COG's Monitoring Workshop

Professor Stanley B. Grant
Dept. of Civil and Environmental Engineering
Occoquan Watershed Monitoring Laboratory
Virginia Tech
(Shantanu Bhide & Emily Parker did the work)

The OWML has a new website: https://www.owml.cee.vt.edu/

Outline

- Monitoring: why and at what scale?
- Example: Mapping out sodium sources in the Occoquan Reservoir
- Proposed next steps for watershed monitoring
- NSF Engineering Research Center (ERC) Workshop

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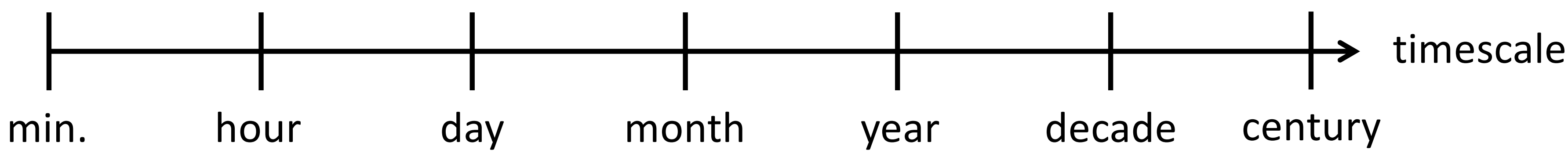
We Monitor to Detect/Manage Water Supply (and Ecosystem) Disruptions



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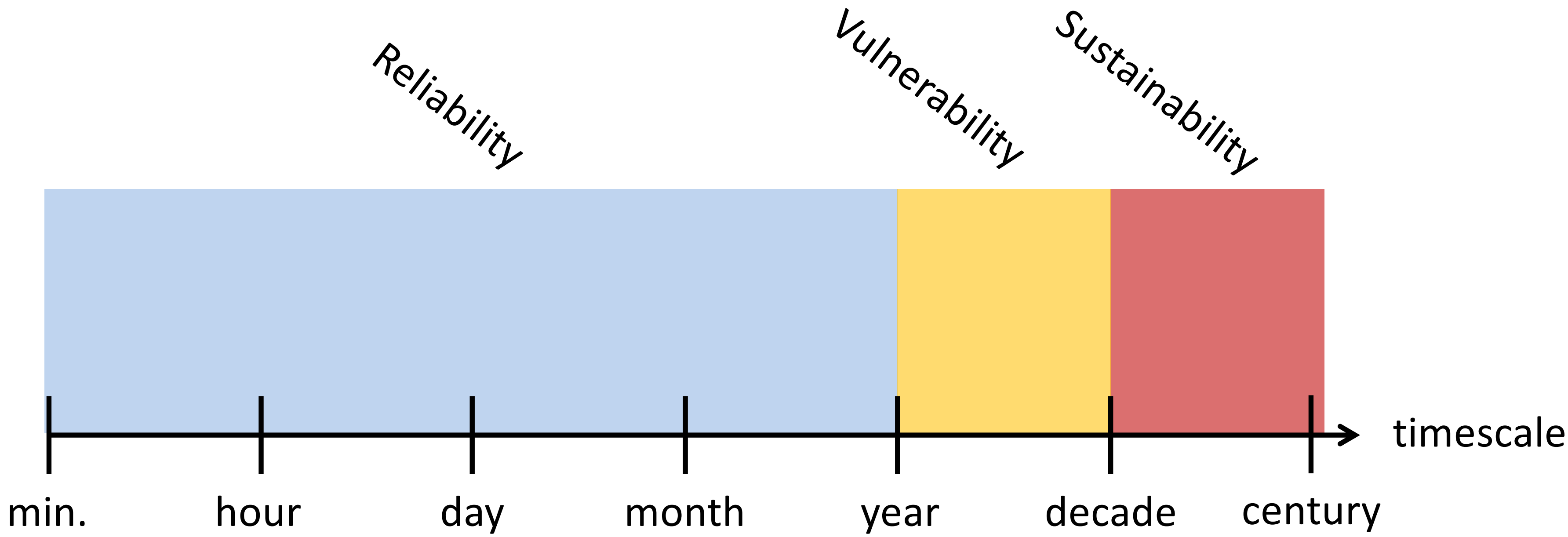

Padowski, J.C., Gorelick, S.M., Thompson, B.H., Rozelle, S., Fendorf, S. (2015) "Assessment of human-natural system characteristics influencing global freshwater supply vulnerability" *Environ. Res. Letters*, 10(10), 204014.

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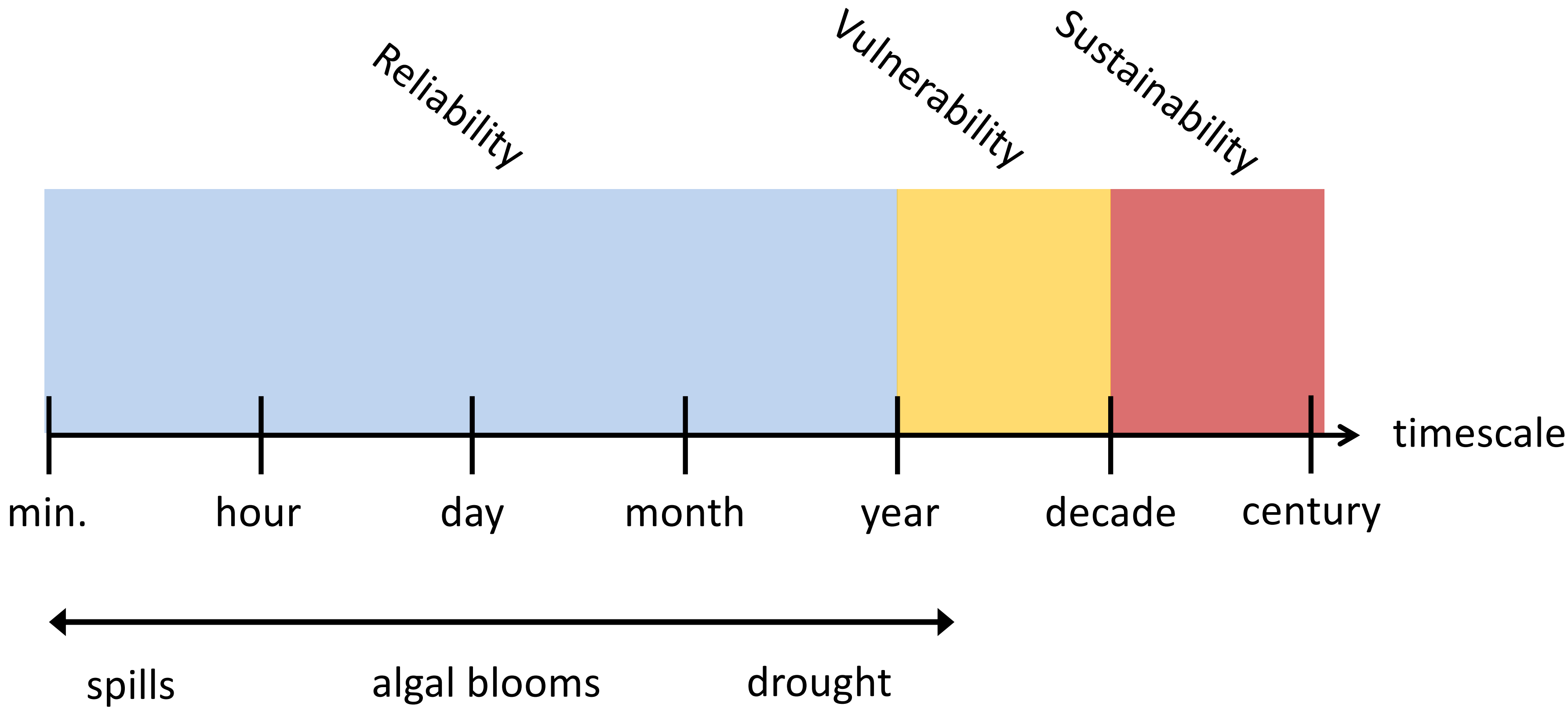

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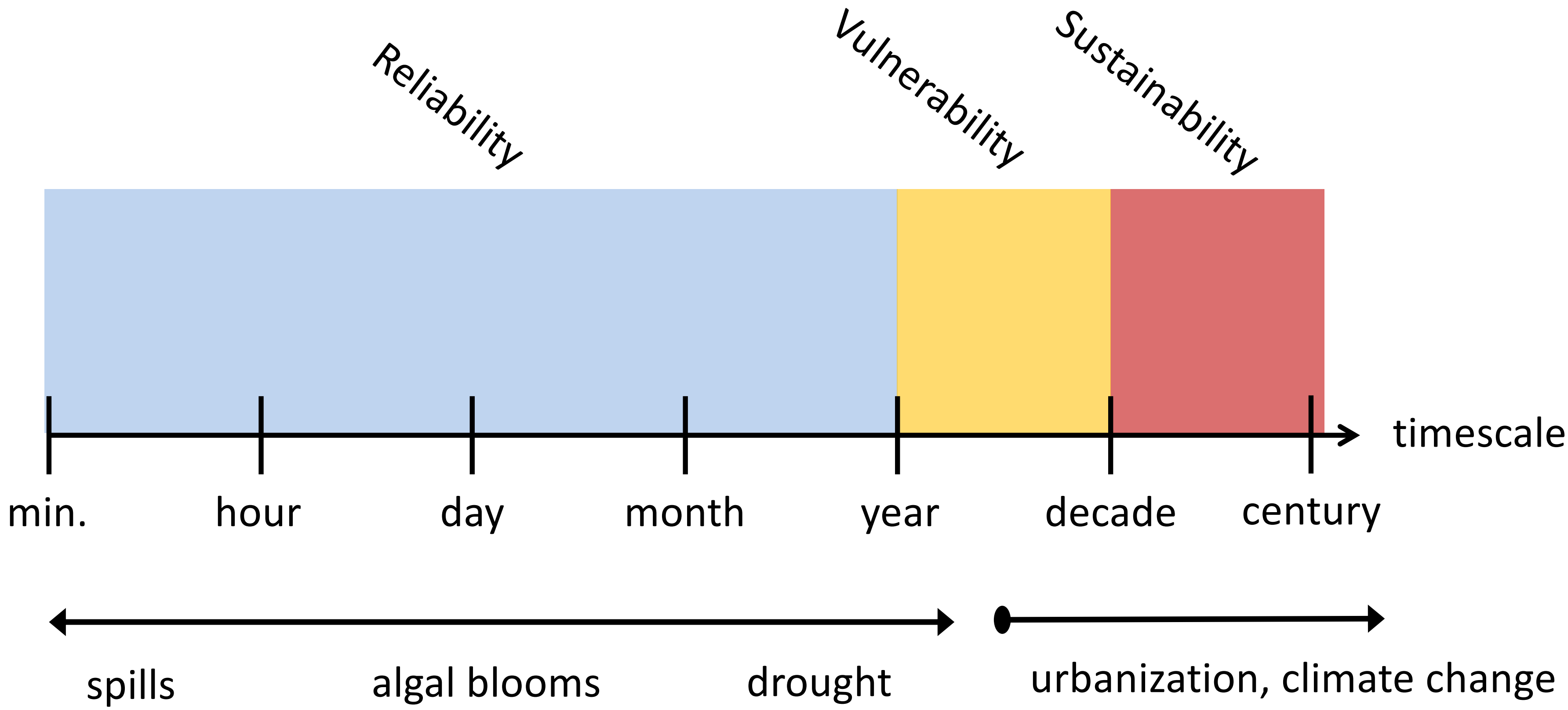

