

Assessment of Coal and Petcoke Pollution Project

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Background

- **Trains transport nearly 70% of coal deliveries in the United States with coal accounting for 1 of every 3 tons of American rail freight. (US Energy Information Administration 2022)**
- **Coal dust lost in uncovered coal train transit is significant, as much as 3% of coal load (BNSF 2011; Baruya 2012)**
- **These emissions produce microscopic fine particles (PM2.5) which enter the blood stream and cause systemic inflammation, with no “safe” level**
- **PM2.5 will disperse widely and exposure associated with wide range of health effects including premature mortality, hospitalization and exacerbation of asthma,**
- **In addition, storage and conveyance of coal often occurs near economically disadvantaged populations**
- **Despite this, to date no study has measured impact of coal trains on U.S. urban populations**

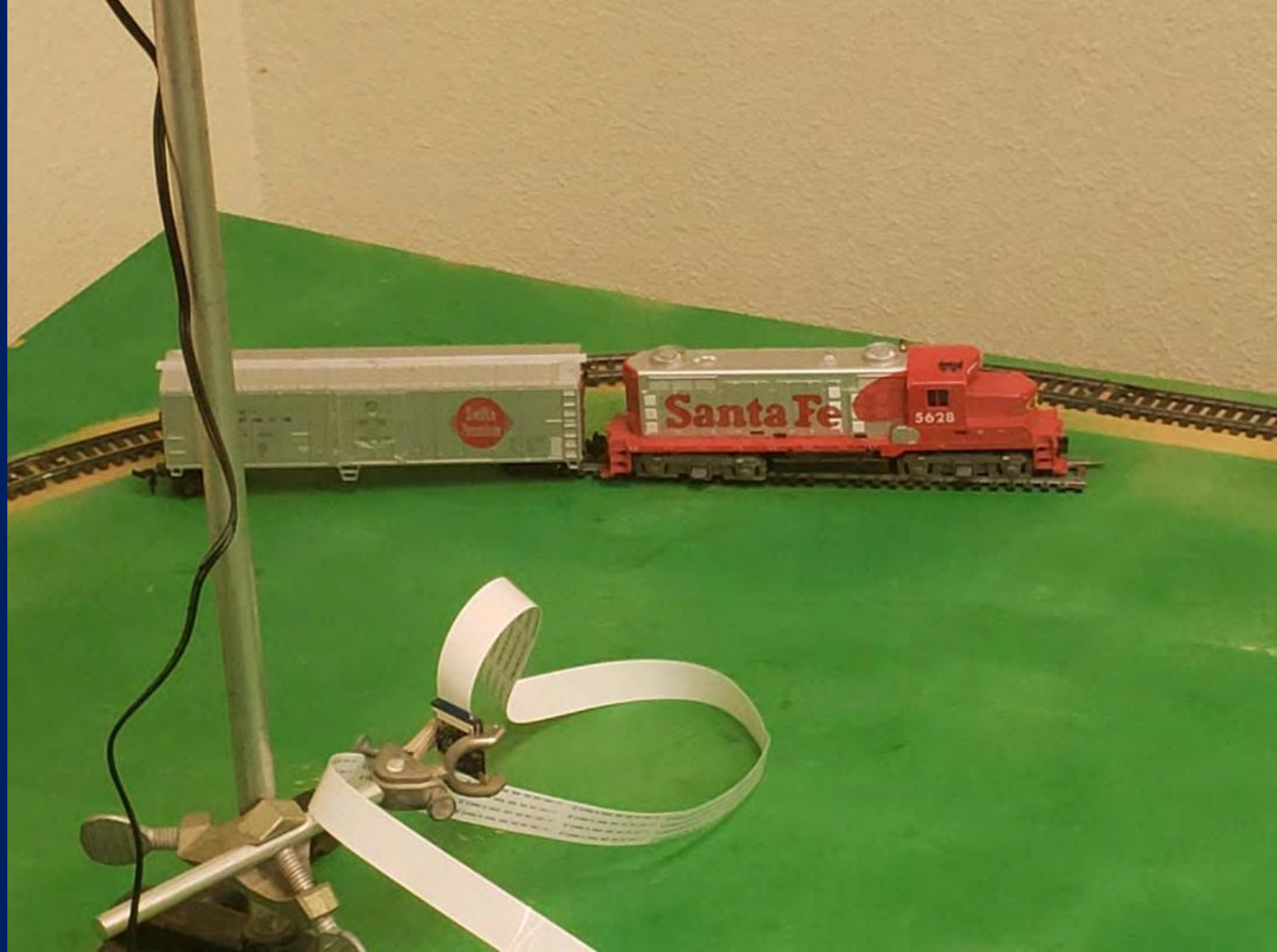
Judge Rules in Favor of Oakland Coal Project

