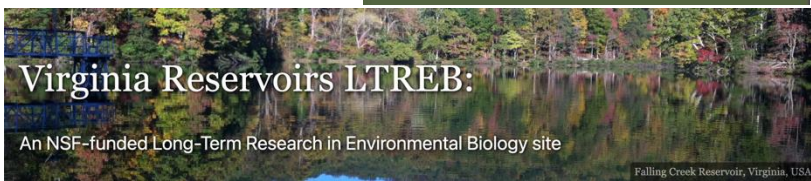
Macrosystems EDDIE:
Exploring Tradeoffs in Water Quality Management Using Environmental Data

Lofton, M.E., Cooke, R.L., and Carey, C.C. 20 September 2025.
Macrosystems EDDIE: Exploring Tradeoffs in Water Quality Management Using Environmental Data.
Macrosystems EDDIE Module 10, Version 1.
https://serc.carleton.edu/eddie/teaching_materials/modules/module10.html
Module development supported by NSF EF-2318861 and NSF RISE-2438447.

Macrosystems EDDIE
Environmental Data-Driven Inquiry & Exploration in Macrosystems Ecology

NSF

SERC the Science Education Resource Center at Carleton College



Overview of today

- Introduce concepts related to drinking water disinfection byproducts (DBPs) and environmental data from drinking water reservoirs
- **Activity A:** Explore how disinfection byproducts are formed during the drinking water treatment process and examine tradeoffs between disinfection and byproduct formation
- **Activity B:** View and interpret environmental data that can indicate when naturally-occurring DBP precursors are present
- **Activity C:** Make water treatment decisions using environmental data that can indicate when DBP precursors may be present

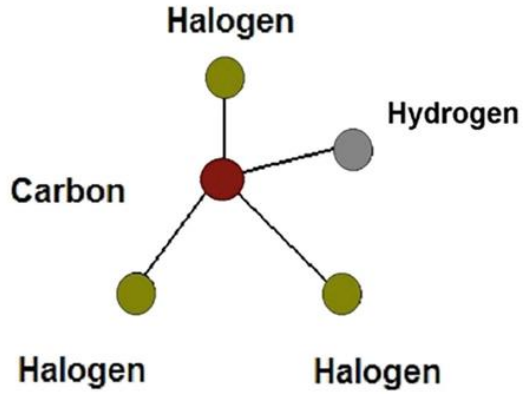
Our focal question for today:

How can we use environmental data to inform our understanding of the tradeoffs involved in water management decision-making?

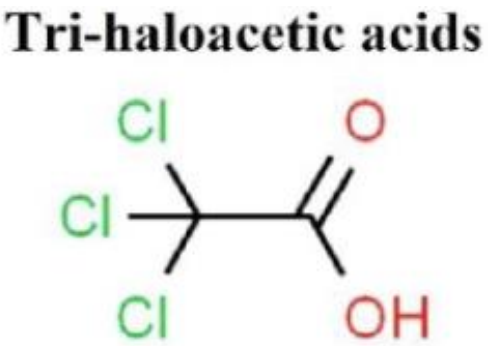
What are disinfection byproducts?

- Disinfection byproducts are compounds that are unintentionally created during the drinking water treatment process
  - Many of them are known to be carcinogens, or capable of causing cancer

- There are dozens of DBPs; two common classes of DBPs are **trihalomethanes** (THMs) and and **haloacetic acids** (HAAs)



Trihalomethanes (THMs)

