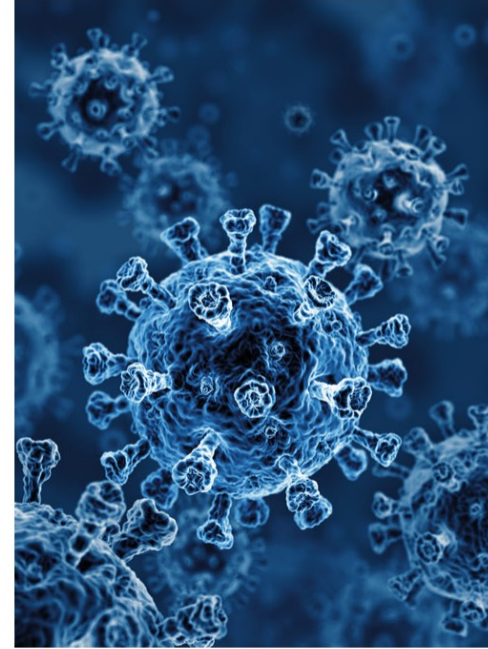
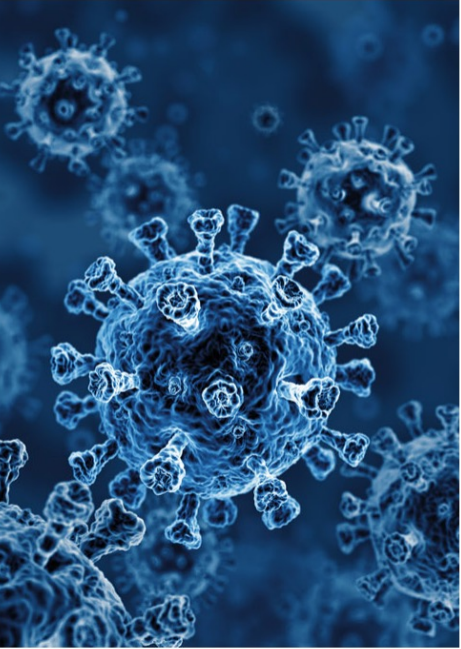
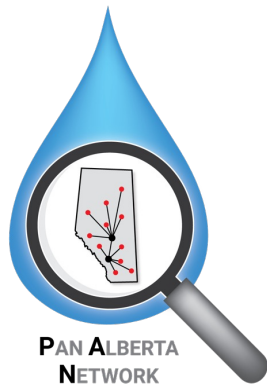




Wastewater Surveillance – *An Emerging Resource for Public Health*



Steve E. Hrudehy,

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Professor Emeritus

Analytical & Environmental Toxicology

Faculty of Medicine & Dentistry

University of Alberta

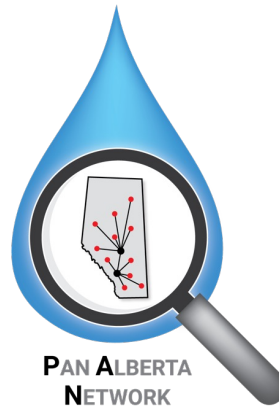
steve.Hrudehy@ualberta.ca

**For the Canadian Water Network,
the Pan Alberta Network,
& the Royal Society of Canada**

November 28, 2022

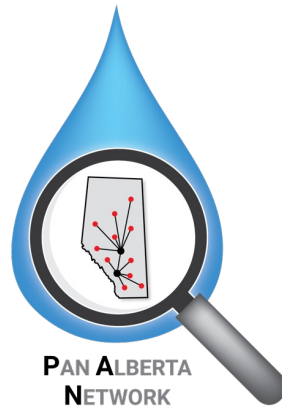


Presentation Outline



- 🦠 Explanation of Wastewater Surveillance (WWS)
- 🦠 Royal Society of Canada – Policy Brief Overview
 - 🦠 Wastewater Surveillance in Canada – CWN Wastewater Coalition
 - 🦠 Case Study: Wastewater Surveillance – Pan-Alberta Network
 - 🦠 Case Study: Wastewater Surveillance – Public Health Agency of Canada
 - 🦠 International uptake of WWS
 - 🦠 Future developments
 - 🦠 Ethics Guidance – CWN
- 🦠 Royal Society of Canada – Recommendations

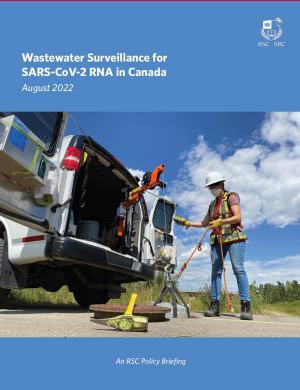
Explanation of WW Surveillance



- ❁ Applications of WWS date back at least as far as the 1940s
- ❁ Polymerase Chain Reaction (PCR) & gene sequencing have greatly facilitated
- ❁ Concept covers monitoring of wastewater from a known source
- ❁ Many had inaccurately referred to this as wastewater-based epidemiology (WBE), but Wastewater Surveillance (WWS) has gradually taken over, e.g., see WHO www.who.int/publications/i/item/WHO-2019-nCoV-SurveillanceGuidance-2022.1, CDC www.cdc.gov/healthywater/surveillance/wastewater-surveillance/wastewater-surveillance.html, etc.
- ❁ Most relevant application prior to COVID-19 has been international use of WWS has been to monitor efficacy of programs to eliminate polio by means of vaccination programs
- ❁ Applications of WWS had also been applied to a variety of other infectious disease pathogens

The Expert Panel on Wastewater Surveillance for SARS-CoV-2 in Canada

The Expert Panel published its Policy Brief in August 2022



- ❁ The RSC is Canada's national academy and it has published 28 policy briefing reports on interdisciplinary issues re: COVID-19
- ❁ We had a 14 member expert panel spanning analysts to public health decision-makers to capture the Canadian experience with WWS
- ❁ The panel included: microbiologists, molecular biologists, public health professionals, environmental scientists and engineers

Heather Bischel, U. California (Davis)

Jeff Charrois, Epcor Utilities (Edmonton)

Alex Chik, Ontario Clean Water Agency

Bernadette Conant, Can. Water Network

Rob Delatolla, U. Ottawa

Sarah Dorner, Polytechnique, Montreal

Tyson Graber, Childrens Hospital E. ON

Steve Hrudehy, U. Alberta

Casey Hubert, U. Calgary

Judy Isaac-Renton, UBC

Wendy Pons, Conestoga College, ON

Hannah Safford, Fed. American Scientists

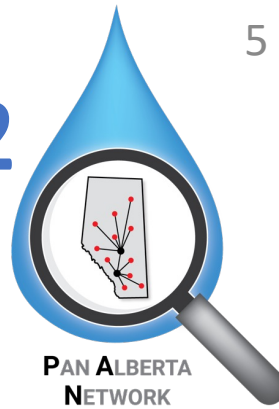
Mark Servos, U. Waterloo, ON

Christopher Sikora, AB Health Services,

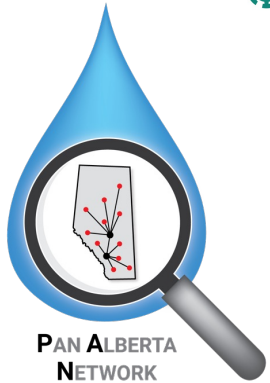
MOH, Edmonton Region



Case Study: Pan-Alberta WBS for SARS-CoV-2



- ❁ WWS Initiated on CIHR funded research at U of A (Pang et al.) & U of C (Parkins et al.) from May / July 2020
- ❁ WWS Funded by Alberta Health mid-November 2021
- ❁ Aiming to cover in Alberta:
 - ~44 cities, towns and 3 FN communities
 - ❖ >83 % of Albertans
 - ❖ >96% of those in communities >5K
 - Select neighborhoods
 - Select high-risk facilities
 - ❖ Hospitals, university campuses
 - ❖ Jails
 - ❖ Shelters
 - ❖ Long-Term Care - Congregate Living
- ❁ (Near) Real-time data reporting to AB Health **&** the public



