EPA United States Environmental Protection Agency

National Scale Monitoring of Antimicrobial Resistance in Surface Water

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National Academy of Sciences Committee on the Long Term Medical and Economic Impacts of Antimicrobial Resistance

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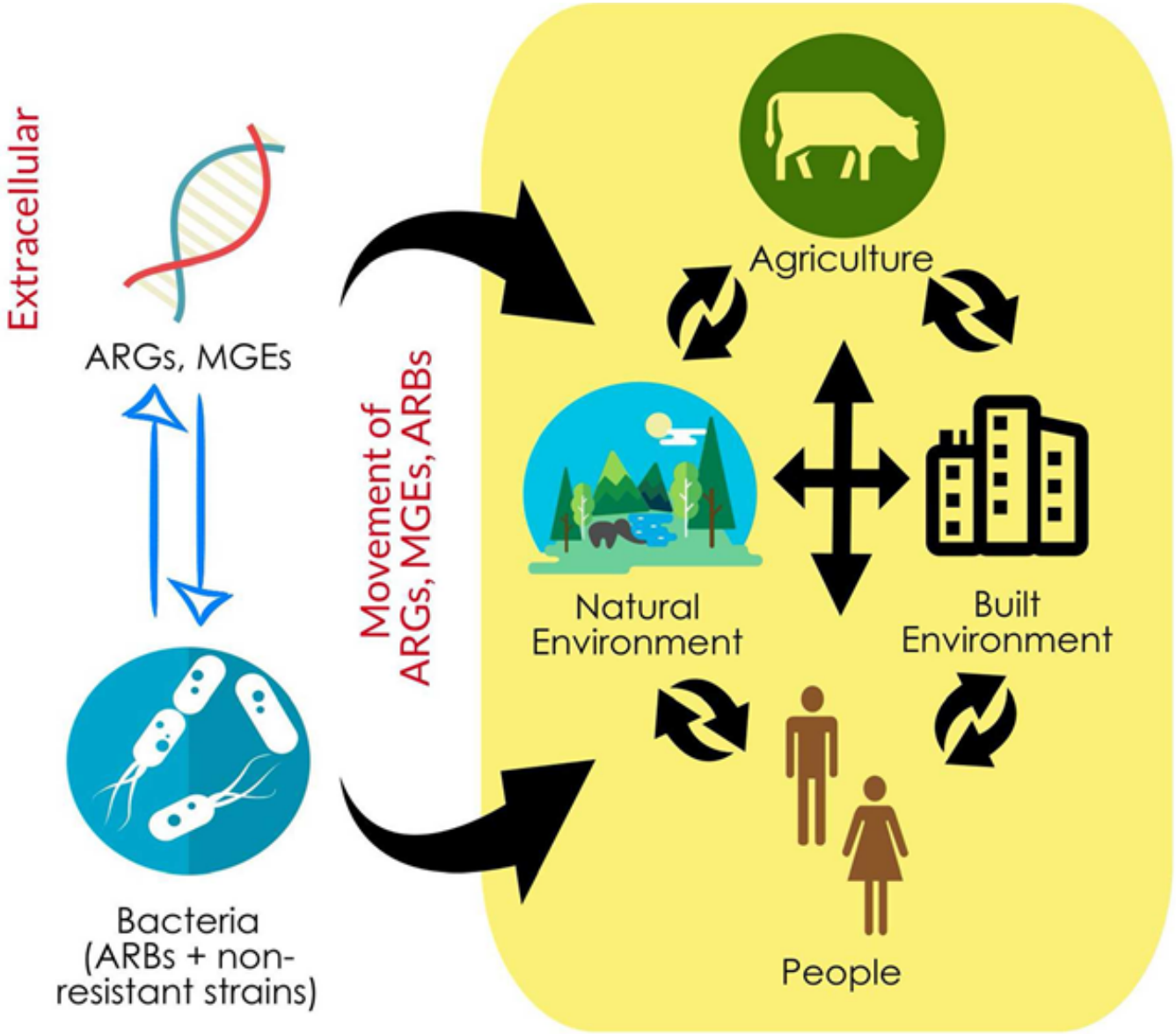
Overview

