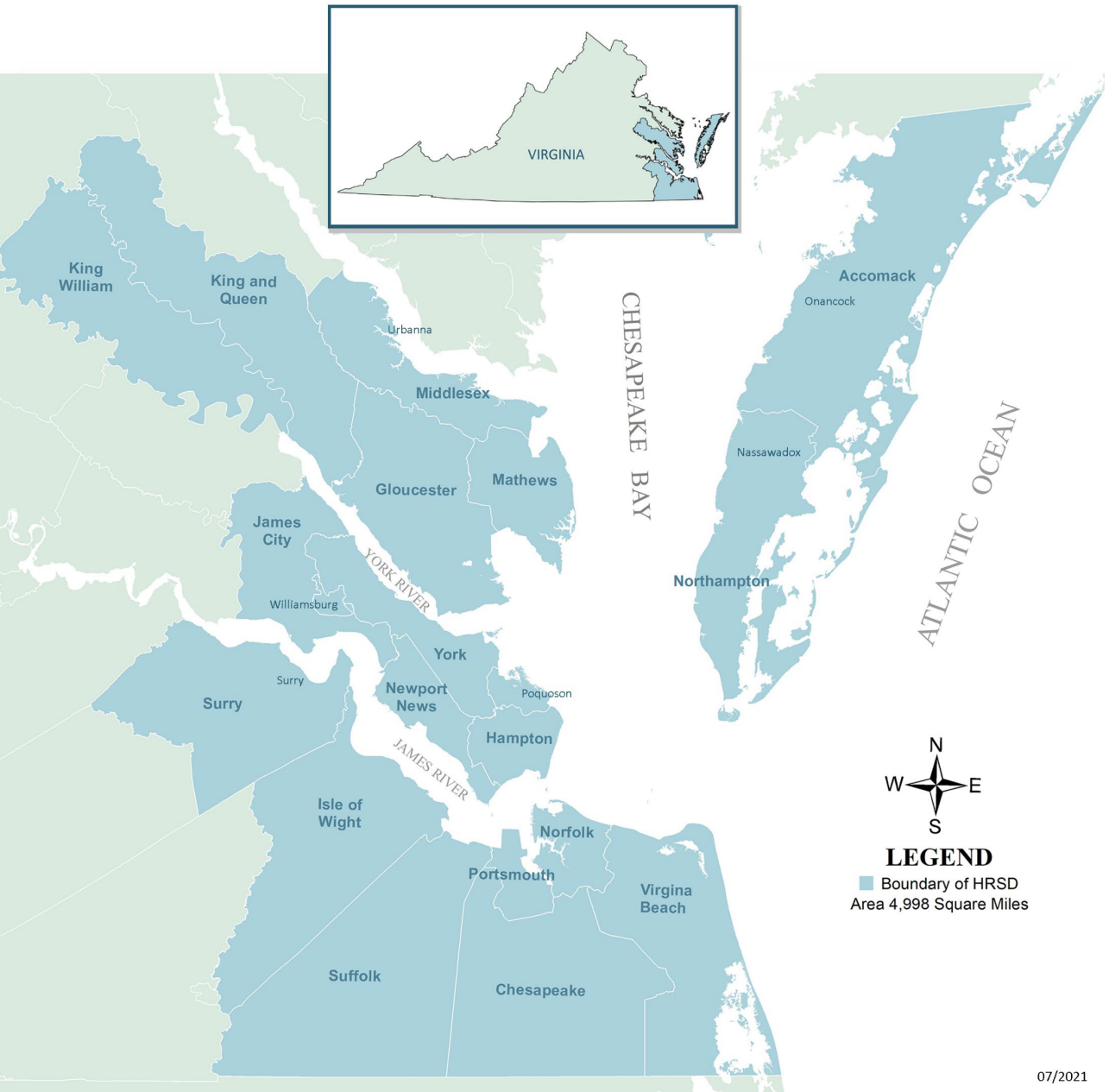
Using QMRA to Establish Shellfish Exclusion Zones for WRF Outfalls

Interstate Shellfish Seminar &
Gulf and South Atlantic States
Shellfish Conference