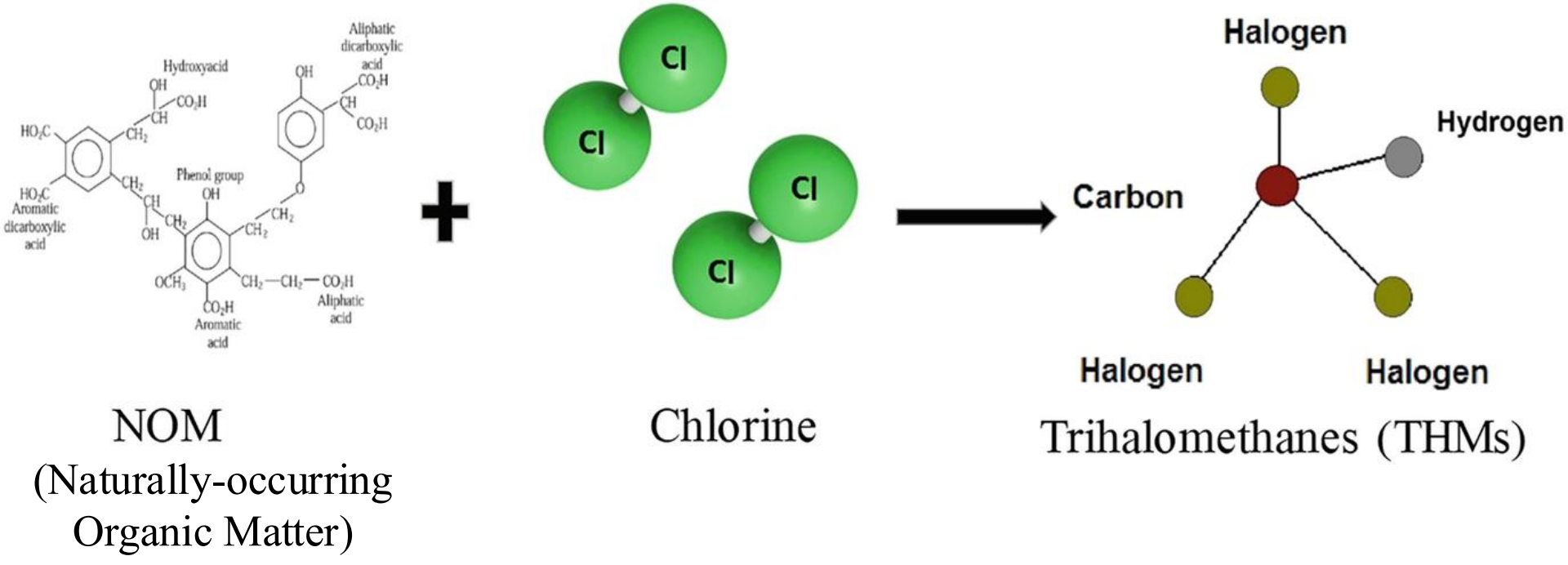


trichloroacetic acid (TCAA)

Image credits: Kumari & Gupta (2022) Trihalemethanes (THMs) in Wastewater: Causes and Concerns. Wang et al. (2020) Journal of Hazardous Materials

How do disinfection byproducts form?

- Disinfection byproducts form when **DBP precursors,** which can be **organic matter** or **inorganic compounds** in drinking water sources, react with chlorine during the disinfection process
  - **Organic matter** is derived from living organisms and contains carbon



NOM (Naturally-occurring Organic Matter)

Chlorine

Trihalomethanes (THMs)

Image credits: Kumari & Gupta (2022) Trihalemethanes (THMs) in Wastewater: Causes and Concerns.

How are DBPs monitored?

- Water samples from both plants and distribution systems must be tested for a range of DBPs quarterly
- In addition, raw and filtered water are tested once a month for **Total Organic Carbon (TOC)**
- High TOC levels can indicate the presence of DBP precursors which may form DBPs during treatment

Water samples from Falling Creek Reservoir, Vinton, VA
Photo credit: Bethany Bookout

How can environmental data help us avoid the formation of disinfection byproducts?

