Using Low-Cost PM Sensors for Industrial, Government, and Educational Applications

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for

New Jersey Clean Air Council Public Hearing
Trenton, NJ

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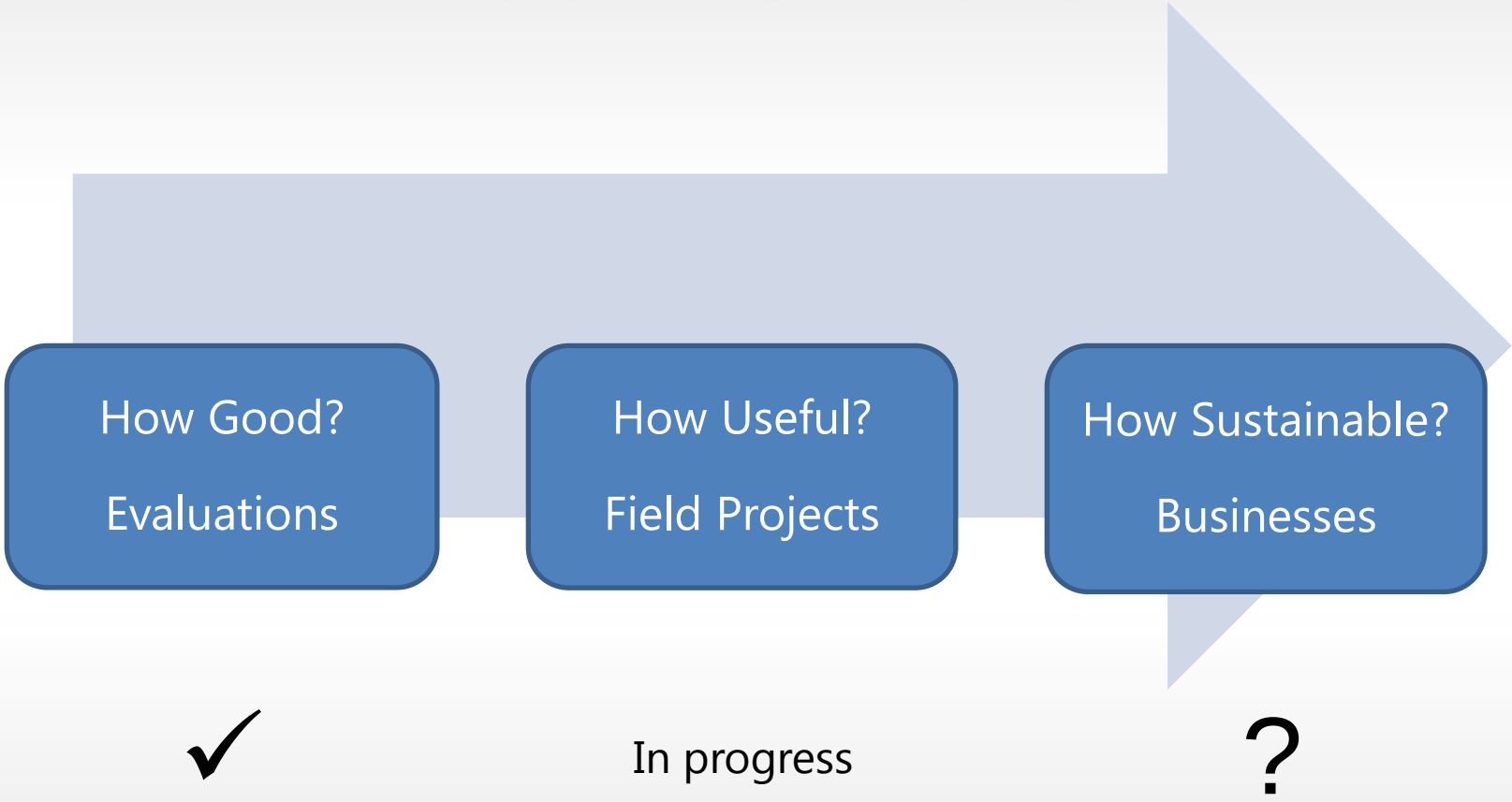
Sonoma Technology, Inc.

Outline

- Path forward
- Studies
  - PM_{10} coal dust for industry
  - PM_{10} windblown dust
  - $PM_{2.5}$ EJ wood smoke
  - $PM_{2.5}$ community wood smoke
  - $PM_{2.5}$ education in schools
- Key challenges