Grant et al., (2012) "Taking the 'waste' out of 'wastewater' for human water security and ecosystem system sustainability" *Science* 337 681, doi:10.1126/science.1216852

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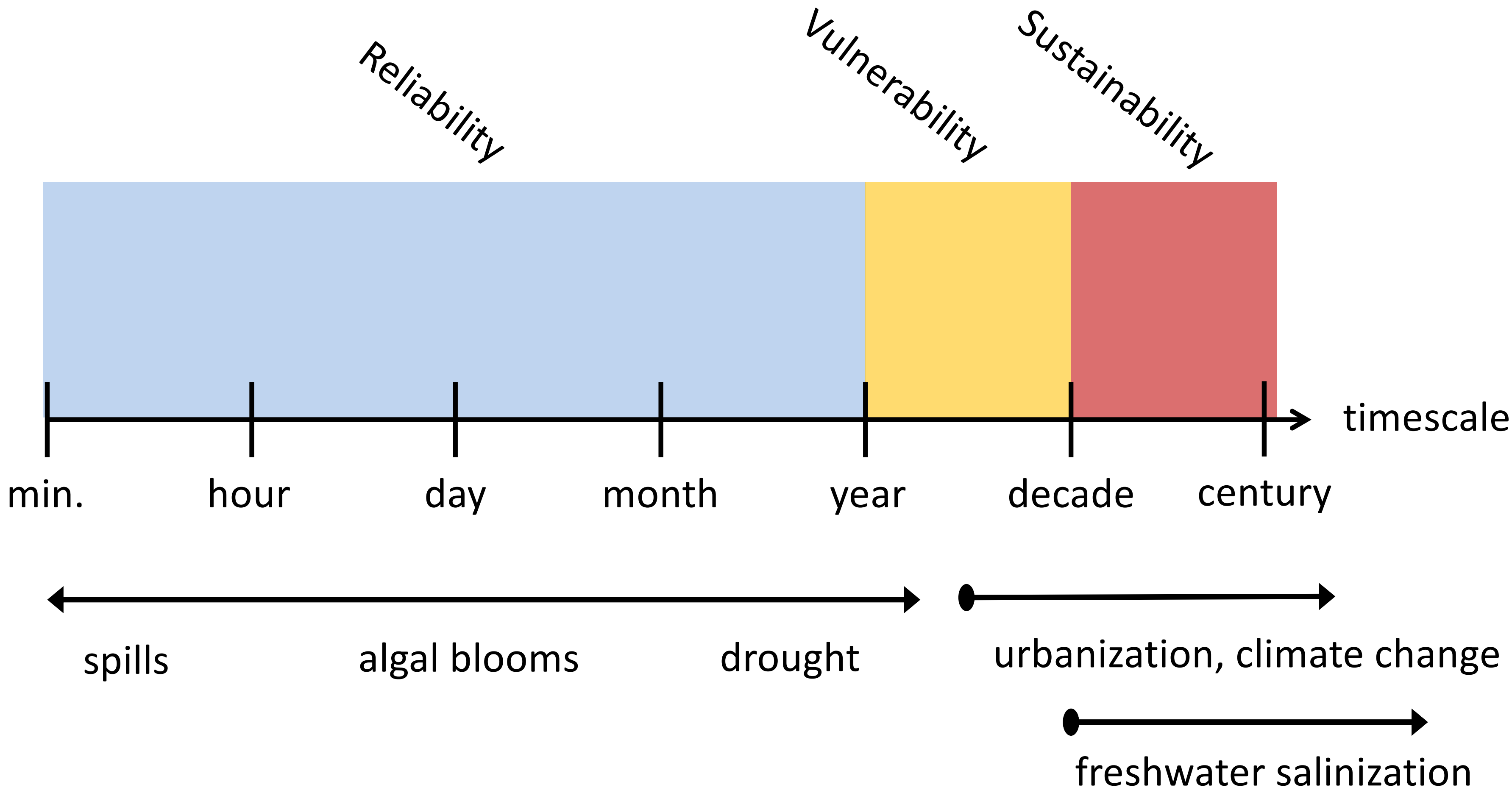

Kaushal, S.S., Likens, G.E., Pace, M.L., Utz, R.M., Haq, S., Gorman, J., Grese, M. (2018) "Freshwater salinization syndrome on a continental scale" *Proc. Nat. Acad. Sci. USA*, doi:10.1073/pnas.1711234115

