In-ROOM HEPA AIR PURIFIER DEPOLYMENT for PM CONTROL IN OCCUPIED SCHOOLS CLASSROOMS

"TRUST but VERIFY"

Mark Hernandez & Friends

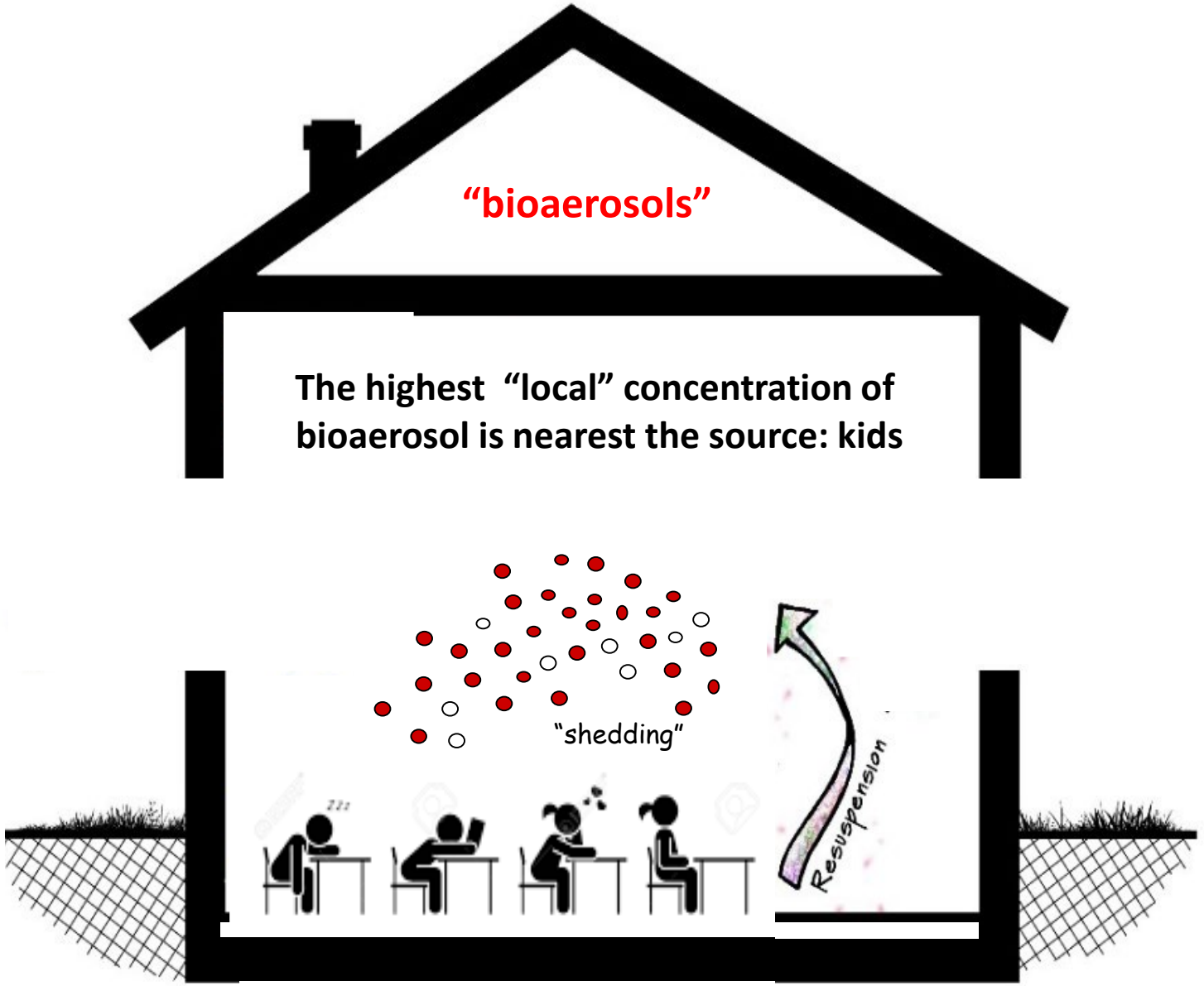
Environmental Engineering
UNIVERSITY OF COLORADO BOULDER

Be Boulder.

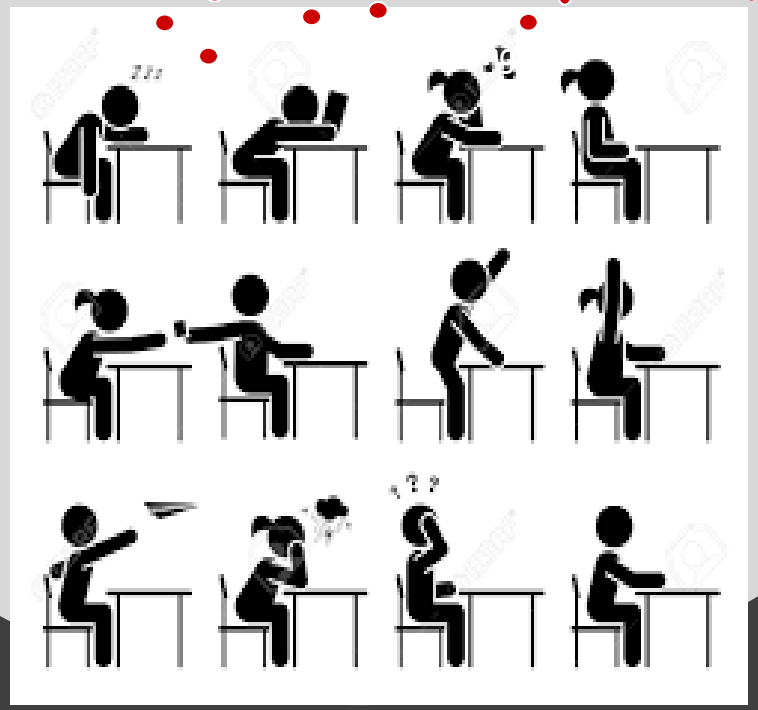
Be Boulder.

Fact : all people***, ill or not,*** shed
and resuspend microbes
in their local indoor environment
(AKA: bioaerosols)

"shedding"
& resuspension



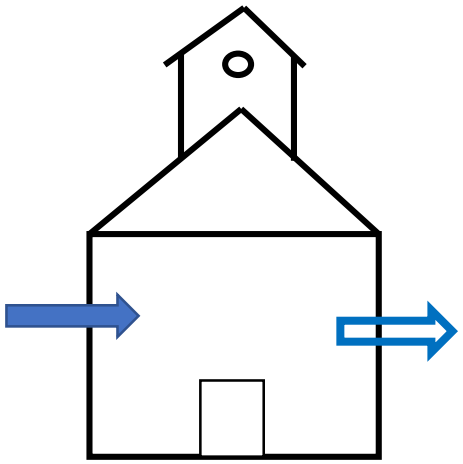
From a practical facilities perspective



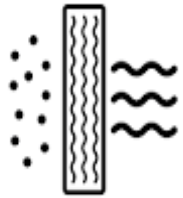
Reducing indoor aerosol load (PM)
= reducing exposure risk !

The product of built environment practices can significantly reduce exposure (risk)

