



Something in the Air

How Communities Are Tracking
the Air They Breathe

A "State of the Air" Supplemental Report

EXECUTIVE SUMMARY



Executive Summary

“Something in the Air” is a report by the American Lung Association that seeks to broaden how air pollution monitoring is understood and used across the United States. Through a range of approaches, air quality monitoring provides communities with the information needed to track conditions, measure progress and advocate for solutions to persistent air pollution problems affecting their health. This report highlights community partners who have worked alongside agencies to interpret pollution data and translate it into information that informs residents, policymakers and the public.

This is the third report on air monitoring technology issued by the Lung Association. The first two “Something in the Air” reports used satellite data to identify broad gaps and localized pollution trends from above; this next phase moves to the ground, where community-driven monitoring and participatory science are increasingly essential complements to the regulatory system. While the U.S. Environmental Protection Agency’s (EPA’s) monitoring network remains the foundation for assessing compliance with the National Ambient Air Quality Standards (NAAQS), it is designed to characterize regional air quality trends rather than neighborhood-scale conditions, block-level variations, short-term emission spikes and local exposure patterns.

Across the United States, communities are building collaborative hyperlocal air monitoring networks to better identify pollution hotspots overlooked by traditional monitoring systems. Community-based monitoring fills these gaps by pairing transparent, publicly accessible data with defined decision pathways rooted in scientific expertise, cross-agency coordination, trust and shared decision-making—turning real-time information into data at the local, state and federal levels. This capacity is built through low-cost sensors, mobile monitoring and other research tools that translate data into tangible protections, enabling communities and agencies to pinpoint priority areas and apply evidence to planning, mitigation and oversight actions for cleaner air.

This report focuses on three air pollution sources for which community-generated data has become essential: wildfire smoke events, heavy-duty transportation corridors and point-source emissions such as industrial facilities and power plants. Drawing on six case studies—two for each source—the report shows how real-time monitoring reveals fine-scale pollution patterns and supports transparent data use, collective governance strategies and community resilience through coordinated response. Interpreted alongside lived experience and supported by regulatory and public health partnerships, these programs can catalyze policy interventions shaped by local priorities.

Each source featured in the case studies presents a distinct pollution dynamic that requires tailored monitoring strategies. Wildfire smoke highlights the value of rapid, hyperlocal information during fast-moving events, while heavy-duty traffic reflects continuous, corridor-based emissions that influence daily exposure. Point-source pollution illustrates persistent, facility-driven emissions concentrated in the same neighborhoods, day after day.



Wildfire Smoke

The first case study focuses on wildfire smoke—now one of the nation’s most widespread and severe air quality threats. Smoke shifts rapidly, traveling hundreds to thousands of miles and creating sharp neighborhood-scale exposure gradients that regional monitoring networks are not designed to capture in real time—especially in rural valleys, small towns and tribal communities. The first case documented here is Methow Valley Citizens Council’s Clean Air Methow’s Clean Air Ambassadors program in Washington, where residents were trained to steward more than 35 PurpleAir PM_{2.5} sensors across a 60-mile rural valley—building one of Washington’s largest community-based sensor networks for smoke response. The second, the PurpleAir in Schools Program in Montana, enrolled more than 100 schools within its first two years, with over 78 installing and operating paired indoor and outdoor air sensors to guide school-based responses during smoke events.



“Regulatory monitors are essential, but they’re expensive and designed to represent regional conditions. Low-cost sensors give us a practical way to understand what’s happening at the community level and to deliver information with real, lifesaving potential.”

— **Kelly Dorsi**, PhD, Section Supervisor, Air Research & Monitoring, Montana Department of Environmental Quality

Heavy-Duty Traffic

The second case study addresses heavy-duty traffic pollution—a daily, cumulative burden that disproportionately affects neighborhoods located near freight corridors, ports, railyards, warehouse districts and major trucking routes. Diesel emissions create sharp, block-level pollution gradients and short-term spikes that are rarely captured by regional monitoring networks designed for compliance, not local exposure. Community-based monitoring has been extremely effective at identifying idling hotspots, truck rerouting needs and differences in exposure across residential blocks. This case study profiles the Albany’s South End Neighborhood Air Quality Initiative in New York, where community input shaped traffic counts and combined fixed-site and portable monitoring to capture near-road pollution along heavy duty truck routes. It also profiles the West Oakland Environmental Indicators Project, which used data from mobile and stationary monitoring to guide investments in local pollution reduction projects, measurably reducing harmful air pollution and driving policy action.



“Transparency alone isn’t enough. Communities need tools and support to analyze and use the data, especially when monitoring is meant to inform decisions, not just document problems.”

— **Randi Walker**, Chief, Air Toxics Section, Division of Air, New York State Department of Environmental Conservation

Point-Source

The third case study focuses on point-source pollution in fenceline communities—areas adjacent to heavy pollution sources like refineries, petrochemical plants, power plants and other heavy industrial operations. Unlike regional background pollution, point-source emissions can occur in short bursts tied to flaring, equipment failures, leaks or nighttime operations—conditions not always adequately captured by regulatory monitors. Community-led monitoring



efforts in these areas have revealed the scale and frequency of emissions events, strengthened permitting and enforcement actions and generated data to inform emergency response and health-protective planning. The two cases examined include the Cultivando AIRE Project in Commerce City, Colorado and Sensing Air Justice in Rubbertown: Louisville, Kentucky. The Cultivando AIRE project documented emissions of 129 toxic chemicals and used those findings as a foundation for community advocacy and regulatory engagement. The Sensing Air Justice project conducted resident surveys and deployed low-cost sensors, integrating the data into broader community strategies to strengthen public participation, transparency, monitoring practices, enforcement and emergency preparedness.



“The first goal was to give families tools to make decisions for themselves—especially families with children with asthma. The second was to push decision-makers to improve permits and policy.” — **Megan Poole**, PhD, Assistant Professor of Rhetoric & Writing, University of Louisville

Taken together, these case studies demonstrate how hyperlocal monitoring is reshaping who can access data, who can act and when—accelerating decision making and enabling action in response to changing conditions. In rural communities affected by wildfire—especially those centered around schools—localized smoke data can guide emergency response and protective decisions in areas not covered by regulatory monitoring networks. Along freight corridors, neighborhood-scale mapping has informed anti-idling enforcement, truck-routing discussions and targeted mitigation investments. In fenceline communities impacted by point-source pollution, community monitoring has strengthened permitting engagement, substantiated reports of episodic emissions and elevated the case for stronger oversight and enforcement.

Across all three settings, shared themes emerge: clearly defined monitoring goals; strong data quality assurance and quality control (QA/QC) with appropriate correction factors; transparent dashboards and data visualization tools; pollutant-specific measurement strategies; and collaborative governance structures that promote shared data use and align monitoring with local decision making priorities. Community storytelling and lived experience—embedded in advocacy efforts and sustained engagement—transform data into credible evidence that shapes policy action. Rather than operating as standalone data efforts, these projects demonstrate the resilience and power of community-owned monitoring—rooted in long-term stewardship, local leadership and relationships that sustain action beyond individual events or funding cycles.

Public, neighborhood-scale monitoring shortens the distance between exposure and accountability, creating real-time information sharing and response mechanisms across agencies and polluters alike. By redistributing decision authority beyond agencies alone, monitoring enables communities, schools, health agencies, academic institutions, research organizations and governments to act in parallel—enhancing overall capacity to improve air quality.

Sustained progress depends on coordinated action across four levels—federal agencies, states, local governments and individuals and community groups. The following, cross-cutting recommendations apply across all three case studies and are reflected within each report, with tailored actions drawn from engagement with local leaders on lessons learned.



Recommendations

Federal Government

- Implement and enforce science-based, health-protective NAAQS, including the 2024 updated PM_{2.5} standard.
- Strengthen hazardous air pollutant standards and enforcement. Expand fenceline monitoring requirements to more stationary sources of hazardous air pollutants.
- Adequately fund state, local and tribal air agencies to sustain robust regulatory monitoring networks, including staffing, data platforms and infrastructure.
- Invest in dedicated, multi-year funding for community-led monitoring, supported across federal agencies (e.g., EPA, FEMA, USDA and others). Include investments in technical assistance hubs that provide calibration and collocation support, QA/QC protocols, quality assurance and data interpretation guidance. Support ongoing research into best practices.
- Develop guidance on minimum performance, documentation and transparency standards to integrate validated, community monitoring data into federal air quality decisions, including enforcement, inspections, permitting, compliance and rulemaking.
- Establish frameworks to utilize community-scale data for public health communications, emergency response and preparedness, and post-event evaluations.
- Building on the success of the EPA U.S. Fire and Smoke Map, improve and modernize federal data platforms to display validated and corrected community monitoring data alongside regulatory measurements. Permanently fund and expand federal wildfire smoke monitoring programs, including EPA's Wildfire Smoke Air Monitoring Response Technology (WSMART).
- Support cross-agency coordination among air agencies, transportation authorities, port and freight authorities and land-use and zoning regulators to integrate community monitoring into decision-making.

States

- Ensure stable, state-level funding streams, beyond short-term grants and projects, for community monitoring. Sustain cross-agency partnerships that build local expertise and tailor to local needs.
- Partner with universities, air agencies and research institutions to provide technical support—including sensor deployment, data hosting, calibration and validation, assessment and maintenance, data useability and hands-on training—for community, school and tribal monitoring programs.
- Integrate properly corrected community sensor data into dashboards, maps, public advisories and communication platforms that support incident-response systems, neighborhood-level messaging, school and outdoor activity guidance, emergency response decisions, post-event assessments and inclusion in state resilience planning.
- Establish frameworks that formalize community participation and transparency in air quality decision-making, including defining how community input informs agency actions and ensuring feedback loops between residents and decision-makers. Ensure a pathway for community-generated data to be used to identify high exposure areas.



- Use quality-assured community data to inform state permitting decisions, cumulative-impact analyses and targeted inspections, and formalize how neighborhood-scale monitoring feeds into state air quality programs to support enforcement screening, mitigation prioritization, emergency monitoring plans, transportation planning and land-use strategies. SIPs can remain anchored to regulatory monitoring for NAAQS compliance while using quality-assured community data to identify hotspots and better target where emission reductions can be applied.
- Support Tribal sovereignty in air monitoring by strengthening EPA State and Tribal Assistance Grant (STAG) support for tribal air programs, including sustained funding for staff, operations and data ownership and use.

Local Governments

- Commit sustained funding to support the full lifecycle of community air monitoring, including sensor maintenance and replacement, staff capacity and training, partnerships, public data platforms and ongoing engagement that links monitoring to public health and emergency response.
- Coordinate across cities, counties, regional agencies, public health and emergency planners and neighboring jurisdictions to align monitoring with pollution patterns, enabling residents and agencies to co-develop priorities, review data and guide mitigation strategies.
- Embed air quality monitoring into local emergency management and hazard-mitigation plans by establishing formal cross-department protocols that define how community sensor networks are used in public communications, emergency operations, recovery planning and future preparedness, require agencies to use real-time data to guide coordinated response during major pollution events, and document lessons learned to improve future decision making.
 - Wildfire smoke: Use data to guide decisions on outdoor activities, worker safety, school and childcare operations, ventilation and clean-air shelter activation.
 - Heavy-duty trucks: Apply data to inform truck routing, idling enforcement, curb management, port operations and roadway design.
 - Point-source pollution: Integrate data into investigations, permitting review, public comment processes and facility-level mitigation actions.
- Regularly review monitoring data to identify areas of elevated concentrations, dominant sources and exposure trends, and conduct after-action reviews following major events to refine communication, sensor placement, outreach and resource deployment.
- Preserve quality-assured community data for public comment and, when needed, legal review, strengthening the administrative record with real-world exposure evidence.
- Support community events and volunteer networks—including schools, faith-based organizations and health clinics—to engage residents as sensor hosts and data stewards.
- Use transparent, plain-language and multilingual reporting tools with visuals and maps to support public understanding and informed participation in policy discussions.



Individuals/Community Groups

- Collaborate with academic entities, public health organizations, government agencies and commercial vendors to secure multi-year grant funding support for deploying monitoring projects and sustaining staffing, data infrastructure and stewardship.
- Bolster community capacity and support through coordination with local schools, tribal, faith-based and neighborhood organizations in under-resourced or rural areas.
- Use publicly accessible air quality data, supported by cross-sector partnerships, to deliver clear findings, actionable requests and health-protective protocols to local municipal boards, school boards, commissions and decision-making bodies.
- Apply neighborhood-scale data to advocate for health-protective actions, including emergency alerts, clean-air shelter activation and smoke-day school and work adjustments, truck rerouting, idling restrictions, buffer zones near homes and schools, and stronger fence-line monitoring, permit modifications, targeted inspections, health symptom tracking and enforceable mitigation during permit renewals or expansions.
- Build data literacy by training local staff, volunteers, leaders and residents to interpret corrected data, document pollution events and communicate findings effectively, while establishing clear governance structures over roles, authority and data ownerships.
- Plan for the full data lifecycle and continuous improvement—from defining monitoring questions and selecting sensors to placement, calibration and maintenance; data collection, backup and useability; to quality assurance and sustained use of results.
- Document and apply lessons learned to improve communication strategies, locally tailored data models, resource deployment and long-term operation and sustainability.
- Maintain public-facing dashboards that integrate sensor data and forecasts with plain-language health guidance, designed to be mobile-friendly, multilingual and accessible to non-experts.
- Educate residents on local emergency preparedness and response protocols, including the communication channels used to deliver rapid public alerts during pollution events.

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55 W. Wacker Drive, Suite 1150 | Chicago, IL 60601 | Ph: 312-801-7630 | Lung.org





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Tracing the Smoke:
Wildfire Pollution in Real Time



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Wildfire smoke has become a defining air quality challenge across the United States, creating rapidly changing conditions that can elevate both immediate health risks and long-term exposure concerns. These impacts are more difficult to characterize in communities where monitoring coverage is sparse, and localized information is limited. As smoke events become more frequent and prolonged, wildfire smoke demonstrates—often with urgency—how hyperlocal, community-generated data can support health decisions during conditions that shift faster than traditional monitoring systems are designed to capture.

The two case studies featured in this section—Clean Air Methow’s Clean Air Ambassadors (CAA) program in Washington and the PurpleAirs in Schools Program in Montana—identify how communities experience wildfire smoke and use real-time data to coordinate protective actions that support both active response and sustained preparedness through locally operated, partnership-based monitoring networks. Together, they show how cross-agency monitoring programs enable decision makers to translate accessible data into proactive public health strategies and rapid-response systems. They also reveal how sustained sensor programs—through long-term operation, maintenance, and data quality assurance—strengthen public communication,



reflect local needs and reinforce existing safeguards during environmental crises. In this report, terms relating to community sensors (e.g., hyperlocal, low-cost, real-time) are used interchangeably to describe affordable air monitoring devices widely deployed by communities, organizations, and affiliated partner agencies to track neighborhood-scale air pollution. Community-focused sensor programs inform personal safety decisions and help document pollution exposure before, during and after smoke events. This data can also support community advocacy for resources and initiatives that strengthen prevention and preparedness for future events. The two subsequent case studies that follow broaden this lens, illustrating additional pathways for integrating community monitoring into a modern, resilient air quality framework. Together, they build on this entry point, showing the utility of community-driven monitoring during periods of increased pollution and their ability to foster partnerships, inform policy, guide investments, and make air quality data more accessible and actionable.



Wildfire Smoke Is a Growing Public Health Crisis

Wildfire activity continues to increase in frequency, severity and duration, expanding the scale and extent of population exposure to smoke. On average, 70,000 wildfires occur across the United States every year (Department of Homeland Security [DHS], 2025). These fires burn millions of acres annually, destroying infrastructure, disrupting communities and claiming lives. The resulting economic, environmental, and social impacts are long-lasting, affecting public health, ecosystems, and regional stability well beyond the fires themselves. In an era of intensifying wildfires, the air we breathe has become an even more critical public health concern.

Wildfires are now the dominant force behind many of the nation's most dangerous particle-pollution days, driving unprecedented numbers of “very unhealthy” and “hazardous” air days as classified using the U.S. Environmental Protection Agency's (EPA) standardized Air Quality Index (AQI). According to the American Lung Association's “State of the Air” 2025 report, nearly half of Americans—approximately 156 million people—now live in places that received failing grades for ozone (O₃) and/or particle pollution. Dozens of metropolitan areas are now experiencing their worst-ever levels of fine particle pollution (PM_{2.5}). This significant rise in risk from wildfire smoke reflects the convergence of extreme heat, prolonged drought, high-wind conditions and increasingly volatile fire behavior—factors that drive sustained periods of dangerous air quality nationwide, a trend expected to intensify as climate change accelerates and hotter, drier conditions fuel more frequent fires and longer periods of heavy smoke.

Together, these dynamics mean more people are breathing more wildfire smoke more often, and frequently without timely, local air quality information to guide their decisions. The EPA notes that wildfire smoke “can travel hundreds to thousands of miles, impacting air quality nationwide” (U.S. EPA, 2024b). Smoke does not respect county lines, monitor locations or agency boundaries: it pools in mountain valleys, shifts quickly and unevenly with changing winds, and can blanket communities far from the flames. In many of these places, the nearest regulatory monitor may sit miles away, upwind or in a different airshed altogether. When wildfires smoke surges, the regional AQI may read “moderate,” but local conditions and exposure risk can vary greatly. This gap is particularly acute in communities already facing heightened vulnerability during wildfire events. In rural valleys, in small towns, on tribal lands, and in under-resourced neighborhoods there are often fewer regulatory monitors, less access to health care, and fewer options for avoiding exposure. The most impacted communities may lack access to data that reflect the true severity of smoke exposure and may not receive prompt, tailored guidance or response-relevant resources.



Community-based monitoring offers a way to change that. Research demonstrates that these monitoring networks can capture PM_{2.5} concentrations with high spatial and temporal resolution during wildfire events, providing detail that traditional networks are not designed to capture on their own (Stampfer et al., 2024). This section, *Tracing the Smoke: Wildfire Pollution in Real Time*, explores how community-based sensor networks, forged through partnerships among grassroots organizations, researchers and public agencies, are reshaping how we prepare for, respond to, and recover from wildfire smoke events. Deployed through partnerships at homes, schools, clinics and tribal facilities, community-



based sensors can supply local policymakers with data needed to track fast-moving smoke and guide timely responses. These responses can include adjusting outdoor activities, opening up clean-air shelters, or distributing masks and air cleaners to those most at risk, including children, older adults, pregnant individuals, outdoor workers and people with heart or lung conditions. Across the U.S., community-led monitoring initiatives demonstrate how participatory approaches are extending beyond a technical tool to serve as a form of collective resilience. To understand why this information is critical, it is important to recognize what wildfire smoke is made of and the health risks it creates.

Por La Creación’s El Aire Que Respiramos (“The Air We Breathe”) program offers one illustrative example, showing how accessible PM_{2.5} monitoring—paired with education and storytelling—can elevate community voices and translate air quality data into personal, public, and policy-relevant action across multiple states.

Pollutants

Wildfire smoke is a complex and dynamic mixture of gases, particulate matter, water vapor and other pollutants that can affect human health through multiple pathways. Some of these pollutants are regulated because of their toxicity and potential to cause serious health effects. Hazardous air pollutants (HAPs) are one such category, defined under the Clean Air Act to include certain toxic gases and particle-bound compounds that are emitted from industrial sources – and are also present in wildfire smoke.

Wildfire Gases	Wildfire Acids & Compounds	Particulate Matter	Secondary Pollutants
<ul style="list-style-type: none"> • Carbon Monoxide (CO) • Ammonia (NH₃) • Nitrogen Oxides (NO_x) • Volatile Organic Compounds (VOCs) • Polycyclic Aromatic Hydrocarbons (PAHs) • Sulfur dioxide (SO₂) 	<ul style="list-style-type: none"> • Sulfuric Acid • Inorganic Compounds: • Ammonium Sulfate • Ammonium Nitrate • Sodium Chloride • Organic chemicals, soil or dust particles, metals & biological materials (e.g., pollen and mold spores) (Badger, 2025). 	<p>Particulate matter refers to a mixture of solid particles and liquid droplets suspended in the air that vary in size, composition, and origin.</p> <ul style="list-style-type: none"> • PM_{2.5} (fine particulate matter) consists of particles 2.5 micrometers or smaller • PM₁₀ inhalable particles, with diameters that are generally 10 micrometers and smaller 	<ul style="list-style-type: none"> • Ozone (O₃) • Secondary Organic Aerosols (SOA)



PM_{2.5} is a primary component of wildfire smoke, as decades of research and evidence link exposure to well-documented serious health effects. Ground-level ozone is a secondary pollutant that is not emitted directly by wildfires but forms through atmospheric reactions involving NO_x and VOCs in the presence of sunlight, allowing ozone to accumulate and persist far downwind of fire activity (Badger, 2025). With strong summertime solar radiation, warm temperatures and stagnant air, ozone and SOA concentrations can increase substantially far from the fire source. Ozone formation depends on the timing, composition and atmospheric processing of smoke, as concentrations can vary widely, making the impacts less predictable but no less consequential for public health (U.S. EPA, 2025b). Escalating wildfire activity has produced larger and more prolonged smoke events, making wildfires a dominant driver of seasonal and episodic PM_{2.5} events across the U.S. and pushing concentrations well beyond health-based standards.

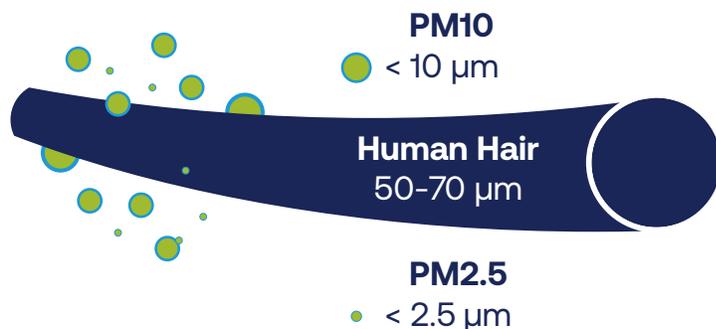


Health Effects

Wildfire smoke can travel hundreds to thousands of miles, and recent increases in wildfire activity have amplified both the duration and intensity of exposure, extending health impacts far beyond fire-affected regions. As smoke moves, it carries a complex mix of pollutants that pose risks to a wide range of populations. HAPs present in wildfire smoke may contribute to adverse health effects in infants, children, pregnant people, older adults, individuals with existing lung and heart disease, and those engaging in outdoor or physical activity. VOCs in smoke can cause respiratory irritation, organ damage and, in some cases, cancer, affecting health both through direct exposure and through their indirect role as precursors to ground-level ozone.

Ozone concentrations may also be elevated during wildfire smoke events, which can lead to a range of respiratory effects such as reductions in lung function, inflammation of the airways, chest pain, coughing, wheezing and shortness of breath—even in healthy people. These effects can be more serious in individuals who have asthma and other lung diseases (U.S. EPA, 2025b).

During major smoke events, PM_{2.5} levels can surge far above normal with little warning. Studies show that wildfire-related PM_{2.5} is often more toxic and more episodically intense than particle pollution from traffic or industry (O’Dell et al., 2023). These tiny particles can bypass the body’s defenses, travel deep into the lungs and enter the bloodstream, where they can trigger inflammation and systemic effects. Short-term PM_{2.5} exposure from wildfire smoke can trigger irritation of the eyes and airways, asthma complications, cardiovascular stress, and premature mortality (U.S. EPA, 2025b). Rapid PM_{2.5} spikes can increase emergency department visits and create chronic obstructive pulmonary disease (COPD), pneumonia, and cardiovascular complications—especially among individuals who are more susceptible to adverse health effects (U.S. EPA, 2024b).



Long-term exposure to PM_{2.5} is associated with heart attacks, strokes, asthma attacks, bronchitis and other respiratory conditions, as well as adverse birth outcomes and the worsening of chronic illnesses. Repeated wildfire smoke episodes now contribute to chronic bronchitis, accelerated lung-function decline, and increased all-cause mortality—especially in regions exposed over multiple seasons (O’Dell et al., 2023). Smoke containing evaluated levels of both ozone and PM_{2.5} pose more severe health impacts than exposure to either pollutant alone (Cooper et al., 2024). Children are particularly vulnerable, as developing lungs increase sensitivity to high-smoke days, with prolonged episodes linked to higher rates of bronchitis, wheezing, and breathing difficulties.