East Bay Express, May 15, 2018

- Oakland developer proposes shipping 10M tons of coal to new port facility in W. Oakland
- Oakland passes bill to prevent storage and handling of coal based on health concerns
- Judge Chhabria ruled that the Oakland City Council didn't have "substantial evidence"...indicating that shipping millions of tons of coal through the city would endanger public health
- But only one study in the U.S. measured coal from trains (Jaffe 2015) and it was based on PRB coal from Wyoming and conducted in rural WA







Key questions

Assess fine particulate matter (PM2.5) using current coal operations in Richmond, CA:

1. Do coal trains contribute to PM2.5?*
2. Do holding yards storing coal trains contribute to PM2.5?*
3. Do terminal operations increase coal and petcoke PM2.5 exposure in the surrounding communities?
4. Are subsequent health effects anticipated?

* and are coal train PM2.5 increments different from freight and passenger

1. Coal Trains: Methods

1. Data Collection

- Dates: May - October, 2022
- Design: Site selection near railroad, clear of other PM sources
- System: Motion detection with AI recognition camera to record and differentiate passing train types (empty or full coal, freight, passenger), infra red light to detect day and night
- Monitor: 3 channel air monitors (similar to Purple Air but with EPA protocol); test and calibrate to measure real-time concurrent PM2.5, meteorology
- Sample: 15 full coal, 14 unloaded coal trains (low economic activity due to Covid, supply issues)

2. Statistical Analysis

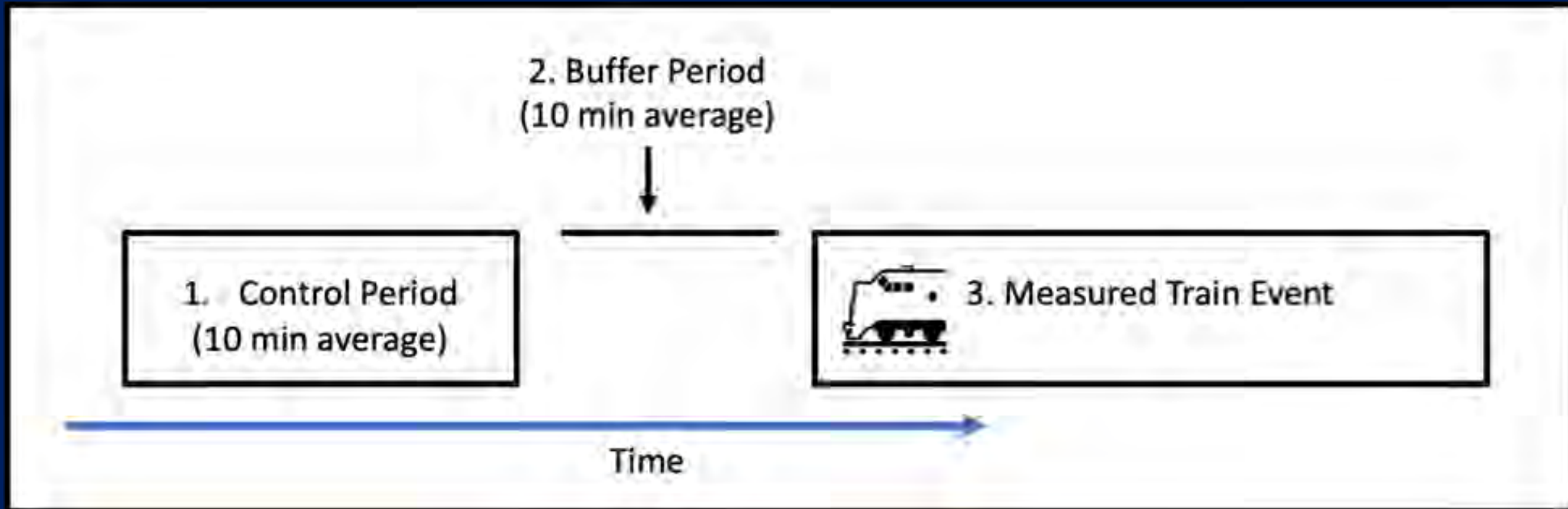
- Calculate increase in avg PM2.5 from trains vs “control” (10 –min avg prior to train)
- Multiple regression analysis controlling for meteorological and other factors
- Multiple models examined to ensure results not by chance