Conventional
FACILITIES & INFRASTRUCTURE

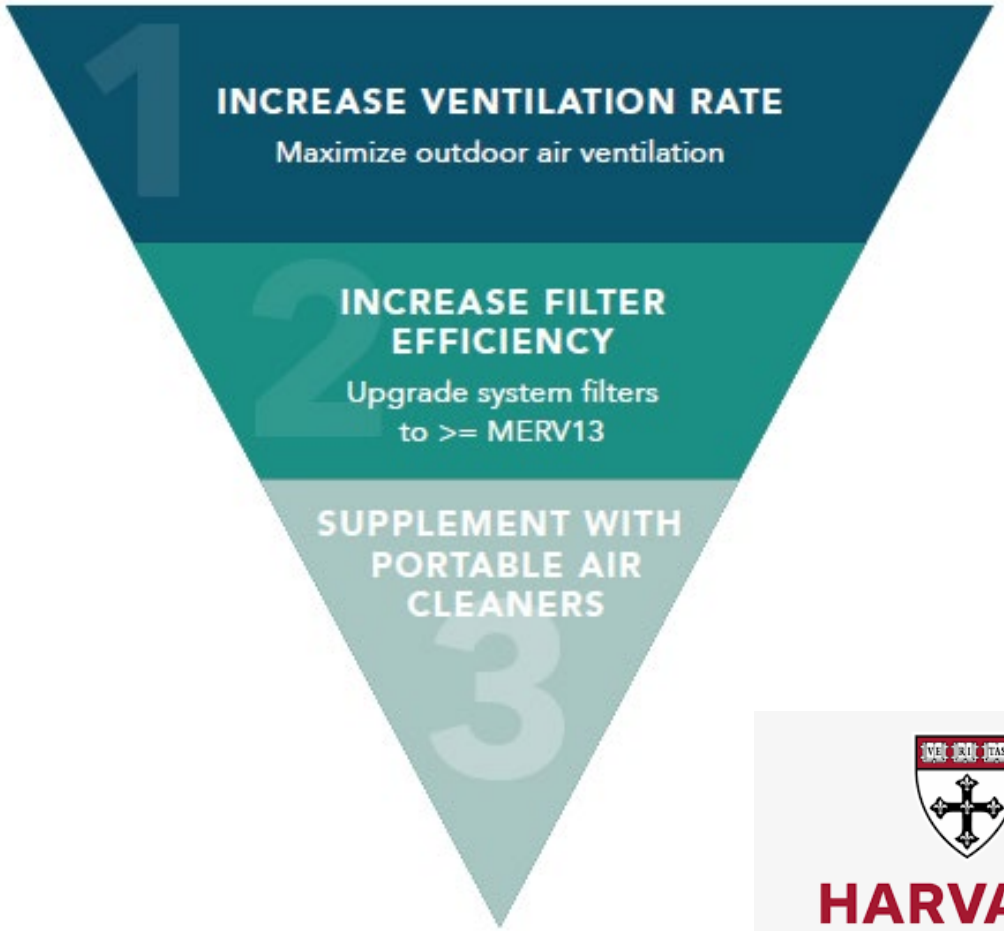


ventilation ↑



enhanced filtration

Prioritization of Engineering Controls to Reduce Long-Range Airborne Transmission



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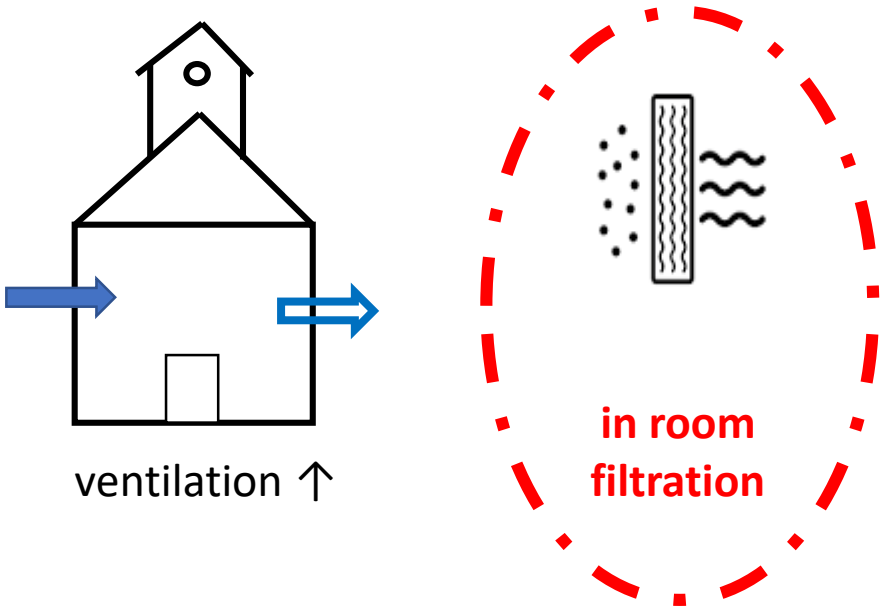
FOCUS: demonstrate effectiveness of flexible engineering controls that *supplements* ventilation with high efficiency filtration nearest the PM source

FACILITIES / INFRASTRUCTURE



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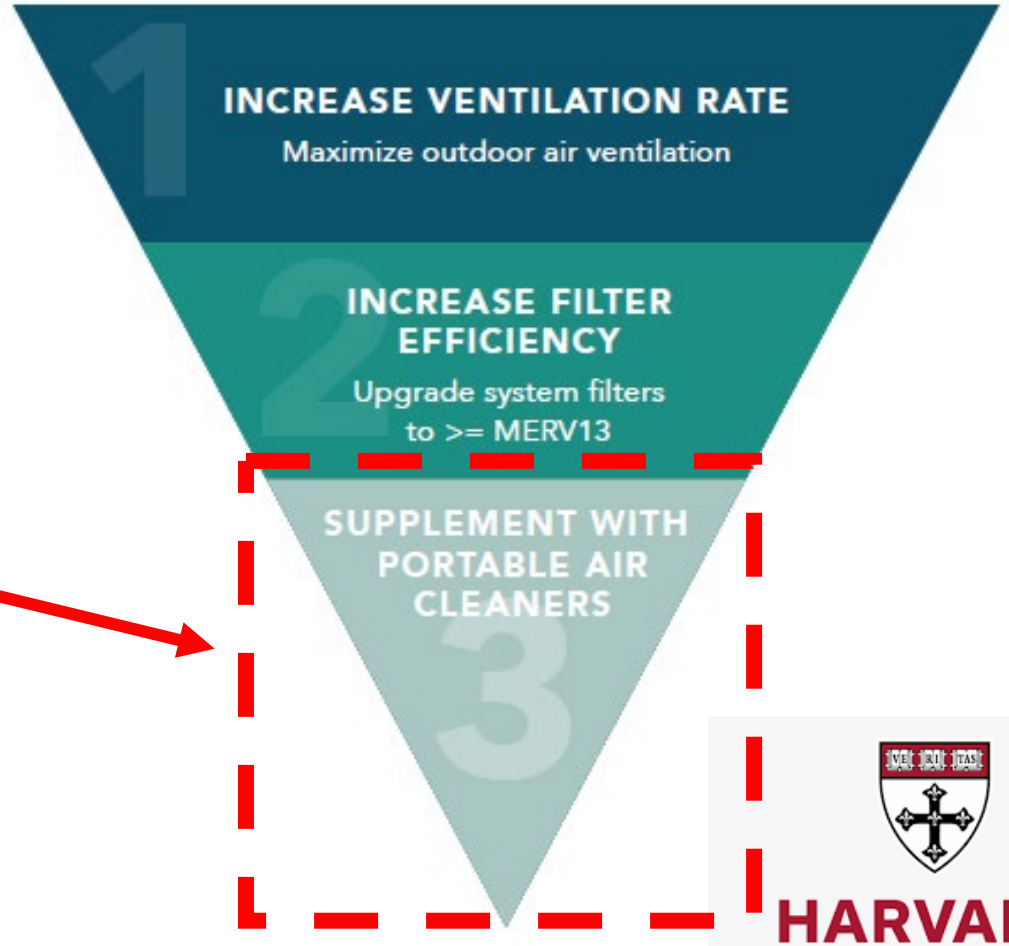