In addition to contaminating the air with toxic pollutants, wildfires also simultaneously impact the climate by releasing large quantities of carbon dioxide and other greenhouse gases into the atmosphere.

Why Real-Time, Hyperlocal Data Is Needed

In today’s shifting regulatory climate, collaboration across grassroots organizations, researchers and public agencies has never been more essential. These collaborations make it possible to secure grants, build capacity and deploy tools that extend hyperlocal sensor data into the hands of residents, while also translating that data into formats that inform decision makers and institutional responses. Grounding this work in transparency, shared goals and mutual trust helps ensure that air quality data moves beyond collection alone. When communities and agencies understand how data are gathered, shared and used, that information can be clearly communicated and applied to prevent harm, support emergency response and guide policy change. From rapid response networks to co-designed public dashboards, these alliances help transform environmental data into meaningful protection—not just measurements.

Regulatory Monitoring

To understand why these hyperlocal systems are so crucial, it’s important to look at the current federal monitoring framework—what it provides and where its limitations create gaps that communities are increasingly working to fill. The national regulatory air monitoring network plays a central role in assessing air quality and supporting air pollution management across the United States. This system is anchored in the National Ambient Air Quality Standards (NAAQS), which require the EPA, in partnership with state, local and tribal air agencies, to monitor six criteria pollutants: PM_{2.5}, PM₁₀, Ozone, CO, NO₂, and SO₂ (U.S. EPA, 2024c).

Federal Reference Method (FRM) and Federal Equivalent Method (FEM) monitors are U.S. EPA-approved devices for accurately measuring criteria air pollutants—forming the backbone of the U.S.’s regulatory air quality monitoring system. These instruments are designed to meet strict performance, calibration and quality assurance requirements to ensure data accuracy, consistency and comparability across locations and over time. This network consists of strategically located monitoring stations designed to characterize population exposure, support regulatory decisions and track long-term air quality trends. As of 2025, the U.S. operates approximately 1,000 regulatory-grade PM_{2.5} monitors (U.S. EPA, 2024a). In addition to supporting regulatory compliance, data collected by FRM and FEM monitors are stored in EPA’s Air Quality System (AQS) and used to generate AQI values that inform the public when air pollution reaches levels that may require protective action. (U.S. EPA, 2024c).



Regulatory-grade monitoring remains the gold standard used to demonstrate NAAQS compliance and to validate and quality assure air quality sensors. Regulatory networks also provide data essential for regional context and long-term statewide trends analysis. However, gaps in coverage and limitations in network design prevent regulatory monitors from capturing hyperlocal, episodic events and rapid neighborhood-scale variability during dynamic pollution conditions, such as wildfire smoke. For example, ozone monitors can detect hourly, regional changes influenced by wildfire-related VOCs and NO_x, but their siting limits insight into fine-scale conditions. At the same time, PM_{2.5} concentrations can shift rapidly over short distances as smoke plumes move across populated areas, creating local exposure patterns that are better captured by complementary monitoring systems such as community-based sensors.

Emerging Wildfire Smoke Monitoring Tools

Agencies are increasingly using specialized monitoring tools that augment existing regulatory networks. These efforts are intended to supplement—not replace—regulatory-grade data by enhancing the ability to track smoke movement, intensity and community-level impacts in real time.

DHS “Sniffing” Wildfire Detection

The Department of Homeland Security Science and Technology Directorate (DHS-S&T), along with the Federal Emergency Management Agency (FEMA), U.S. Fire Administration (USFA), industry partners, and state and local fire agencies continue to develop new capabilities for reducing wildfire impact. From 2021 to 2024, federal agencies deployed specialized wildfire sensors focused on early ignition detection to support community protection and public safety. These advanced sensors use particulate, gas and environmental measurements—paired with artificial intelligence—to “sniff out” fires within seconds, often before they’re visible (DHS, 2025). While critical for emergency response, these systems were designed to identify wildfire ignition rather than to characterize evolving smoke exposures.

Wildfire Smoke Air Monitoring Response Technology (WSMART)

U.S. EPA and various commercial vendors focus on tracking wildfire smoke after ignition. Their sensors monitor PM_{2.5} levels over wide areas, helping assess exposure, inform public health alerts and guide protective actions. The WSMART loan program supports state, local and tribal air agencies by providing supplemental air monitoring equipment in wildfire-affected areas. WSMART offers a range of stationary and mobile air monitoring systems, including PurpleAir and multipollutant systems from manufacturers like Outpost Environmental and QuantAQ, Inc. These supplemental sensor technologies primarily measure PM_{2.5}, CO, total VOCs (tVOCs), and in some systems, black carbon. Available systems include two stationary configurations—a PM_{2.5} sensor and a multipollutant unit measuring PM_{2.5}, CO and other gases—as well as a portable option, the Vehicle Add-on Mobile Monitoring System (VAMMS), which provides high-resolution, GPS-linked air quality data (U.S. EPA, 2025c). EPA provides technical support, training and data visualization tools for agencies borrowing equipment, including opportunities to test equipment outside the fire season to strengthen preparedness and expand use during prescribed burns. As of January 14, 2026, new loan requests were temporarily on hold, pending further operational project updates.



State Agency-Run Monitoring

In addition, wildfire-prone states across the West have expanded their own state agency-run monitoring systems to supplement the federal network and address gaps in coverage. Oregon's Department of Environmental Quality (ODEQ) operates a statewide smoke-monitoring framework that combines permanent regulatory monitors with ODEQ-deployed temporary "smoke monitors" during active fires and integrates corrected PurpleAir data into the state-managed Oregon Smoke Blog and public smoke map (ODEQ, 2024). In addition, California's Air Resources Board (CARB) operates the state's regulatory monitoring system and supplements it with state-owned rapid-deployment air monitoring trailers, low-cost sensor networks and statewide smoke-communication tools such as Smoke Spotter and AQ View, providing real-time information during major fire events (CARB, 2024).

These efforts underscore the importance of collaboration across departments, air agencies, governments, Tribal Nations, researchers and community organizations, each of which carries a critical piece of the wildfire-response puzzle. No single system can meet the speed, scale and distribution challenges posed by today's smoke events, but together these partnerships can create a more adaptive and resilient monitoring infrastructure. This multilevel coordination is the foundation on which the next generation of air-quality tools is being built, and it is central to the case studies that follow.

In practice, community-driven wildfire smoke data can be used by federal, state and local agencies in several complementary ways. Agencies may integrate validated sensor data into existing public-facing smoke and air quality maps to improve spatial coverage and timeliness. They can use real-time sensor trends to inform public health advisories, school and outdoor activity guidance and workplace protections, while also incorporating sensor networks into emergency response operations to support awareness during active fire and smoke events. Over the longer term, agencies can embed sensor data into state hazard-mitigation plans, climate resilience strategies and emergency-response protocols to guide preparedness planning, resource deployment and post-event evaluation.

These approaches are supported by detailed recommendations and an accompanying resource toolkit that outline practical pathways for operationalizing data for decision-making, communication and preparedness.

Community Sensor Networks

These case studies focus on $PM_{2.5}$ because it is the pollutant most often measured by community sensors and the EPA criteria pollutant used to assess health impacts from wildfire smoke, making it the most operationally useful indicator for tracking smoke exposure and informing real-time decisions.

The case studies focus on Clarity and PurpleAir sensors, which are commercial sensors integrated into the U.S. EPA's Fire & Smoke Map. Clarity sensors are built for wildfire conditions, using solar power, cellular connectivity and weather-resistant enclosures to operate reliably without external power or Wi-Fi. Clarity's Node-S extends $PM_{2.5}$ monitoring into remote or infrastructure-limited areas, and in July 2025 it became the second commercial sensor approved for inclusion on the U.S. EPA's Fire & Smoke Map (Clarity Movement Co., 2025). PurpleAir sensors estimate $PM_{2.5}$ using laser-based optical particle counters that detect how airborne particles scatter light inside the sensing chamber. Dual laser channels



provide built-in redundancy and quality checks, and the device averages their readings for greater stability. The compact, weather-resistant units operate continuously outdoors, updating data about every 120 seconds and transmitting it via Wi-Fi to publicly accessible maps. PurpleAir was first incorporated into the U.S. EPA Fire & Smoke Map in 2020, when EPA introduced a national correction factor for displaying adjusted PurpleAir readings alongside FRM/FEM monitors.

As founder of Purple Air Adrian Dybwad explained, **“We want to offer our free, real-time maps to assist the public when dealing with traumatic disasters created by wildfires.”** Communities across the country are using PurpleAir, Clarity and other low-cost sensors not as perfect instruments, but as sources of immediate information that can drive action during smoke events.

U.S. EPA Fire & Smoke Map

The U.S. EPA and U.S. Forest Service developed the AirNow Fire and Smoke Map to provide the public with information on fire locations, smoke plumes, near real-time air quality, smoke outlooks and actions people can take to protect their health — all in one place. The map combines data from satellite imagery, ground-based sensors and modeled smoke forecasts. Used for rapid response, information sharing, and coordination during wildfire events, they provide tools for action, communication and protection, and are accessible to decision makers and the public (U.S. EPA, 2025d). As burned acreage and smoke exposure grow each year, residents, schools, clinics and governments can use this tool to interpret shifting conditions and make informed choices about work or school closures, outdoor activity, ventilation and protective equipment. These sensors, often sampling every one to two minutes, provide families with information when they need it most. This is why community monitoring projects are essential for local resilience.



Air Quality Index (AQI)	
Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300
Hazardous	301+



Limitations of Sensors

Community sensor devices respond to humidity, temperature and particle composition in ways regulatory instruments do not. As a result, their raw measurements of can overestimate or underestimate true PM_{2.5} concentrations depending on wildfire smoke composition, ambient moisture and regional aerosol types. Regulatory-grade monitors and community sensors can complement each other, but operate on fundamentally different principles, serve different purposes, and produce data that cannot be directly compared without careful correction. Sensor performance may also decline over time due to environmental exposure, requiring periodic maintenance. The data these tools provide are user-friendly, but effective interpretation depends on scientific guidance and community education to ensure accurate understanding and to avoid misinterpretation. Power or internet outages during wildfires can interrupt data transmission—one reason many networks rely on solar and cellular setups. Community-based sensors are only effective when paired with reliable platforms that translate real-time data into actionable guidance. Without tools to interpret and deliver this information, communities may be left without the insight needed for health decisions or emergency responses. Offering clear

“A critical step is understanding what low-cost sensors can reliably measure and the value they provide—while also recognizing their limitations. Asking what these sensors do and don’t do, and what practical use their data has, is a big and necessary question for any community.” — George Wyeth, a former EPA attorney for 27 years, now assisting the Environmental Protection Network.



visualizations, maps, time-series trends and infographics, these platforms are designed for non-expert audiences, making technical information more relatable, accessible, and responsive. Multiple entry points—like mobile-friendly dashboards, downloadable data and multilingual content—ensure that people with varying needs can access and use the information.

Despite their limitations, community sensors—when properly maintained and paired with accessible platforms—fill a critical gap by providing minute-by-minute visibility in areas with limited regulatory monitoring, enabling health agencies, emergency responders and the public to make rapid, potentially lifesaving decisions during fast-changing wildfire conditions.

Case Studies

According to the 2025 “State of the Air” rankings, counties in Washington and Montana are represented eight times among the top 25 most polluted counties for both the short-term and annual PM_{2.5} categories. In these contexts, wildfire smoke has emerged as a defining air quality challenge, and the case studies that follow examine how these monitoring programs, coordinative efforts and data-sharing approaches are the catalyst to reduce local exposure.

Clean Air Methow Clean Air Ambassador program- Washington

The Methow Valley sits on the eastern flank of Washington’s North Cascades, carved by glacial and river processes that created a long, narrow basin running roughly 60 miles from Mazama through Winthrop and Twisp toward the Columbia River (U.S. Census Bureau, 2024). Situated in Okanogan County, it is one of the state’s most wildfire-prone regions.

Okanogan County’s population of roughly 45,000 includes nearly 25% older adults, 21% Latino residents, and 12% Native Americans —groups with elevated vulnerability to smoke exposure and particle pollution (Washington State Department of Ecology, 2025c). The Methow Valley’s geography—characterized by deep mountain bowls and narrow canyon corridors—restricts air movement, particularly overnight when strong temperature inversions form and cold, dense air settles along the valley floor. These inversions can lock heavy smoke near the ground for hours or days, with smoke funneled through narrow passes, pooling in basin-like pockets and recirculating with shifting nighttime winds. Smoke impacts in the Methow Valley are driven both by local fires and by smoke transported from regional wildfires across the North Cascades, eastern Washington, and southern British Columbia, prolonging exposure even when no fire is burning nearby. The regions continental climate intensifies these conditions: hot, dry summers, low annual precipitation and increasingly early snowmelt extend periods of dry fuels and contribute to a wildfire season that now commonly stretches from late spring into October. Limited road access and long travel distances further constrain residents’ ability to avoid smoke exposure, increasing reliance on local, real-time information to guide daily activities, school operations and health-protective decisions. This combination of topography and climate produces sharp, hyperlocal



Figure 2: Map of Methow Valley, WA



smoke gradients that are not captured by the two regulatory monitors located in Twisp and Winthrop—shown in the circle on **Figure 3** (Washington State Department of Ecology, 2025b). In Washington, air Pollution is tracked through the Washington Ambient Air Monitoring Network, operated by the Department of Ecology and partner agencies. As of July 2025, this network included about 70 monitoring sites and incorporates FRM/FEM monitors required for federal compliance, as well as special-purpose monitors for wildfire smoke, ozone and tribal air quality (Washington State Department of Ecology, 2025b). To expand smoke preparedness, Washington launched SensWA— a statewide network of low-cost PM_{2.5} sensors funded through the Climate Commitment Act (Washington State Department of Ecology, 2025b). As of mid-2025 there were roughly over 63 SensWA sensors deployed and reporting PM_{2.5} (Washington State Department of Ecology, 2025a). Many of these sensors are positioned in places without regulatory monitors, while many others were collocated with FRM/FEM instruments to support calibration and data validation. Despite these expansions, the state’s 2025 Ambient Air Monitoring Network Assessment concludes that Washington’s regulatory system still cannot capture neighborhood-scale smoke variations across mountain valleys and rural regions. Community-based monitoring is identified as essential for filling these gaps—especially as smoke event concentrations can shift dramatically within minutes (Washington State Department of Ecology, 2025b). The Methow Valley exemplifies these challenges.

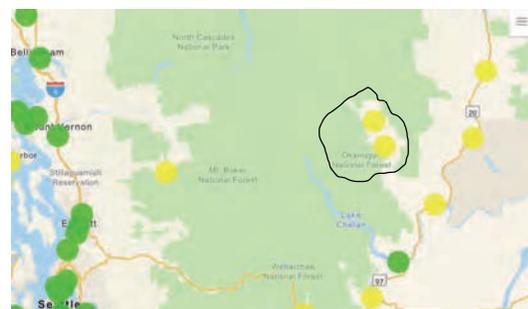


Figure 3: Washington Department of Ecology Regulatory Monitors (2026)

Founded in 2013 under the fiscal sponsorship of the Methow Valley Citizens Council, a 501(c)(3) nonprofit organization, Clean Air Methow worked in collaboration with air quality managers and scientific guidance from Liz Walker, PhD, Principal of Smoke Ready Solutions and Affiliate Assistant Professor in the Department of Occupational and Environmental Health Sciences at the University of Washington. In 2018, Clean Air Methow launched the Clean Air Ambassadors (CAA) program, anchoring a long-term framework for community-led public health protection strategies grounded in local action. Originally launched in the Methow Valley, the PurpleAir sensor network and CAA program expanded into an Okanogan County–wide effort. By spring 2019, it managed one of the largest rural PurpleAir sensor networks in the nation, with CAA currently hosting and maintaining over 35 sensors across the Methow and Okanogan Valleys, spanning approximately 180 miles (Clean Air Methow, 2022). Through this work, the program integrated technical rigor with community capacity-building to help residents navigate wildfire smoke, winter woodsmoke and complex local microclimates. While the CAA sensor network remains deployed and active, the program is currently dormant due to the absence of dedicated funding and staffing capacity, with plans to resume as new funding opportunities become available.

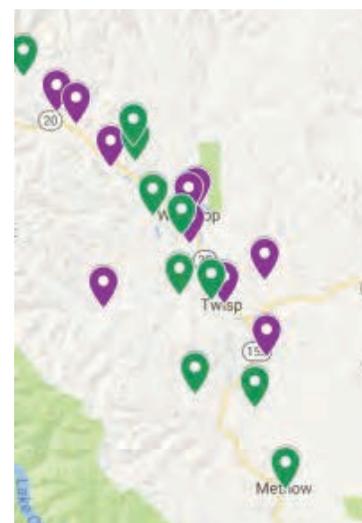


Figure 4: CAA Phase I sensors (purple) and Phase II sensors (green)

Despite the current pause in funding, the program’s staged deployment model and community partnerships established a lasting foundation for future monitoring efforts. This integrated approach was carried out through a phased expansion of the community sensor network. **Figure 4** depicts Phase I and Phase II of the CAA program.



Phase I shows the initial deployment of air quality sensors across the Methow Valley, while Phases II and III expanded the network to additional locations and elevations across the county, increasing spatial coverage and the ability to capture localized smoke conditions. This phased expansion was paired with intentional community recruitment. The CAA program strategically engaged volunteer residents across diverse elevations, populations and neighborhoods to ensure broad geographic and demographic representation. These low-cost sensors were hosted by community members, including those without scientific backgrounds. Ambassadors received training to maintain instruments and interpret data for practical decision-making, including interpreting PM_{2.5} trends and data, applying EPA correction factors and understanding differences between real-time and 24-hour averages (Clean Air Methow, 2020). This training component was a defining feature of the program, turning residents into trusted local data stewards. In practice, ambassadors not only maintained sensors but also taught neighbors about smoke readiness, assisted with clean-air room setup, provided real-time local observations during fires, helped extend monitoring coverage across remote areas and supported community education on wildfire smoke and indoor air quality improvements, using portable sensors and air cleaners (Clean Air Methow, 2022). Participants were included in hands-on workshops, seasonal smoke-preparedness campaigns and events focused on high-efficiency particulate air (HEPA) filtration and mask use (Clean Air Methow, 2023). The program also incorporated student interns that were selected to help conduct academic research towards the improvement of smoke readiness, risk communication and disaster preparedness and response.

“In Okanogan County, our network of purple air monitors really helps the community navigate fire season. Real-time, reliable information about fire and smoke activity is crucial to maintaining a sense of safety and agency.” — Liz Walker, PhD, Principal, Smoke Ready Solutions, and Affiliate Assistant Professor, Department of Occupational and Environmental Health Sciences, University of Washington

The CAA program expands beyond monitoring and supports broader resilience efforts—including guidance on clean-air shelters and partnerships with clinics and senior centers to protect medically vulnerable residents. The program supports school air quality protocols by including local schools as sensor hosts, giving administrators decision-making tools and information to determine whether conditions are safe for outdoor recess and athletic activities (Clean Air Methow, 2022).

During major wildfire seasons, Clean Air Methow’s sensors are often the most-viewed stations on the Washington PurpleAir map, capturing rapid smoke spikes that are not reflected in nearby federal monitors. The CAA program has grown from a small woodsmoke-awareness effort into a regional hub for smoke preparedness, public education and sensor deployment, supported by publicly-accessible, real-time air quality data that supplement state messaging during smoke emergencies. The program is a model for how rural communities with limited regulatory coverage can build their own reliable, real-time air quality infrastructure. By blending scientific oversight with community participation, the Methow Valley built one of the most durable and trusted wildfire-smoke monitoring systems in the rural West—a model for rural, tribal and underserved communities nationwide.





What Community Monitoring Enabled in the Methow Valley

- Application of EPA-endorsed PM_{2.5} correction factors to improve data usability.
- Data-literacy education for residents and sensor hosts.
- Guidance on interpreting real-time versus 24-hour PM_{2.5} averages.
- Indoor air quality strategies, including the use of HEPA air cleaners.
- Outreach and support during severe wildfire smoke events.

Clean Air Methow’s experience highlights a broader vulnerability shared by many community wildfire preparedness efforts: without sustained funding and staffing support, even well-established programs face challenges maintaining continuity over time. This underscores the importance of stable investment to support smoke readiness and long-term public health protection. What Clean Air Methow established—community relationships, monitoring infrastructure and practical strategies—provides a strong operational foundation to build on when securing new funding and staffing, offering a model for communities nationwide facing similar funding disruptions.

Public-Facing Dashboards

Clean Air Methow utilizes social media, a mobile app, and an online website to communicate air quality data. Their website’s air quality map mirrors and links to the Washington Smoke Blog which provides corrected sensor data and helps support decisions on school activities, outdoor work, masking, and whether to shelter indoors during smoke episodes. Tools like this function as more than transparency mechanisms; they serve as instruments of accountability, accessibility and knowledge, enabling community members to ask more data-informed questions, support policy responses and build air quality literacy. Across the West, similar dashboards—such as Montana’s “Today’s Air,” Oregon’s “Air Quality Index Map,” and California’s AQ View—demonstrate that clear visualization is critical during wildfire events. Residents consistently seek real-time clarity on conditions at the block or valley level—not just the regional averages displayed on traditional AQI tools. These dashboards translate dense data into practical guidance, bridging the gap between measurement and action.

“Rigorous data quality control and community training are what turn sensors into decisions.” — Liz Walker, PhD, Principal, Smoke Ready Solutions, and Affiliate Assistant Professor, Department of Occupational and Environmental Health Sciences, University of Washington

Durability through Collaboration

Clean Air Methow sustains its work through community partnerships, local champions and creative outreach models, resulting in an adaptive network that tracks pollution, activates local response, shapes public understanding, supports climate resilience and advances regional air quality policy grounded in lived experience. The program also contributes to regional and statewide policy discussions, including communications related to prescribed burning, smoke complaint documentation, wildfire response planning and the integration of low-cost air quality sensors into public health decision-making. These activities reinforce how community-based monitoring functions as both an information network and a public health intervention.



As noted, the region has maintained relationships with local institutions and community partners, preserving the groundwork for future efforts pending renewed funding. The program’s trajectory underscores that community monitoring systems can be sustained through trust, transparency and shared ownership even as funding disruptions constrain operations (Clean Air Methow, 2023). With strong local leadership, cross-agency cooperation and shared commitments to public health, these collaborations provide continuity when funding fluctuates, technology evolves or wildfire seasons intensify.

Rapid Response Networks

Clean Air Methow demonstrates how community-based monitoring can fill major geographic gaps in federal and state systems, generate minute-to-minute $PM_{2.5}$ data, strengthen emergency response, improve smoke literacy and mobilize residents during severe smoke episodes—functions that form the backbone of emerging community-centered rapid response networks as wildfire seasons grow longer and more unpredictable.

In moments of instability, community-sourced data becomes a form of collective resilience—helping communities document harm, coordinate response and advocate for protection. These networks use hyperlocal data to guide school and workplace decisions, activate clean-air shelters, support real-time communication through dashboards and alerts, and help residents understand shifting conditions at the neighborhood level. They also foster preparedness and policy development by documenting lived experience and ensuring communities can act quickly during extreme smoke events. Importantly, they build redundancy into wildfire communication systems—using radio, local check-in networks, bulletin boards and pre-established neighborhood pathways to deliver safety information when power or cell service fails. Together, these capabilities show how monitoring can move beyond data collection to function as an integrated early-warning, decision-support and public health protection system grounded in the needs and realities of wildfire-affected communities.

PurpleAirs in Schools Program, Montana

Montana is one of the most wildfire smoke-impacted states in the country—a vast, sparsely populated landscape where long fire seasons, dense forest fuels, recurring drought and prevailing westerly winds drive some of the nation’s highest concentrations of smoke-derived $PM_{2.5}$ (O’Dell et al., 2021). With just over 1.13 million residents spread across more than 147,000 square miles—only 7.4 people per square mile—Montana’s communities are widely dispersed, leaving many rural and tribal areas far from regulatory-grade air quality monitors (American Community Survey [ACS], 2024). Montana’s vast landscape is characterized by steep, forested mountains and narrow valleys in the west and semi-arid plains in the east—this complex geography can trap air pollution from wildfire smoke for days or even weeks.