Coal trains: Monitoring site



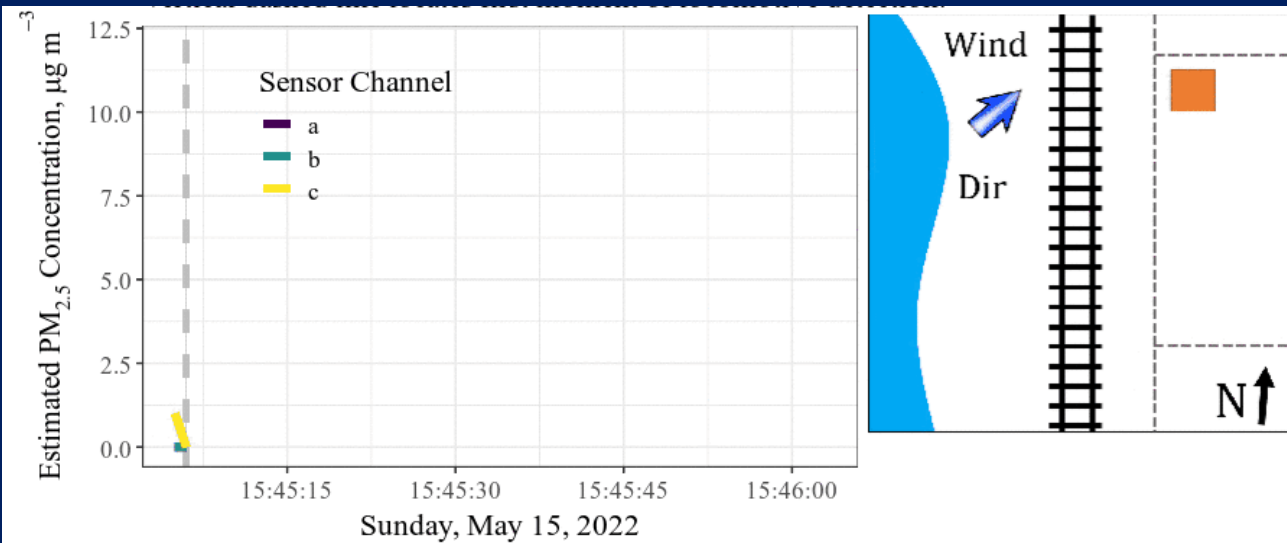
Challenge: find site close to RR tracks, not impacted by other major pollution sources, willing to host site

Coal Trains: Protocol Schemata



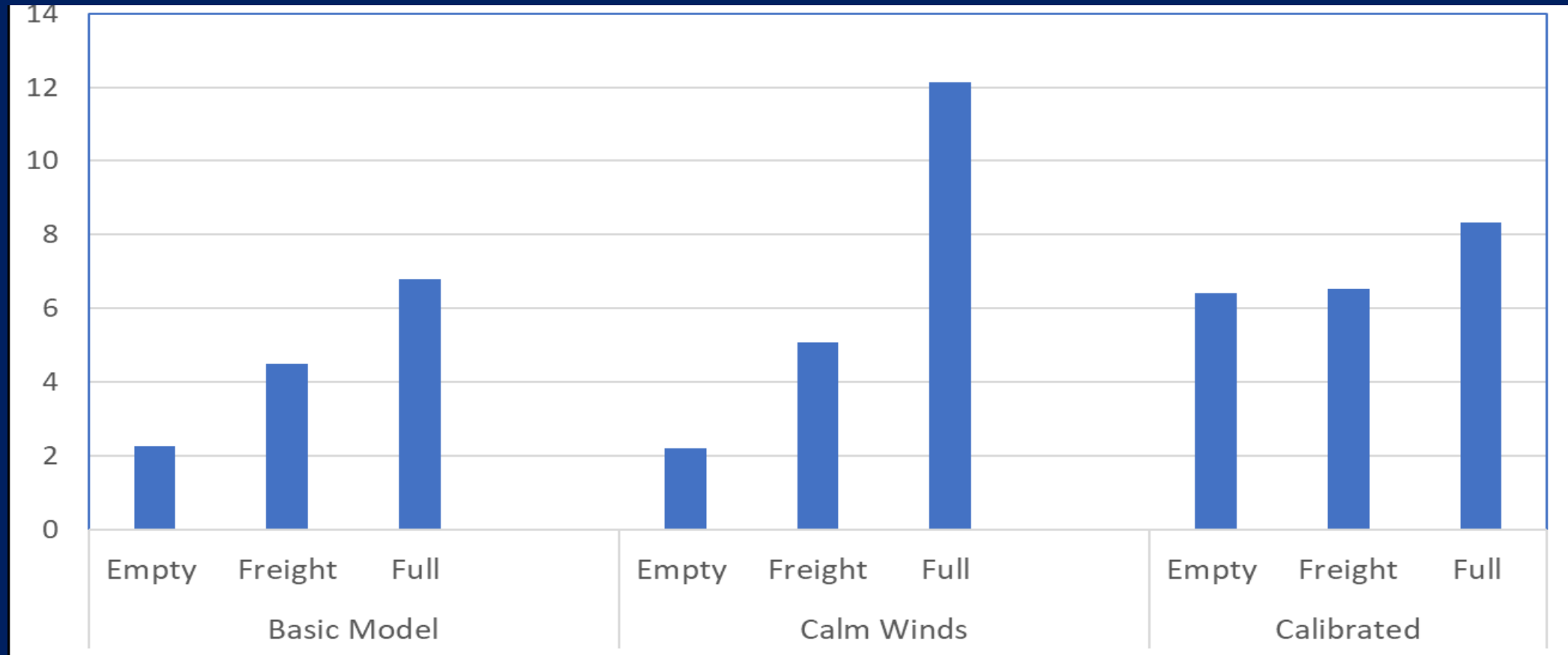
- Calculate change in PM_{2.5} from passing trains
- Controls for Day of Week and time of day

