakes Tributaries, 2010-2018.

Daniel L. Villeneuve¹, Erin M. Maloney², Matthew A. Pronschinske³, Austin Baldwin⁴, Steve Corsi³, Kimani Kimbrough⁵, Michael Edwards⁵, John Frisch⁶, Stephanie Hummel⁷, Amber Bellamy⁷, Natalia Vinas⁸

¹ US EPA, Great Lakes Toxicology and Ecology Division, Duluth, MN, USA

² University of Minnesota-Duluth, Duluth, MN, USA

³ US Geological Survey, Upper Midwest Water Science Center, Middleton, WI, USA

⁴ US Geological Survey, Idaho Water Science Center,

⁵ National Centers for Coastal Ocean Science, NOAA National Ocean Service, Bethesda, MD, USA

⁶ General Dynamics Information Technology, Duluth, MN, USA

⁷ US Fish and Wildlife Service, Ecological Services, Bloomington, MN, USA

⁸ US Army Corps of Engineers, Engineer Research and Development Centre, Vicksburg, MS, USA

The contents of this presentation neither constitute, nor necessarily reflect US EPA policy.

- Focus Area 1: Toxic Substances and Areas of Concern
 - Goal 5: The health and integrity of wildlife populations and habitat are protected from adverse chemical and biological effects associated with the presence of toxic substances in the Great Lake Basin.
 - Increase knowledge about contaminants in Great Lakes fish and wildlife
 - Identify **emerging contaminants** and assess impacts on Great Lakes fish and wildlife

Great Lakes
RESTORATION



Prioritization:

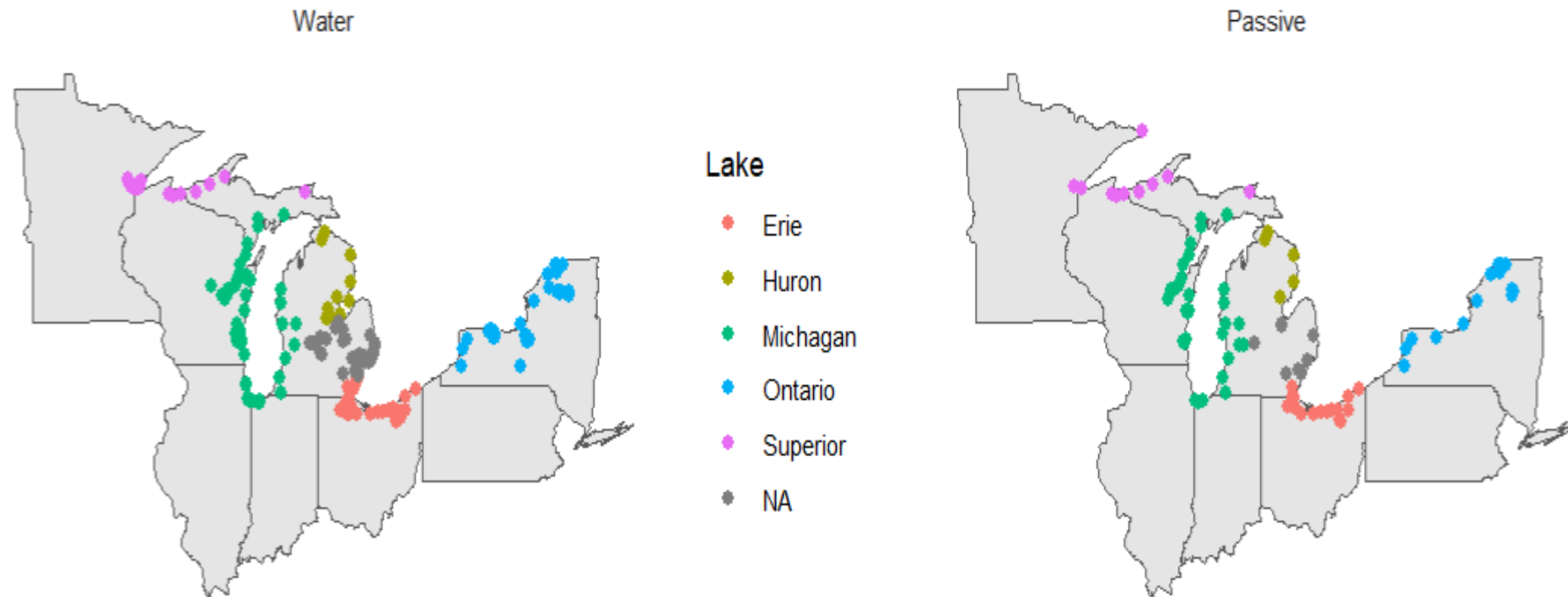
Which chemical(s) are of potential concern for impacts on Great Lakes ecosystems?

