Development of an Aggressive-Air Activity-based Air Sampling System for Collection of Bioaerosols in Outdoor Areas

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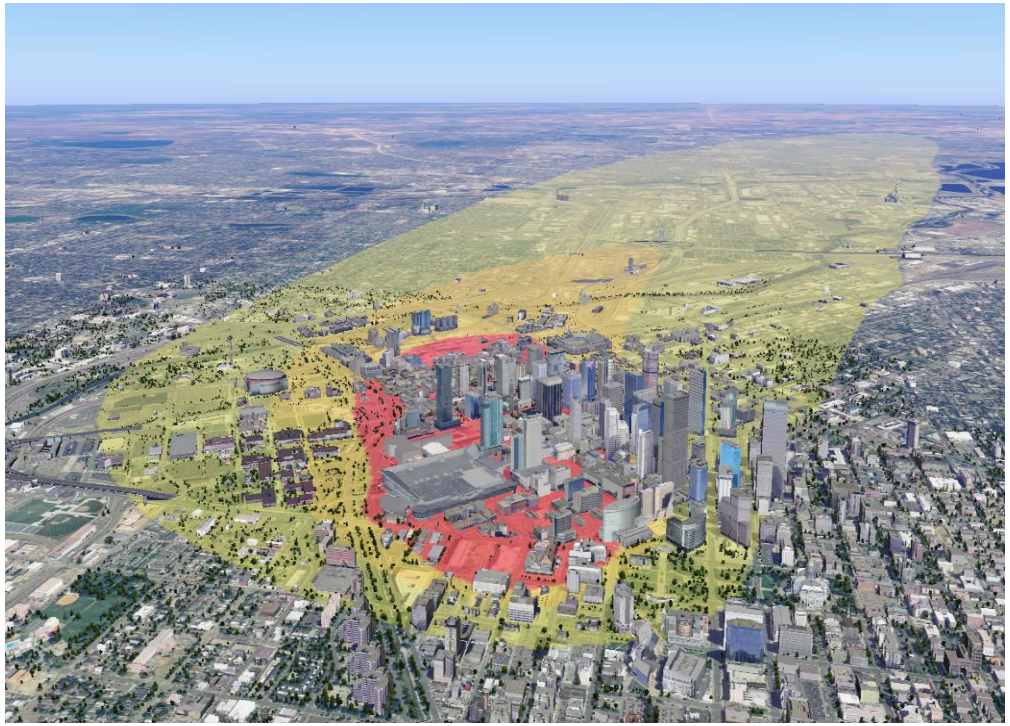
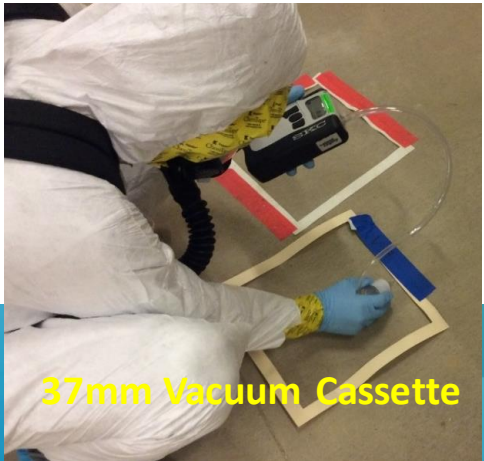
Consider a Wide-Area Biological Agent Incident



- How many samples (using traditional surface sampling methods) would need to be collected for
  1) Characterization
  2) Clearance
- How long would it take?

- Wide Area Contamination Challenges:
  - Large scale, Complex, Dynamic
- Representative sampling for wide area will require **large number of samples or sampling area**.
- There is **no universal sampling method** for characterizing contaminants because site characteristics vary widely.
- The sampling methods and equipment must be suited to the **specific sampling situation**.



Wide Area Sampling Method Development

Main sampling objectives are to

- Identify bio contaminants, including composition and characteristics
- Determine if there is an imminent or substantial threat to public/environment
- Develop remediation strategies
- Verify treatment goals or clean-up levels

Need to develop **representative sampling methods** that are **applicable to outdoor environment** for a wide area incident

Sampling methods need to be

- Efficient and repeatable
- Scalable to large area
- Widely-available
- Easy to use and process/analyze

Approaches

- Assessment of existing sampling methods for scale up
- **Assessment of innovative sampling approaches**

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Aggressive Air Sampling (AAS)

- Developed as a clearance sampling technique following indoor asbestos abatement
- Used indoors only at the completion of an asbestos removal project inside the abatement containment area