Observed PM concentrations during train passing



Coal Trains: Results

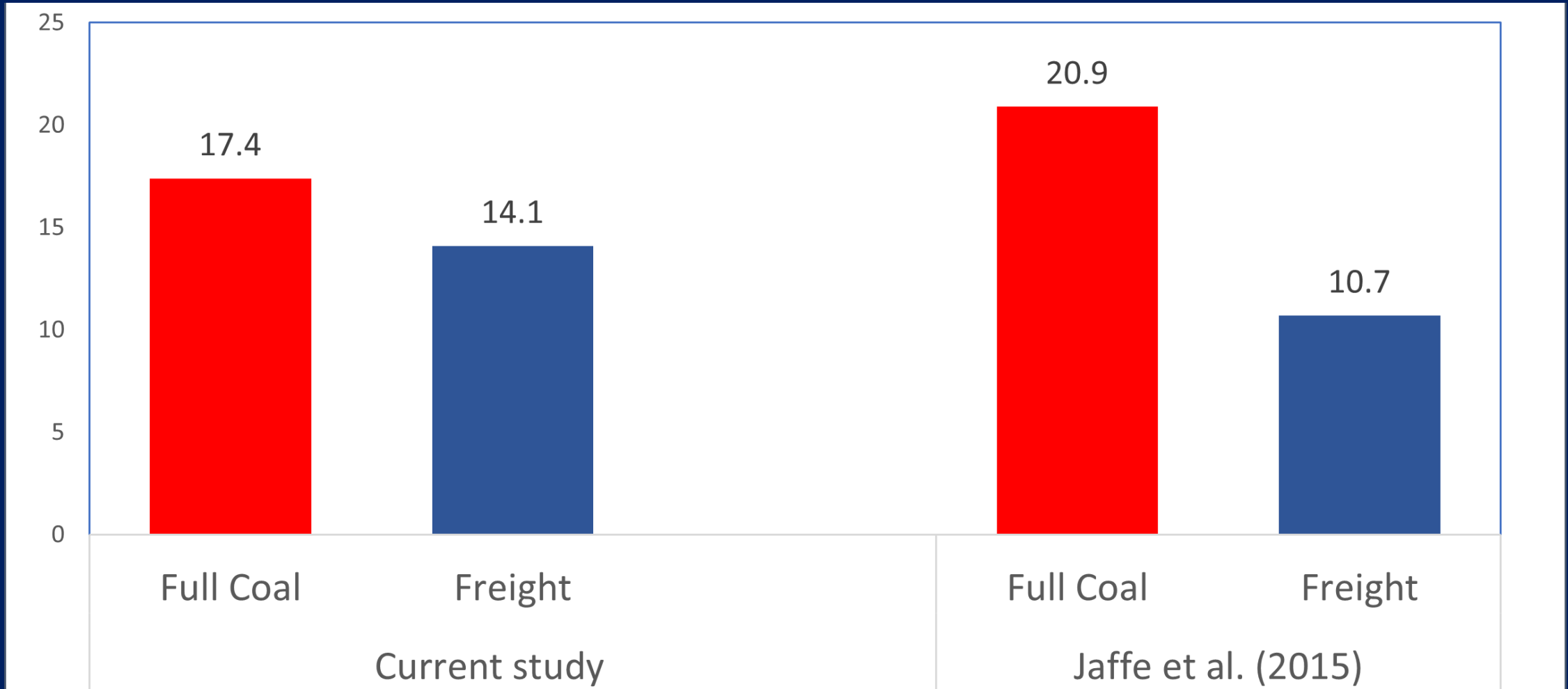
Mean change in PM_{2.5} from passing trains, micrograms/m³ (5 min average)



