

Everything You Need to Know About **Wastewater-Based Surveillance**

North Carolina Pretreatment Consortium Conference
September 18, 2023

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Agenda

Introduction

Presentation and Q&A: wastewater-based surveillance 101

Group discussion: pathogen targets of most interest

Presentation and Q&A: public health uses of wastewater data

Small group work: supporting utilities

Wrap up

Objectives

01

Understand the past, present, and future of wastewater-based surveillance

02

Describe public health uses of wastewater data for specific pathogens

03

Brainstorm how money can be spent to support utilities

Why is WEF talking about this?

Five-year Cooperative Agreement with CDC under program on
“Protecting and Improving Health Globally: Building and
Strengthening Public Health Impact, Systems, Capacity and Security”

Cooperative Agreement activities

Year Three

October 2022 through September 2023

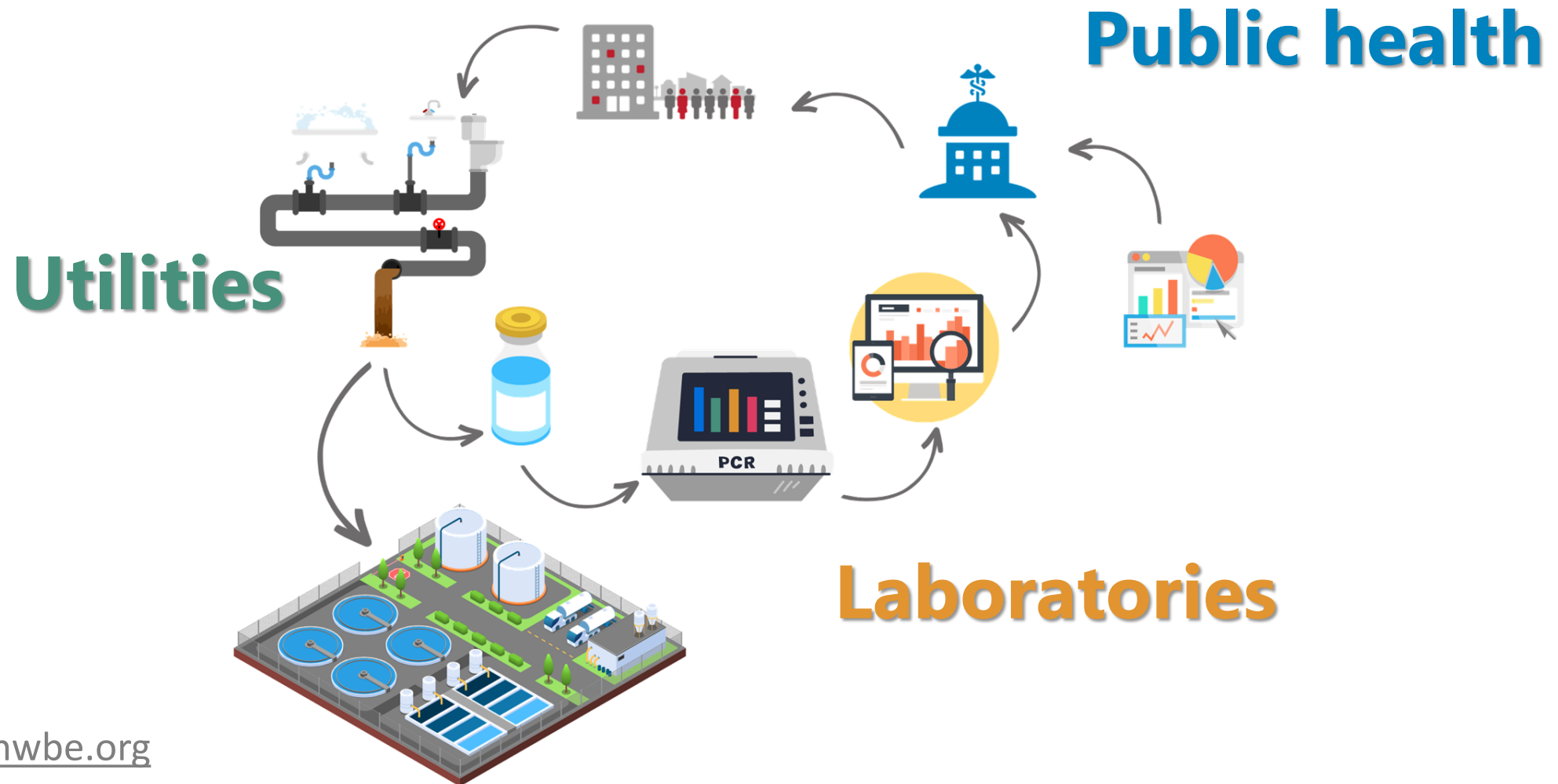
- Utilities Community of Practice
- GeneXpert pilot
- In-person “utility barrier” workshops
- Awareness trainings & workshops
- Free autosamplers and flow meters for small facilities
- Wastewater Disease Surveillance Summit
- nwbe.org



“Join” at nwbe.org

Presentation: wastewater-based surveillance 101

Wastewater-based surveillance (WBS) is the systematic sampling and analysis of **untreated** wastewater, and **interpretation** of wastewater data, to better understand **community** health



FAQs at [nwbe.org](https://www.nwbe.org)

(Nearly) equivalent terms

Sewage
epidemiology

Wastewater-
based
epidemiology

Wastewater
public health
monitoring

Wastewater-
based disease
surveillance

Wastewater
disease
surveillance

Wastewater
surveillance

Related terms

 **Public health surveillance** is *“The ongoing, systematic collection, analysis, and interpretation of health-related data essential to planning, implementation, and evaluation of public health practice closely integrated with the timely dissemination of these data to those responsible for prevention and control.”*¹