- Prioritization has been conducted on numerous sub-sets (e.g., certain years, chemical classes, locations, etc.).
 - Pronschinske et al. – pharmaceuticals [05.11.07]
 - Baldwin et al. – sediment [02.04.17]
 - Maloney et al – Milwaukee [05.06.02]
 - Corsi et al. – PFAS [05.06.15]
 - Multiple peer reviewed publications
- Present study takes a more global view across all water and passive samples collected over the eight year monitoring effort.



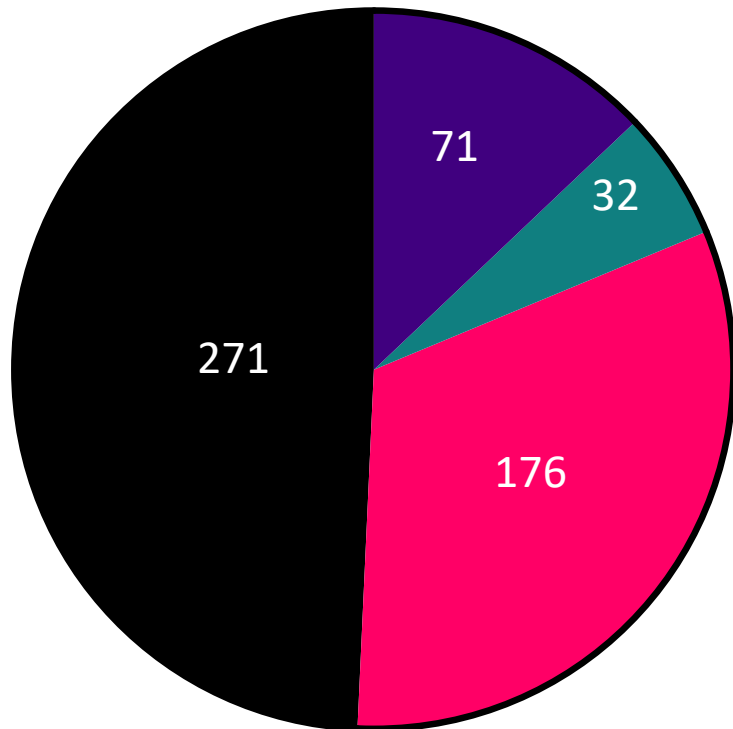
Chemicals Monitored

- 2010-2018
- 830 unique compounds
- Chemical Classes: antimicrobial disinfectants, antioxidants, detergent metabolites, dyes/pigments, fire retardants, flavours and fragrances, fuels, hormones, multi-use, PAHs, pesticides, pharmaceuticals, and personal care products (PPCPs), plastics additives, solvents, and sterols.
- Uneven coverage – some intensively sample areas, some sparsely sample



Chemicals detected

Out of 830 monitored, 550 were detected in grab/composite and/or passive samples



- 49.27% Pesticides
- 32.00% PPCPs
- 5.82% PAHs/Fuels
- 12.91% Other
(Industrial, Waste Indicators)

**463 detected in
grab/composites**

278 detected from
passive samplers

(191 detected in both)