Satellite image of smoke transport into Montana from across state lines (National Oceanic and Atmospheric Administration [NOAA], 2024).



While regulatory monitoring coverage in Montana is primarily determined by population and regulatory requirements rather than terrain, the state’s varied geography can intensify localized smoke behavior and impacts. The state is approximately 88–89% White, with 6–7% identifying as American Indian or Alaska Native. Its 684 public schools serve roughly 149,000 students, about 11% of whom are American Indian (ACS, 2024). In most of Montana’s counties, 10–20% of the citizens are living below the poverty level; counties with the highest percentages, upwards of 30%, are often located on or near tribal lands.

Figure 5 shows the percentile of residents over the age of 64, plotted alongside prevalence of heart disease, asthma, and a representation of medically underserved areas in Montana. Elevated baseline risk factors, such as these, contribute to increased susceptibility to wildfire smoke exposure among Montana residents. Montana has long faced limited access to air quality monitoring, driven in part by funding constraints and the challenges of covering a large sparsely populated state. These gaps disproportionately affect communities located far from regulatory-grade monitors,

where immediate air quality information can be lifesaving. Wildfires within Montana and across the region generate the vast majority of the state’s PM_{2.5} burden; one recent assessment estimates that about 85% of the smoke-derived PM_{2.5} emissions from within the Montana’s state borders come from wildfires, dwarfing contributions from prescribed burning (10 times less), woodstove emissions (12 times less) and the state’s largest industrial PM_{2.5} source (100 times less) (Montana Department of Environmental Quality [MTDEQ], 2025). MTDEQ operates a robust regulatory monitoring network that meets and exceeds all Clean Air Act requirements, but there is also a recognized need for more localized sensor data to support public health and safety decision making. This has prompted increased interest in community-scale data. The PurpleAirs in Schools Program is a compelling example of cross-sector collaboration to build community resilience in the face of intensifying wildfire smoke. Led by the MTDEQ in partnership with the University of Montana (UM), the initiative was designed to address spatial limitations in the state’s regulatory ambient air monitoring network by deploying additional sensors in key locations, particularly in communities where real-time air quality information was previously unavailable. The project focuses on PM_{2.5}, the pollutant of greatest health concern for Montana’s population, and is underpinned by MTDEQ’s established capacity to operate and maintain a statewide air monitoring network across a large geographic area.

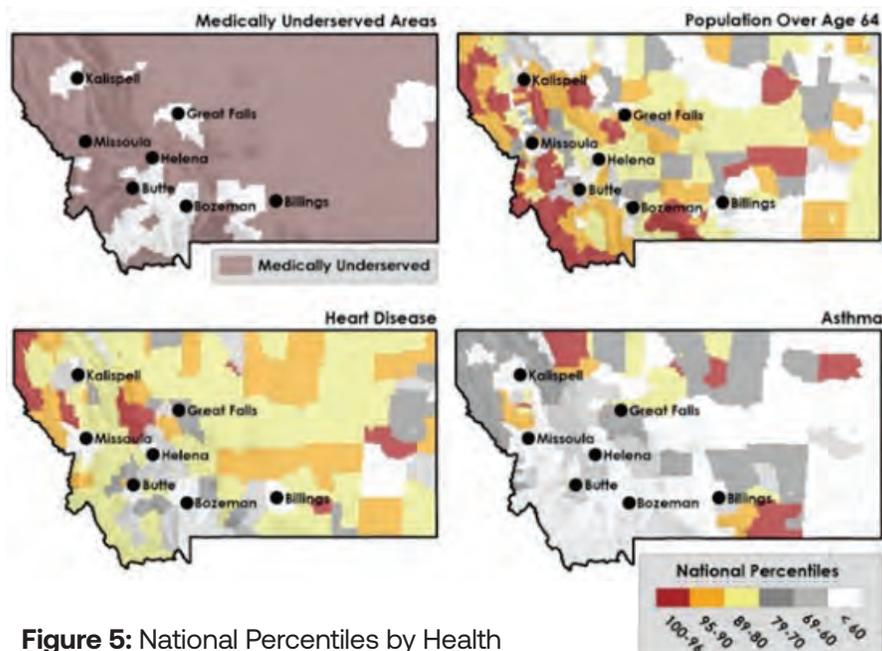


Figure 5: National Percentiles by Health Indicator (used in PurpleAirs assessment)

“Wildfire smoke has become the primary air quality challenge in Montana. Even though we experience many days of very clean air, smoke now drives the most severe and widespread health impacts across the state.”

— Bo Wilkins, MTDEQ Air Quality Bureau Chief



The program launched with a goal of deploying 200 sensors and, within the first two years, enrolled more than 100 schools, with over 78 installing and operating air sensors in locations without prior monitoring. Two monitors were placed at each school that signed up, one indoors and one outdoors. Program funds were used to advance three primary objectives, including 1] expanding statewide monitoring coverage for vulnerable and underrepresented populations, 2] fostering sustained partnerships with schools, tribal communities, and local organizations, and 3] expanding air quality awareness through participatory, science-led monitoring tools and resources. The project was designed not only to monitor PM_{2.5} pollution from wildfire smoke indoors and outdoors, but also to empower schools with information that can guide decisions about outdoor activities and student safety. Most of the sensors deployed are PurpleAir sensors, selected for their affordability, publicly accessible data, minimal maintenance requirements and suitability for broad spatial coverage. While PurpleAir sensors produce a less robust data product than regulatory-grade instruments, if a correction algorithm is applied to the raw data, they will correctly report the AQI health concern color category more than 90% of the time.

“The pollutant of greatest concern in Montana is wildfire smoke. To inform the public we need to be responsive to that.”

— Bo Wilkins, MTDEQ Air Quality Bureau Chief

MTDEQ determined that the benefits of using low-cost sensor data to represent and reach previously unmonitored communities outweighed concerns related to data precision, particularly for outreach, education and health-protective decision-making. The map on **Figure 6** (below) shows the location of MTDEQ’s primary/regulatory monitoring sites without the support of a sensor network. **Figure 7** (also below) shows MTDEQ’s goal map for sensor deployment. To date, about 80 of these sensors are online and reporting live data, mostly from schools around the state. This map demonstrates how the addition of community-based sensors substantially increases spatial coverage, fills critical gaps between regulatory monitors and enables more localized tracking of wildfire smoke across the state. To ensure this expanded network translates into timely, practical decision-making, the program was designed with clear pathways for how sensor data are shared and used. Outdoor sensor data are publicly available on the AirNow Fire & Smoke Map,

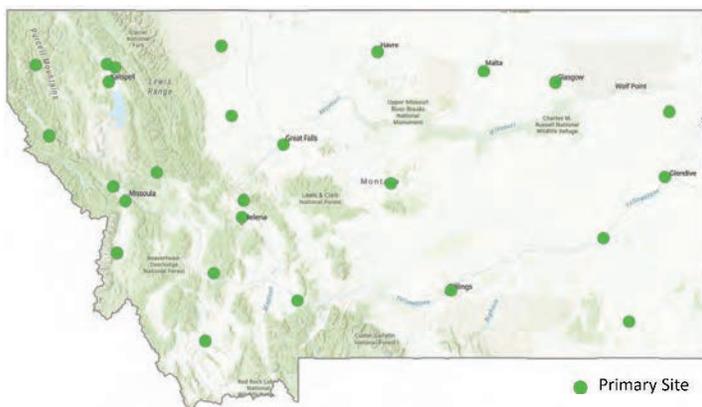


Figure 6: MTDEQ primary and regulatory monitoring locations

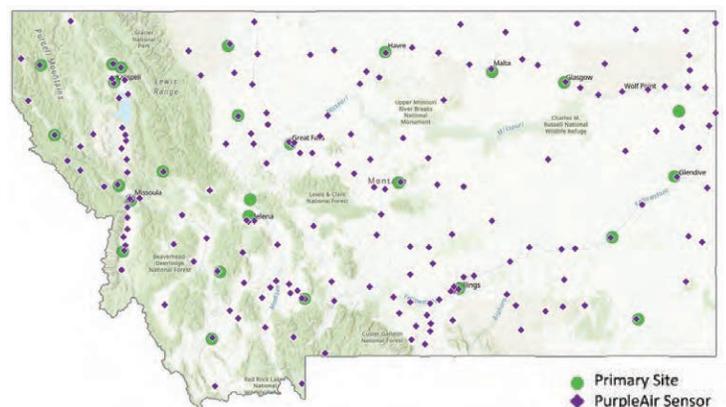


Figure 7: MTDEQ’s goal map for sensor deployment



allowing residents to track changing conditions and respond accordingly. Indoor sensor data are kept private for school use, enabling administrators, athletic directors and teachers to make localized decisions regarding outdoor activities, practices and events. Each participating school receives a start-up kit that includes sensors and guidance on proper siting, installation, maintenance and data interpretation. Schools receive a link for a personalized dashboard displaying the school's data along with activity guidelines for current AQI conditions. In some districts, sensor data are also incorporated into science curricula to increase student awareness of air pollution and health. By partnering with schools that serve as trusted community hubs, the program extends benefits beyond students and staff, serving as a reliable source of local air quality information for the broader community.

“Regulatory monitors are essential, but they’re expensive and designed to represent regional conditions. Low-cost sensors give us a practical way to understand what’s happening at the community level and to deliver information with real, lifesaving potential.”

— Kelly Dorsi, PhD, Section Supervisor, Air Research & Monitoring, MTDEQ.

Residents frequently contact schools and the MTDEQ for updates, creating opportunities to share health guidance and connect community members to nearby monitoring data. While initially designed to support school-based decision-making, the initiative is evolving to strengthen community-wide preparedness and education. This coordinated effort bridges multiple sectors— public health, education and air quality. Collaboration has been central to the program's success, bringing together public health departments, climate resilience organizations and the Montana High School Association (MHSA), with outreach conducted through county health conferences and direct engagement with school nurses, athletic directors and science educators. The UM research partners developed a custom dashboard that applies

“Schools are trusted anchors in communities. When a school has a sensor, it doesn’t just support students—it becomes a source of information for the entire community.” — Keri Nauman, MTDEQ, Community Air Monitoring Coordinator

EPA-endorsed correction factors to community-based sensor data—adjusting raw measurements to better reflect actual PM_{2.5} concentrations—and pairing that data with clear, health-based activity recommendations for schools, ensuring data is reliable and easy to use. In doing so, the PurpleAirs in Schools Program offers a scalable model for community sensor deployment that supports immediate health-protective decisions and strengthens long-term environmental literacy. It also demonstrates the importance of tribal and rural inclusion, school-based infrastructure and multi-agency collaboration for protecting public health in a changing climate. This program works because it brings together regulatory expertise, public health research and on-the-ground partners. No single organization could do this alone.

“Linking community air monitoring with health research helps translate data into meaningful guidance—especially for understanding cumulative and long-term smoke exposure.” — Bo Wilkins, MTDEQ Air Quality Bureau Chief



Durability Through Collaboration

Montana's wildfire smoke monitoring effort is sustained through layered, cross-sector partnerships that distribute responsibility, expertise and resources across institutions rather than concentrating them within a single program or funding source. MTDEQ provides regulatory oversight and technical expertise, complemented by UM's Research Education on Air and Climate Change Health (REACH) program's public health research and education leadership. The MHSA offers a trusted, statewide network of schools that anchor monitoring in local communities. Together, these partners share knowledge, equipment, data infrastructure, training and outreach, allowing the sensor network to continue operating and expanding even as individual grants fluctuate or priorities shift. This collaborative structure is particularly well suited to Montana's geography and wildfire smoke reality. In a state where smoke sources are unpredictable, monitoring gaps are widespread and regulatory networks are necessarily sparse, durability depends on flexibility and shared ownership. By providing sensors to schools, leveraging existing community relationships and integrating public-health messaging alongside air quality data, the program creates a monitoring system that reflects how Montanans actually experience wildfire smoke—across seasons, across jurisdictions and across landscapes. Importantly, this approach allows the network to persist beyond individual fire seasons or emergency response windows. It supports year-round smoke awareness, with the capacity to rapidly scale activities during severe wildfire seasons and maintain community engagement in lower-smoke years. Montana's model demonstrates how collaboration can transform low-cost sensor networks from short-term pilot projects into durable public-health infrastructure—capable of adapting to increasing wildfire impacts while continuing to serve under-resourced communities over the long term.

“This novel PM_{2.5} monitoring network throughout Montana schools provides an opportunity for students to learn about the impacts of wildfire smoke and other sources of air pollution in their communities. The monitoring results provide an opportunity for teachers to discuss solutions to air pollution issues, including things that students can do on an individual basis to protect their health and the health of their community.”

— Tony Ward, professor, School of Public and Community Health Sciences, University of Montana.

Rapid Response Networks

In a large, rural state with highly variable smoke conditions, schools and other trusted community hubs have become the cornerstone of rapid response to wildfire smoke. The PurpleAir in Schools network captures sharp smoke gradients between valleys, towns and school districts—often revealing conditions that differ dramatically over short distances and change within hours. From individuals learning when to wear a mask or keep children indoors, to communities presenting monthly pollution trends to elected officials, hyperlocal data bridges the gap between personal health impacts and public accountability.

This hyperlocal visibility allows MTDEQ, agency partners and community leaders to coordinate timely advisories, adjust outdoor events and respond to worsening conditions that would otherwise go undetected by the sparse regulatory network. Rapid response networks also support indoor decision-making. By pairing indoor and outdoor sensor data,



schools can identify smoke infiltration, assess the effectiveness of existing heating, ventilation and air conditioning (HVAC) systems and connect with available public health resources and mitigation programs. Over time, this continuous feedback loop strengthens preparedness by linking monitoring, education, communication and intervention—particularly during prolonged smoke episodes when exposure risks accumulate.

Together, these networks function as a statewide early-warning and decision-support system, where community-scale monitoring can move beyond awareness alone to enable faster, more coordinated public-health responses—particularly in communities where emergency and monitoring infrastructure are limited.

Conclusions

Wildfire smoke has become one of the defining air quality challenges of our time, reshaping how communities understand, experience and respond to air pollution. The case studies in this report—Clean Air Methow’s CAA program in Washington and the PurpleAirs in Schools Program in Montana—demonstrate how community-driven data systems support prompt and health-protective measures, sustain engagement across seasons and strengthen smoke readiness beyond episodic events. Community data is strongest when institutions support it responsibly—pairing local knowledge with open dashboards, technical rigor and shared decision-making.

Through expanded sensor networks, trusted partnerships and accessible data tools, communities are bolstering the capacity, knowledge and situational awareness needed to reduce exposure and respond effectively during wildfire smoke events. Across these efforts, locally developed approaches weave together current data, lived experience and storytelling to help translate numbers into meaning, sustain community engagement and provide policymakers with the context needed to act. This reflects a broader shift in how evidence is generated and used, showing how community-led data reshapes dynamics by recognizing residents as stewards and holders of knowledge rather than passive data sources. In moments of uncertainty, this shift strengthens shared trust, accountability and collective resilience by grounding action in everyday realities and community authority.

These lessons point to a broader takeaway: community monitoring functions as a complementary layer—helping address localized information gaps—while operating alongside and reinforcing the federal regulatory framework. Science-backed, health protective $PM_{2.5}$ standards play a critical role in today’s age of large, prolonged, multi-source smoke events: they reduce background pollution, lessen cumulative exposure and help ensure that communities are not already burdened before wildfire smoke arrives. EPA’s regulatory monitoring network and NAAQS provide protection through a standardized and legally enforceable framework that local systems alone cannot. While regulatory standards provide this foundational, population-level protection, community monitoring offers the localized resolution and data granularity needed for day-to-day decision-making and ongoing protection during rapidly changing conditions.

As wildfire seasons grow longer and smoke concentrations vary sharply over small spatial and temporal scales, the nation needs both: a robust federal framework grounded in strong NAAQS and community-based systems capable of capturing rapid fine-scale variability. This combined approach closes long-standing monitoring gaps in rural, tribal and underserved regions while embedding community-generated data into preparedness, response and decision pathways that endure beyond a single smoke season.



From Response to Recovery

Community-driven monitoring is increasingly extending beyond immediate wildfire smoke response to inform air quality conditions during recovery, cleanup and rebuilding phases. As smoke exposure has become a recurring, seasonal reality in many regions, understanding the longer-term health implications of these exposures is critical. Even after fires are extinguished, resuspended ash, fine particulate matter and debris-related dust can continue to affect air quality and pose ongoing health risks. Community-based monitoring helps define this next phase of wildfire science by enabling rapid post-fire assessment, sustained tracking of pollution and swift public-health guidance during recovery.

Post-Fire Community Monitoring

An example of this approach, the PHOENIX Project (Post-fire airborne Hazard Observation Environmental Network for Integrated Exposure-monitoring) was launched following the 2025 Eaton Canyon Fire in Altadena, California and led by the California Institute of Technology and local partners. As of March 2025, the project deployed an initial network of 19 solar-powered, cellular-connected community sensors made by QuantAQ, with plans to expand to approximately 25 sensors across the burn area. These sensors measure particulate matter across multiple size ranges, including (PM_{1.0}), PM_{2.5} and PM₁₀ and were designed to provide real-time air quality information during debris removal, cleanup and rebuilding, when post-fire dust and ash pose ongoing risks (Fesenmaier, 2025). By capturing highly localized particulate conditions after containment, PHOENIX complements federal and state recovery efforts while illustrating exposure awareness and health-protective actions during post-fire recovery phases.

By carrying air quality monitoring into the recovery phase, these efforts redefine wildfire assessment as a sustained public health function rather than a momentary emergency response. This expanded lens enables pollution exposure data to directly inform recovery decisions, rebuilding strategies and long-term community protection across the entire arc of wildfire impacts.

Even as community-based wildfire smoke monitoring proves its value, many programs face persistent funding and staffing challenges. Maintaining partnerships, transparent data practices and cross-agency collaboration often depend on grassroots' advocacy and sustained local engagement during funding gaps. These pressures are widespread across community sensor efforts, underscoring the need for clearer pathways to continuity and scale. Building on these lessons, the recommendations that follow outline practical actions to help stabilize and sustain this work over time. Together, they translate the insights and case studies presented here into practical, multi-level actions—advancing a vision of cleaner air that is informed by science, responsive to community needs and strengthened by the voices and experiences of those most affected by wildfire smoke.



Recommendations

Wildfire seasons are becoming longer, more unpredictable and more hazardous, and communities are increasingly relying on their own networks, partnerships and novel approaches to stay informed and protected—particularly to integrate local data into state and federal systems. To strengthen protection during smoke events, expand access to real-time local data and ensure that monitoring networks remain resilient even when grants end or budgets shift, the American Lung Association offers the following calls to action:

Federal Government

- Implement and enforce science-based, health-protective NAAQS, including the 2024 updated PM_{2.5} standard.
- Strengthen hazardous air pollutant standards and enforcement. Expand fence-line monitoring requirements to more stationary sources of hazardous air pollutants.
- Adequately fund state, local and tribal air agencies to sustain robust regulatory monitoring networks, including staffing, data platforms and infrastructure.
- Invest in dedicated, multi-year funding for community-led monitoring, supported across federal agencies (e.g., EPA, FEMA, USDA and others). Include investments in technical assistance hubs that provide calibration and collocation support, QA/QC protocols, quality assurance and data interpretation guidance. Support ongoing research into best practices.
- Develop guidance on minimum performance, documentation and transparency standards to integrate validated, community monitoring data into federal air quality decisions, including enforcement, inspections, permitting, compliance and rulemaking.
- Establish frameworks to utilize community-scale data for public health communications, emergency response and preparedness, and post-event evaluations.
- Building on the success of the EPA U.S. Fire and Smoke Map, improve and modernize federal data platforms to display validated and corrected community monitoring data alongside regulatory measurements. Permanently fund and expand federal wildfire smoke monitoring programs, including EPA's WSMART.
- Support cross-agency coordination among air agencies, transportation authorities, port and freight authorities and land-use and zoning regulators to integrate community monitoring into decision-making.

States

- Ensure stable, state-level funding streams, beyond short-term grants and projects, for community monitoring. Sustain cross-agency partnerships that build local expertise and tailor to local needs.
- Partner with universities, air agencies and research institutions to provide technical support – including sensor deployment, data hosting, calibration and validation, assessment and maintenance, data useability and hands-on training—for community, school and tribal monitoring programs.
- Integrate properly corrected community sensor data into dashboards, maps, public advisories and communication platforms that support incident-response systems, neighborhood-level messaging, school and outdoor activity guidance, emergency response decisions, post-event assessments and inclusion in state resilience planning.
- Establish frameworks that formalize community participation and transparency in air quality decision-making, including defining how community input informs agency actions and ensuring feedback loops between residents



and decision-makers. Ensure a pathway for community-generated data to be used to identify high exposure areas.

- Use quality-assured community data to inform state permitting decisions, cumulative-impact analyses and targeted inspections, and formalize how neighborhood-scale monitoring feeds into state air quality programs to support enforcement screening, mitigation prioritization, emergency monitoring plans, transportation planning and land-use strategies. SIPs can remain anchored to regulatory monitoring for NAAQS compliance while using quality-assured community data to identify hotspots and better target where emission reductions can be applied.
- Support Tribal sovereignty in air monitoring by strengthening EPA State and Tribal Assistance Grant (STAG) support for tribal air programs, including sustained funding for staff, operations and data ownership and use.

Local Governments

- Commit sustained funding to support the full lifecycle of community air monitoring, including sensor maintenance and replacement, staff capacity and training, partnerships, public data platforms and ongoing engagement that links monitoring to public health and emergency response.
- Coordinate across cities, counties, regional agencies, public health and emergency planners and neighboring jurisdictions to align monitoring with pollution patterns, enabling residents and agencies to co-develop priorities, review data and guide mitigation strategies.
- Embed air quality monitoring into local emergency management and hazard-mitigation plans by establishing formal cross-department protocols that define how community sensor networks are used in public communications, emergency operations, recovery planning and future preparedness, require agencies to use real-time data to guide coordinated response during major pollution events, and document lessons learned to improve future decision making.
 - Wildfire smoke: Use data to guide decisions on outdoor activities, worker safety, school and childcare operations, ventilation and clean-air shelter activation.
 - Heavy-duty trucks: Apply data to inform truck routing, idling enforcement, curb management, port operations and roadway design.
 - Point-source pollution: Integrate data into investigations, permitting review, public comment processes and facility-level mitigation actions.
- Regularly review monitoring data to identify areas of elevated concentrations, dominant sources and exposure trends, and conduct after-action reviews following major events to refine communication, sensor placement, outreach and resource deployment.
- Preserve quality-assured community data for public comment and, when needed, legal review, strengthening the administrative record with real-world exposure evidence.
- Support community events and volunteer networks—including schools, faith-based organizations and health clinics—to engage residents as sensor hosts and data stewards.
- Use transparent, plain-language and multilingual reporting tools with visuals and maps to support public understanding and informed participation in policy discussions.

Individuals/Community Groups

- Collaborate with academic entities, public health organizations, government agencies and commercial vendors to secure multi-year grant funding support for deploying monitoring projects and sustaining staffing, data



- Bolster community capacity and support through coordination with local schools, tribal, faith-based and neighborhood organizations in under-resourced or rural areas.
- Use publicly accessible air quality data, supported by cross-sector partnerships, to deliver clear findings, actionable requests and health-protective protocols to local municipal boards, school boards, commissions and decision-making bodies.
- Apply neighborhood-scale data to advocate for health-protective actions, including emergency alerts, clean-air shelter activation and smoke-day school and work adjustments, truck rerouting, idling restrictions, buffer zones near homes and schools, and stronger fence-line monitoring, permit modifications, targeted inspections, health symptom tracking and enforceable mitigation during permit renewals or expansions.
- Build data literacy by training local staff, volunteers, leaders and residents to interpret corrected data, document pollution events and communicate findings effectively, while establishing clear governance structures over roles, authority and data ownerships.
- Plan for the full data lifecycle and continuous improvement—from defining monitoring questions and selecting sensors to placement, calibration and maintenance; data collection, backup and usability; to quality assurance and sustained use of results.
- Document and apply lessons learned to improve communication strategies, locally tailored data models, resource deployment and long-term operation and sustainability.
- Maintain public-facing dashboards that integrate sensor data and forecasts with plain-language health guidance, designed to be mobile-friendly, multilingual and accessible to non-experts.
- Educate residents on local emergency preparedness and response protocols, including the communication channels used to deliver rapid public alerts during pollution events.