 **Environmental disease surveillance** can include monitoring wastewater, air, soil, high-touch surfaces²

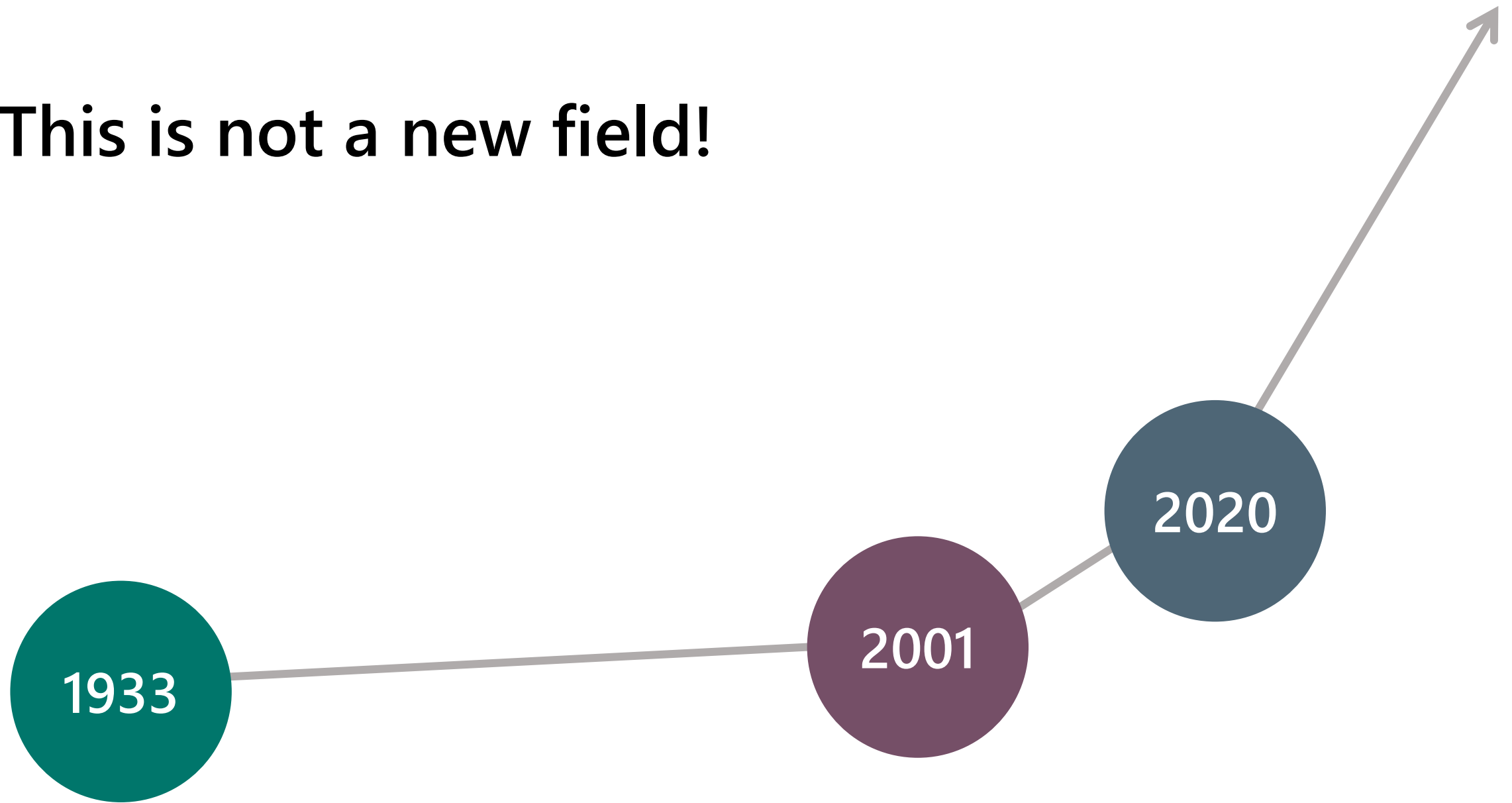
References:

1. <https://www.cdc.gov/training/publichealth101/documents/introduction-to-surveillance.pdf>
2. Larsen et al. 2021 *FEMS Microbes* <https://doi.org/10.1093/femsmc/xtab011>



- Captures all infections independent of healthcare-seeking behavior/testing access
- Gives community-level, aggregated information
- Complements other public health surveillance data, perhaps providing a leading indicator

This is not a new field!



1933

ISOLATION OF ENTERIC BACILLI FROM
SEWAGE AND WATER AND ITS
BEARING ON EPIDEMIOLOGY*

BY

W. JAMES WILSON, M.D., D.Sc.

PROFESSOR OF HYGIENE AND PUBLIC HEALTH, QUEEN'S UNIVERSITY,
BELFAST

1939

PERIODIC EXAMINATION OF SEWAGE FOR THE VIRUS OF POLIO-
MYELITIS*

By JAMES D. TRASK, M.D., AND JOHN R. PAUL, M.D.

WITH THE TECHNICAL ASSISTANCE OF JOHN T. RIORDAN

(From the Department of Pediatrics and the Section of Preventive Medicine of the Yale
University School of Medicine, New Haven)

1988

Guidelines for environmental
surveillance of poliovirus circulation

WHO/V&B/03.03
ORIGINAL: ENGLISH

1989

Intensified environmental surveillance supporting
the response to wild poliovirus type 1 silent
circulation in Israel, 2013

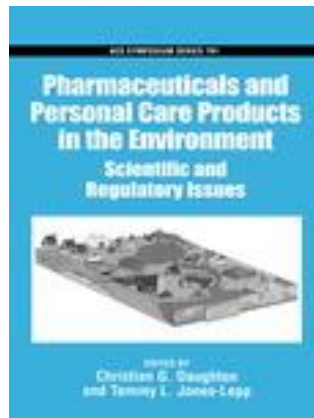
- a. Wilson. 1933. BMJ.
- b. Trask and Paul. 1942. *J. Exp Med.*
- c. WHO. 2013. *Guidelines for environmental surveillance of poliovirus circulation.*
- d. Manor et al. 2014. *Eurosurveillance.*

2001

Illicit Drugs in Municipal Sewage

Proposed New Nonintrusive Tool to Heighten Public Awareness of Societal Use of Illicit-Abused Drugs and Their Potential for Ecological Consequences

Christian G. Daughton



Pharmaceuticals and Care Products in the Environment

Daughton. 2001. <https://pubs.acs.org/doi/pdf/10.1021/bk-2001-0791.ch020>

Illicit Drugs

Amphetamines
Cannabis
Cocaine
Heroin

“Licit” Drugs

Alcohol
Caffeine
Nicotine

Counterfeit Meds

Sildenafil

Pharmaceuticals

Antibiotics
Antidepressants
Benzodiazepines
Opioids

Population Markers

Ammonia
Creatinine
5-HIAA

Stress Bio-markers

8-iso-PGF2 α

Industrial Chemicals

Flame retardants
Pesticides
Plasticizers

Antibiotic Resistance

Various genes

Viruses

Adenoviruses
Coronaviruses
Enteroviruses (including polio)
Hepatitis viruses
Noroviruses
Orthopoxviruses

2020



pubs.acs.org/journal/estlcu

Letter

Presence of SARS-Coronavirus-2 RNA in Sewage and Correlation with Reported COVID-19 Prevalence in the Early Stage of the Epidemic in The Netherlands

Gertjan Medema,* Leo Heijnen, Goffe Elsinga, Ronald Italiaander, and Anke Brouwer