Wilmington, NC



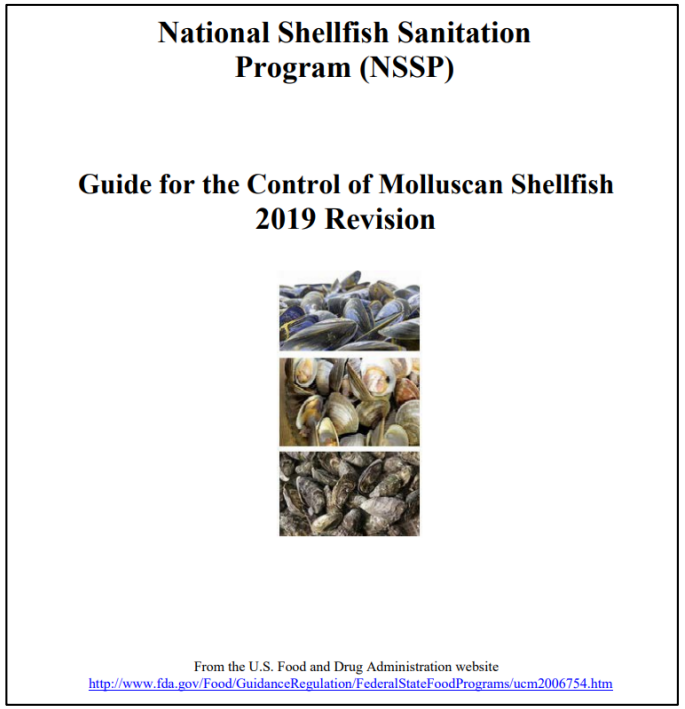
Objectives

1. Translate the 31 FC (CFU $100mL^{-1}$) shellfish criteria to an acceptable risk

2. Use this threshold to determine shellfish exclusion zones for WRF effluent structures

Current Shellfish Regulation

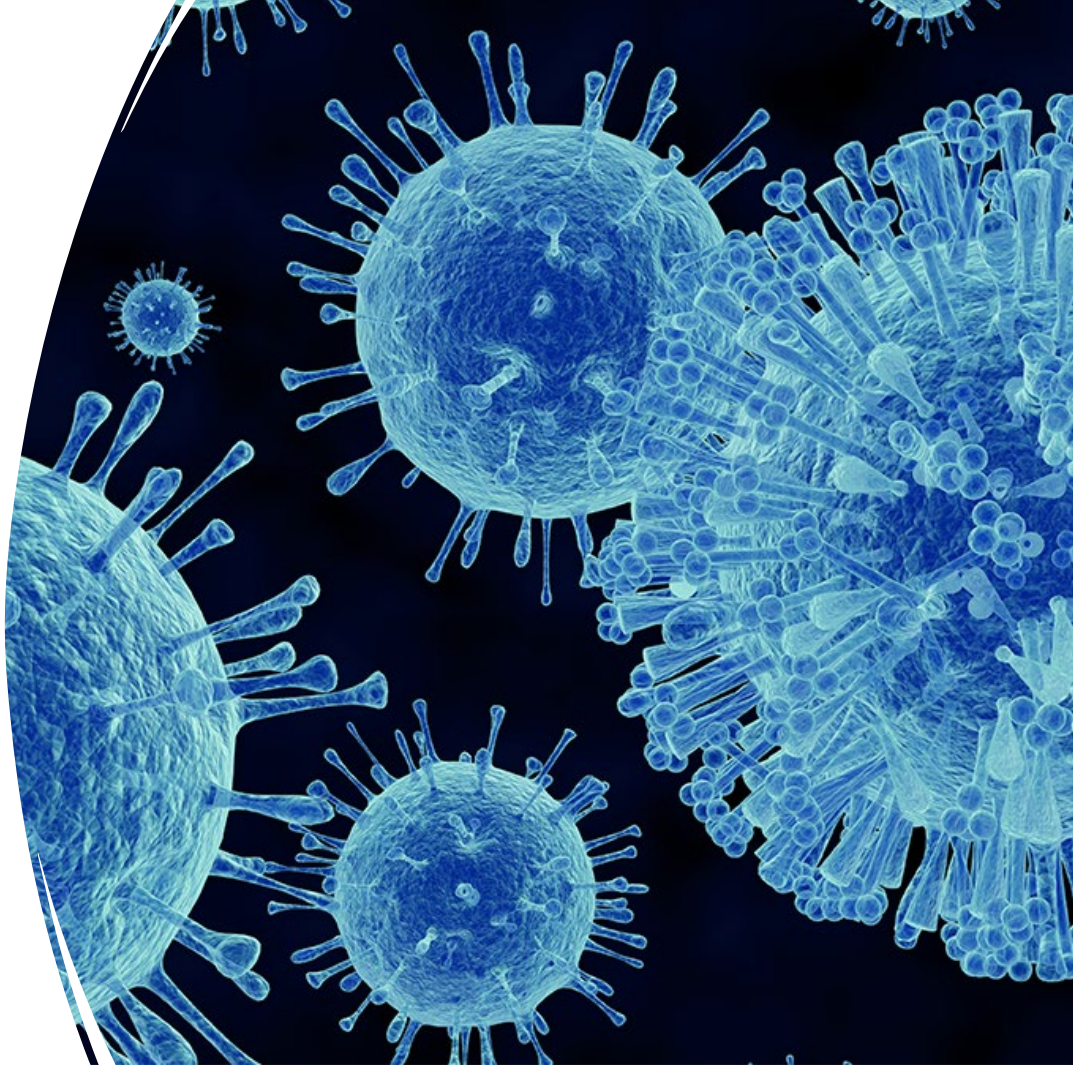
- Microbiological Standards *(Section II Model Ordinance - Chapter IV)*
  - Median FC shall not exceed 14 CFU $100mL^{-1}$
  - *No more than 10% of samples shall exceed 31 CFU $100mL^{-1}$ FC*



- What does this mean in terms of risk?
  - FIB concentration implies some acceptable risk
  - What is the probability of illness due to shellfish consumption?

FIB vs Pathogens

- Fecal Indicator Bacteria (FIB)
  - Fecal coliform, *E. coli*, enterococci, MSC*
  - FIB presence is linked to GI illness risk
    - FIB are not the etiological agent
  - Limitations
    - Not host specific
    - Sensitive to seasonal temperature changes
    - Can persist and grow in the environment