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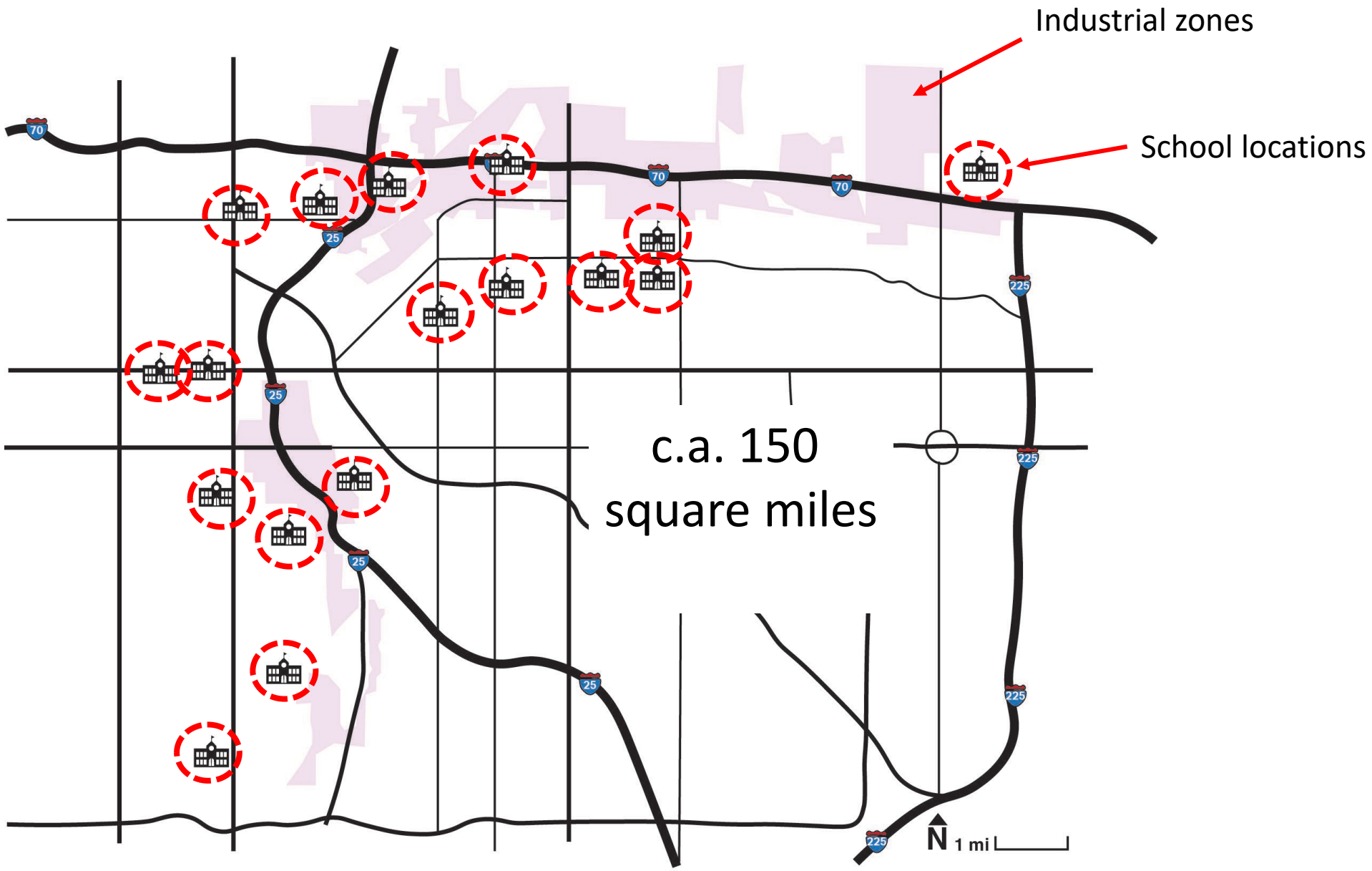
HEPA AIR PURIFIER EFFECTIVENESS DEMONSTRATION

Started with (*in situ*): Ventilation Survey

20 (19) Elementary Schools

stratified
socioeconomic
backgrounds
(6 bilingual schools)

bordering
commercial
suburban
industrial zones &
interstate highways

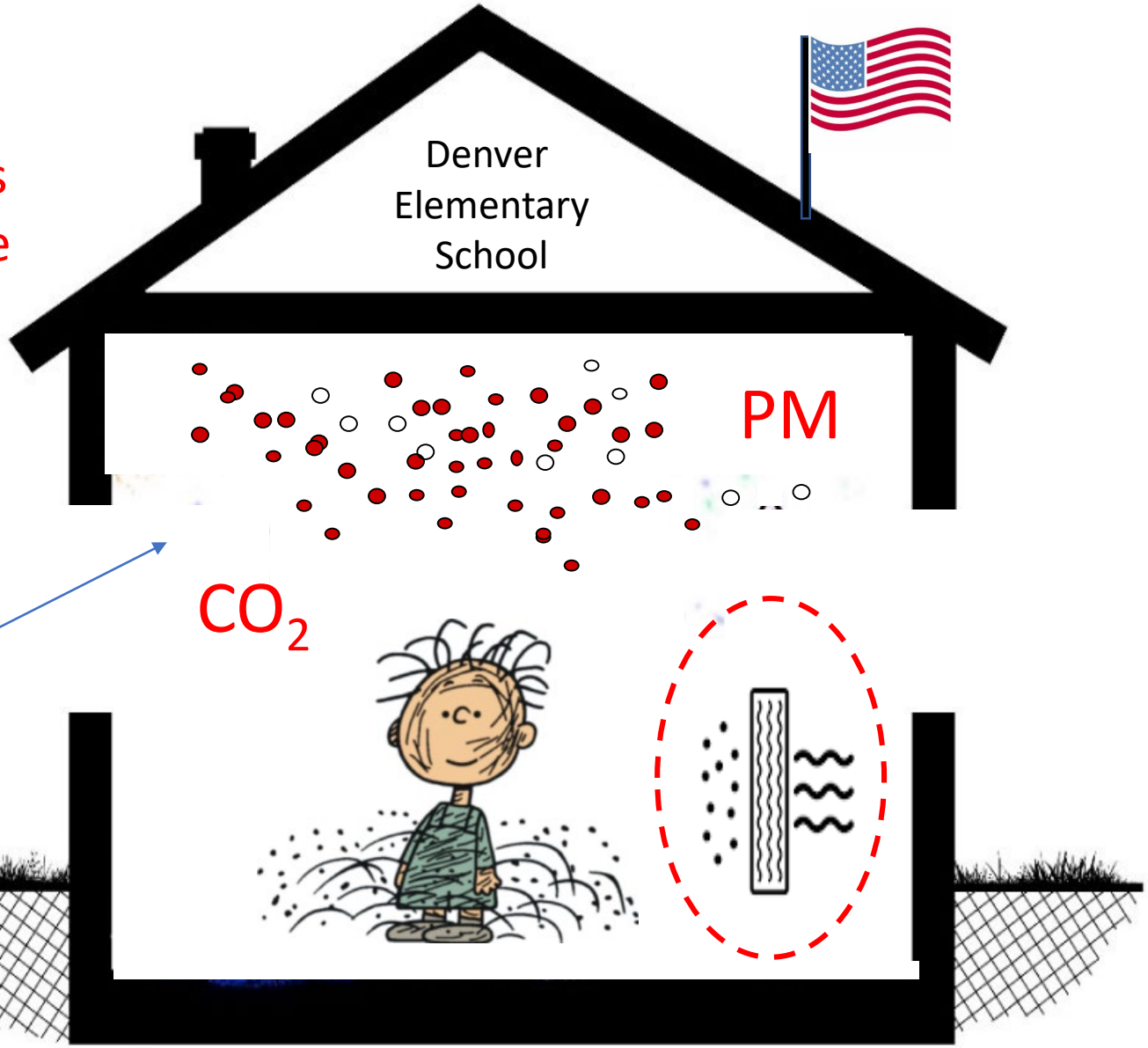


while we "trust" HEPA filters can work

THE POINT: determine *actual* filtration effects by continuous measurements that can expose patterns of CO_2 & PM departures

wall-mounted composite sensors (near return)

mobile bioaerosol sensor (aerosol cytometer)