Cite This: *Environ. Sci. Technol. Lett.* 2020, 7, 511–516



Read Online

Medema et al. 2020. <https://pubs.acs.org/doi/10.1021/acs.estlett.0c00357>

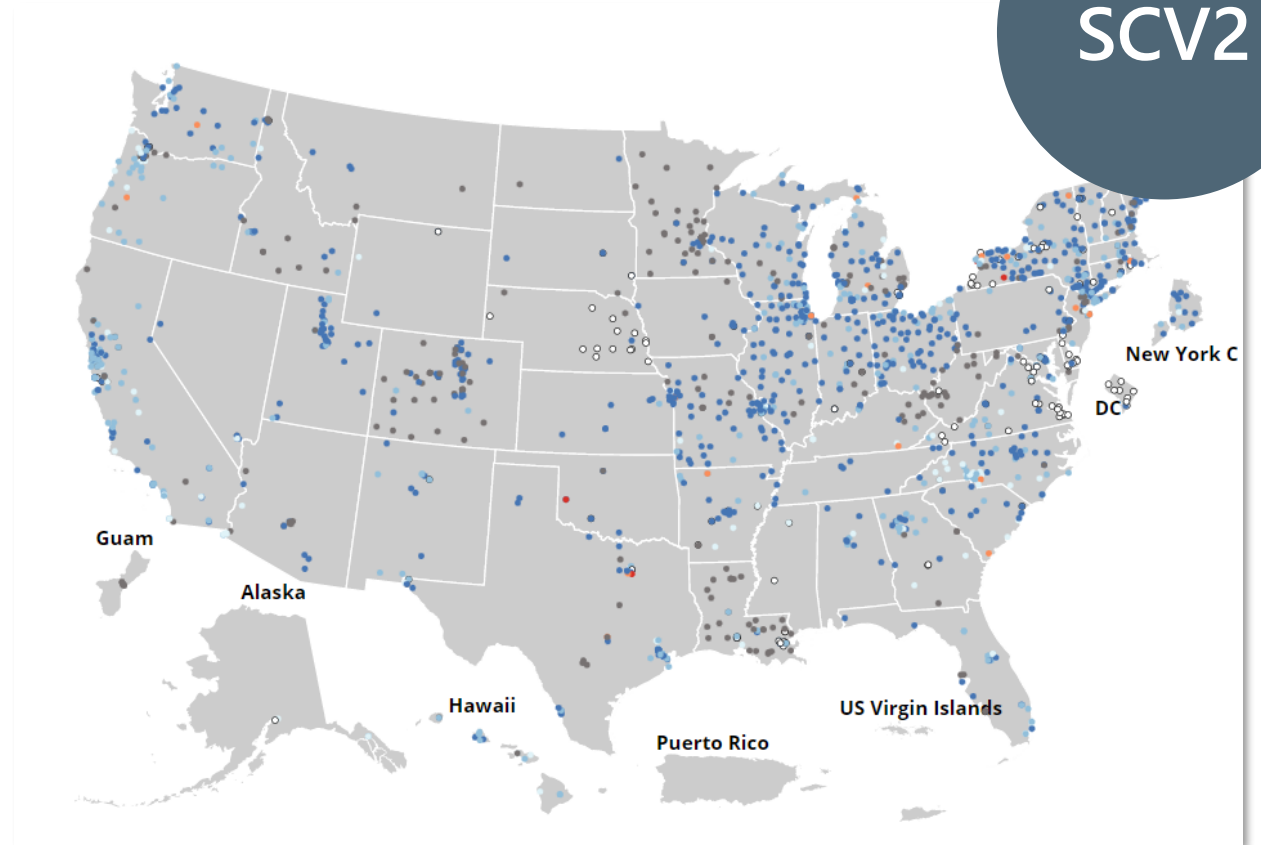


Accessed June 17, 2023

National Wastewater Surveillance System

- Established September 2020
- > 1,600 sites
- SARS-CoV-2 data available on COVID Data Tracker and via public data request
- mpox data also available online

SCV2

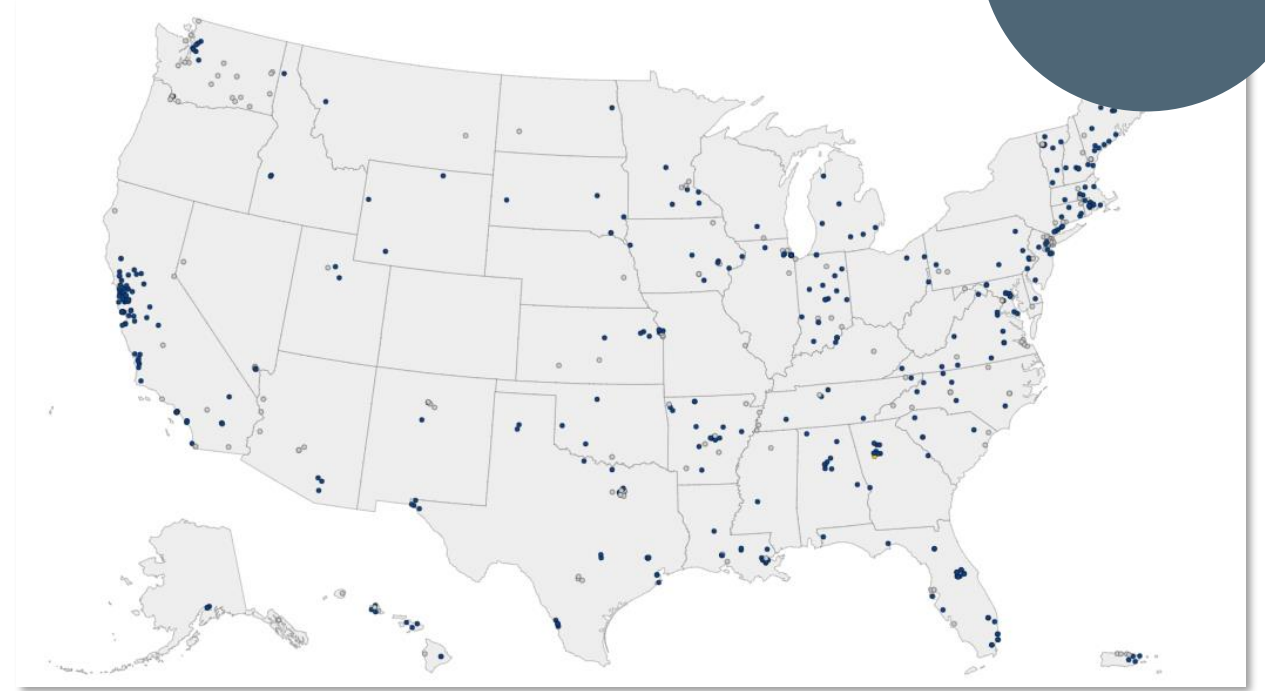


<https://covid.cdc.gov/covid-data-tracker/#wastewater-surveillance>

June 17, 2023

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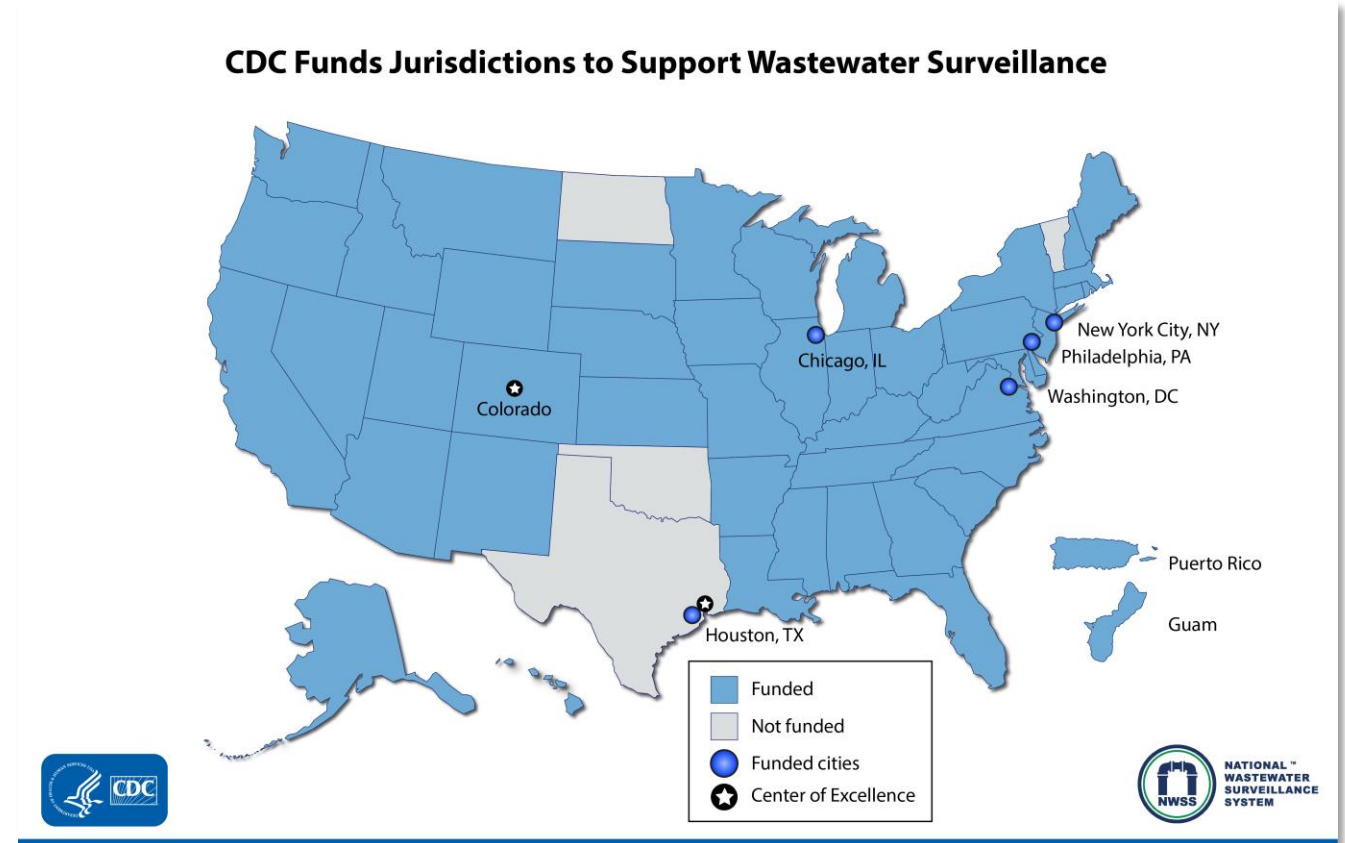
<https://www.cdc.gov/poxvirus/mpox/cases-data/wastewater-surveillance.html>