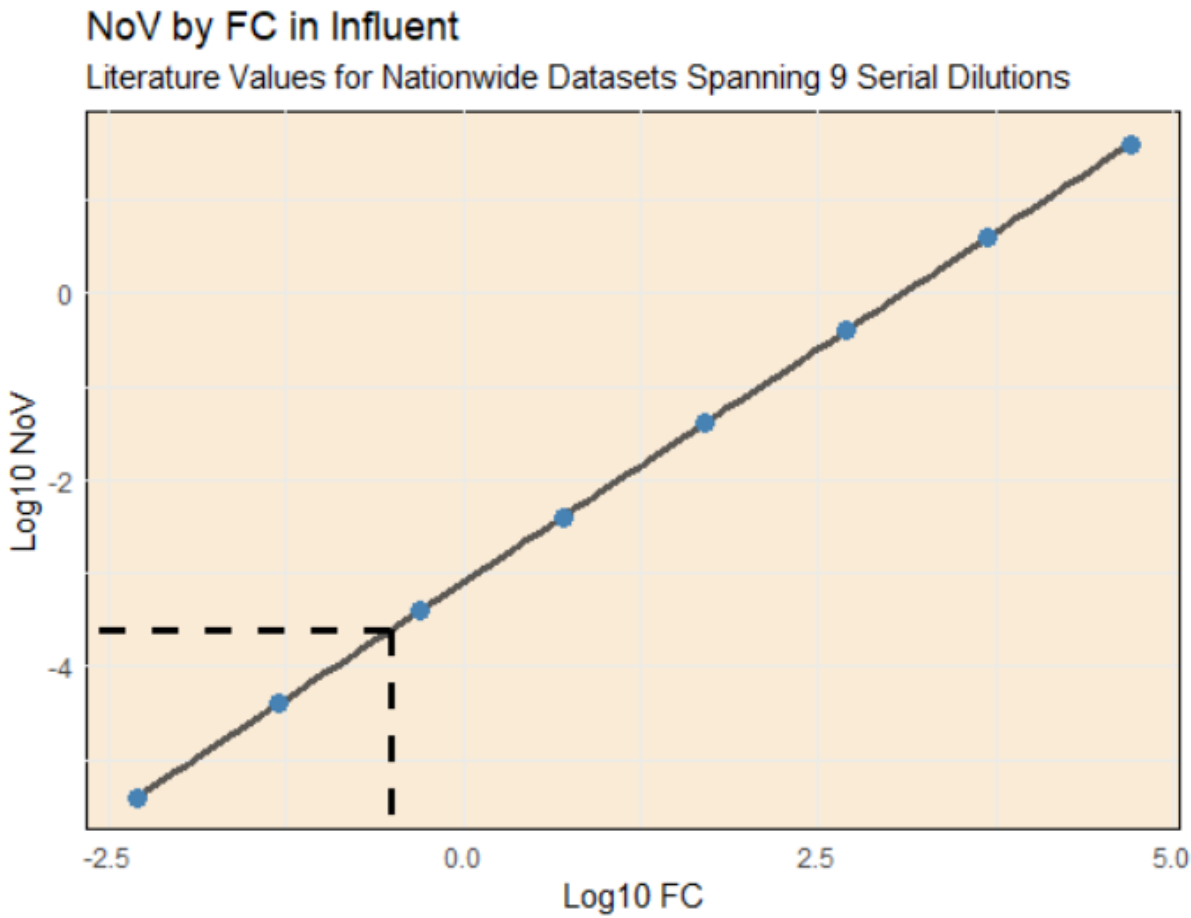


Project Spotlight: Integrating Deep Learning with High Throughput Materials Engineering for Detecting Noroviruses. (2020, July 22). Pittsburgh Health Data Alliance. https://healthdataalliance.com/blog/project-spotlight-norovirus-detection/

NoV as a model pathogen

FC and NoV Relationship in Wastewater

- What NoV concentration corresponds to 31 FC $100mL^{-1}$?
- FC and NoV data from nationwide meta-analyses *(Rose et al. 2004, Eftim et al. 2017)*
- Solve regression equation
  - 0.02 copies NoV $100mL^{-1}$

