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Using Air Sensors to Build Capacity to Measure Air Pollution Mitigation Strategies at Schools – A Case Study at Brookfield Elementary School, Oakland, CA

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Abstract

Research indicates that noise and vegetative barriers, separately or in combination, can reduce downwind air pollutant concentrations near busy roads. EPA and its project partners are participating in an ongoing effort to measure the spatial patterns of traffic-related gas- and particle-phase pollutants consistent with traffic activity both with and without a vegetation barrier at Brookfield Elementary School (grades K-5) in Oakland, CA. Brookfield is directly adjacent to a busy goods movement corridor (I-880); a noise barrier currently separates the school from the highway shoulder. EPA collected initial air quality samples at the school before vegetation was planted on the downwind side of the sound wall in early 2017 using a combination of low-cost mobile and fixed sensors to establish on-site conditions.

In the project's second phase, EPA is developing low-cost black carbon (BC) and nitrogen dioxide (NO_2) mobile and fixed sensor packages that will be deployed at the school by teachers, staff and students to learn more about exposure to near-road pollutants including how newly planted vegetation affects their air quality over time. Prior to deployment, EPA is developing a hands-on training for teachers and staff on how to operate the sensors and evaluate the data. EPA is also developing educational materials to accompany the sensor deployment. The lessons learned at Brookfield will be transferable as a case-study to other schools/communities interested in air quality.

Background & Timeline

In early 2017, Brookfield Elementary School (Figure 1) broke ground on a "greening Brookfield" initiative utilizing grant funding provided under California's AB32 cap-and-trade program in partnership with CALFIRE, the Bay Area Air Quality Management District, Urban Releaf, and Higher Ground. EPA's near-road research program has been investigating the use of roadside vegetation to mitigate local air pollution impacts and partnered with Brookfield to bring an air quality research element to the project.

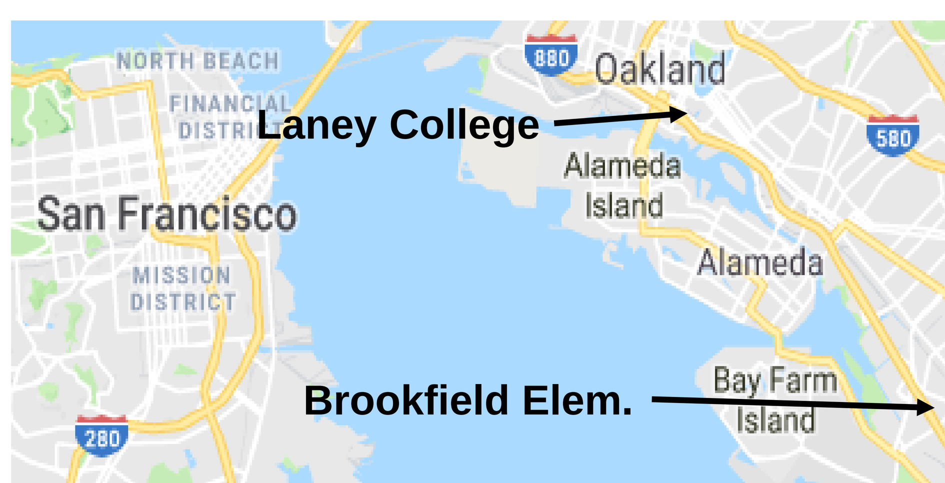

Figure 1. Location of Brookfield Elementary School and the Laney College near-road NAAQS monitoring station.