June 17, 2023

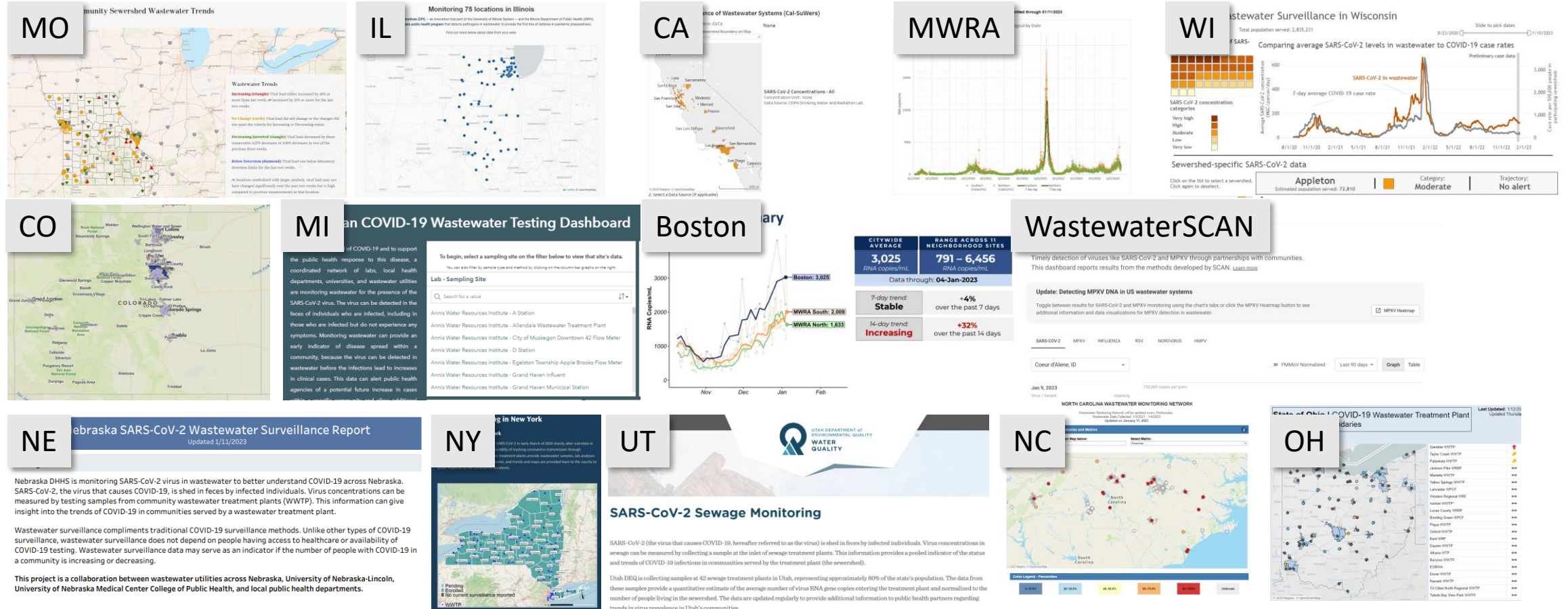
National Wastewater Surveillance System

Collection of local programs, with CDC providing:

- Funding
 - Directly to health departments
 - For commercial testing contract
- Data analytics
- Direction



Some of the (many) state & local programs



WastewaterSCAN

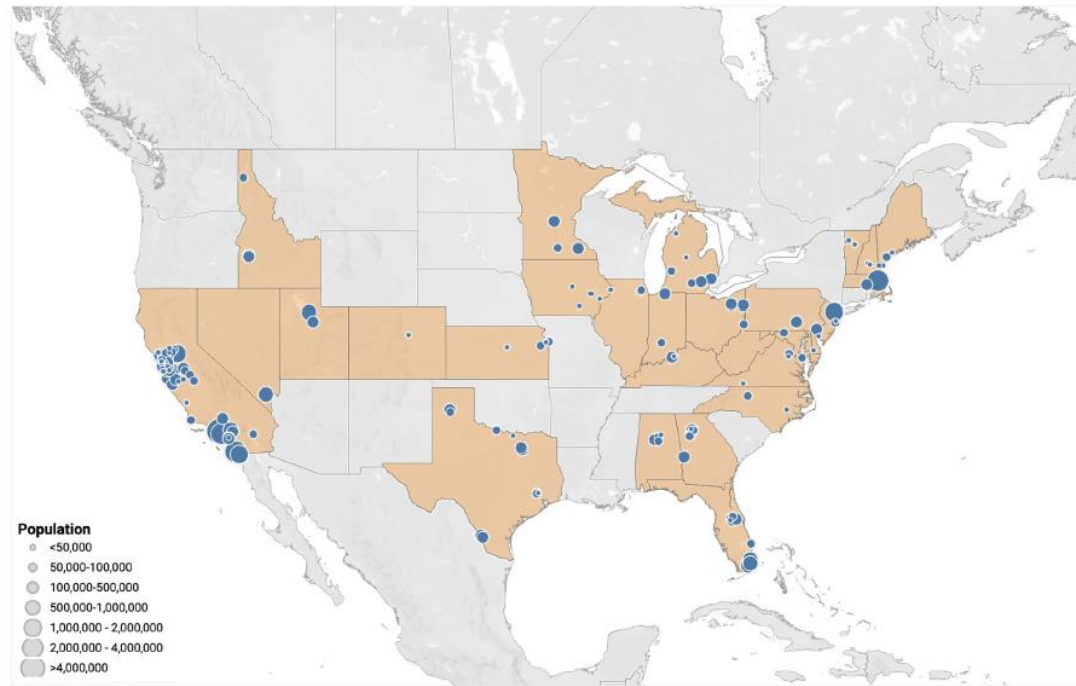
Program Update

Participants:

- **153** plants sampling
- **10.78%** US population represented (*35,518,459 people*)
- **29** states represented

Welcome, New Plants!