Path Forward



1. Study – Coal Dust (PM_{10})

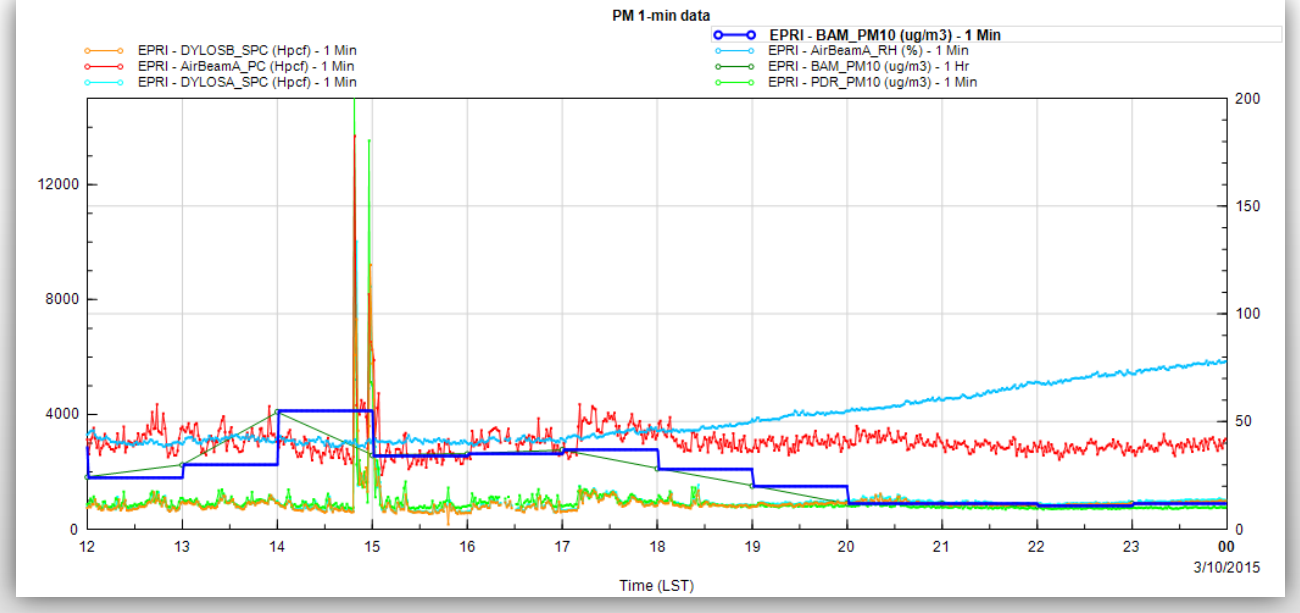
- Objectives
  - Determine whether sensors can detect and quantify fugitive PM_{10} from coal piles
  - Identify sensor limitations and technical challenges
- Study
  - 2-month study in warm climate
  - Weather station

Equipment	
Reference Instrument	MetOne BAM-1020 PM_{10} Thermo PDR-1500
Sensors	Dylos AirBeam

Sponsor: Electric Power Research Institute (EPRI)

1. Results – Coal Dust (PM_{10})

- 17 events were identified
  - Short in duration (a few minutes)
  - Concentrations were 2 to 5 times higher than background
- 37 of 1,392 hours (2.7%) were impacted by windblown dust events



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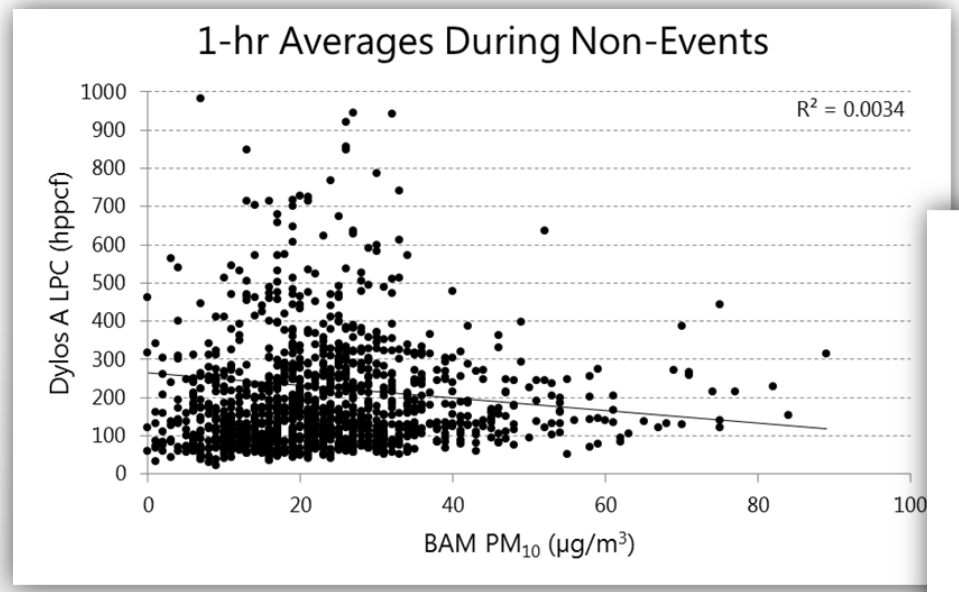
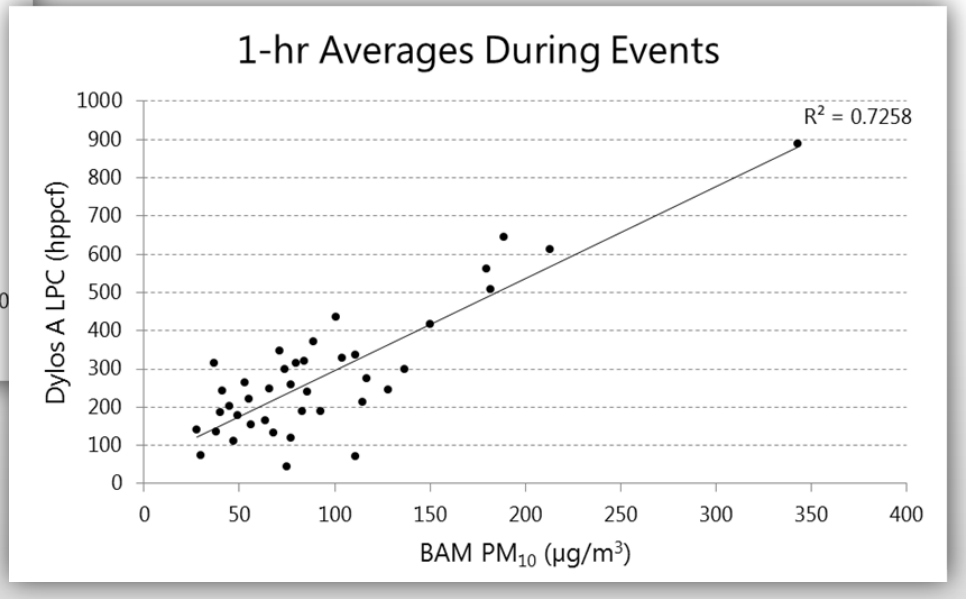
1. Results – Coal Dust (PM_{10})