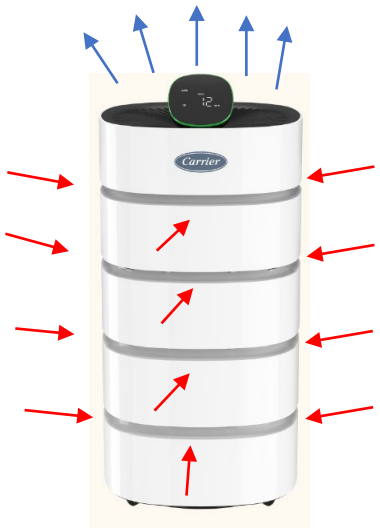
Longitudinal Observations → Spring 2021

"little kids": first to come back; last to vaccinate

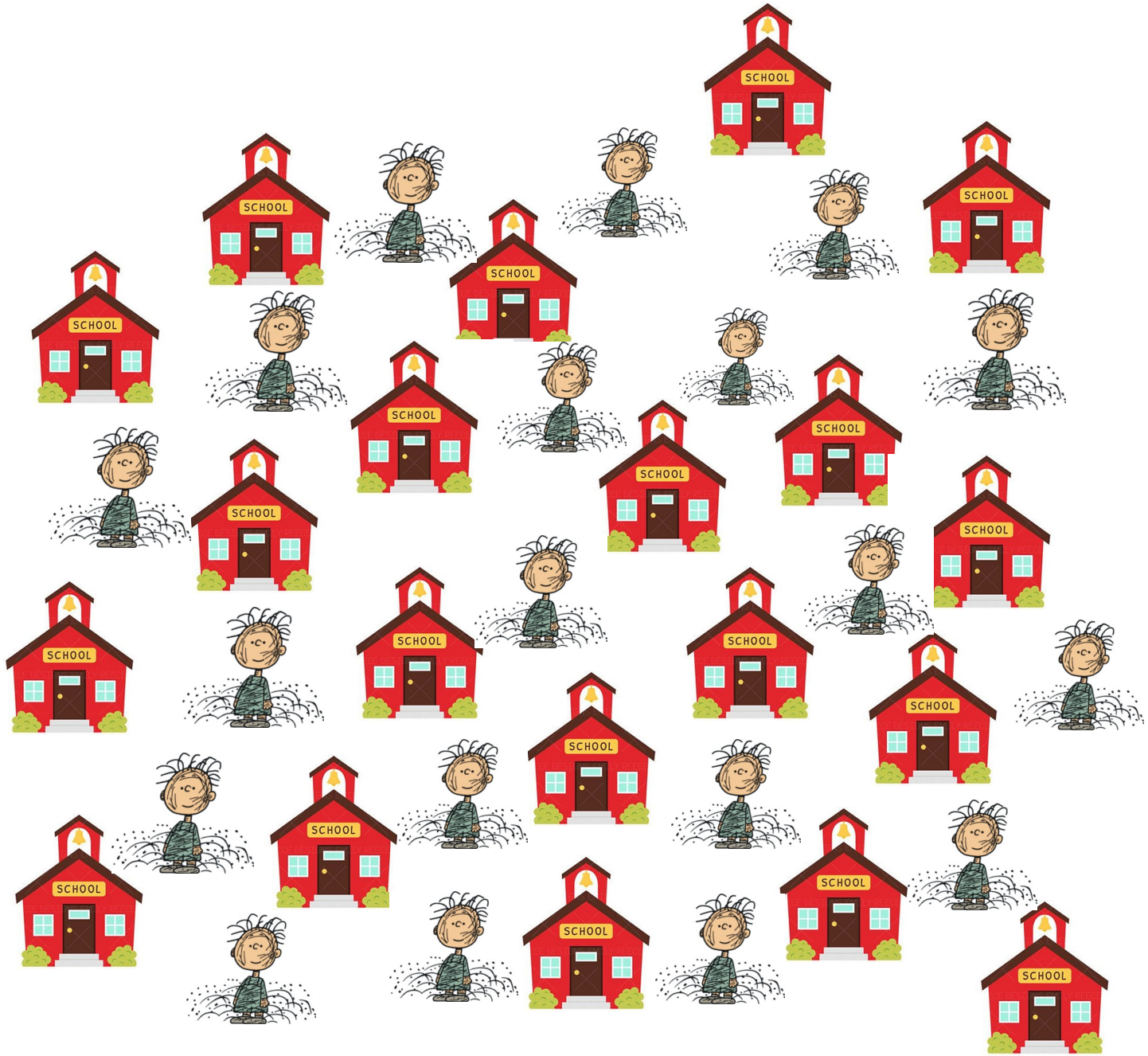
Survey design

Randomized Control Trial: (n=79 classrooms)
of in-room air purifier deployments

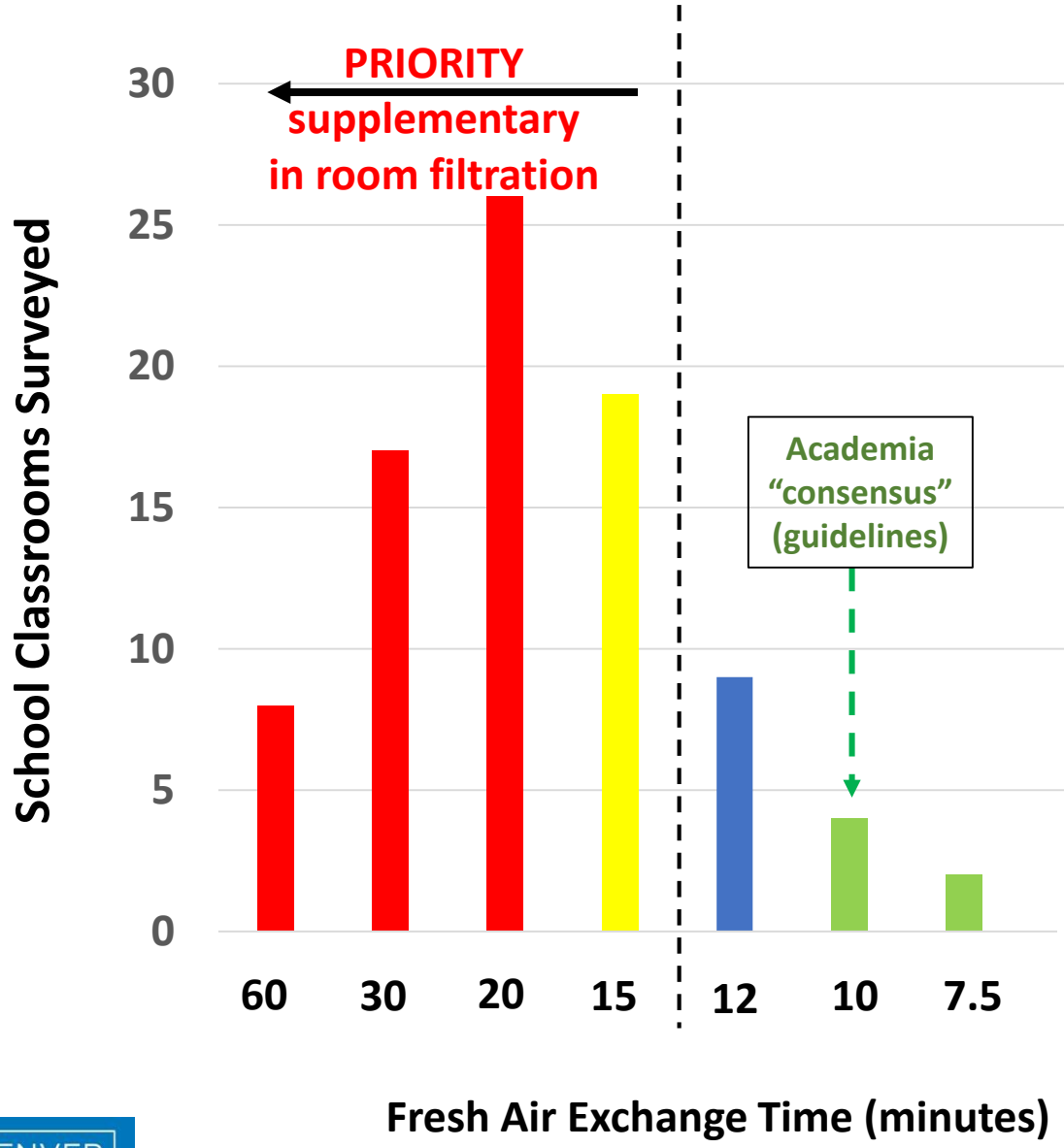
New generation of radial intake
HEPA air (filter) purifiers



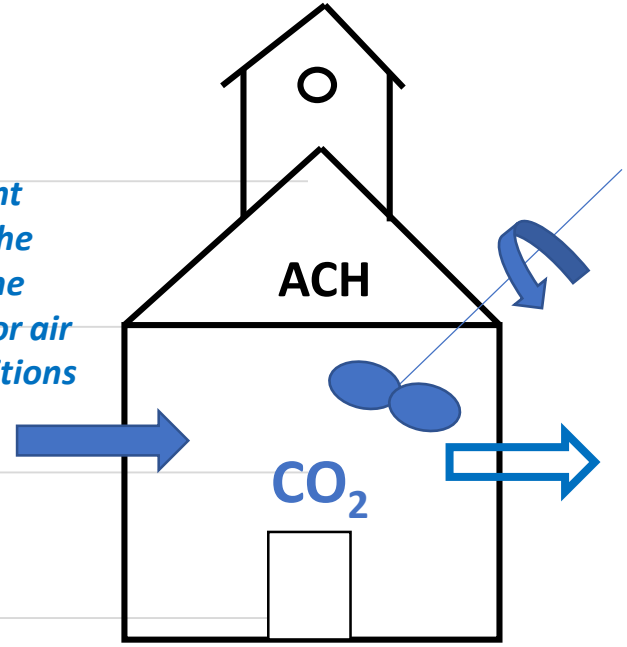
in situ flow rate (CADR)
determined by instructional
"acoustic tolerance"
(average was 2 x c.a. ∑ 500 cfm)



Strategy for Staged Air Purifier Installations



The average amount of time to replace the entire indoor volume with "fresh" outdoor air in well-mixed conditions