Total=550

Putting concentrations into context

Risk-based prioritization

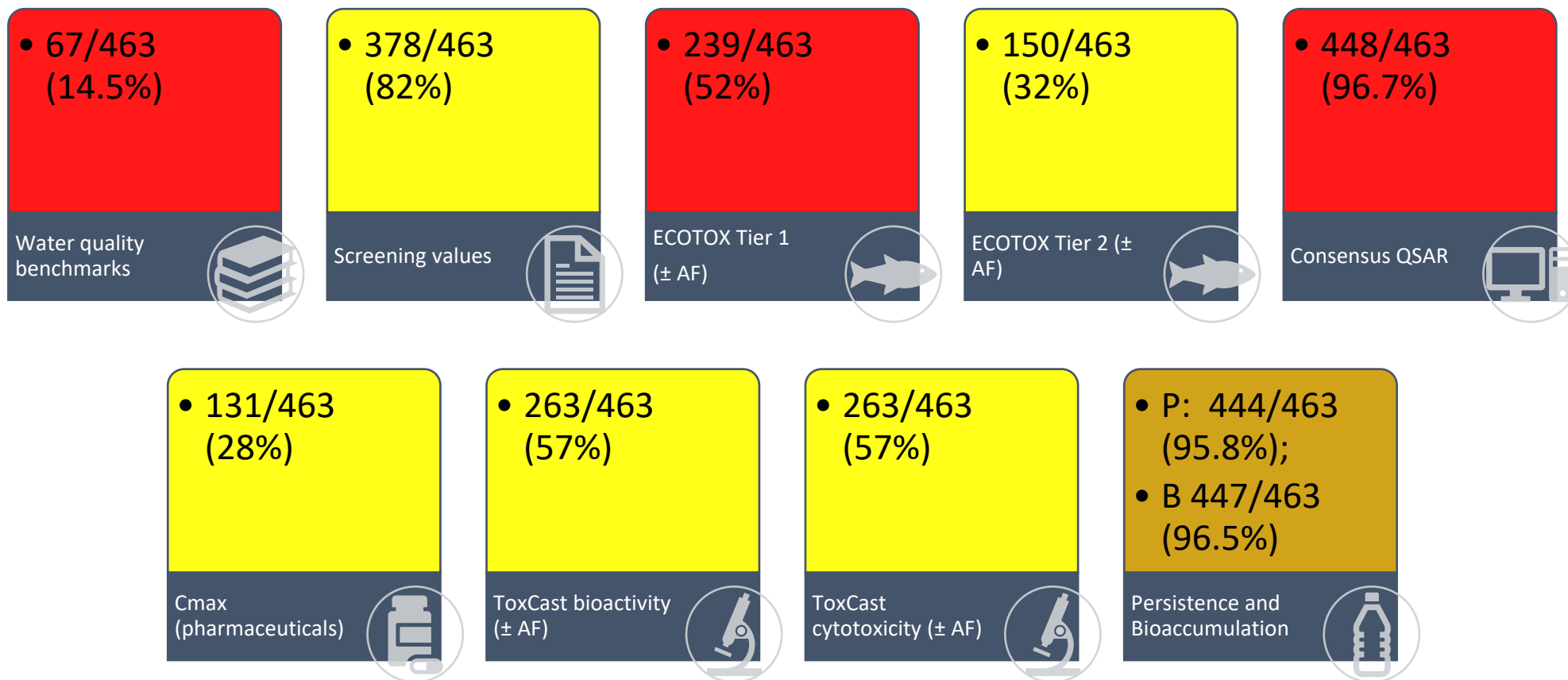
$$\text{Toxicity Quotient } (TQ)_{x,n} = \frac{[x]_{max}}{\text{toxicity or bioactivity benchmark concentration}_n}$$

- Used maximum concentration detected across all samples
- Concentration distribution, sampling effort, and site-specificity - next tier



Putting concentrations into context

- Eight types of toxicity/ bioactivity benchmarks considered
- Traditional to NAMs
- Apical adverse Effects, not necessarily adverse
- Indicators of persistence and/or bioaccumulation