Dylos had good correlation with the BAM for events; weak correlation for all data





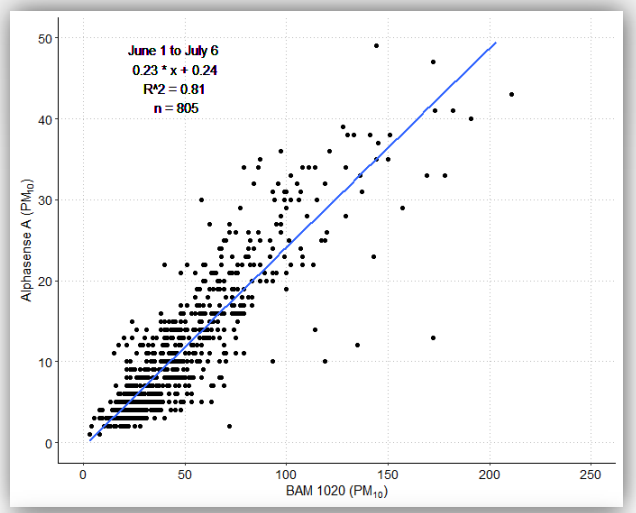
2. Study – Windblown Dust (PM_{10})

- Objectives
  - Can low-cost PM sensors detect dust events?
  - How precise are the sensors?
  - Are they reliable?
  - Can they provide sufficient warning time?
- Study
  - 3-month springtime study
  - School in eastern Santa Barbara County

Equipment	
Reference Instrument	MetOne BAM 1020 (FEM for PM_{10}) GRIMM 11-R (Particle counts) MetOne E-BAM (PM_{10})
Sensors	AirBeam (3 units) Alphasense OPC-N2 (3 units)

Sponsor: Santa Barbara County Air Pollution Control District

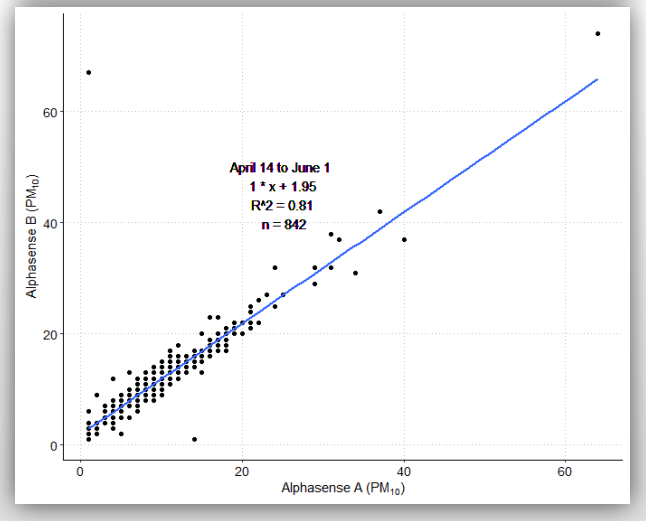
2. Results – Windblown Dust (PM_{10})



Alphasense A vs. BAM

Hourly PM_{10} measurements

$R^2 = 0.81$



Alphasense A vs. Alphasense B

Hourly PM_{10} measurements

$R^2 = 0.81$

BAM = 1*x + 1.95

Sponsor: Santa Barbara County Air Pollution Control District

3. Study – Wood Smoke ($PM_{2.5}$)

- Objectives
  - Use low-cost sensors to provide spatial coverage and engage community
  - Assess the contribution of wood burning to air toxics in Sacramento
- Study
  - Sacramento Metropolitan AQMD project funded by EPA Grant
  - Two existing regulatory monitoring stations, 4 new monitoring sites with FEMs, 12 new sites with low-cost monitors
  - Three-month wintertime study
  - Do "no burn" rules result in lowered air toxics concentrations?

Equipment	
Reference Instrument	MetOne BAM 1020 (FEM for $PM_{2.5}$) Aethalometer (BC)
Sensors	AirBeams