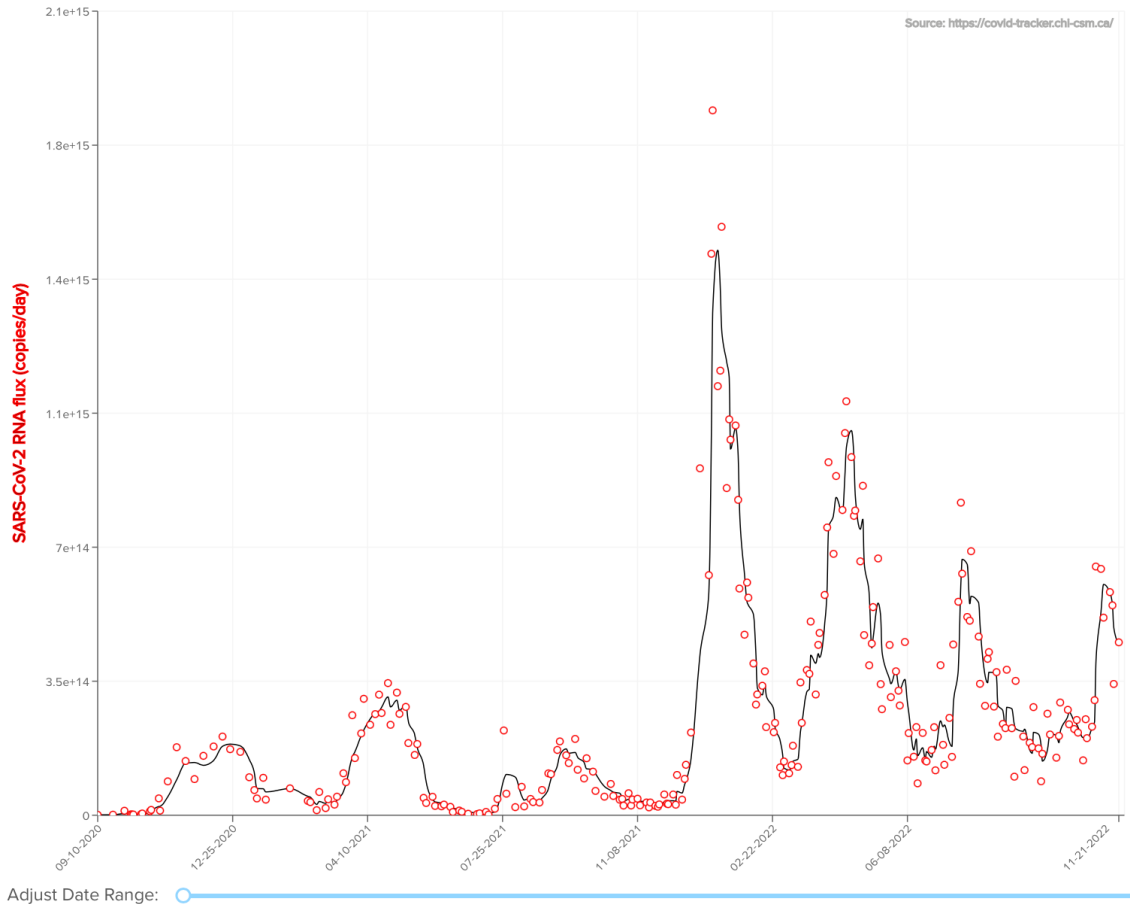
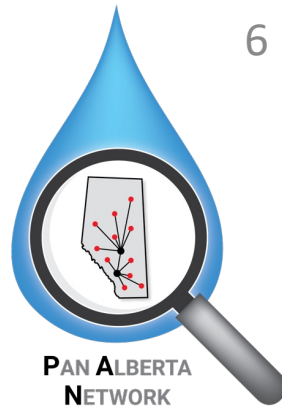


Community Level Monitoring

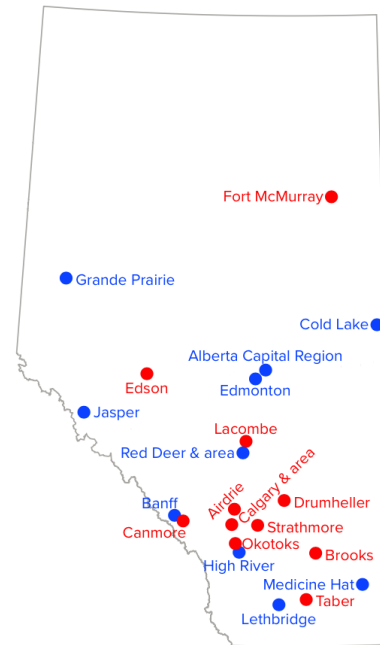


<https://covid-tracker.chi-csm.ca>

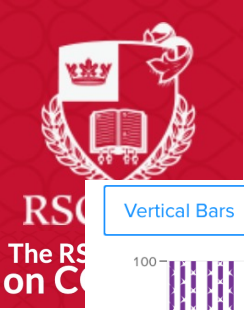
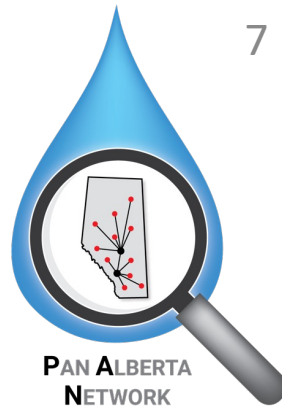
CENTRE FOR HEALTH INFORMATICS



