NVBL Viral Fate and Transport for COVID-19

Katrina Waters,
Project Lead

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Drivers of airborne transport and fate impacting virus transmission

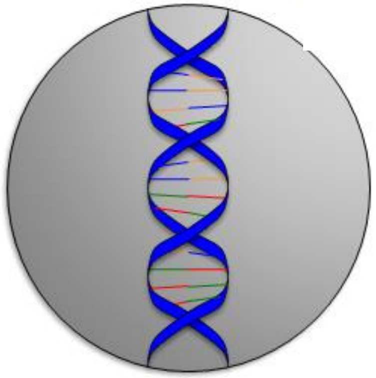
- Motivated by evidence that people have been infected while indoors, despite social distancing
- Focused on understanding particle transformation and removal processes that influence transmission
- Primary questions:
  - Are current mitigation approaches effective?
  - Can HVAC systems contribute to transmission indoors?
  - How do we reopen workplaces, schools, and businesses safely?
- Expected outcome:
  - Estimate absolute and relative risk of airborne infection including measures to reduce direct transfer and average airborne concentration of virus

Particles emitted from mouth of a mannequin illustrating different flow paths for different particles

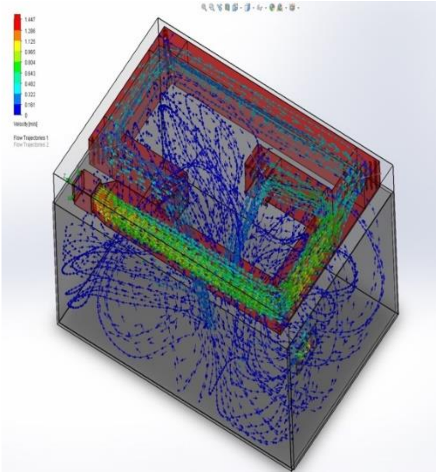
Drivers of airborne transport and fate impacting virus transmission

Leveraging national laboratory research facilities, aerosol processes expertise, high-performance computing (HPC) resources, and other unique capabilities

FLEXLAB Testbed	Multi-zone Research Buildings	DNATrax	HPC	Aerosol and Fluid Dynamics Expertise
LBNL	PNNL • ORNL	LLNL	SNL • ANL LBNL	ANL • BNL • SNL LANL• PNNL



DNA barcoded bioaerosol surrogate



Drivers of airborne transport and fate impacting virus transmission

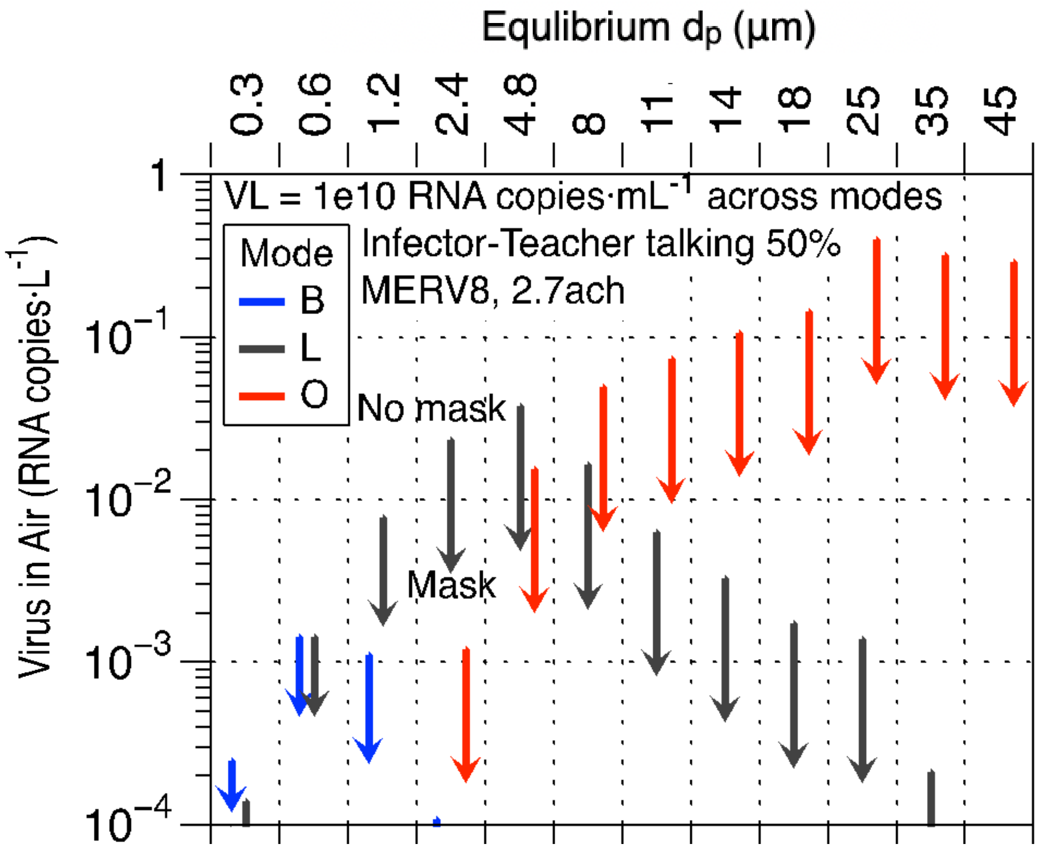
Simulation framework enables tracking of virus transfer from infected person to others in room