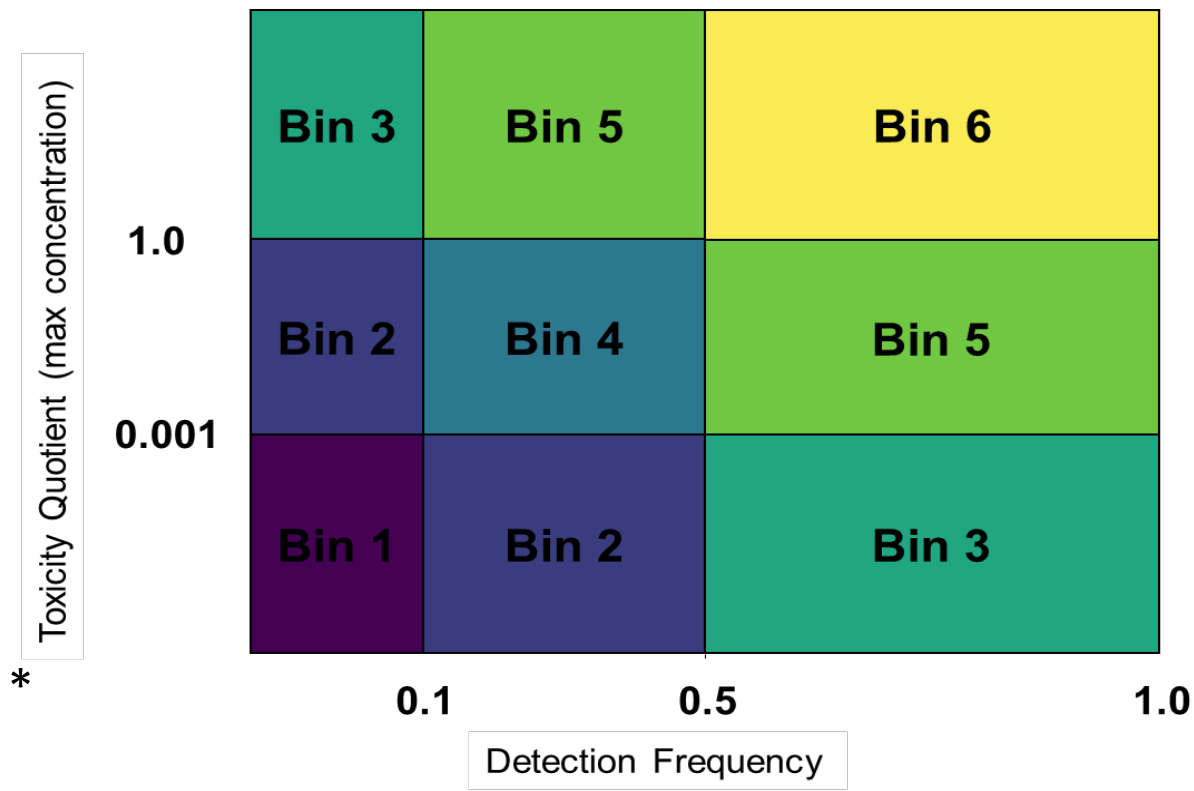


Hazard benchmarks considered and coverage*

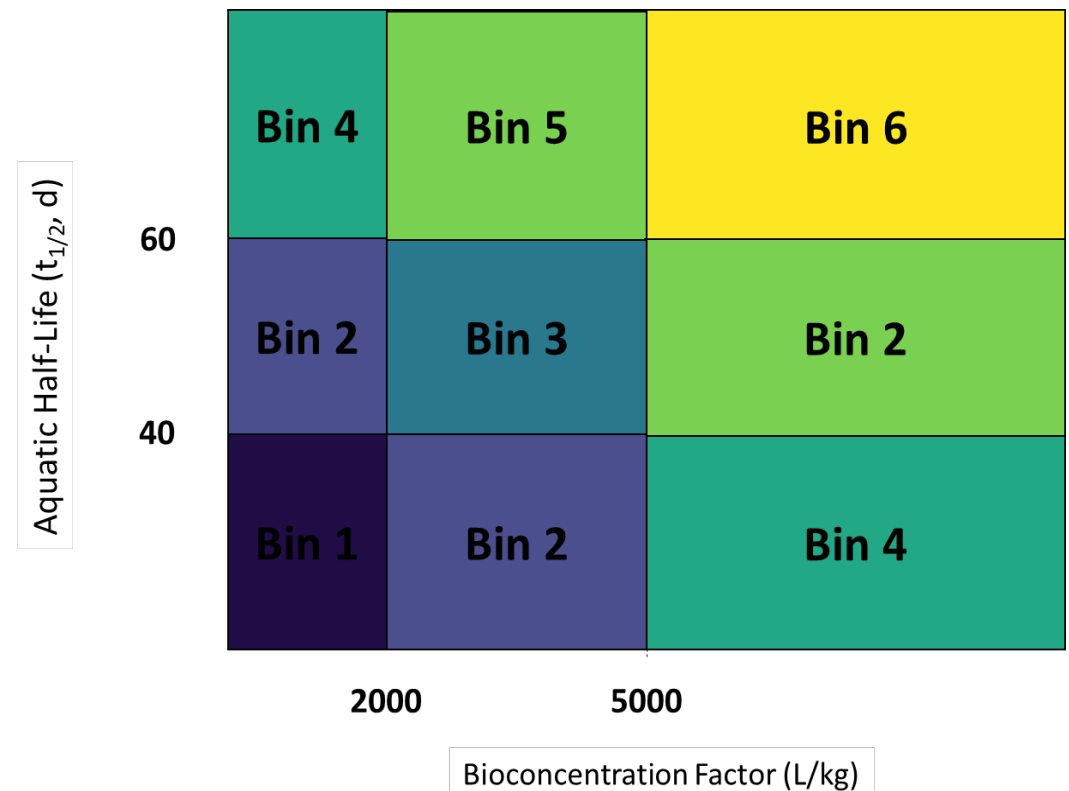
**Coverage listed is for chemicals detected in water; 87 additional compounds detected via passive samplers not considered here.*

Dimensional prioritization (within each line of evidence)

Risk-based prioritization



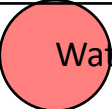
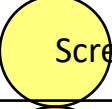

