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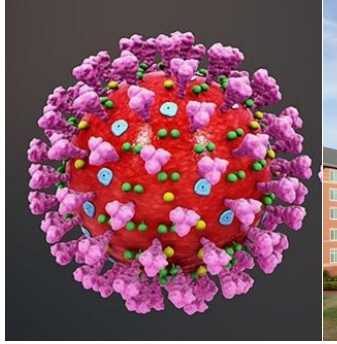
School of Chemical, Biological
& Environmental Engineering



COVID-19 Wastewater-based Epidemiology at OSU

1) **NSF-RAPID:** Microsewershed surveillance in collaboration with Clean Water Services (CWS).
2) **TRACE-Oregon State University (OSU)** (Internally funded project): monitoring for SARS-CoV-2 at the building/dorm level & at the campus level for all 3 OSU campuses.
3) **TRACE-Community** (founded by David & Lucile Packard Foundation): combines WBE with random house-to-house nasal swab sampling to determine the "true" COVID-19 prevalence of a community
4) **OHA/U.S. CDC** : state-wide monitoring for SARS-CoV-2 and genotypes at 40+ WWTPs across the state of Oregon on a weekly basis.

Main advantages of WBE

- Wastewater-based epidemiology (WBE) for COVID-19 monitors wastewater for the presence of SARS-CoV-2 and provides an unbiased complimentary approach to clinical disease surveillance at a variety of geo-spatial scales.
    - Economically monitor an entire city with one sample
    - Monitor trends (correlates with prevalence estimates)
    - Identify hotspots within a community
    - Obtain genetic (variant) information with a single sample
    - No sampling bias
    - 100% participation rate (no testing fatigue)

WBE efforts in Oregon



1. **NSF-RAPID:** Microsewershed surveillance in collaboration with Clean Water Services (CWS)
2. **OHA/CDC**: State-wide monitoring for SARS-CoV-2 and genotypes at 40+ WWTPs across the state of Oregon on a weekly basis
3. **TRACE-Community:** (founded by David & Lucile Packard Foundation) Combines WBE with random house-to-house nasal swab sampling to determine the "true" COVID-19 prevalence of a community
4. **TRACE-OSU:** (Internally funded project) Monitors for SARS-CoV-2 at the building/dorm level & at the campus level for all 3 OSU campuses

NSF RAPID Sewers in Washington County with CWS

TRACE Community Sewers

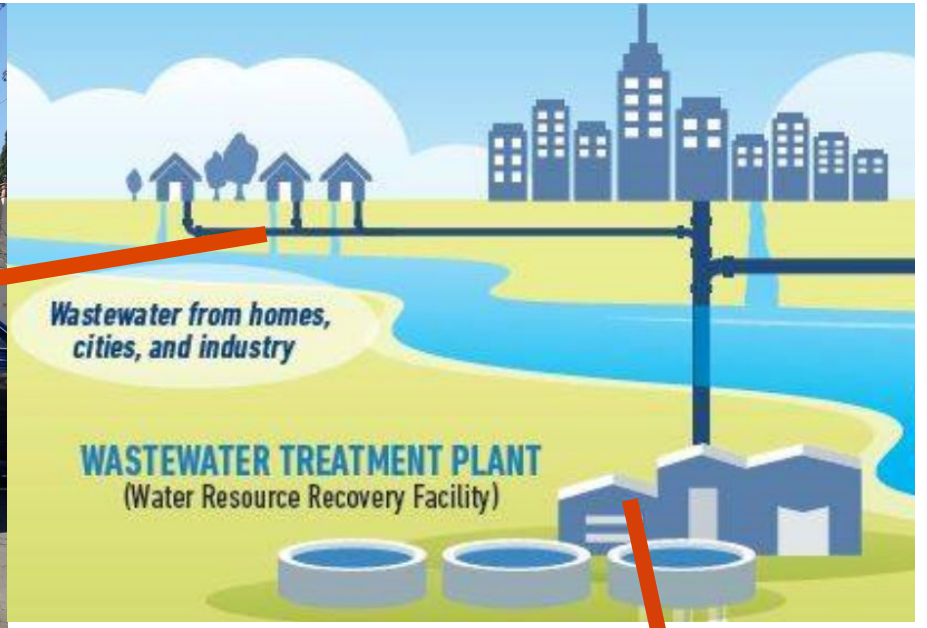
- Corvallis
- Corvallis, Bend
- Corvallis, Newport
- Newport, Hermiston
- Corvallis
- Eugene
- Bend/Redmond
- Redmond
- Corvallis
- Woodburn

Oregon Health Authority Facility Influents State-wide

TRACE OSU Campus Sewers

MATERIALS & METHODS

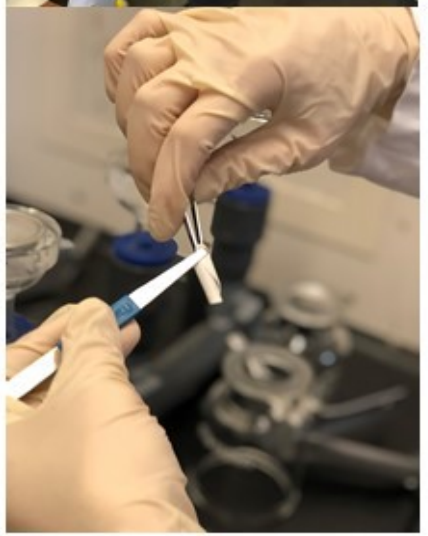
- Oregon State University's TRACE team have successfully used SARS-CoV-2 concentrations in wastewater samples to determine the number of COVID-19 infections present in a city, neighborhood or individual building.
- Over 4000 nasal swab samples from residents in over 2500 randomly selected households in Bend, Corvallis, Eugene, Hermiston, Newport and Redmond, Corvallis, Oregon from May, 2020 to March, 2021.
- The response rates were up to 71%, with an average response rate of 60%.
- The methods used for the random household sampling and prevalence estimate models are presented at the TRACE team website (https://trace.oregonstate.edu)



24-hr composite wastewater samples

Methods

1. Sample Filtration



2. Filter stabilization and transport

3. Automated RNA Purification

4. SARS-CoV-2 Quantification (RT-ddPCR)

5. Sequencing for variant detection

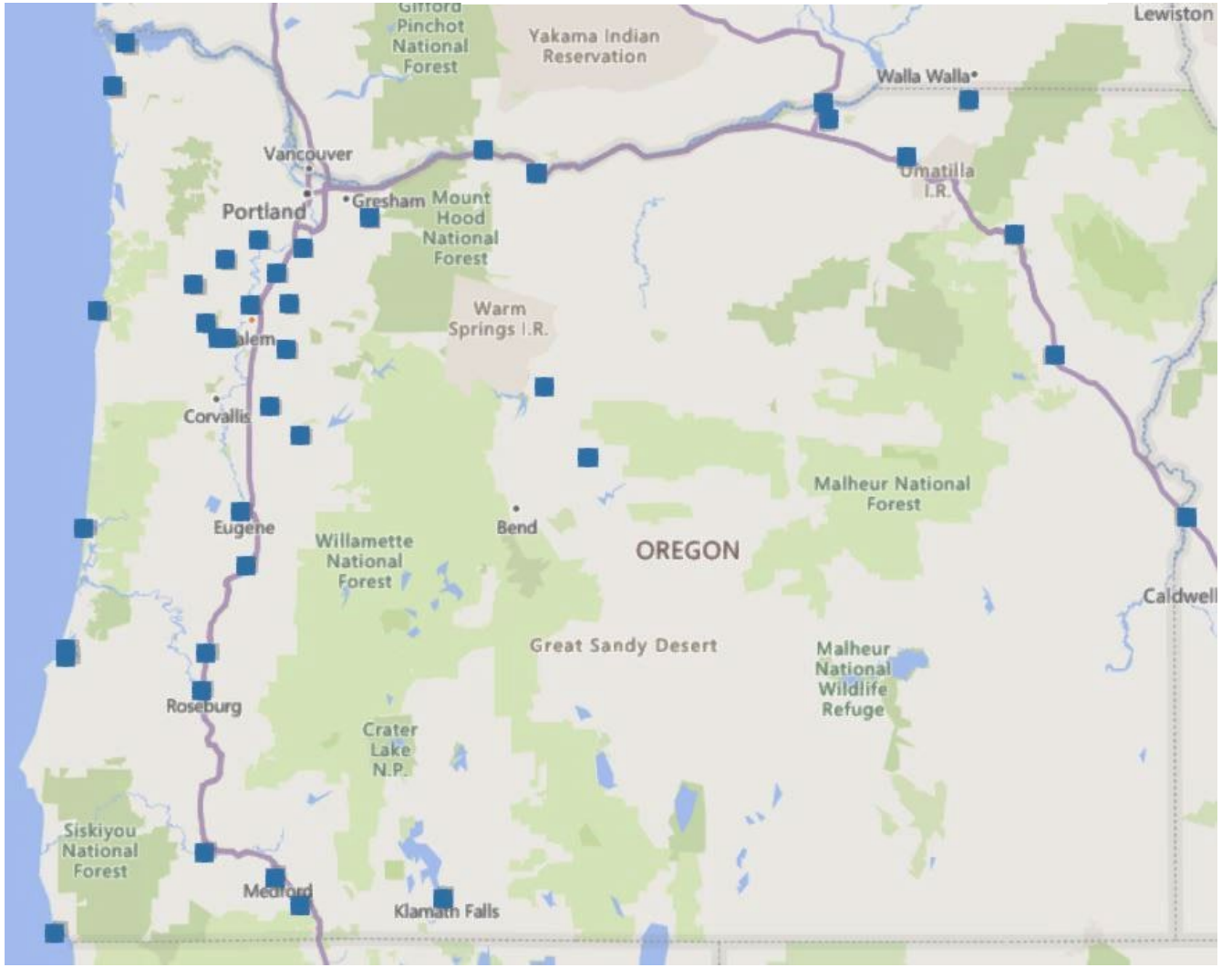
OHA

Statewide/City Scale

Using WBE to track COVID-19 dynamics throughout Oregon

OHA Statewide Surveillance

- 40+ wastewater treatment plants statewide
- Effective collaboration with treatment facilities
- Weekly monitoring, started early September, 2020
- 2.5 year duration