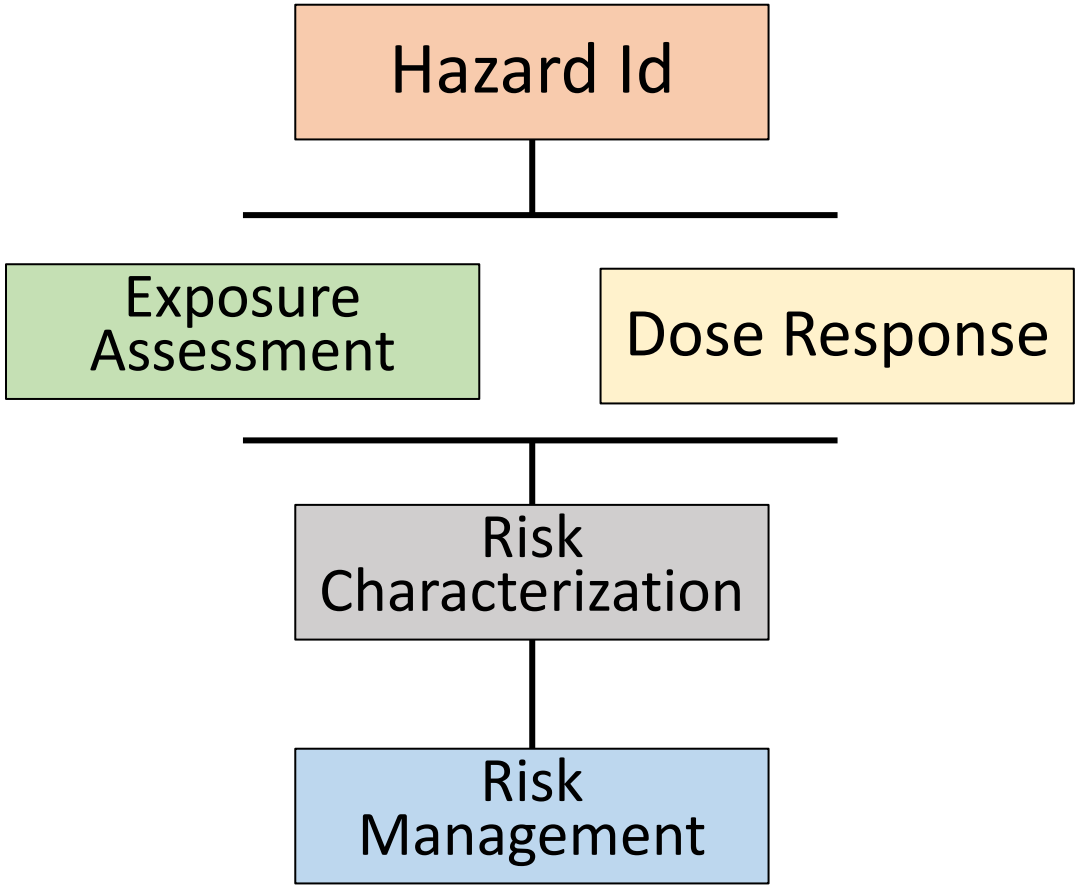


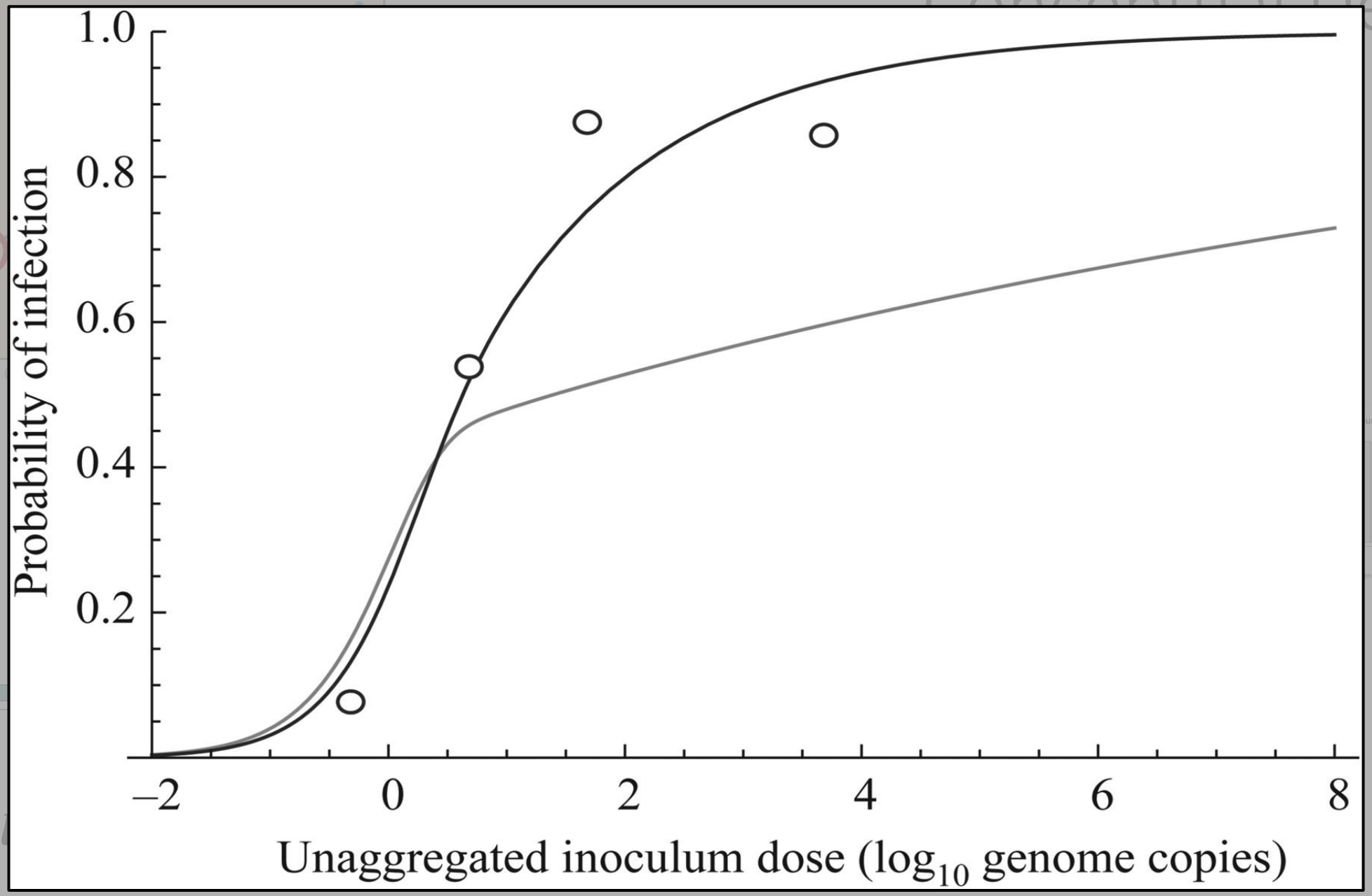
Running a Point Risk Assessment

- The 0.02 NoV copies $100mL^{-1}$ as input to QMRA
- Translate 31 FC CFU $100mL^{-1}$ to a p(illness)

FC ⇨ NoV ⇨ P(illness)

31 CFU $100mL^{-1}$	0.02 copies $100mL^{-1}$	??





Norovirus Possible at the Republican National Convention. (2016). Utah.edu. https://healthcare.utah.edu/healthfeed/postings/2016/07/RNC%20Norovirus.php

What is an Acceptable Risk for Shellfish Harvest ?

- Recreational Waters[1] – 32/1,000 = 3.2%
- **Shellfish Consumption ~ 3/1,000 = 0.3%**
- Drinking Water[2] – 1/10,000 = 0.01%

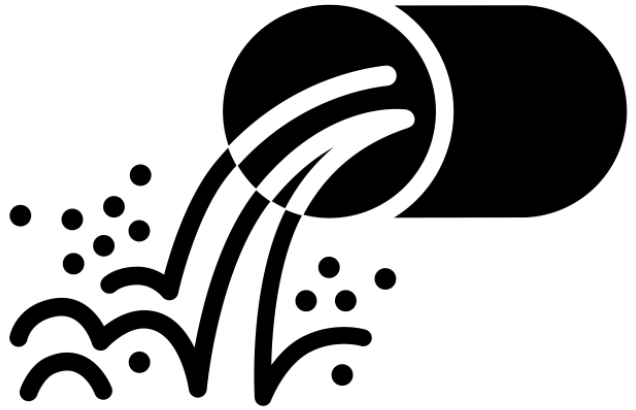
Unique Technology Gives Underwater View of Hampton Roads Oyster Reefs. (n.d.). Www.cbf.org. Retrieved January 24, 2023, from https://www.cbf.org/news-media/newsroom/2019/virginia/unique-technology-gives-underwater-view-of-hampton-roads-oyster-r

[1]Fujioka, R.S., Solo-Gabriele, H.M., Byappanahalli, M.N. and Kirs, M., 2015. US recreational water quality criteria: a vision for the future.