Key Findings

- Simulated student exposure in classrooms with ventilation, filtration, and mask wearing
- Particles from upper respiratory regions increase airborne viral concentration >> than from lower

Significance

- Pre-symptomatic and asymptomatic may be more likely to have upper respiratory infections shedding virus; masks are critically important to reduce transmission exposure risk



Simulated airborne virus from bronchiolar (B), laryngeal (L), and oral (O) regions with masks (bottom of arrows) and without masks (top of arrows)

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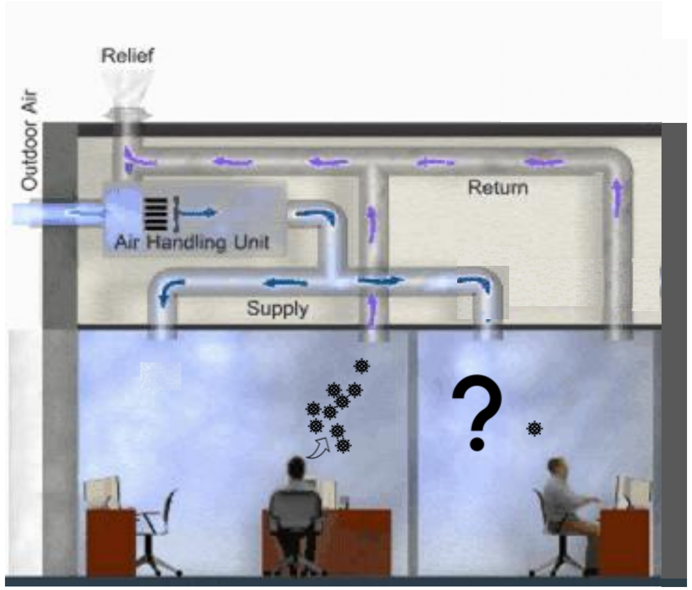


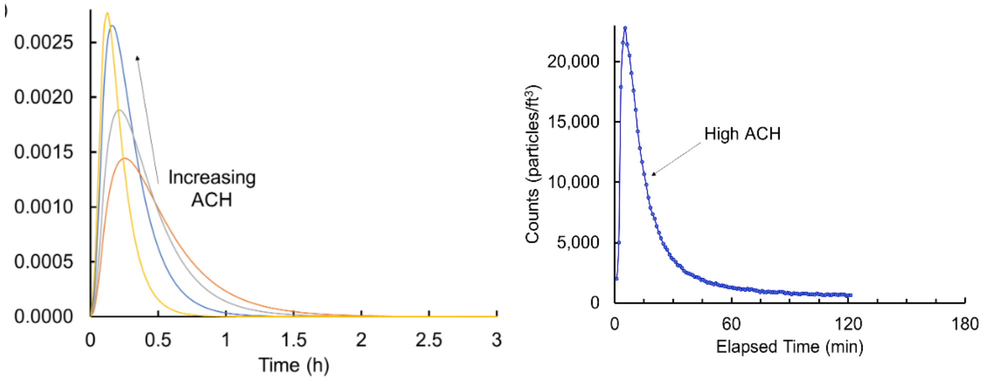
Can virus transmit through building HVAC and what is the impact of operational design?