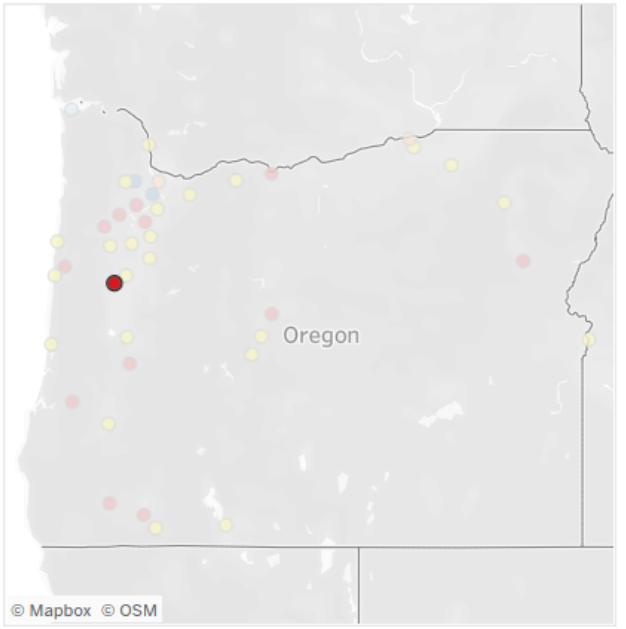
OHA Public Dashboard

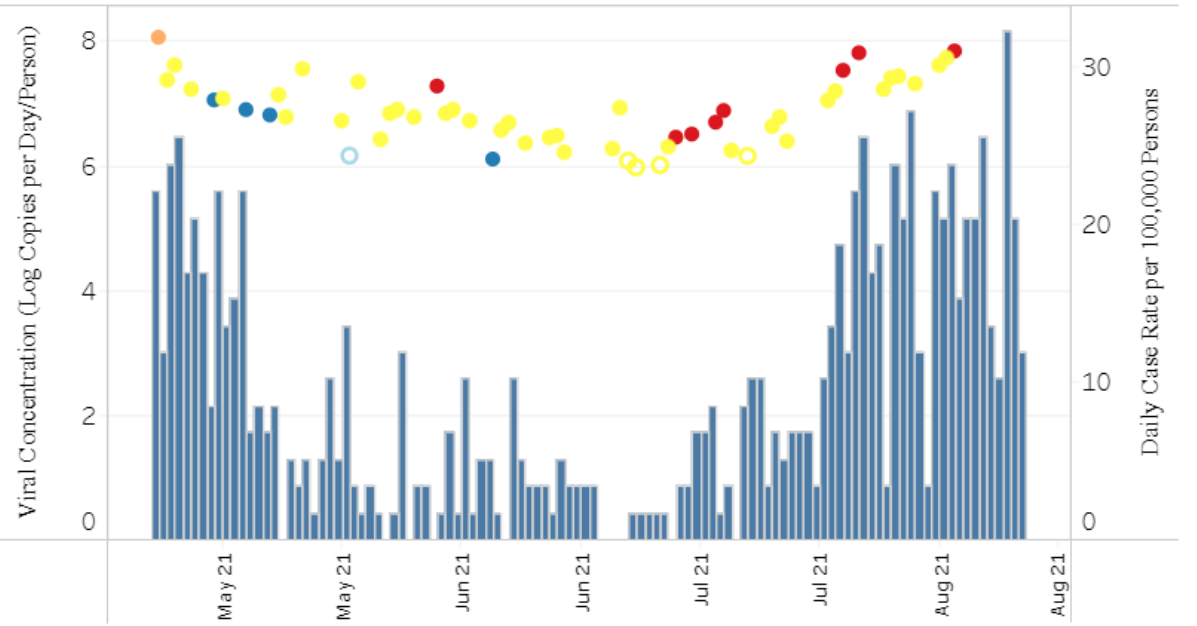
https://public.tableau.com/profile/oregon.health.authority.covid.19#!/vizhome/OregonsSARS-CoV-2WastewaterMonitoring/WastewaterDashboard

Oregon's SARS-CoV-2 Wastewater Monitoring

Corvallis, OR
Population: 58,856
Last Sample: 8/10/2021

Hover over a dot to see more information about the wastewater sample, including detection of variants of concern. Use the date filter at the bottom to limit the data in the view. Click a blank area of the map to clear your city selection.





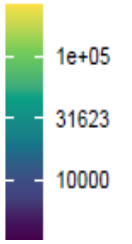
[Take me to the introduction page]

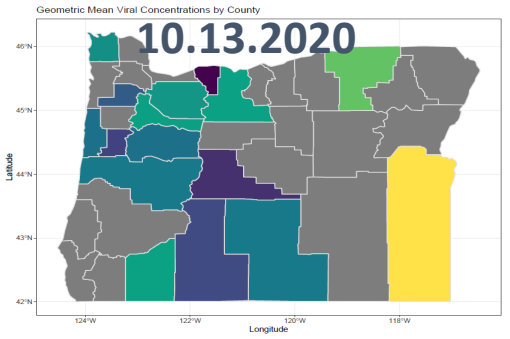
Sustained Decrease	Decrease	Plateau	Increase	Sustained Increase
7%	2%	56%	5%	30%

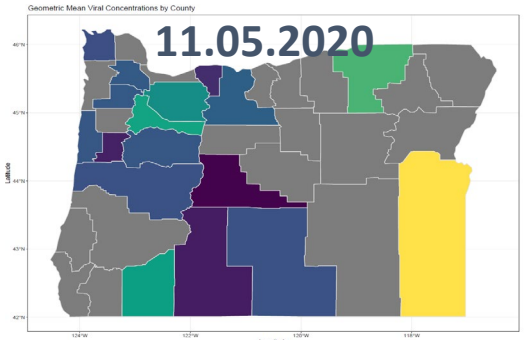
Oregon Counties (24)

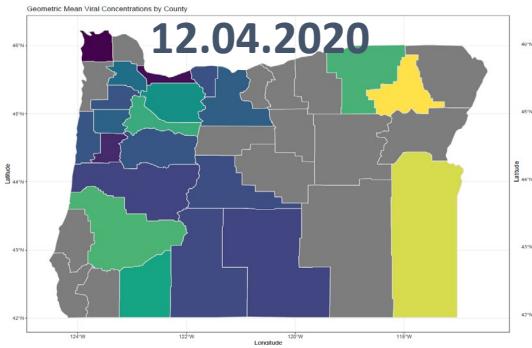
Geometric Mean WWTP Viral Concentrations