[2]Sinclair, M., O'Toole, J., Gibney, K. and Leder, K., 2015. Evolution of regulatory targets for drinking water quality. *Journal of Water and Health*, *13*(2), pp.413-426.

Establishing Shellfish Exclusion Zones

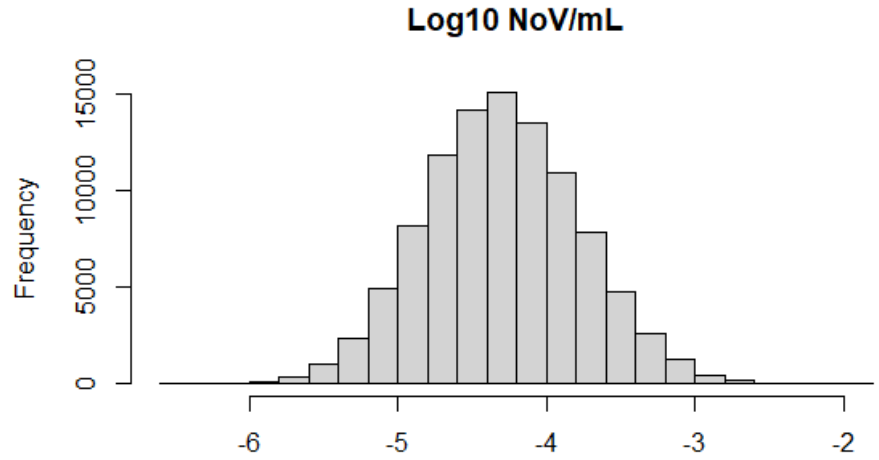
- How to apply 0.0031 risk threshold to classify shellfish exclusion zones?
- Waters w/ <1000:1 effluent dilution classified as Prohibited *(FDA)*
  - Prohibited = harvest is never permitted
- Our approach
  - Facility-specific pathogen data
  - NoV (vs FIB or MSC) to feed into QMRA



Input data

- NoV effluent data
  - 8 facilities in southeastern VA
  - Monthly/quarterly
  - ddPCR quantification
- Treatment facilities
  - Rated flow ranges 18-54 MGD
  - Chlorine disinfection
  - Various BNR configurations