Key Findings

- Model simulation shows that some transmission occurs; infectivity risk > 0
- Quantified effects of changing ventilation, filtration, and outdoor air supply

Significance

- HVAC operation can be optimized to reduce transmission
- Potential to minimize energy penalty



Simulated (left) and experimentally measured (right) particle concentration in room adjacent to emitter

Drivers of airborne transport and fate impacting virus transmission

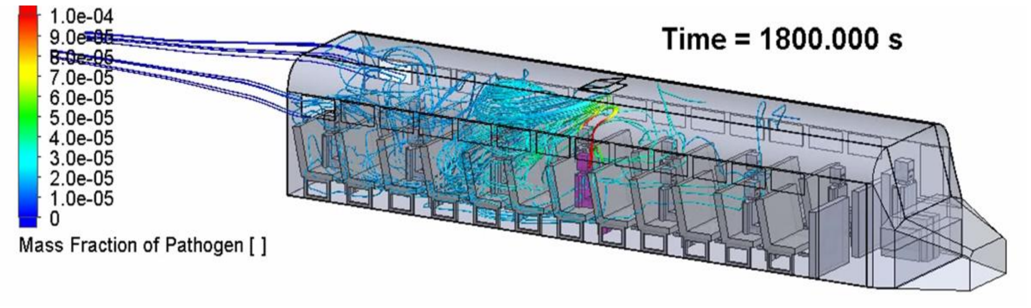
School-bus scenarios and window configurations that minimize airborne exposure risks?

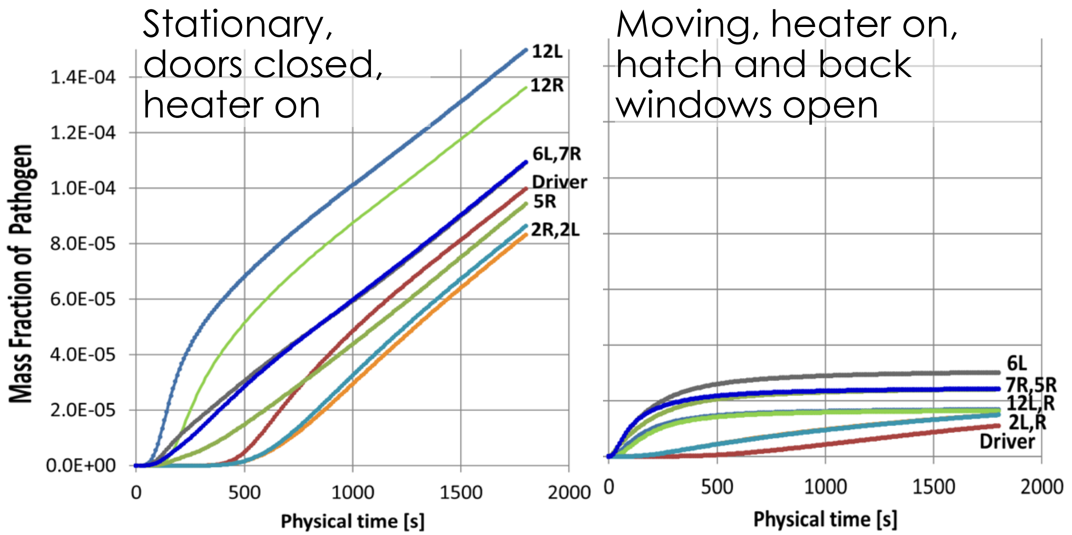
Key Findings

- Pathogen concentrations and exposure risks are minimized when through-flow conditions exist with at least two sets of windows or openings

Significance

- Working with Albuquerque and other school transportation directors to implement and test strategies that minimize exposure risk while maintain thermal comfort