- Some forms of organic matter can be measured using sensors deployed in a drinking water reservoir
- We can develop a relationship between these sensor data and total organic carbon (TOC) to determine when DBP precursors might be present

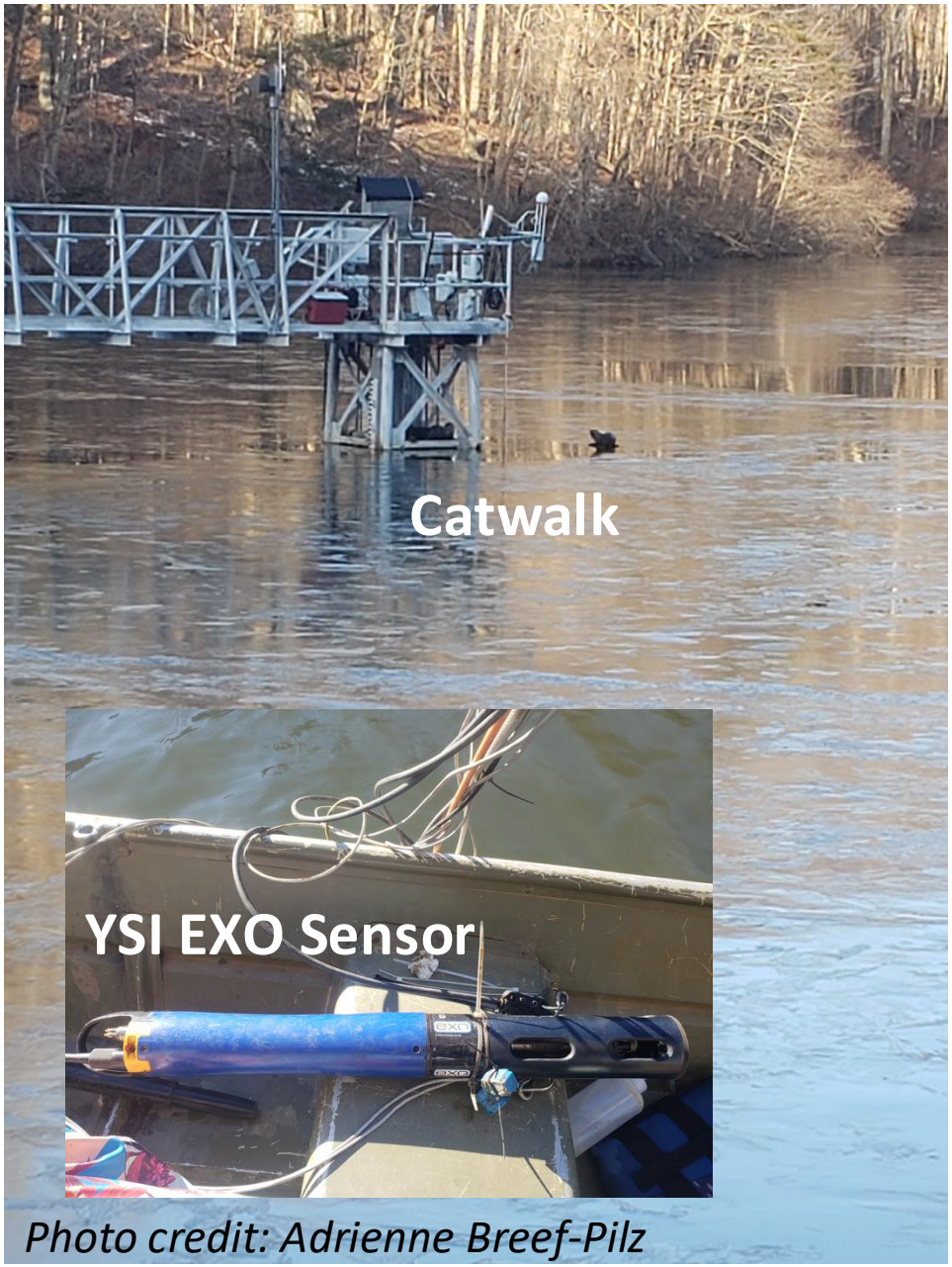
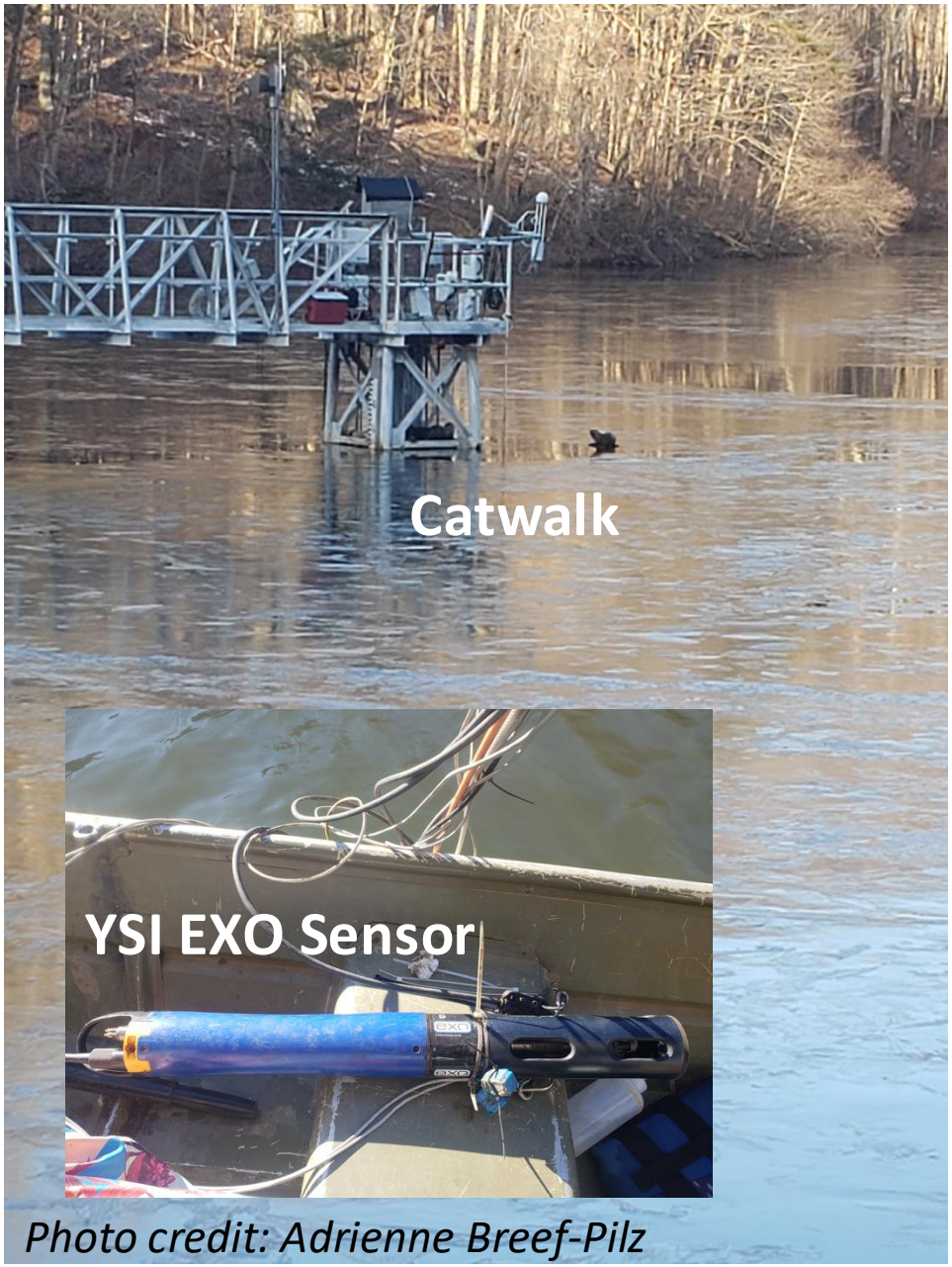