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Something in the Air

How Communities Are Tracking
the Air They Breathe

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On the Move:
Heavy-Duty Traffic Pollution
in Nearby Communities



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Introduction

Across the United States, millions of people live near freight corridors and transportation hubs where daily air quality is shaped by heavy-duty truck traffic. Associated activity at ports, highways, railyards, distribution centers and warehouse districts drives steep changes in concentrations over very short distances, with the greatest impacts concentrated in communities that have long experienced elevated levels of air pollution.

A single corridor can function as both an economic engine and an exposure hotspot. In these places, pollution is neither episodic nor accidental; it is ambient and routine, woven into daily life through diesel exhaust, idling vehicles and surrounding industrial activity. Exposure does not arrive all at once; it accumulates—hour by hour, block by block—often invisibly. Pollution levels can shift dramatically from one block to the next, creating sharp gradients that mirror the boundaries of infrastructure design, traffic flow, and land or zoning allocation, yet the systems used to track air quality are not designed to reflect these neighborhood-scale realities.

As freight volumes continue to rise—with the growth of e-commerce, expanded port capacity and logistics hubs moving deeper into residential areas—communities are increasingly turning to participatory science as both a diagnostic tool and a form of self-advocacy to fill persistent information gaps about local exposure. These projects make exposure legible—pinpointing when it peaks, where it concentrates and how it intersects with daily routines—while supporting decisions related to health, transportation and land use. While regulatory monitoring networks are designed to reflect broader regional conditions and regulatory compliance, they are not equipped to capture fine-scale exposure patterns or the cumulative, day-to-day reality of diesel exhaust concentrated at the edges of freight infrastructure, where truck activity rarely pauses. Community-based air sensor networks, mobile monitoring and neighborhood-scale partnerships have become essential complements to the regulatory system, providing the street-level evidence needed to understand how freight operations shape exposure near homes, schools and workplaces.



At the same time, these tools provide policymakers with usable data. When deployed through trusted partnerships, they increase transparency, strengthen cross-agency collaboration, engage regulatory institutions and help sustain monitoring in places where chronic exposure is the norm rather than the exception. *On the Move: Heavy-Duty Traffic Pollution in Nearby Communities* examines how community-centered approaches are reshaping what we know about freight-related air pollution, who has access to data, who has a seat at the table and how solutions are co-produced. The case studies featured here—Albany’s South End Neighborhood Air Quality Initiative and the West Oakland Environmental Indicators Project (WOEIP)—demonstrate the practical value of community-generated data not only to characterize exposure, but also to translate lived experience into evidence that informs decision-making, strengthens accountability and supports meaningful policy action. These examples illustrate the broader purpose of this report: community-rooted data systems do not replace the official monitoring record—they strengthen it.

Across both efforts, a clear throughline emerges around transparency across the full data lifecycle—from collection and quality control to analysis, visualization and public communication. Visibility is not treated as an endpoint but as infrastructure. Open dashboards and accessible reporting play a critical role in ensuring that information is interpretable, responsive and fit for use. By pairing transparent data practices with intentional outreach and policy engagement, these programs shift monitoring from a technical function into a civic one, supporting sustained policy adaptation, institutional learning and community action.

When community-driven sensor networks are intentionally aligned with regulatory networks, they transform isolated data points into a coherent picture of on-the-ground conditions creating a stronger evidence base for decisions related to freight routes, transportation, land development, mitigation investments and enforcement. These case studies underscore the need for greater visibility and accountability along the nation’s freight corridors, where diesel emissions remain a persistent driver of health burdens and highly uneven exposure patterns.

Freight Pollution Community Impacts

Heavy-duty trucks are the backbone of the national freight system, moving goods through ports, railyards, distribution centers and major logistics corridors. But the infrastructure that supports this economy—port and rail centers, urban trucking routes, warehouse districts and beyond— also concentrates some of the nation’s highest levels of diesel pollution within a narrow band of communities. The U.S. Environmental Protection Agency [U.S. EPA] estimates that approximately 72 million people live in areas with elevated rates of multiple health impacts associated with proximity to major trucking corridors (U.S. EPA, 2022b). Freight corridors tend to cluster near highways and industrial zones, creating steady traffic from Class 8 tractor-trailers, medium- heavy box trucks, drayage trucks serving ports and vocational vehicles such as yard tractors. Although these trucks represent a relatively small

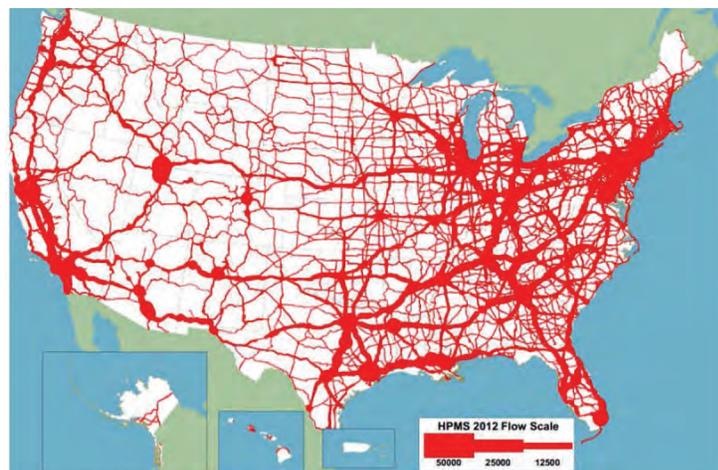


Figure 1: Map of Major U.S. Truck Routes (U.S. EPA, 2022b)



share of total vehicles on the road, they are responsible for a disproportionate share of harmful emissions. In California, for example, heavy-duty trucks constitute about 3% of the fleet but produce more than 50% of on-road nitrogen oxide (NO_x) emissions and a similar share of diesel particulate matter [DPM] (California Air Resources Board [CARB], 2024). Technological improvements have reduced emissions from newer engines, yet older, higher-polluting diesel trucks remain common as emissions rise throughout the useful life of these vehicles—especially in freight hubs where aging fleets, weak enforcement and demand for goods movement intersect.

These realities mean that many neighborhoods experience pollution levels far higher than regional averages indicate, with exposure driven not by broad atmospheric trends but the daily flow of freight through neighborhood streets. This case study focuses on roadway-based freight movement, specifically medium- and heavy-duty diesel trucks operating along highways, major corridors and designated truck routes rather than other freight-related sources such as ships, off-road industrial equipment or [locomotives \(see the American Lung Association’s report on locomotive pollution\)](#). Medium- and heavy-duty trucks emit a mixture of harmful pollutants —some covered by National Ambient Air Quality Standards

Heavy-duty Vehicles	Medium-duty Vehicles
<ul style="list-style-type: none"> • Long-haul tractor-trailers • Yard tractors and other industrial freight-movement vehicles • Drayage (vehicles moving freight in and out of ports, railyards, terminals, etc.) trucks serving ports and railyards • Freight haulers and regional distribution trucks • Dump trucks, cement mixers and vocational trucks <p>*Heavy-duty trucks dominate traffic in logistics hubs and along major freight corridors, producing the majority of diesel exhaust, NO_x, DPM, ultrafine particles (UFPs) and black carbon (U.S. Department of Energy [DOE] & EPA, 2024).</p>	<ul style="list-style-type: none"> • Large delivery vans • Box trucks • Utility and service trucks • Some commercial pickup trucks • Smaller cargo and parcel-delivery vehicles <p>*They operate in and out of distribution centers, commercial corridors and dense urban delivery zones, often making frequent stops that increase emissions from braking and acceleration.</p>

(NAAQS), others not—that collectively define the exposure profile of communities living near these large transportation hubs. Because heavy-duty traffic emits multiple co-occurring pollutants, understanding each is critical for interpreting localized, block-level conditions. The featured cases illustrate how community-driven monitoring can capture this range of pollutants using both established and emerging tools.

Pollutants

Transport-related air pollution is not a single-pollutant problem. Because monitoring truck activity requires understanding what people are actually breathing, it is important to recognize the chemical mixture diesel engines release. Diesel emissions contain a dense blend of particles, gases and air toxics shaped by vehicle duty cycles, including idling, low-load operations in congested conditions and repeated movement along freight corridors. Freight operations emit a complex mixture of pollutants, including fine particulate matter (PM_{2.5}), NO_x, carbon monoxide (CO) and volatile organic compounds (VOCs) (U.S. DOE & EPA, 2024). NO_x causes health harms on its own and contributes to ground-level ozone

(O₃) formation. PM_{2.5} and black carbon pose serious health risks; black carbon is a major component of DPM and a potent, short-lived climate pollutant.

Exposure is most intense near the physical points of where truck activity concentrates—freeway interchanges, port gates, warehouse districts and distribution centers— and where emissions accumulate from frequent idling, braking, restarting and grade changes that increase engine load. Studies consistently show that residents living closest to these freight operations breathe significantly higher levels of PM_{2.5}, NO_x and diesel-related toxics than those just a few blocks farther away (Lathwal, Vaishnav, & Morgan, 2022). In neighborhoods where heavy-duty traffic repeats throughout the day, these pollutants create persistent, hyperlocal exposure zones that the regulatory monitoring network is not designed to detect.

Heavy-duty diesel engines emit:

PM_{2.5} – inhalable particles linked to heart and lung disease.

UFPs – ultrafine particles smaller than 0.1 microns; highly reactive and able to cross into the bloodstream.

Black carbon (soot) – a component of diesel particulate matter; a harmful air contaminant and major short-lived climate pollutant.

NO_x – precursors to ground-level ozone and secondary PM_{2.5}.

VOCs – including benzene, formaldehyde and 1,3-butadiene.

CO – an asphyxiant most concentrated during idling and low-speed operations.

Polycyclic aromatic hydrocarbons (PAHs) – carcinogenic compounds that adhere to diesel particles.

Metals – including nickel, chromium and vanadium from fuel and engine wear.

Because diesel pollution is chemically complex and physically concentrated at the street level, understanding exposure requires examining not just which pollutants are released, but also how they interact with human health. The next section summarizes the major health effects linked to truck-related emissions—drawing from federal assessments, epidemiological studies and scientific reviews.

Health Effects

The health risks associated with diesel emissions are among the most thoroughly documented in environmental health science. PM_{2.5} and UFPs from diesel engines can penetrate deep into the lungs, enter the bloodstream and trigger systemic inflammation. These exposures are linked to a wide range of adverse outcomes, including asthma attacks and new-onset asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disease and arrhythmias, heart attacks, stroke, adverse birth outcomes, premature death, lung cancer and emerging evidence of neurodevelopmental harm and cognitive decline (U.S. EPA, 2024b). NO_x can worsen respiratory illness, contribute to ground-level ozone formation and react in the atmosphere to create secondary PM_{2.5}.

Diesel exhaust also contains hazardous air toxics such as PAHs, benzene and formaldehyde—compounds associated with cancer risk, DNA damage and long-term organ effects (International Agency for Research on Cancer [IARC], 2012). A review by the Health Effects Institute [HEI], drawing on more than 350 studies, found consistent links between traffic



pollution and higher rates of all-cause mortality, heart disease, lung cancer, asthma onset in children and adults, and acute respiratory infections in children (HEI, 2023).

The American Lung Association’s analyses show that heavy-duty truck pollution remains one of the most consequential sources of air pollution exposure in the U.S. Medium- and heavy-duty vehicles make up only about 6% of the on-road fleet, yet they generate 59% of ozone- and particle-forming NOx emissions and 55% of all on-road particle pollution, including brake and tire particles. These emissions contribute to a national landscape where 41% of Americans—137 million people—live in communities experiencing unhealthy levels of ozone and/or particle pollution. At the neighborhood scale, the burden intensifies. People living near freight hubs experience the highest cumulative exposures and the most severe health consequences.

Many of these neighborhoods face longstanding gaps in resources and limited protective infrastructure—such as tree canopy, indoor air filtration and building insulation—that would otherwise reduce the infiltration of outdoor pollutants. The layering of diesel exhaust with chronic noise, industrial land use, limited healthcare access and other baseline stressors produces a compounding health burden—reflected in elevated rates of asthma, heart disease and pollution-sensitive illnesses (Adegboye et al., 2023). **Figure 2** (below) maps deaths attributable to diesel pollution across the U.S., examining health impacts at the state, county and metropolitan levels, including premature death estimates and related health and economic risks. An interactive version is available through the Clean Air Task Force’s [CATF] Deaths by Dirty Diesel map, with mortality and morbidity estimates derived from EPA’s CO–Benefits Risk Assessment (COBRA) screening model.

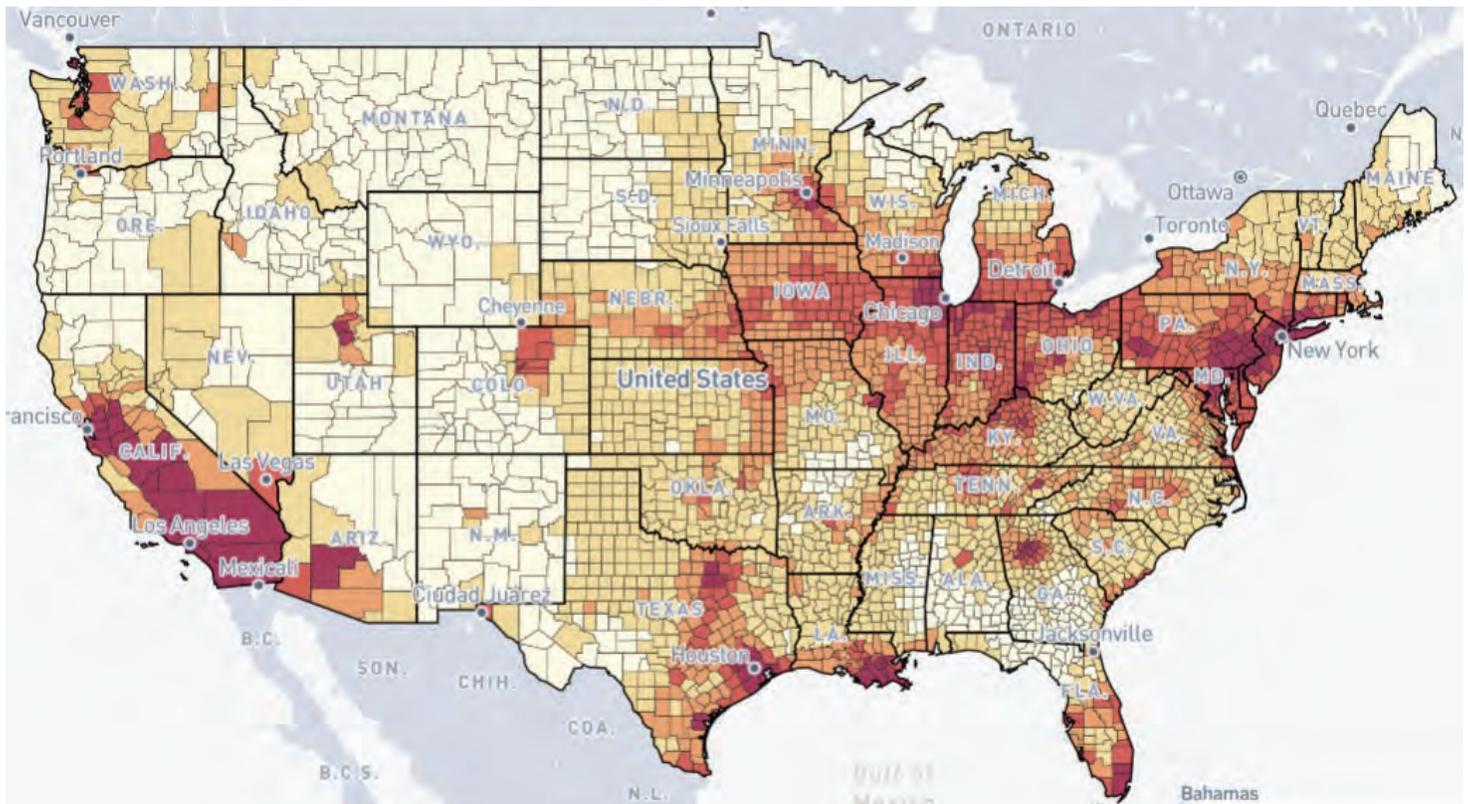


Figure 2: January 2026 CATF’s Deaths by Dirty Diesel



Long-term exposure to traffic-related air pollution has been linked to increased rates of respiratory and cardiovascular harm in nearby communities. Heavy-duty trucks amplify these risks even further. These exposure patterns reinforce what communities have described for decades: freight emissions do not disperse evenly across a region but accumulate along specific blocks, intersections and travel routes where truck activity is constant. In response, localities are turning to community-led monitoring networks as a critical tool to address these gaps.

Real-Time, Neighborhood-Scale Monitoring

The limits of the federal regulatory system demonstrate the value of community-scale monitoring as a complementary approach. EPA's network provides the backbone of national air-quality oversight and was built to answer a specific regulatory question: Are regions meeting the NAAQS? The system excels at identifying broad regional trends but cannot track whether a child walking to school, a senior living near a warehouse district or a worker standing at a port gate is breathing more harmful levels of diesel exhaust than the area at large on any given day. Regulatory-grade monitoring remains the standard for demonstrating NAAQS compliance, but its design and coverage mean it often misses the hyperlocal pollution spikes that shape real-world health risks for communities living alongside heavy-duty truck corridors. EPA's regulatory network captures only part of what heavy-duty diesel traffic emits.

Although the NAAQS regulate six criteria pollutants, only two—PM_{2.5} and nitrogen dioxide (NO₂)—are routinely measured in locations relevant to freight corridors, using Federal Reference Method (FRM) and Federal Equivalent Method (FEM) instruments (U.S. EPA, 2025a). In addition to PM_{2.5} and NO₂ monitoring, smaller networks for CO, ozone precursors and particulate matter 10 micrometers or smaller (PM₁₀) provide supplemental information yet coverage for these pollutants remains limited near warehouse districts, port entrances and major trucking routes. As a result, the regulatory system establishes an essential regional baseline while leaving substantial neighborhood-scale data gaps in communities experiencing the highest pollution burdens. These limitations become more pronounced when viewed at the scale of freight activity itself. FRM/FEM monitors track PM_{2.5} and NO₂ effectively at a regional scale, but diesel exhaust reflects a far more complex emissions profile than the NAAQS framework captures. As noted above, heavy-duty trucks emit black carbon, UFPs, PAHs, carbonyl compounds and precursors to secondary organic aerosols (SOAs)—pollutants that fall outside the NAAQS, are rarely monitored continuously and often peak sharply within tens to hundreds of feet of a roadway.

Emissions peak at friction points in the freight system—idling zones, acceleration lanes, freeway ramps, distribution centers and port gates. Because regulatory monitors are spaced miles apart, these short-lived, neighborhood-scale spikes largely go undetected. The result is a system that can confirm regional compliance while overlooking the diesel-related pollutants driving block- by-block exposure and elevated health risks in freight-impacted communities. Even at the county scale, the 921 counties containing the nation's busiest trucking routes exhibit PM_{2.5} levels above more health-protective benchmarks—while countywide averages obscure the sharp, short- term pollution spikes experienced daily by residents living near roadways (National Aeronautics and Space Administration [NASA], 2024). Launched by EPA in 2013, the Near-Road Ambient Monitoring Network established roughly 140–150 sites in major metropolitan areas to measure roadway-adjacent concentrations of NO₂ (and, at some sites, CO and PM_{2.5}) in places with high traffic volumes and significant heavy-duty diesel activity; an important step to reduce these gaps (U.S. EPA, 2024c).



Launched by EPA in 2013, the Near-Road Ambient Monitoring Network established roughly 140–150 sites in major metropolitan areas to measure roadway-adjacent concentrations of NO₂ (and, at some sites, CO and PM_{2.5}) in places with high traffic volumes and significant heavy-duty diesel activity; an important step to reduce these gaps (U.S. EPA, 2024c).

The network was intended to improve the understanding of near-road exposure and support NAAQS compliance, but it covers only select cities and captures only a narrow portion of the diesel emissions mixture as monitors are not necessarily located where truck volumes are highest, where freight has expanded or where warehousing growth and rerouted traffic now concentrate exposure. In addition, research increasingly shows that policies focused solely on primary PM_{2.5} mass underestimate the true health risks from road traffic, given the additional harms from NO₂, black carbon, UFPs and SOAs (Hänninen et al., 2025). Federal monitoring provides

a strong regional foundation, while real-world freight operations introduce variability that unfolds at finer spatial and temporal scales. As trucks reroute, idle and respond to port and warehouse activity, air quality conditions shift leaving many neighborhoods without data that reflects local conditions—gaps that neighborhood monitoring systems are designed to fill. This is where community-scale monitoring becomes essential.

The cases in this report pick up precisely where the regulatory system leaves off. They focus on pollutants that traditional monitors miss, on conditions they cannot fully characterize and the core questions residents have raised for decades: What are we breathing? Where is it coming from? And how can credible data drive action?

“More effort and resources to check sensor accuracy and correct data would address a major gap. This support helps community groups turn raw data into more reliable information that decision makers and scientists take seriously.” — Wilton Mui, Ph.D., Program Supervisor in the Monitoring & Analysis Division of South Coast Air Quality Management District [South Coast AQMD]



Figure 3: Current Active Near-Road Monitors (U.S. EPA, 2025)



Different Sensors, Different Needs

Across the country, communities, researchers and public agencies are coordinating efforts to deploy a mix of stationary sensors, mobile monitoring platforms and mid-tier research-grade instruments in freight corridors to capture diesel-related pollution. Stationary PM_{2.5} sensors—such as PurpleAir, AirNote, Clarity Nodes and AirGradient—provide continuous, real-time data that reveals sharp particle spikes from truck queues, idling zones and warehouse traffic.

Mobile monitoring systems, including backpack monitors, bicycle-mounted sensors and instrumented vehicles, are used to map black carbon, UFPs, NO_x and roadway-specific VOCs along freight corridors; programs such as the Environmental Defense Fund/Google Street View mobile mapping work and EPA-supported mobile monitoring pilots demonstrate how these platforms reveal steep near-road gradients and diesel plumes (U.S. EPA, 2022). Meanwhile, mid-tier multi-pollutant monitoring systems—including QuantAQ’s MODULAIR and STELLA platforms, AQMesh pods and 2B Technologies’AQ-Sync—support measurement of combinations of NO₂, ozone, black carbon, UFPs and PM_{2.5} (AQMesh, 2026). These tools vary in measurement performance and application: the AQ-Sync is a higher-quality reference-adjacent instrument, while AQMesh and QuantAQ systems are air sensors designed for screening, spatial coverage and pattern identification rather than regulatory-grade precision (AQMesh, 2026).

Importantly, cost alone does not determine data quality; sensor performance depends on pollutant type, deployment context, calibration and data validation practices. Used appropriately, these complementary technologies identify sources, screen hotspots and inform early enforcement, mitigation and risk-reduction decisions—providing a more complete picture of freight-related air pollution (2B Technologies, 2022).

These technologies do have limitations that shape how the data can be interpreted and used. Some commercial PM_{2.5} sensors respond well to changes in fine particles but cannot distinguish between diesel exhaust, brake-and-tire wear, resuspended road dust or other traffic-related sources—and they require calibration or collocation to ensure accuracy near busy roadways (U.S. EPA, 2022). Mobile monitoring provides unparalleled spatial resolution, but measurements capture only the moments and routes sampled, meaning short-lived plumes or nighttime truck activity may be missed without repeated runs. Mid-tier multi-pollutant instruments offer stronger performance for pollutants like black carbon, UFPs and NO₂, but they are costlier and require trained operators. They also demand stringent quality assurance procedures (system-level plans that ensure the monitoring project produces trustworthy data) and quality control procedures (day-to-day checks that ensure the data produced is valid and not drifting, malfunctioning or biased) to ensure regulators view the data as credible (2B Technologies, 2022). These constraints reinforce the need for thoughtful design, collaborative partnerships and clear goals—because the usefulness of any sensor network depends as much on its scientific rigor and community capacity as on the hardware itself.