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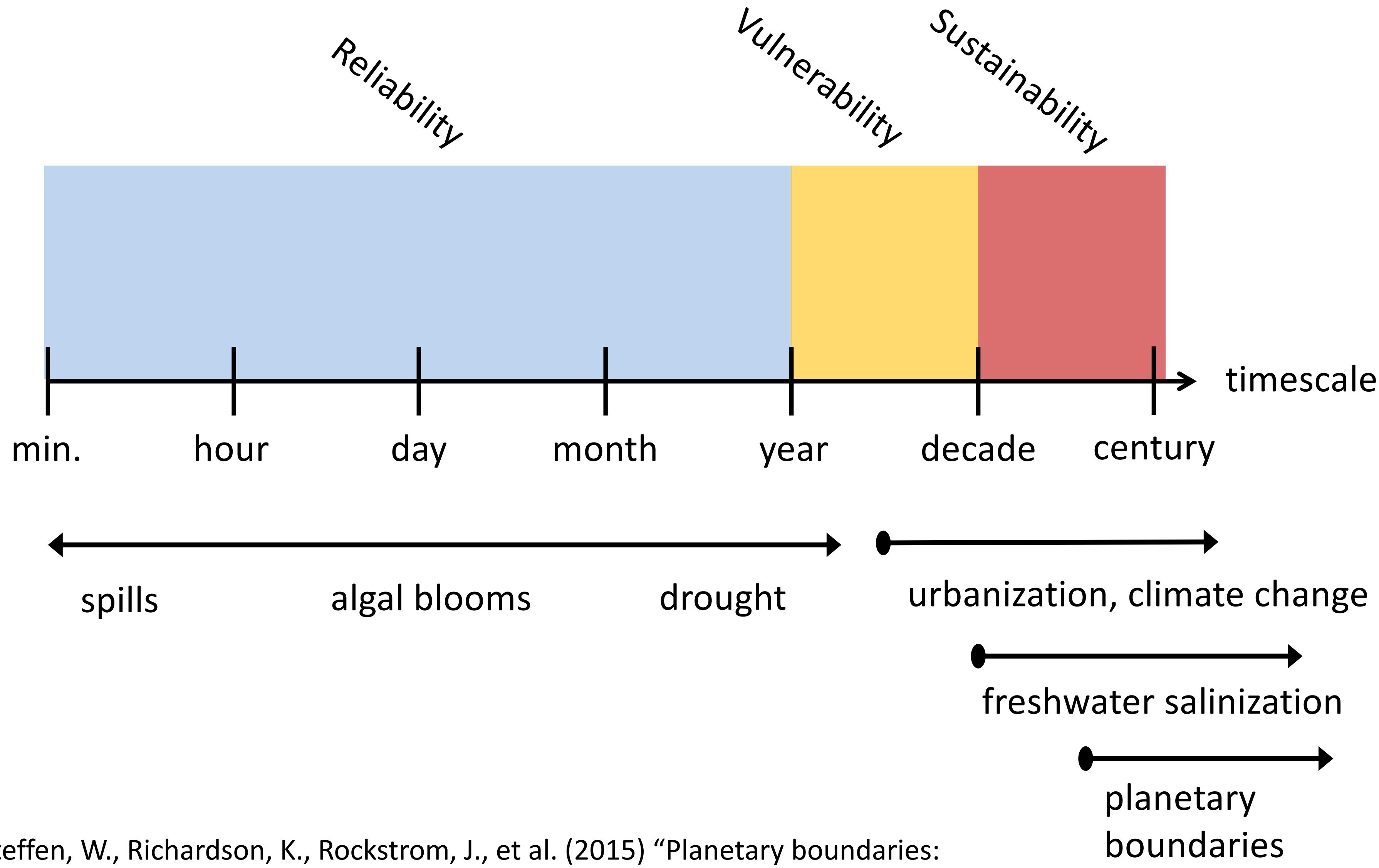
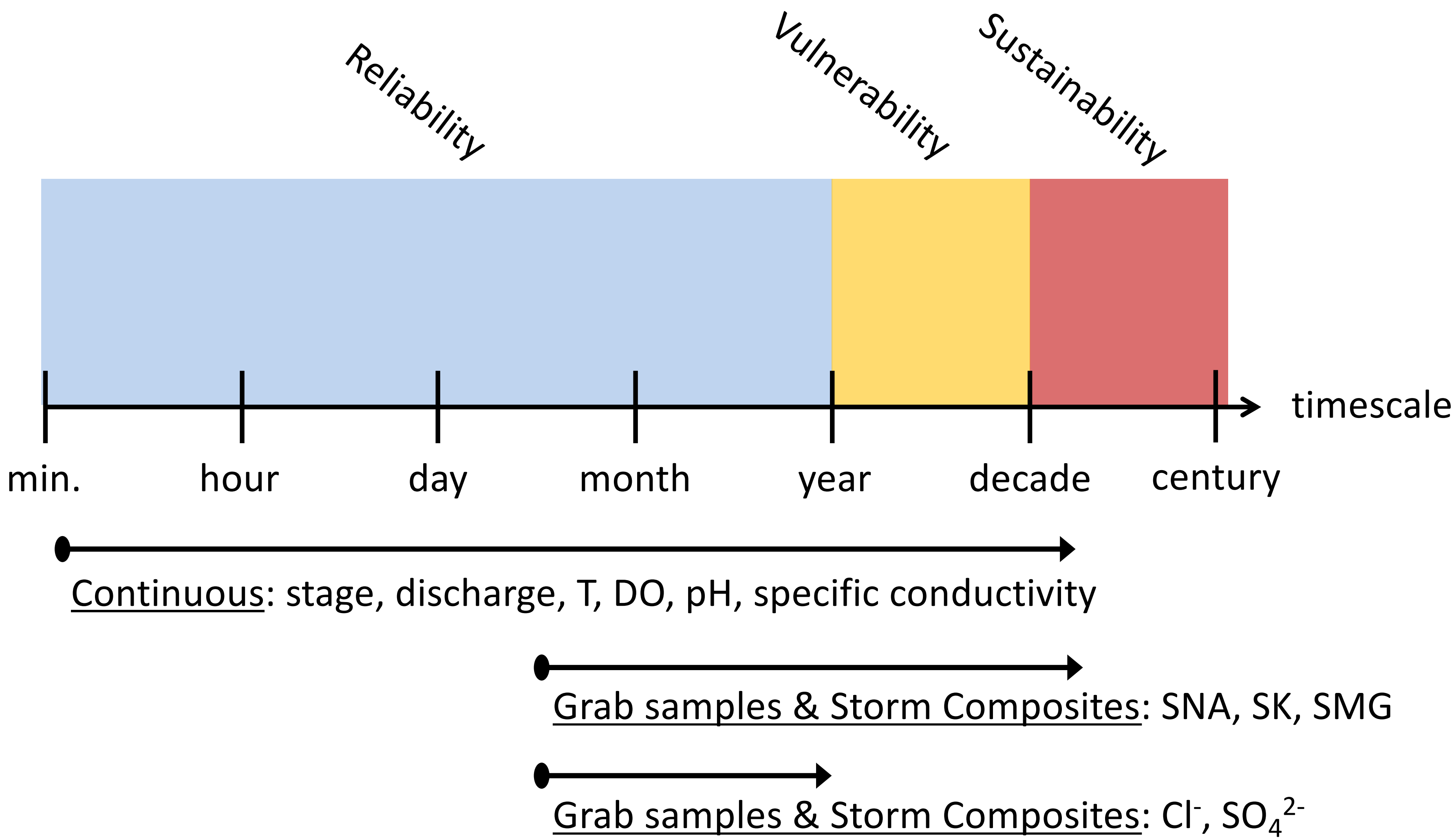
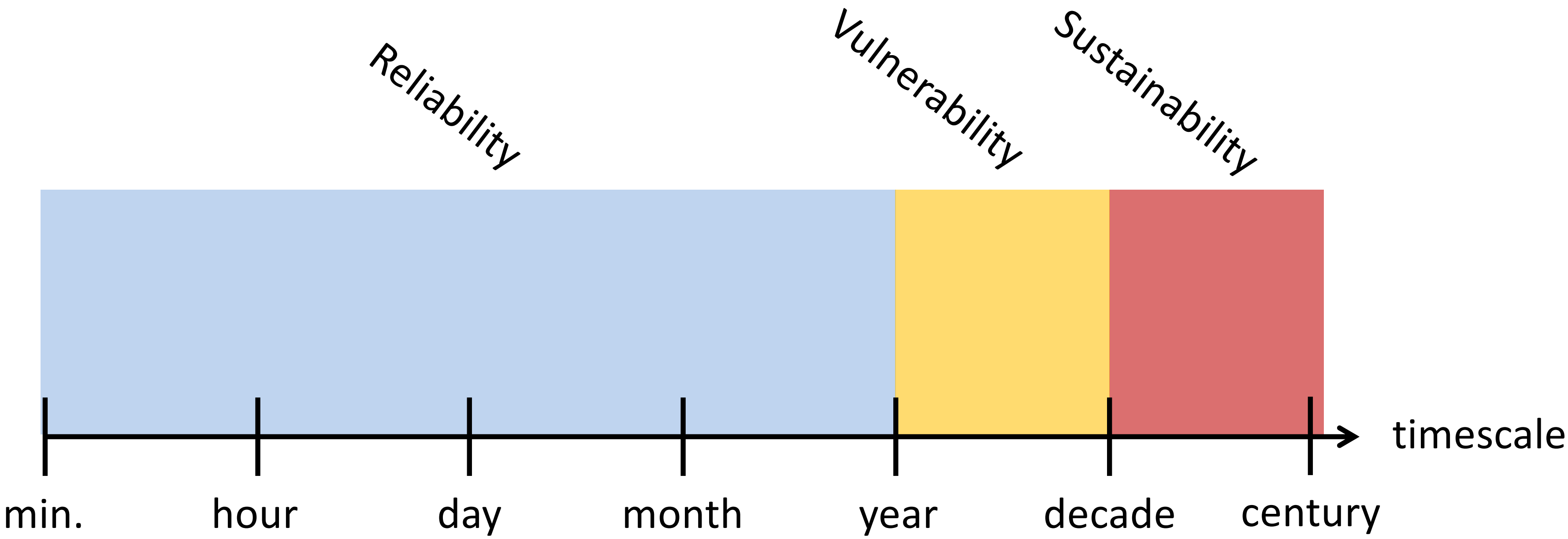


Steffen, W., Richardson, K., Rockstrom, J., et al. (2015) "Planetary boundaries: Guiding human development on a changing planet" *Science* **347**, 6223.

OWML Monitoring at Chain Bridge



OWML Monitoring at Chain Bridge



Continuous: stage, discharge, T, DO, pH, specific conductivity

Grab samples & Storm Composites: SNA, SK, SMG

Grab samples & Storm Composites: Cl^-, SO_4^{-2}

Leverage the dataset!

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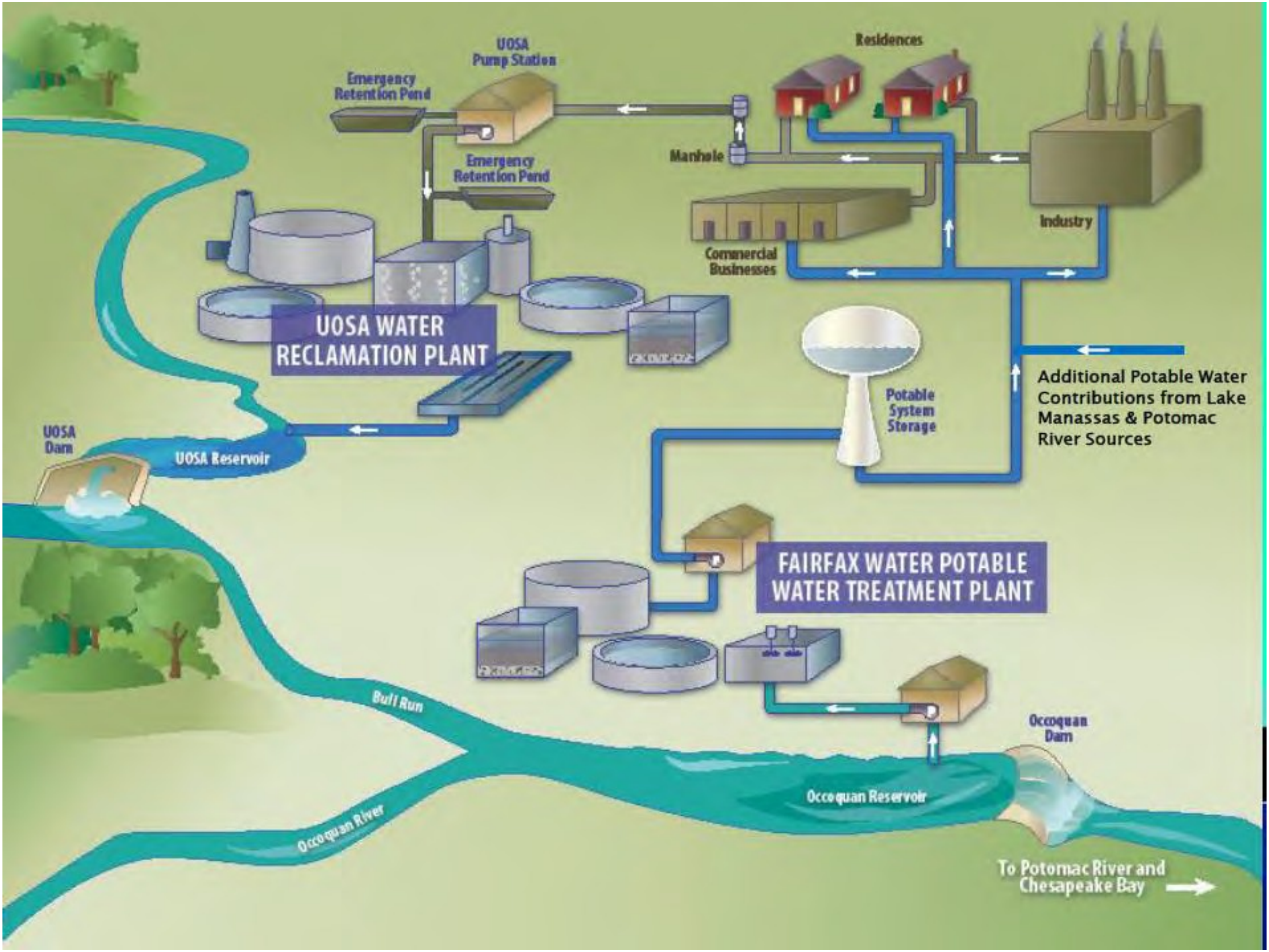
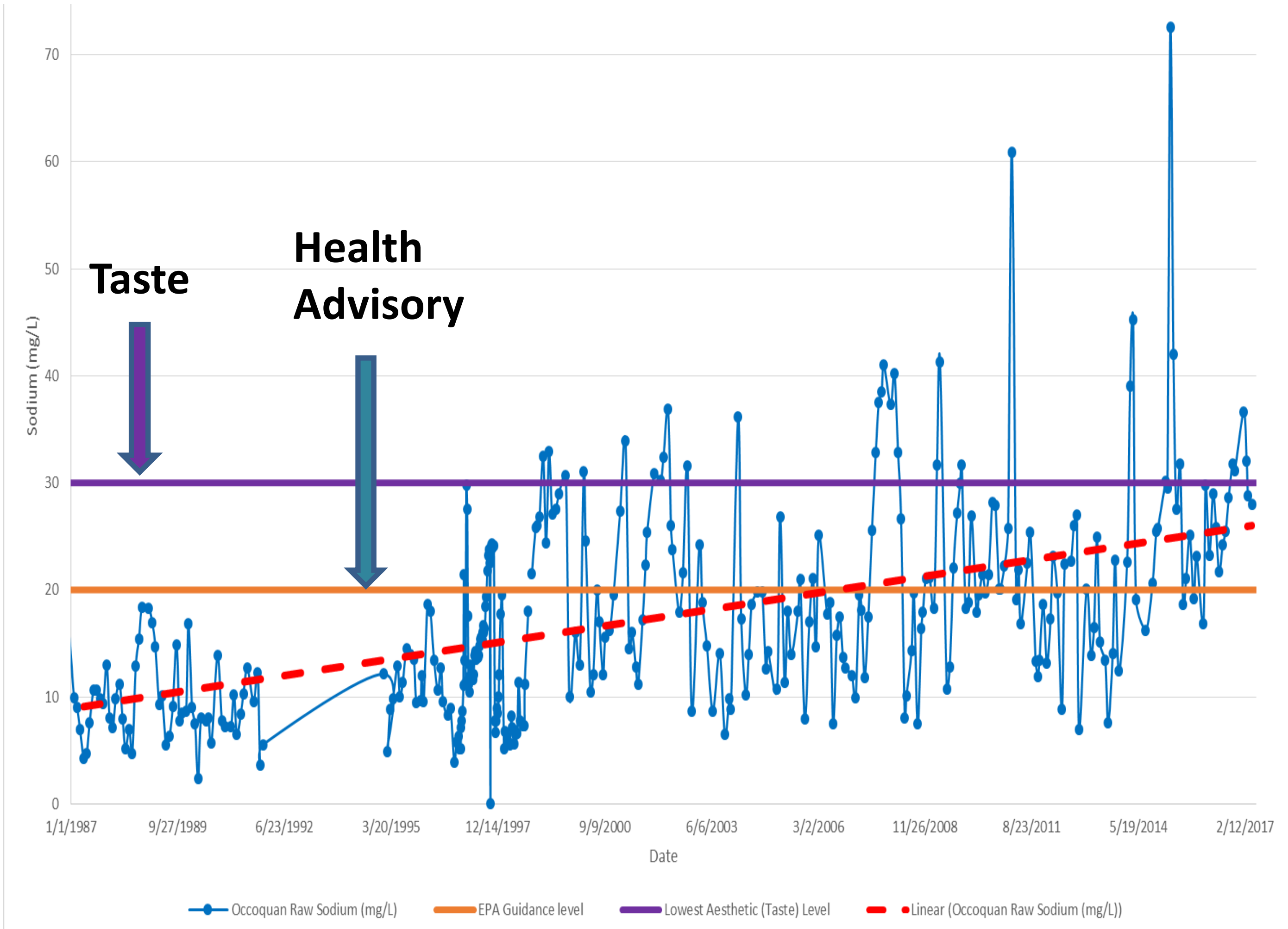