Translated to minutes

TARGET IS AT LEAST 5 TOTAL AIR CHANGES PER HOUR

10 min	*Ideal (6 ACH)*
12 min	*Excellent (5-6 ACH)*
15 min	*Good (4-5 ACH)*
20 min	*Bare minimum (3-4)*
30 min	*Low (<3 ACH)*

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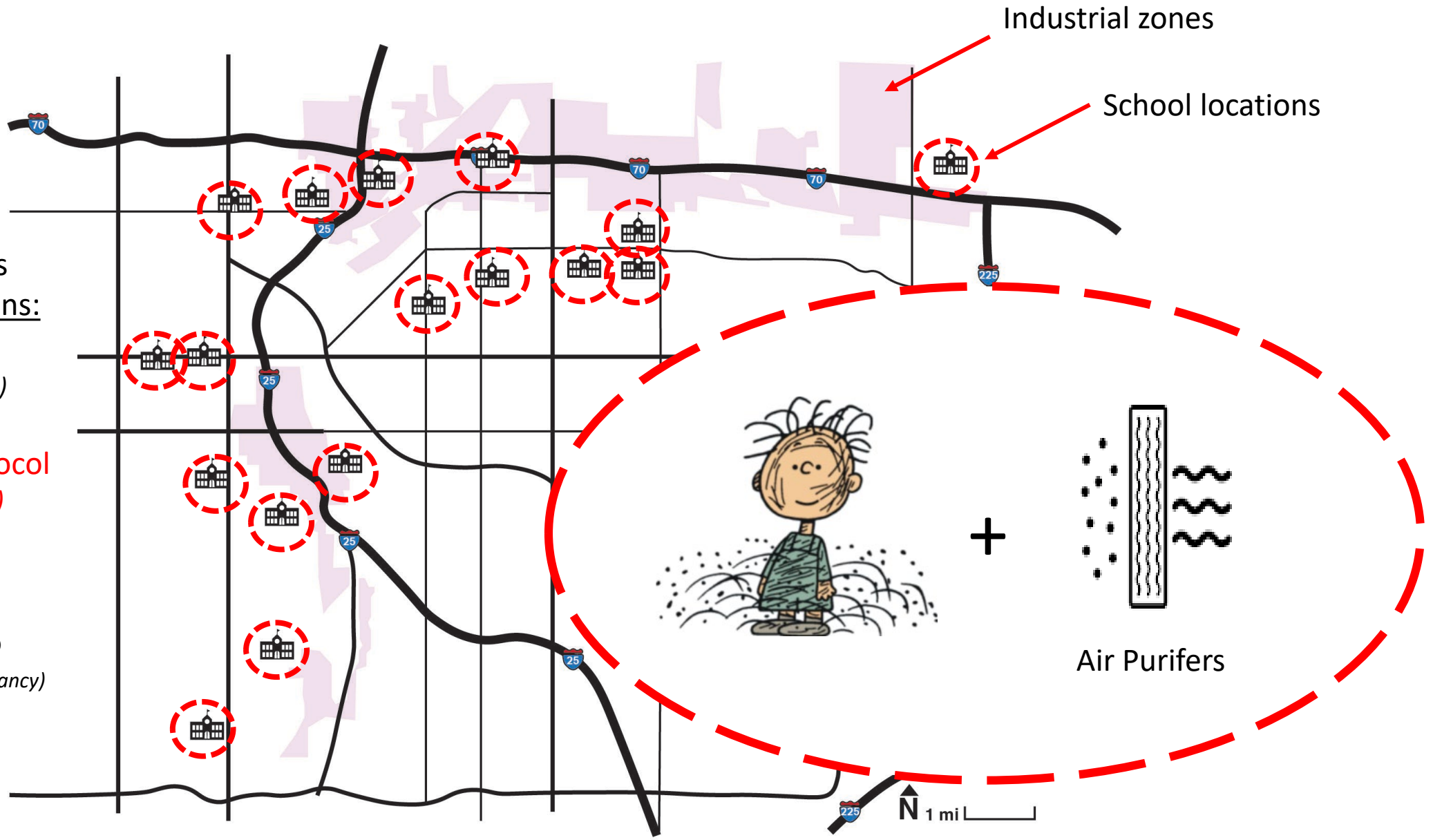
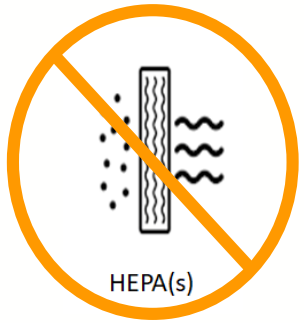
HEPA AIR PURIFIER EFFECTIVENESS DEMONSTRATION

(OCCUPIED k-5 Classrooms)

PM Reduction Trials
performance conditions:

- fully occupied *(c.a. 25)*
- COVID building protocol
  (classroom doors open)
- *As-is* ventilation
- 3 HEPA : 1 control ratio
  (identical grade levels & occupancy)





Max [PM $_{10-2}$] =
3 x 10^4 #/m^3
(per occupant)

Min [PM $_{10-2}$] =
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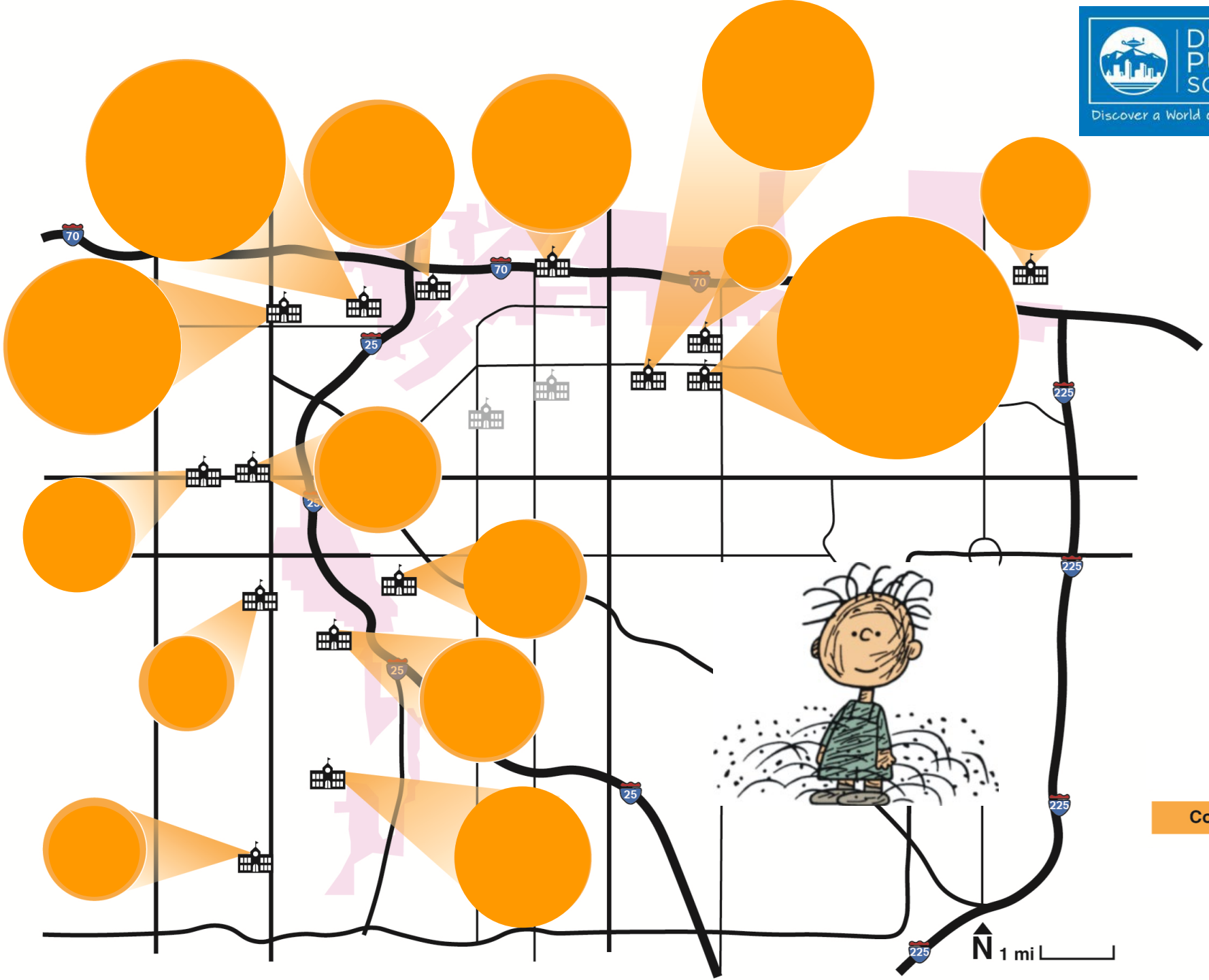
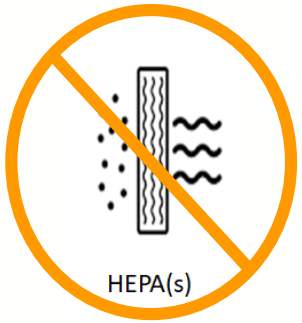
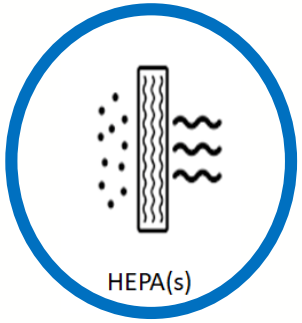