Sponsor: SMAQMD

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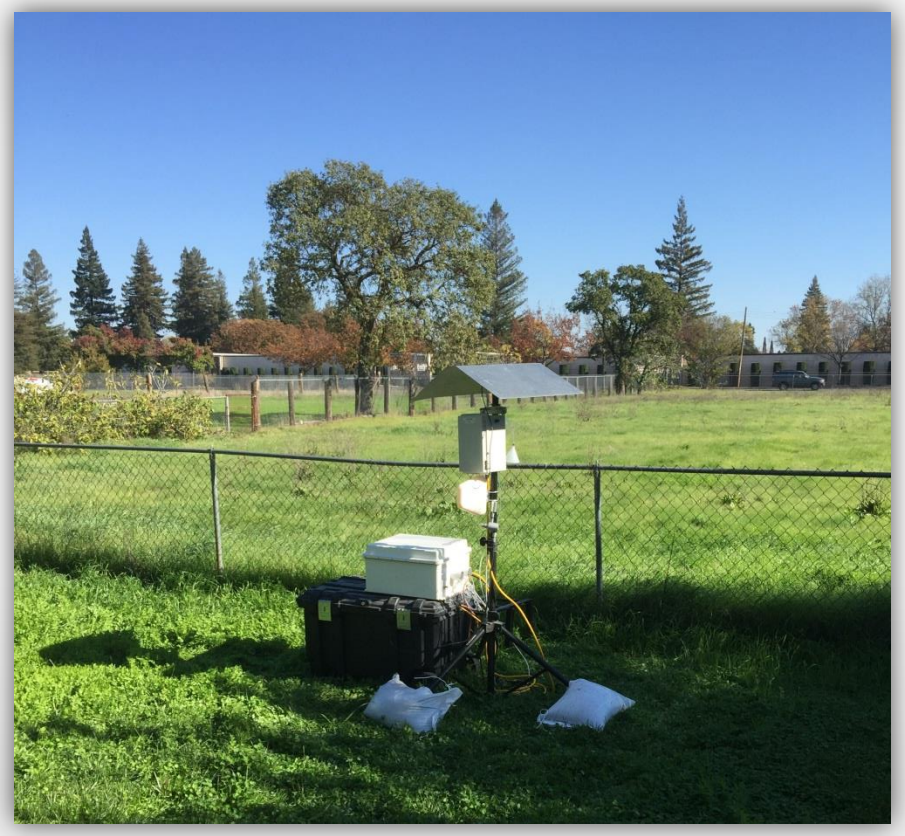

Sponsor: SMAQMD

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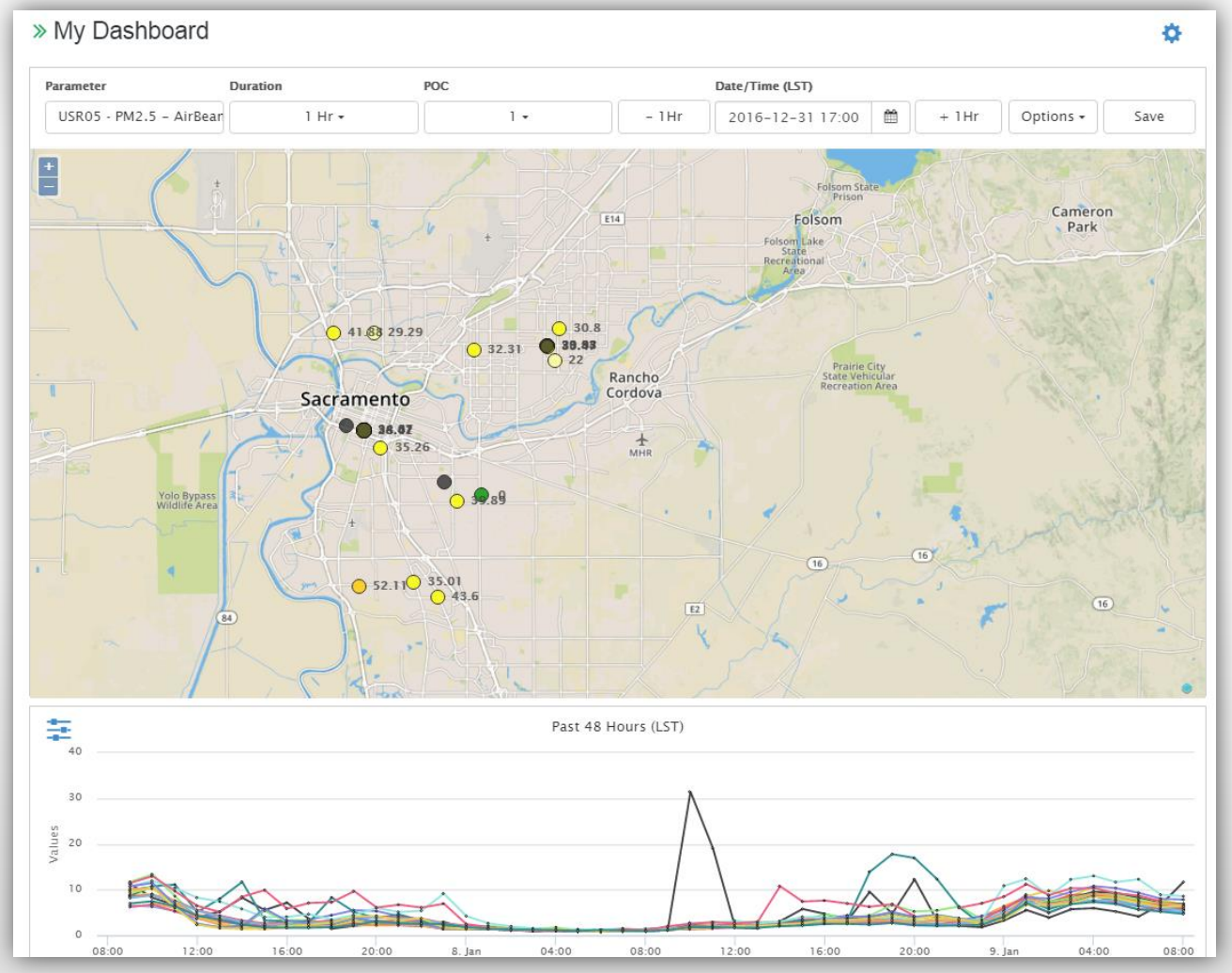