- ***2016*** – EPA joins Brookfield team as project partners.
- ***Spring, 2016*** – EPA collects pre-planting **Black Carbon (BC) and Nitrogen Dioxide (NO_2) samples** to determine conditions at Brookfield before trees and shrubs were planted and to measure air quality variability in various sampling locations. Mobile measurements in surrounding area were also collected. (Figures 2-4)
- ***July, 2016*** – EPA publishes ***"Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality Planting."*** (Figure 5)
- ***Winter, 2016-2017*** – EPA provided planting design assistance to Brookfield project partners.
- ***February, 2017*** – Project partners, school and community members volunteer at **Martin Luther King, Jr. Day of Service** event to help plant the vegetative barrier. Approximately 40 trees and additional vegetation were planted. (Figures 6 and 7)
- ***Winter/Spring, 2017*** – Unseasonably wet weather combined with insufficient drainage caused **flooding at the planting site**. Approximately 10 trees and some vegetation was lost. Intermittent replanting has happened since then.
- ***Fall/Winter, 2017-2018*** – EPA developed **sensor packages** to measure the spatial patterns of traffic-related gas- and particle-phase pollutants consistent with traffic activity with and without the presence of the recently planted vegetation barrier. (Figures 8 and 9; **see related ASIC poster by Deshmukh et al.**)
- ***Winter/Spring, 2017-2018*** - EPA developed draft **K-5 air quality teaching aids** that include the role vegetative barriers play in improving air quality. The lesson plans also:
  - Align with Next Generation Science Standards (NGSS) and consider other state-specific standards for Math, Art and other subjects
  - Can be modified for classrooms with varying learning abilities
  - Contain goals, key vocabulary, and a teacher background section
  - Cover four major introductory level topics: air quality, sensor use, air pollution, and the impact of emissions on health
  - Include in-class and field activities that utilize the sensors
- ***May, 2018*** – EPA piloted a hands-on sensor package training to Brookfield staff to build capacity so that data can be collected as the vegetation barrier matures. (Figure 10)

Figures


Figure 2. Brookfield Elementary School playground and diesel truck traffic on I-880.