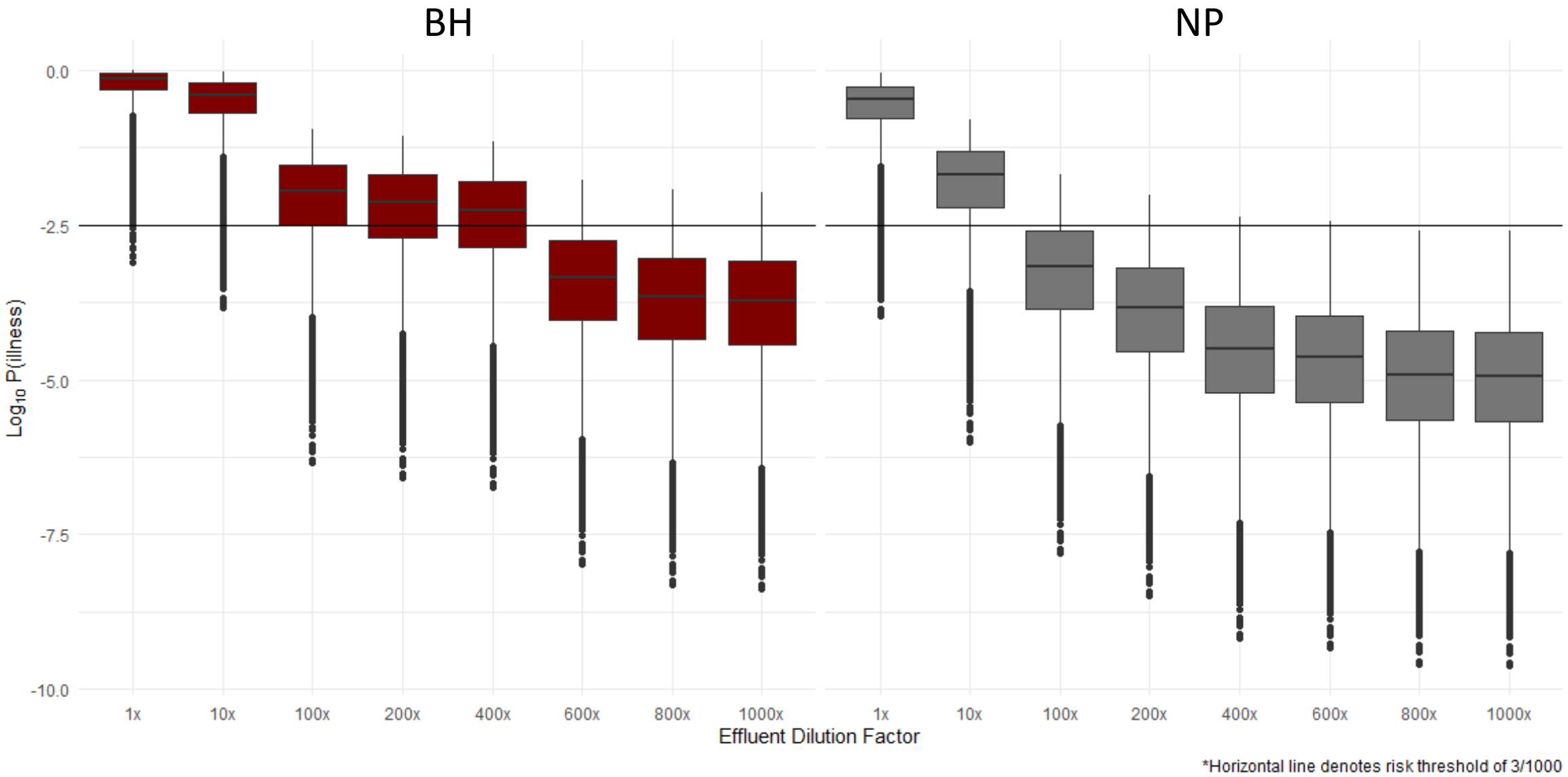
Modeling Approach



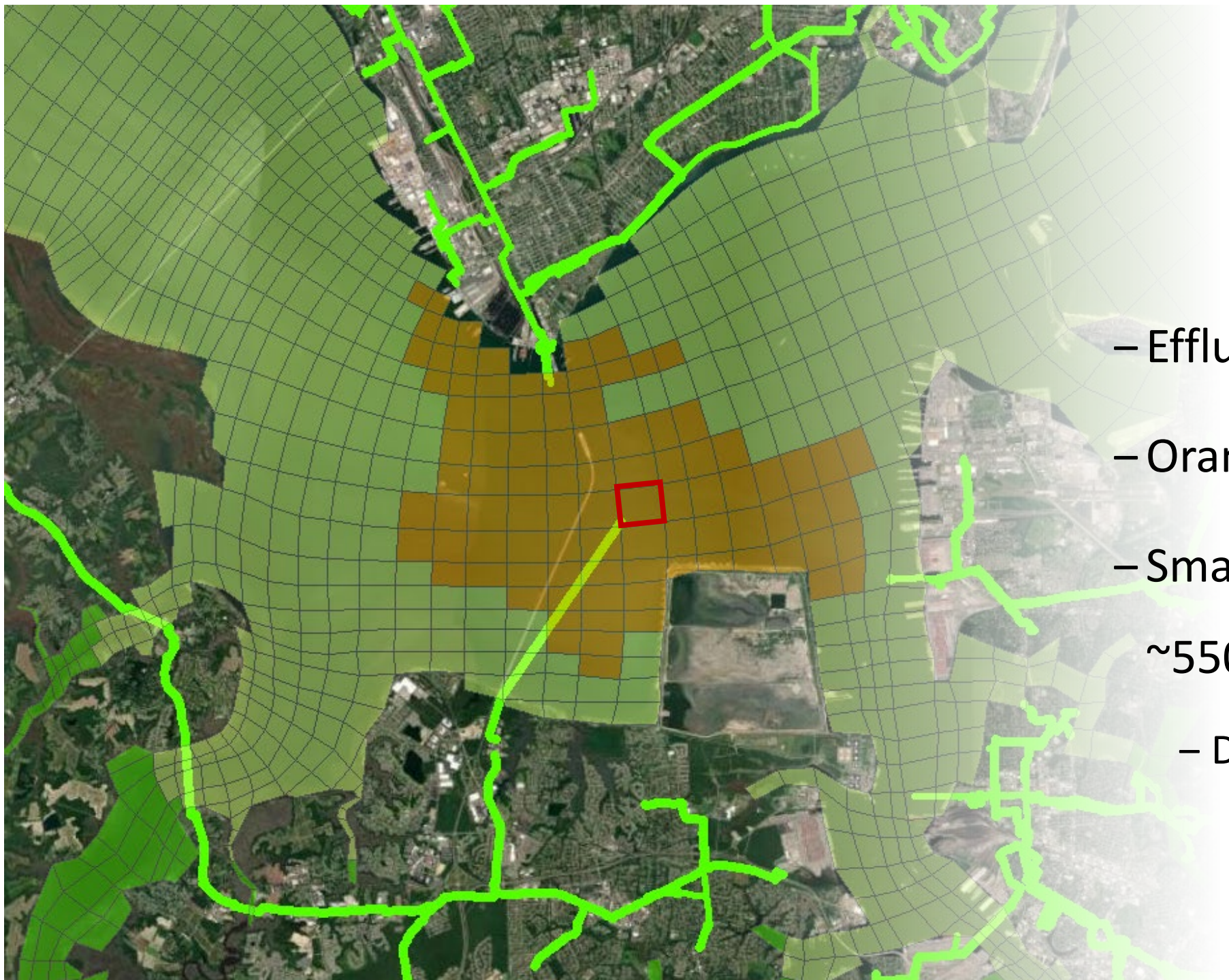
- Generate NoV distributions using effluent data
  - Simulate a range of effluent dilutions
  - Effluent diluted 1x – 1000x as input to QMRA

- When do most (>90%) simulations fall below the 0.0031 criteria?
  - How do the required dilution factors to get <0.0031 compare to 1000:1 dilution zones?