Photo credit: Adrienne Breef-Pilz

Today…

We are going to explore **environmental data** from **drinking water reservoirs in southwest Virginia**, and then use that data to **explore tradeoffs in drinking water treatment decisions.**

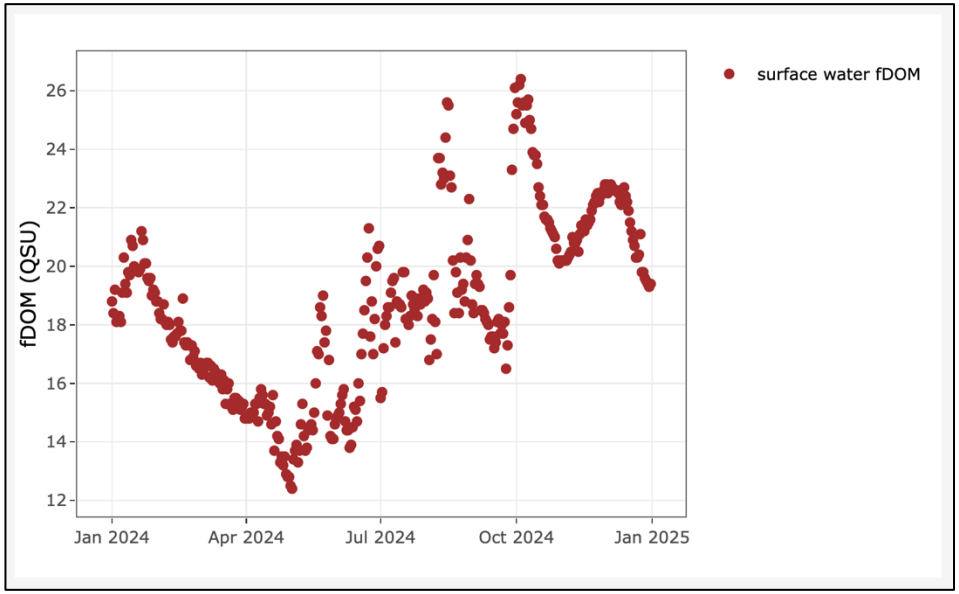
Some of our environmental data are collected using a YSI EXO sensor deployed in a drinking water reservoir.



Today…

We are going to explore **environmental data** from **drinking water reservoirs in southwest Virginia**, and then use that data to **explore tradeoffs in drinking water treatment decisions.**

We will explore **fDOM (fluorescent dissolved organic matter)** data as an indicator of TOC and possible DBP precursors.



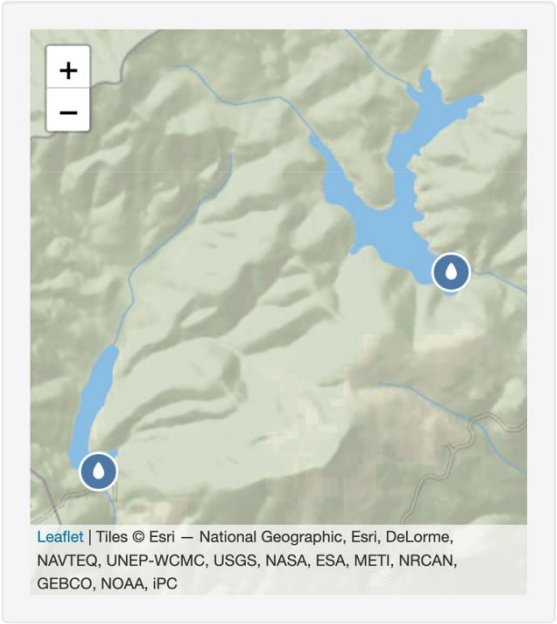
The color in coffee is an example of dissolved organic matter. Photo credit: Wikipedia

Today…

We are going to explore **environmental data** from **drinking water reservoirs in southwest Virginia**, and then use that data to **explore tradeoffs in drinking water treatment decisions.**

We will explore data from Falling Creek Reservoir and Beaverdam Reservoir in Vinton, VA.

Map of Virginia Reservoir LTREB sites



Today…

We are going to explore **environmental data** from **drinking water reservoirs in southwest Virginia**, and then use that data to **explore tradeoffs in drinking water treatment decisions.**

We will use environmental data to inform decisions about **drinking water treatment** to optimize for both disinfection and avoiding byproduct formation.