- New research area emphasis within EPA Office of Research & Development / Office of Water

- Touch on several EPA-specific research areas
  - Measurements in the water cycle
    - Municipal wastewater systems
    - Recreational water
  - Modeling and mitigating environmental exposure risks

- Interagency effort on surface water in support of National Antimicrobial Resistance Monitoring System

The Challenge



Vikesland et al. 2017. EST

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Initiatives for Addressing Antibiotic Resistance in the Environment: *Current Situation and Challenges* *https://wellcome.org/sites/default/files/antimicrobial-resistance-environment-report.pd (2018)*

Assessing & Improving Sanitation & Wastewater Treatment

Improve global sanitation by identifying efficient, affordable waste processing

Evaluate need for on-site pretreatment from high strength facilities (e.g., hospitals)

Evaluate the effectiveness of existing wastewater treatment process & identify factors resulting in inefficiencies or failures

AMR Environmental Risk Measurements

- **Wastewater**
  - Influence of hospital wastewater on AMR in municipal sewer networks (ongoing sampling, on hold)
    - ESBL *E. coli* and VRE loading and isolates for genetic study
    - ARGs including high-throughput PCR panel development
  - Linkages to current SARS-CoV-2 monitoring

- **Recreational Water**
  - Gulf Coast Beach Study
    - Leverage existing planned sampling campaign (on hold)
    - ESBL *E. coli* and MRSA occurrence and genetic profiling
    - Inform exposure studies and public health risk assessments
    - Determine relationships with potential water quality predictors

Environmental Risk Modeling

- **Water Research Foundation White Paper Collaboration**
  - "A human health risk modeling framework for environmental sources of AMR: Toward quantitative risk predictions"
- **Framework Applications**
  - ***Water Reuse*** – MRSA risk during showering with reclaimed graywater
    - Broadens exposure pathway to opportunistic skin pathogens common in source water
    - Considers stain virulence and additional disease burden of drug-resistant infections
    - Incorporates horizontal gene exchange during treatment
  - ***Recreational Water*** – ESBL *E. coli* in wastewater-impacted surface waters
    - Breadth of gene transfer data for modeling additional risks of ARG dissemination
    - Synergy with WHO Tricycle and planned measurement studies
    - Potential for source apportionment and control point evaluations

National-Scale Surface Water Efforts

Initiatives for Addressing Antibiotic Resistance in the Environment*: Current Situation and Challenges*
https://wellcome.org/sites/default/files/antimicrobial-resistance-environment-report.pd *(2018)*

- **Environmental waters one of the areas in the report**
  - Geospatial distribution of resistance to inform risk
  - Sources & selective pressures for amplification/transmission
  - Define & standardize sampling/analysis methods

"Following the NARMS Review Subcommittee recommendations to incorporate the three major domains of the One Health model (humans, animals, environment), an important theme of this strategic plan is the expansion of testing to examine resistance in animal pathogens and the environment. For environmental monitoring, what constitutes the best sampling points will be refined over time. Surface waters as confluence points of ecosystems differentially affected by built environments is a starting point."