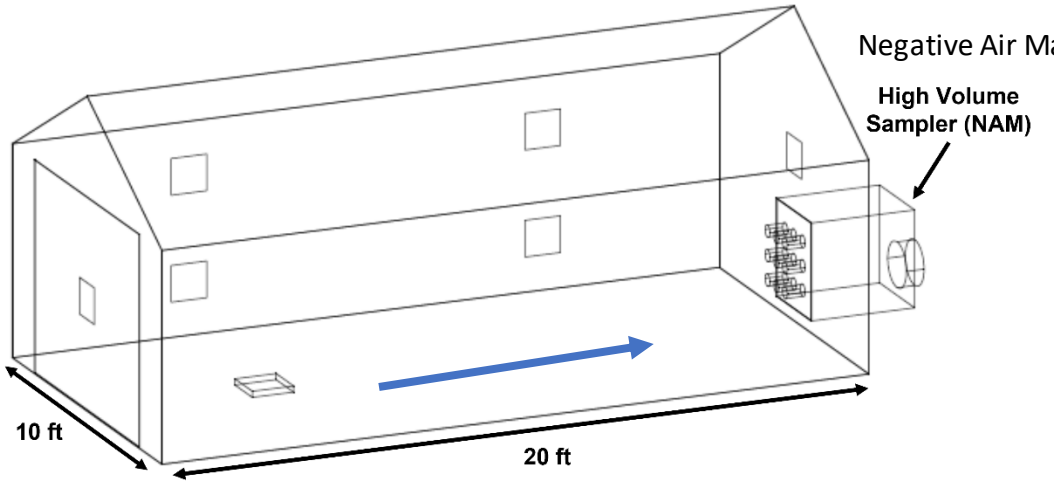
Activity-based Sampling (ABS)

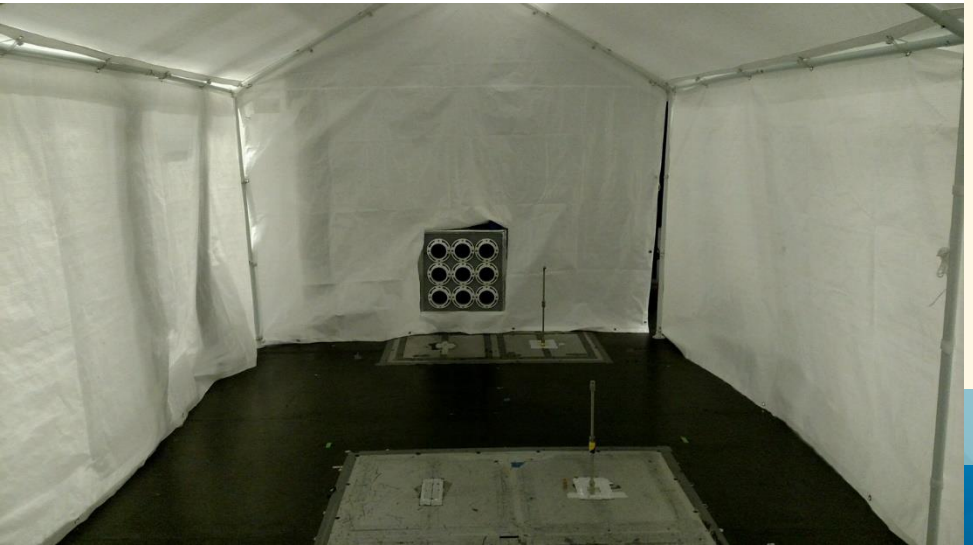
- Evaluate aggressive methods to reaerosolize spores from outdoor surfaces
  - complimentary to surface methods
- Fill outdoor sampling gaps and provide personal exposure data
  - inform mitigation and consequence management decisions
- Develop sampling protocol and determine appropriate uses in wide area biological incident

What is Activity-Based Sampling (ABS)?

- Developed as a tool to evaluate the potential for exposure to asbestos or other contaminants
- Task-based air sampling during “representative” activities
- Follows screening sampling during raking, leaf blowing, or other activities that can resuspend asbestos fibers from outdoor surfaces
- **Generic ABS or Screening Sampling** utilizes a rake to disturb the soil over a known area in conjunction with collection of air samples.
  - Used to evaluate potential for fiber release from soil over a large area
- **Site Specific ABS** utilizes activities based on land use
  - Used to simulate likely site activities to evaluate exposure
- **We have adapted for biological agent sampling (surrogate spores)**

Development of Activity-Based Aggressive-Air Contained Sampling System (AACeSS)





- Containment
- Aggressive resuspension methods
- Full volume air sampling
- Personal air sampling