Figure 3. Co-located Aclima/Google Street View sampling vehicles

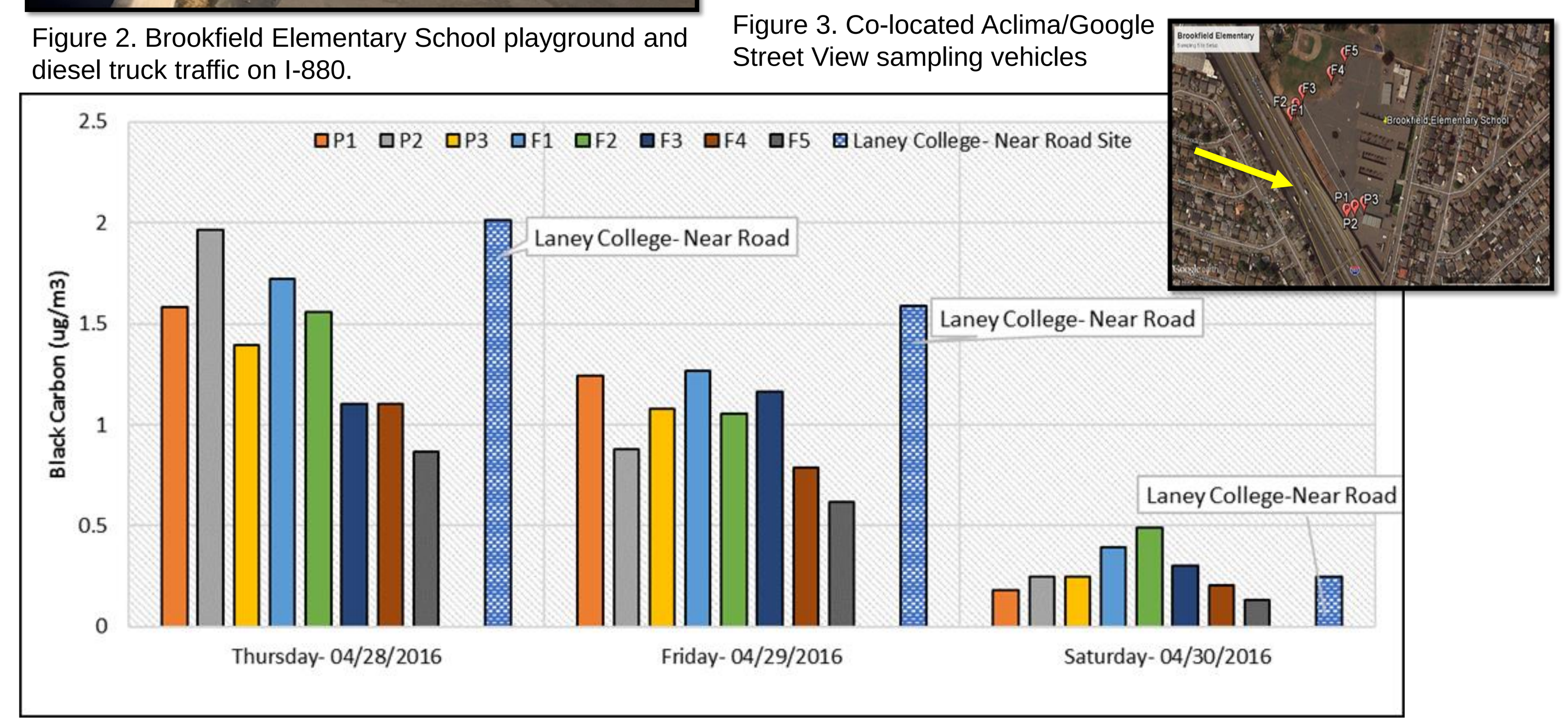

Figure 4. Sensors provided data on the spatial variability of air pollutants around the school. Concentrations generally decrease with distance from the road. Buildings and other structures can influence levels during varying winds. Pollution concentrations at Brookfield were similar to other locations near I-880 (e.g., Laney College Near-Road NAAQS monitoring station 2km away. Inset: Locations of fixed monitors and most common wind direction (yellow arrow).

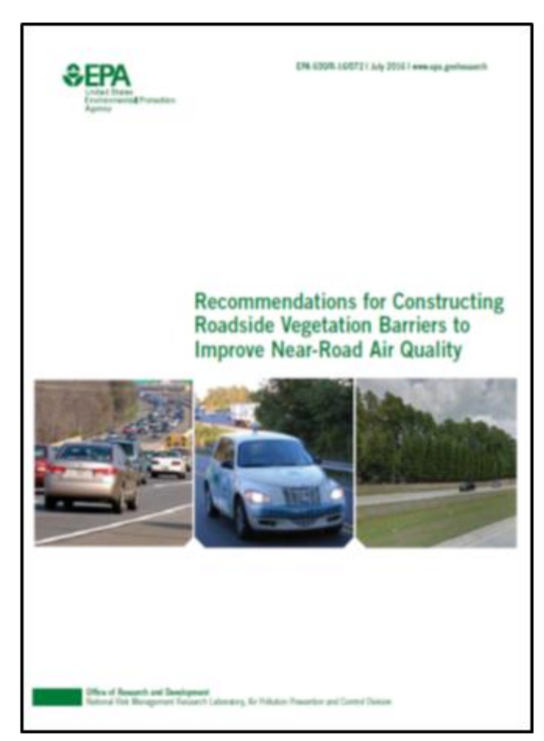
EPA
Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality

Figure 5. Near-road vegetation barrier planting recommendations.


Figure 6. Planting at Brookfield during the Martin Luther King, Jr. Day of Service event.


Figure 7. Planting at Brookfield during the Martin Luther King, Jr. Day of Service event.

Figures (cont.)


Figure 8. Solar Powered Air Quality Bird House (S-PAQ) includes solar-powered fixed system, Black Carbon Aethlabs AE-51 sensor, NO_2 CairClip sensor, and wind speed/direction sensor.

Figure 9. Portable Air Quality Sampler (PAQS) is an Arduino-based portable system with GPS, Black Carbon Aethlabs MA-200 sensor, NO_2 CairClip sensor, and interactive display with RETIGO-ready files.