Output for Two Facilities



*Horizontal line denotes risk threshold of 3/1000



Spatial Context

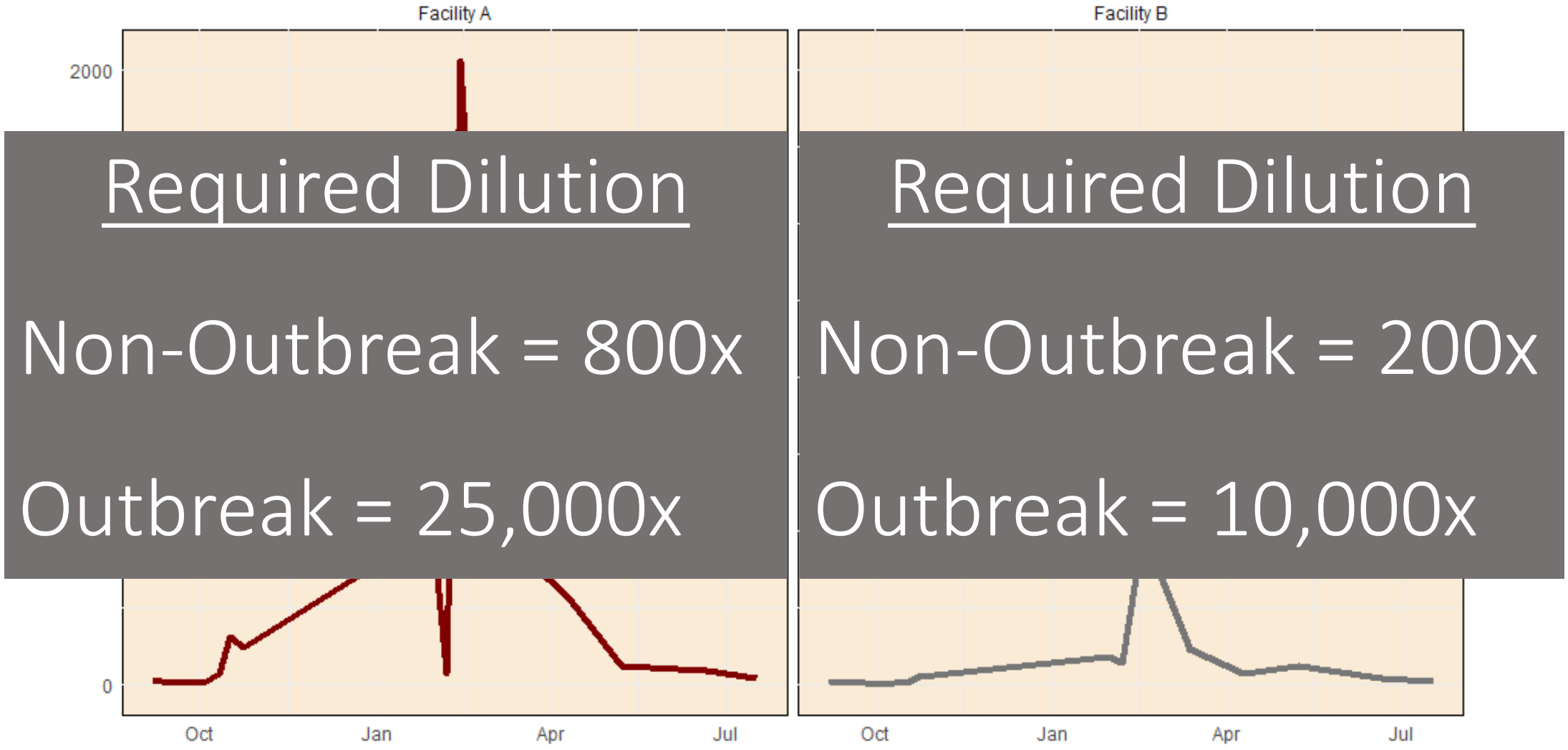
- Effluent dilution modeling
- Orange zone <1000:1
- Smallest dilution value is ~550:1
  - Dilution >200:1 immediately

Effluent NoV Data

- How much data to characterize NoV?
  - Seasonal effects – outbreak driven
  - What is your model input?

- Effluent NoV driven by a combination of factors
  - Community infection rates
  - Log reductions at facility
    - BNR configuration and SRT