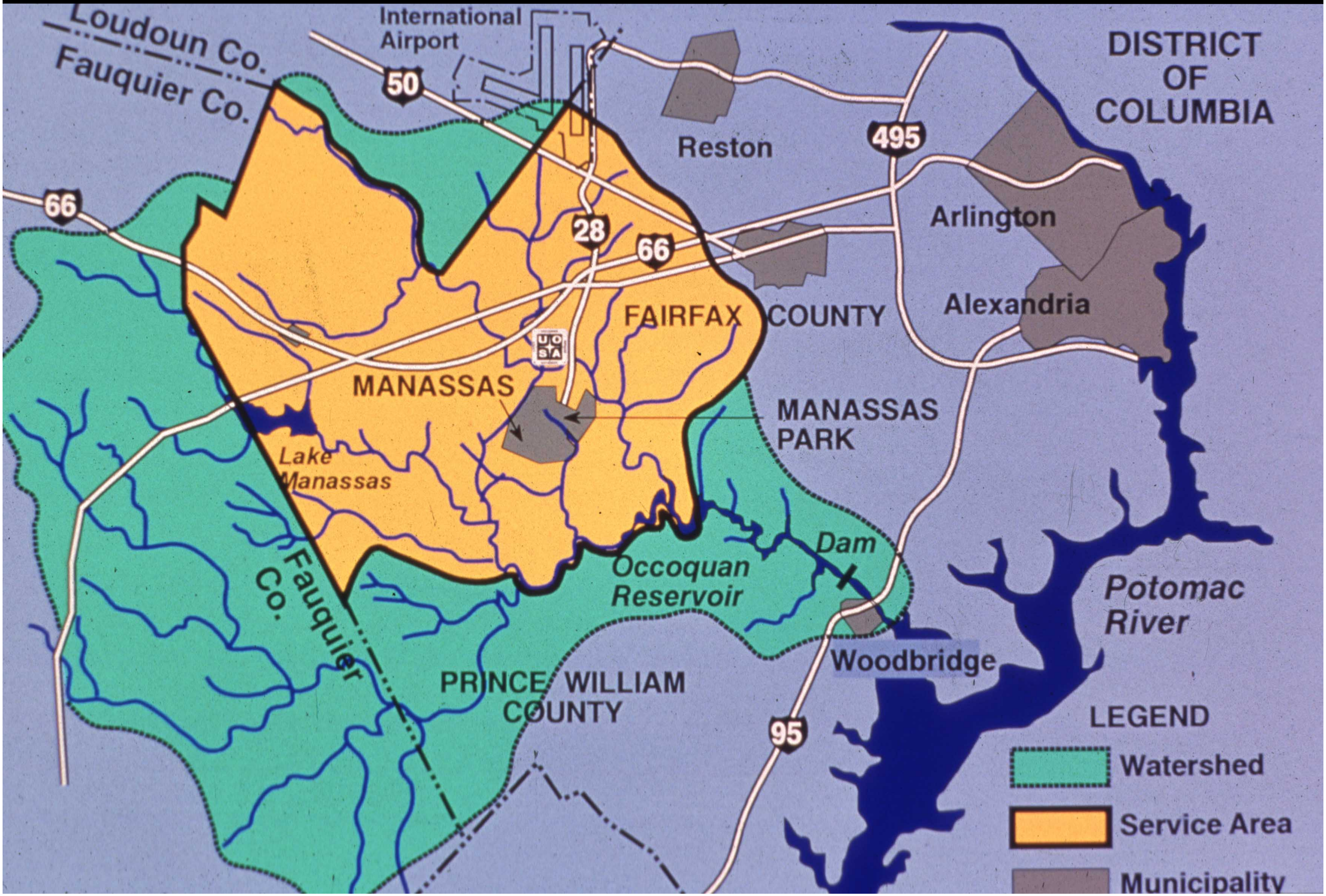
UOSA Pump Station
Emergency Retention Pond
Residences
Manhole
Emergency Retention Pond
Industry
Commercial Businesses
UOSA WATER RECLAMATION PLANT
Additional Potable Water Contributions from Lake Manassas & Potomac River Sources
Potable System Storage
UOSA Dam
UOSA Reservoir
FAIRFAX WATER POTABLE WATER TREATMENT PLANT
Bull Run
Occoquan Dam
Occoquan Reservoir
Occoquan River
To Potomac River and Chesapeake Bay

Occoquan Reservoir Today

Sodium Concentration in the Fairfax Water Intake is Rising Fast



Is the Na+ from the Watershed or Sewershed?

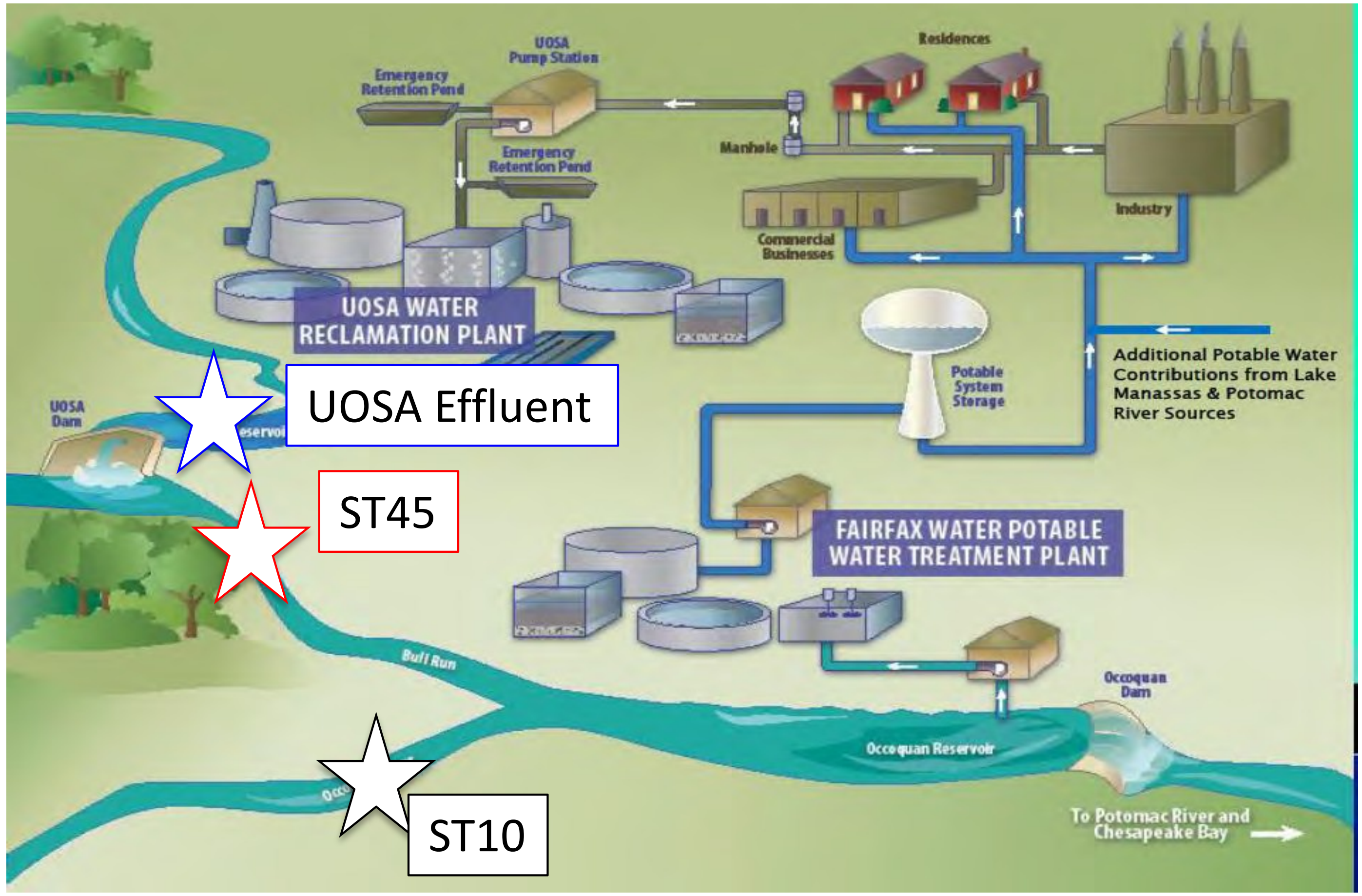


Plan of Attack

Set-up weekly meetings with the key stakeholders (OWML, UOSA, Fairfax Water, Fairfax County)

Combine the OWML's historical monitoring data with data from UOSA and Fairfax Water

Work closely with stakeholders every step of the way, from data curation to analysis to interpretation



Sodium in UOSA effluent is from the sewershed

Sodium at ST45 is from: (a) UOSA effluent + (b) non-point sources in the Bull Run drainage

Sodium at ST10 is from: non-point sources in the Occoquan River drainage

Technical details (in short!)