Sponsor: SMAQMD

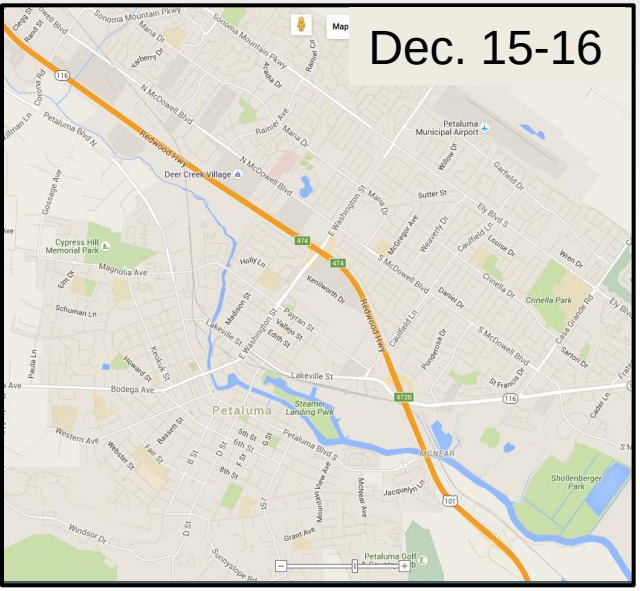
4. Study – Community Sensing ($PM_{2.5}$)

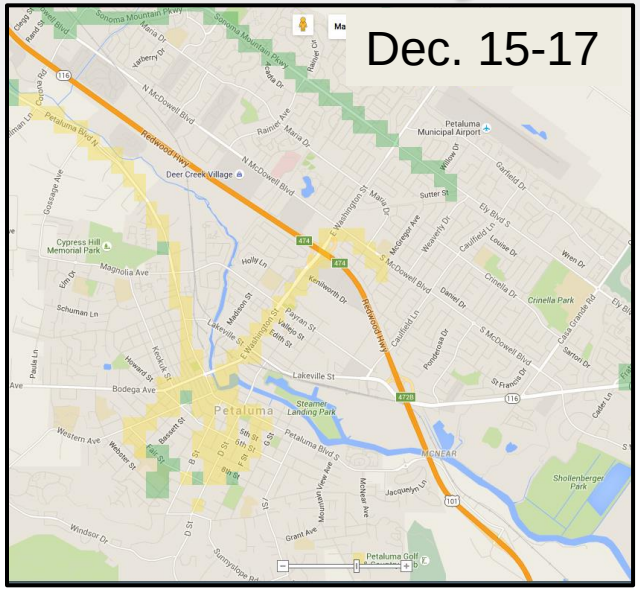
- Objectives
  - Explore how the public would use air sensors
  - Generate a Big Data set for analysis and applications
- Study
  - Petaluma, CA, air study (funded by STI)
  - 1 regulatory monitoring station, 30 air sensors
  - 4-day study

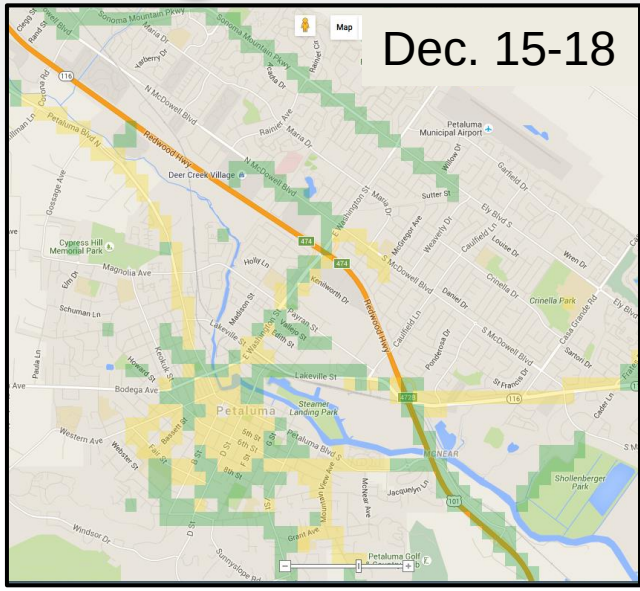
Equipment	
Reference Instrument	MetOne BAM 1020 (FEM for $PM_{2.5}$)
Sensors	AirBeams