Union Beach, NJ
Mt. Pleasant, MI
Red Wing, MN
Yankton, SD
Harrison, AR
Carmel, IN



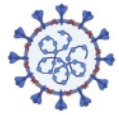
*map only shows plants that have sent in samples

WastewaterSCAN Stakeholder Update 4/14/23

<https://wastewaterscan.org/>

WastewaterSCAN

Currently Measuring



SARS-CoV-2

- **N gene** (pan-SARS-CoV-2 targets)
- **HV69-70 mutation** (BA.4 and BA.5, including B.Q.*)
- **XBB*** (targets 5 adjacent SNPs -Y445P, G446S, E484A, F486S/P and F490S)

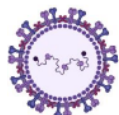


Influenza A (IAV)

- **M1 gene** in influenza A genome

Influenza B (IBV)

- **M gene** in influenza B genome



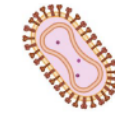
Respiratory Syncytial Virus (RSV)

- **N gene** of RSV genome (detects RSV A and RSV B)



Human Metapneumonia virus (HMPV)

- **L gene** in the HMPV genome



Mpox virus

- **G2R_WA** marker in the mpox virus genome



Norovirus GII

- **ORF1-ORF2 junction** in norovirus GII genome

Controls



- PMMoV (pepper mild mottle virus) - endogenous control
- BCoV (bovine coronavirus) - exogenous control

WastewaterSCAN Stakeholder Update 4/14/23

<https://wastewaterscan.org/>

The wastewater utility's role

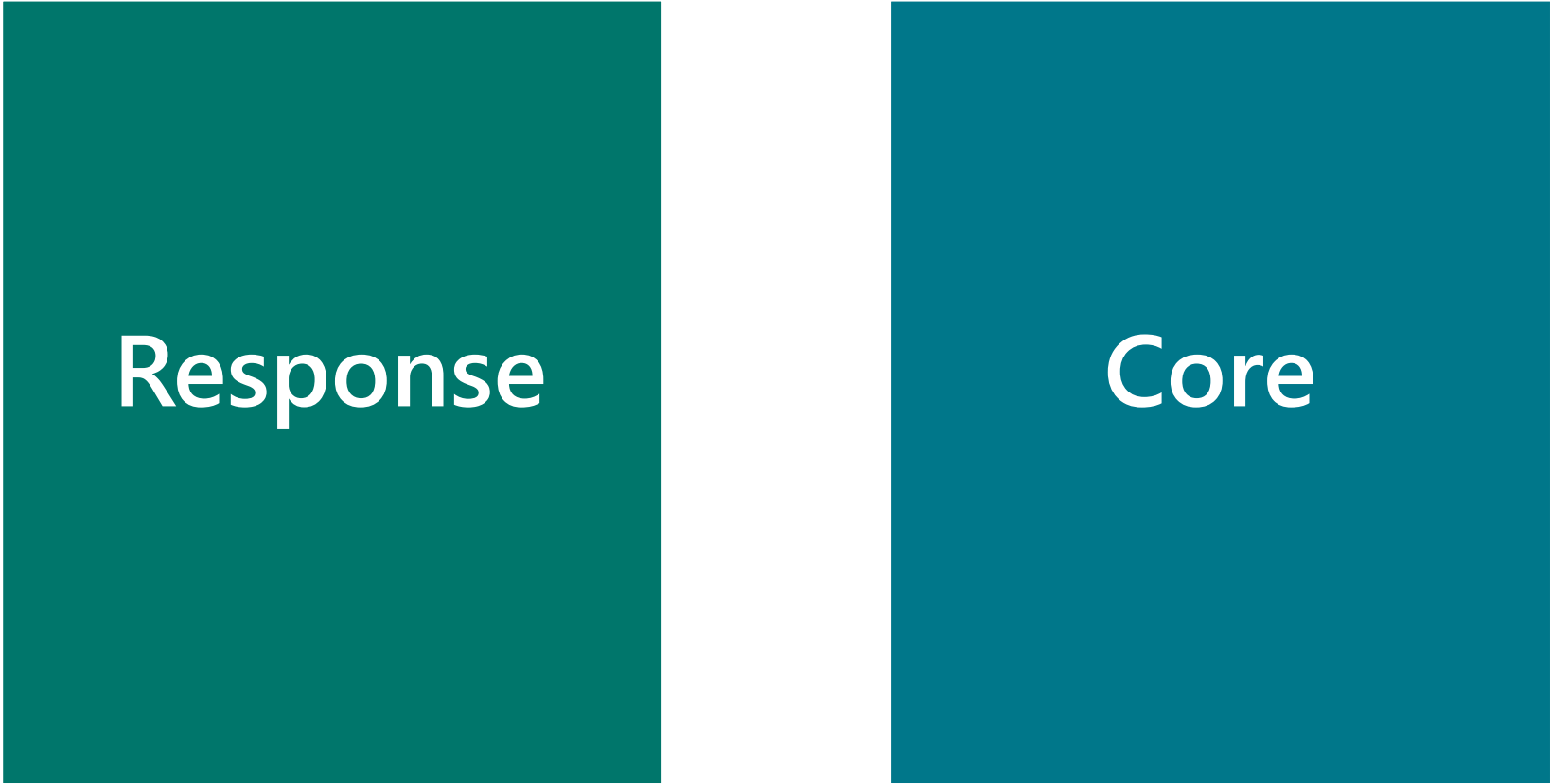
- Development of wastewater sampling plan in coordination with health department partner
- Ongoing collection of wastewater samples:
 - Packaging sample for transport to analytical laboratory
 - Completing the chain of custody
 - Providing sample-related "metadata" (flow + maybe pH, temperature and EC)



20 to 30
minutes
per sample

**Group discussion:
pathogen targets of
most interest**

What's next for NWSS



Response

Core

Response targets

- Mpox virus (MPXV)
 - Already incorporated into NWSS
 - Commercial testing contract amended to include MPXV
 - Data shared with public
- Poliovirus (PV)
 - Testing taking place in select locations
 - Universal wastewater testing for PV not warranted
 - Complicated by national and global polio containment requirements

Likely future **core** targets

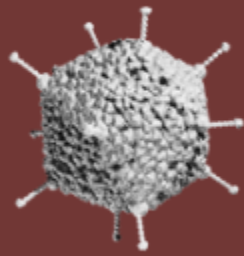
Pathogen targets

- SARS-CoV-2
- Influenza A and B
- Respiratory Syncytial Virus
- Adenovirus 40/41
- Shiga-toxin-producing *E. coli*
- Norovirus
- *Campylobacter*
- *Candida auris*

Antibiotic resistance genes

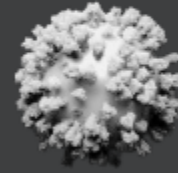
- Carbapenemases
- Extended spectrum beta lactamases
- Colistin resistance
- Vancomycin resistance

*Final targets subject to change



ADENOVIRUS 40/41

Common cause of acute gastroenteritis in children that is challenging to diagnose due to a wide variety of symptoms