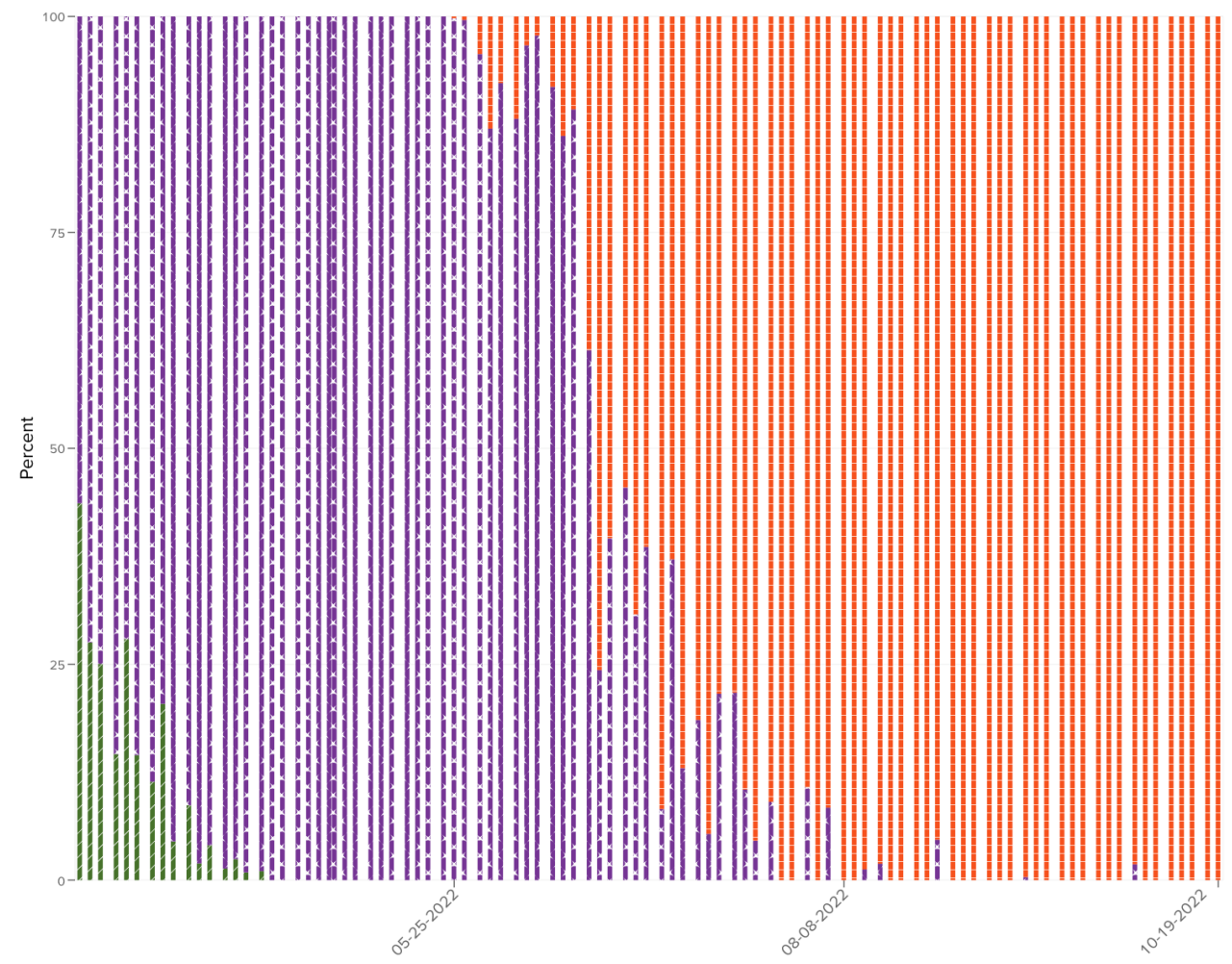
All of Calgary and surrounding area



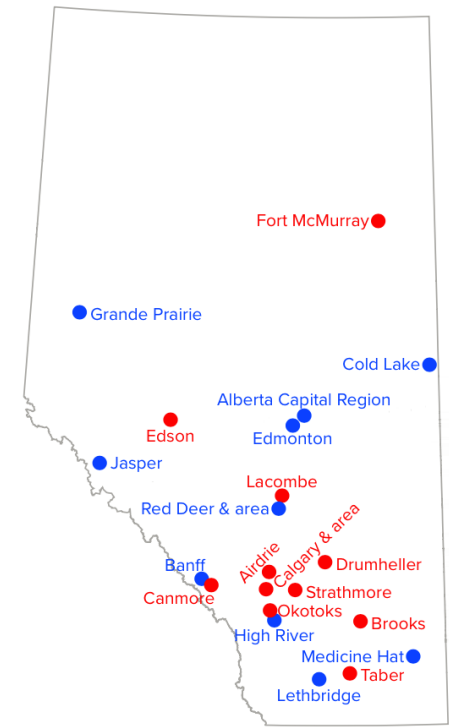
Tracking VOCs in Alberta Communities



Vertical Bars Horizontal Bars



Edmonton

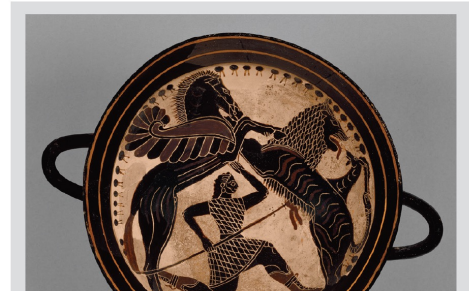


- Have been tracking VOCs in Alberta communities
- Shows evolution of VOC transition from 14 Mar to 19 Oct 2022

EMERGING INFECTIOUS DISEASES®

High-Consequence Pathogens

September 2022



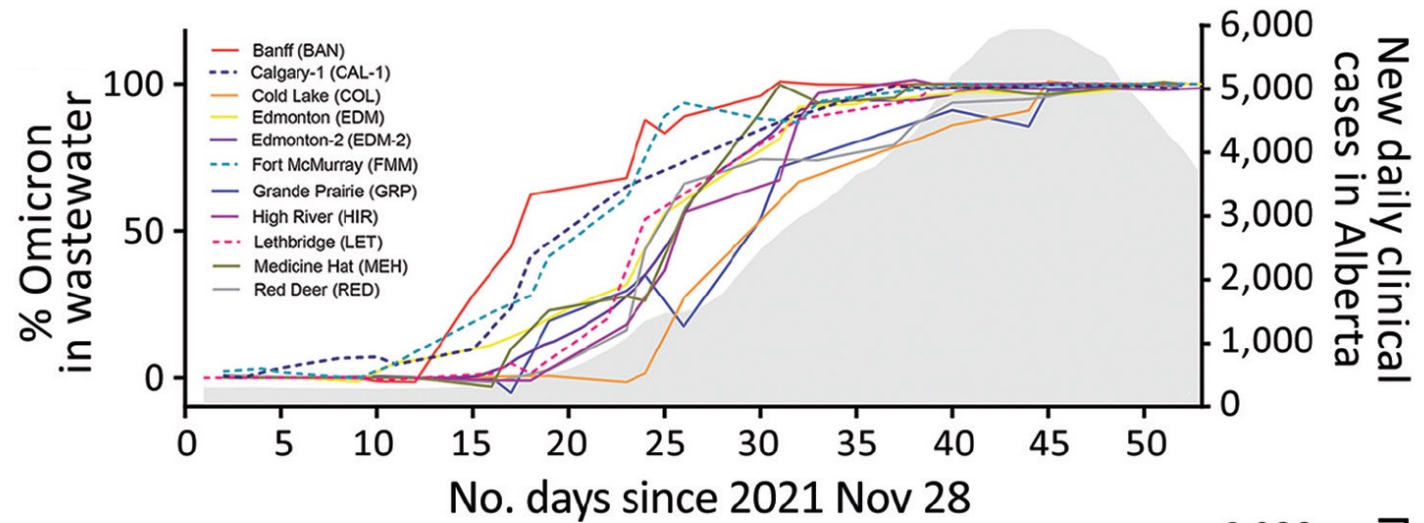
Tracking Emergence and Spread of SARS-Omicron Variant in Large and Small Communities by Wastewater Monitoring, Alberta, Canada
C.R.J. Hubert et al.



Centers for Disease Control and Prevention

Tracking Emergence and Spread of SARS-CoV-2 Omicron Variant in Large and Small Communities by Wastewater Monitoring in Alberta, Canada

Casey R.J. Hubert, Nicole Acosta, Barbara J.M. Waddell, Maria E. Hasing, Yuanyuan Qiu, Meghan Fuzzen, Nathanael B.J. Harper, Maria A. Bautista, Tiejun Gao, Chloe Papparis, Jenn Van Doorn, Kristine Du, Kevin Xiang, Leslie Chan, Laura Vivas, Puja Pradhan, Janine McC Calder, Kashtin Low, Whitney E. England, Darina Kuzma, John Conly, M. Cathryn Ryan, Gopal Achari, Jia Hu, Jason L. Cabaj, Chris Sikora, Larry Svenson, Nathan Zelyas, Mark Servos, Jon Meddings, Steve E. Hruday, Kevin Frankowski, Michael D. Parkins, Xiaoli (Lilly) Pang, Bonita E. Lee



- Tracking the Omicron wave in Dec 21 through Jan 22 in Alberta WW confirmed the expectation that new VOCs appeared first in major national / international travel hubs (Banff, Calgary, Ft. McMurray first, then Edmonton region, followed by smaller centres distant from international airports)
- Cost for WWS, based on 3 daily composites per week estimated to be a few cents per person per year for large communities

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/jes

- 🦠 Alberta Prov Lab of PH / U of Alberta (Dr. Lilly Pang) funded by CIHR
- 🦠 Sampled 12 Alberta WWTPs serving 10 communities, large & small, from May 2020 to June 2021
- 🦠 Analyzed over 1,800 WW samples - clinical test rate - highest in Canada
- 🦠 Performed Probit analyses to determine probability of WW detection of confirmed cases
- 🦠 Small communities 50% probability of detecting 1 case in 6250 pop. 99% probability for 1 case in 1408 pop.
- 🦠 Large communities 50% prob. of detect 7 cases/100,000 ; 99% prob. of detect 21 cases/100,000

Number of COVID-19 cases required in a population to detect SARS-CoV-2 RNA in wastewater in the province of Alberta, Canada: Sensitivity assessment

Qiaozhi Li¹, Bonita E. Lee², Tiejun Gao³, Yuanyuan Qiu³, Erik Ellehoj⁴, Jiao Yu³, Mathew Diggle⁵, Graham Tipples⁵, Rasha Maal-Bared⁶, Deena Hinshaw⁷, Christopher Sikora⁷, Nicholas J. Ashbolt⁸, James Talbot⁷, Steve E. Hrudey³, Xiaoli Pang^{3,5,*}

¹ School of Public Health, University of Alberta, Edmonton, AB T6G 2R3, Canada

² Department of Pediatrics, University of Alberta, Edmonton, AB T6G 1C9, Canada

³ Department of Laboratory Medicine and Pathology, University of Alberta, Edmonton, AB T6G 2B7, Canada