Selecting the right monitoring approach requires more than choosing a sensor—it begins with understanding what the community wants to uncover, and which partners can help turn data into action. Before deployment, community groups and agencies must clarify core questions: What pollutants matter most along this corridor? Are we trying to document truck-related spikes, identify specific emission sources, evaluate exposure at homes and schools or support rerouting and enforcement? Do local partners have the capacity to host monitors, maintain equipment, download data and apply correction factors? Who will analyze the data, interpret results and ensure findings are credible to regulators? Funding



also shapes what is possible—whether small grants can support stationary PM_{2.5} networks or if larger collaborations are needed for mobile mapping or mid-tier multi-pollutant systems. Equally important is establishing a collaborative structure that clarifies roles—whether a community organization can sustain the project, a municipal or state agency can support siting and data transparency and a technical or academic partner can calibrate sensors, validate performance and translate findings into policy-relevant insights. These questions—what to measure, why, with whom and to what end—form the foundation of any effective community monitoring effort. They also help determine whether sensors will primarily be used to document a problem and inform the public, or primarily to inform advocacy for solutions. Either way, when residents have reliable local measurements, the conversation shifts: individuals can better make decisions that protect their health and community groups can enter regulatory discussions with evidence that documents what people are actually breathing.

“People living near truck routes already know the air feels different. Sensors help make those conditions visible. When communities can see pollution peaks in real time, they are better equipped to advocate for truck rerouting, buffer zones, stronger enforcement, and healthier land-use decisions.”

— Nicole Merino Tsui, WOEIP Director of Strategic Partnerships

While no single approach fits every neighborhood, consistent lessons emerge: collaborative design strengthens credibility, transparent data builds trust and locally grounded measurements can shape decisions in ways traditional monitoring cannot. The cases that follow show how partnerships among residents, researchers, advocates, commercial vendors and air agencies translate data into action—demonstrating what becomes possible when communities closest to pollution have the tools and support to understand their air and push for cleaner conditions.

Case Studies

Albany, NY – South End Neighborhood Air Quality Initiative

Albany is the capital of New York State and the core of the Capital Region metropolitan area, which includes surrounding cities such as Schenectady, Troy and Saratoga Springs. The Albany–Schenectady–Troy metropolitan area houses approximately 900,000 residents across several counties. The region has a historic transportation and industrial corridor: the Hudson River, rail lines, truck routes and the Port of Albany are key freight pathways. Albany sits roughly 150 miles north of New York City—positioning it within a major Northeast transportation route that carries significant truck traffic between downstate population centers and upstate industrial hubs. Within the City of Albany, about 40% of residents identify as people of color, and roughly one-quarter of the population lives below the federal poverty line (U.S. Census Bureau, 2023). In 2017, the Albany South End Neighborhood Air Quality Initiative launched a year-long intensive air monitoring study in response to long-standing community air quality concerns. Residents in the South End had long reported diesel odors, soot on windowsills and disruptive late-night truck activity. The neighborhood sits at the intersection of a major transportation and industrial corridor—including Interstate 787, active rail lines and marine traffic on the Hudson River—



—where heavy-duty diesel trucks, trains, cargo-handling equipment and port operations operate in close proximity to homes, schools and community facilities. There was little block-level data available to determine whether pollution was originating from port operations, truck traffic or other nearby sources. A central area of concern was the Ezra Prentice Homes, a public housing community located directly along South Pearl Street (New York Route 32)—a designated truck access highway carrying roughly 1,700 diesel truck trips per day (New York State Department of Environmental



Conservation [NYSDEC], 2020). Community engagement was central to the study. Through its Office of Environmental Justice, NYSDEC worked with residents and local stakeholders to incorporate community concerns —particularly around freight-related emissions—into the study design. That engagement was sustained through seven community meetings between 2016 and 2018, with progress shared through in-person updates, a dedicated website and real-time monitoring displays, shaping the study’s focus. Defining the questions early helps align expectations with what the tools and methods can actually show, keeping the work focused on practical outcomes.

“Do your homework first—understand who lives there, what work has already been done, and the community’s history. If you skip that, you risk collecting data that isn’t interpretable or trusted.”

— Marilyn Wurth, Research Scientist 3, Division of Air Resources, NYSDEC

The four main questions in the study

1. How much particulate matter (PM) comes from motor vehicles versus port activities?
2. How far does particulate pollution travel from the road into the neighborhood?
3. How do port activities and road traffic contribute to benzene concentrations?
4. How can the community better understand local air quality?



This early alignment ensured the study generated results that extended beyond analysis, providing a defensible foundation for enforcement actions, policy discussions and longer-term strategies to address freight-related pollution. The study was implemented through a multidisciplinary partnership that included the New York State Department of Health [NYSDEH], the New York State Department of Transportation [NYSDOT], the Albany County Health Department and researchers and educators from the University at Albany. NYSDEC staff specializing in air quality monitoring, emissions analysis and exposure assessment contributed across all phases of the project, from design through execution. The study targeted



traffic- and petroleum-related pollutants, including particulate matter (PM₁₀ and PM_{2.5}), black carbon, UFPs, NO₂, other traffic-related gases, benzene and related VOCs. NYSDOT installed a traffic counter to document vehicle counts, including truck volumes. Meteorological data—such as wind speed, wind direction and temperature—were used to interpret pollutant dispersion patterns. To capture pollution patterns at multiple scales, NYSDEC operated two fixed monitoring stations—one at the Ezra Prentice Homes and one on Third Avenue. These fixed stations continuously collected pollutant concentrations over extended periods, allowing evaluation of diurnal and seasonal patterns (NYSDEC, 2019). The fixed station at Ezra Prentice began operation in July 2017 and continued into late 2018. Quality assurance was a priority throughout the project. Where feasible, portable instruments were collocated, with results generally within 10–30% of the reference site—sufficient to confirm spatial gradients and patterns while clearly communicating the limits of short-term or low-cost measurement tools.

“You need to know what the government agency, or audience for your data, actually wants before you pursue funding or starting the project—that conversation has to happen at the beginning.” — Tim Dye, Founder of TD Environmental Services LLC with over 30 years of experience in monitoring and data technology.

Collocation

Collocation refers to placing two or more air monitoring instruments side-by-side—often pairing portable or research-grade tools with regulatory-grade reference monitors—to compare how measurements align under the same environmental conditions.

Why it matters: Collocation builds confidence in data by showing whether different instruments capture the same trends and timing, even when absolute values differ. In community and research-based monitoring, it helps clarify uncertainty, contextualize measurements, and prevent misinterpretation.

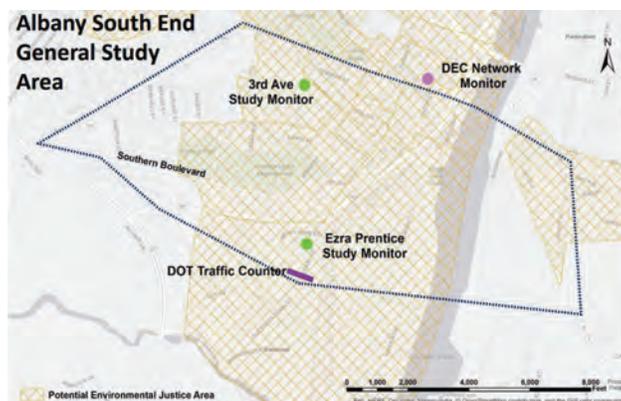


Figure 4: Study Area for Albany South End

Data from the fixed sites informed targeted deployment of portable backpack monitors and temporary “mini-stations” which were used in 3–5-hour sampling sessions to map block-by-block concentrations and assess how far truck emissions extended into nearby residential areas. Portable monitoring was conducted throughout the study period to capture spatial gradients and peak episodes. Near-roadway and walk-around monitoring tracked PM_{2.5}, UFPs and black carbon along freight routes and intersections. In parallel, NYSDEC conducted an extensive benzene monitoring campaign, placing two-week passive samplers at more than 100 locations across roadways, residential blocks, commercial zones and port facilities. These fenceline samplers used [EPA Method 325A](#) to measure benzene, providing a defensible assessment of petroleum-related impacts alongside particle



measurements. These coordinated methods produced a detailed, multi-scale picture of air pollution around the Port of Albany and South Pearl Street, allowing the study to differentiate contributions from trucks, rail activity, industrial sources and port operations. The monitoring approach was deliberately multi-layered, combining regulatory grade instruments with portable, research-grade tools to capture short-term, neighborhood-scale variation.



Findings

- Mobile sources: Heavy-duty trucks and buses were the primary contributors to elevated particle concentrations, with traffic on South Pearl Street exerting a stronger influence than activities within the Port of Albany.
- PM_{2.5}, UFPs and black carbon were consistently highest closest to truck routes, bus corridors and port-related roadways, especially near the Ezra Prentice Homes (concentrations nearly double those measured at nearby background and comparison locations and decreased with distance from the roadway).
- The data show clear near-roadway effects linked to traffic activity on South Pearl Street, with ultrafine particle levels peaking during weekday truck and vehicle periods.
- Walk-around sampling captured sharp spikes during truck queues, turning movements and idling, demonstrating the role of freight-related activity in shaping short-term air-quality conditions.
- Benzene concentrations were highest within the Port of Albany and Port of Rensselaer near petroleum storage and transfer operations, but residential areas outside the ports did not exhibit elevated benzene levels.
- A small number of diesel-fueled heavy-emitting vehicles, particularly trucks and buses, were responsible for short-term pollution spikes, highlighting the impact of specific vehicle types on local air quality.

While **Figure 5** shows the average vehicle counts and related pollution exposures on South Pearl Street, **Figures 6 and 7** (next page) show how vehicle activity shapes local pollution levels in the South End. As vehicle proximity increases, particle counts rise, reinforcing the link between heavy-duty traffic and near-road exposure. Weekday averages further show sustained elevation during peak traffic periods. Together, these findings demonstrate how traffic density and vehicle distance influence neighborhood air quality.

South Pearl Street: cars and trucks

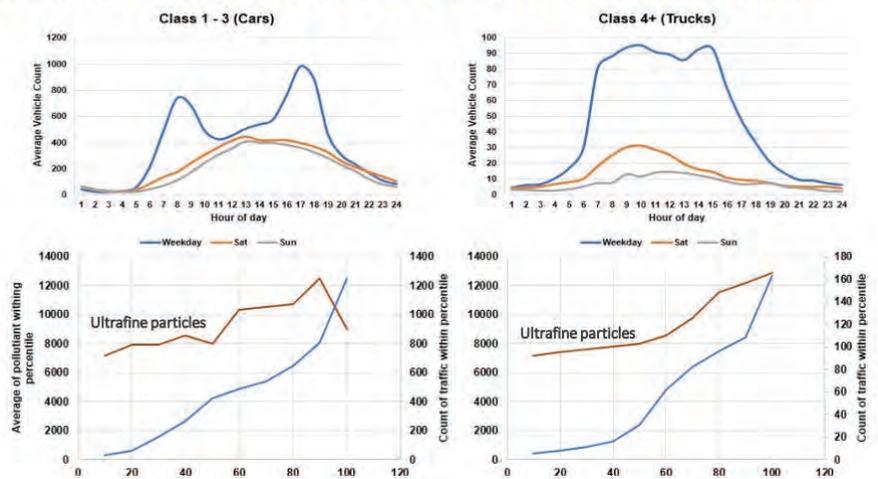


Figure 5: South End Average Vehicle Counts & Pollution Exposure



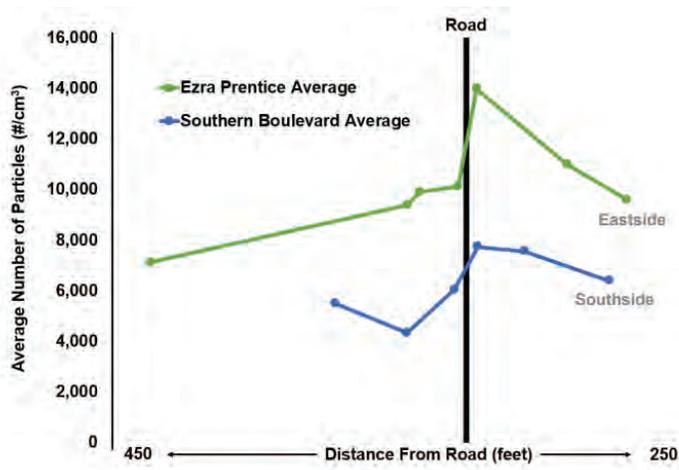


Figure 6: Avg Number of particles & Vehicle Distance

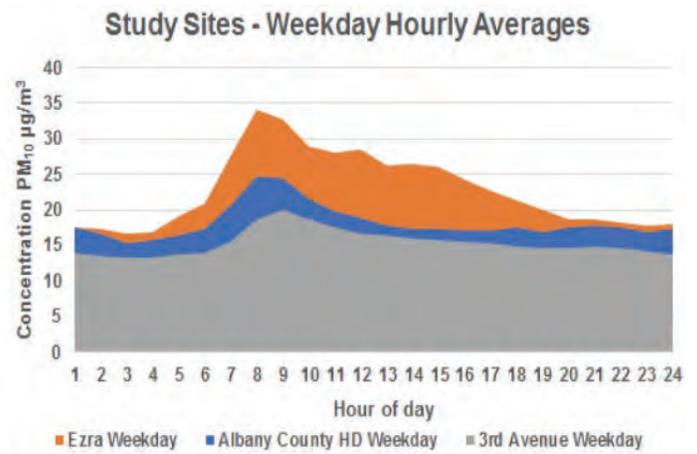


Figure 7: South End Weekday Avg. Pollution Concentration

Figure 8 (below) summarizes the length of time each instrument operated at the fixed monitoring locations. By translating these patterns into place-specific evidence, the project generated data that elevated community voices and informed more targeted discussions about reimagining interstate access and reducing exposure along heavily traveled corridors. information network and a public health intervention.

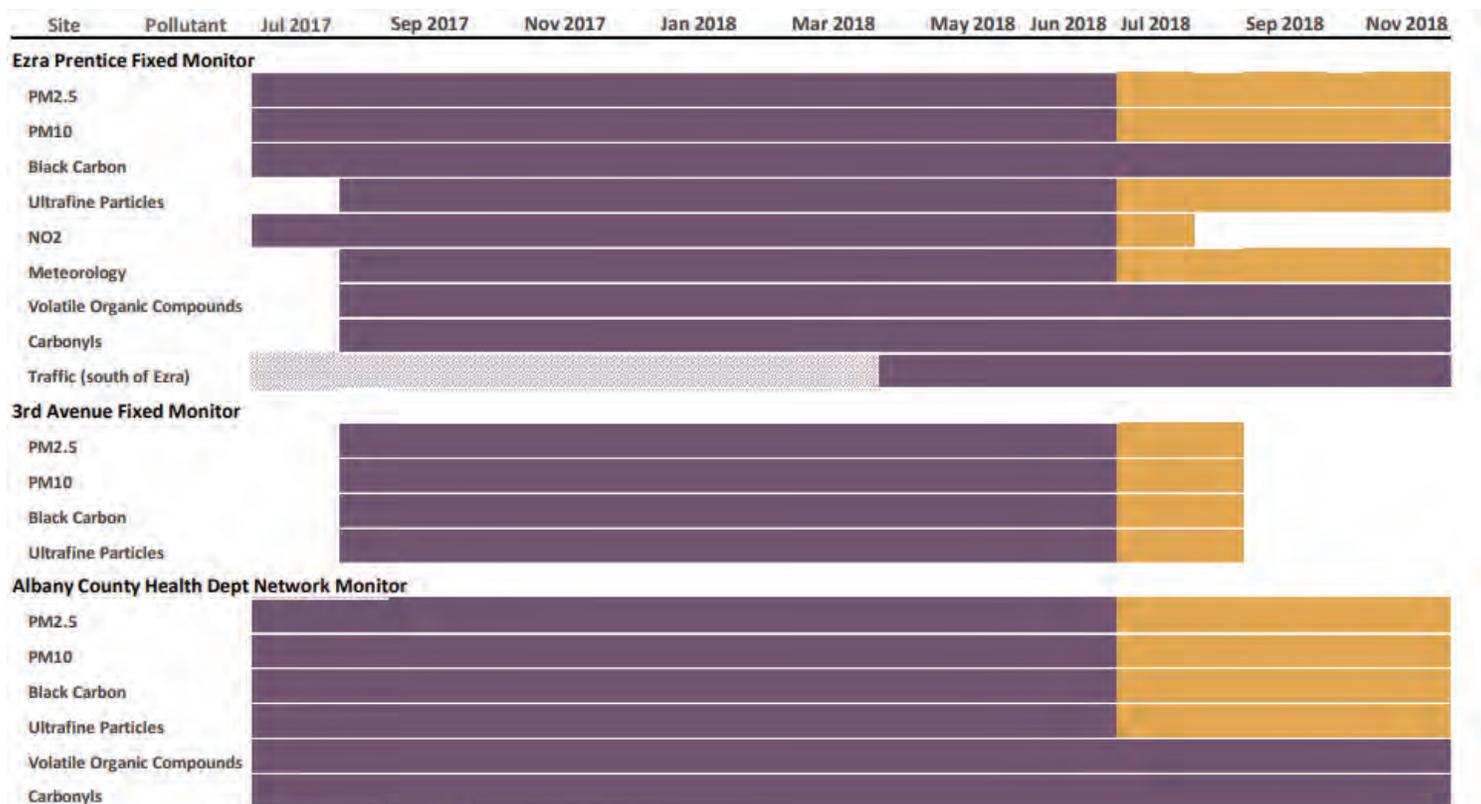


Figure 8: Albany Pollutant Measures [Pattern] Invalid Data Collection [Dark Purple] Data Collection Period [Orange] Beyond



The final report, released in 2019, translated monitoring results into concrete recommendations that informed local policy discussions. NYSDEC recommended reducing heavy-duty truck traffic on residential streets, reclassifying priority roadways to restrict diesel access, assessing freight rerouting options through the port and improving coordination among transportation, permitting and land-use planning agencies to address traffic-related air pollution. The City of Albany coordinated voluntary truck rerouting with several commercial entities and prohibited city vehicles from using South Pearl Street. NYSDOT reclassified roads within the Port of Albany to enable trucks to shift routes away from Ezra Prentice. In parallel, the Port of Albany requested that tenant trucks avoid South Pearl Street and required new tenants to route truck traffic through the north or south port entrances rather than past the neighborhood.

Other recommendations stalled due to a combination of funding constraints and limited governmental coordination with the onset of the COVID-19 pandemic—highlighting how difficult it can be to translate monitoring results into infrastructure or policy changes. Alongside the air monitoring analysis, a health outcomes review was conducted to assess patterns in respiratory and cardiovascular conditions within the study area. Using age- and sex-adjusted hospital admission and emergency department visit data from 2005–2015, the health outcomes review compared the South End with a nearby reference area and found consistently higher rates of asthma, COPD, acute bronchitis, hypertension and diabetes, while emphasizing that the results indicate associations rather than causation (NYSDEC, 2020). “That’s why we’re careful about health conclusions—short-term monitoring can’t answer long-term health questions, and it’s easy to overreach if you don’t have the right exposure and health data,” explains Randi Walker. The South End project demonstrated the value of combining near-road, mobile and passive monitoring to capture conditions missed by a single regulatory site. Despite concluding more than five years ago, it helped elevate attention to disproportionate transportation-related burdens in communities with higher exposure to air pollution.

“Transparency alone isn’t enough. Communities need tools and support to analyze and use the data, especially when monitoring is meant to inform decisions, not just document problems.” — Randi Walker, Chief, Air Toxics Section, Division of Air, NYSDEC

This community-centered, hyperlocal monitoring framework anticipated elements later adopted statewide through NYSDEC’s separate 2024 Community Air Monitoring Initiative, which applied mobile and stationary monitoring, formal community advisory processes and data-to-action tools—such as story maps—to support the development of air pollution reduction strategies in under-resourced communities (NYSDEC, 2024).

“You don’t want communities collecting data for years only to find out it doesn’t fit how agencies are allowed to use it.”

— James Bradbury, PhD, Director of Research & Policy Analysis, Georgetown Climate Center, Georgetown Law

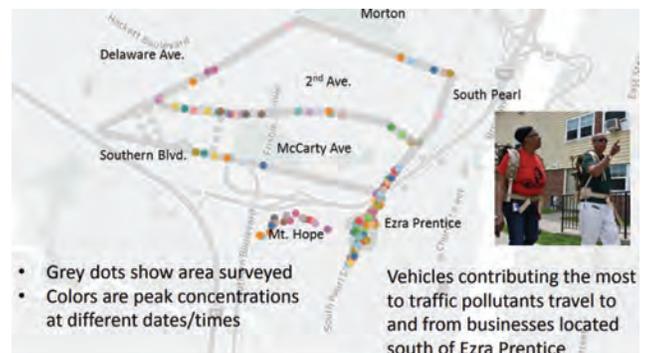


Figure 9: Area Surveyed with Peak Pollution Concentrations



Durability Through Collaboration

This project demonstrates how early and sustained collaboration strengthens both the scientific integrity and longevity of community air monitoring. NYSDEC engaged residents and local stakeholders at the outset to define study questions and identify priority locations, then sustained that engagement through regular communication, community meetings and publicly accessible data sharing designed to ensure transparency, build trust and keep findings grounded in community priorities. This ongoing exchange allowed participating stakeholders to develop a shared understanding of the findings and their limitations. It also underscores ongoing challenges: sustaining funding, coordinating across agencies and establishing mechanisms that allow localized data to inform permitting decisions, land-use planning, enforcement and long-term solutions. More broadly, the South End experience shows that neighborhood-scale monitoring efforts are most durable when air quality, health, transportation and research agencies collaborate from the outset, creating shared ownership of the data and clear pathways for findings to inform policy, planning and long-term monitoring frameworks.

Data Lifecycle: Collection, Maintenance and Useability

A robust data lifecycle is foundational to producing air quality datasets that are scientifically defensible and decision-relevant. Defining the questions early helps align community expectations with what the data and methods can realistically support. In the South End project, the lifecycle began with a hypothesis-driven monitoring design informed by community-identified exposure concerns, which guided pollutant selection, site placement and temporal resolution (how frequent data measurements are). NYSDEC implemented a multi-scale measurement strategy that integrated continuous fixed-site monitoring, targeted short-duration mobile and walk-around sampling, and time-integrated passive sampling to characterize spatial gradients, temporal variability and source-related signatures over a year-long study period.

Data quality assurance and quality control procedures were integrated throughout data collection and analysis, including instrument performance checks, documentation of data completeness and collocation with higher-grade reference systems to assess measurement agreement and drift. Collocation strengthened confidence in observed patterns by demonstrating consistency in concentration trends and temporal response, even where absolute values differed. Ongoing data management and analysis incorporated meteorological normalization, traffic activity indicators and distance-to-road assessments to distinguish near-road impacts from broader background conditions. Transparent dissemination of results—paired with explicit communication of uncertainty, detection limits and methodological constraints—ensured findings were interpreted appropriately by residents, agencies and decision-makers. A defining feature of the project was its emphasis on data transparency. Real-time displays of pollutants in neighborhood community rooms allowed residents to see hour-by-hour changes and discuss patterns directly with NYSDEC staff. By sustaining monitoring long enough to capture diurnal, weekday-weekend and seasonal variability, and by documenting methods in replicable terms, the South End study demonstrates how rigorous lifecycle planning can elevate community-centered monitoring into a credible exposure assessment tool capable of informing transportation planning, mitigation strategies and regulatory action.

“Toxics are challenging to measure with community sensors. Sensors can pick up a signal, but total VOCs and many air toxics aren’t straightforward, so you have to be clear about what the technology can and can’t tell you.” — Randi Walker, Chief, Air Toxics Section, Division of Air, NYSDEC



Data-to-Decision Pathways

The South End project identified clear near-road pollution gradients, time-of-day traffic peaks and the contribution of heavy-duty trucks and buses, translating long-standing resident concerns into measurable, place-specific evidence. Rather than serving as a standalone technical exercise, the data supported practical decision-making in the City of Albany and clarified where pollution was concentrated, when exposures were highest and which sources mattered most. As seen in the findings and graphics above, this case illustrates how applied, evidence-based community governance functions in practice. Cross-agency partners were able to develop study designs that helped gather and interpret credible data for policymakers to take strategic actions, changing local freight operations based on neighborhood-level conditions. When paired with structured engagement and clear pathways to enforcement, planning or mitigation, community-based monitoring can move beyond documentation to support targeted local action. Programs that integrate education, storytelling and lived experience help translate technical air quality data into resident-, public- and policy-relevant insight while elevating community voices. Through interviews, community events and public-facing communication, these approaches contextualize data, sustain long-term engagement and strengthen local advocacy capacity and strategy.