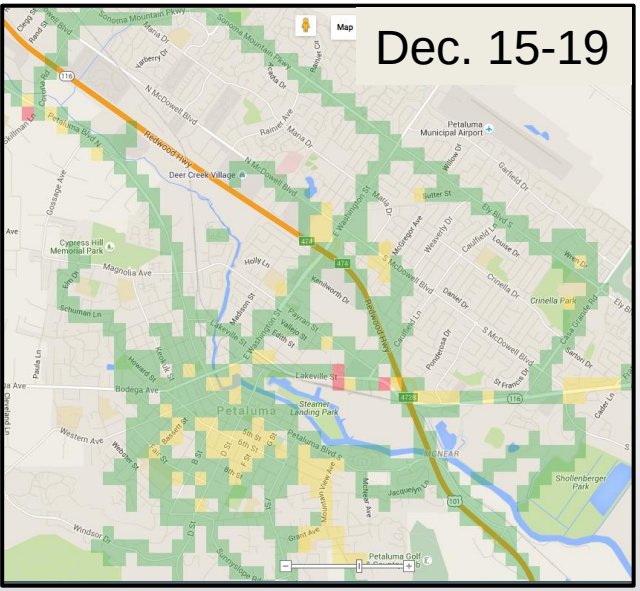
Sponsor: STI

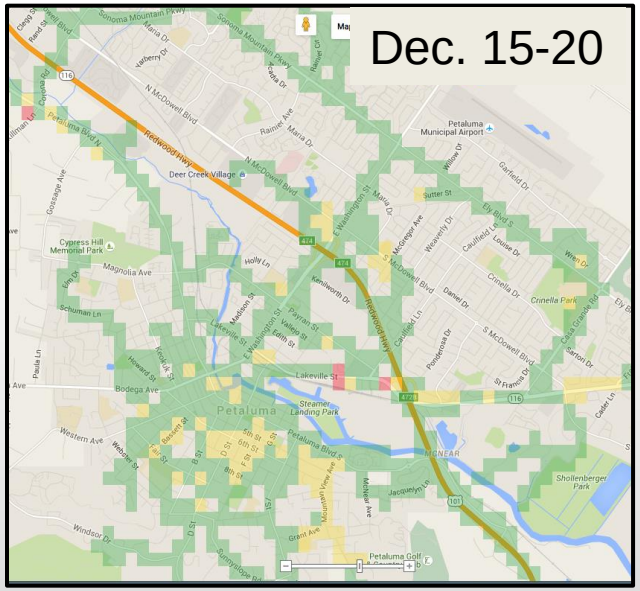
4. Results – Community Sensing ($PM_{2.5}$)

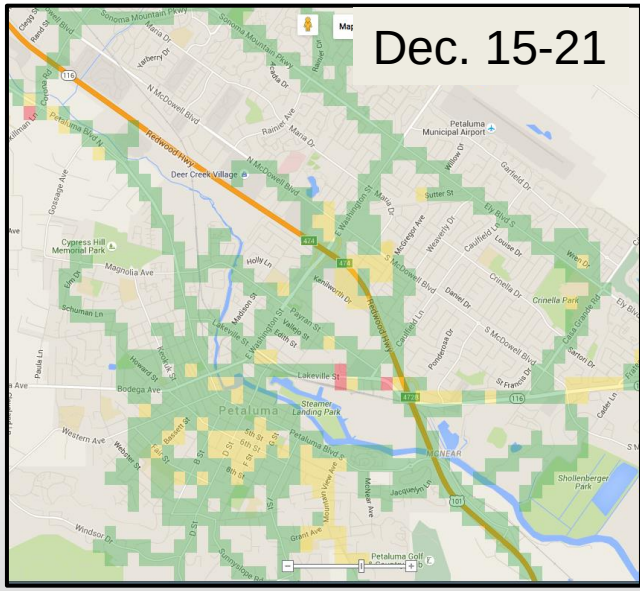












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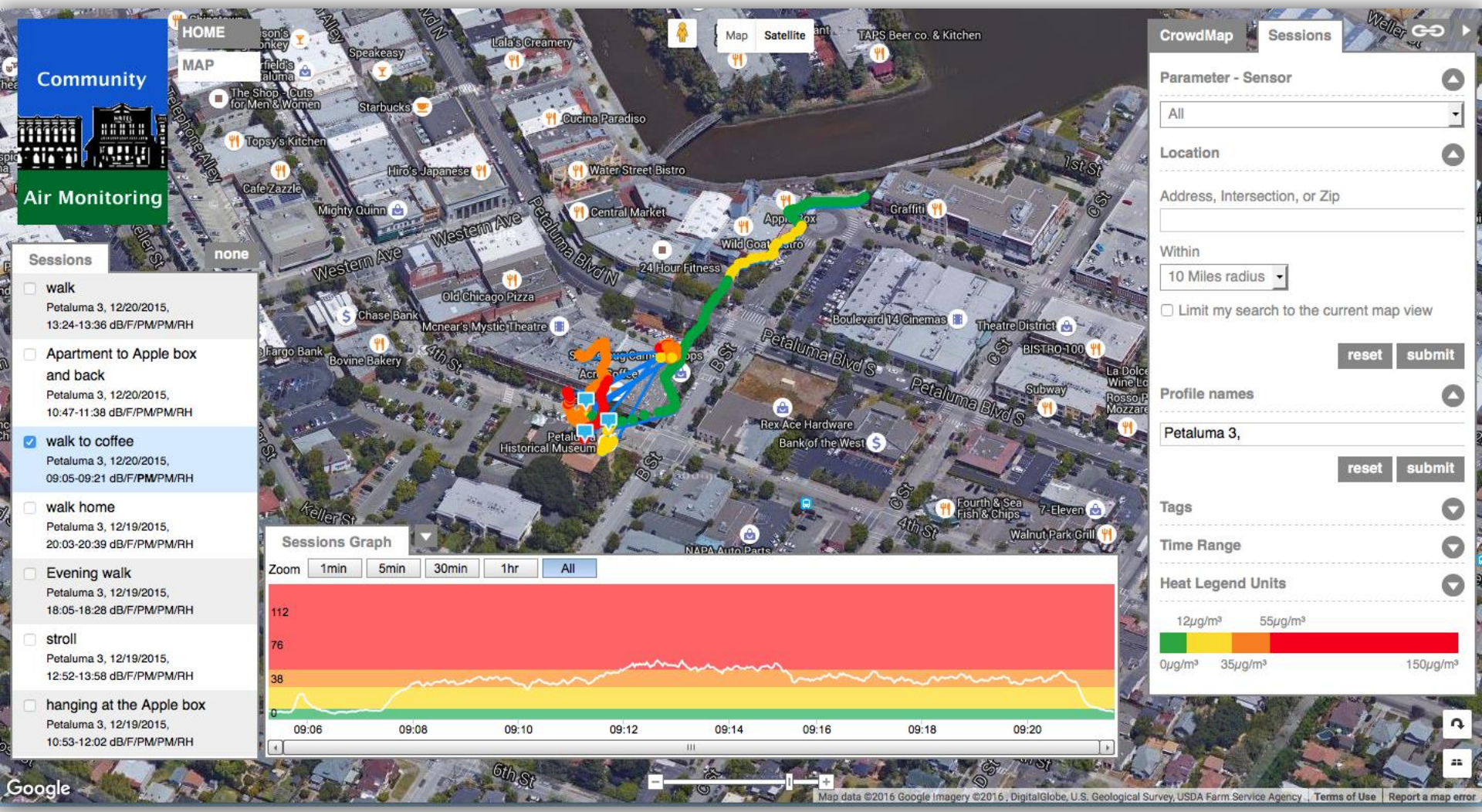