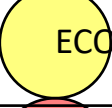
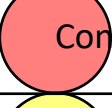
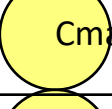


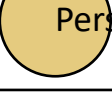
P/B considerations



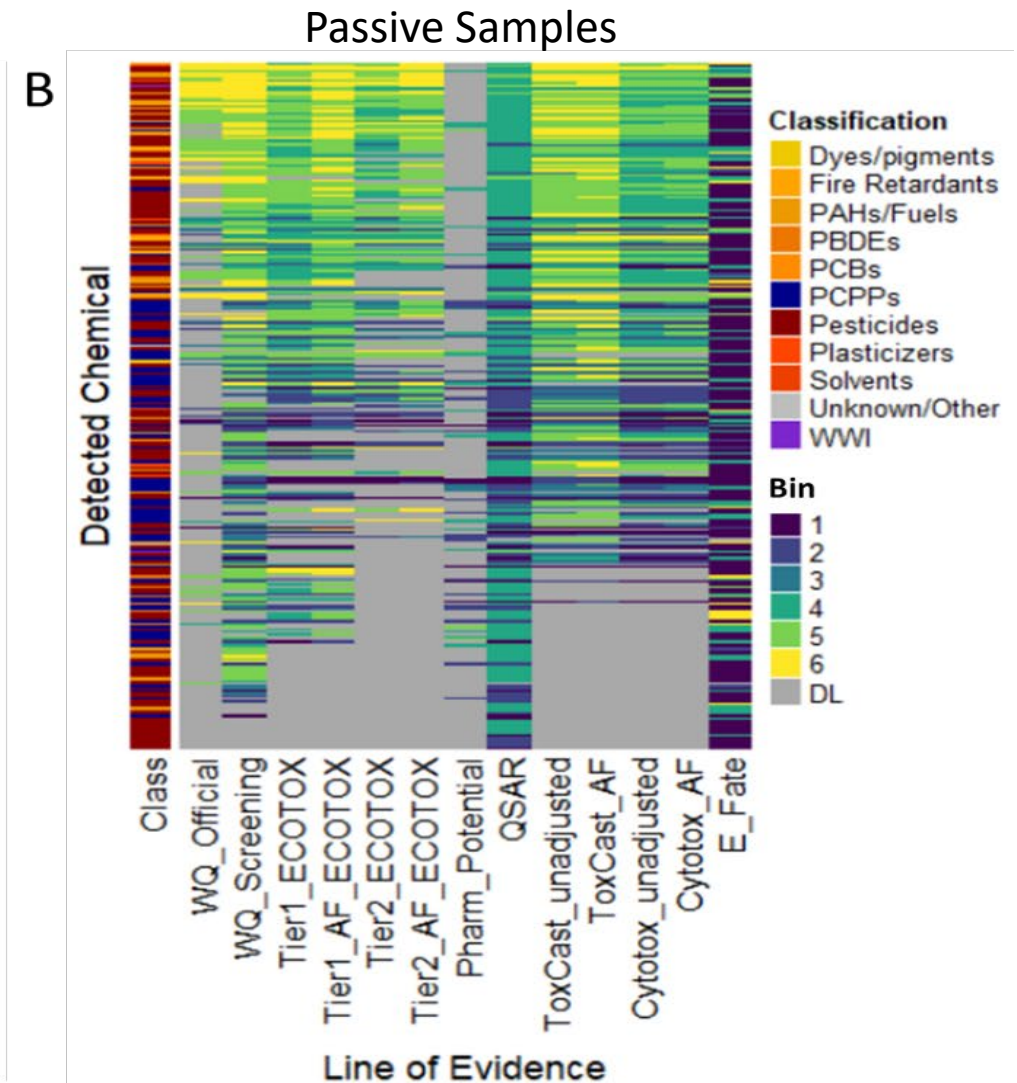
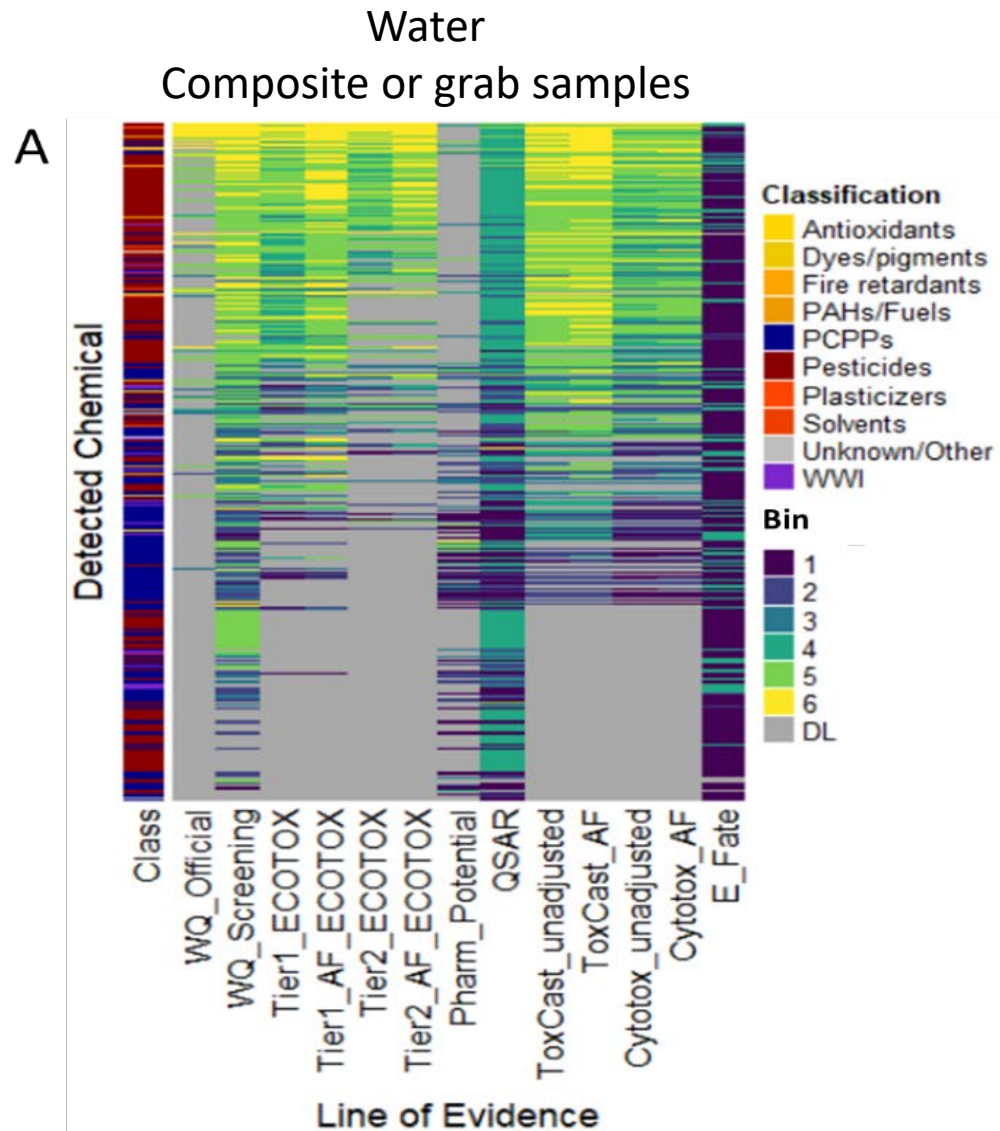
*TQ cut-off for bins vary by benchmark type