⁴ University of Alberta Central Receiving, Edmonton, Alberta, T6G 2R3, Canada

⁵ Provincial Laboratory for Public Health, Edmonton, Alberta, Canada

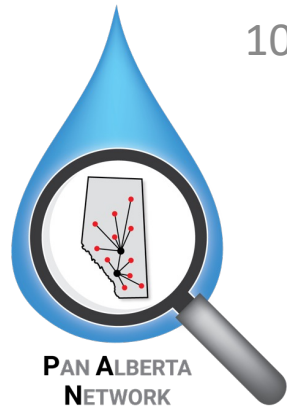
⁶ EPCOR, Edmonton, AB T5H 0E8, Canada

⁷ Department of Medicine, University of Alberta, Edmonton, AB T6G 2G3, Canada

⁸ Faculty of Science and Engineering, Southern Cross University, East Lismore NSW 2480, Australia



Case Study: Public Agency of Canada WBS



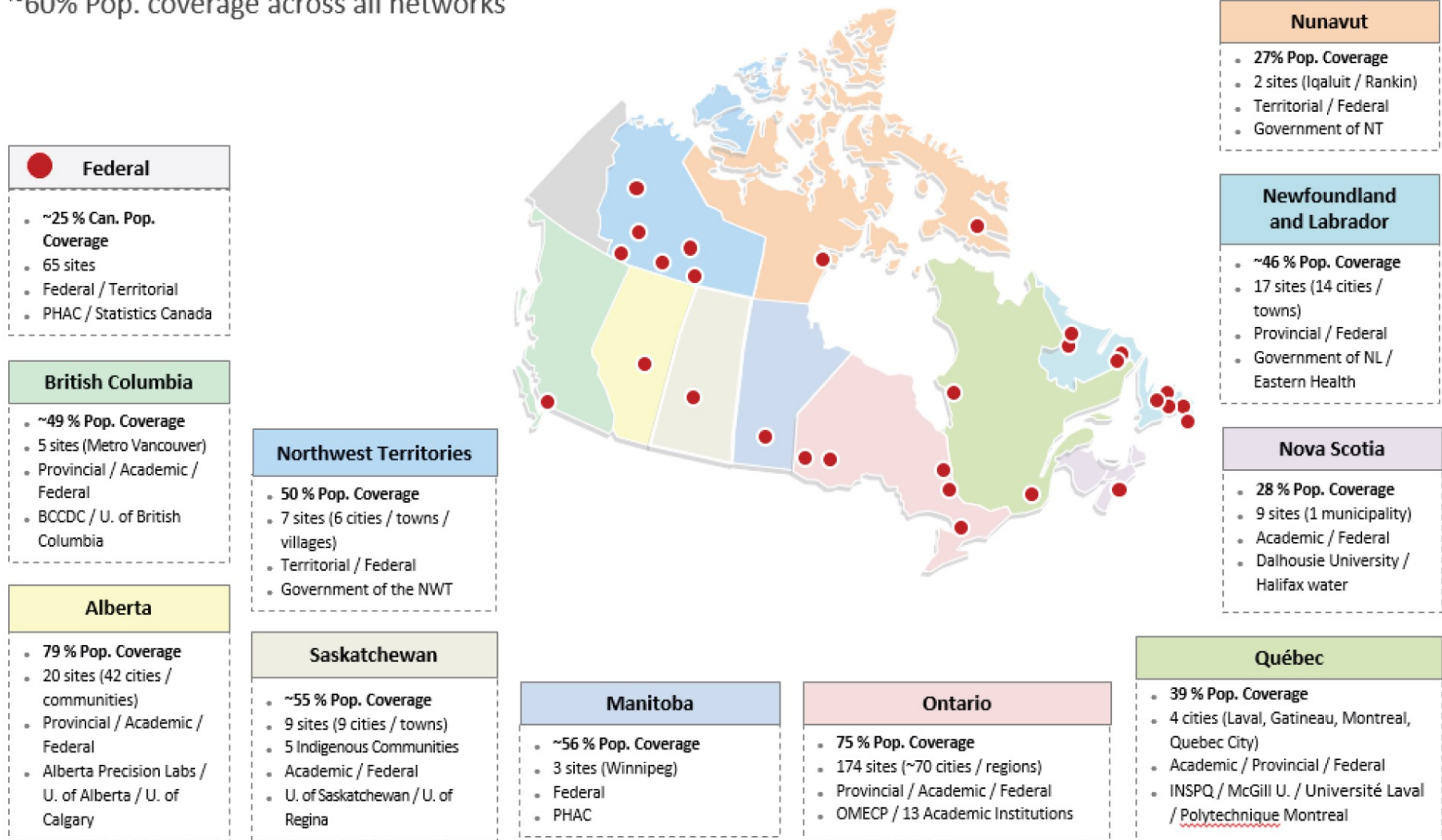
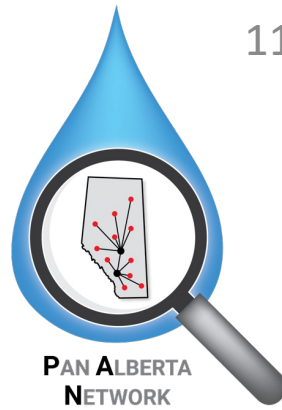
- Partnered with CWN to conduct first inter-lab trial Aug 2020
- Leveraged previous Statistics Canada wastewater monitoring program of 5 Canadian cities to initiate WBS for SARS-CoV-2 by Spring 2021, expanded to direct support for more than 65 sites
- Including remote, smaller communities in northern Territories
- Developed metagenomics sequencing to support VOC monitoring
- Collaborated in developing multiple RT-qPCR assays for VOCs
- Developed analytical models to interpret WBS results

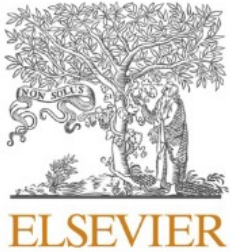


Case Study: Public Agency of Canada WBS

Current Federal, Provincial and Territorial Wastewater Surveillance Networks

~60% Pop. coverage across all networks

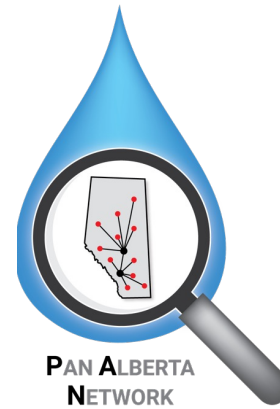




Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Epidemics

journal homepage: www.elsevier.com/locate/epidemics



A wastewater-based epidemic model for SARS-CoV-2 with application to three Canadian cities

Shokoofeh Nourbakhsh ^{a,1}, Amir Fazil ^a, Michael Li ^a, Chand S. Mangat ^b, Shelley W. Peterson ^b, Jade Daigle ^b, Stacie Langner ^b, Jayson Shurgold ^c, Patrick D'Aoust ^d, Robert Delatolla ^d, Elizabeth Mercier ^d, Xiaoli Pang ^{e,f}, Bonita E. Lee ^g, Rebecca Stuart ^h, Shinthuja Wijayasri ^{h,i}, David Champredon ^{a,*,1}

^a Public Health Risk Sciences Division, National Microbiology Laboratory, Public Health Agency of Canada, Guelph, ON, Canada

^b One Health Division, National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, MB, Canada

^c Antimicrobial Resistance Division, Infectious Diseases Prevention and Control Branch, Public Health Agency of Canada, Ottawa, ON, Canada

^d University of Ottawa, Department of Civil Engineering, Ottawa, ON, Canada

^e Public Health Laboratory, Alberta Precision Laboratory, Edmonton, AB, Canada

^f Department of Laboratory Medicine and Pathology, University of Alberta, Edmonton, AB, Canada

^g Department of Pediatrics, University of Alberta, Edmonton, AB, Canada

^h Toronto Public Health, Toronto, ON, Canada

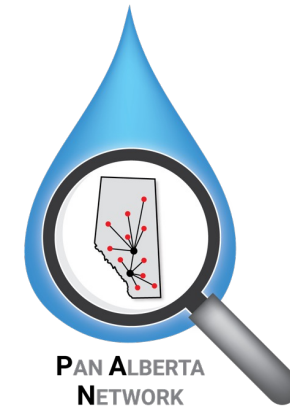
ⁱ Canadian Field Epidemiology Program, Emergency Management, Public Health Agency of Canada, Canada

“Found that WBS, paired with this model, can complement clinical surveillance by supporting the estimation of key epidemiological metrics and hence better triangulate the state of an epidemic using this alternative data source.”