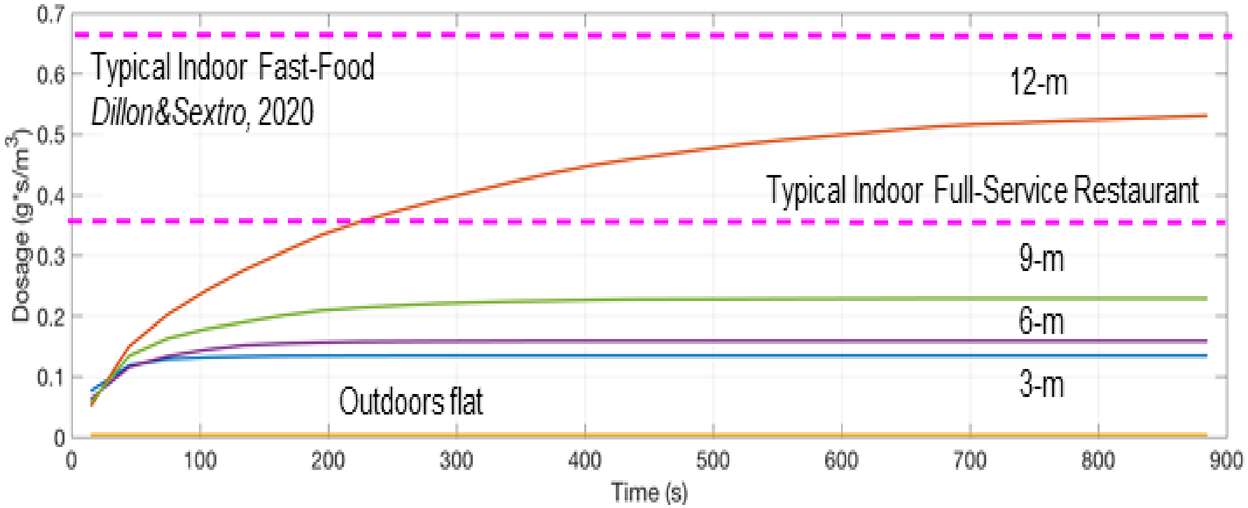
Simulated pathogen concentration over time at different locations on school bus

Drivers of airborne transport and fate impacting virus transmission

Semi-enclosed outdoor dining: Is it safe?

Key findings: Outdoor courtyard dining spaces can have airborne dosage levels similar to those found in fast-food and full-service indoor environments

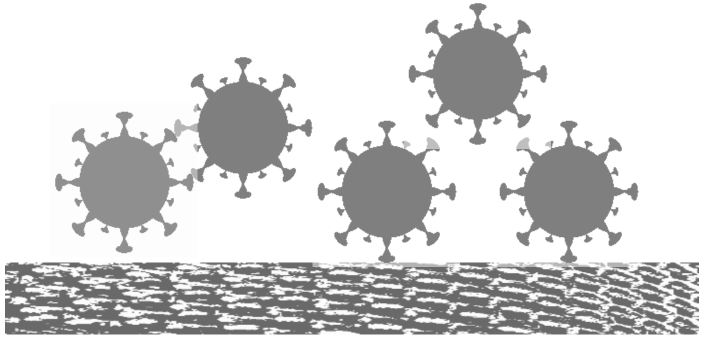
Significance: Dining outdoors has been suggested as a safe alternative; however, some outdoor dining geometries may lead to reduced ventilation and a higher risk of transmission



Simulated pathogen dosage for patron of outdoor dining courtyard with different wall heights: 0 to 12 meters tall

Role of surface chemistries in viral transmission and spreading

Motivated by the potential for fomite transmission in the built environment



Primary questions:

- How do virus–material interactions impact the fate and viability of coronaviruses?
- Can surface-bound coronaviruses serve as reservoirs for airborne and waste/ground water transmission?