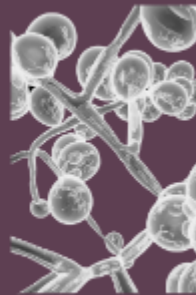


INFLUENZA

In combination with pneumonia, consistently one of the top ten leading causes of death in the US; causes mild to severe seasonal epidemics

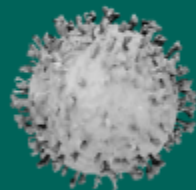
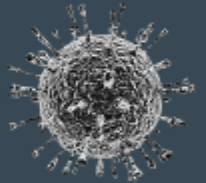
CANDIDA AURIS

Potentially deadly fungal pathogen that is often resistant to multiple drugs and can cause outbreaks in healthcare settings



NOROVIRUS

Very contagious virus that is the leading cause of vomiting, diarrhea, and foodborne illness in the US, with common outbreaks in winter



RESPIRATORY SYNCYTIAL VIRUS

Common respiratory virus that can cause severe disease in infants and older adults

Antibiotic resistance genes

Carbapenemases

- Beta-lactamases that have the ability to hydrolyze penicillins, cephalosporins, monobactams, and carbapenems
- Carbapenems in particular are a “last resort” antibiotic for multi-drug resistant infections
- Produced by *Klebsiella*, *Escherichia coli* (E. coli), *Acinetobacter*, and *Pseudomonas*
- Infections are most likely acquired through health care exposures in areas where these bacteria are commonly found.

Pathogen	Cases per year in US	Deaths per year in US
SARS-CoV-2	~46 million (2022)	267,000 (2022)
Influenza	~29-41 million	~25,000-50,000
Norovirus	~20 million	570-900
AMR infections	~2.8 million	~35,000 (2019)
RSV	> 1.5 million	~15,000
<i>Campylobacter</i>	~1.5 million	~120
STEC	~265,000	~30
Mpox	~30,000 (2022)	~40
<i>C. auris</i>	~2,400 (and growing)	30-60% of cases

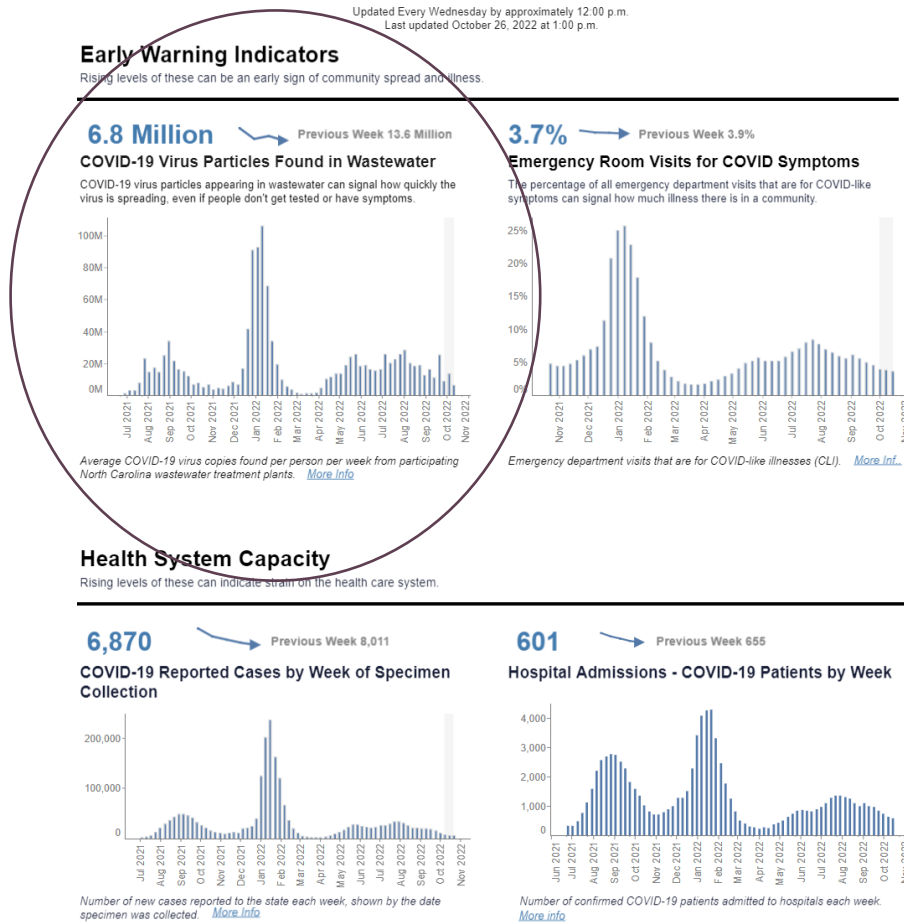
Presentation: public health uses of data

Types of wastewater data use

1. Validating other public health surveillance data
2. Informing resource allocation
3. Increasing public awareness
4. Informing clinical decisions
5. Informing policies

1. Validating other data

Most common



North Carolina Department of Health and Human Services uses wastewater data as one of four key early warning metrics to monitor for increasing community transmission

<https://covid19.ncdhhs.gov/dashboard>

Accessed October 31, 2022

2. Informing resource allocation

Very common

- Messaging
 - Local health departments
 - Public
- Testing
- Vaccines
- Contact tracing

City of Salem, MA: masks, test vouchers, information, and vaccines distributed to locations with high wastewater viral loads

Oklahoma City, OK: public school district targeted communication to parents of students in areas with high wastewater viral loads

Chesapeake Local Health Department and State of Virginia: wastewater results used to target vaccination campaigns to high-prevalence areas and educate public

State of Ohio: tenfold increase in wastewater viral load triggered email warning to local health departments, utilities and community leaders and informed allocation of testing, contact tracing, and vaccine resources