Overall prioritization

- Greater median bin score > greater concern / priority

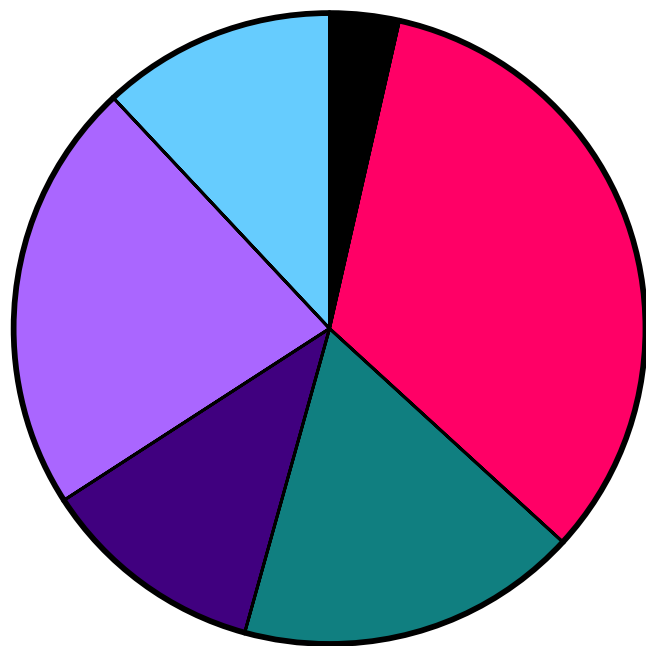
Lines of evidence	Chemical 1 Bin scores	Chemical 2 Bin scores	Chemical Bin scores
 Water quality benchmarks			
 Screening values			
 ECOTOX Tier 1 (± AF)			
 ECOTOX Tier 2 (± AF)			
 Consensus QSAR			
 C _{max} (pharmaceuticals)			
 ToxCast bioactivity (± AF)			
 ToxCast cytotoxicity (± AF)			
 Persistence and Bioaccumulation			
MEDIAN BIN SCORE			