Wastewater Surveillance in Canada

COVID-19 WASTEWATER COALITION

A national collaboration of municipal utilities, researchers, public health agencies and government with a shared goal of protecting public health from COVID-19



COALITION UPDATES

NEWS STORIES

INTER-LAB STUDY

REGIONAL HUBS

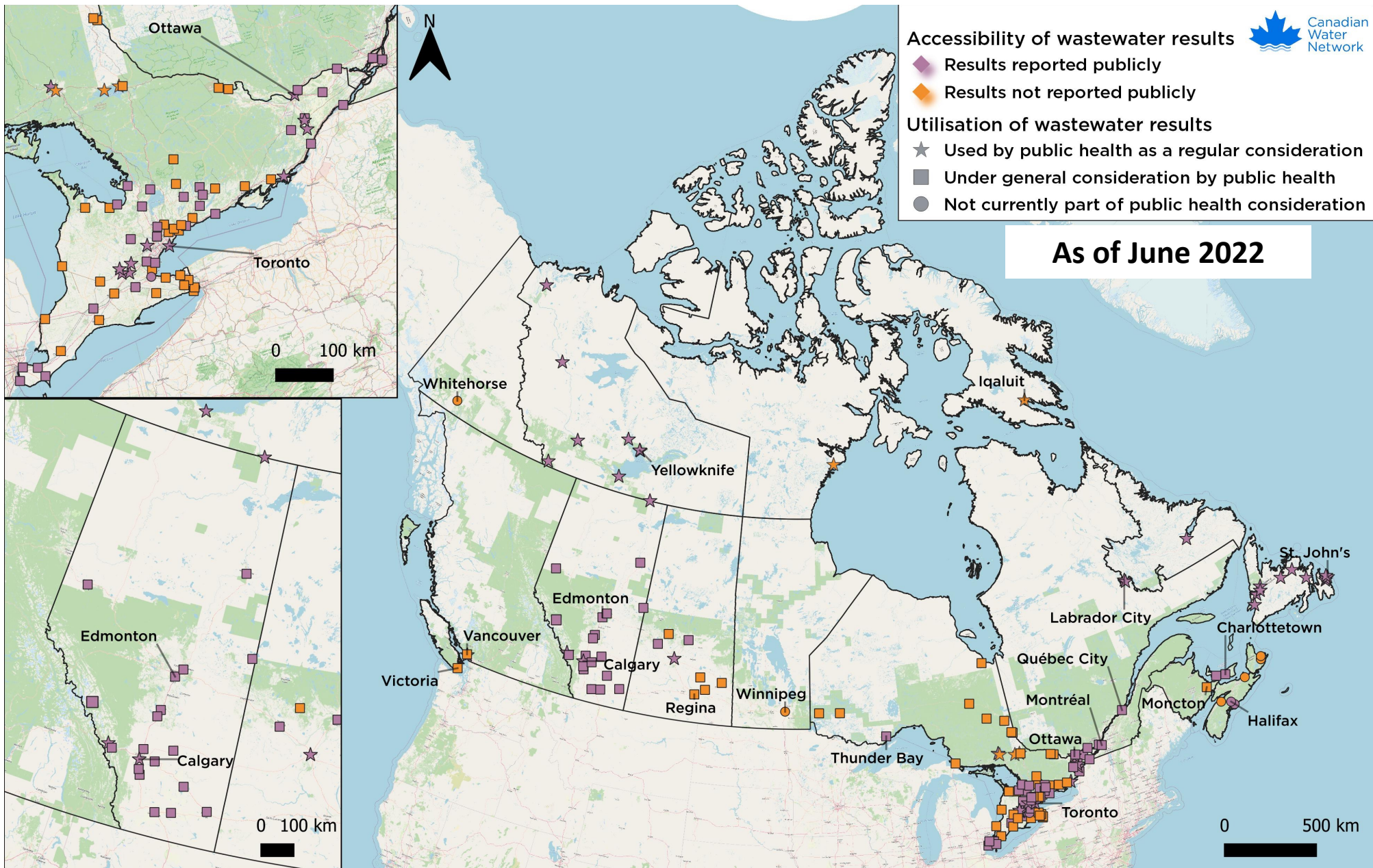
RESOURCES

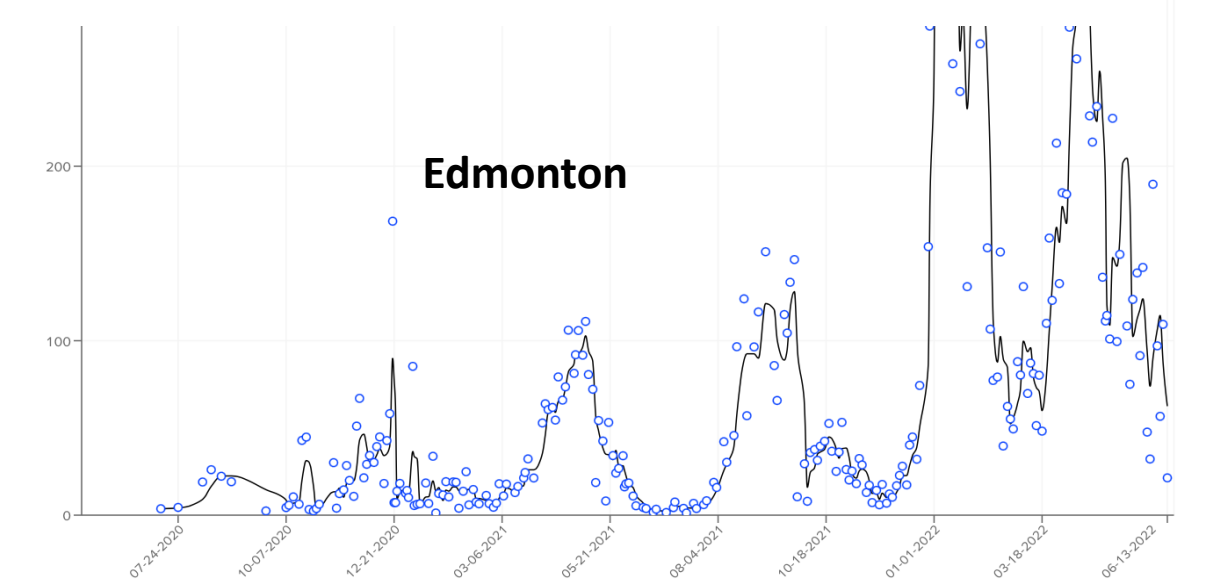
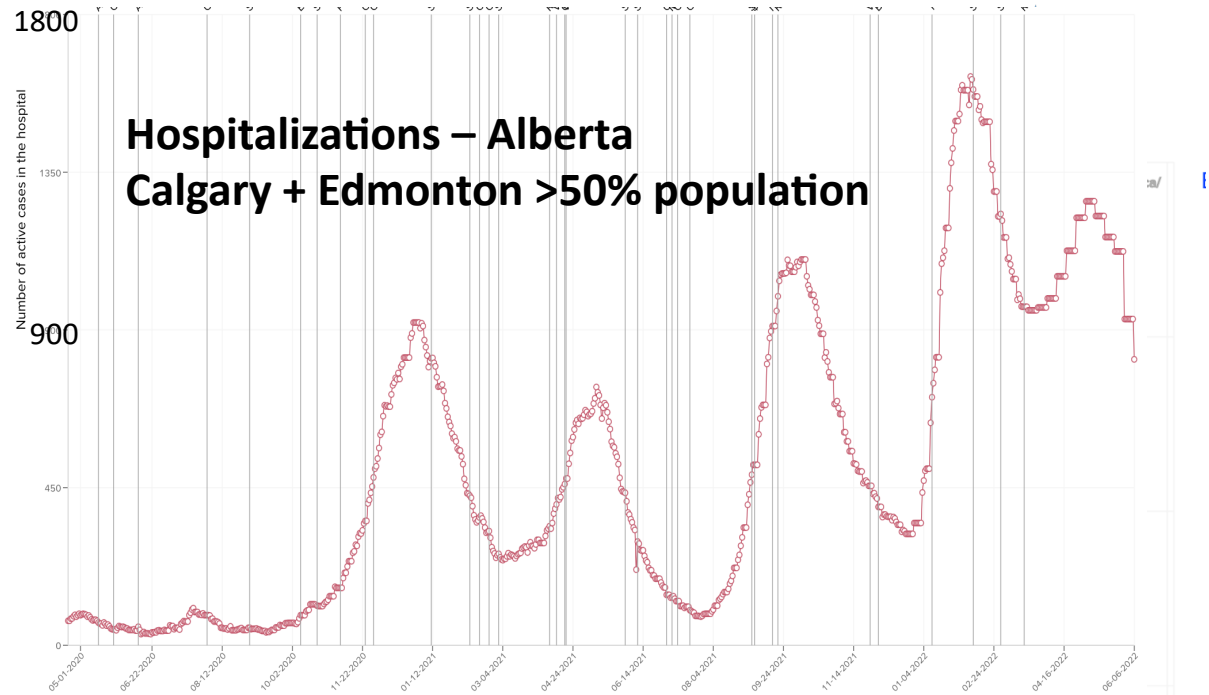
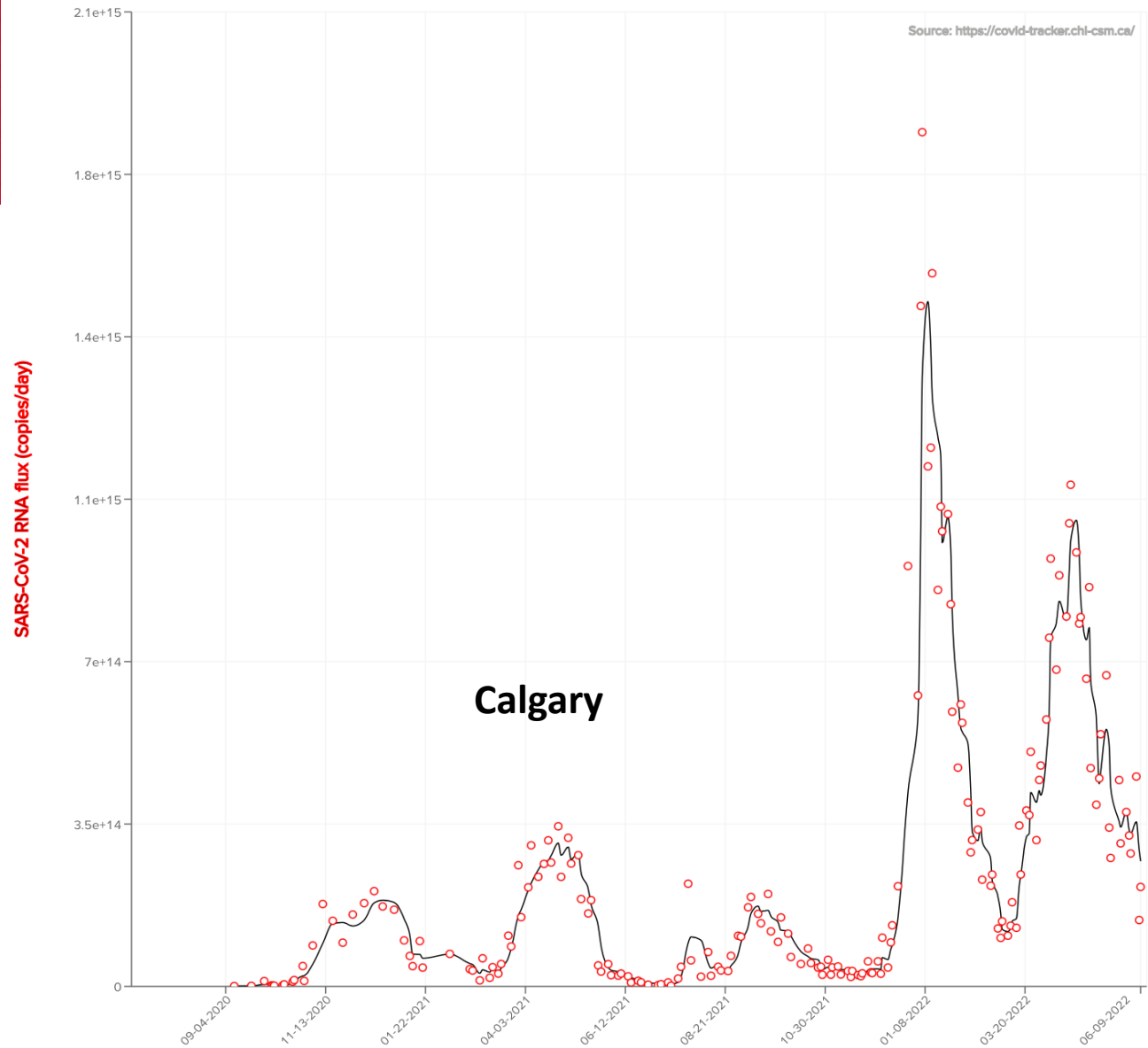
GET INVOLVED