Control





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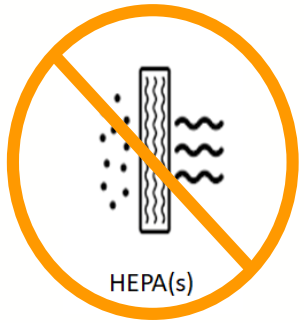
HEPA

Control

N 1 mi



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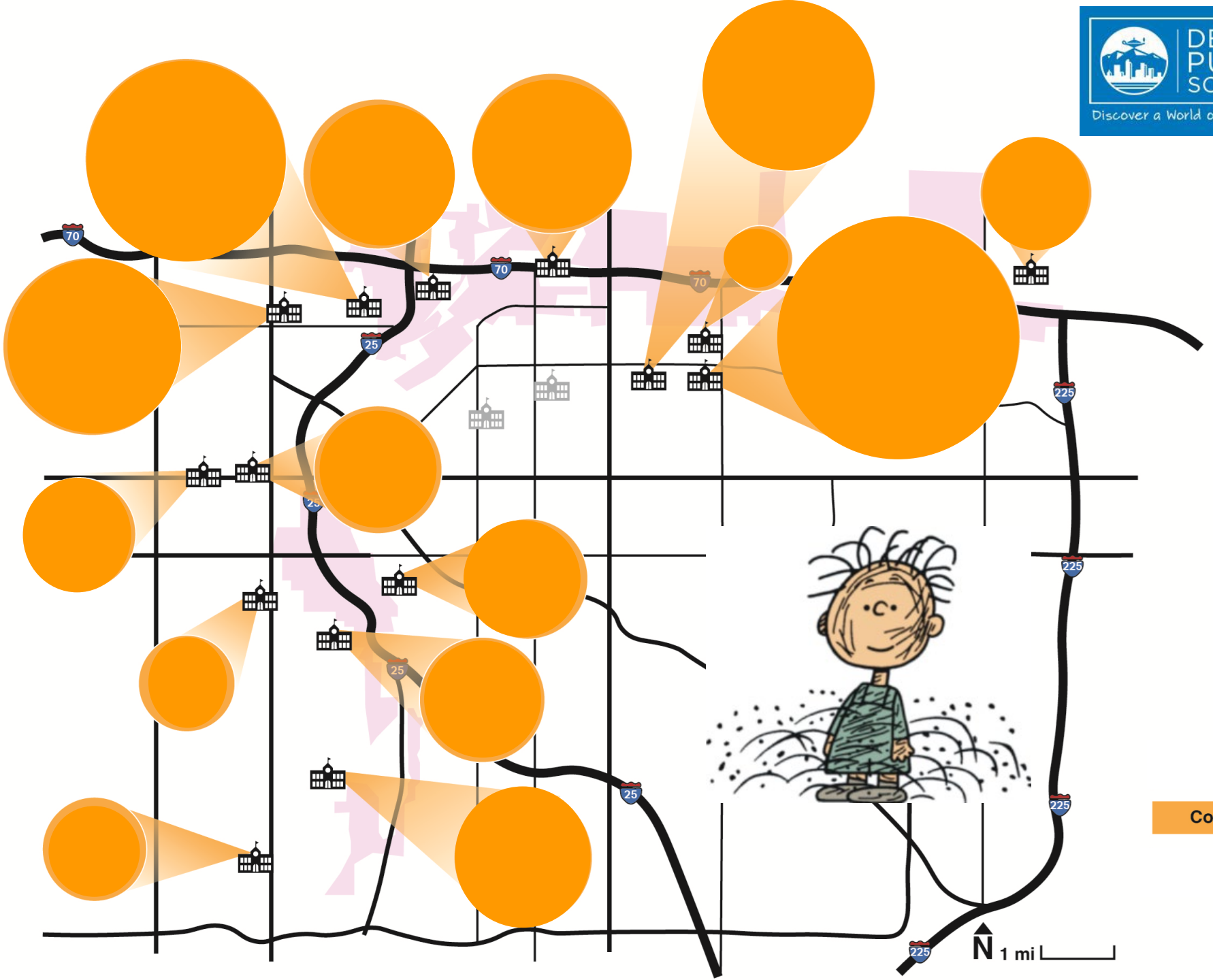
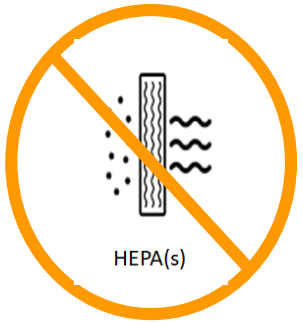


Control



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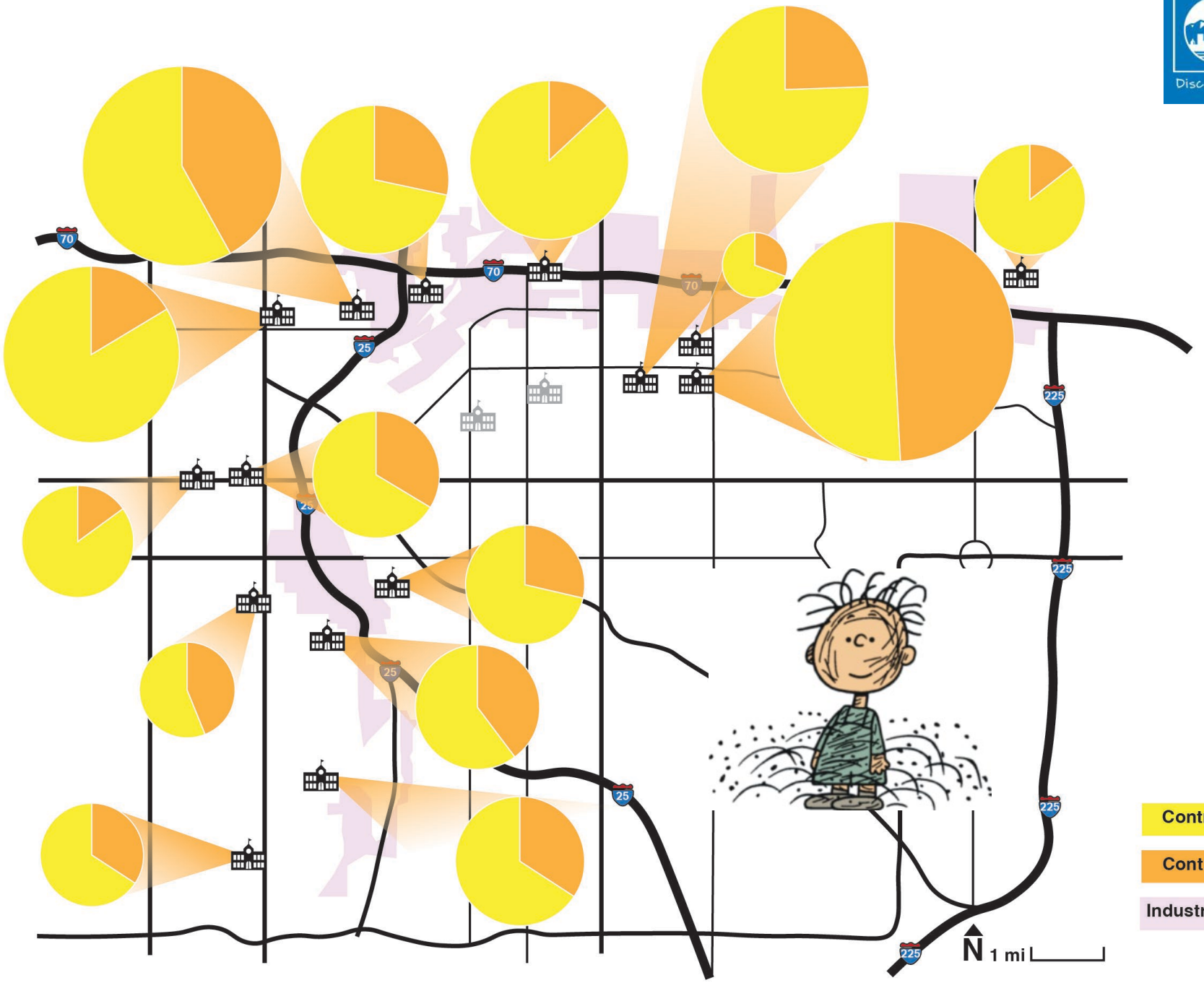