Overall prioritization



Risk-based Prioritization

Based on median bin score



3.55% Bin 6
33.26% Bin 5
17.52% Bin 4
11.53% Bin 3
22.17% Bin 2
11.97% Bin 1

High Priority (37%)

- A measured concentration exceeded one or more hazard/fate thresholds
- Frequently detected among the samples collected

Tris(dichloroisopropyl)phosphate	Naled
Tris(2-butoxyethyl)phosphate	Diuron
Pyrene	Acetochlor
Fluoranthene	Diflubenzuron
Simazine	Chlorimuron-ethyl
Atrazine	Tolyltriazole
Imidacloprid	Caffeine
Metribuzin	Bisphenol A

Median bin
score 6

Low Priority (34%)

- Maximum concentration generally did not exceed benchmark(s)
- Infrequently detected among the samples collected

Median bin
score 1

Examples:

Isoborneol, Epitestosterone, Nordiazepam, Nevirapine, Abacavir, Sulfadimethoxine, Alprazolam, Quetiapine, Oxaprozin, Oseltamivir, Diazepam (valium), Sumatriptan, Indapamide, Fenofibrate, Amphetamine, Penciclovir

Adding consideration of information richness

- Extent of the evidence was considered to determine whether:

Lines of Evidence for Hazard Evaluation	Extent of sampling (#'s, sites)	Priority For.....
Multiple (e.g., ≥ 6)	>200 samples >10 locations	Detailed risk assessment / management action
Limited	Extensive	Additional hazard characterization
Extensive	Limited	Additional monitoring
Limited	Limited	Additional information gathering

Candidates for Detailed Risk Assessment*

- Multiple lines of available evidence (≥ 6)
- Higher median bin scores (5-6)
- Frequently sampled ($\geq 75\%$ of max) and detected ($\geq 50\%$)

*Deeper dive into the details

- Which benchmarks exceeded
- Quality/reliability of BMs exceeded
- At which locations
- Etc.