NARMS Strategic Plan 2020-2025

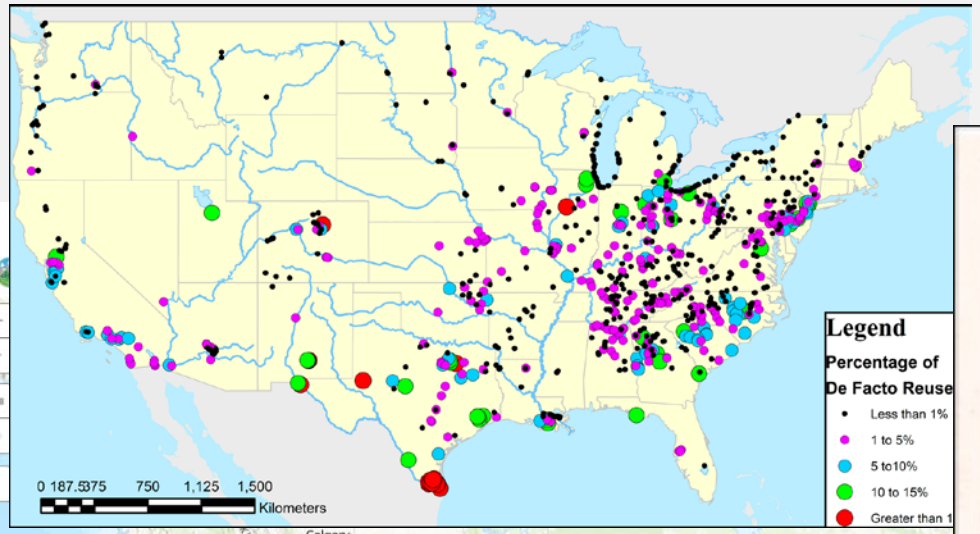
Surface Water AMR Monitoring (SWAM)
Objectives

- A pilot environmental effort within a One Health focused NARMS

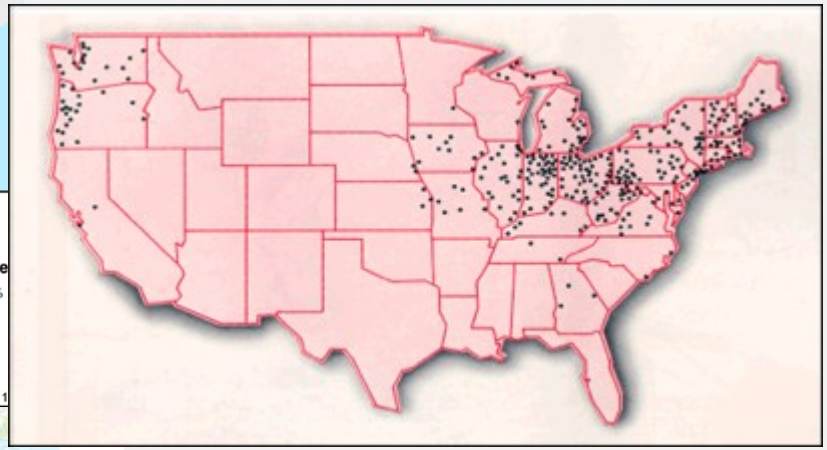
- Develop a national-scale, quantitative assessment of AMR within surface water:
  A. Standardized measure (and library of samples) to monitor trends as part of NARMS
  B. Input to models of AMR risks for various end uses of water (recreational, drinking, agricultural, water reuse).
  C. Help quantify drivers of occurrence and selective pressures for potential amplification
  D. Identify critical control points and assess current and new mitigation strategies

Why Water?

Rice J. and P. Westerhoff. 2015. Spatial and temporal variation in de facto Wastewater reuse in drinking water systems across the USA ES&T 49, 982



Human Wastewater



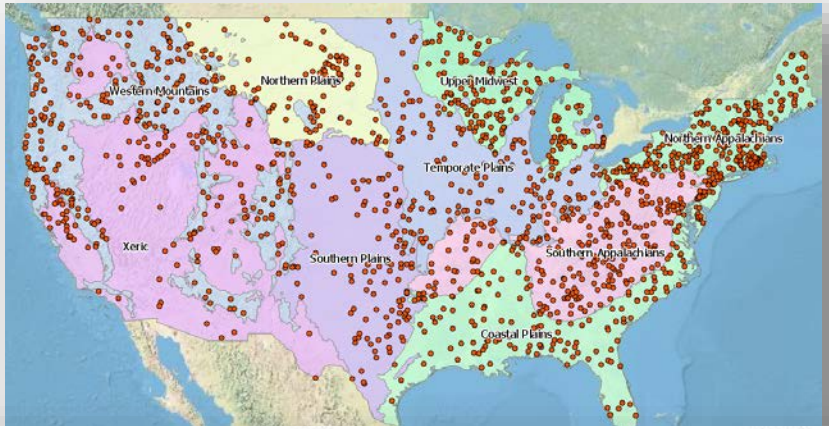
Animal Manure

https://enviroatlas.epa.gov/enviroatlas/DataFactSheets/pdf/ESN/Manureapplication.pdf