"Helping Canada to better address and assess what is needed and what the reliable use of the technique could look like is the fundamental rationale for the Canadian COVID-19 Wastewater Coalition." – Steve E. Hrudehy

<https://cwn-rce.ca/covid-19-wastewater-coalition/>

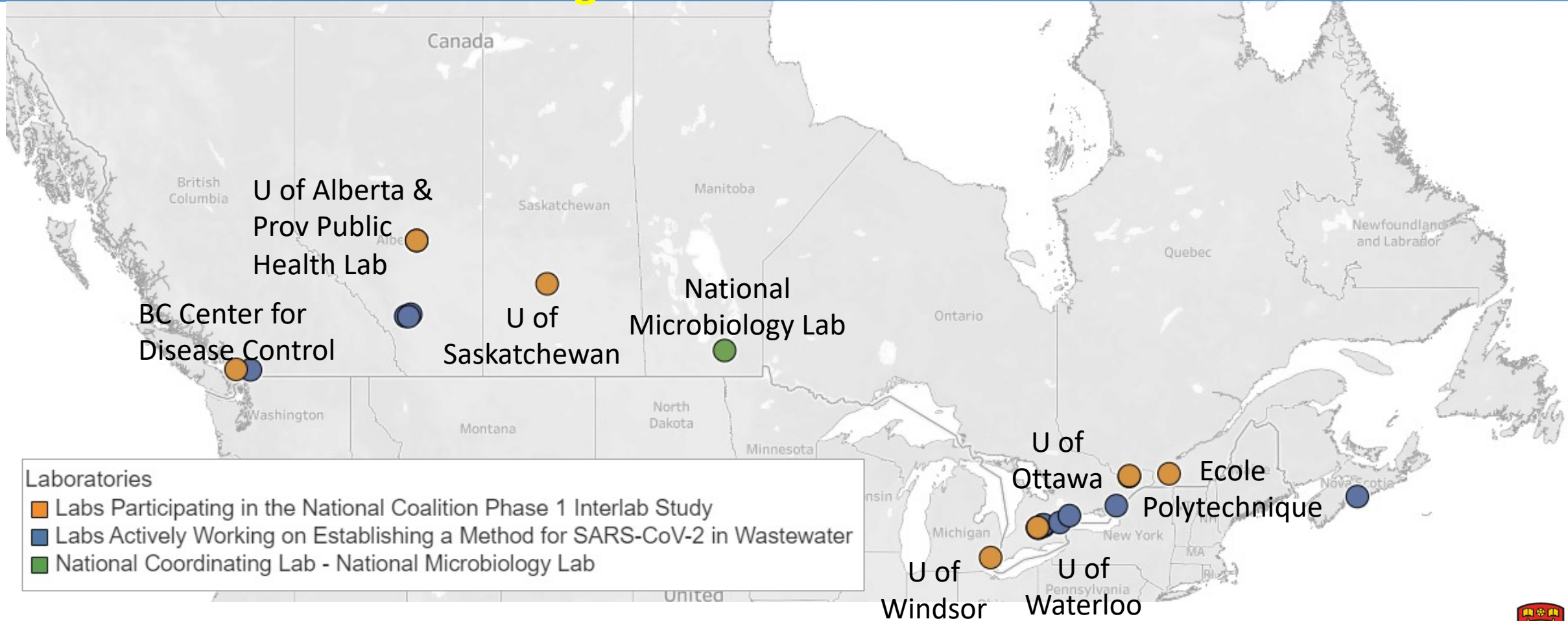
- 🌿 The Canadian Water Network (CWN) established the COVID-19 Wastewater Coalition in **April 2020**.
- 🌿 The Coalition was created with the goal of informing a better understanding of *if, how* and *where* wastewater surveillance for SARS-CoV-2 might provide value for public health decisions.