Full coal cars about 2 $\mu\text{g}/\text{m}^3$ > freight; larger impact when calm wind and from the West (up to 25 $\mu\text{g}/\text{m}^3$); monitor location and dispersion important; calibration important, not perfect

Coal Trains Results: ACAPP and Jaffe

Cross study comparison of change in PM_{2.5}, $\mu\text{g}/\text{m}^3$ (10 second max)



(Jaffe study: dirtier coal, faster speed, rural WA)

2. Holding Yard: Methods

1. Data Collection

- Dates: June – September, 2021; February – October, 2022
- Design: Monitor site 700 ft from holding yard, multiple background “control” sites
- System: Camera to record and differentiate stored coal (loaded and unloaded) and freight trains, day and night
- Monitor: 3-channel air monitors, test and calibrate to measure real-time concurrent PM2.5, meteorology
- Sample: 4,670 hourly observations, 1,097 full coal cars over 200 days of observations

2. Statistical Analysis

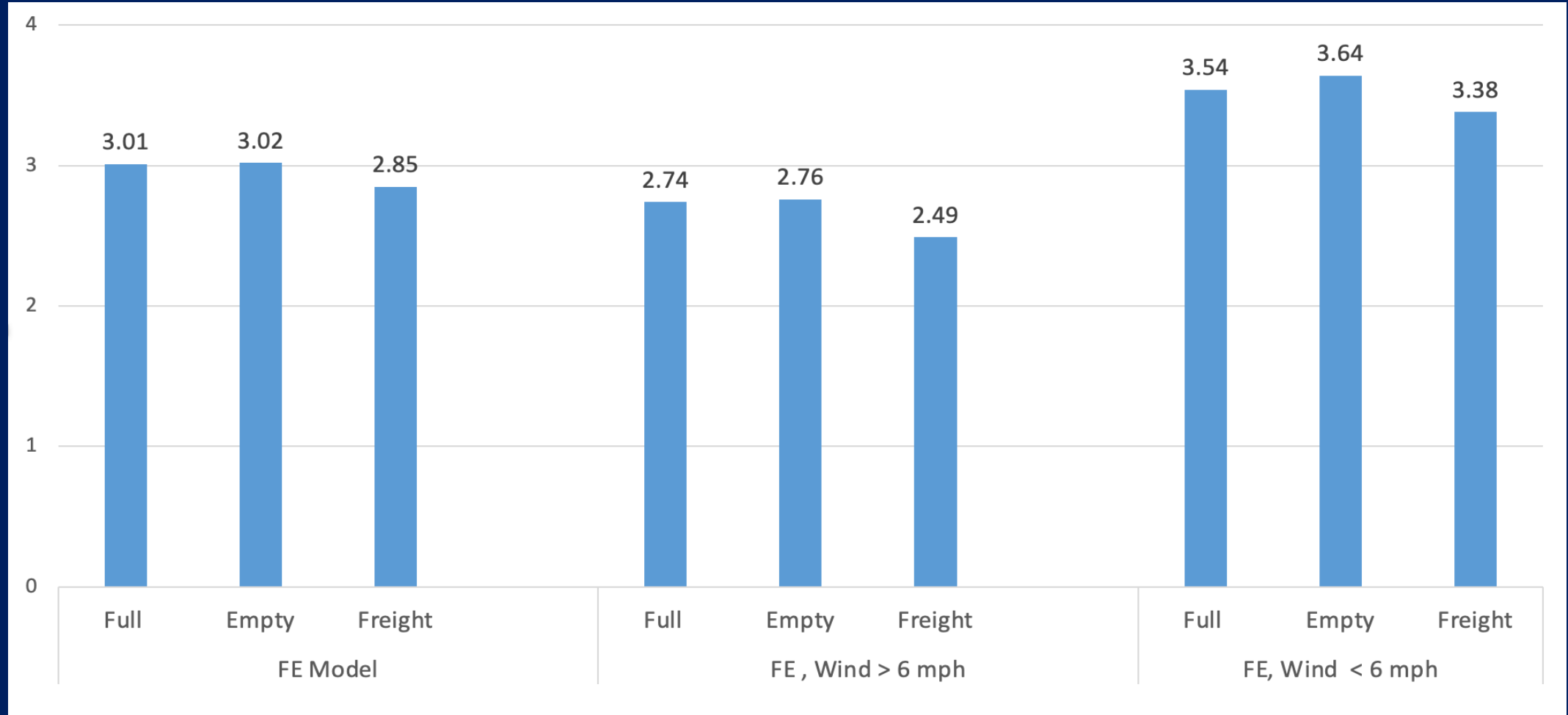
- Calculate increase in PM2.5 trains (1 –hr avg) vs 4 background control monitors
- Multiple regression analysis controlling for meteorological and other factors
- Multiple models examined to ensure results not by chance