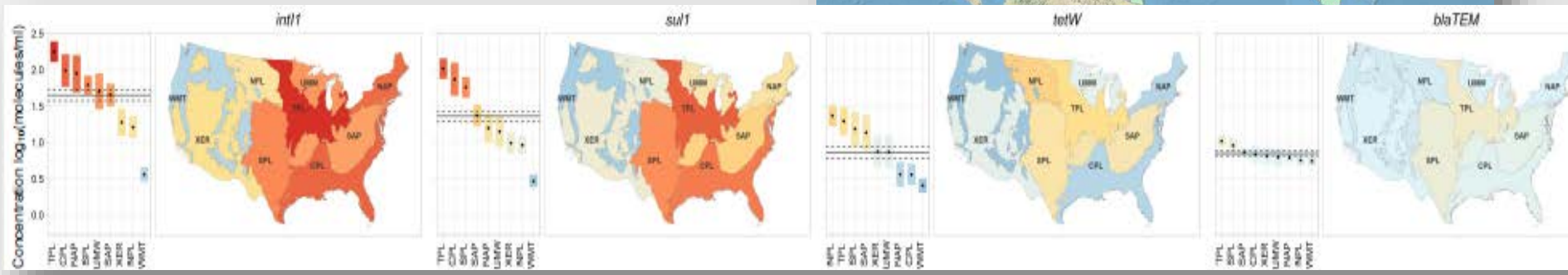
Multiple Inputs to Watersheds

Designing the Study

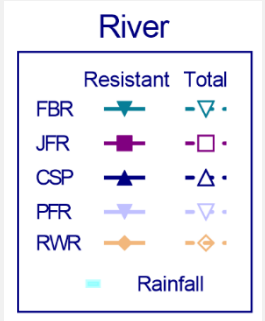
Go Big and Slow?

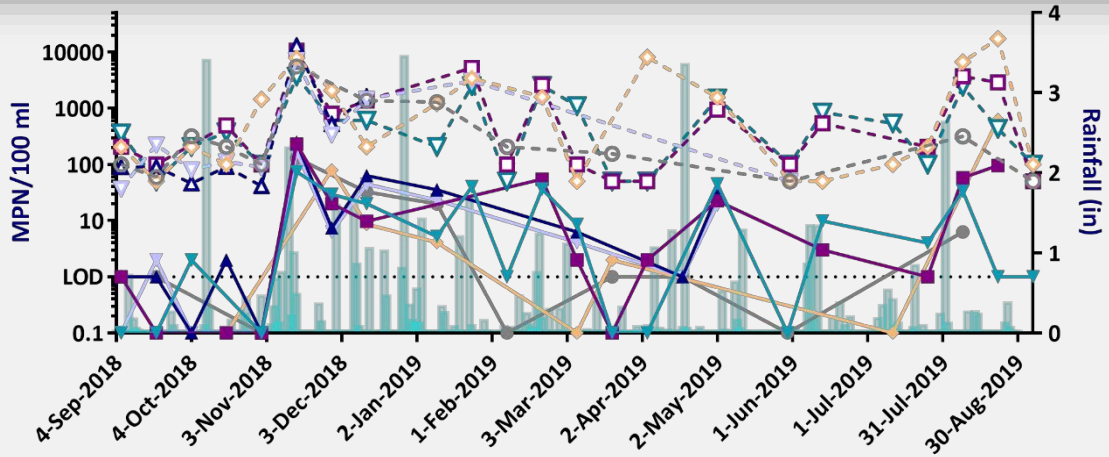


EPA National Rivers and Streams Assessment
5 year, probabilistic survey of aquatic resource