West Oakland, California – West Oakland Environmental Indicators Project

West Oakland is a historically residential neighborhood in the northwestern corner of the city of Oakland, in Alameda County, California, situated along the San Francisco Bay near the eastern end of the Bay Bridge, just west of Downtown Oakland and south of Emeryville. Bordered on nearly all sides by major freight infrastructure, approximately 29,000 people live within this 7-square-mile area, including long-established Black communities, immigrant families and households living in older single-family homes, duplexes and multifamily apartments (WOEIP, 2024). The neighborhood's geography is unique: three interstate highways—I-580, I-880 and I-980—form a ring around it, while the Port of Oakland, two large railyards, truck lots, distribution warehouses and metal and recycling facilities surround much of the remaining perimeter (Bay Area Air Quality Management District [BAAQMD] & WOEIP, 2020). This area has experienced decades of elevated air pollution tied to historic land-use decisions, industrial activity and major transportation corridors, while residents have long reported diesel odors, visible soot, metallic dust and nighttime freight noise.

Black residents in West Oakland continue to live approximately 15 years fewer than those with the highest life expectancy (WOEIP, 2024).

This concentration of freight corridors means thousands of diesel trucks pass through West Oakland every day, alongside locomotive activity, port drayage, cargo handling and heavy industrial operations. Homes, schools and childcare centers sit within blocks—and sometimes within feet—of idling queues, warehouse entrances and arterial truck routes, making it one of the Bay Area's most pollution-impacted neighborhoods (WOEIP, 2024). Scientific assessments have consistently documented elevated levels of DPM, black carbon UFPs, PM_{2.5} and air toxics in the area, leading to higher asthma and cardiovascular illness rates.



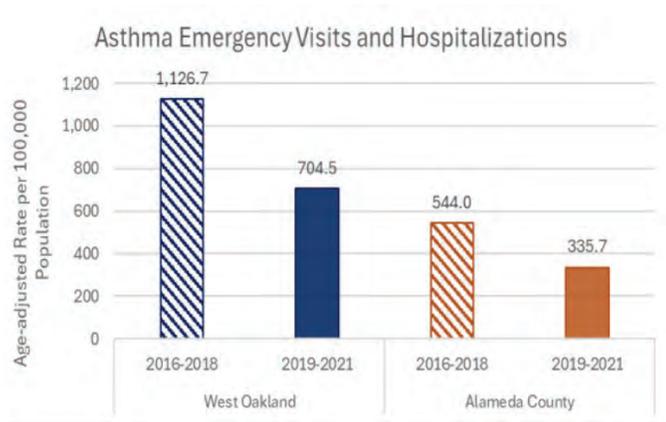


Figure 10: West Oakland & Alameda County Asthma Incidences

In West Oakland, asthma-related emergency visits and hospitalizations were very high in 2016–2018, at about 1,127 per 100,000 residents, and declined to roughly 705 per 100,000 by 2019–2021. While this represents improvement, rates remain substantially elevated compared with Alameda County overall, where asthma-related visits declined from about 544 per 100,000 in 2016–2018 to approximately 336 per 100,000 in 2019–2021— Asthma-related visits in West Oakland occur at more than twice the county average rate (WOEIP, 2019).

The broader San Jose–San Francisco–Oakland metropolitan area continues to rank among the worst in the U.S. for air quality in the American Lung Association’s “State of the Air” 2025 report: it is 14th worst for high ozone days, 11th worst for short-term particle pollution and 6th worst for annual particle pollution out of more than 200 metropolitan areas assessed nationally. For decades, the community had access to only one regulatory air-monitoring station, a level of coverage insufficient to describe block-level exposure associated with truck and port activity.

The WOEIP was established around 2000 by local community leaders and has operated for over 20 years as a resident-led organization focused on air quality, health and equitable development in West Oakland. Since 2008, WOEIP has partnered with academic researchers and technology providers to advance hyperlocal monitoring approaches through participatory research and collaborative problem-solving. These models equip community members with scientific, grassroots and advocacy expertise, ensuring that those most affected by pollution help define the questions, conduct the research and interpret the findings. In doing so, they transform monitoring from a technical function into a mechanism of shared governance—redistributing authority, deepening local capacity and elevating community knowledge as a catalyst for planning, enforcement and sustained accountability.

The turning point came in 2017 with the passage of California’s AB 617, which established a statewide framework for community-driven air quality planning. West Oakland was selected by the California Air Resources Board as one of the first Community Emissions Reduction Program (CERP) pilot sites, launching a locally guided planning process supported by supplemental environmental grant funding. To complement this planning work, WOEIP built the West Oakland Air Quality (WOAQ) Monitoring Network—21 sensors: seven advanced units capable of measuring black carbon, heavy metals and other diesel tracers, and fourteen PurpleAir PM_{2.5} sensors installed at homes, businesses and community sites across truck-impacted corridors. The first wave of sensors was installed in winter 2023–2024, followed by community training and data testing in spring 2024 and continued monitoring and refinement through summer and fall 2024. Mobile monitoring, first on foot and then with cars—through partnerships with Google/Aclima vehicles—provided millions of additional block-level measurements of black carbon, NO_x, UFPs and localized port plumes (WOEIP, 2020). WOEIP is continuing to develop a public data portal that will house collected data and make it publicly accessible, reinforcing transparency and community ownership.

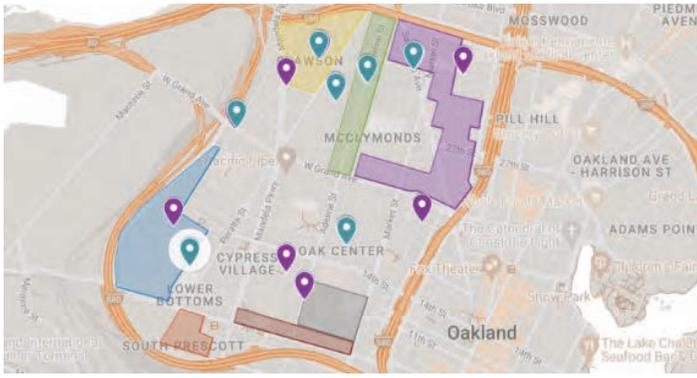


Figure 11: Study Image of WOEIP’s sensor network

“We don’t rely on a single sensor or method. We use multiple approaches —mobile monitoring, stationary sensors, modeling—because no one tool tells the full story.” — Nicole Merino Tsui, Director of Senior Partnerships, WOEIP

Program Success

WOEIP co-led the development of the West Oakland Community Action Plan (WOCAP) alongside the BAAQMD. The WOCAP Steering Committee—comprising neighborhood residents, technical advisors, local business representatives and city, county and state officials—developed more than 80 implementation-ready strategies addressing freight pollution, land-use conflicts, transportation design and neighborhood buffers. Adopted in 2019 under California’s AB 617 framework, the plan is now in its multi-year implementation phase. The Steering Committee meets quarterly in public sessions to guide implementation, track progress and ensure ongoing accountability through monitoring and reporting. Over the past five years, the plan has driven investments and enforceable actions across port, city, county and regional partners. The 2024 5-Year Progress Report documents measurable progress: DPM emissions have fallen by about 31%, measured DPM exposure has dropped by 56% across most impact zones and cancer-risk-weighted emissions have decreased by 28%, contributing to an estimated 54% reduction in community-wide cancer risk (WOEIP, 2024). The combination of plan actions, existing and new statewide regulations, fleet turnover and other changes resulted in significant emissions reductions in West Oakland between 2017 and 2024. Building on the progress, investments and actions detailed above, the following figures illustrate how emissions and exposure outcomes have changed across West Oakland’s seven impact zones since 2017. The tables on the next page accompanies **Figures 12** and **13** and documents how on-road vehicle emissions were modeled.

“Residents knew where pollution was coming from long before there were studies. The challenge has always been translating lived experience into data that government and academic institutions are willing to act on” — Nicole Merino Tsui



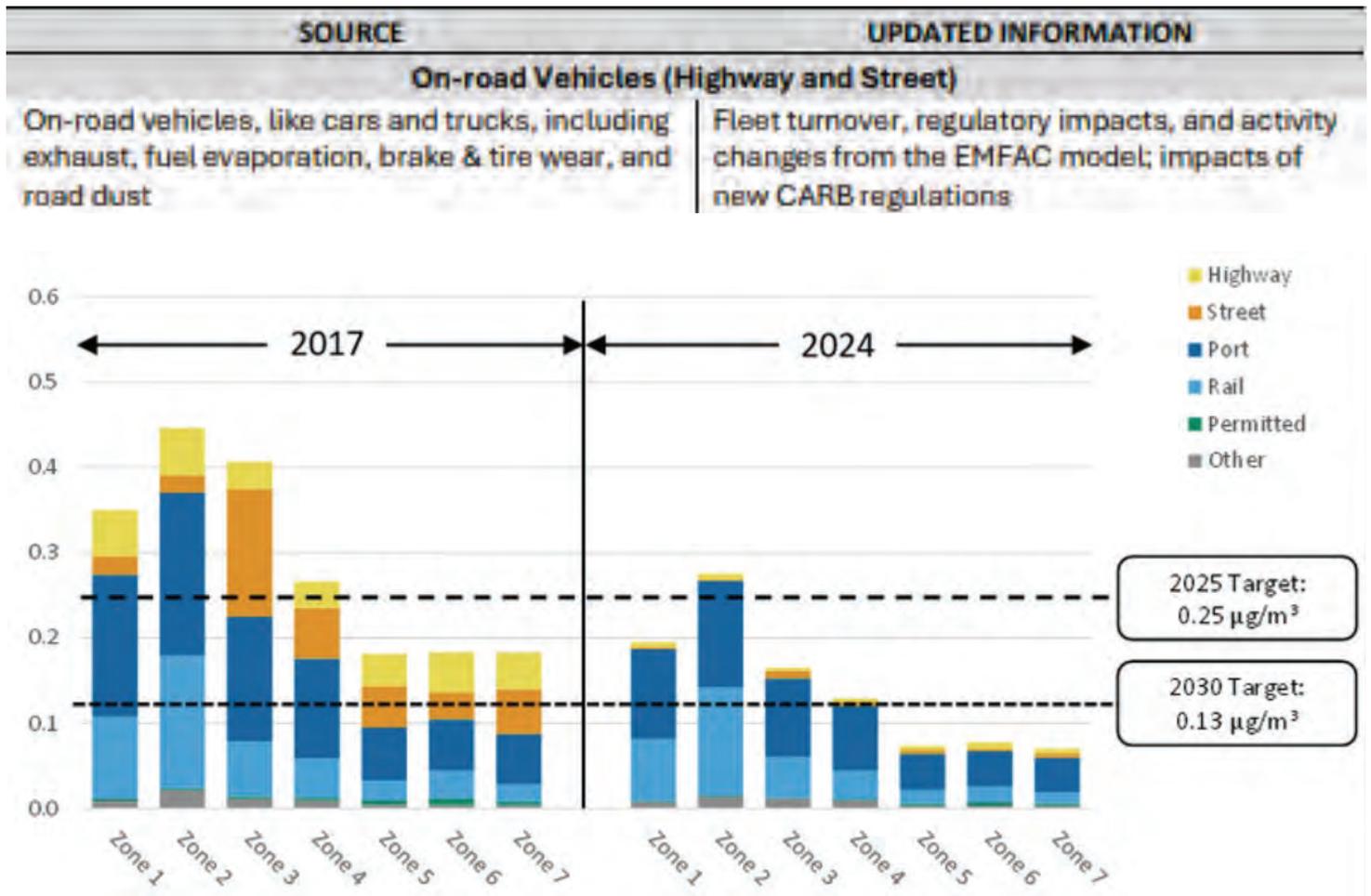


Figure 12: Comparison of DPM levels across 7 impact zones

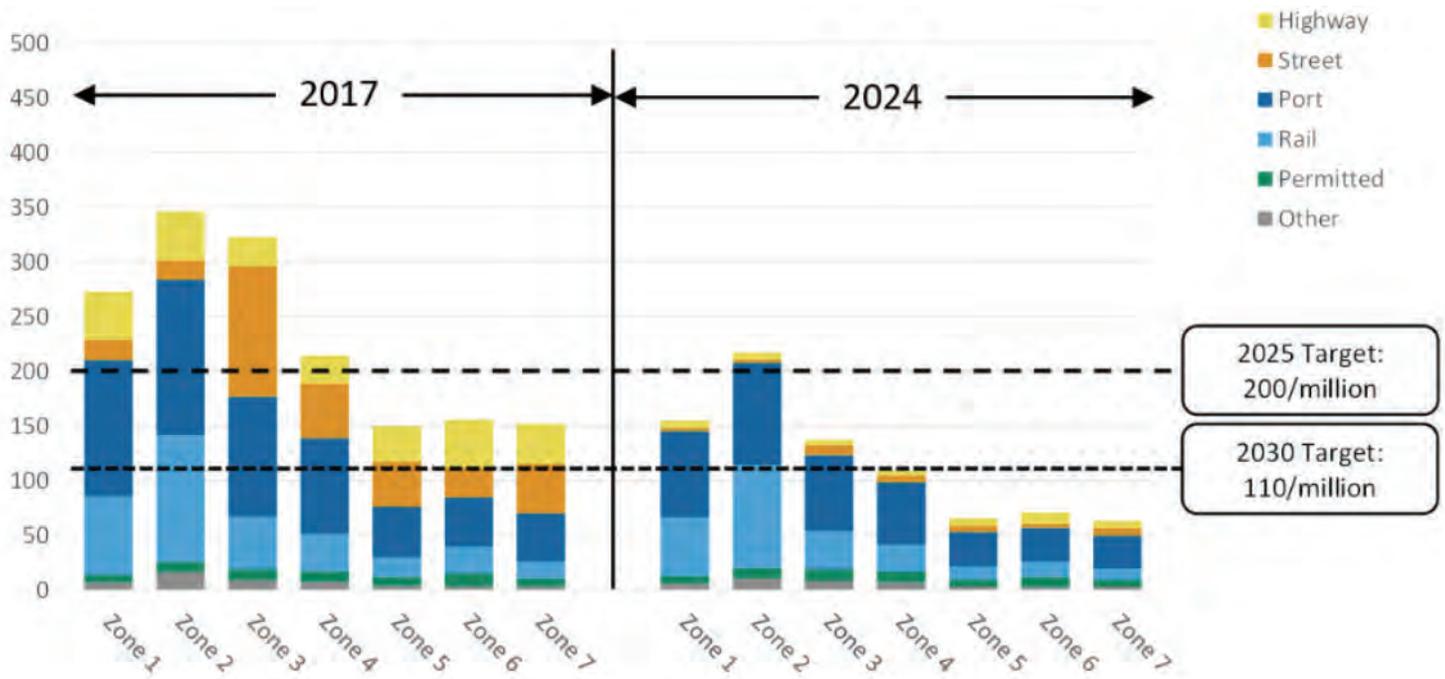


Figure 13: Cancer-risk weighted emissions across 7 impact zones



Figure 12 and 13 show measurable reductions in diesel particulate matter and cancer-risk weighted emissions. Further emissions reductions between 2024 and 2029 are projected at approximately 7%, reflecting continued growth in on-road motor vehicle activity (WOEIP, 2024). These estimates are based on modeling, which is useful for planning but depends heavily on the quality and representativeness of the underlying data—reinforcing the need to pair modeled projections with direct, on-the-ground measurement. Notably, the WOCAP plan moves beyond projections to implementation. Its strategies are implementation-ready and subject to annual progress reporting, with air districts required to submit both qualitative and quantitative updates supported by standardized metric

workbooks. This structure enables state oversight while strengthening transparency and public accountability. These outcomes were supported by more than \$51 million invested in 114 local pollution-reduction projects—ranging from cleaner truck programs and railyard improvements to industrial retrofits and port upgrades—that collectively prevented over 1,000 tons of NO_x, particulate matter and air toxics. WOEIP’s multi-sensor approach has also informed transport and freight decisions in real time—including truck rerouting proposals and street-sweeping strategy changes.

Open Dashboard and Public Communication

Public dashboards are a vital tool in this effort. WOEIP’s WOCAP data and implementation progress are publicly posted on the BAAQMD website, enabling public visibility and accountability. WOEIP will continue to advance the development of a future public-facing portal, designed to make air quality data transparent, accessible and directly usable. Dashboards can translate technical data into visual stories that support neighborhood planning and emissions reductions. Through color-coded maps, mobile sensor readings and comparisons across days and seasons, dashboards allow residents and policymakers to see specific health burdens in their area and make connections between freight activity and air quality. These are not just transparency tools; they are instruments of accountability, advocacy and education. They enable community members to ask more data-informed questions, demand targeted policy responses and build a broader base of air quality literacy. Transparency goes beyond data access to include clear explanations of methods, corrections and uncertainty. By embedding this context directly into dashboards and tools, programs allow users to engage with the data at different levels of technical depth while maintaining trust. When communities understand why corrections are made and what they mean, the data becomes credible, usable and defensible for both residents and regulators (U.S. EPA, 2025b).

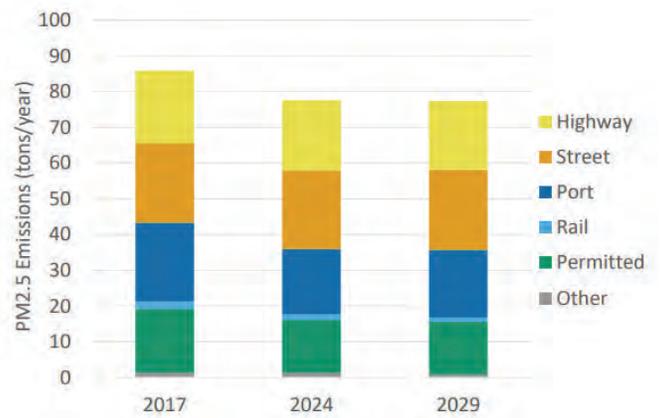


Figure 14: West Oakland PM2.5 emissions by year and source category (WOEIP, 2024)

“All data is valuable—it’s just a matter of how we use it.”

— Michael Ogletree, Senior Director, State Air Quality Programs, Colorado Department of Public Health and Environment



Data Lifecycle: Collection, Maintenance and Useability

Community-generated datasets reveal the acute, street-by-street pollution patterns—capturing short-term spikes, idling hotspots and cut-through truck traffic—and localized burden that can vary dramatically within the span of a few hundred feet. In West Oakland, the air monitoring program was built around a transparent and trusted data lifecycle designed to reflect how pollution is actually experienced. Sensor placement and analysis explicitly accounted for time-of-day and seasonal patterns, capturing elevated nighttime and weekend pollution linked to port activity and train idling—conditions that traditional monitoring often miss. Credibility and usability were strengthened through a staged rollout that paired early sensor deployment with community training, testing and refinement.

Quality assurance was central to this process, with calibration checks, correction factors for conditions such as wildfire smoke and humidity, and clear documentation embedded directly into data sets, so uncertainty and methodology were visible alongside the data. By combining technical rigor, open data practices and sustained resourcing through state funding and technical partnerships, the West Oakland network ensures monitoring is not a one-time exercise but a durable, community-owned system—one that supports accountability, tracks progress over time and turns data into a long-term asset for local action and policy change.

Data-to-Decisions Pathways

The WOEIP shows how community air monitoring can function as a governance mechanism rather than a standalone data exercise. Through calibrated measurement, collaborative evaluation and formal decision pathways, monitoring was embedded into how policies were shaped and enforced. Central to this approach was the resident-led Community Steering Committee that shifted planning authority toward local leadership, positioning residents as decision-makers rather than data subjects. By anchoring monitoring priorities, data interpretation and implementation in lived experience, the program ensured that evidence remained actionable—moving monitoring from observation to sustained systems change. Over time, this participatory framework was institutionalized. WOEIP's role was formalized through contracts with the BAAQMD, embedding community expertise directly into regulatory workflows. This integration improved coordination across air quality, transportation, port and land-use agencies and enabled more timely responses during pollution events. Calibrated, validated monitoring data became actionable—informing enforcement, freight-routing decisions and mitigation investments rather than remaining confined to technical reports. In practice, community-generated pollution maps and exposure analyses were leveraged to advance zero-emission freight goals, restrict diesel traffic near schools and homes and support the development of the West Oakland Truck Management Plan. The longevity of this work underscores a broader lesson for future programs: durable environmental change emerges when community leadership, regulatory authority and scientific rigor advance together.

“This work has always required partnership—with local agencies, the Port of Oakland, regional regulators, and researchers—to understand emissions, exposure, and health risk in a way that could actually lead to change.” — Nicole Merino Tsui



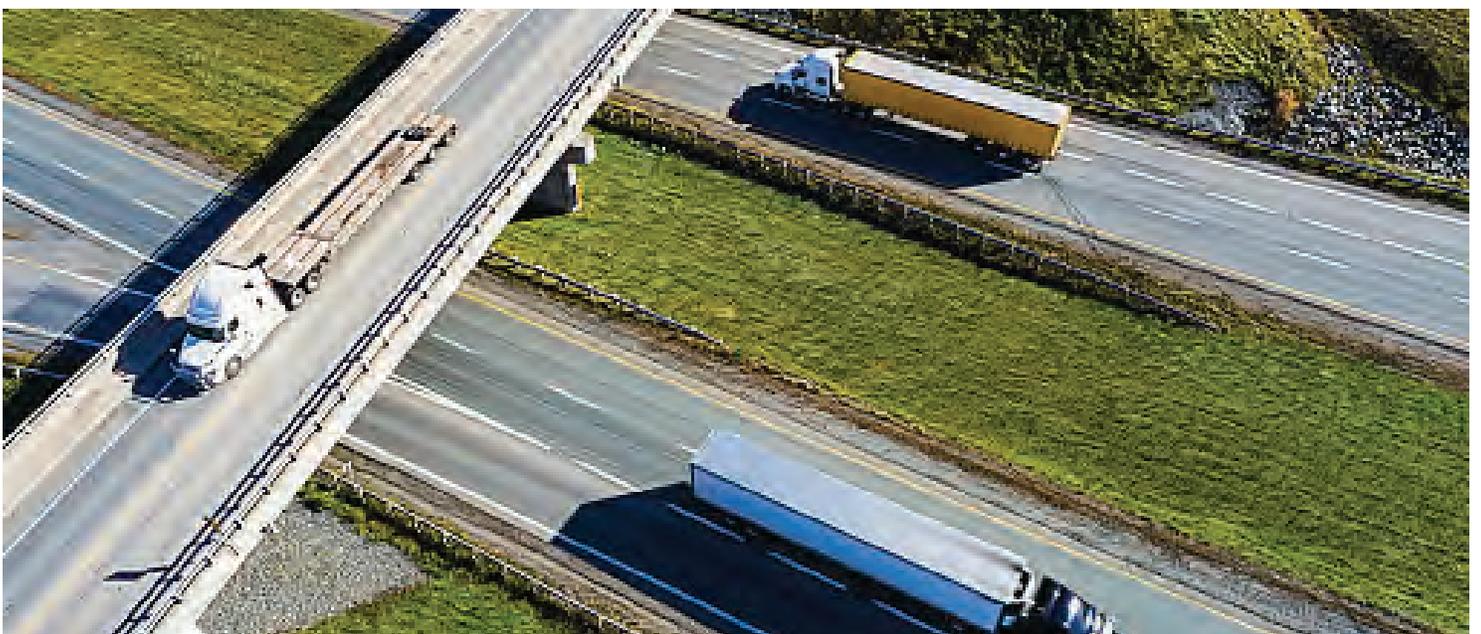
Conclusions

Community-based air monitoring is transforming how pollution is identified, understood and addressed in neighborhoods shaped by heavy-duty traffic. The South End Neighborhood Air Quality Initiative in Albany and the WOEIP demonstrate that community-driven data can reveal exposure patterns that fixed regulatory monitors cannot. By integrating these sensors, mobile monitoring and near-roadway measurements, these efforts document real-world exposure and substantiate long-standing resident concerns about diesel pollution and related health risks (Gao et al., 2022).