Step 1

Leverage the data! Create hourly time series of sodium load and concentration at ST45, ST10, and UOSA* (glmulti, R Software)

Step 2

Aggregate the hourly sodium time series at ST10 and ST45 to daily timeseries and propagate errors (loadflex, USGS)

Step 3

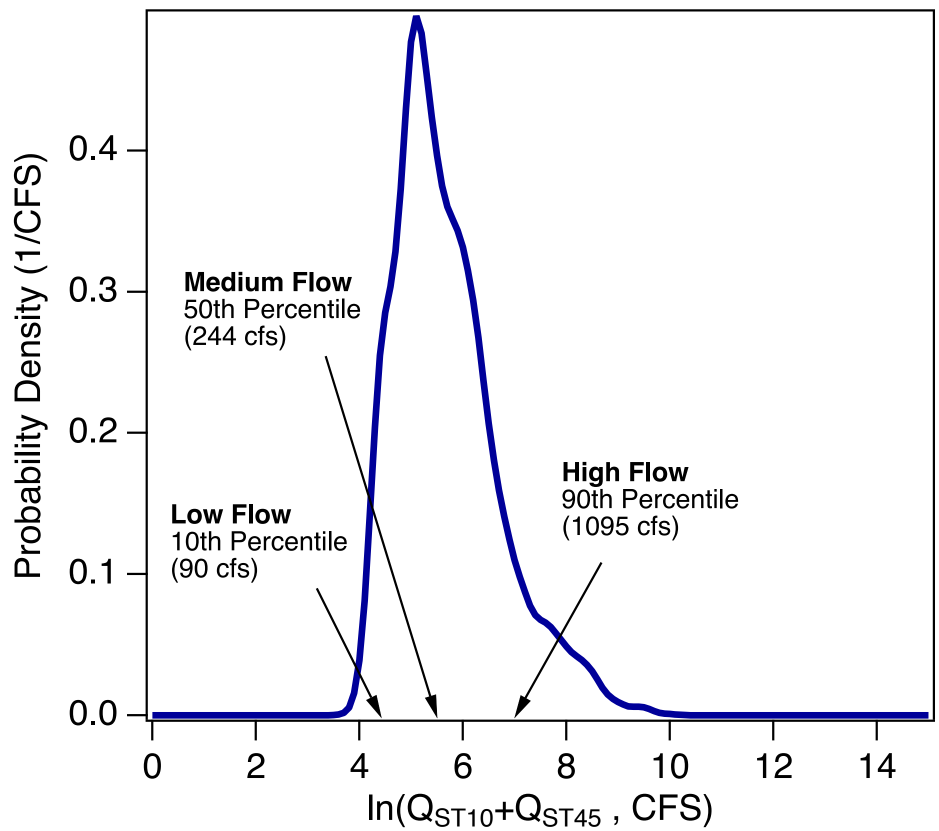
From mass and flow balance, compute the daily sodium load and concentration from the Bull Run drainage

Step 4

Compare the relative contributions of Bull Run, UOSA, and Occoquan River to sodium load and concentration to reservoir under different flow conditions (Copula analysis, MvCAT)

*Sodium concentration and load at UOSA was daily, not hourly

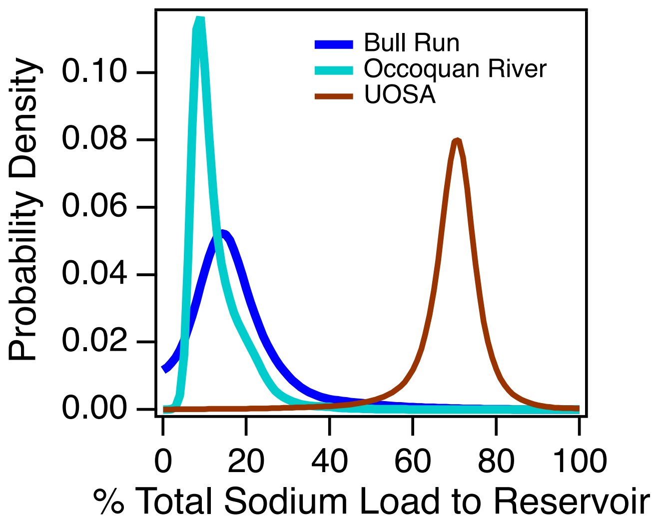
Results separated by “low”, “medium”, and “high” flow

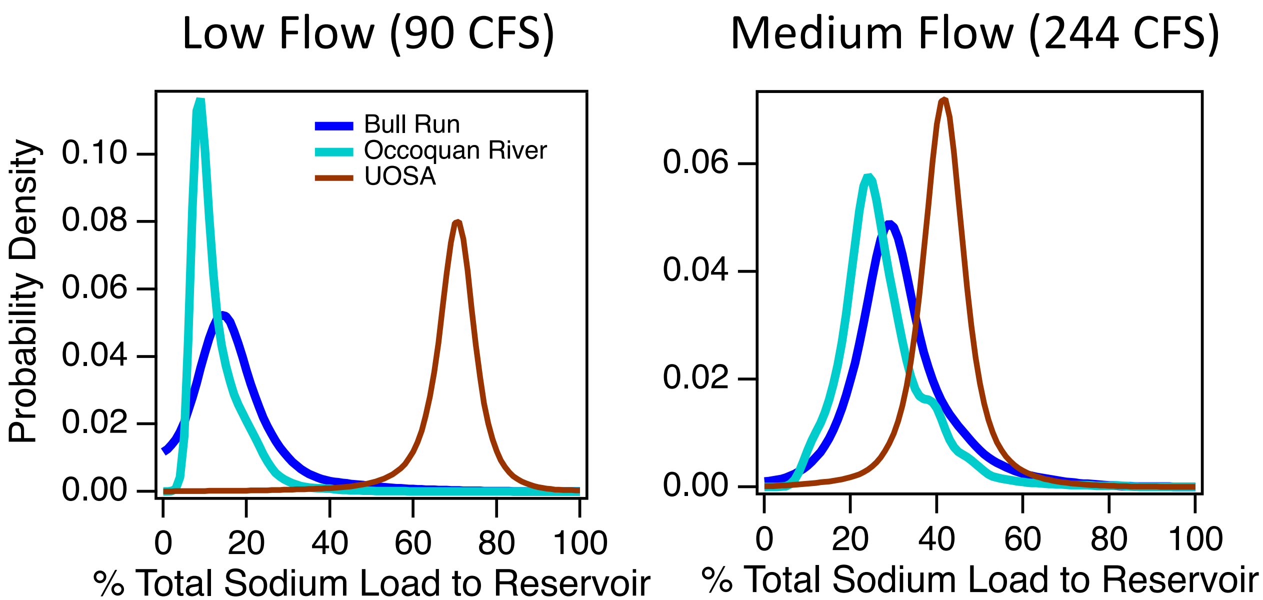


First Result:

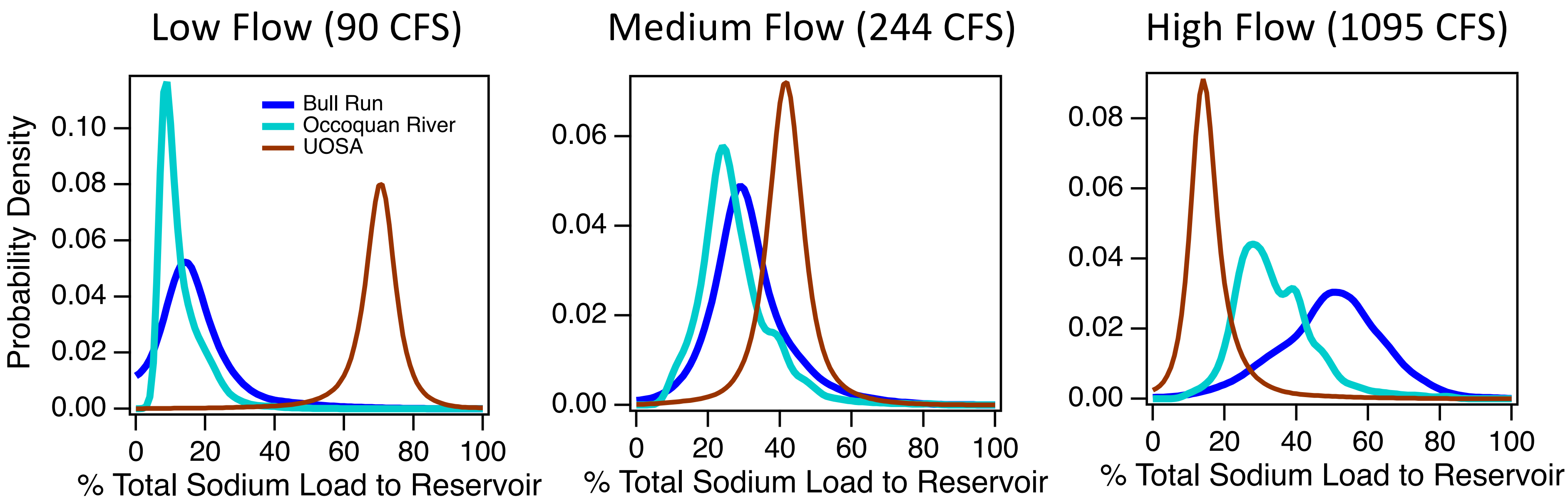
% of Daily Sodium Loading to the Occoquan Reservoir from (1) Bull Run, (2) Occoquan River, (3) UOSA