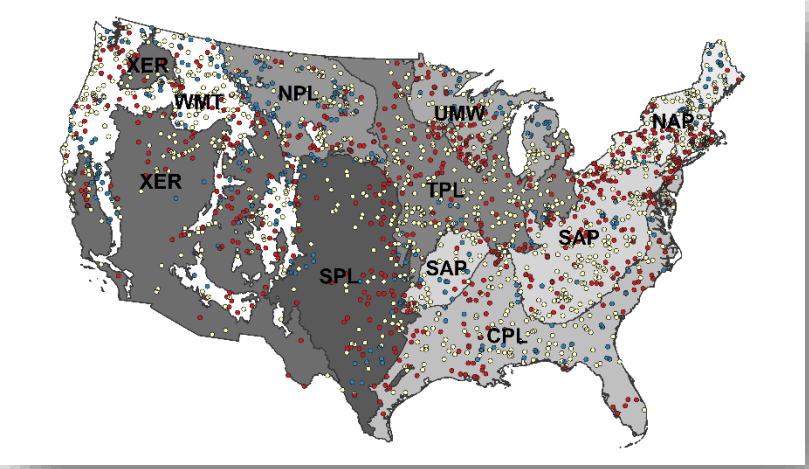
Or Small and Fast?





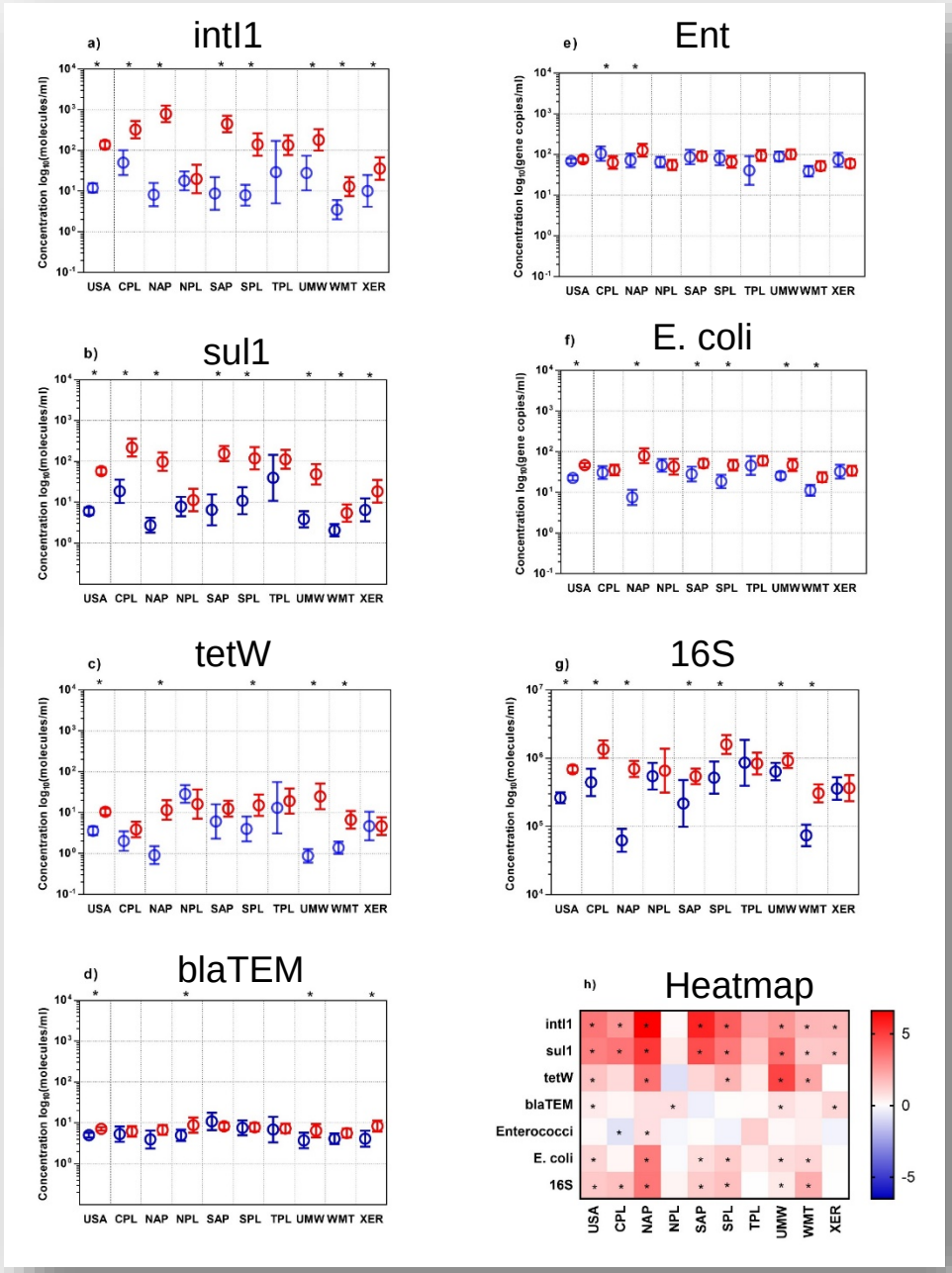
CDC Preliminary Surface Water Study in Chattahoochee River