Holding Yard Monitoring Site



Holding Yard Monitoring Site

Mean change in PM_{2.5} from storing empty and full coal trains in holding yard micrograms/m³ (1 hour average)



Full coal cars about 0.2 $\mu\text{g}/\text{m}^3$ > freight

Task 3. Community Exposure to Coal/petcoke from Terminal Operations

- Measured from 2020 - 2022 and analyzed using:
 1. Passive monitors (5 community sites) provided and analyzed by **Independent Lab** using single particle analysis (Scanning Electron Microscopy): determines precise identification by size, shape and chemistry
 2. Surface adhesive tape samples at 4 locations to corroborate and add to above; Analyzed at Crocker Nuclear Lab at UC Davis using SEM
 3. Sampling of particle size and chemical species near the terminal using DRUM sampler for Carbon plus other elements

Terminal Operations: Community exposure PM2.5

Coal and Petcoke PM2.5 concentrations ($\mu\text{g}/\text{m}^3$)



RJ Lee analysis of passive sampler plates detect coal and petcoke

Terminal Operations: Community exposure PM10

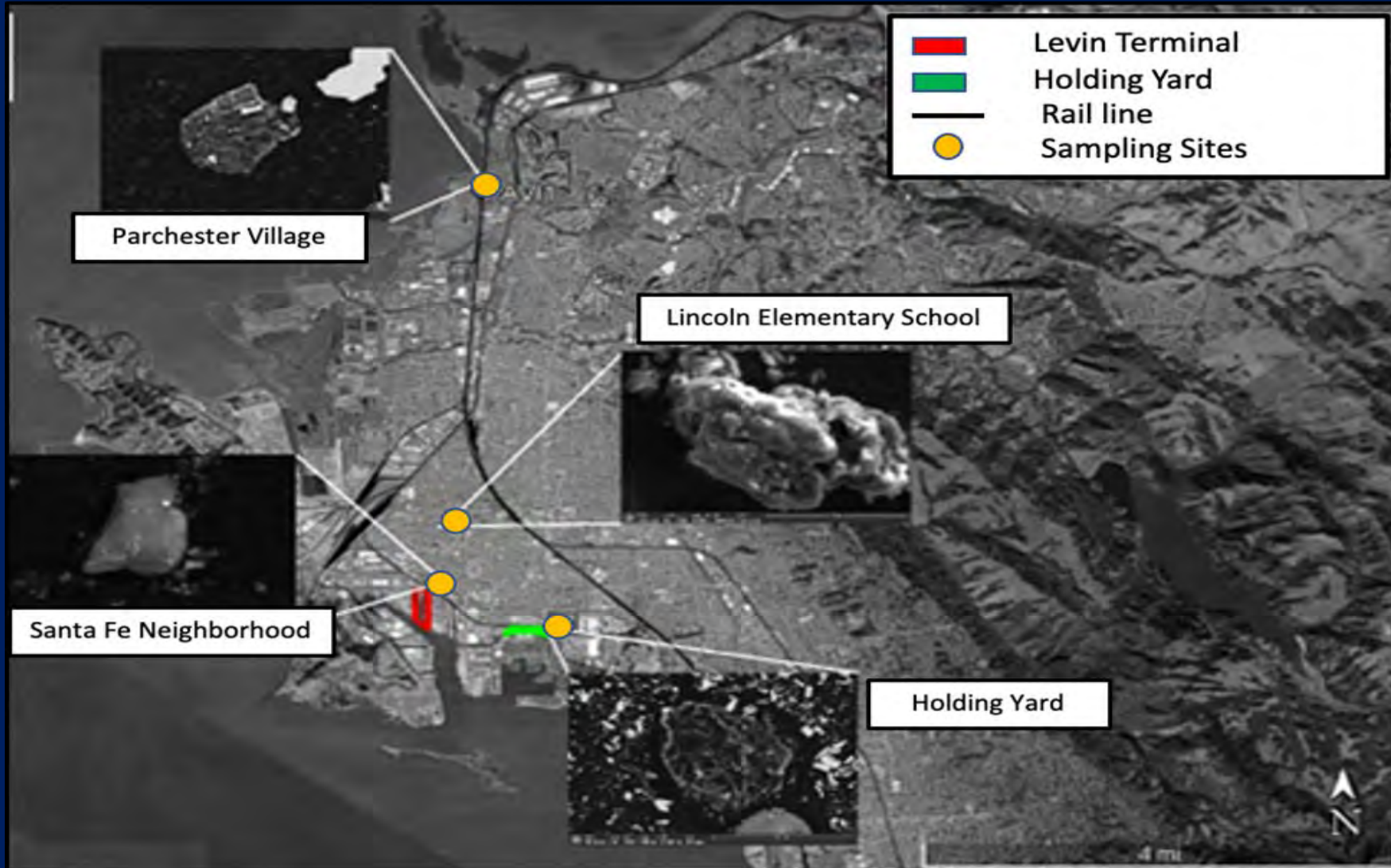
Coal and Petcoke Coarse (PM10- PM2.5) concentrations ($\mu\text{g}/\text{m}^3$)