Low Flow (90 CFS)





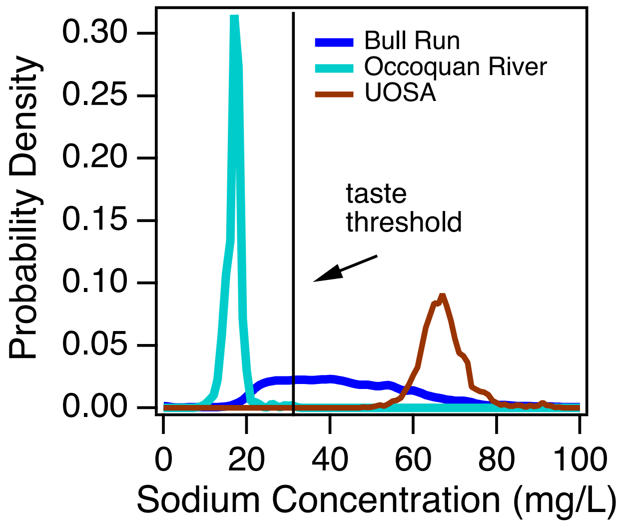
Low Flow (90 CFS)
Medium Flow (244 CFS)
Probability Density
0.10
0.08
0.06
0.04
0.02
0.00
Bull Run
Occoquan River
UOSA
0
20
40
60
80
100
% Total Sodium Load to Reservoir
0.06
0.04
0.02
0.00
0
20
40
60
80
100
% Total Sodium Load to Reservoir

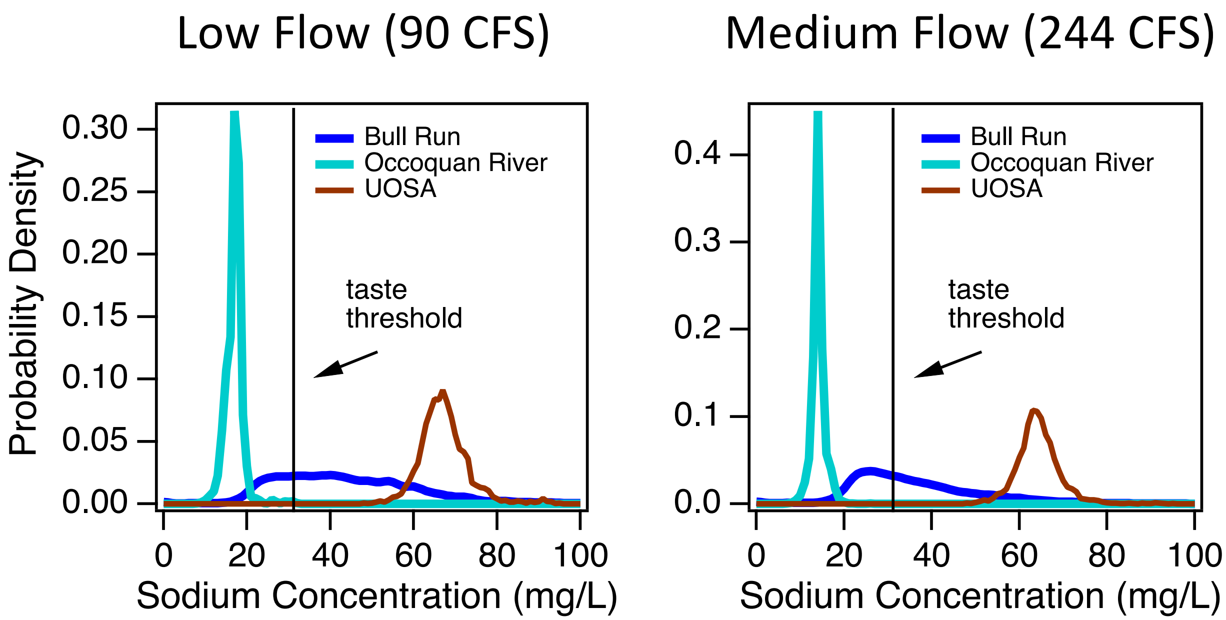


Low Flow (90 CFS)
Medium Flow (244 CFS)
High Flow (1095 CFS)
Bull Run
Occoquan River
UOSA
Probability Density
0.10
0.08
0.06
0.04
0.02
0.00
0
20
40
60
80
100
% Total Sodium Load to Reservoir

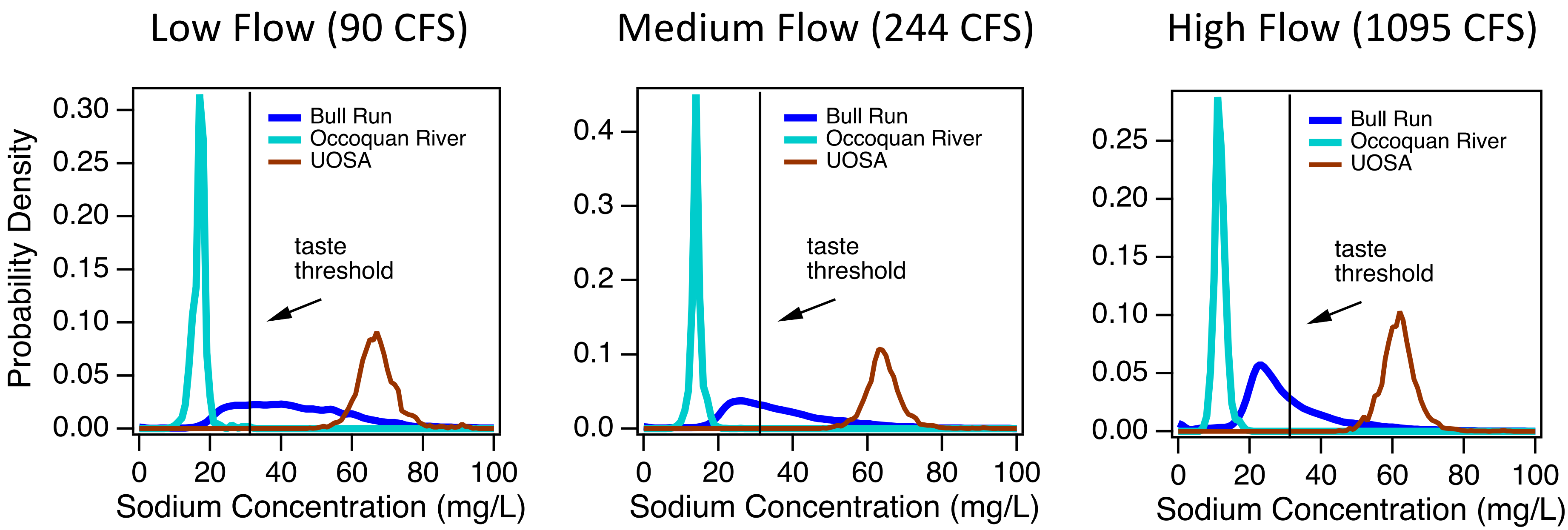
Second Result:
Daily Sodium Concentrations in Flow from (1) Bull Run, (2) Occoquan River, and (3) UOSA

Low Flow (90 CFS)





Low Flow (90 CFS)
Medium Flow (244 CFS)
Probability Density
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.4
0.3
0.2
0.1
0.0
Bull Run
Occoquan River
UOSA
taste threshold
0
20
40
60
80
100
Sodium Concentration (mg/L)



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Bull Run
Occoquan River
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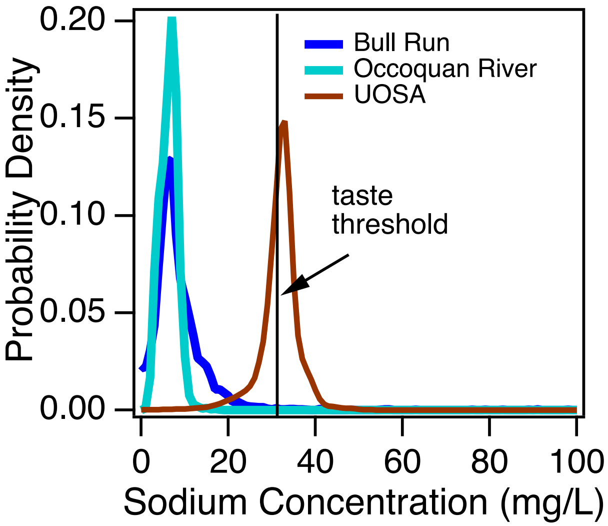
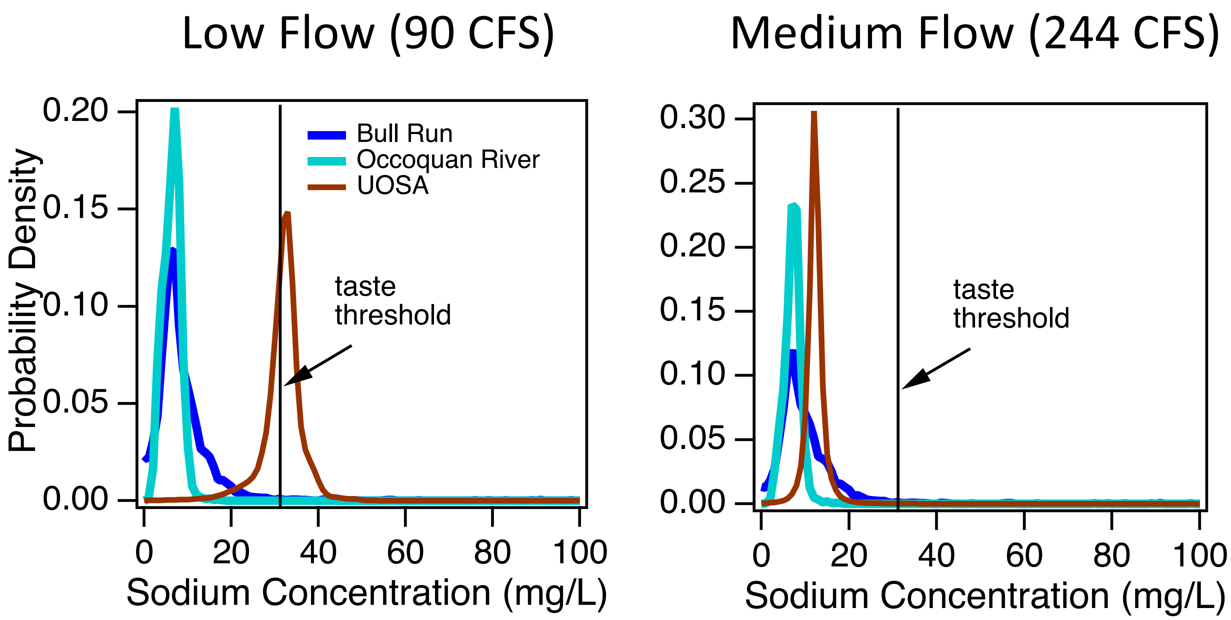
threshold
Sodium Concentration (mg/L)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.0
0.1
0.2
0.3
0.4
0
20
40
60
80
100