AACeSS – Tent-Based Pilot-Scale

INITIAL WIND TUNNEL TESTS

- Conducted pilot-scale experiments in EPA aerosol wind tunnel
- Inoculated surface coupons with *Btk* and conducted AACeSS protocol
  - 2 surfaces: Concrete and Asphalt
  - 2 conditions: 30% (low) and 80% (high) relative humidity (RH)
  - Identify limitations (pros and cons) to using AACeSS in outdoor environment

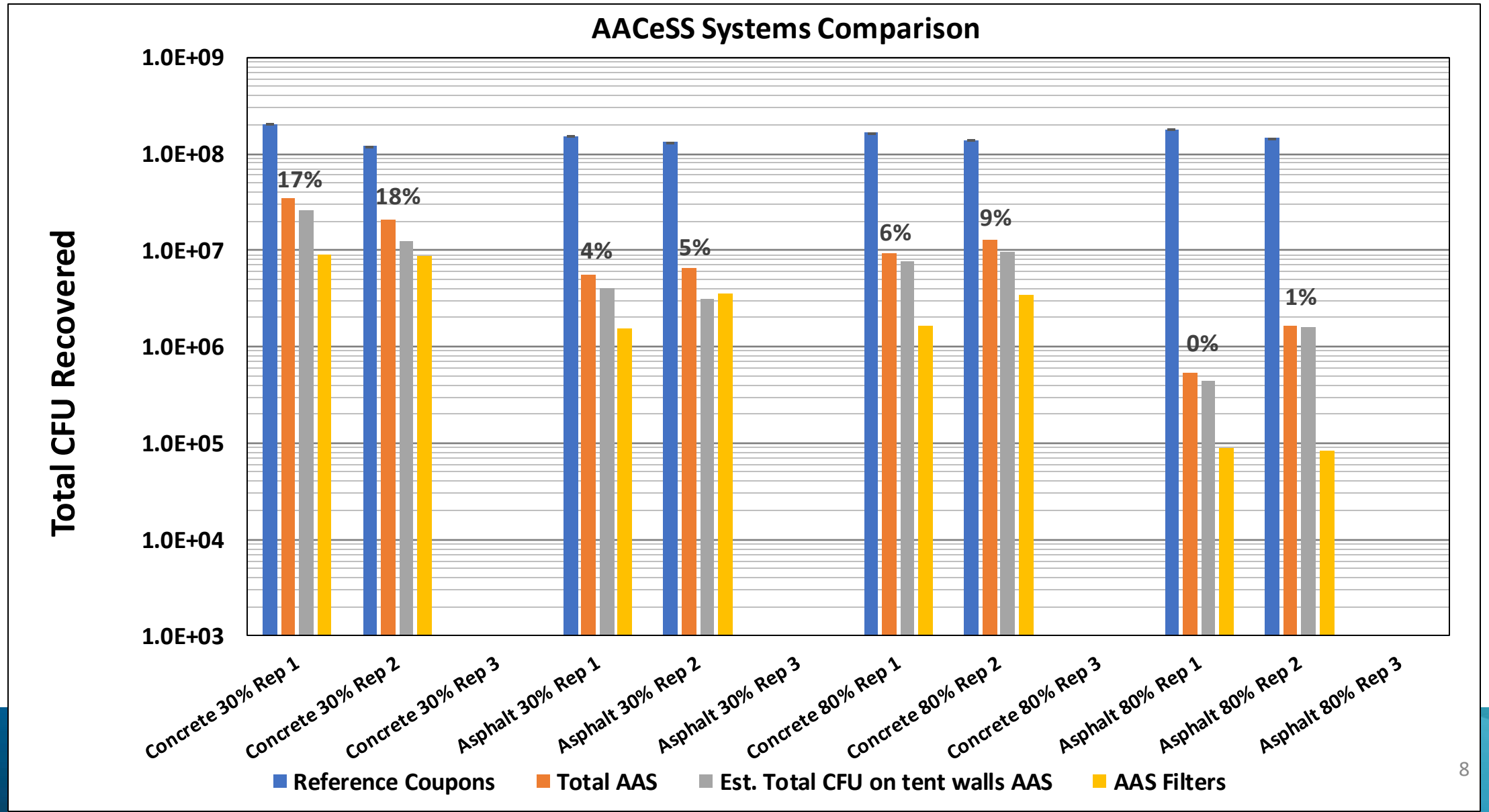
FINDINGS

Btk = Bacillus thuringiensis var. kurstaki

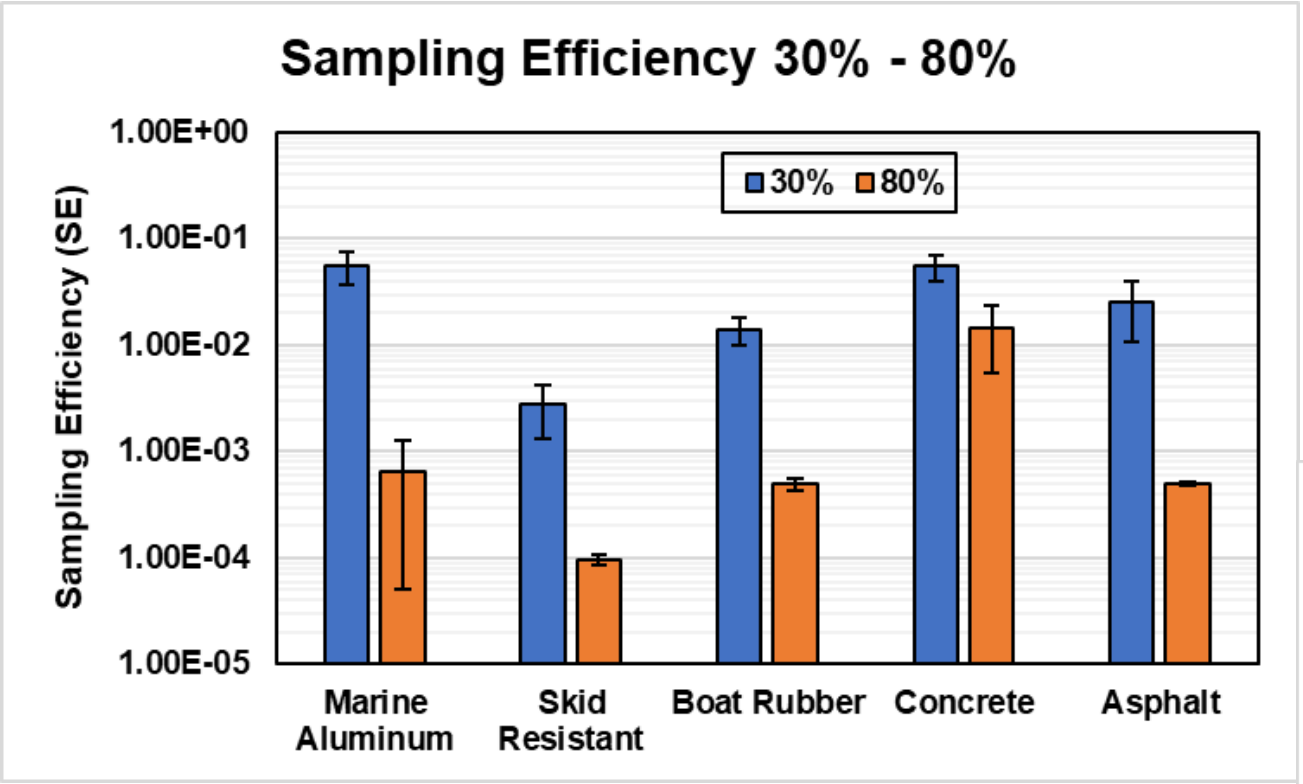
- Concrete AACeSS spore recovery order of magnitude higher than asphalt
- Reduction in spore resuspension and NAM collection with increasing RH
- NAM collection from asphalt at low RH and concrete at high RH are similar
- Low collection from asphalt at high RH
- Tent walls – good collector, but NAM better for low contamination and high RH
- Minimal settling of spores

AACeSS – Pilot-Scale Testing

Coupon BTK Deposition Range – Low E8 to High E7 colony forming units (CFU)