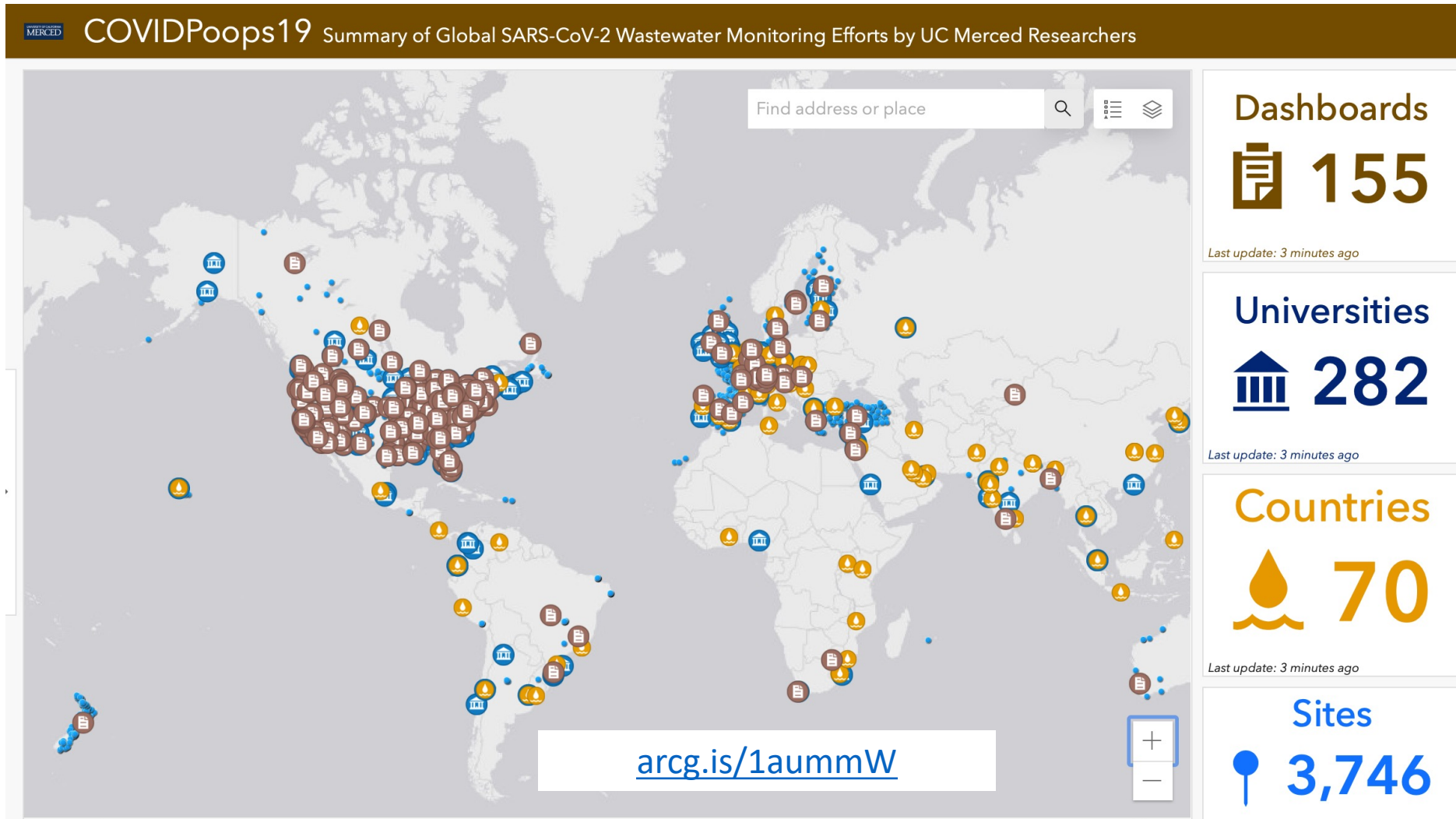
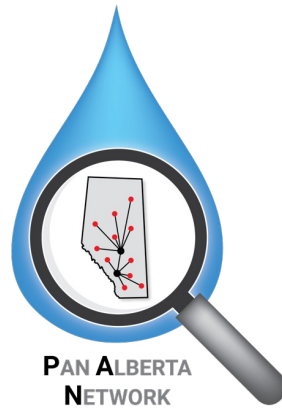


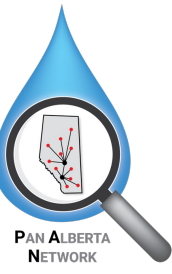
COVID-19 Wastewater Coalition: Phase 1 Inter-lab Pilot Study and Labs Developing Methods in Canada