Third Result:

Daily Sodium Concentration Results—but this time diluted with “DI Water” from other sources

Low Flow (90 CFS)





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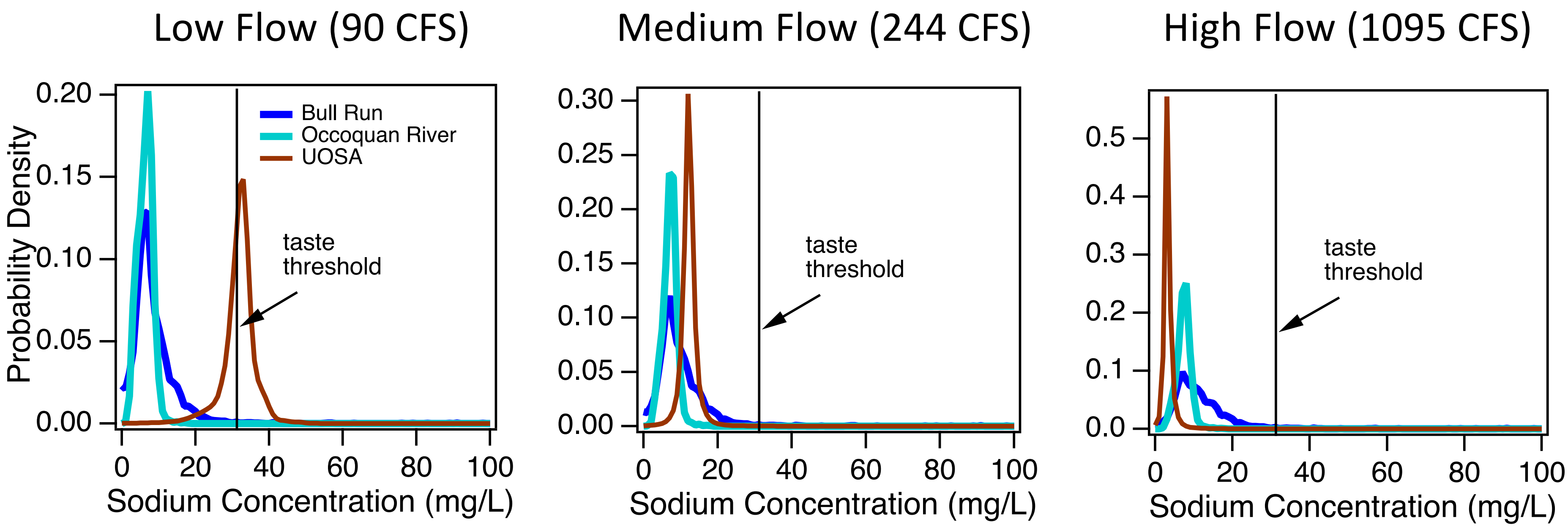
Sodium Concentration (mg/L)



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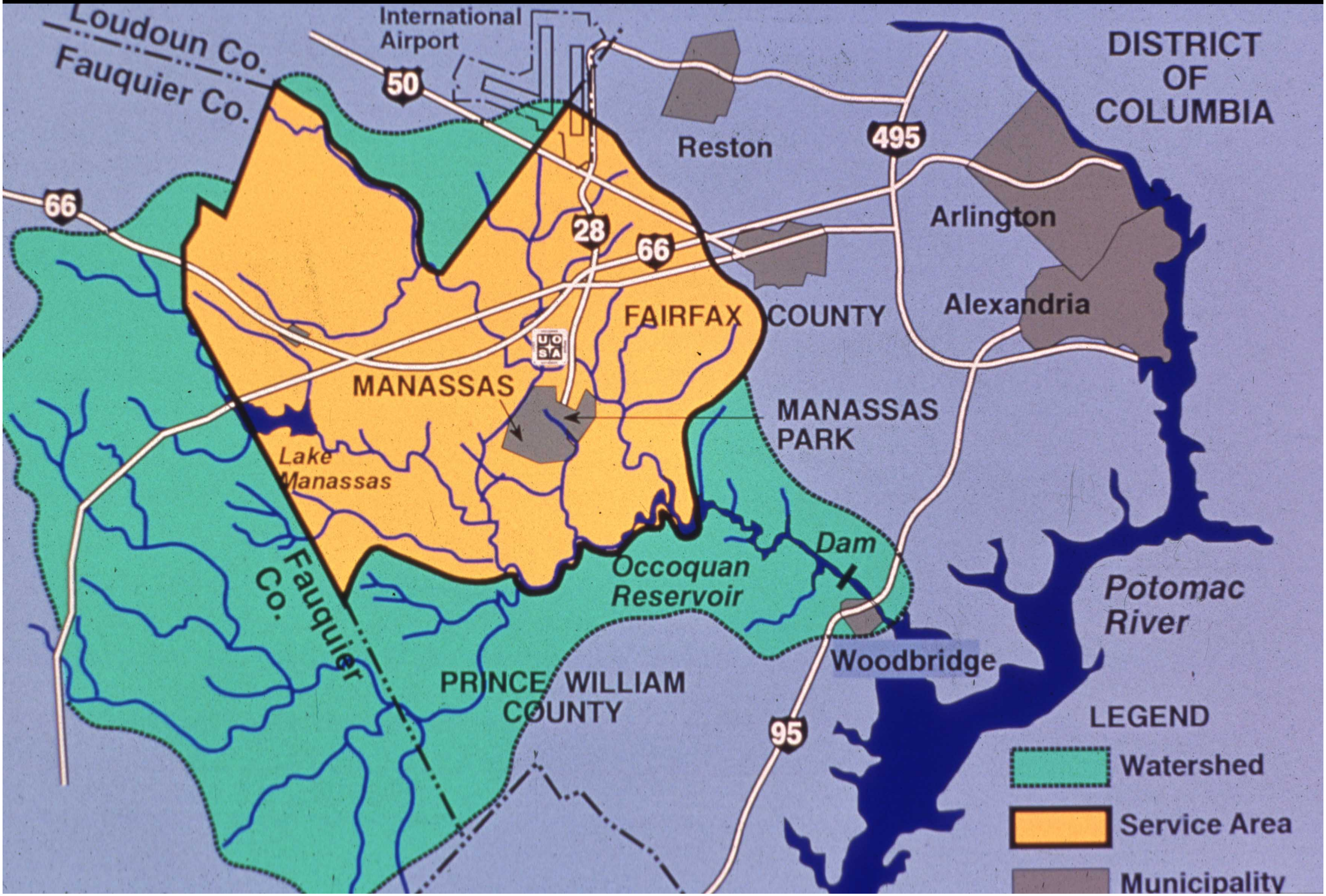

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Where do we take it from here…?

- First and foremost…keep monitoring!
- The "copula approach" outlined above (for identifying the contribution of specific sources by their conditional PDFs) can be **replicated for other analytes** (e.g., chloride, nitrate, bromide,…) and **other locales**
- The analysis can also be extended to multiple analytes, to quantify sources relative to their "**biogeochemical fingerprints**", "**taste fingerprints**", and "**pathogen fingerprints**"

“Biogeochemical Fingerprints”: stable isotope and biogeochemical signals in freshwaters

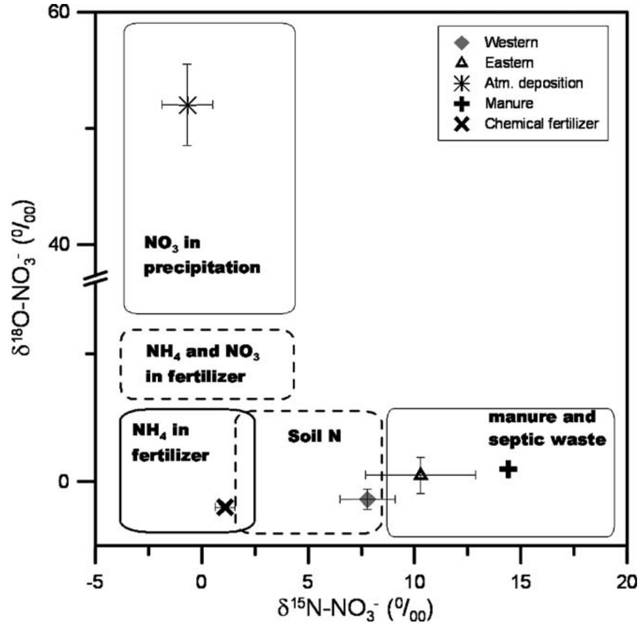
Erin Hotchkiss, Assistant Professor

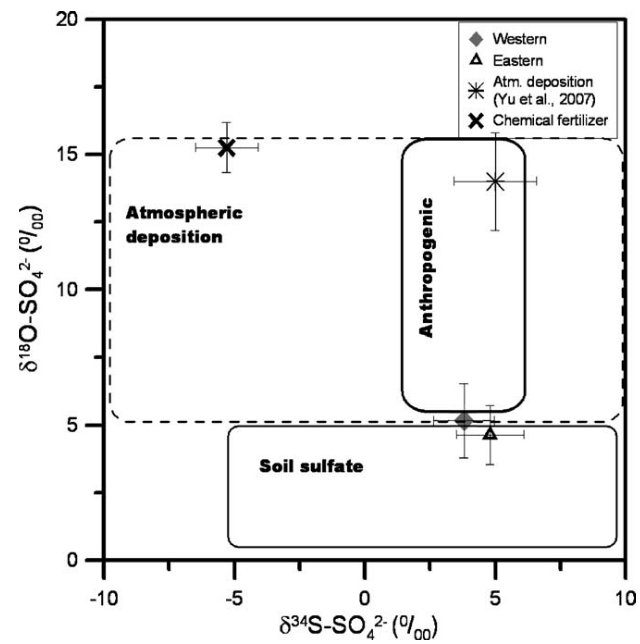
School of Biological Sciences

Virginia Tech

“Biogeochemical Fingerprints”