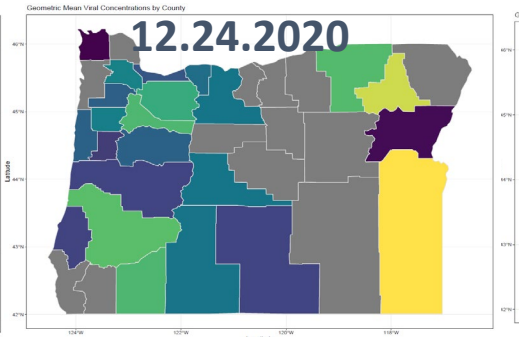
Gene copies/L

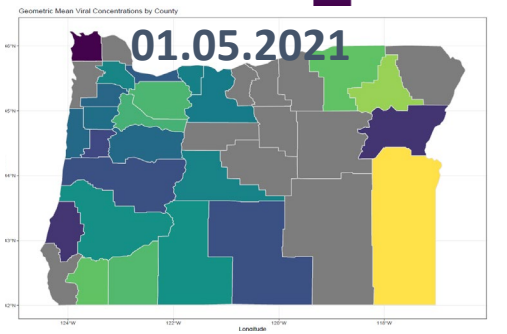


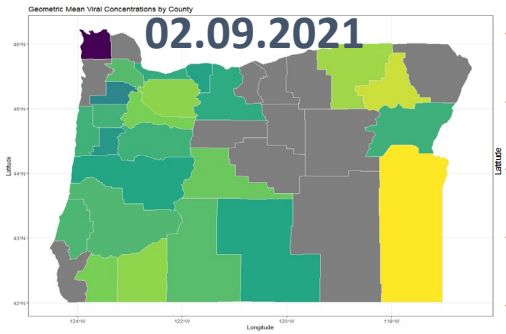


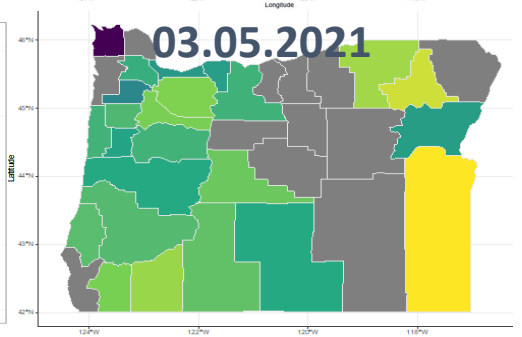


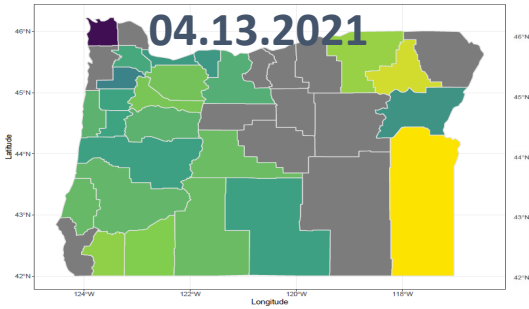


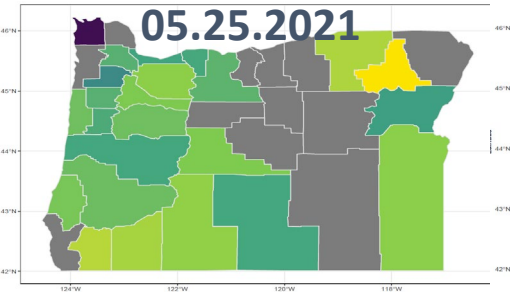


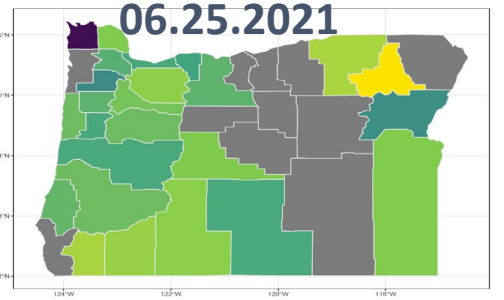


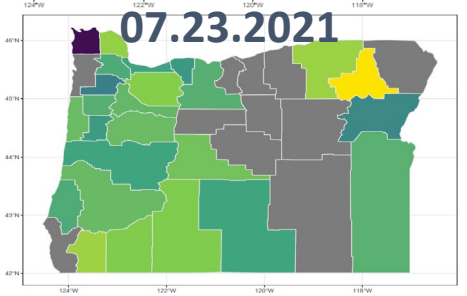


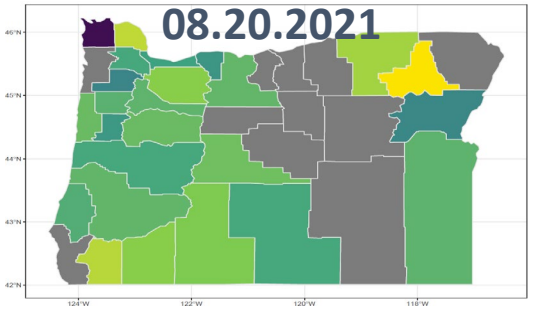




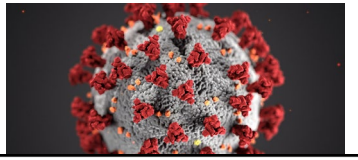








Oregon Health Authority



Oregon Cities (45)-Log WWTP Viral Concentrations

Oregon Health Authority

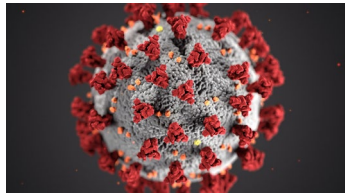
Time Series of OHA Cities/Sites

Albany
Ashland
Astoria
Baker City
Bend
Canby
Corvallis
Cottage Grove
Dallas
Durham
Eugene
Florence
Forest Grove
Grants Pass
Hermiston
Hillsboro
Hood River
KF S Suburban
Klamath Falls
La Grande
Lincoln City
McMinnville
Medford
Newberg
Newport
North Bend
Ontario
Ontario-Prison
Pendleton
Portland
Redmond
Rock Creek
Roseburg
Salem
Sandy
Sheridan
Siletz
Siletz Tribe
Silverton
St. Helens
Stayton
Sunriver
The Dalles
Umatilla
Woodburn

Log Gene Copies Per L

0 2 4 6

09/20 10/20 11/20 12/20 01/21 02/21 03/21 04/21 05/21 06/21 07/21 08/21 09/21

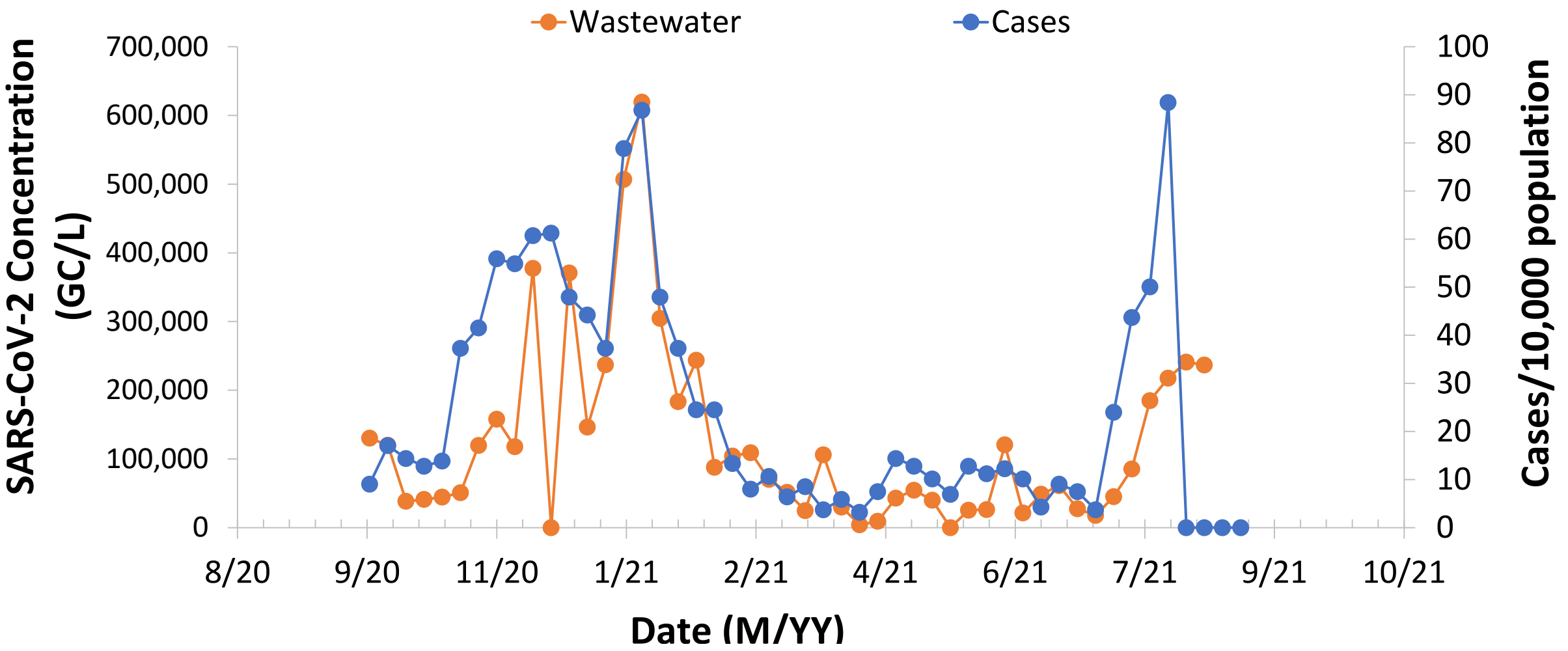


Oregon Cities (45)
Log WWTP Viral Concentrations

- Started as weekly: moving to twice a week
- Expanding to include at least 1 city in each county
- Quantified over 4,000 samples
- Over 2000 samples are sequenced