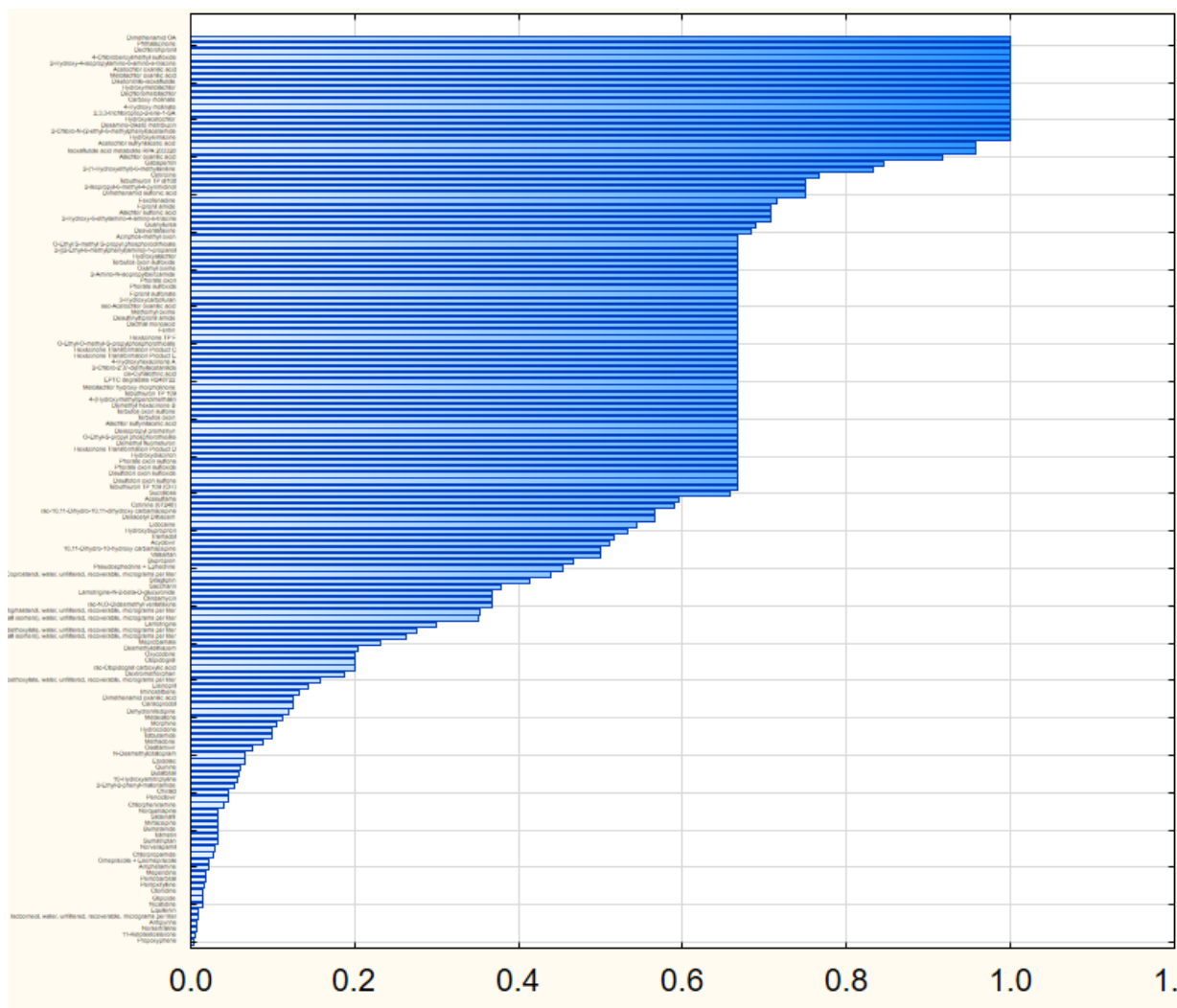
Water Composite or grab samples

Category (9)	Compounds (21)
Antimicrobials (1)	triclosan
WW indicator (2)	p-cresol, caffeine
Fire retardants (3)	tributyl phosphate, tris(dichloroisopropyl)phosphate, tris(2-butoxyethyl)phosphate
Multi-use (1)	1,4-dichlorobenzene
PAHs (4)	Pyrene, fluoranthene, benzo[a]pyrene, phenanthrene
Pesticides (5)	atrazine, metolachlor, dichlorvos, carbaryl, pentachlorophenol
PPCPs (1)	venlafaxine
Plasticizers (3)	triphenyl phosphate, bis(2-ethylhexyl)phthalate, bisphenol A
Solvent (1)	isophorone

Information rich, low priority

- Sampled at high frequency
 - Multiple benchmark types available
 - Low median bin scores
- Pesticides
 - Chlorpyrifos
 - Diazinon
 - PPCPs
 - Paroxetine
 - Warfarin
 - Norethindrone
 - Codeine

Prioritize for hazard data collection



146 chemical for which no WQ benchmarks, ECOTOX, or ToxCast data were available

Pesticide degradates	69
PPCPs	66
Detergent metabolites	4
Flavors/fragrances	1
Hormones	2
Sterols	2
Other	2

Prioritized for hazard data collection based on detection frequency

Conclusions

- Priority chemicals have been identified based on:
 - Eight-year interagency CEC monitoring effort
 - Nine lines of evidence
 - QSAR, in vitro bioactivity, in vivo toxicity, chem properties
- There is a small proportion of the prioritized chemicals for which information availability is likely high enough to support a risk assessment.
- Among the ≈170 prioritized CECs, deeper dive into the type of benchmarks exceeded and sampling intensity will guide collection of additional information.
- At present, around 570 of the 830 monitored compounds for which there was currently no evidence of potential ecological risk across the G.L. tributaries sampled.



Acknowledgements

- **US Fish and Wildlife Service** (Bloomington, MN)
 - St. Cloud State University (St. Cloud, MN)
 - Central Michigan University (Mount Pleasant, MI)
- **US Geological Survey** (offices in La Crosse and Middleton, WI, and Mounds View, MN)
- **US Environmental Protection Agency**
 - **ORD/** (offices in Athens, GA, Cincinnati, OH, and Duluth, MN)
 - **Great Lakes National Program Office** (Chicago)
- **Army Corps of Engineers (ACOE)/Engineer Research and Development Center (ERDC)** (Vicksburg, MS)
- **National Oceanic and Atmospheric Administration/Center for Coastal Monitoring and Assessment** (Silver Spring, MD)