August to October 2020

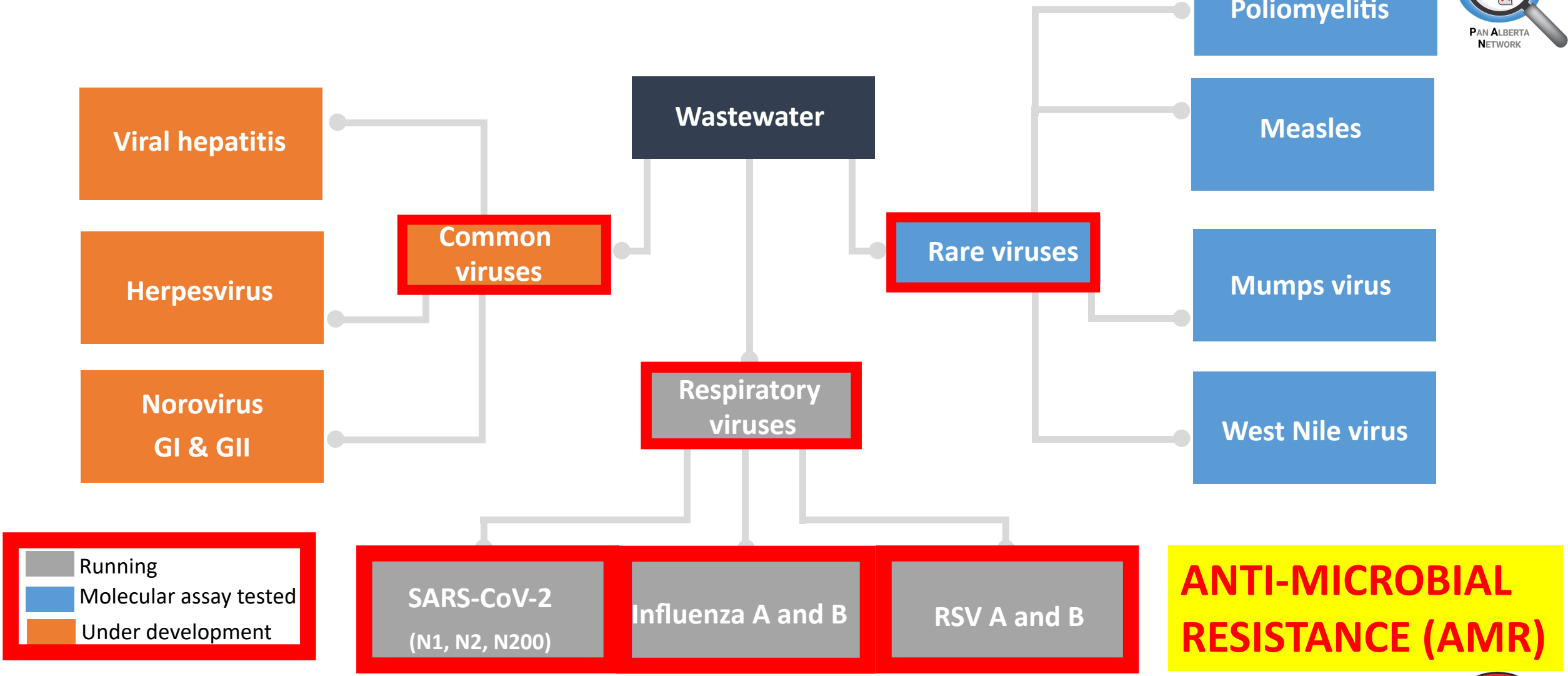


International WWS Activity

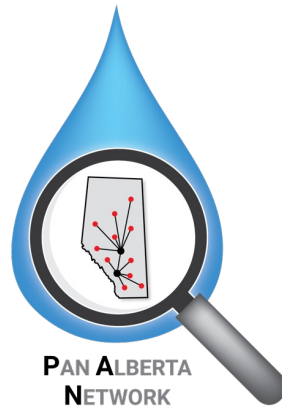




WBS-Pathogen Targets: Current & FUTURE



Ethics and Communications Guidance



- ❁ Wastewater monitoring for signals of SARS-CoV-2 is an application of public health surveillance and requires appropriate ethical guidance – **WWS must have a legitimate public health purpose**
- ❁ The purpose is to inform public health decision-making for the protection of public health - that requires **public trust** to be effective and trust can be lost **IF** ethical guidance is not considered.
- ❁ This requires collaboration between investigators and public health decision-makers. Most academic investigators may not be familiar with the ethical obligations for such public health evidence

Ethics and Commu

- Wastewater monitoring for application of public health appropriate ethical guidance **public health purpose**
- The purpose is to inform pu protection of public health effective and trust can be Ic considered.
- This requires collaboration health decision-makers. Mc familiar with the ethical obl evidence

Ethics Guidance for Environmental Scientists Engaged in Surveillance of Wastewater for SARS-CoV-2


Steve E. Hrudehy,* Diego S. Silva, Jacob Shelley, Wendy Pons, Judy Isaac-Renton, Alex Ho-Shing Chik, and Bernadette Conant

 Cite This: *Environ. Sci. Technol.* 2021, 55, 8484–8491

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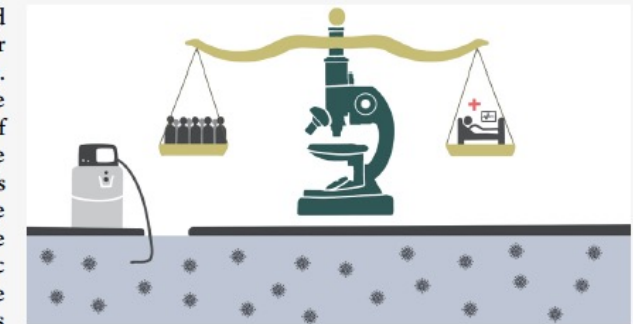
ACCESS |

 Metrics & More

 Article Recommendations

ABSTRACT: The COVID-19 pandemic has given rise to rapid and widespread international pursuit of wastewater surveillance for genetic signals of SARS-CoV-2, the virus causing the pandemic. Environmental scientists and engineers familiar with the techniques required for this endeavor have responded. Many of the environmental scientists engaged in these investigations have not necessarily had experience with the ethical obligations associated with generating and handling human health data. The Canadian Water Network facilitated adoption of these surveillance methods by creating a national coalition, which included a public health advisory group that recognized a need for ethics guidance for the wastewater approach to public health surveillance. This Policy Analysis addresses that need and is based on a review of relevant ethics literature tightly focused on ethics applicable to public health surveillance. That review revealed that classical health bioethics governing clinical practice and general public health ethics guidance did not adequately address key issues in wastewater surveillance. The 2017 World Health Organization guidelines, directly based on a systematic literature review, specifically addressed ethical issues in public health surveillance. The application of relevant ethical guidance to wastewater surveillance is analyzed and summarized for environmental scientists.

KEYWORDS: COVID-19, virus, sewage, public health, bioethics





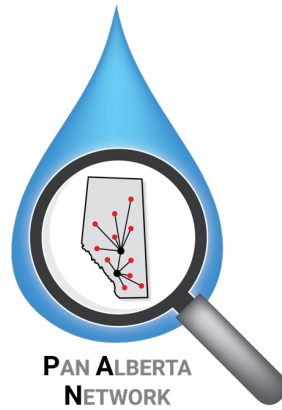
An RSC Policy Briefing

Recommendations

1. Capture useful lessons from WWS for SARS-CoV-2
2. Create structures and capacity to sustain capability and develop rapid response to future public health threats
3. Develop frameworks for WWS program design
4. Develop frameworks for interpretation of WWS program results
5. Maintain and promote academic partnerships and communication networks that will help identify new opportunities and threats.
6. Build upon existing infrastructure and programs

<https://rsc-src.ca/en/covid-19-policy-briefing/wastewater-surveillance-for-sars-cov-2-rna-in-canada>

Concluding Comments



- ❁ Wastewater Surveillance for SARS-CoV-2 RNA has become an international scientific phenomenon
- ❁ Canada has been a leader in many aspects of WWS
- ❁ Canada's emergence initiated as a grass roots phenomenon led by Canadian academics who responded creatively to the pandemic challenge with major commitment of diverted resources
- ❁ Canada now has some of the most comprehensive WWS
- ❁ The full potential of WWS will require a serious commitment by government public health agencies to learn and support future potential
- ❁ The future public health potential of WWS is substantial – **learn more!**

Discussion

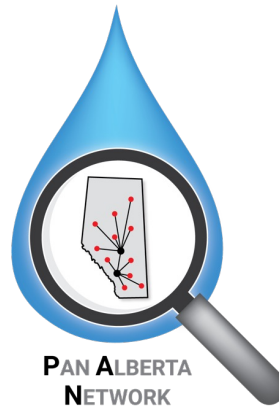
steve.hrudey@ualberta.ca

Canadian Publications on WWS -1

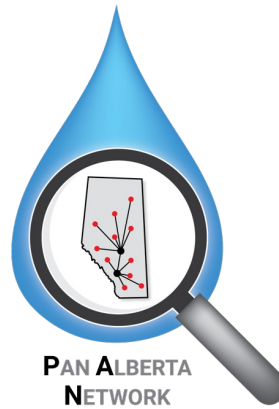
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Canadian Publications on WWS-2



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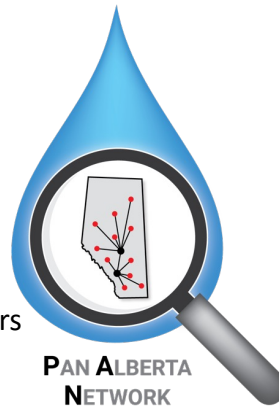
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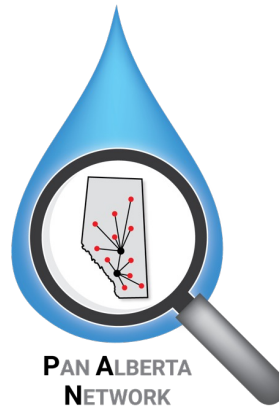
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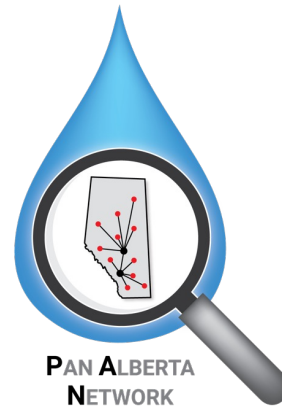


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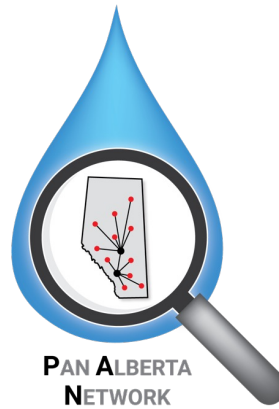


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