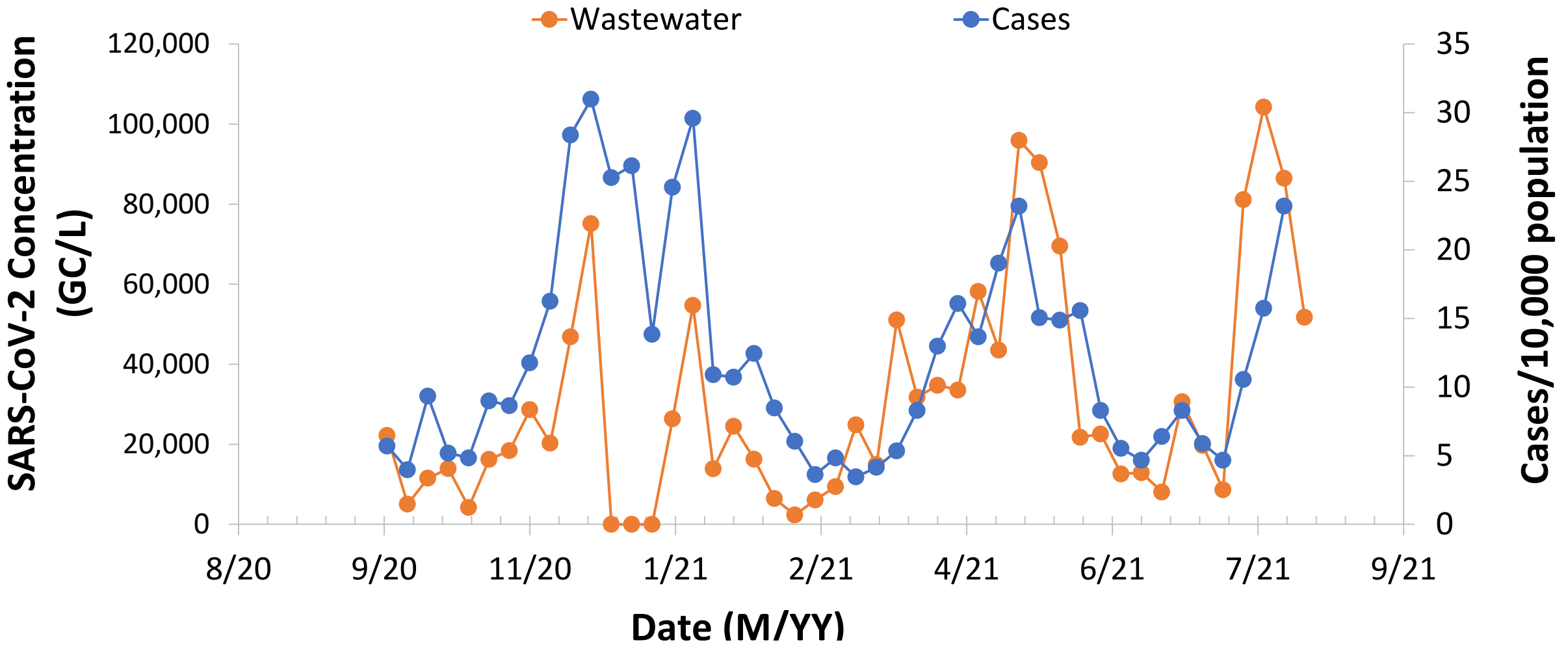
Hermiston

Correlation: Virus concentration to cases



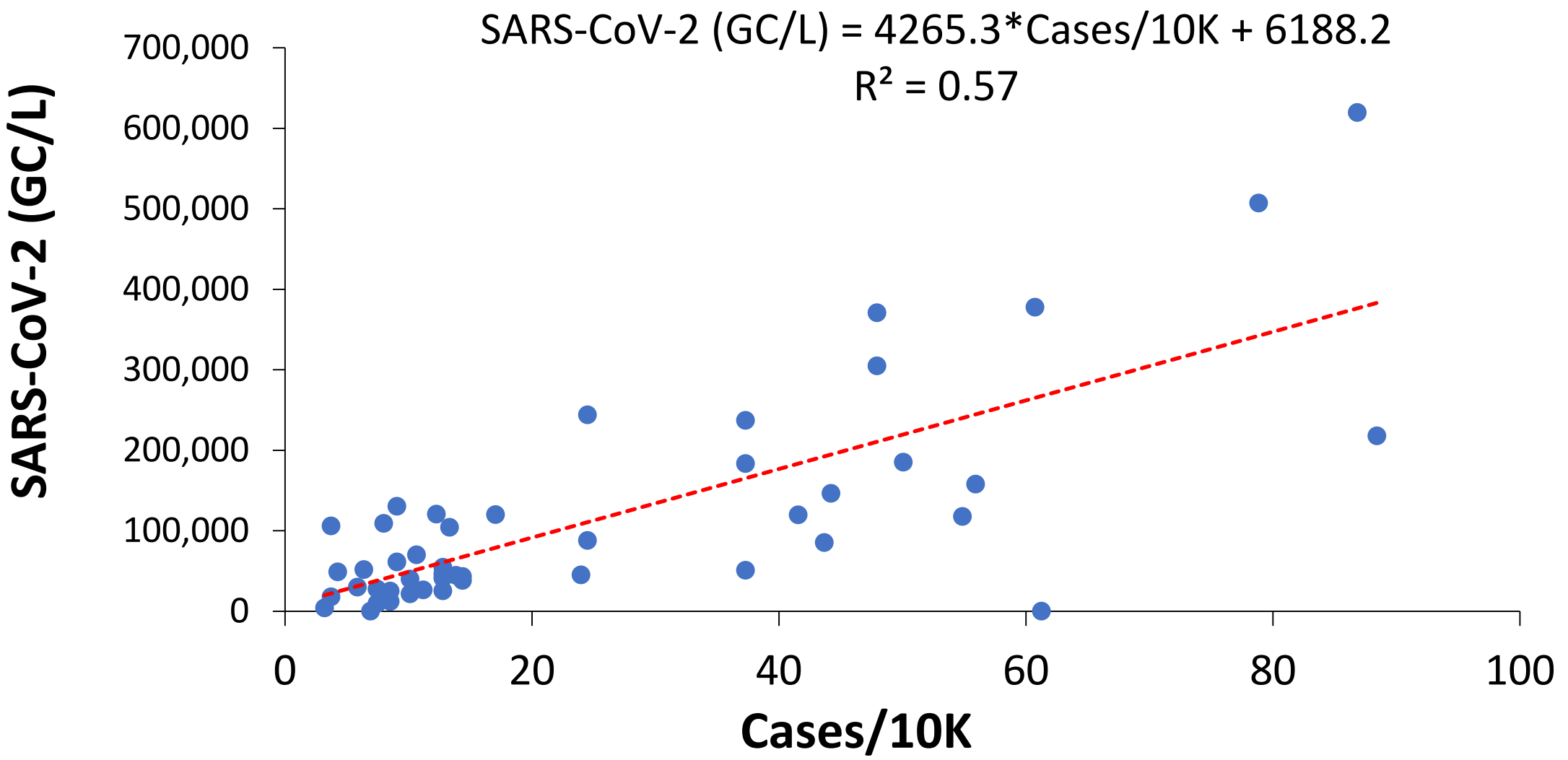
Albany

Correlation: Virus concentration to cases

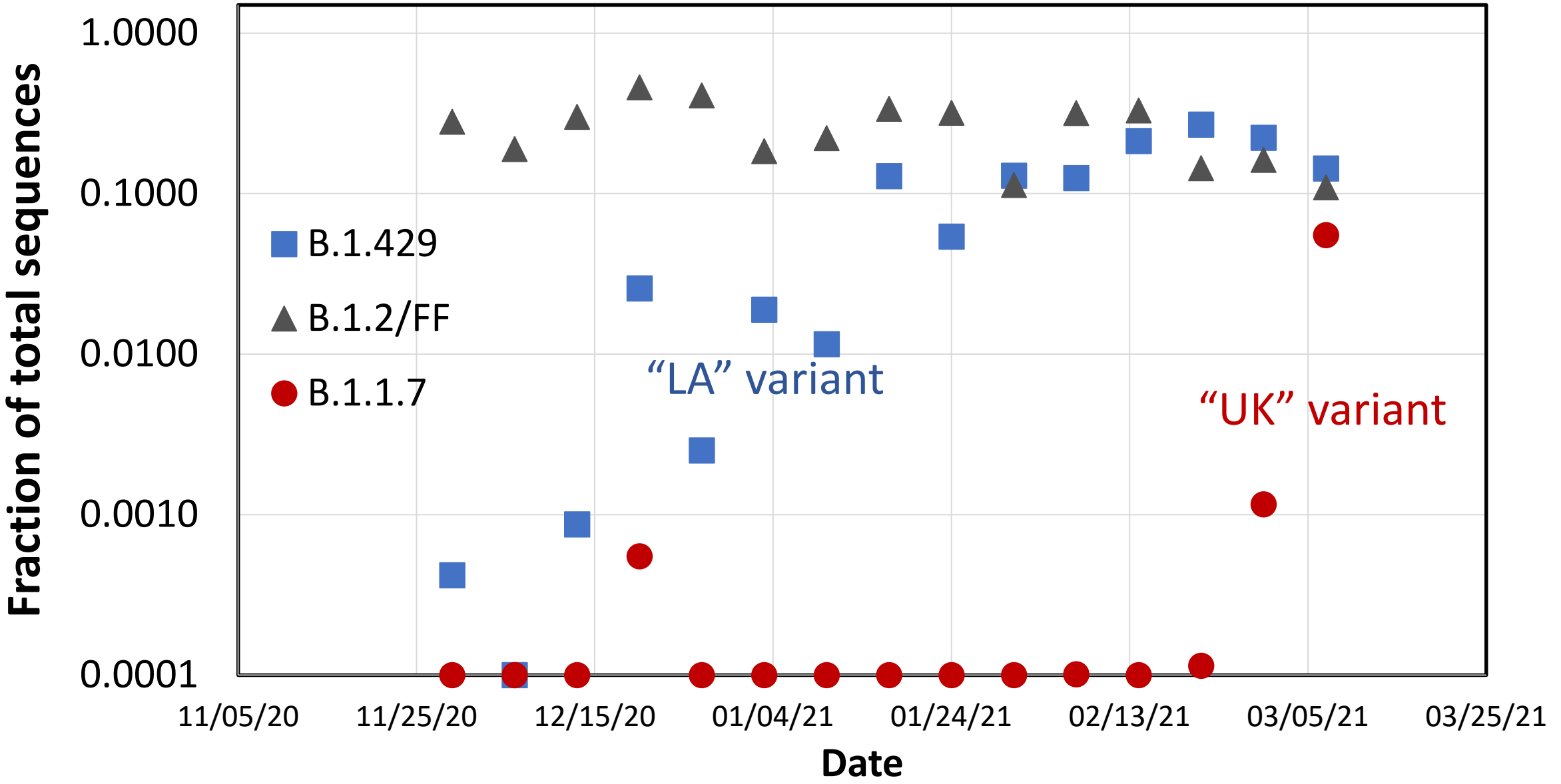


Hermiston

Correlation: Virus concentration to cases



Sequencing: Statewide Weekly Fraction of WW RNA



OHA Statewide Surveillance
Factors affecting correlation strength

Wastewater

- Degradation of signal during transport
- Variability in influent contributions – i.e. Brewery
- Variability in sewer system characteristics (temperature, chemistry, residences time)
- Differences in on-site filtration technique
- Visitors in the city contributing to the signal

OHA Statewide Surveillance
Factors affecting correlation strength

Cases

- Cases by zip code – imperfect match with treatment collection boundaries
- Differences in testing culture, availability
- Asymptomatic shedding
- Prolonged shedding

TRACE COVID-19

A Scalable Community-Based Approach to Estimate the Prevalence of SARS-CoV-2 Infection