Control FL

Control nFL

Industrial Zone

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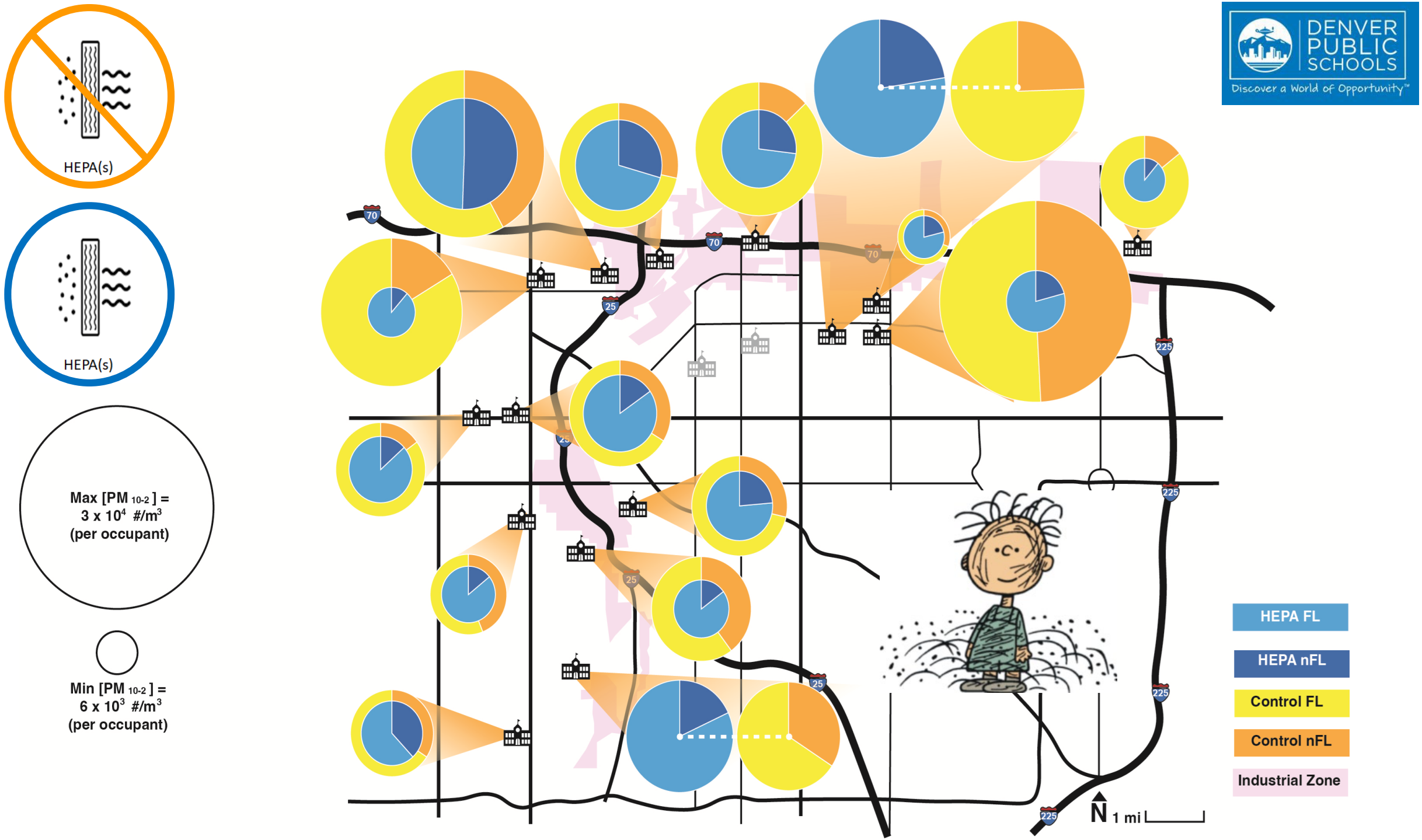
HEPA(s)
HEPA(s)
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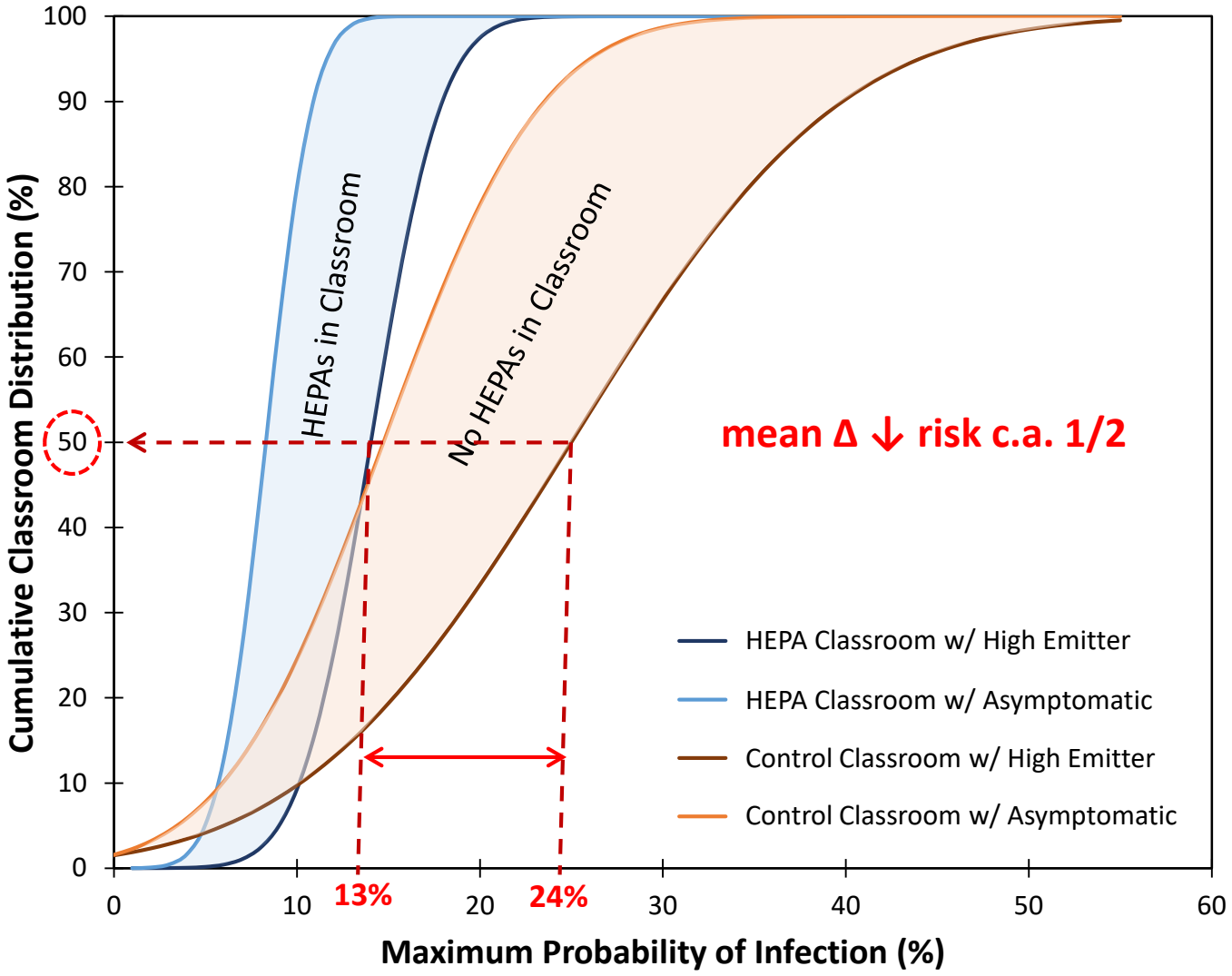
HEPA FL
HEPA nFL
Control FL
Control nFL
Industrial Zone
N
1 mi