Baseline Analysis



ECO9 Regions Shown; blue is reference; yellow is intermediate; red is impacted

Filter criteria
Total P (µg/L)
Total N (µg/L)
Cl– (µeq/L)
$SO4^{2-}$ (µeq/L)
ANC (µeq/L) , DOC (mg/L)
Turbidity (NTU)
Riparian Disturbance Index
% fine substrate



Analytical Targets

There is a need for rigorous QA/QC in data collection, as well as agreement in the community regarding standardized methods and reporting. Until priority monitoring targets are agreed on, analysis of a suite of culture-based and molecular based indicators is logical

Pruden et al. 2018 *Environmental science and engineering framework for combating antimicrobial resistance*

Culture

Enterococci, E.coli: links to existing water method

Salmonella: links to NARMS, food cycle

Targeted Gene

Quantitative measure

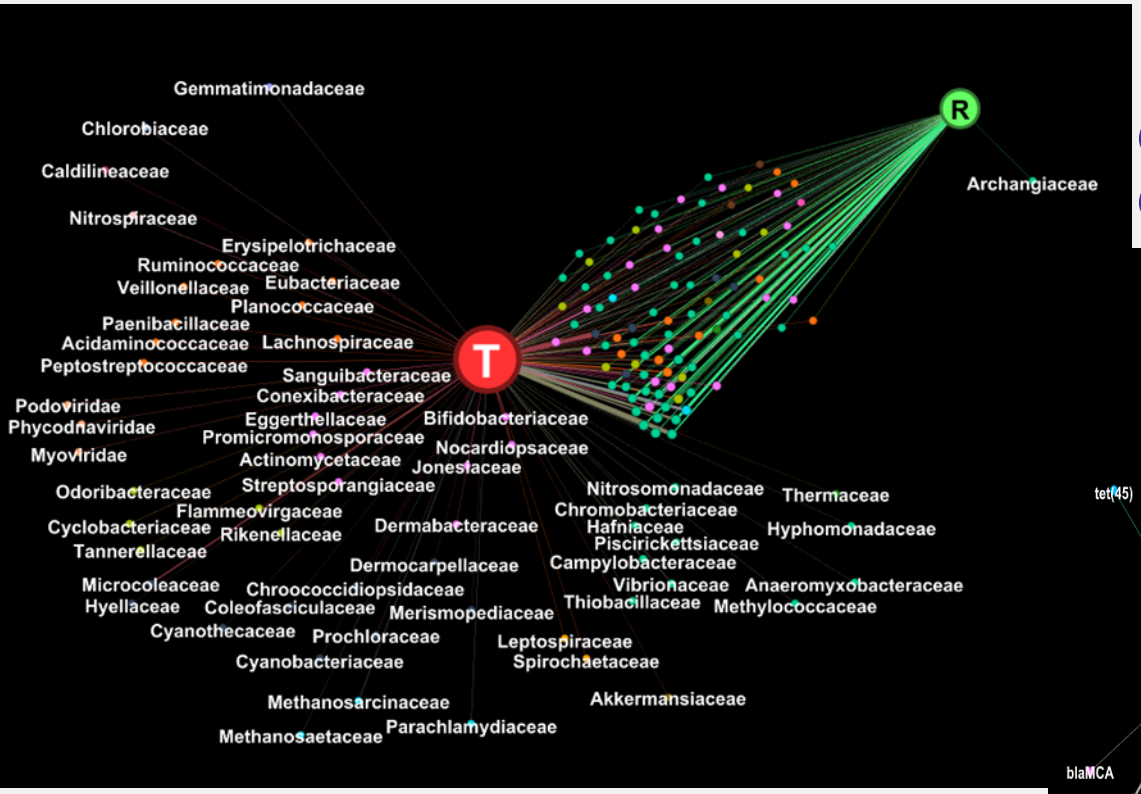
Defined panel, including fecal source trackers