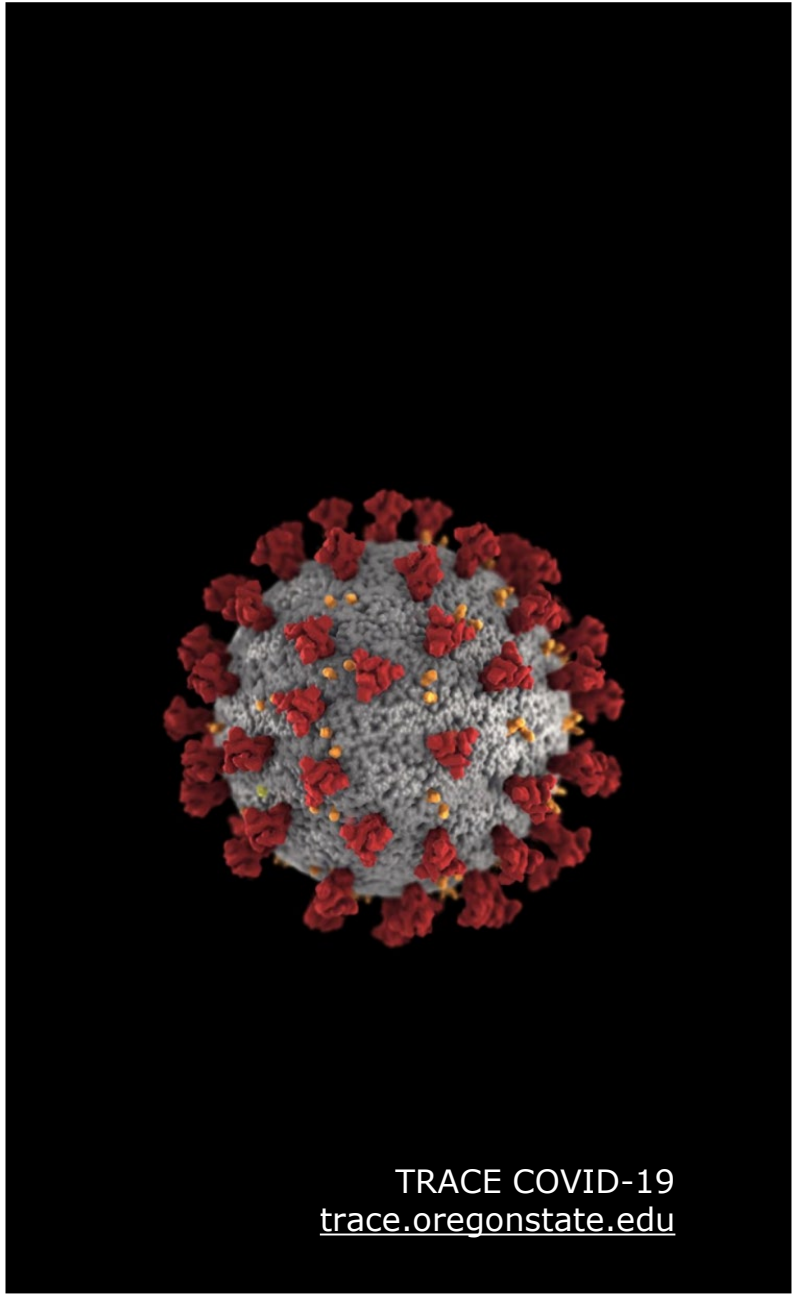
Team-base **R**apid **A**ssessment of **C**ommunity-level coronavirus **E**pidemics (TRACE)

Oregon State University

TRACE COVID-19
trace.oregonstate.edu

TRACE Objectives

- Estimate the prevalence of SARS-CoV-2 infections in a city in near real time, including *asymptomatic* individuals
- Develop a scalable system that can be rapidly deployed in other communities
- Harness untapped potential in universities to adapt and respond to COVID-19



TRACE Team: Collaboration is Key

College of Public Health & Human Sciences

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Associate Professor

Javier Nieto
Dean

Aslan Noakes
Registered Nurse

Denise Hynes
Professor; Director of Health Data & Informatics

College of Science

Ben Dalziel
Assistant Professor

Tze-Yiu Yong
Project Manager

Roy Haggerty
Dean

Jane Lubchenco
University Distinguished Professor

TRACE Team: Collaboration is Key

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Assistant Professor

College of Veterinary Medicine

Justin Sanders
Assistant Professor

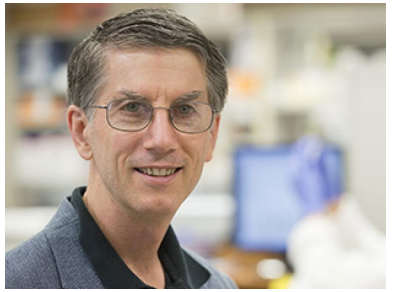
College of Engineering

Kathryn Higley
Professor

Christine Kelly
Professor

Tyler Radniecki
Associate Professor

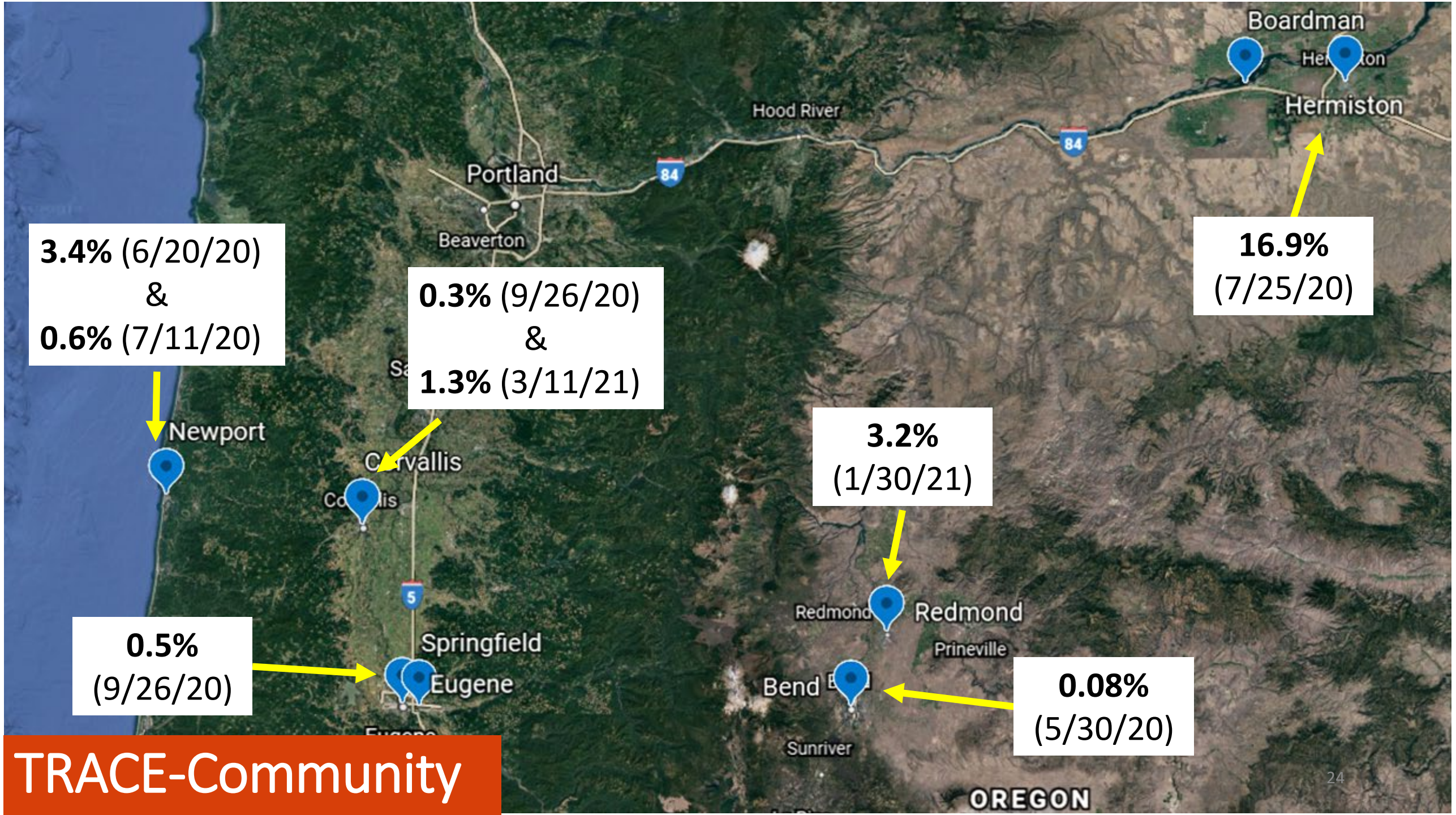
Center for Genome Research & Biocomputing