Accessible data platforms are critical for turning monitoring into action by making trends, hotspots and progress visible—moving data from observation to leverage and enabling coordination across community partners and public agencies. Across both projects, localized, participatory data drives action not simply because it exists, but because it is shared, trusted and acted upon—reshaping policy pathways and accelerating regulatory and community response. These case studies also make clear that data alone does not produce change.

Sustained investment in training, quality assurance, maintenance and evaluation—alongside mobile monitoring and community capacity-building programs—is essential to keep data credible, community-owned and policy-relevant over time. When monitoring is supported as a long-term public good rather than a short-term project, it becomes infrastructure for governance rather than evidence in isolation. Together, these efforts reflect what scholars describe as shared environmental governance, in which communities actively shape data collection, interpretation and outcomes rather than serving as passive recipients of information (O'Rourke & Macey, 2021).

Taken together, these cases show that reducing pollution from heavy-duty traffic requires more than data collection—it requires continuity, accountability and partnership embedded over time. Participatory science strengthens public health, builds local leadership and repositions data as a bridge between lived experience and institutional decision-making. In freight-impacted communities, this shift is not abstract: it is how invisible exposures become visible, how concerns become evidence and how cleaner, safer conditions move from possibility to practice, shifting power toward the people most affected and enabling measurable change where it matters most.



Looking Forward

These programs signal an evolution in air quality monitoring—toward models that are more adaptive, community-centered and capable of pairing emerging technologies with on-the-ground engagement to address persistent data gaps. Two models of innovative projects in the field are included below.

Mobile Monitoring Innovation

In June 2025, California launched the first-of-its-kind Statewide Mobile Monitoring Initiative (SMMI), deploying sensor-equipped vehicles and mobile labs across 64 communities disproportionately affected by air pollution. Led by CARB in partnership with Aclima, UC Berkeley, UC Riverside and Aerodyne, the project collects block-by-block data on criteria pollutants, black carbon, methane and other toxic air contaminants, with more than 60% of effort focused on low-income and overburdened communities. Over 40 community-based organizations helped shape monitoring priorities, ensuring that residents' concerns drive where and what gets measured. Data collection runs through June 2026, after which all pollution measurements and visualizations will be publicly available to support local air-quality solutions, guide policy, inform research and bolster grant applications. This statewide initiative sets a new precedent for how air monitoring can be reimaged—by centering communities that are under-resourced, integrating advanced mobile technology and creating a replicable model that can expand options for community-driven monitoring in areas historically left out of regulatory data collection.

CleanAIRE North Carolina's AirKeepers

The AirKeepers Dashboard is a dynamic, community-informed air quality platform developed through CleanAIRE North Carolina's community science program over two and a half years, in partnership with ten stakeholder groups across the state. Guided by participatory science efforts, the dashboard integrates sensor data from over 300 deployed monitors and is designed to be responsive to the needs and goals of impacted communities. The tool provides real-time air quality readings, accessible correction factors and community-generated context to support both public understanding and scientific use. Importantly, residents can access individual reports, filter real-time and historic-sensor data and learn why certain corrections are applied, giving them greater ownership of their local data. As a result, the dashboard remains one of the few readily accessible platforms providing localized, community-scale insights in a single, public-facing format. The AirKeepers project emphasizes storytelling, transparency and access—using stipends, language testing and community pilot feedback to build trust and usability. With a growing user base across all 50 states, the dashboard includes a built-in

“Transparency isn't just publishing numbers. It's explaining correction factors, uncertainty, and why different methods are applied—right next to the data itself.”

— Daisha Wall, Director of Programs & Impact, CleanAIRE NC



guided tour to support first-time users in navigating community-scale air quality data. Concurrently, CleanAIRE NC launched the CleanAIRE Academy in August 2025 as a dedicated learning platform that offers training modules on permitting, clean air advocacy and data literacy, enabling communities to interpret and apply air quality information without relying solely on external experts. Together, the AirKeeper Dashboard and CleanAIRE Academy support communities across North Carolina—from Charlotte to Sampson County—using approaches that range from securing EPA reference-grade monitors to challenging industrial permits. This integrated, but not singular, model reflects CleanAIRE’s commitment to meeting communities where they are, whether through regulatory engagement, litigation support, policy advocacy or expanded access to health and environmental data. As these tools and programs continue to evolve, they create new opportunities for stakeholders to generate actionable, community-informed data that supports local solutions, policy development and long-term air quality improvements.



“The AirKeepers dashboard was built with communities, not for them. Over two and a half years, residents tested it, shaped it, and told us what transparency actually needed to look like...The fact that we see users well outside North Carolina tells us this need isn’t regional. Communities everywhere are looking for usable air data.” — Madison Fragnito, Development Director, CleanAIRE NC.

Recommendations

To reduce freight-related air pollution by ensuring hyperlocal monitoring data reach decision makers and inform mitigation strategies, the American Lung Association offers the following calls to action:

Federal Government

- Implement and enforce science-based, health-protective NAAQS, including the 2024 updated PM_{2.5} standard.
- Strengthen hazardous air pollutant standards and enforcement. Expand fence-line monitoring requirements to more stationary sources of hazardous air pollutants.
- Adequately fund state, local and tribal air agencies to sustain robust regulatory monitoring networks, including staffing, data platforms and infrastructure.
- Invest in dedicated, multi-year funding for community-led monitoring, supported across federal agencies (e.g., EPA, FEMA, USDA and others). Include investments in technical assistance hubs that provide calibration and collocation support, QA/QC protocols, quality assurance and data interpretation guidance. Support ongoing research into best practices.



- Develop guidance on minimum performance, documentation and transparency standards to integrate validated, community monitoring data into federal air quality decisions, including enforcement, inspections, permitting, compliance and rulemaking.
- Establish frameworks to utilize community-scale data for public health communications, emergency response and preparedness, and post-event evaluations.
- Building on the success of the EPA U.S. Fire and Smoke Map, improve and modernize federal data platforms to display validated and corrected community monitoring data alongside regulatory measurements. Permanently fund and expand federal wildfire smoke monitoring programs, including EPA's Wildfire Smoke Air Monitoring Response Technology (WSMART).
- Support cross-agency coordination among air agencies, transportation authorities, port and freight authorities and land-use and zoning regulators to integrate community monitoring into decision-making.

States

- Ensure stable, state-level funding streams, beyond short-term grants and projects, for community monitoring. Sustain cross-agency partnerships that build local expertise and tailor to local needs.
- Partner with universities, air agencies and research institutions to provide technical support – including sensor deployment, data hosting, calibration and validation, assessment and maintenance, data useability and hands-on training—for community, school and tribal monitoring programs.
- Integrate properly corrected community sensor data into dashboards, maps, public advisories and communication platforms that support incident-response systems, neighborhood-level messaging, school and outdoor activity guidance, emergency response decisions, post-event assessments and inclusion in state resilience planning.
- Establish frameworks that formalize community participation and transparency in air quality decision-making, including defining how community input informs agency actions and ensuring feedback loops between residents and decision-makers. Ensure a pathway for community-generated data to be used to identify high exposure areas.
- Use quality-assured community data to inform state permitting decisions, cumulative-impact analyses and targeted inspections, and formalize how neighborhood-scale monitoring feeds into state air quality programs to support enforcement screening, mitigation prioritization, emergency monitoring plans, transportation planning and land-use strategies. SIPs can remain anchored to regulatory monitoring for NAAQS compliance while using quality-assured community data to identify hotspots and better target where emission reductions can be applied.
- Support Tribal sovereignty in air monitoring by strengthening EPA State and Tribal Assistance Grant (STAG) support for tribal air programs, including sustained funding for staff, operations and data ownership and use.

Local Governments

- Commit sustained funding to support the full lifecycle of community air monitoring, including sensor maintenance and replacement, staff capacity and training, partnerships, public data platforms and ongoing engagement that links monitoring to public health and emergency response.
- Coordinate across cities, counties, regional agencies, public health and emergency planners and neighboring jurisdictions to align monitoring with pollution patterns, enabling residents and agencies to co-develop priorities, review data and guide mitigation strategies.



- Embed air quality monitoring into local emergency management and hazard-mitigation plans by establishing formal cross-department protocols that define how community sensor networks are used in public communications, emergency operations, recovery planning and future preparedness, require agencies to use real-time data to guide coordinated response during major pollution events, and document lessons learned to improve future decision making.
 - Wildfire smoke: Use data to guide decisions on outdoor activities, worker safety, school and childcare operations, ventilation and clean-air shelter activation.
 - Heavy-duty trucks: Apply data to inform truck routing, idling enforcement, curb management, port operations and roadway design.
 - Point-source pollution: Integrate data into investigations, permitting review, public comment processes and facility-level mitigation actions.
- Regularly review monitoring data to identify areas of elevated concentrations, dominant sources and exposure trends, and conduct after-action reviews following major events to refine communication, sensor placement, outreach and resource deployment.
- Preserve quality-assured community data for public comment and, when needed, legal review, strengthening the administrative record with real-world exposure evidence.
- Support community events and volunteer networks—including schools, faith-based organizations and health clinics—to engage residents as sensor hosts and data stewards.
- Use transparent, plain-language and multilingual reporting tools with visuals and maps to support public understanding and informed participation in policy discussions.

Individuals/Community Groups

- Collaborate with academic entities, public health organizations, government agencies and commercial vendors to secure multi-year grant funding support for deploying monitoring projects and sustaining staffing, data infrastructure and stewardship.
- Bolster community capacity and support through coordination with local schools, tribal, faith-based and neighborhood organizations in under-resourced or rural areas.
- Use publicly accessible air quality data, supported by cross-sector partnerships, to deliver clear findings, actionable requests and health-protective protocols to local municipal boards, school boards, commissions and decision-making bodies.
- Apply neighborhood-scale data to advocate for health-protective actions, including emergency alerts, clean-air shelter activation and smoke-day school and work adjustments, truck rerouting, idling restrictions, buffer zones near homes and schools, and stronger fenceline monitoring, permit modifications, targeted inspections, health symptom tracking and enforceable mitigation during permit renewals or expansions.
- Build data literacy by training local staff, volunteers, leaders and residents to interpret corrected data, document pollution events and communicate findings effectively, while establishing clear governance structures over roles, authority and data ownerships.
- Plan for the full data lifecycle and continuous improvement—from defining monitoring questions and selecting sensors to placement, calibration and maintenance; data collection, backup and useability; to quality assurance and sustained use of results.



- Document and apply lessons learned to improve communication strategies, locally tailored data models, resource deployment and long-term operation and sustainability.
- Maintain public-facing dashboards that integrate sensor data and forecasts with plain-language health guidance, designed to be mobile-friendly, multilingual and accessible to non-experts.
- Educate residents on local emergency preparedness and response protocols, including the communication channels used to deliver rapid public alerts during pollution events.

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Something in the Air

On the Move: Heavy-Duty Traffic Pollution in Nearby Communities

A “State of the Air” Supplemental Report

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Something in the Air

How Communities Are Tracking
the Air They Breathe

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At the Fenceline: Utilizing Data on
Pollution from Stationary Sources



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Introduction

For decades, point-source pollution from refineries, petrochemical plants, metal fabrication operations, power plants and other heavy industrial facilities has been among the most persistent—and unevenly monitored—sources of hazardous air emissions in the United States. Although these facilities operate under federal and state permits, traditional ambient monitoring networks are not designed to capture the full, local scope of their impacts. Emissions can shift significantly with day-to-day operations, maintenance and unplanned emissions events, creating short-duration spikes—often involving hazardous air pollutants—leaving nearby neighborhoods exposed to pollution that is not represented in regional data.

As the “Something in the Air” series moves from broad, satellite-derived views of air pollution to conditions experienced at the neighborhood level, this report “At the Fenceline: Utilizing Data on Pollution from Stationary Sources” centers on point-source pollution as a distinct and persistent risk. Unlike diffuse or regional pollution, emissions from point source facilities originate in specific locations and often recur in the same communities over long periods of time. These impacts are localized, cumulative and frequently underrepresented in regional monitoring systems. In this context, fenceline and neighborhood-scale monitoring are essential for capturing site-specific variability, identifying recurring pollution trends and grounding regulatory oversight in the lived realities of communities located near major stationary sources.

Such sources present monitoring challenges common to other fixed emitters, where day-to-day operational variability and near-source conditions shape exposure patterns that broader regional systems are not designed to detect or fully characterize. Resolving these conditions requires monitoring approaches designed to capture proximity, persistence and variability—core dimensions of community experience. Fenceline communities—neighborhoods located immediately

Fenceline: A fenceline community lives immediately adjacent to highly polluting facilities and is directly affected by traffic and fuel sources (The Climate Reality Project, 2025)



adjacent to polluting sites—face a distinct challenge: point-source pollution is highly localized, episodic and often most intense at the facility boundary where people live, work and go to school. These emissions are driven by operational cycles, flaring, maintenance activities and equipment failures, producing sharp, short-duration plumes. Because the nearest monitor may sit miles away and is often calibrated to reflect regional background levels, exposures experienced at the fenceline can be far more severe than what appears in official datasets. This creates important gaps in understanding how pollution is experienced at the community level. While certain industrial source categories are subject to facility-level fenceline monitoring under federal and state regulations, those programs typically target specific pollutants and defined permit requirements. They are not intended to assess cumulative neighborhood-scale conditions across multiple sources and variable operations. Localized monitoring therefore complements existing regulatory programs by providing finer-scale information that can inform health-protective decision-making and community engagement.

The case studies featured here—the Sensing Air Justice program in the Rubbertown industrial corridor in Louisville, Kentucky and the Cultivando AIRE initiative focused on the Suncor petroleum refinery in Commerce City, Colorado—demonstrate how community-led monitoring makes emissions visible at the scale of exposure, generating data that support enforcement, risk reduction and more effective responses to localized air quality impacts. While the case studies focus on specific industrial settings, the monitoring challenges they reveal extend across point-source sectors, including power generation, where emissions are similarly fixed in place yet highly variable over time.

Community-generated data can support enforcement actions, elevate local health concerns, guide industrial inspections, inform permitting decisions, strengthen emergency response and create shared governance structures between agencies and affected residents—all making air quality information more accessible and actionable where it is needed most. Even where sources operate under permits and meet regulatory requirements, emissions from fixed facilities can fluctuate with operational cycles, maintenance activities and unplanned events, producing localized exposure patterns that escape the reach of regional monitoring.

The case studies that follow build on this context and show how these efforts rely on clearly defined monitoring objectives, rigorous quality assurance, accessible data platforms and partnerships that link community knowledge with regulatory and technical expertise. Together, they illustrate how localized data can be translated into meaningful, health-protective action.

Point-Source Pollution Is a Persistent Public Health Threat

Point-source pollution poses a longstanding public health threat because it exposes nearby communities to concentrated mixtures of hazardous air pollutants that are emitted repeatedly and often unpredictably. National assessments show that industrial and manufacturing emissions account for a substantial share of the country's cancer risk from hazardous air pollutants, with the highest-risk census tracts often located next to large petrochemical or refinery complexes (U.S. Environmental Protection Agency [EPA], 2018).

National research reinforces this picture. Studies using EPA emissions inventories, hazardous air-pollutant risk assessments, and U.S. Census data consistently show that communities closest to refineries, power plants, petrochemical facilities and



other major industrial sources have higher concentrations of low-income residents and larger proportions of Black and Latino households than the national average (U.S. EPA, 2023a). A 2024 study from the National Cancer Institute examined EPA emissions data and U.S. Census tract characteristics and found that industrial facilities released approximately 11 million pounds of known human carcinogens—including benzene, formaldehyde and 1,3-butadiene—into 1,763 census tracts in a single year, potentially affecting about seven million residents (Madrigal et al., 2024). Census tracts with the highest levels of these emissions were more likely to include higher proportions of Black, Hispanic and Latino residents, as well as households with lower income or educational attainment. Communities experiencing poverty were associated with up to 51% higher burdens of carcinogenic industrial air emissions, indicating measurable differences in where these pollutants are concentrated nationwide (Madrigal et al., 2024).

These findings point to a structural pattern in where pollution sources are sited. Industrial facilities and fossil fuel infrastructure are frequently located near communities of color and lower-income neighborhoods, concentrating exposure in the same places over time. One recent study estimates that 46.6 million Americans—more than 14% of the population—live within one mile of fossil fuel infrastructure, with exposure clustered in urban areas and communities of color (Gold, 2025). Taken together, this evidence reinforces why gaps in fence-line and real-time monitoring have greater consequences in communities already facing sustained and cumulative pollution burdens.

Point-Source Pollution

The EPA defines point source pollution as “any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack” (National Oceanic and Atmospheric Administration [NOAA], 2026). This definition encompasses a wide range of facilities, from individual industrial operations to dense clusters of major emitters operating within the same geographic area, each subject to distinct regulatory, operational and compliance requirements based on emissions and source characteristics.

Clean Air Act Title V Facilities

- Title V is the operating permit program created by the 1990 Clean Air Act Amendments.
- A Title V permit does not set new limits; it consolidates existing air requirements into a single, enforceable permit.
- Facilities covered under Title V must clearly document how they comply with all applicable air pollution requirements (U.S. EPA, 2025h).
- Facilities must obtain a Title V operating permit if they qualify as “major sources”—generally emitting 100 tons per year of a regulated pollutant, or 10 tons per year of a single hazardous air pollutant (U.S. EPA, 2025h).

The Clean Air Act (CAA) establishes a dual regulatory framework for addressing air pollution. At the population level, the CAA directs the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants that are widespread and emitted by numerous sources, with the goal of protecting health. At the source level, it regulates emissions from individual facilities through permitting and performance standards that limit emissions at its point of release, regardless of whether



an area currently meets ambient standards (U.S. EPA, 2020). Under this framework, the CAA regulates point sources as stationary sources, treating each facility as an individual, identifiable emitter subject to federal and state air pollution control requirements. Facilities regulated under the CAA include major stationary sources that emit criteria pollutants and hazardous air pollutants (HAPS) at levels requiring oversight through technology-based emission standards, operating permits and ambient air quality quality protections. Compliance is evaluated through permitting reviews, emissions testing and, in some cases, fence-line or near-facility monitoring. Oversight of industrial point sources is implemented through multiple, interrelated CAA programs. Technology-based emission limits are established through New Source Performance Standards (NSPS), which apply to new, reconstructed or modified emission units within defined industrial source categories. Emissions of HAPs are regulated separately at the source level through National Emission Standards for Hazardous Air Pollutants (NESHAP), which apply to specific industrial source categories and are enforced on a facility-by-facility basis, rather than through cumulative exposure conditions (U.S. EPA, 2025d).

Toxics Release Inventory (TRI)

- It is a public EPA database that requires certain industrial and federal facilities to report annual releases and waste management of listed toxic chemicals.
- Established under the Emergency Planning and Community Right-to-Know Act, TRI provides communities, agencies and researchers with facility-level data to track pollution trends, identify risks and support accountability and pollution reduction efforts (U.S. EPA, 2026a).

For major sources, these standards require the application of Maximum Achievable Control Technology (MACT), based on the performance of best-controlled facilities within each category (U.S. EPA, 2025d). State and local air agencies implement and enforce these requirements through federally approved State Implementation Plans (SIPs), which translate CAA requirements into facility-specific permits, standards and compliance (U.S. EPA, 2020). Through this structure, the CAA regulates point source pollution by holding each individual facility accountable for its emissions while relying on national standards to protect public health. Additional transparency regarding facility-level releases of toxic chemicals is provided through the Toxic Release Inventory (TRI), a public disclosure program administered by the EPA.

How Point Sources Differ

Across the country, many communities, agencies and organizations are generating their own air quality data to better understand emissions from the sources that shape local exposure. However, the types of facilities being monitored—and the regulatory frameworks that govern them—vary widely, meaning data needs, monitoring approaches and policy pathways differ by facility type.

The chart on the next two pages summarizes major air pollution source categories, the regulatory frameworks that apply to them and the primary pollutants they emit. Distinguishing among power plants, petroleum refineries and industrial corridors dominated by CAA Title V facilities is essential, as each category operates under different regulatory structures, produces distinct pollutant mixtures and presents different monitoring needs. These distinctions help explain why community-led monitoring efforts have evolved differently across source types and why tailored data approaches are critical for capturing real-world exposure conditions.



	<h2>Power Plants</h2> <ul style="list-style-type: none"> Fossil-fuel electricity-generating units—such as coal-, natural gas- or oil-fired power plants—sell electricity to the grid and operate major boilers, turbines or combined-cycle systems. These facilities generate electricity by burning large quantities of fuel, producing primarily combustion-related air pollutants (U.S. EPA, 2025a). Emissions vary by fuel source but are primarily combustion-related and often occur for long operating periods, though rates vary with load and cycling (U.S. EPA, 2025e). The electric power sector accounted for roughly 24–25% of total U.S. greenhouse gas emissions in 2022, making it the second-largest emitting sector (U.S. EPA, 2025b). Power plants are regulated under CAA programs that set sector-specific performance standards and require standardized continuous emissions monitoring systems (CEMS) that apply to specific regulated pollutants and source categories, in addition to holding Title V operating permits (U.S. EPA, 2025h).
Pollutants	<ul style="list-style-type: none"> “Primarily combustion pollutants such as sulfur dioxide (SO₂), nitrogen oxides (NO_x), carbon dioxide (CO₂), particulate matter, formaldehyde and mercury.
Select EPA Rules	<ul style="list-style-type: none"> 40 CFR Part 75: federal rule requiring monitoring and reporting of SO₂, NO_x, CO₂, and flow, while most of these emissions are measured with CEMS (U.S. EPA, 2025e). Mercury and Air Toxics Standards (MATS): national emission standards for HAPs from coal- and oil-fired electric utility steam generating units, including mercury, acid gases, and other toxic metals (U.S. EPA, 2026c). NSPS: Emission standards for newly constructed, modified, or reconstructed power plants. (U.S. EPA, 2025d). Greenhouse Gas Performance Standards (GHG): emission limits for new and certain existing fossil fuel-fired power plants (U.S. EPA, 2025b). Acid Rain Program, Regional Haze Program, and Cross-State Air Pollution Rule (CSAPR): federal and interstate programs reducing SO₂ and NO_x emissions from power plants to address acid deposition, interstate transport and visibility impairment (U.S. EPA, 2024a).
	<h2>Other Title V Facilities</h2>
	<ul style="list-style-type: none"> Includes chemical plants, metal fabrication facilities, cement plants, plastics manufacturing, and other large stationary sources.



	<ul style="list-style-type: none"> Industrial facilities are often located near other chemical and manufacturing operations, creating overlapping and cumulative exposure patterns even outside formally defined corridors. When these areas contain multiple CAA Title V facilities, they can produce especially varied mixtures of pollutants that combine across a shared airshed.
Pollutants	<ul style="list-style-type: none"> Benzene, 1,3-butadiene, vinyl chloride, ethylene oxide, formaldehyde, volatile organic compounds (VOCs), particulate matter (PM_{2.5} and PM₁₀), SO₂, NO_x, CO, acid gases; as well as fugitive releases of these pollutants.
Select EPA Rules	<ul style="list-style-type: none"> Required to obtain and maintain a Title V operating permit if classified as a major stationary source or otherwise subject to Title V under the CAA. Title V permits (40 CFR Parts 70 and 71) compile all applicable CAA requirements and include monitoring sufficient to assure compliance. Monitoring may include periodic stack testing, parametric monitoring, recordkeeping, and, where required by underlying standards, CEMS. Some facilities report annual emissions to the TRI if they meet applicable sector and chemical threshold criteria, and most major sources report emissions to state or federal inventories; however, continuous monitoring is not required for all pollutants and varies on applicable regulatory standards (with oversight focused on compliance with permitted limits rather than real-time exposure) (U.S. EPA, 2026a). Facilities with covered chemical processes above regulatory threshold quantities must develop and maintain CAA Risk Management Programs (RMP) and plans under CAA. Includes emission limits and standards from applicable programs, such as: <ul style="list-style-type: none"> NESHAP/MACT, NSPS, New Source Review (NSR), a CAA preconstruction permitting program, and Prevention of Significant Deterioration (PSD) which applies to new major sources or major modifications in areas that are in attainment or unclassifiable under the NAAQS (U.S. EPA, 2023b).