RJ Lee analysis of passive sampler plates detect coal and petcoke

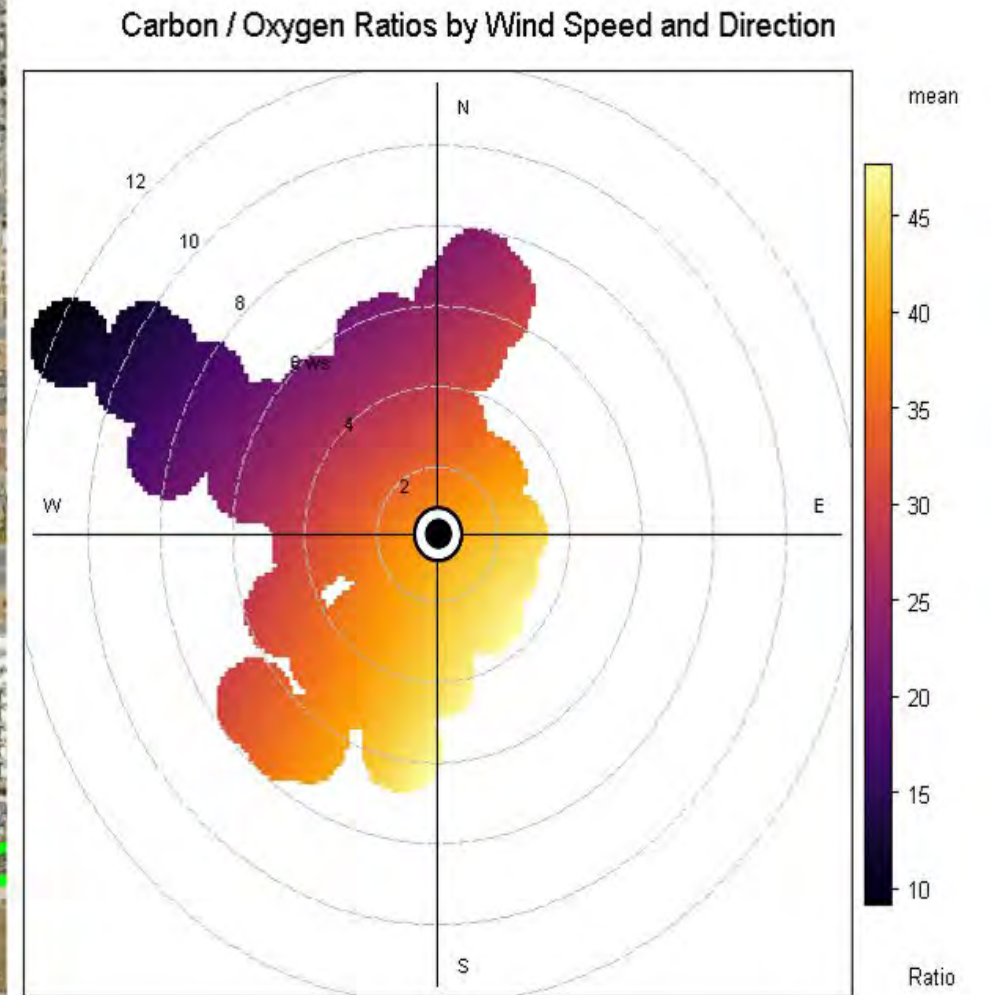
Terminal Operations: Community exposure corroboration

UCD Carbon tape: Carbon particles clearly coal: different shape, much larger than diesel