Brett Tyler
Director, CGRB

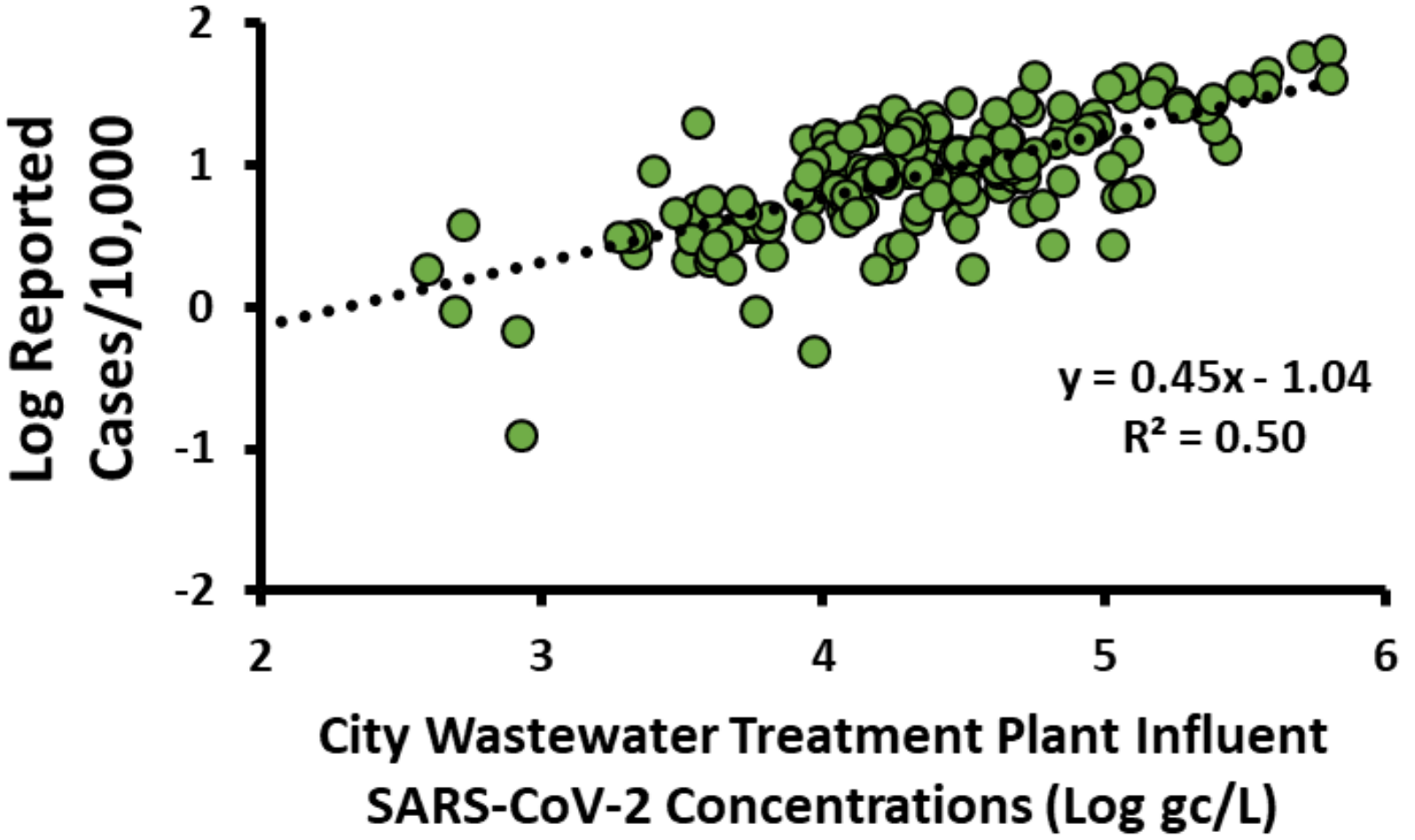
OSU Center for Health Innovation

Allison Myers
Director, CHI

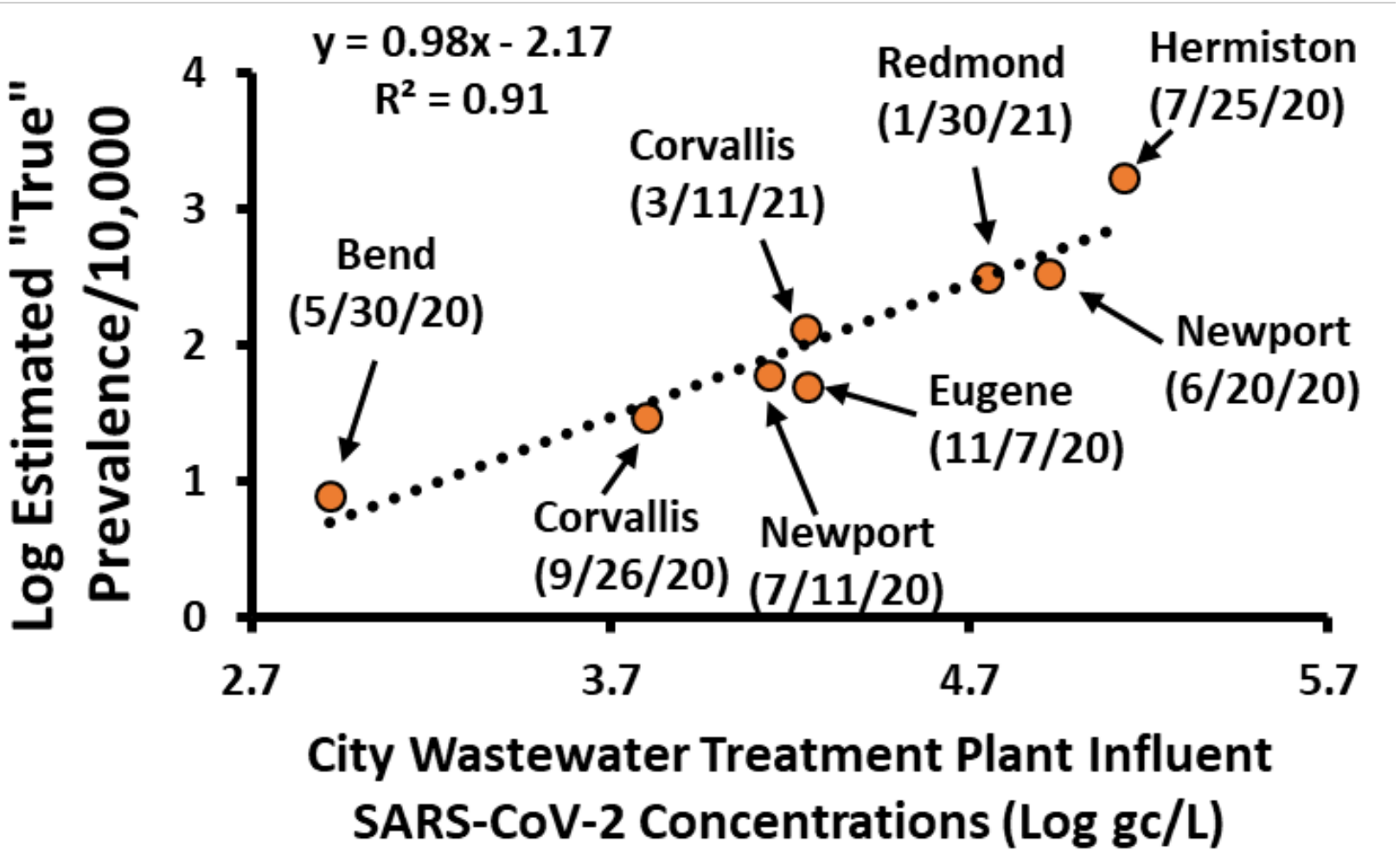


TRACE-Community

Wastewater vs. Reported Cases



Wastewater vs. Prevalence



TRACE-Community

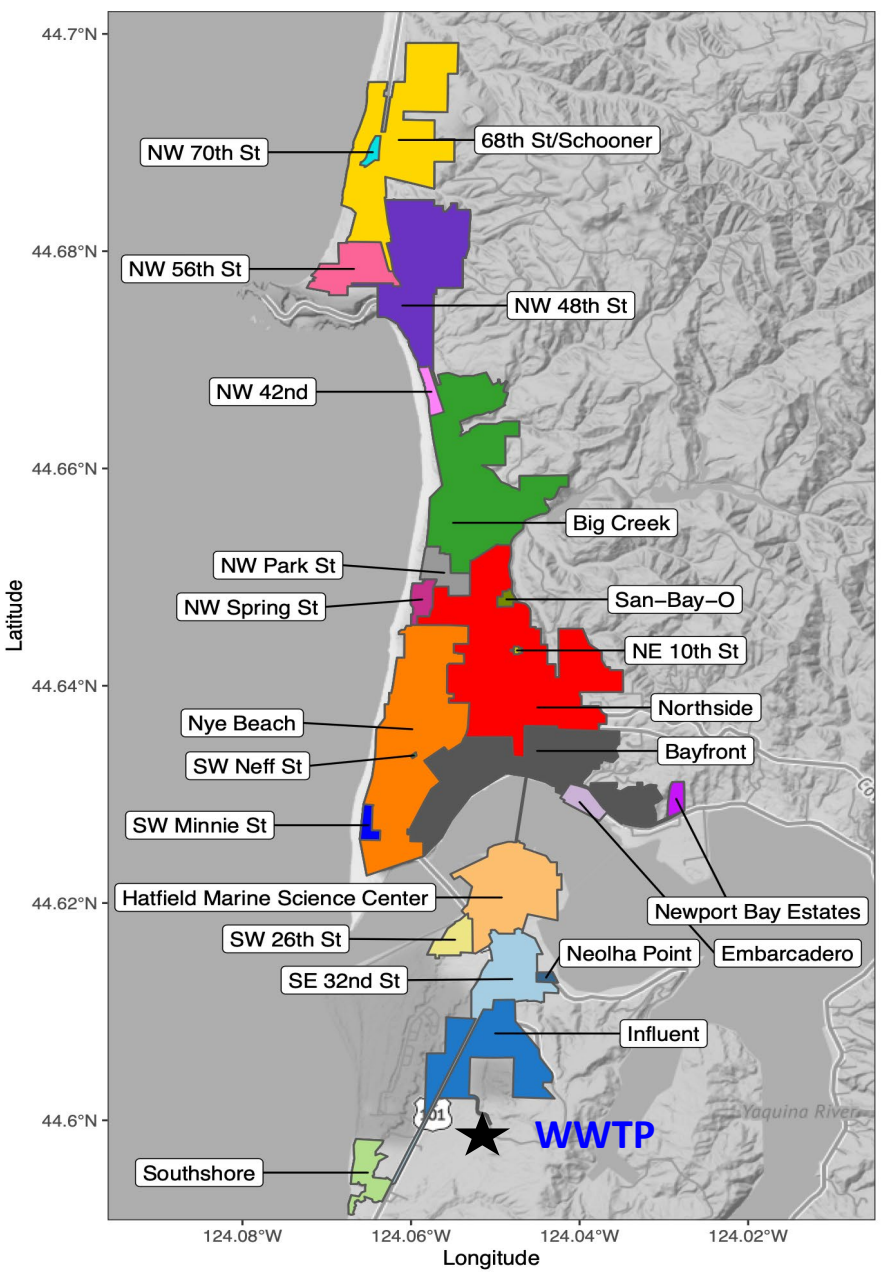
Neighborhood/Microsewershed Level

Using WBE to identify COVID-19 hotspots within a community

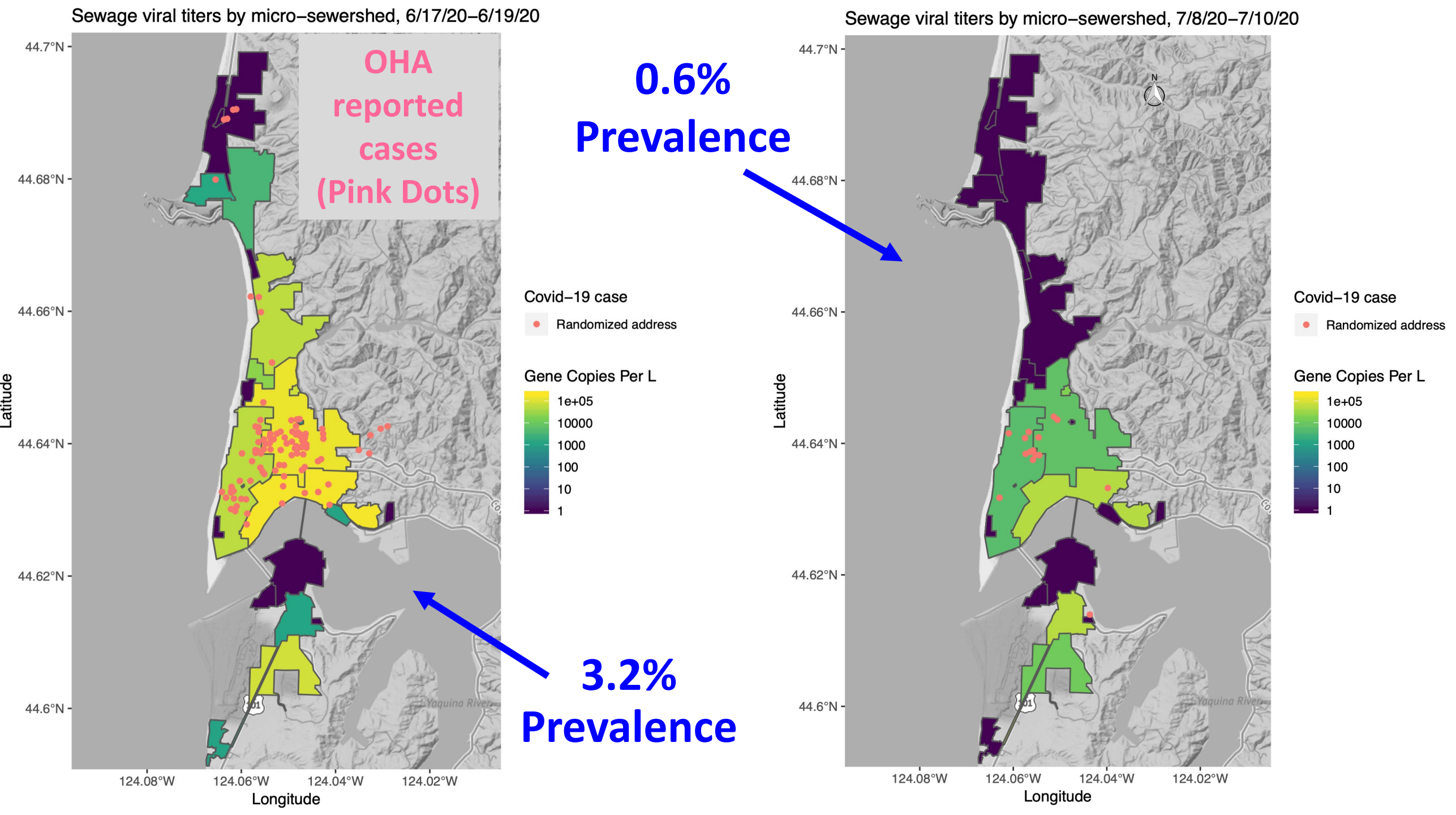
TRACE-Community

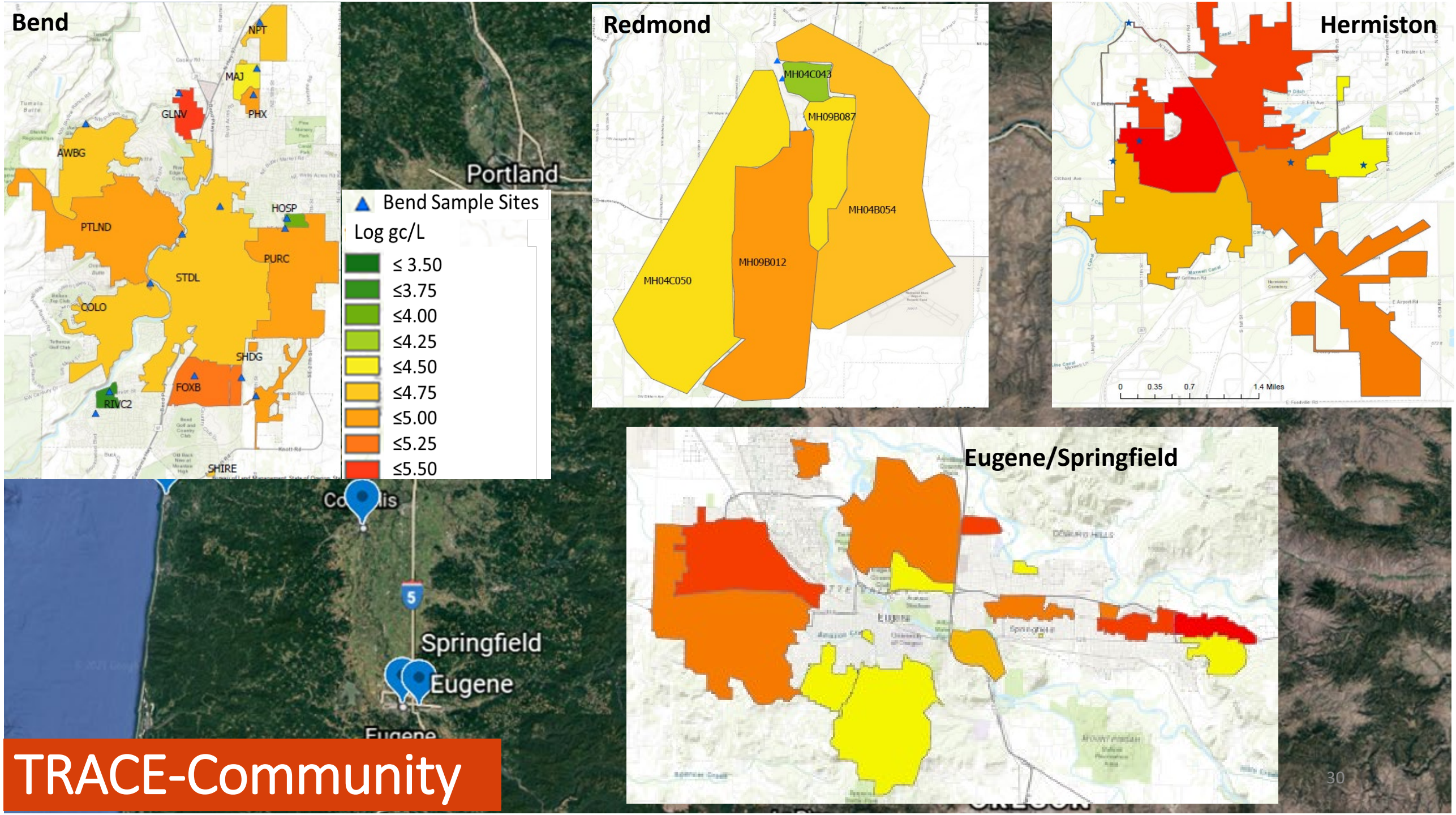
Newport Sewershed Study

- TRACE deployed during known COVID-19 outbreak (in early June, 2020)
- Sampled in conjunction with TRACE nasal swab sampling (two weekends: June and July, 3 weeks apart)
- 22 pump stations plus influent



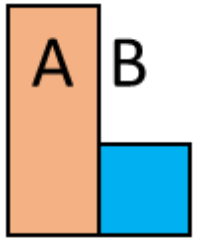
28


Sewage viral titers by micro–sewershed, 6/17/20–6/19/20
OHA reported cases (Pink Dots)
0.6% Prevalence
3.2% Prevalence
Sewage viral titers by micro–sewershed, 7/8/20–7/10/20
Covid–19 case
Randomized address
Gene Copies Per L
1e+05
10000
1000
100
10
1
Latitude
Longitude
44.7°N
44.68°N
44.66°N
44.64°N
44.62°N
44.6°N
124.08°W
124.06°W
124.04°W
124.02°W
Yaquina River
101