The Effect of NoV Outbreaks



Required Dilution

Non-Outbreak = 800x

Outbreak = 25,000x

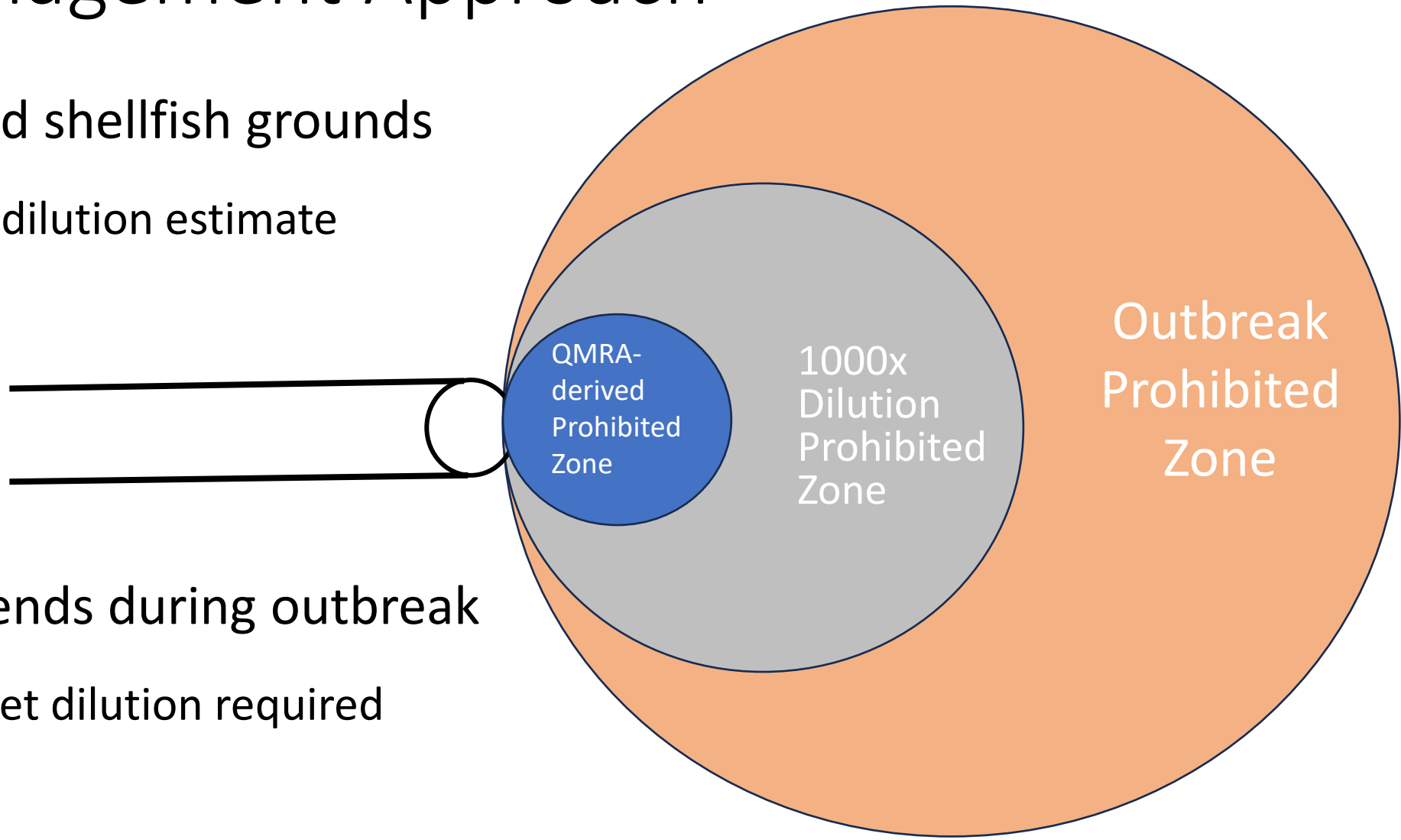
Required Dilution

Non-Outbreak = 200x

Outbreak = 10,000x

A Possible Management Approach

- Conditionally opened shellfish grounds
  - Use QMRA-derived dilution estimate



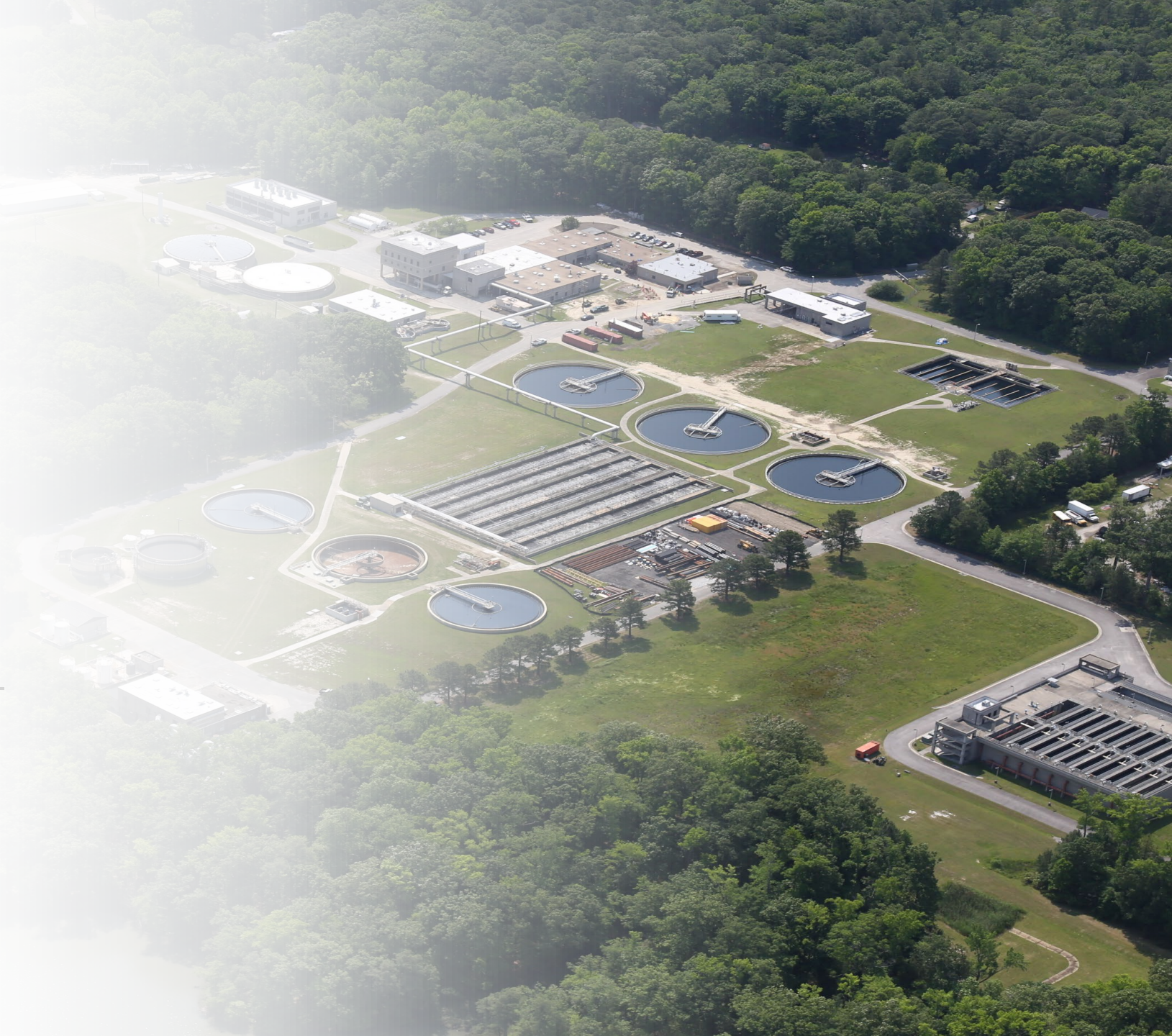
- Prohibited zone extends during outbreak
  - Same approach to set dilution required during outbreak

A Few Takeaways

https://www.chesapeakebaymagazine.com/good-neighbors/

- FIB concentration (Obj 1) and effluent dilution (Obj 2) act as proxies for risk
  - QMRA can be useful for translating into the language of risk (probability of illness)
  - Perhaps easier to manage when risk is stated explicitly
- This approach is facility-specific but modular
  - Other inputs (FIB / pathogens)
  - Effluent dilution estimates required
- Possible Management Approach
  - Shellfish grounds conditionally opened
  - Requires coordination w/ clinical community

Thanks!



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