Metagenomics

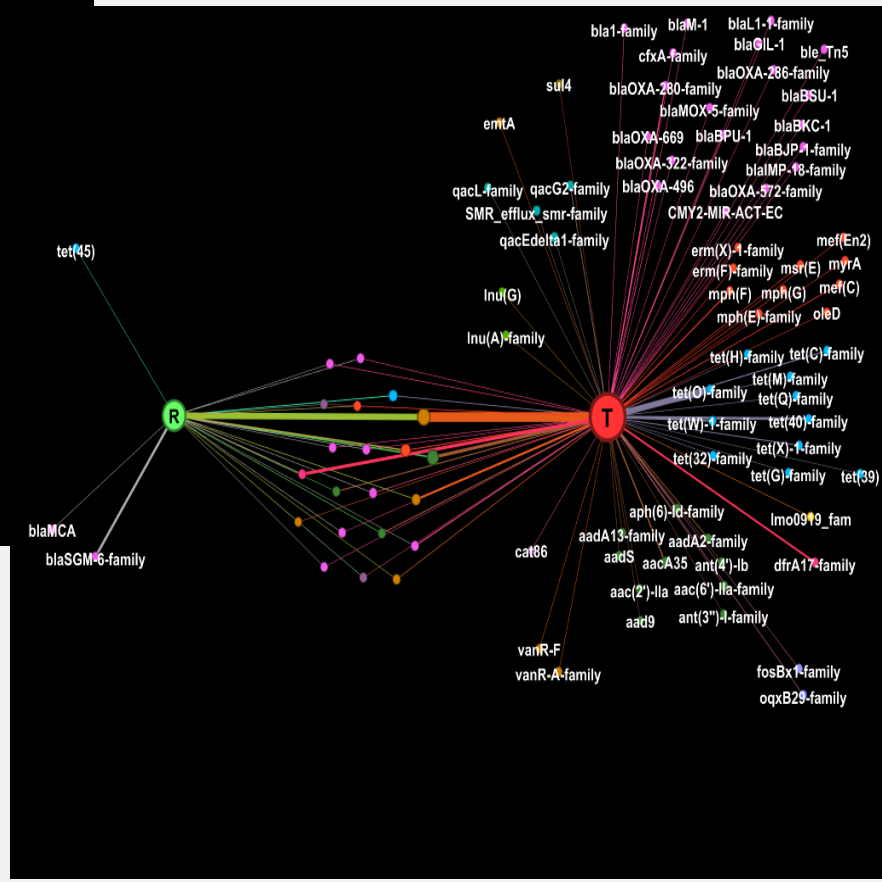
Deeper view

Link resistance genes to hosts?

Pilot Metagenomics Effort within NRSA (Northern Appalachians)