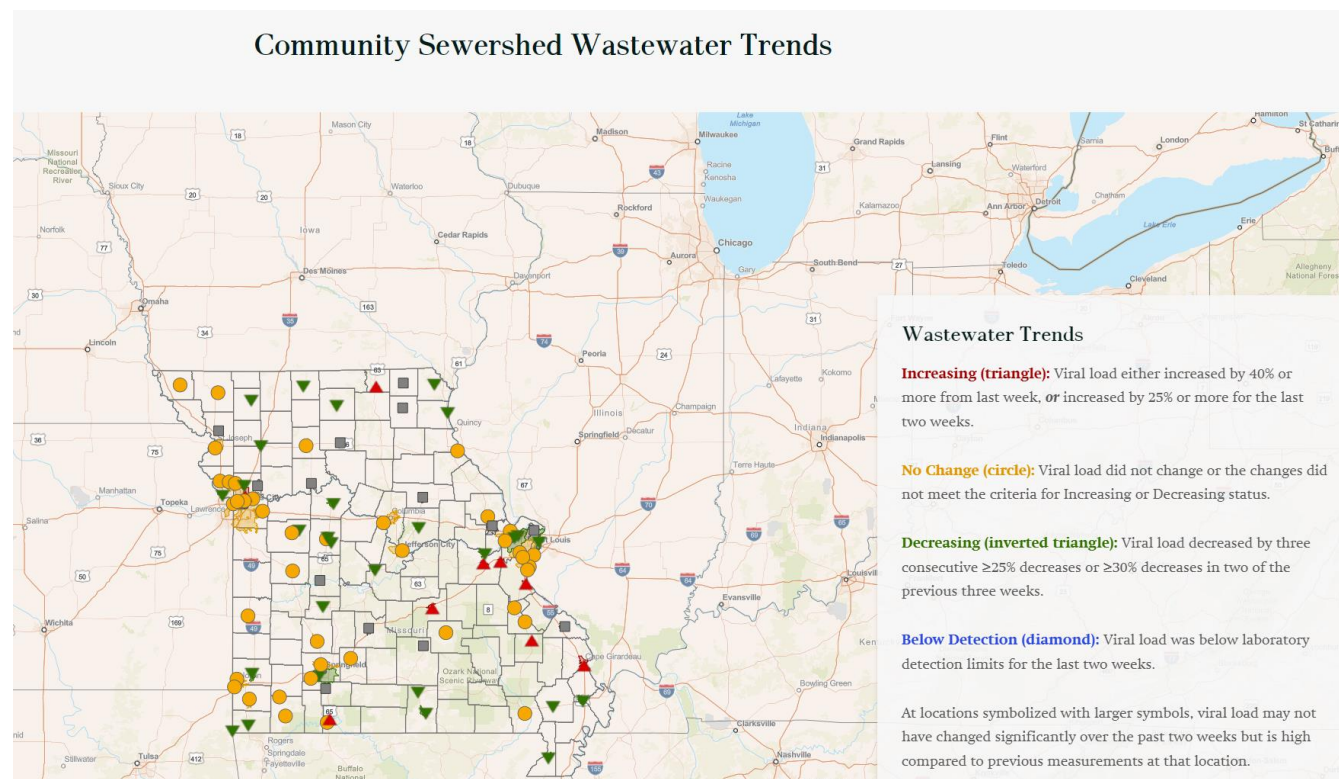
State of Missouri: wastewater viral loads used to prioritize testing resources and messaging

3. Increasing public awareness

Very common

- Data sharing

Missouri
Department of
Health & Senior
Services



<https://storymaps.arcgis.com/stories/f7f5492486114da6b5d6fdc07f81aacf>

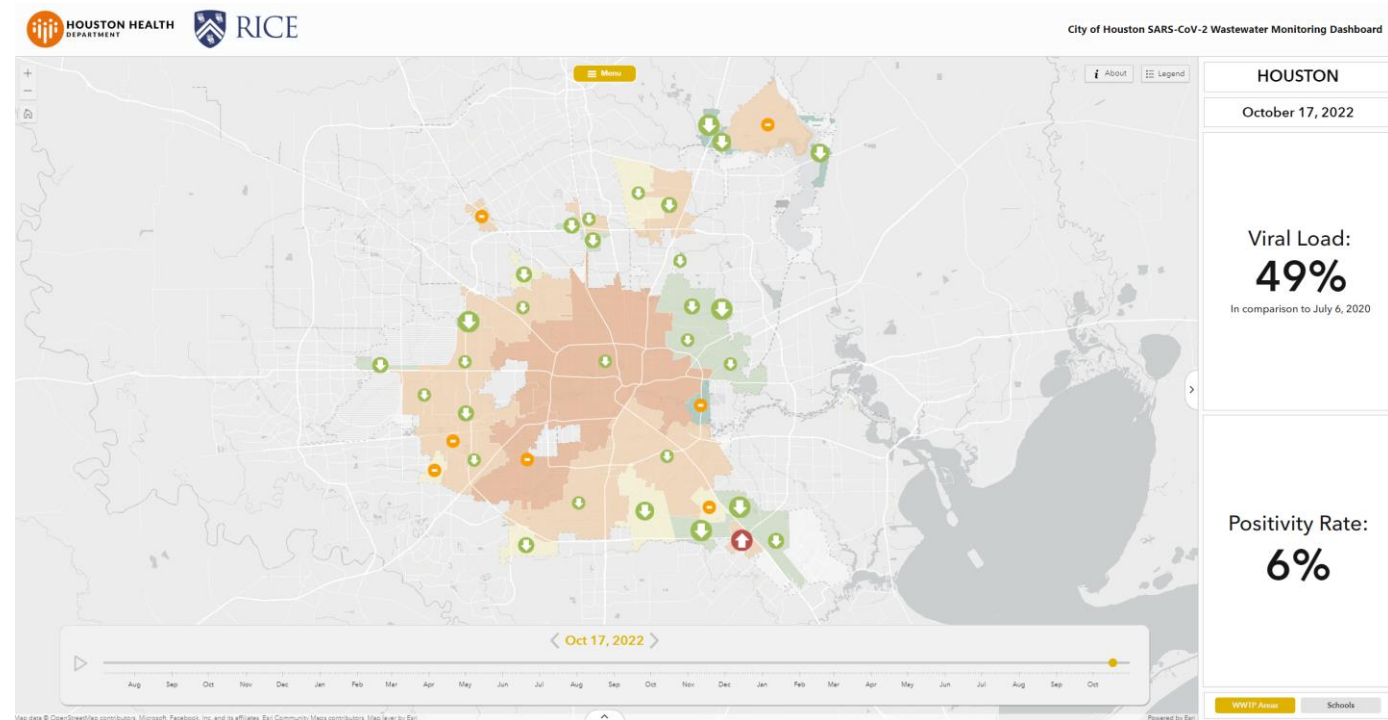
Accessed October 31, 2022

3. Increasing public awareness

Very common

- Data sharing

City of Houston
Health
Department



<https://covidwwtp.spatialstudieslab.org/>
Accessed October 31, 2022

3. Increasing public awareness

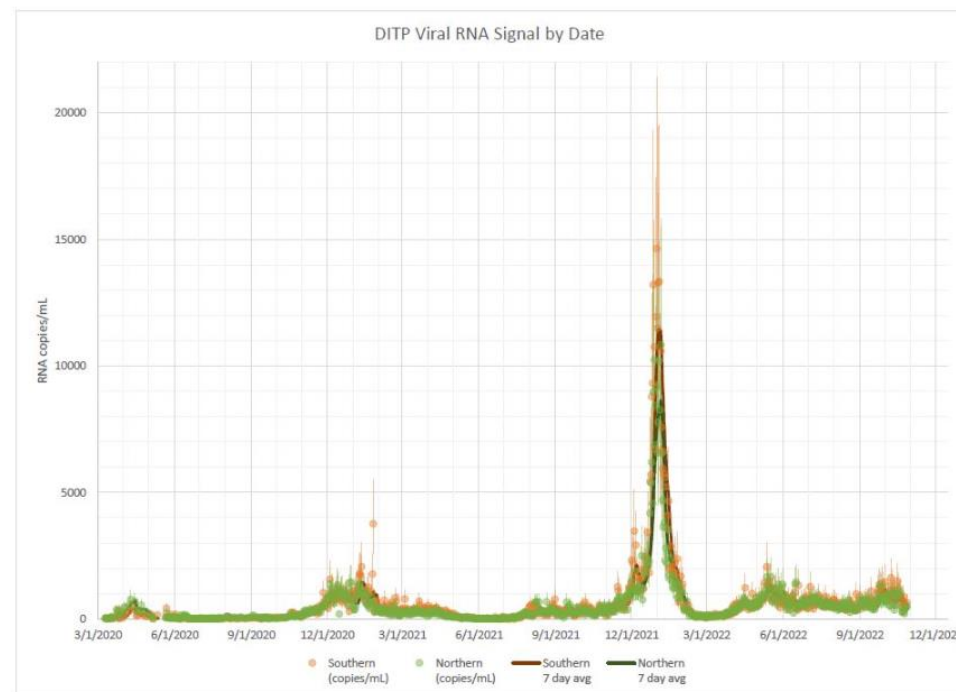
Very common

- Data sharing

Massachusetts
Water Resources
Authority

Biobot Data - samples submitted through 10/27/2022

Biobot Analytics recently requested extra sample volume from MWRA to test out procedures for testing Monkeypox. We have been notified that at least one sample collected on 8/11/2022 has tested positive. We are not routinely monitoring for Monkeypox at this time.