Terminal Operations: source corroboration

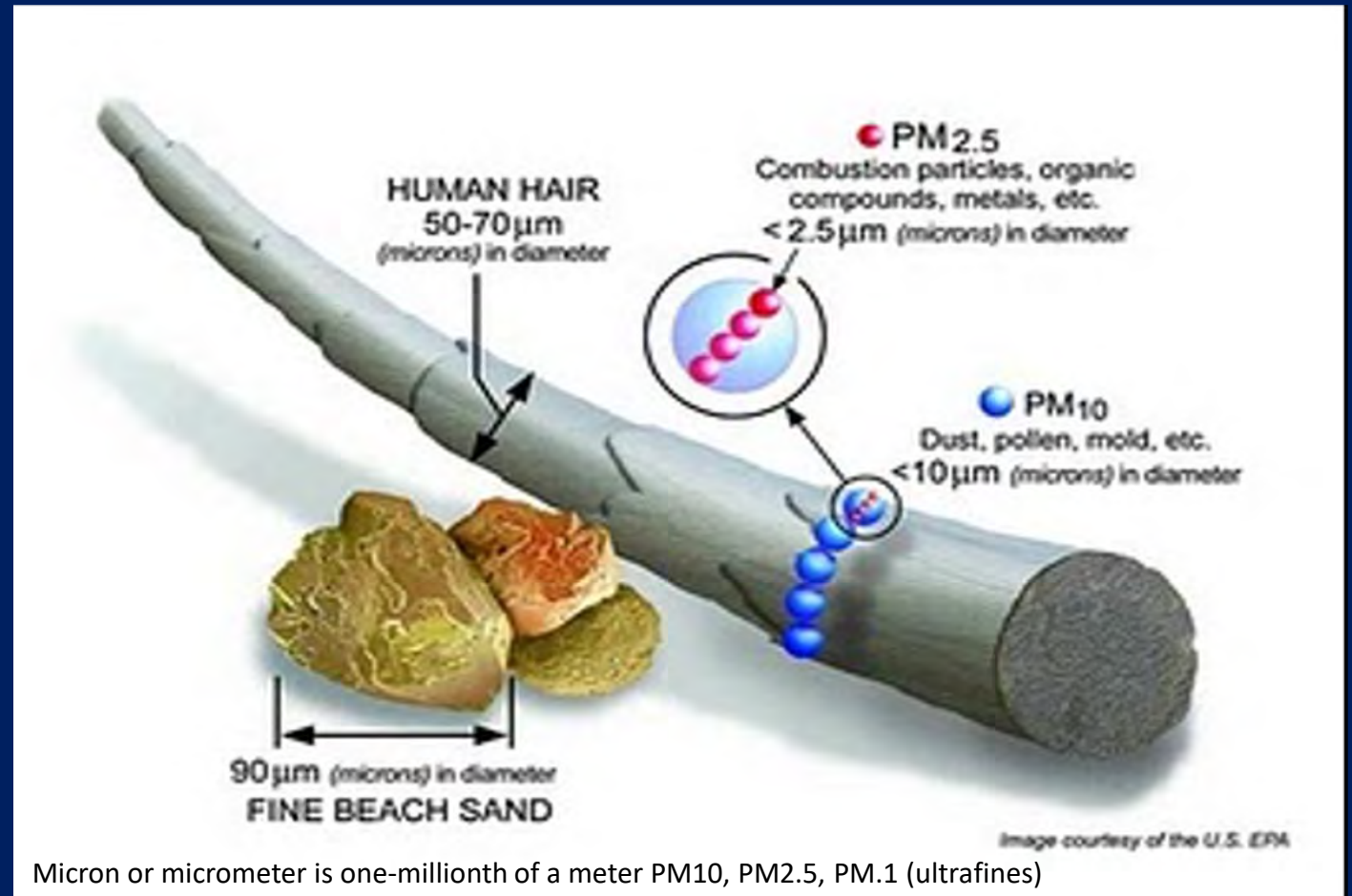
Markers of coal particles observed downwind of terminal using DRUM samplers



Health Implications

Fine particulate matter (PM_{2.5}) is a complex mixture of airborne solid particles and liquid droplets

PM_{2.5} includes black carbon, which has impacts on both health and climate change



Health impacts of PM2.5

Thousands of epidemiological studies show PM2.5 impacts:

- Cardiovascular and respiratory mortality and hospitalization
- Lung and other cancers
- Nonfatal heart attacks, stroke, diabetes, irregular heartbeat
- Emergency room visits
- Aggravated asthma and other respiratory conditions
- School and work loss
- Adverse birth outcomes
- Neurodevelopment in children (children (ADHD, autism, IQ)?
- Adult cognitive effects (Autism, Parkinson's, Alzheimer's)?

Averaging times for Health Effects

- Most studies have used exposure windows of days or years
- Health effects also observed from one- or multi-hour exposures
 - acute myocardial infarction
 - emergency department visits for cardiovascular and respiratory disease
 - ambulance calls
 - asthma exacerbation
 - Heart rhythm

Refs: Peters et al. 2001; Bhaskaran et al. 2011; Yorifuji et al. 2014, 2015; Kim et al. 2015; Chen et al. 2019; Chen et al. 2020; Wu et al. 2020; Liu et al. 2021; Fu et al. 2023

Conclusions

- Coal from trains, holding yards and terminal operations increases ambient PM_{2.5} greater than freight or passenger trains
- Associated particulate matter reaches residential communities
- Levels of exposure are enough to cause important health effects



Questions?