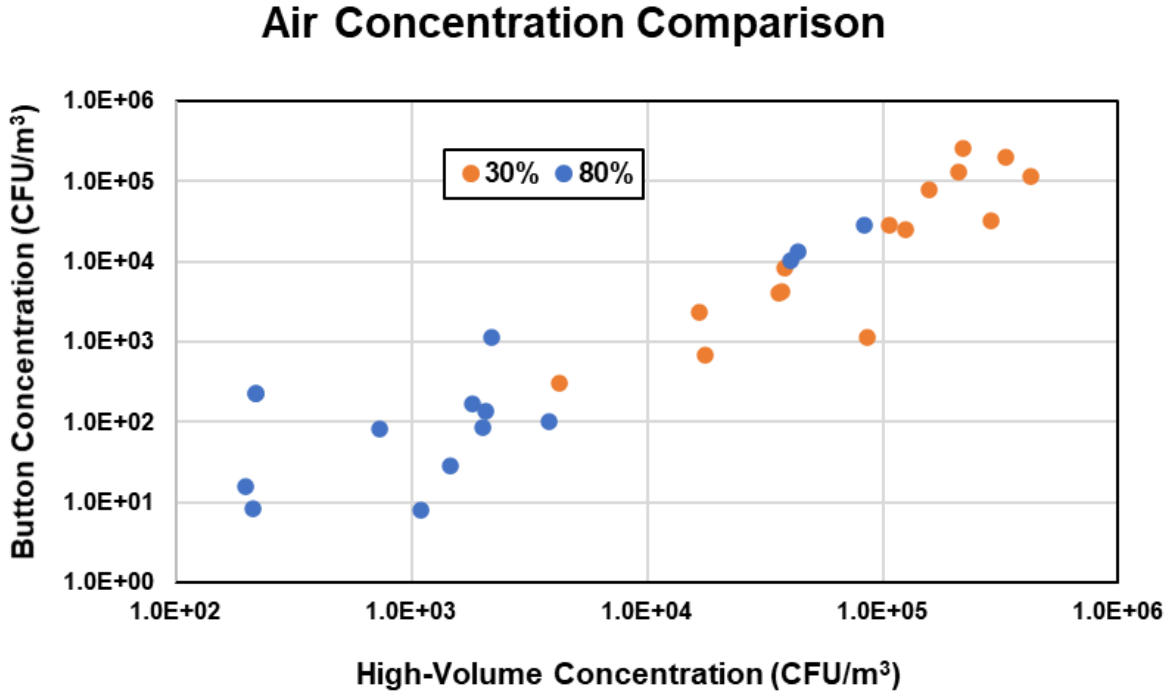


AACeSS – Pilot-Scale Testing



- Outdoor and US Coast Guard (USCG) vessel surfaces
- Reduced resuspension and collection at higher RH
- AACeSS spore collection highest from concrete for low and high RH

- Positive correlation between AACeSS measurements (CFU/m^3) and the personal Button samples.
- Pearson Correlation Coeff (r = 0.7693) and p-value <0.0001