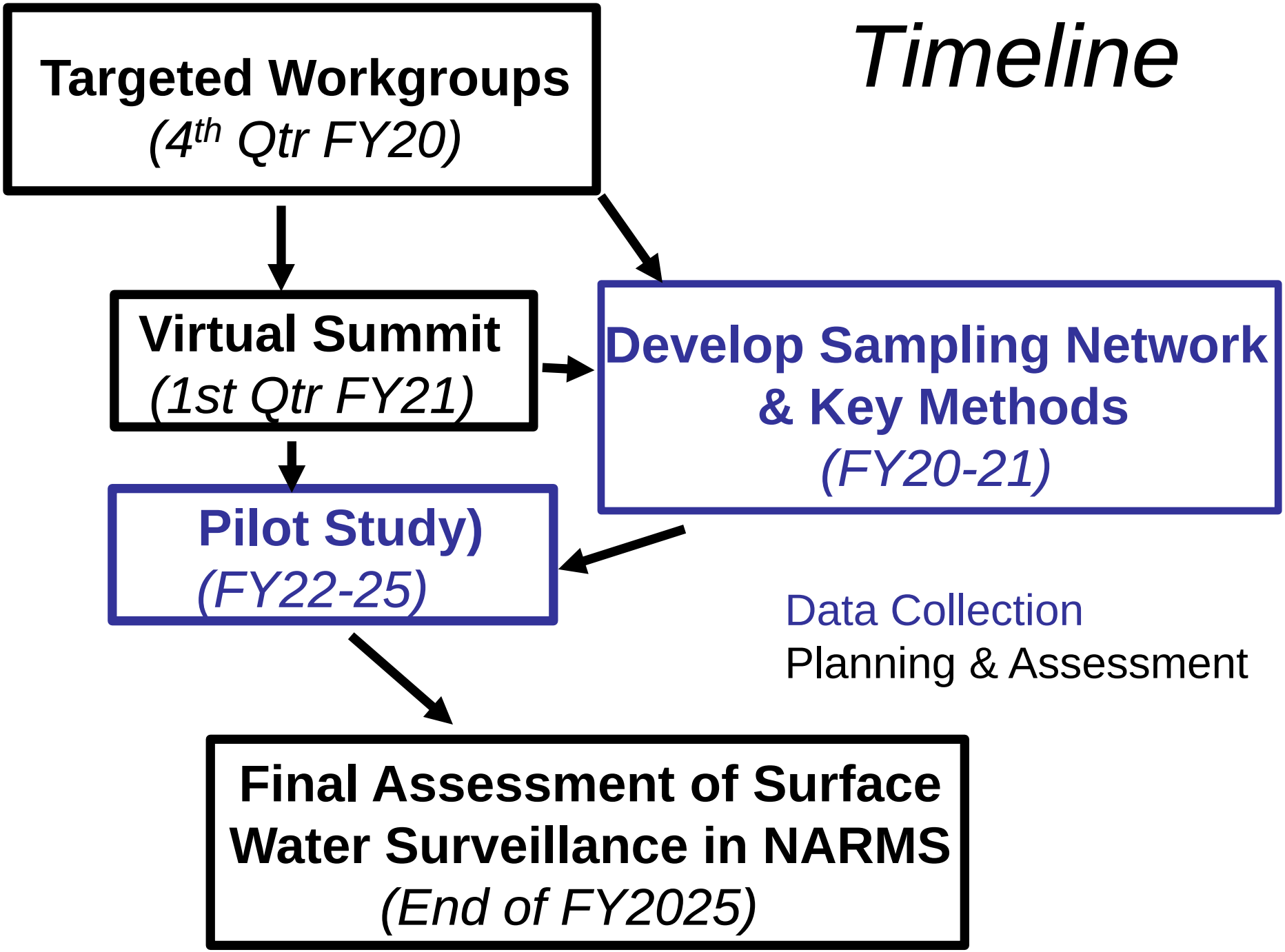
Collaboration with FDA Center for Veterinary Medicine



Taxonomic Comparison Between Reference vs stressed

Comparison of **Resistance** Genes

Timeline


Targeted Workgroups
(4th Qtr FY20)
Virtual Summit
(1st Qtr FY21)
Develop Sampling Network & Key Methods
(FY20-21)
Pilot Study)
(FY22-25)
Data Collection
Planning & Assessment
Final Assessment of Surface Water Surveillance in NARMS
(End of FY2025)

Summary

Developing information on AMR measurements and risk modeling to inform EPA Office of Water

Actively engaged in an interagency effort to both determine the value of, and standard approach to, environmental monitoring within a One Health, national scale effort

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