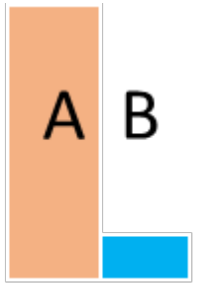


TRACE-Community

Using WBE to identify SARS-CoV-2 strains at the neighborhood level



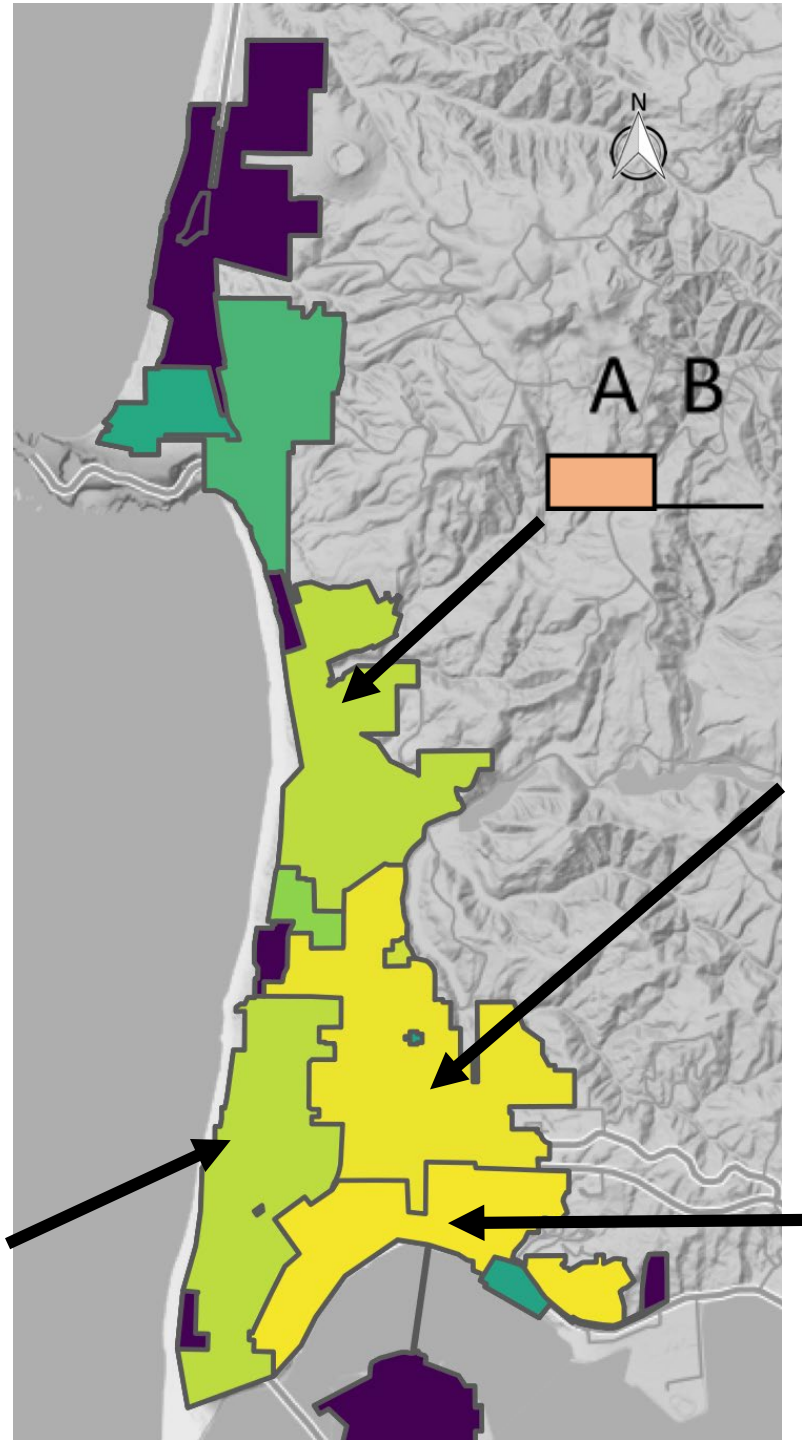
participant ratio

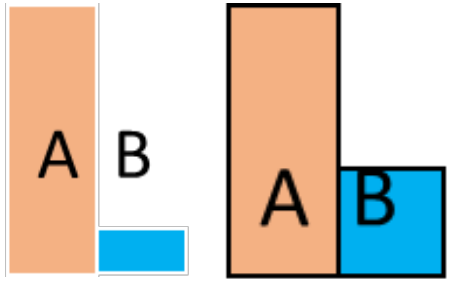


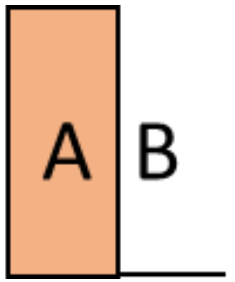
sewershed ratio

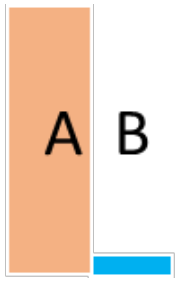
A = B.1.399

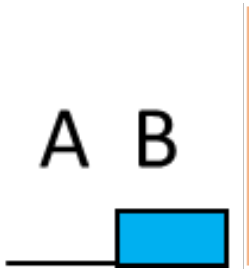
B = B.1.1.289





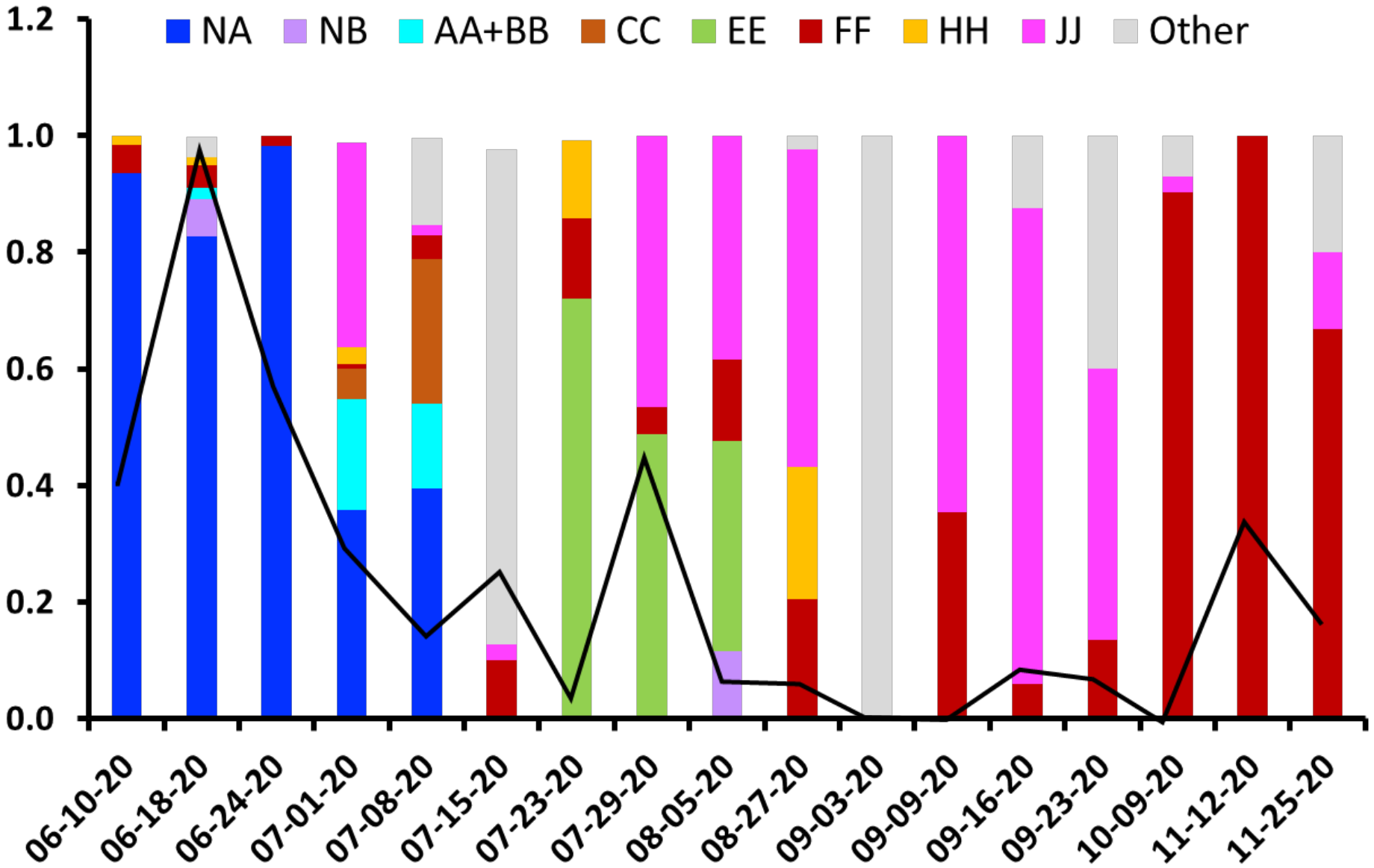






Genotypes and viral levels in Newport, OR

% Virus Genotype
&
% Max Wastewater Concentration



Wastewater-Based Epidemiology

Summary

What have we learned?

Where to next?

Lessons Learned

- Can determine the presence and trends of SARS-CoV-2 at the state-level
- Can identify SARS-CoV-2 VOCs
- Wastewater correlates more strongly with prevalence than reported cases

Lessons Learned

- High-resolution spatial sampling can pinpoint infection “hotspots”
- Able to detect a single infection at the building scale
- **WBE is a cost effective and scalable tool for monitoring COVID-19**

Challenges & Opportunities

- Lower the sensitivity
- Shorten the turnaround times
- Standardize methods/results interpretations between labs
- Continue optimizing communication of results with the public and public health agencies

Oregon Health Authority
PacificSource HEALTH PLANS
the David & Lucile Packard FOUNDATION
NSF
RAPID #2027679

Thank you!

TRACE: Wastewater team

- Tyler Radniecki, Ph.D. (OSU / PI)
- Christine Kelly, Ph.D. (OSU / PI)
- Devrim Kaya, Ph.D.
- Michael Harry
- Numerous students
- Numerous city & county employees

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- Brett Tyler, Ph.D.
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- Katie Carter
- Anne-Marie Girard
- Mark Dasenko

CWS: Wastewater team

- Ken Williams, Ph.D.
- Blythe Layton, Ph.D.

TRACE-OSU: Prevalence team

- Katherine McLaughlin, Ph.D.
- Benjamin Dalziel, Ph.D.
- Jeff Bethel, Ph.D.
- Roy Haggerty, Ph.D.
- Kathryn Higley, Ph.D.
- Denise Hynes, Ph.D.
- Jane Lubchenco, Ph.D.
- F. Javier Nieto, Ph.D.
- Aslan Noakes, RN
- Justin Sanders Ph.D.

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