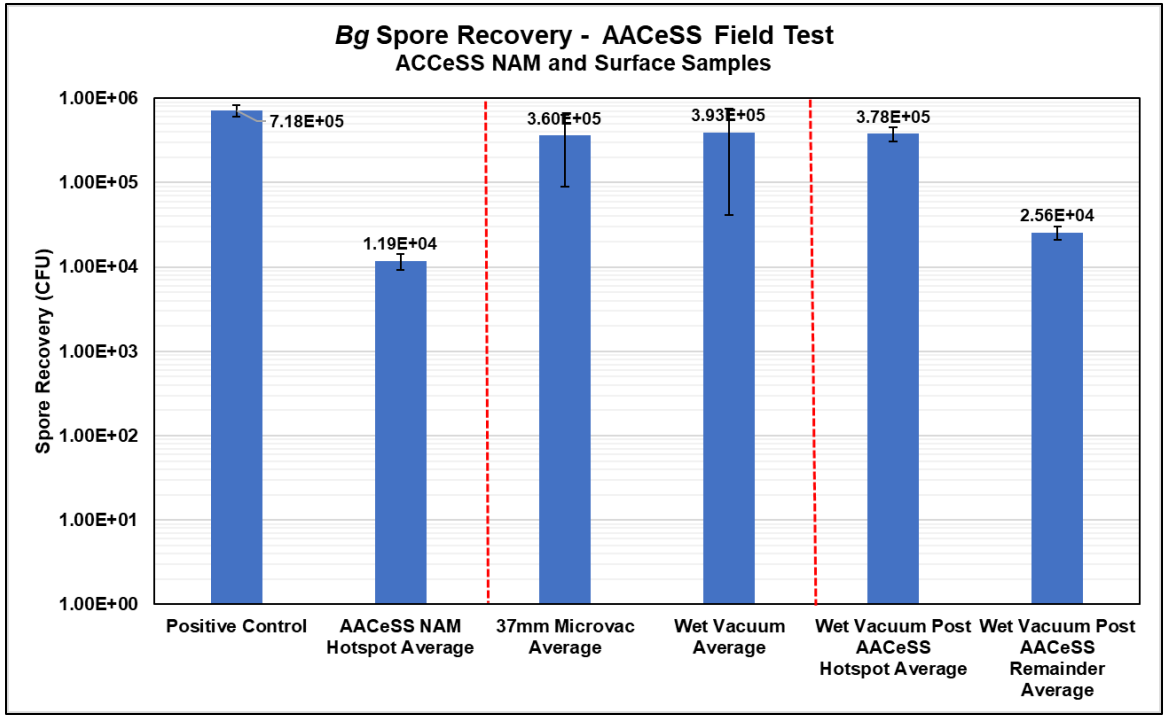


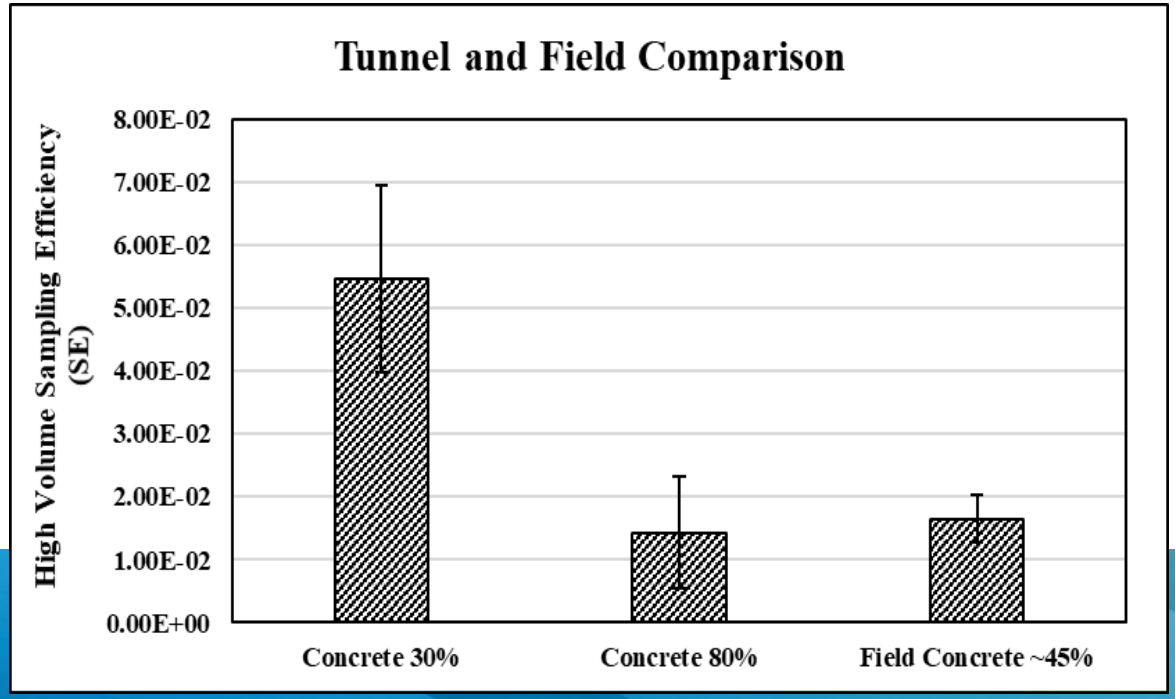
ACCeSS – Field Tests

- Compare surface sampling and AACeSS
  - Identify limitations and document lessons learned
  - Determine steps for AACeSS optimization
- Inoculate “hot spots” on concrete
- Triplicate AACeSS tests using “garage” tent and modified sampling system with negative air machine (NAM)
- Surface Samples
  - Triplicate microvac and wet vacuum tests
- Personal Button Samplers on leaf blower operator for each test
- Dry Filter Unit (DFU) and wet vacuum sample outside tent to assess breach in containment

AACeSS Field Tests

- Used *Bg* for outdoor field tests due to background interference
- AACeSS (air sample) recovery order of magnitude lower than wet vacuum (surface) sample as expected – recovery ~ 2%
- Field results comparable to Pilot-scale, so field AACeSS sampling potential is good





After Field Test: Take a Step Back to Think

- What are advantages for AACeSS in terms of cost, manpower, data collected, etc?
- Tent-based AACeSS system is feasible, provides efficient sampling and adequate containment
- Large coverage than surface sampling, can use for multiple surfaces (concrete, asphalt, grass)
- Logistical issues are limiting for easy deployment
- **A "mobile" solution that is more easily deployed is desired**
- Same leaf blower AAS and NAM sampling apparatus
- Can we obtain resuspension and capture of spores from surface, cover a larger area, and provide containment to eliminate the need for a tent?