For example, isotope values of NO_3^- and SO_4^{2-} ($\delta^{18}O$, $\delta^{15}N$, $\delta^{34}S$) can reflect different sources of N, S in freshwaters





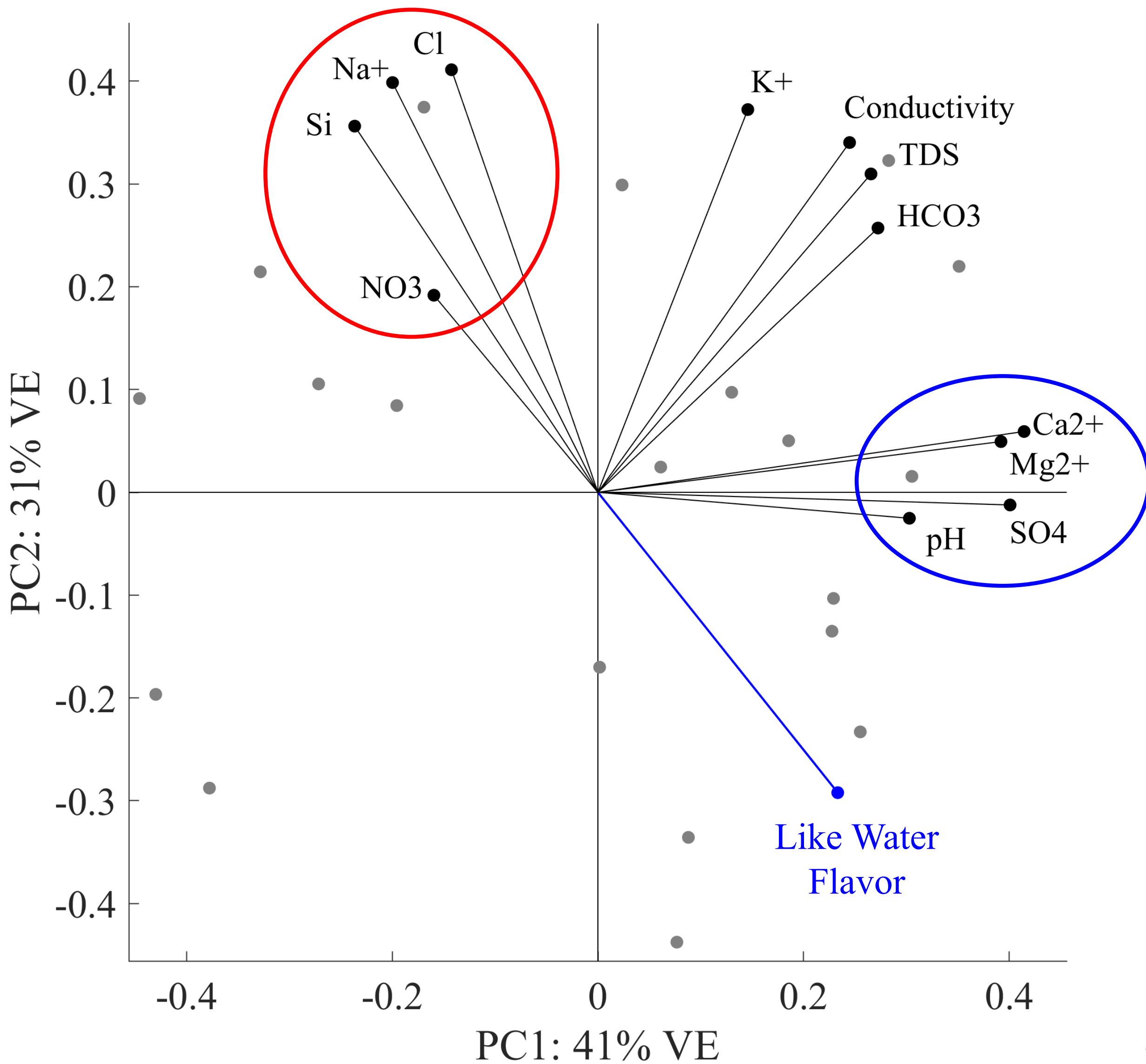
“Taste Fingerprints”: forget sodium, let’s quantify the sources of “bad taste”

Megan Rippy, Assistant Professor

Civil and Environmental Engineering

Virginia Tech, OWML

Many minerals contribute to overall water flavor



- People prefer water with calcium, magnesium, sulfate and moderately low pH (8), which reduces metallic taste
- Water with high sodium, chloride, silicon and nitrate is least preferred

Estimated from data by Platikanov et al., 2013

“Pathogen Fingerprints”: library independent Microbial Source Tracking (MST)

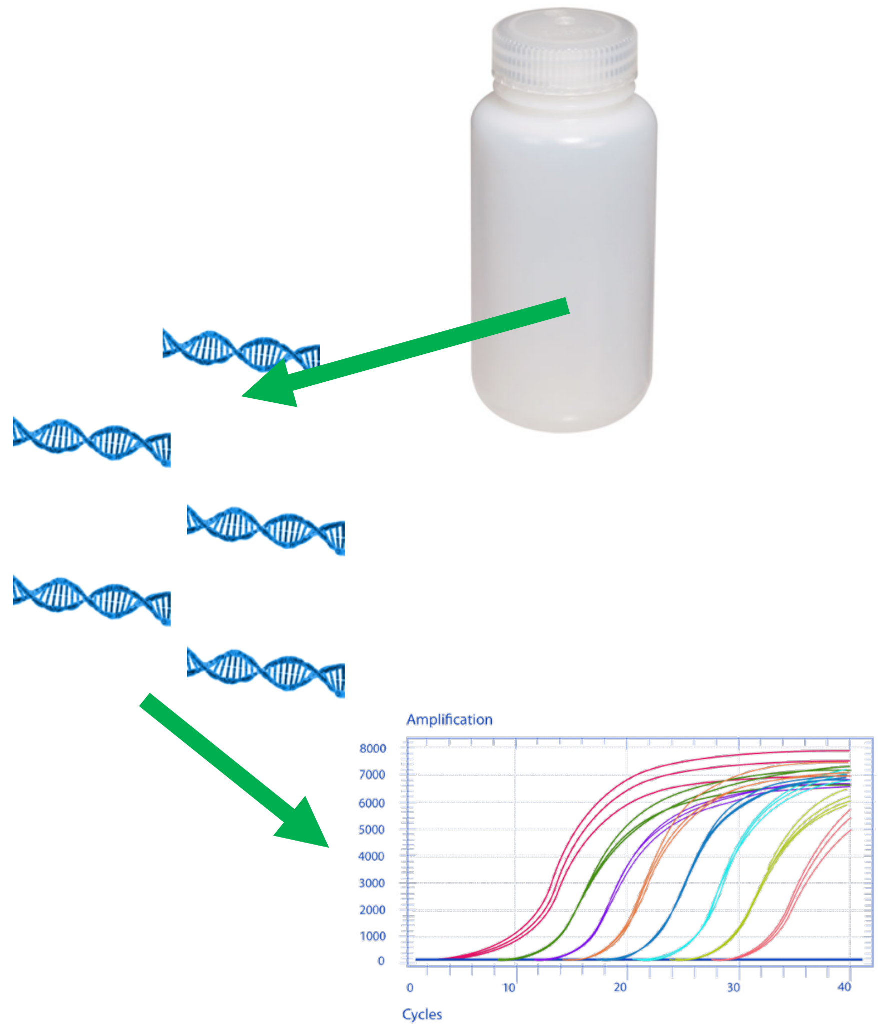
Brian Badgley, Associate Professor

School of Plant and Environmental Sci.

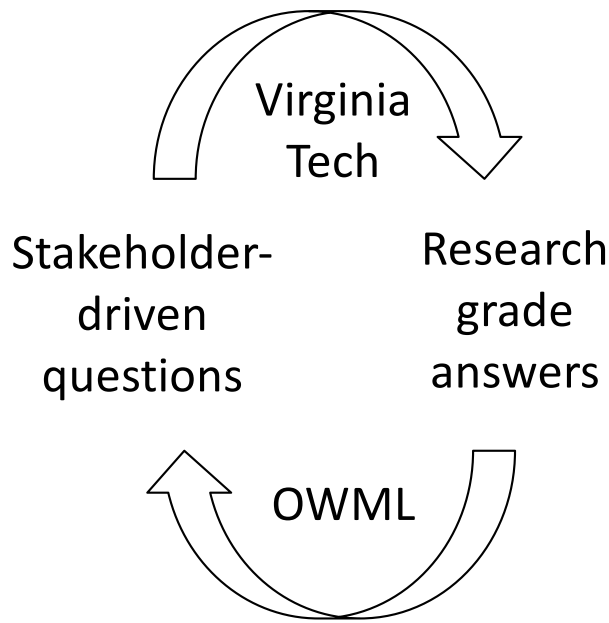
Virginia Tech, Blacksburg

Microbial Source Tracking Approaches

- “Library-independent” approaches use qPCR to count genetic sequences specific to bacteria from particular animal hosts (e.g., HF183)
- Most promising in terms of scientific validation of accuracy and agency support
- Not yet straightforward to link to TMDL or epidemiology data, but work is progressing in this area



Vision: make the OWML a nexus of stakeholder needs and cutting-edge water quality research



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- $50M from NSF over 10 years, + matching funds from university & industrial partners
- VT had one in Power Electronics (1998 to 2008), but none since (a priority for the university)
- The upcoming “Gen-4” NSF ERC competition cycle focuses on:
  - Convergent Engineering
  - Societal Grand Challenge

“Convergent Engineering”

“Integrates knowledge, tools, and ways of thinking across disciplinary boundaries…to form a synthetic framework for tackling scientific and societal challenges” also requires significant “stakeholder involvement”

National Research Council, “Convergence: Facilitating Transdisciplinary Integration of Life Science, Physical Sciences, Engineering, and Beyond” (2014). doi: 10.17226/18722

NSF ERC Planning Workshop

- I received $100K from NSF to develop the ERC bid
- First workshop will take place at Fairfax Water's Griffith Auditorium in Loudoun, VA on **January 14th** (reception the evening before at the OWML)
- Two components: (a) a workshop in the morning; (b) panel discussion in the afternoon
- **Please Join us!!**

Questions?

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949-677-9478

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