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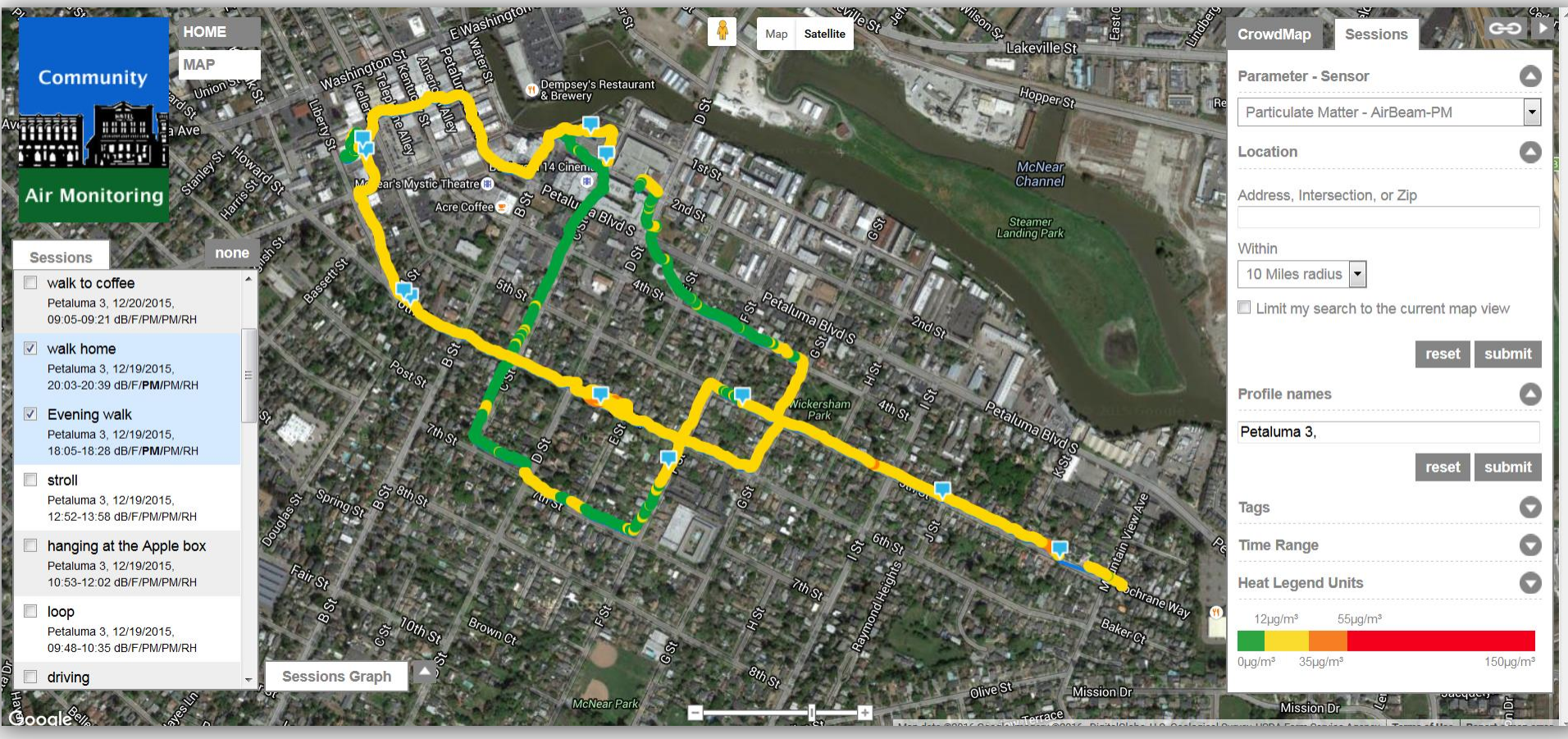


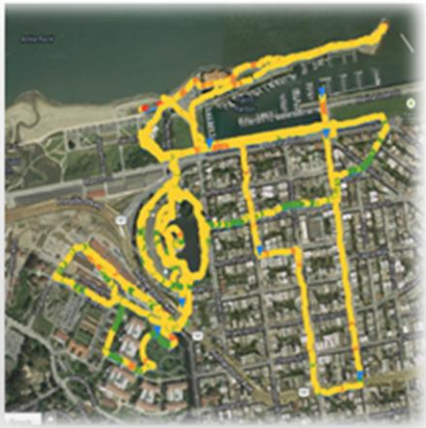
5. Kids Making Sense

Kids Making Sense is a complete environmental education and measurement system that teaches youth about air quality, how to measure pollution using small sensors, and how to interpret the data they collect.