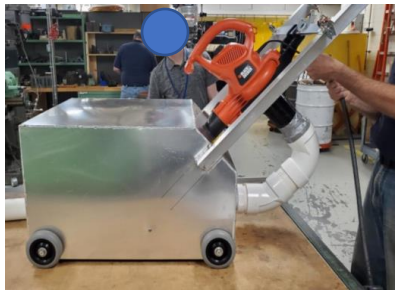
AACeSS Evolution Timeline

1.0 Tent-based to 2.0 Mobile System

AACeSS 1.0

AACeSS 1.0 Field Test

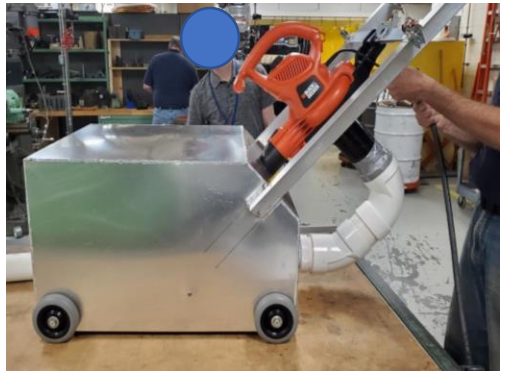
Birth of AACeSS 2.0



AACeSS 2.0 Optimization/Field Test

AACeSS 2.0 – Mobile Sampler

- Conducted pilot-scale tests with AACeSS 2.0 cart system
  - Two versions tested
    1. Leaf Blower Recirculated Sampler – single inline filter
    2. Leaf Blower Aggressive Air with Large NAM Sampler – Filter plate with 9 filters
  - Inoculation of *Bg* (1E7 CFU/coupon) onto 12” X 12” concrete coupons