<https://www.mwra.com/biobot/biobotdata.htm>

Accessed October 31, 2022

“I love looking at the wastewater data,
said no one prior to the Covid pandemic....
but here we are.”

Dr. Vincent Chiang
Chief Medical Officer
Boston Children's Hospital

New York Times, January 19, 2022

<https://www.nytimes.com/2022/01/19/health/covid-omicron-wastewater-sewage.html>

Less common

4. Informing clinical decisions

- Selecting monoclonal antibodies
- Deferring elective surgeries
- Opening new hospital units
- Including differential diagnoses

5. Informing policies

Uncommon

City of Tempe closes all public facilities through March 27 due to COVID-19 outbreak

By FOX 10 Staff and Associated Press | Published March 16, 2020 | Coronavirus | FOX 10 Phoenix

| CORONAVIRUS |

Update: Tempe Mayor Issues Proclamation Closing Bars and In-Store Dining

STEVEN HSIEH | MARCH 19, 2020 | 11:47AM

City of Tempe, Arizona used wastewater data (with other data) to decide to cancel events and temporarily close dining and other venues

<https://www.phoenixnewtimes.com/news/tempe-coronavirus-emergency-bars-closure-mayor-mitchell-11458723>

<https://www.fox10phoenix.com/news/city-of-tempe-closes-all-public-facilities-through-march-27-due-to-covid-19-outbreak>

EXAMPLE 1: HOUSING COMPLEX

2020-2021

SCALE

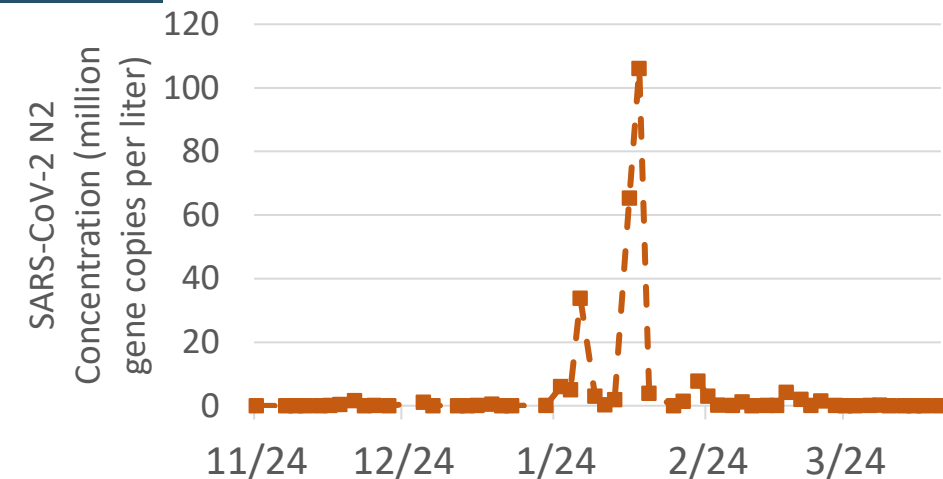
100 people in a city housing authority building

APPROACH

24-hour composite samples from manhole



DATA



ACTIONS

- Distribute flyers with testing voucher and mask
- Prioritize site for vaccination

Data courtesy of the City of Salem, MA

EXAMPLE 2: COMMUNITIES

2021

SCALE

70,000 to 470,000 people

APPROACH

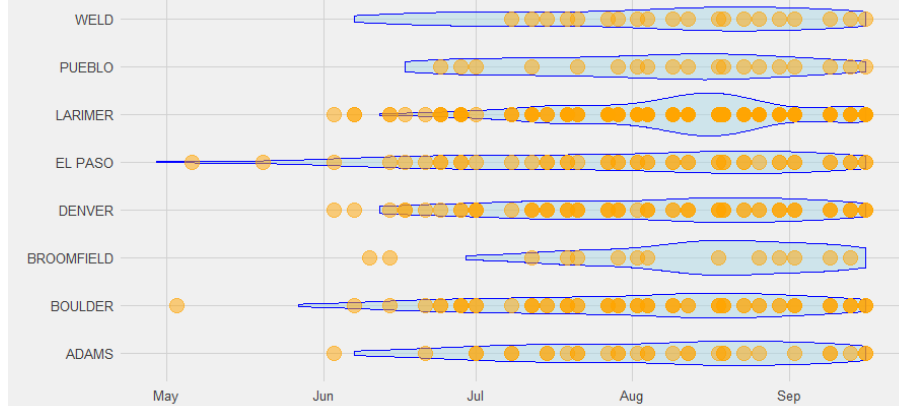
24-hour
composite
samples
from WWTP
influent



DATA

Dates of Detection of Delta Variant (or Indicative Mutations)

Clinical Samples Blue, Wastewater Detections Orange



ACTIONS

- Alert local health departments and healthcare providers

Data courtesy of the CO Department of Public Health and Environment

EXAMPLE 3: NURSING HOME

2022

SCALE

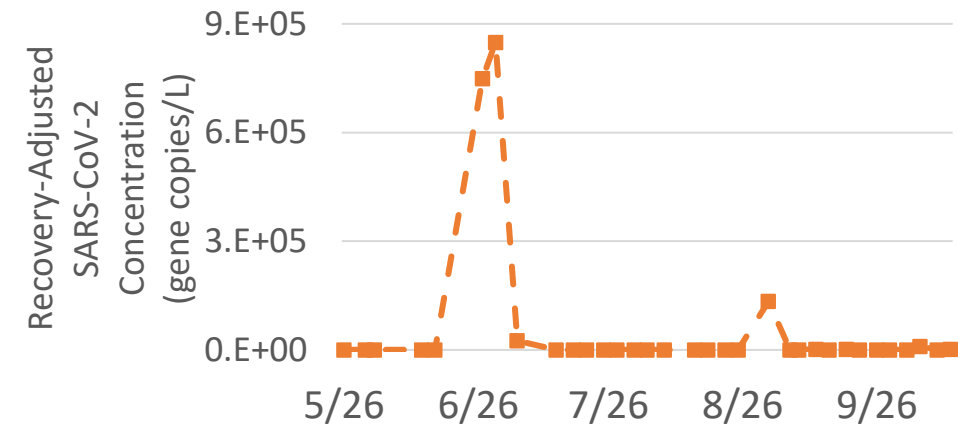
~100 veterans in congregate care facility

APPROACH

24-hour composite samples from manhole



DATA



ACTIONS

- Point prevalence testing of residents

Data courtesy of the Louisiana Department of Health

**Small group work:
how to spend money to
support utilities**

The question

In what ways – other than hiring staff – could money be spent to support utility participation in WBS that would, ideally, also help that utility in some way with their day-to-day operations?

Thank you!

- jsabater@wef.org
- wef.org
- nwbe.org