Expected outcome:

- Identify factors responsible for the affinity of coronaviruses to manmade materials and ability of the surface-bound pathogens to contribute to viral transmission
- Define the ways to control viral transmission via surfaces by using virus-binding or -repelling materials and coatings

Role of surface chemistries in viral transmission and spreading

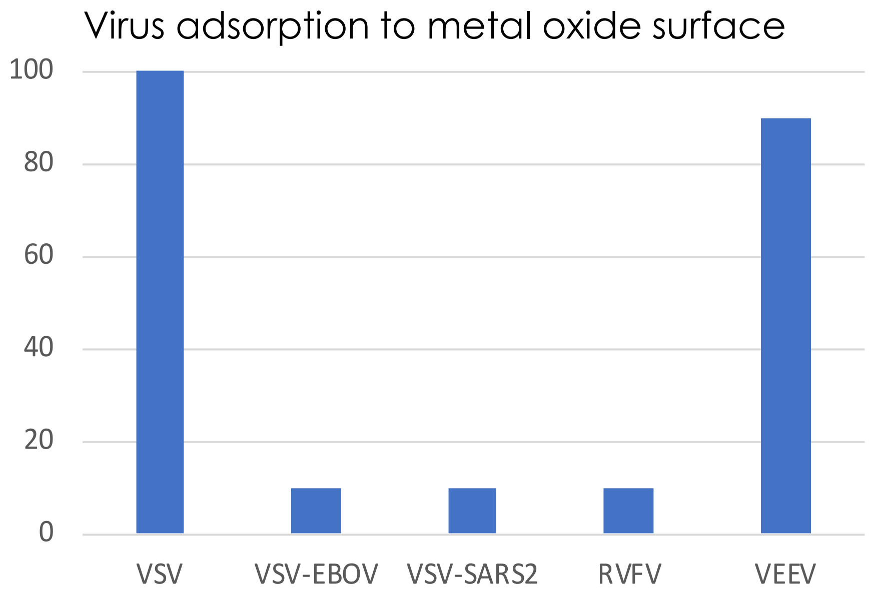
Virus Viability and Surface Adhesion

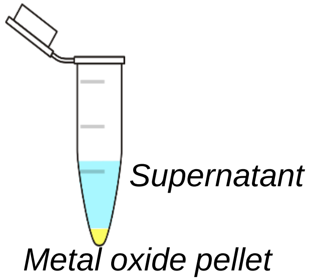
Key Findings

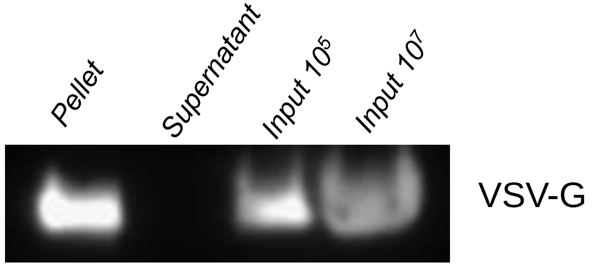
- No antiviral activity by tested manmade surfaces
- Strong adsorption of a viral surrogate system to metal oxide surface
- Selective affinity of metal oxides to different viruses

Significance

- Identifying materials with exceptional affinity to enveloped viruses
- Surface structure and chemistry could be engineered to reduce transmission potential







Role of surface chemistries in viral transmission and spreading

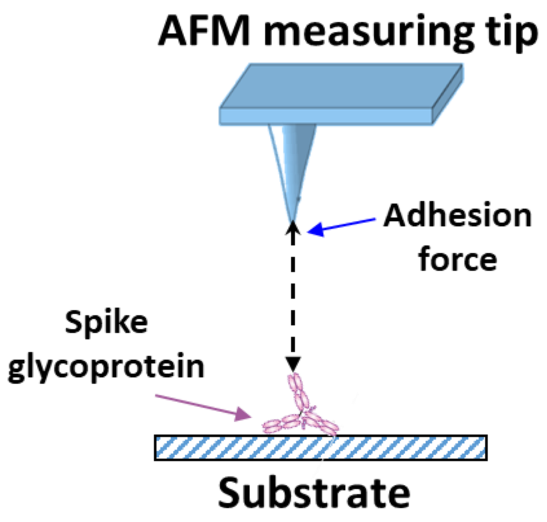
Interaction of viral particles with non-biological surfaces