Learn

Measure

Discover



Interpret

5. Results – Kids Making Sense

- Training materials
  - Workbook
  - Teacher's guide
  - Labs and experiments
- Sensors
  - Particulate matter
  - Gases (in progress)
- Website: kidsmakingsense.org
  - Data exploration
  - Learning more

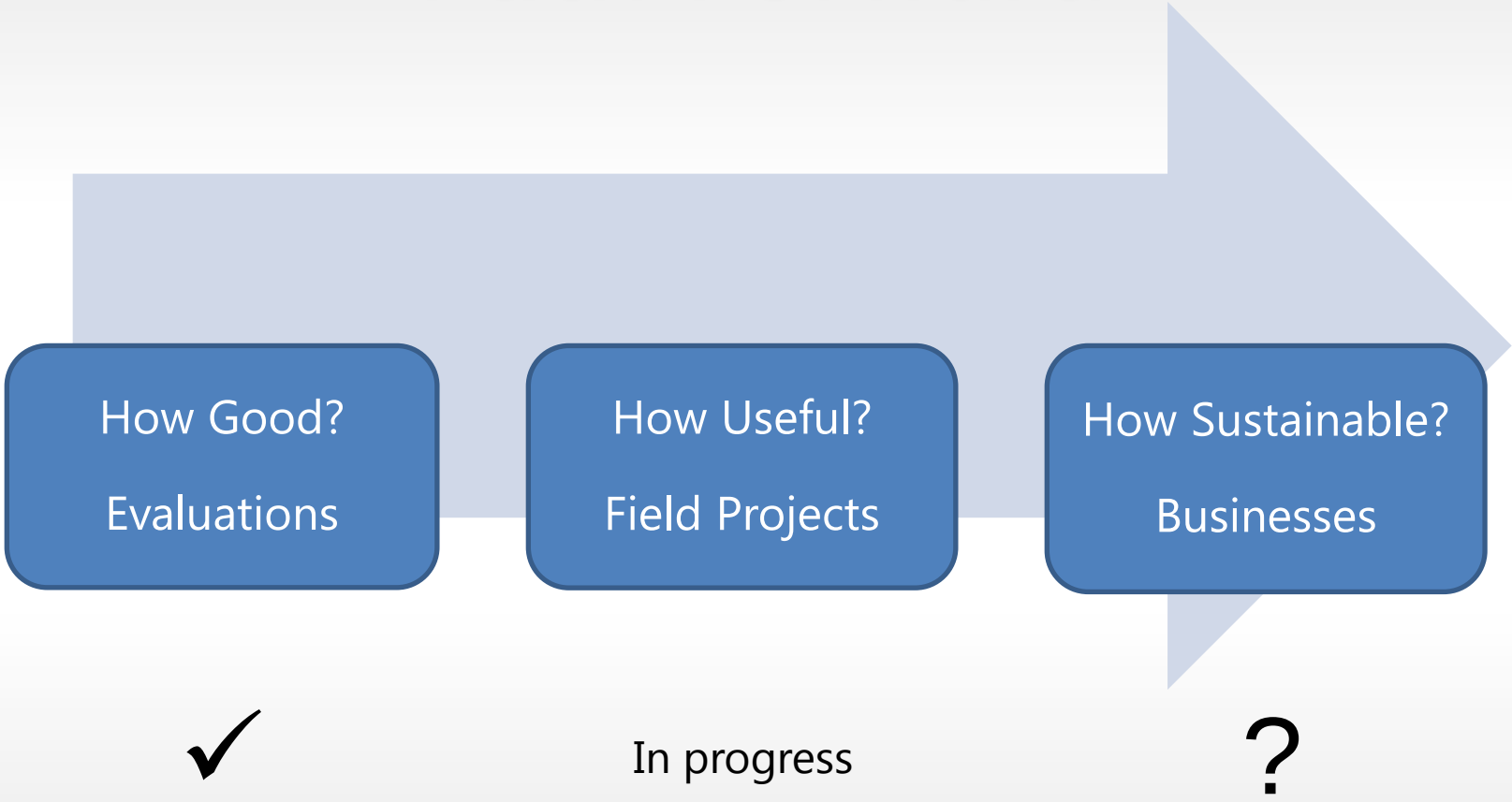
Key Challenges

- New technology
  - Rapid changes; versioning issues with firmware
  - Drift, calibration requirements, and “soiling” issues
  - Hardware issues
  - Unknown lifetime
- Data logging
  - Data acquisition systems don’t always handle sensors
  - Data formats and time standards
- Communications
  - Critical for high data availability
  - More challenging and costly

Key Challenges

- Data management
  - More challenging than FEM instrument (60 to 3600 times more data and more uncertainty)
- Cost
  - Projects cost much more than one sensor
  - Operations and data management are more intense
- Scale
  - 3 sensors vs. 10 sensors vs. 100 sensors
  - Scale affects everything (logistics, data management, reliability, costs)

Path Forward



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Innovative Environmental Solutions