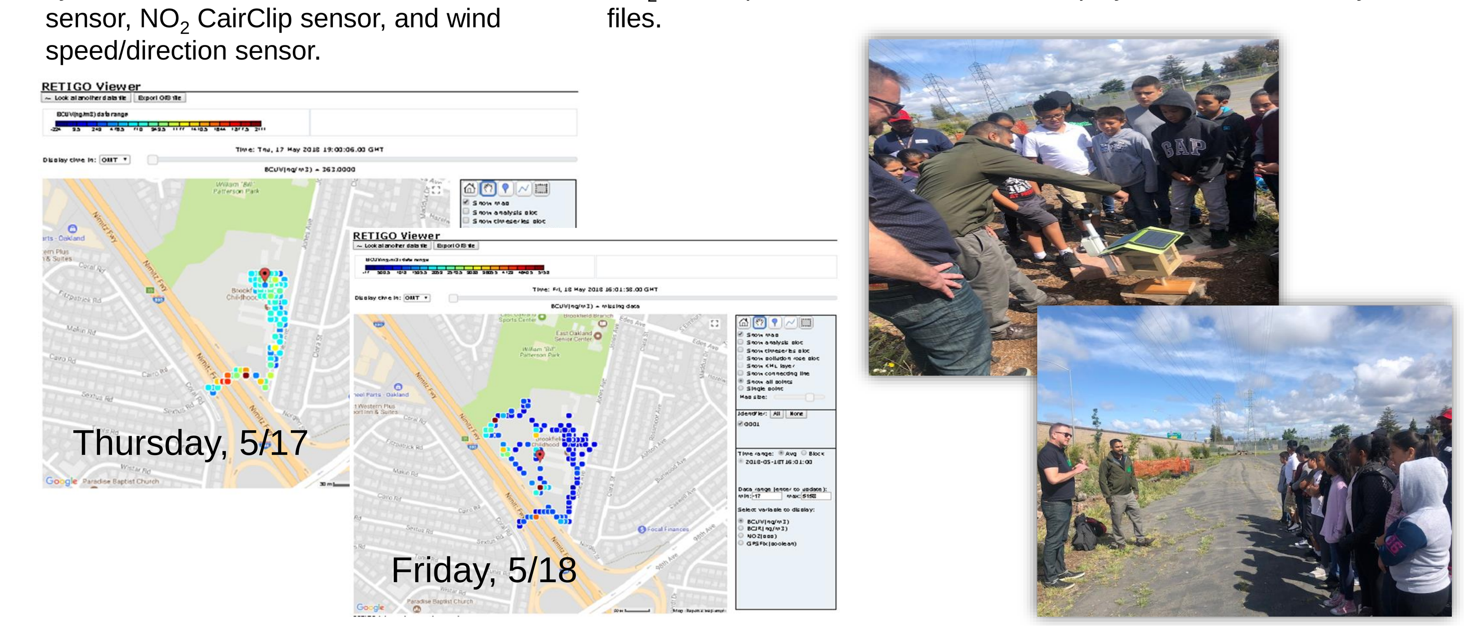

Figure 10. Example PAQS output collected during on-site training. Photos of equipment demonstration to students at Brookfield Elementary.

Lessons Learned and Next Steps

We learned a few lessons during the early phases of this project that could help inform future efforts to deploy sensors in a school/research setting:

- The presence of an on-site after school care program, or connection with a community organization that supports environmentally-focused STEM work, is crucial for maintaining engagement, supporting data collection, and expanding teaching opportunities.
- Planting infrastructure (e.g., irrigation) is a necessity to ensure appropriate vegetation care.
- Adequate soil preparation before planting may help protect against weather-related vegetation loss.
- Ongoing use of EPA's Near Roadway Planting Recommendations should be encouraged, especially during follow-up vegetation planting.
- Other design considerations should be discussed, such as maintaining visibility through the barrier to ensure student safety.
- Clear, stepwise instructions should accompany sensor package deployment.
- There will be a time lag between planting and an observable air pollution mitigation signal. This should be clearly communicated to project partners and the community.

EPA is working to enhance the utility of the sensor packages to provide the Brookfield community with real-time opportunities to collect data, learn about their local air quality and engage in air pollution awareness (**see related ASIC poster by Deshmukh et al**.). Enhancements include an expansion of the S-PAQ package to make them more portable and to require very little infrastructure (e.g., adding an interactive video display and provide online data availability features). For the PAQS system, we plan to incorporate the design into a portable, easy-to-use backpack (retaining the PAQS interactive video display/online data features). The enhanced sensor packages will be transferable to schools, communities, and citizen scientists.

Acknowledgments

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