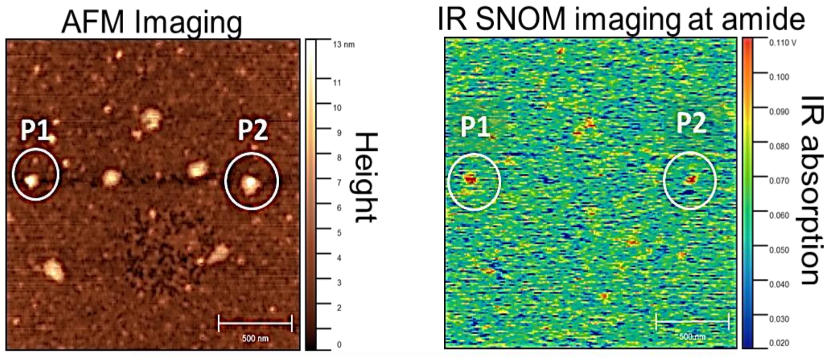
Key Findings

- Glycoproteins can be identified on substrate using advanced imaging technologies
- Imaging force-distance measurements show stronger interaction of the spike protein with copper vs aluminum

Significance

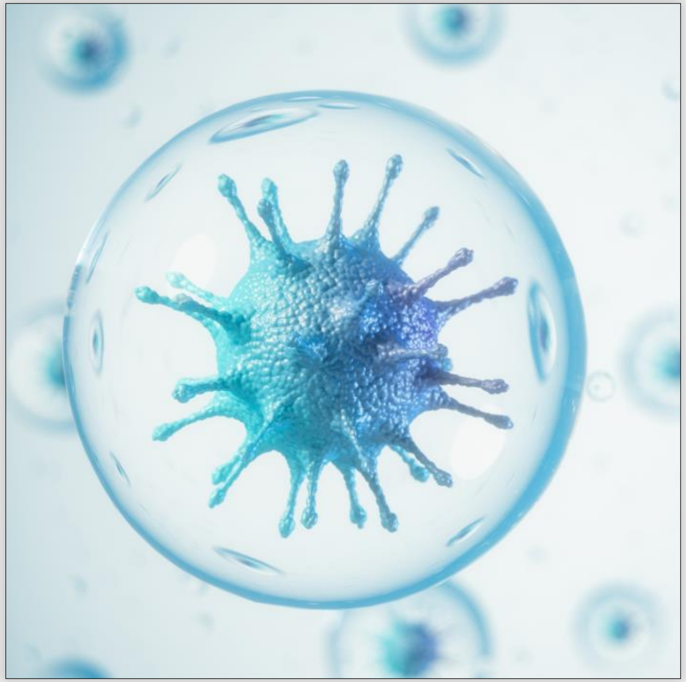
- Biofunctionalized imaging will allow for unlimited materials, composition and morphology testing
- Measure interactions in native environment and different solution chemistries to correlate with viability and surface adhesion studies





Fate and transport of SARS-CoV-2 within environmental reservoirs

Motivated by the potential for enteric transmission of COVID-19 through contaminated water sources



Primary questions:

- Does fecal transmission represent a significant form of environmental contamination?
- What environmental conditions contribute to viral stability?
- How might extreme weather events contribute to environmental fate and transport?

Expected outcome:

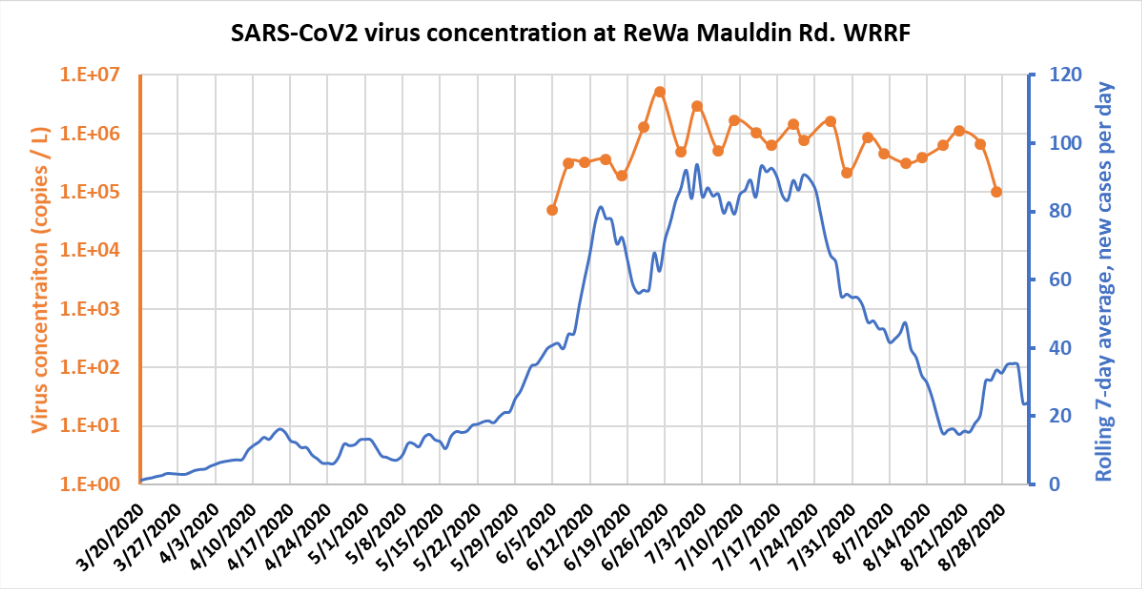
- Identify potential exposure scenarios from contaminated wastewater and groundwater and develop source tracking methodologies

Fate and transport of SARS-CoV-2 within environmental reservoirs

Monitoring in wastewater facilities

Key findings:

- SARS-CoV-2 detection in wastewater appears to be reflective of the local infected population
- Detection methods are not measuring viability of the virus
- Sequencing of virus detects mutational changes over time



Significance:

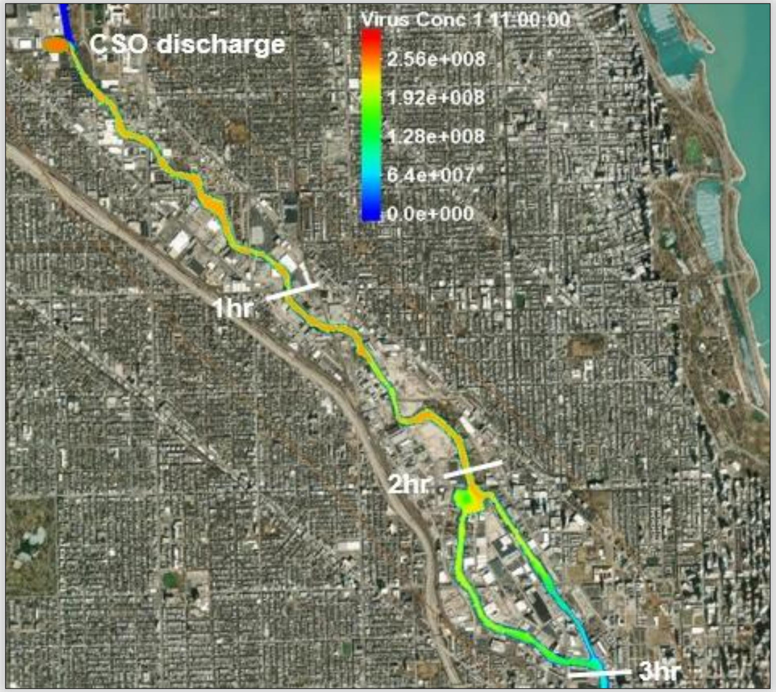
- Amount of infectious virus in wastewater is unknown
- Mutational rates have implications for vaccine development and efficacy

Fate and transport of SARS-CoV-2 within environmental reservoirs

Transport via Groundwater

Key Findings:

- Pathogens can seep from wastewater sources into groundwater and create a reservoir for transmission
- Modeled combined sewer overflow events from stormwater runoff include temperature effects on viability
- Travel time demonstrates that virus can reach recreational areas with a few hours of an event



Significance:

- Exposure risk can be estimated to populations with regional vulnerability based on infection rates, existing groundwater models and predicted weather events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