Spring Hollow Reservoir Treatment Plant
Photo credit: Western Virginia Water Authority

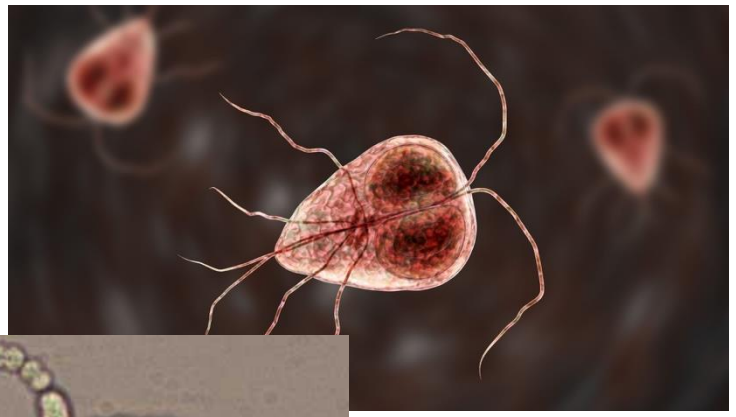
Learning objectives of today's module:

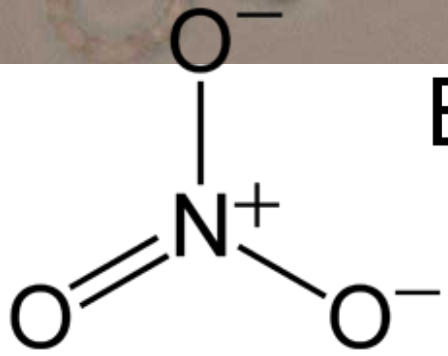
1. Define what disinfection byproducts are
2. Describe the environmental and water treatment processes that influence the formation of disinfection byproducts
3. Understand the trade-offs between disinfection and byproduct formation that can occur when chlorinating water, and treatment techniques that can be used to manage these tradeoffs (e.g., coagulation, activated carbon filters)
4. Use environmental data visualizations to identify when additional treatment techniques to avoid disinfection byproduct formation should be used to meet water quality objectives

Activity A: Explore how disinfection byproducts are formed

Objective 1: Understand factors affecting DBP formation and drinking water thresholds for DBPs

Objective 2: Explore tradeoffs in disinfection vs. DBP formation





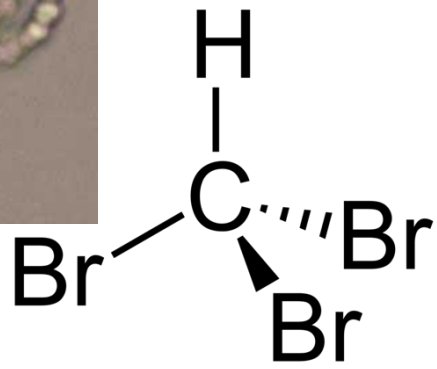


Image sources:
Bromoform - https://commons.wikimedia.org/wiki/File:Bromoform-2D.png
Phytoplankton - https://coastalscience.noaa.gov/monitoring-and-assessments/pmn/image-gallery/freshwater-plankton-gallery/
Nitrate molecule - https://en.wikipedia.org/wiki/Nitrate#/media/File:Nitrate-ion-resonance-2D.png
Giardia - https://www.cdc.gov/giardia/about/index.html

Activity B: Explore environmental data that can indicate the presence of DBP precursors