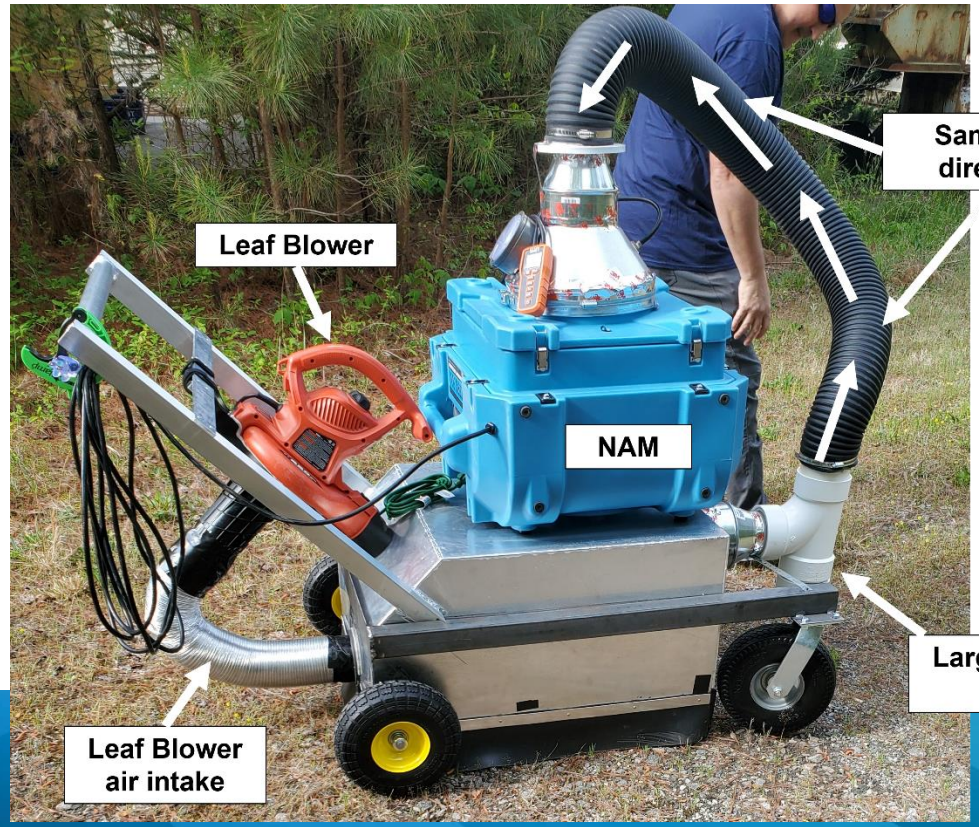
Mobile AACeSS 2.0

Optimization Summary

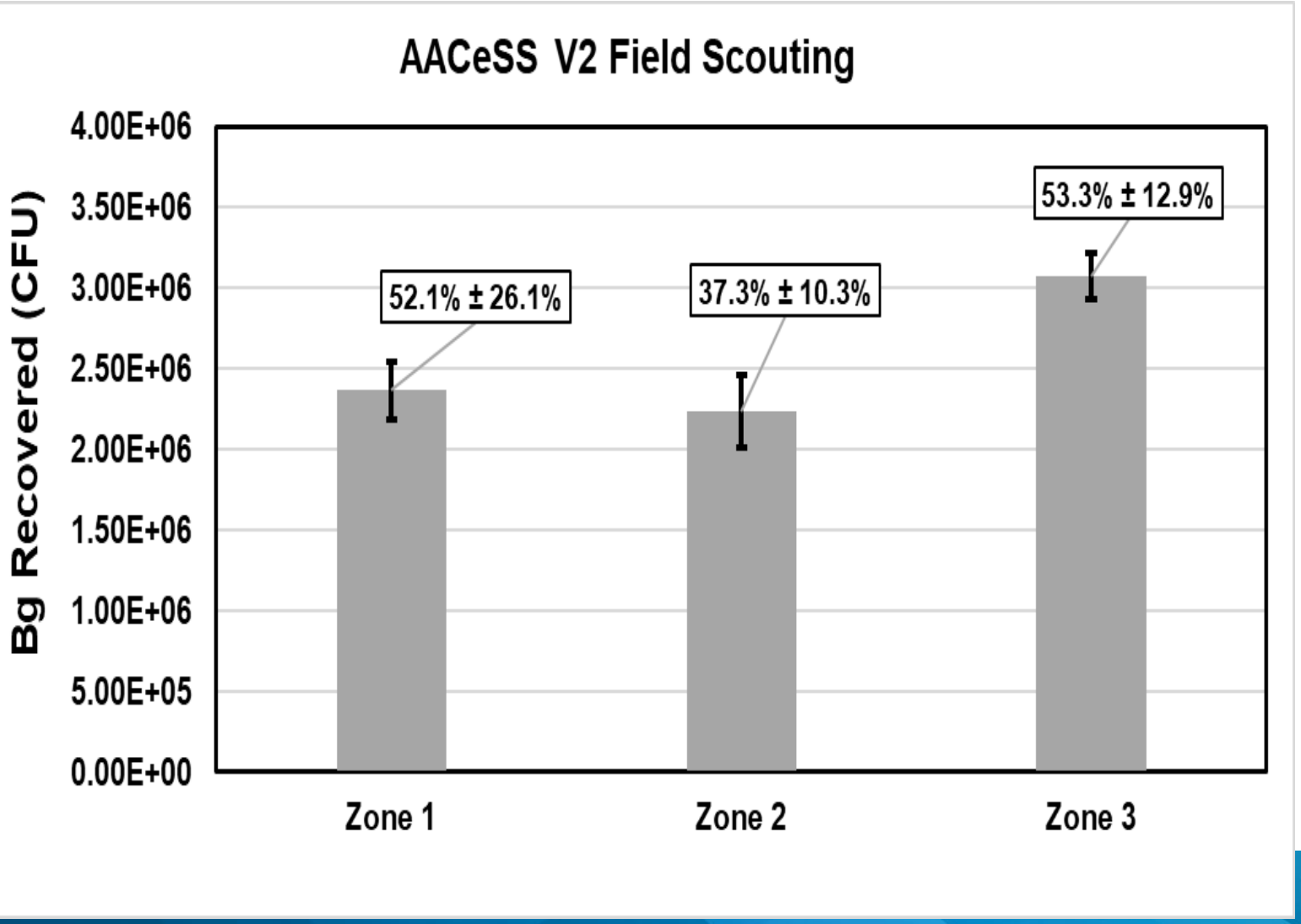
- Increased mobility
- Increased collection efficiency
- Decreased variation in sampling collection
- Simplified collection by using smaller NAM and filter plate
- Vertical duct configuration into NAM will likely reduce large particle load on filters
  - *Important for outdoors*
- Keep AACeSS 2.0 under negative pressure
  - Added recirculation loop by pulling leaf blower air from inside sampling box
  - Higher NAM flow should ensure negative pressure – blowing vs vacuuming balance
- Lowered skirt for better containment
- Incorporate new plate with filter holder O-rings for better seal around filters
- Added large particle/debris collection cup
- Incorporated improved cart “field decon”

Mobile AACeSS Field Tests – Spring 2022

- *Bg* inoculation onto concrete
- Used generator for power
- Tested mobile cart over triplicate concrete 200 ft^2 areas
- Offroad tires and new filter plate holder



Mobile AACeSS Field Tests – Spring 2022



AnCOR Wide Area Demo Sampling

- 29 total samples collected (including field blanks) – (5) background, (11) pre-decon, (9) post-decon
- Sampled asphalt, concrete, grass, gravel
- High debris collected on grass
- Average cart sample is 30-45 min – turnaround time
- Actual sampling time is 5-10 min for 400 ft^2 sample, depending on surface type
- Field decon procedure (wearing PPE) takes 15-20 min
- Having multiple pre-loaded AACeSS carts would minimize turnaround time
- Recommend two-person sampling team and two-person sample processing/field decon team
- Ideal field decon would use vaporous hydrogen peroxide (VHP)

Acknowledgements & References

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QUESTIONS

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