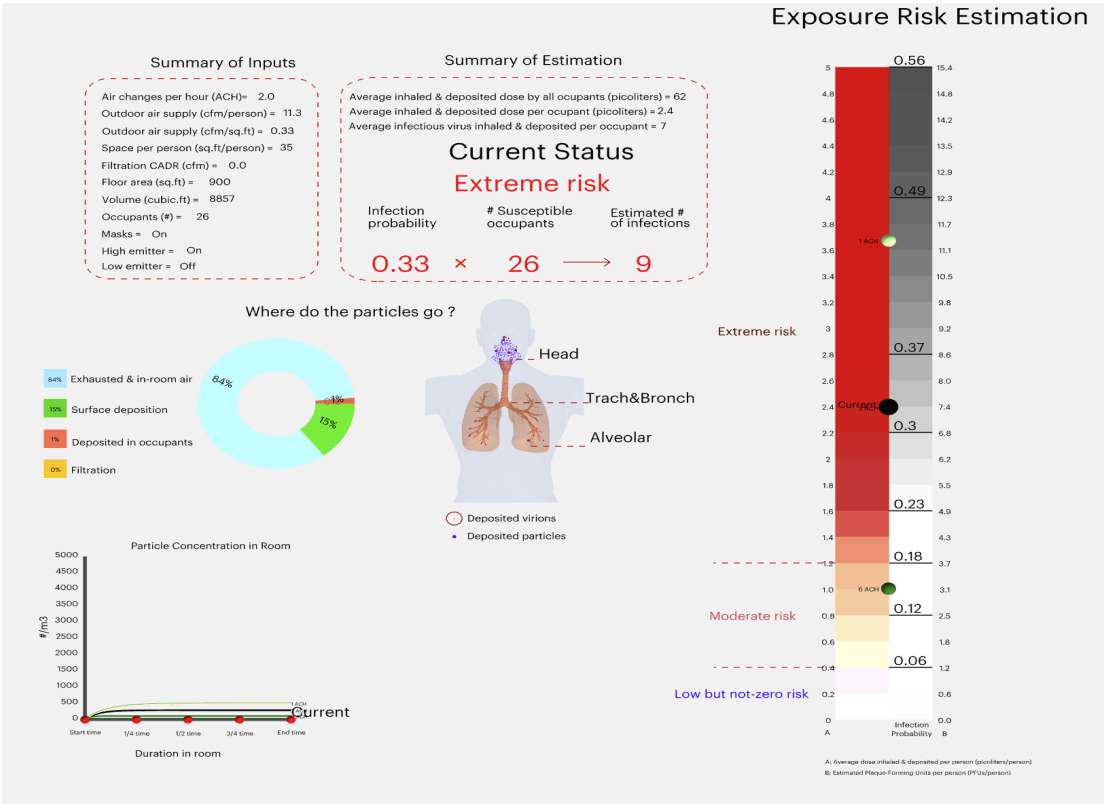
How can this translate toward estimating risk reduction *in-situ* ?:

SAFEAIRSPACES COVID-19 *Relative* Risk Estimator *with measured inputs*

(maximum probability of infection adapting Wells-Riley, mixing regime and other common assumptions)



https://safeairspaces.com/safeairspaces-estimator



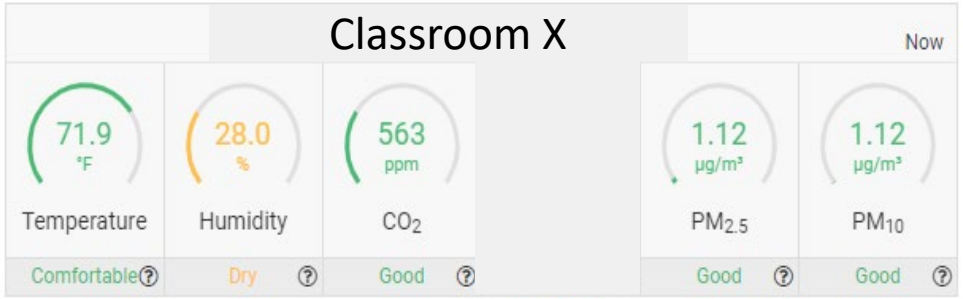
Measured inputs: volume, occupancy, CADR, ACH

In the Post-CoVID era of school infrastructure investments (ESSER, ARP, etc.)

While we know engineering controls "can" work, its does not mean they do !

"Trust by Verify !"

Monitoring is a fraction of capital improvement costs;
performance verification is important now and in the future !



Monitoring benefits reach well beyond the CoVID era ! (including co-morbidity control)

smoke, allergens, hypersensitivity triggers, urban pollution

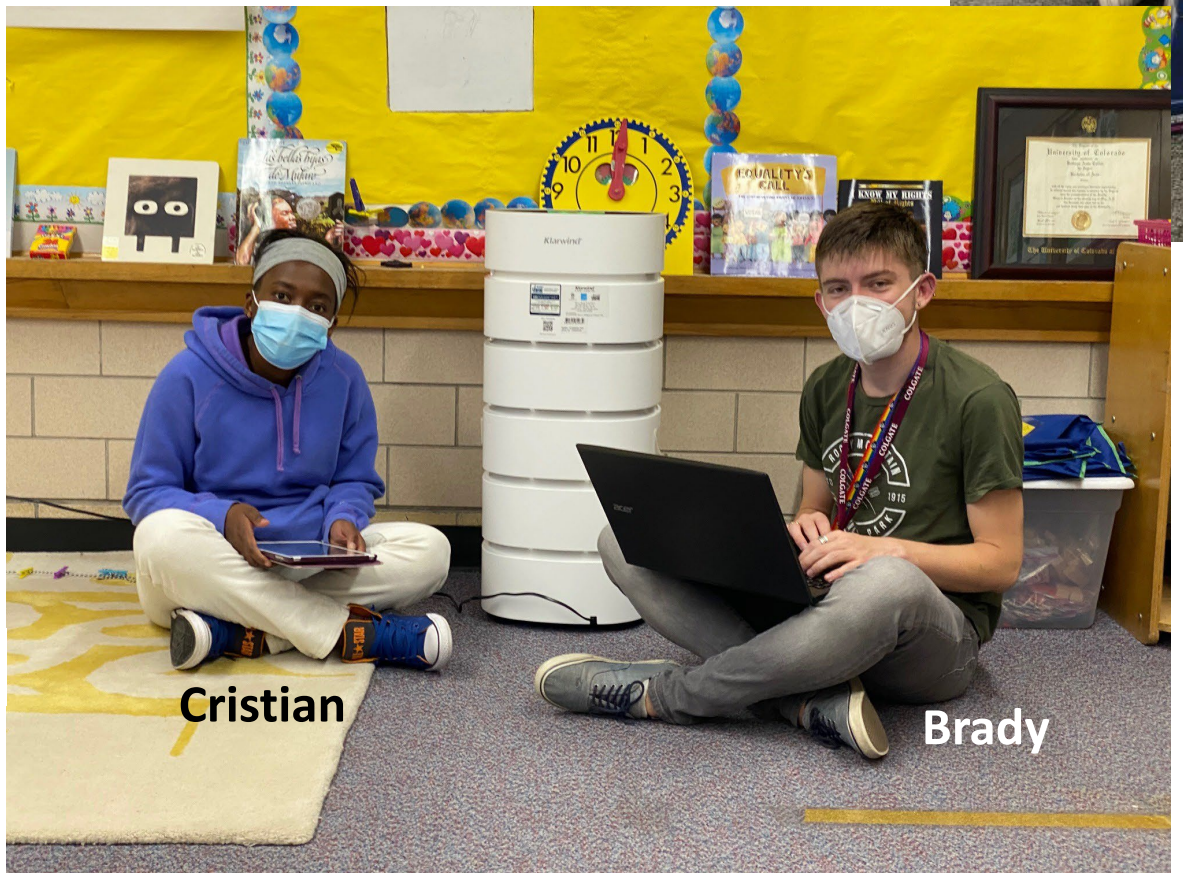
Environmental Quality → Performance & Absenteeism

TEAM CU + DPS

Joni Rix

Dr. Odessa Gomez

Sra. Anna Segur



In theory, practice and theory are the same; in practice, they are not……..Yogi Berra

Sales

Reality