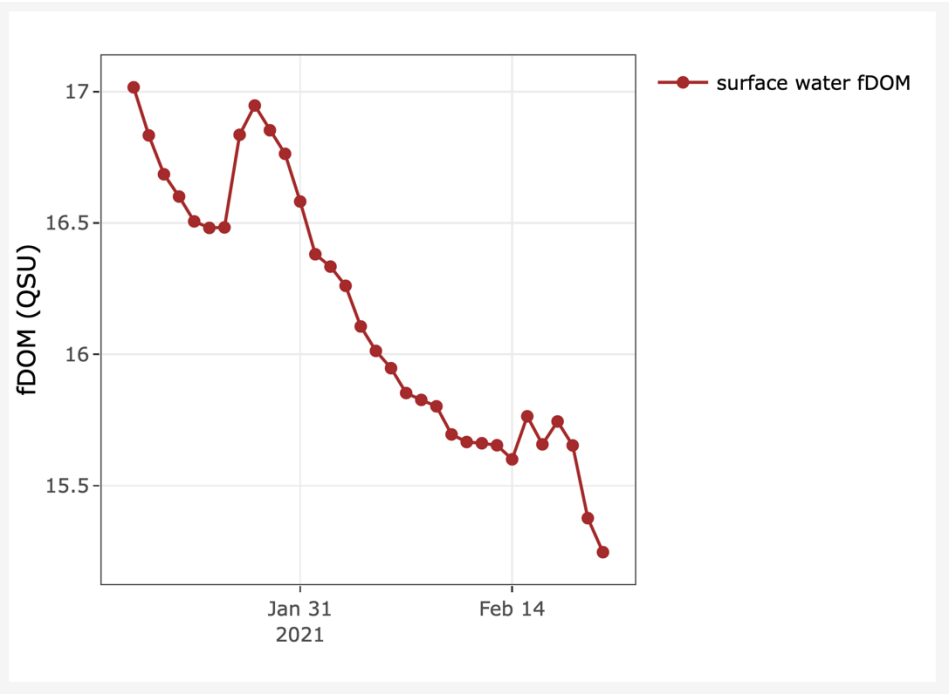
Objective 3: Learn about your focal drinking water reservoir

Objective 4: View and interpret organic matter data from your focal reservoir

Falling Creek Reservoir, Vinton, VA, USA
Photo credit: Adrienne Breef-Pilz

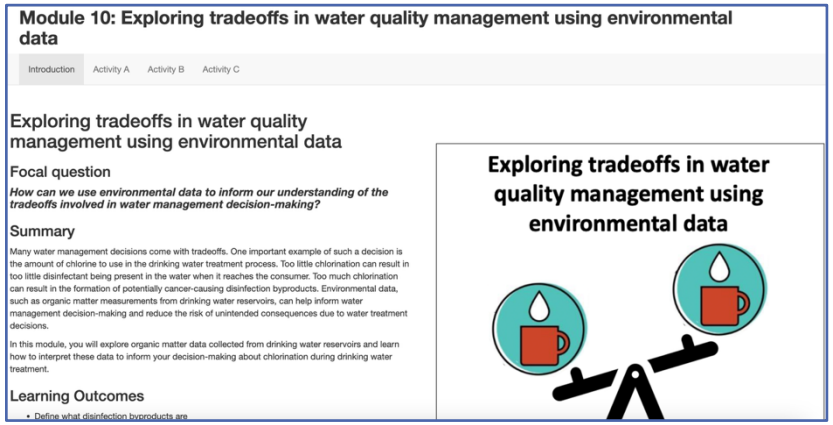
Activity C: Use environmental data to inform water treatment decisions

Objective 5: Use organic matter data to make water treatment decisions



Canvas + Shiny App

- The module can be accessed through your course Canvas site
- You will complete module activities in an R Shiny app, which is an interactive website
- Be sure to complete the ”Quick-start” guide to the module and watch the video that explains the interactive module features
- Questions are embedded in the app and you will answer these in a Canvas quiz



Thank you for participating!

Check out our other water quality & management modules:

- **Module 8:** Using Ecological Forecasts to Guide Decision Making
- **Module 9:** Using High-Frequency Data to Manage Water Quality

Find out more at:
macrosystemsEDDIE.org

Macrosystems EDDIE
Environmental Data-Driven Inquiry & Exploration in Macrosystems Ecology

NSF

SERC the Science Education Resource Center at Carleton College