As shown in the chart above, the chemical makeup of emissions varies across power plants, refineries and other industrial facilities, but each source releases hazardous pollutants that pose significant risks to nearby neighborhoods. While pollutant mixtures vary by facility type—ranging from combustion-related gases to complex petrochemical hazardous air pollutants—they can all contribute to elevated exposure risks for nearby fence-line communities. Large industrial facilities are typically subject to multiple CAA programs simultaneously, including permitting requirements, technology-based standards, and preconstruction review. However, these programs regulate emissions by source category and pollutant rather than by cumulative neighborhood impact. Community-generated monitoring can therefore help illuminate how emissions from different regulated sources combine at the local level, providing additional context for interpreting pollutant patterns and translating data into meaningful public health insight.



This distinction between regulatory compliance and cumulative neighborhood impact makes it essential to examine how point source emissions are actually monitored at the fenceline. Recognizing the gap between source-based regulation and community-level exposure shifts the focus to whether existing monitoring systems capture—or fail to capture—real-world conditions. The following section examines how industrial air pollution is monitored in practice and where those systems leave critical gaps for fenceline communities.

At the Fenceline: Monitoring

Understanding how industrial air pollution is monitored begins with how it is regulated. EPA's Air Quality System (AQS) data show that regulatory monitors are limited in number and unevenly distributed, and because NAAQS monitors are sited to reflect regional air quality and long-term compliance, they are not designed to capture short-term spikes, facility-level gradients or many hazardous air pollutants common in refinery and chemical corridors—gaps that communities increasingly address through localized monitoring.

For refineries and chemical manufacturing corridors, the CAA relies on a layered system of permitting, hazardous-air-pollutant standards and ambient air-quality protections—each designed to address different risks, pollutants and time scales. The mixture of combustion byproducts, chemical-process emissions and episodic releases creates complex exposure patterns that cannot be captured by single-pollutant or regional monitoring alone. Together, these conditions illustrate why localized monitoring and real-time data are essential for understanding how industrial emissions translate into health risks at the fence line. Fenceline monitoring is the practice of measuring air pollutants at or near the property boundary of an industrial facility, rather than only at distant or regional regulatory monitors. For communities living adjacent to these facilities, conditions at the fenceline often differ substantially from what is reflected at regional regulatory monitoring sites.

At the federal level, the monitoring landscape differs by source category. Power plants are subject to standardized continuous emissions monitoring requirements for certain pollutants under programs such as 40 CFR Part 75, as reflected in the chart above. In contrast, most other Title V facilities—including refineries, chemical manufacturers, cement plants and metal processors—are not uniformly required to conduct continuous, perimeter-level monitoring. While more than 16,000 facilities operate under Title V permits nationwide, only a limited subset, most notably petroleum refineries subject to benzene fenceline requirements and certain chemical manufacturing sectors regulated under specific NESHAP standards, must conduct fenceline monitoring (U.S. EPA, 2025e). For many industrial corridors, regulatory oversight instead relies on periodic stack testing, emissions inventories, parametric monitoring and compliance reporting rather than continuous, location-specific measurements at the neighborhood scale. Monitoring obligations therefore vary significantly across Title V facilities depending on the underlying regulatory standards that apply.

The Suncor Refinery and the Rubbertown Industrial Corridor represent two settings where criteria pollutants, air toxics and process-specific compounds are released through both continuous operations and episodic events. Looking closely at these pollutant categories—and how they are monitored—helps explain why exposure patterns near industrial facilities can vary sharply over space and time, and why community-scale data are often needed to complement existing monitoring systems.



Petroleum Refineries		Other Title V Industrial Facilities
Monitoring	<ul style="list-style-type: none"> • Refineries subject to CAA requirements, including CEMS, stack testing, Leak Detection and Repair (LDAR) programs, flare monitoring requirements, and HAPs monitoring under applicable NESHAP standards. • NESHAP benzene fenceline monitoring: facilities required to conduct benzene fenceline monitoring under the Refinery MACT rule. • Refineries are subject to applicable NSPS subparts, which establish emission limits and associated monitoring, testing, recordkeeping and reporting requirements. • In certain states, additional fenceline or community-scale monitoring requirements apply to specific industrial sectors beyond federal mandates. 	<ul style="list-style-type: none"> • Title V does not automatically require CEMS, it requires monitoring adequate to demonstrate compliance with applicable CAA requirements. • Many facilities require periodic stack testing, control-device monitoring and tracking of hazardous air pollutants, most do not have mandatory fenceline monitoring requirements. • Title V permits must include periodic monitoring sufficient to assure compliance where underlying standards do not specify monitoring requirements (EPA Title V Periodic Monitoring Guidance) (U.S. EPA, 2025h). • Certain emission units are subject to Compliance Assurance Monitoring (CAM), which requires monitoring of control device performance to ensure compliance with emission limits.
Local Impacts	<ul style="list-style-type: none"> • Complex and variable exposure patterns, including episodic releases of benzene, sulfur compounds, VOCs, and flaring events that can cause rapid short-term spikes not always captured by regional monitors. (Colorado Department of Public Health and Environment [CDPHE], 2005). 	<ul style="list-style-type: none"> • Impacts vary by facility type and emission profile and may include continuous process emissions or intermittent releases of HAPs.
Suncor Refinery		Rubbertown Industrial Corridor
Criteria Pollutants Regulated under the Clean Air Act & monitored for public health impacts	<ul style="list-style-type: none"> • SO₂, NO_x, CO, PM_{2.5} and PM₁₀. • Ozone precursors (NO_x + VOCs reacting in the atmosphere) (CDPHE, 2025). 	<ul style="list-style-type: none"> • Chemical, plastics, polymer, and synthetic rubber facilities emit a mix of combustion-related pollutants (NO_x, SO₂, CO, PM), process-related VOCs that contribute to ozone formation, and trace metals from certain catalyst systems.



<p>Hazardous Air Pollutants (HAP) & Other Air Toxics</p> <p>Are of particular concern because of their toxicity and potential long-term health impacts</p>	<ul style="list-style-type: none"> • Benzene, 1,3-Butadiene, Toluene, Xylenes, Ethylbenzene, Formaldehyde, Acetaldehyde, Naphthalene, Polycyclic aromatic hydrocarbons (PAHs), Ammonia (NH₃), Hexane and other alkanes. • Hydrogen sulfide (H₂S), and episodic emissions from flares and storage systems. 	<ul style="list-style-type: none"> • Chlorodifluoromethane (HCFC-22) – emitted primarily by Chemours. • Toluene – emitted primarily by American Synthetic Rubber Company. • Ammonia – emitted primarily by Clariant Corporation and Bakelite Synthetics (Louisville Metro Air Pollution Control District, 2026).
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These differences in monitoring scope shape how—and where—federal oversight has focused efforts to strengthen fenceline data collection. Rather than applying uniformly across industrial sectors, EPA has concentrated on a limited subset of high-risk facilities where emissions profiles and exposure concerns warrant enhanced monitoring requirements. EPA has expanded fenceline monitoring requirements for specific source categories, including petroleum refineries and certain chemical manufacturing operations, but coverage remains narrow and sector-specific (South Coast Air Quality Management District, 2025). EPA’s benzene fenceline monitoring requirements now play a major role in identifying refinery emissions and triggering corrective actions when pollution levels remain elevated, a point underscored in EPA’s 2025 Enforcement Alert on nationwide refinery noncompliance. The alert highlighted that many exceedances originate from storage tanks, marine loading operations and wastewater systems, and reinforced that facilities must investigate exceedances quickly, identify true root causes and implement timely corrective actions to bring concentrations back below the 9 µg/m³ action limit (U.S. EPA, 2025b).

This federal focus signals a targeted shift toward using fenceline data as an enforcement and accountability mechanism for select high-impact industrial sectors—not a comprehensive monitoring expansion across all Title V facilities. In this context, fenceline monitoring has become a critical tool for tightening oversight of refinery emissions and elevating the role of reliable, community-scale data in identifying persistent or episodic exposure risks near major point sources. In response to these gaps, communities living near refineries and chemical facilities have increasingly deployed their own monitoring approaches to better understand and document local conditions. Community-led efforts commonly use low-cost sensors, passive samplers and portable monitoring equipment to measure criteria pollutants and, in some cases, specific HAPs associated with nearby facilities. These tools are often placed along facility boundaries, near schools and homes, or in areas where residents report odors, flaring events or health symptoms—areas not consistently captured existing regulatory monitoring networks. This context frames the case studies that follow, which focus on industrial settings where monitoring requirements vary across source categories, real-time data are limited and exposure risks are concentrated in adjacent neighborhoods. In refinery and chemical-corridor settings, pollutants can disperse through stacks, flares, storage systems and equipment leaks in ways that do not always align with how regulatory monitoring networks are designed. As a result, localized community monitoring plays a critical role in capturing on-the-ground conditions and revealing exposure patterns that may otherwise remain invisible within compliance-based reporting frameworks.

“Different communities face different sources and different pollutants. Monitoring needs to be tailored to those realities—that’s why community networks are so important.”

— Michael Olgetree, Senior Director of State Air Quality Programs, CDPHE



At the same time, these efforts underscore an important reality: while community monitoring can reveal exposure patterns and gaps in oversight, it cannot replace durable, enforceable regulatory frameworks. Meaningful emissions reductions depend on strong federal and state standards, protective permit conditions and consistent enforcement. In the absence of comprehensive fenceline monitoring requirements across industrial sectors, many communities remain reliant on their own data to surface risks that regulatory systems do not consistently measure. Understanding this regulatory and monitoring landscape is essential to interpreting health impacts at the fenceline. The health risks discussed below are shaped not only by what pollutants are emitted, but by how those pollutants are measured, reported and enforced.

Health at the Fenceline

The pollutants and health impacts discussed in this section reflect the distinct emission profiles of the primary industrial point-source contexts examined in this report: large petroleum refineries and multi-facility chemical and manufacturing corridors. These case studies center on sectors characterized by complex mixtures of hazardous air pollutants and documented fenceline exposure concerns. Together, these industrial contexts illustrate a critical point: health risks at the fenceline are shaped not only by proximity to major emission sources, but by the type, toxicity and persistence of the pollutants released. The following section outlines the pollutants most consistently identified in each case-study area and summarizes the associated health impacts, drawing from state monitoring networks, regulatory reporting and community-generated data.

Power plants, while not the central case-study focus, remain part of the broader point-source landscape considered throughout this report, as they are included to contextualize the broader health burden from combustion-related air pollution, which differs in composition but remains consequential for communities living near major stationary sources.

Power Plants

Power plants referenced throughout the report provide broader regulatory and policy context. Understanding how power plants fit within the broader point-source landscape is especially important in the current regulatory context, as changes to federal air quality standards, enforcement approaches and monitoring expectations continue to shape how risks are assessed and managed. Power plants are among the largest emitters of criteria pollutants regulated through NAAQS, particularly $PM_{2.5}$, ozone-forming pollutants such as NO_x and SO_2 , making them a critical point of comparison for understanding how ambient-based regulation differs from facility-specific controls applied to refineries and other industrial sources. Because these emissions contribute to regional $PM_{2.5}$ concentrations and ground-level ozone formation and disperse across wide geographic areas, associated health impacts are often population-wide rather than confined to immediate fenceline exposure, with well-established links to asthma exacerbation, cardiovascular disease and premature mortality (U.S. EPA, 2025a).

Although this report does not examine power plants in depth, their central role in NAAQS implementation provides important context for how risks from power generation are assessed, controlled and communicated (U.S. EPA, 2025a). This context explains why community monitoring efforts—many of which already focus on power generation and combustion-related sources nationwide—are essential for capturing real-world exposure patterns and informing policy decisions across different point-source categories.



Petroleum Refineries

Petroleum refineries represent a distinct category of industrial point source, characterized by the scale and complexity of emissions from a single facility, yet they are often located near or within broader industrial areas and in close proximity to residential communities. Petroleum refineries—approximately 130 nationwide, processing more than 18 million barrels of crude oil each day—play a central role in the nation’s energy infrastructure and are among the most complex and emission-intensive industrial sources in the U.S. (Environmental and Energy Law Program, 2025). Refineries produce gasoline, diesel, jet and marine fuel through complex processes that emit a wide range of pollutants, including petroleum-derived VOCs, benzene, sulfur compounds and combustion byproducts.

Unlike single-stack emissions sources, refineries are comprised of interconnected process units such as catalytic crackers, heaters and boilers, storage tanks and wastewater systems. Many of these refining operations emit a wide range of pollutants through multiple pathways, including fugitive leaks, tank vents, pressure-relief devices and intermittent flaring rather than a single exhaust point—releasing hazardous air pollutants during routine operations as well as malfunctions. As mentioned in the chart above, these sources create highly variable emissions that differ significantly from those of non-refinery industrial facilities.

Petrochemical facilities produce a range of products, including rubber, chemicals and plastics. These facilities also emit a wide range of harmful pollutants linked to serious and chronic health risks. Key pollutants include PM_{2.5}, which reaches deep into the lungs and bloodstream and is associated with asthma exacerbation, cardiovascular disease, and premature death. These facilities also release NO₂ and SO₂, gases that irritate the respiratory system and contribute to ground-level ozone (“smog”) formation. VOCs—including benzene, toluene, and 1,3-butadiene—are common byproducts of combustion and refining; many are carcinogenic or mutagenic and pose significant risks even at low concentrations (U.S. Energy Information Agency, 2010).

Benzene—a hazardous air pollutant linked to anemia, immune suppression, nervous system damage and increased leukemia risk—regularly appears at elevated levels near U.S. refineries. The Environmental Integrity Project’s (2022) analysis shows that nearly half of all refineries reported long-term fence-line benzene concentrations above health-based thresholds.

Other Title V Industrial Facilities

Across the United States, non-refinery Title V industrial facilities emit pollutant mixtures that differ from those of petroleum refineries because their emissions reflect the specific processes used in each sector. These facilities rely on multiple emission points—such as boilers, curing ovens, reaction vessels, kilns, solvent operations or material-handling equipment—producing combinations of combustion byproducts, process chemicals and mechanical emissions. As a result, exposure patterns vary widely across facilities. In corridor settings, many industrial facilities operate in close proximity—such as chemical manufacturers, plastics and rubber producers, metals processors and hazardous waste facilities—collectively creating persistent, cumulative exposure conditions for nearby communities (U.S. EPA, 2025h).

Industrial facilities in Louisville’s Rubbertown corridor release a complex mix of hazardous air pollutants and criteria pollutants that contribute to severe and chronic health burdens for nearby residents. Key toxics—including HCFC-22,



22, toluene and ammonia—cause airway irritation, central nervous system effects, cardiovascular impacts and, in some cases, carcinogenic risks, with additional pollutants such as 1,3-butadiene, vinyl chloride, formaldehyde, dioxin, benzene and multiple heavy metals further elevating cancer and respiratory risks (U.S. EPA, 2025g).

These facilities also emit criteria pollutants such as PM_{2.5}, PM₁₀, NO_x, SO₂ and CO. Burning sulfur-containing feedstocks produces SO₂, a gas that can trigger bronchoconstriction and acute breathing difficulties, especially for people with asthma (U.S. EPA, 2025g). NO_x and CO can aggravate respiratory conditions and strain cardiovascular function. High-temperature operations emit PM₁₀ and PM_{2.5}—fine particles strongly linked to respiratory and cardiovascular disease, and premature mortality (Centers for Disease Control and Prevention [CDC], 2024). Combined, NO_x and VOC emissions also drive ground-level ozone formation, contributing to airway inflammation and increased asthma attacks. Although Lead (Pb) emissions are typically low, metal-catalyst processes may still release trace amounts, and even low-level exposure is associated with neurological and developmental harm (U.S. EPA, 2025g). Together, these pollutants create persistent and compounding public health hazards in the communities surrounding Rubbertown.

Stationary sources release complex mixtures of harmful pollutants that can accumulate in the environment and are linked to severe neurological, developmental and reproductive harms. Many of these compounds interact synergistically, amplifying their health effects, especially in communities already facing multiple environmental and socioeconomic stressors. These risks are compounded in industrial corridors, where clustered facilities produce overlapping emission plumes and cumulative exposure patterns within a shared geographic area. EPA risk assessments show that these chemical and petrochemical regions represent some of the highest cancer risks in the nation. EPA's AirToxScreen shows that census tracts closest to refineries, chemical plants and other major HAP sources bear higher cumulative cancer risk, and long-term exposure contributes to chronic disease and increased emergency-room visits (U.S. EPA, 2018). Specifically, fenceline communities experience 20–30% higher average HAP-related cancer risk than non-fenceline areas (The Climate Reality Project, 2025).

Consequently, emissions profiles are highly variable, and exposure patterns can shift sharply over short distances and time periods, making community-level impacts difficult to capture through regional monitoring alone (U.S. EPA, 2010). For fenceline communities, multi-point emissions, operational variability and limited continuous monitoring create persistent uncertainty about harmful exposures, reinforcing the need for fenceline monitoring and real-time community air data. These distinctions help frame the complex emission landscape of point sources nationwide.

Across these sectors—from combustion-dominated power plants to chemically complex refineries and multi-facility industrial corridors—a consistent pattern emerges: the nature of health risk is shaped by both pollutant composition and regulatory design. What distinguishes fenceline communities is not simply proximity to industry, but proximity to variability—fluctuating emissions, intermittent releases, fugitive leaks and chemical mixtures that may not be fully captured in routine compliance reporting. Health risk at the fenceline is therefore dynamic rather than static, influenced by operational patterns, regulatory coverage and the limitations of traditional monitoring systems.

Understanding these differences is essential before turning to the lived reality of communities navigating them. The case studies that follow move beyond pollutant lists and regulatory frameworks to examine how community-driven



monitoring initiatives are redefining what it means to document exposure. These projects do more than measure air quality; they surface patterns that reshape local decision-making, inform enforcement conversations and shift the narrative from abstract compliance metrics to tangible public health outcomes—offering a model for how ongoing, community-scale evidence can transform how industrial risk is understood and addressed (Sarr et al., 2021).

Case Studies

Cultivando AIRE Project: Commerce City, Colorado

The Suncor Energy oil refinery in Commerce City is Colorado’s only petroleum refinery and the state’s largest industrial source of criteria pollutants and hazardous air emissions. Located in Adams County just northeast of Denver, the refinery sits within an industrial corridor immediately adjacent to predominantly Latino and Indigenous communities that experience higher rates of poverty, cumulative environmental burdens and adverse health outcomes compared to state averages (CDPHE, 2020). Commerce City is home to approximately 70,000 residents as of July 1, 2024, nearly half of whom identify as Hispanic or Latino—a proportion that exceeds the statewide average (U.S. Census Bureau, 2024).

The facility operates under state air and water permits and has faced enforcement actions related to air quality compliance, resulting in expanded monitoring, reporting and performance review requirements. As the dominant industrial emitter in the region, communities around Suncor are exposed to both criteria pollutants (such as NO_x, SO₂, PM, and CO) and hazardous air pollutants including benzene, H₂S, formaldehyde and other VOCs—pollutants strongly linked to respiratory disease, cardiovascular harm, cancer risk and other serious health outcomes (CDPHE, 2025). In Commerce City, concerns about refinery emissions have persisted for years, particularly given the facility’s close proximity to homes, schools and community spaces. Residents have documented recurring smoke and odor events linked to flaring and operational upsets, as well as chemical releases and strong odors. Community members have also reported health symptoms consistent with refinery-related exposure, including asthma exacerbations and other respiratory effects. Suncor’s history of permit violations and enforcement actions has further heightened



concern about whether traditional regulatory monitoring alone is sufficient to protect nearby communities (CDPHE, 2020). The CDPHE, primarily through its Air Pollution Control Division (APCD), oversees the facility’s compliance with state and federal air quality requirements. Because of its emissions levels, the refinery is classified as a “major source” under the CAA and must maintain Title V operating permits. Although legally considered one facility, Suncor operates under two Title V permits due to historic ownership structure (CDPHE, 2025). CDPHE conducts continuous oversight of the refinery, including comprehensive annual inspections and formal enforcement when violations occur. Air monitoring near the refinery occurs at multiple levels. CDPHE operates five permanent monitoring stations in the surrounding area with hourly data publicly available.



Although CDPHE maintains continuous oversight and operates multiple monitoring stations, questions remained about how well existing systems captured neighborhood-level conditions. In response, Cultivando, a Latino-led non-profit in Colorado, helped implement a community-driven air monitoring effort designed to characterize real-world exposures near the refinery. The Cultivando Air Quality Investigation and Research for Equity [AIRE] project emerged following a 2020 enforcement settlement between Colorado regulators and Suncor that addressed multiple air quality violations. As part of that settlement, a portion of the penalty funds were allocated to support community-based environmental projects in Commerce City and North Denver (CDPHE, 2025). Cultivando received the largest share of this funding and used it to build an independent monitoring network. The organization partnered with Boulder A.I.R. to design, deploy and operate the monitoring system.

Between November 2022 and June 2023, Cultivando's air monitoring initiative employed five distinct sampling strategies and identified a total of 129 chemicals, including PM, CO, CO₂, SO₂, Nox, Methane, VOCs, ethane, propane, benzene, hexane, toluene, H₂S and hydrogen cyanide. Across sampling methods, the network detected a broad range of pollutants: weekly integrated samples identified 16 chemicals, 15-minute canister samples detected 21 chemicals and year-long continuous monitoring captured 22 chemicals (Cultivando, 2024a). Additional data from the CDPHE and the U.S. EPA expanded the analysis to include 14 carbonyl compounds and 58 ozone precursor chemicals. The assessment also incorporated hourly meteorological data and radon measurements to better understand dispersion patterns and background conditions.

Approximately 20–30 sensors were strategically placed near schools, parks and residential areas to capture conditions where people live and gather—measuring at minute-to-hour resolution and reported publicly in near real time (Cultivando, 2024a). Cultivando trained local residents as promotoras—community health workers—to help deploy these sensors. These promotoras assisted with installation, maintenance and community outreach, helping ensure the equipment functioned properly while building local understanding of the data. The approach combined technical monitoring with on-the-ground engagement, creating a system where residents were not just data subjects but active participants in tracking and interpreting neighborhood air quality conditions.

Study Components

- Acquired, fabricated, equipped, and installed the Commerce City Fixed Site (CCF) monitoring trailer.
- Acquired, fabricated, equipped, installed, and later relocated the Commerce City Mobile Site (CCM) monitoring trailer.
- Developed and shared public dispersion modeling of Suncor emissions.
- Implemented residential PM_{2.5} monitoring using PurpleAir sensors.
- Built, launched and maintained a public website portal with real-time data reporting.
- Integrated CCF and CCM data into the Interactive Data Analysis Tool (IDAT).
- Implemented and operated a 9-month passive sampling program for VOCs.
- Conducted whole air sampling for residential VOC monitoring.
- Implemented the nation's first real-time, high time-resolution monitoring of gases, particles and associated radioactivity.
- Developed and provided preliminary data analyses and interpretation to project members and the public.

(Helmig, 2023).



Findings

1. Monitoring results revealed sharp spatial and temporal variability in pollutant concentrations, frequent short-duration spikes that are masked by longer-term averages, and pollutant levels consistently higher than those observed at regional comparison sites.
2. Multiple pollutants were detected simultaneously, with elevated concentrations occurring more frequently at night and during winter months, highlighting distinct exposure patterns not captured by traditional monitoring approaches (Cultivando, 2023). High variability in pollutant concentrations with time; day-night and seasonal behavior.
3. Pollutant concentrations were seen to be higher at night, and also higher in winter.
4. Pollutant concentrations are much higher in Commerce City than at comparison sites.
5. Airborne radioactivity was detected during the monitoring period.

(Cultivando, 2023).

	Threshold	Number of Exceedances past 6 Months								Sampling average	Criterion
		CCF	CCM	BNP	BSE	BRZ	ECC	LLG	LUR		
Benzene	> 0.9 ppb	316	233	3	0	1	75		5	10 minutes (once/hour)	CA chronic lifetime no effects
H₂S	> 8 ppb	3895			0					Every minute	Odor threshold
Methane	> 5000 ppb	4337	118	101		0	487	0	15	Every minute	2.5 times ambient background
Ethane	> 50 ppb	218	320	37	22	2	48		93	10 minutes (once/hour)	25 times usual background
Propane	> 50 ppb	174	7	3	1	0	2		24	10 minutes (once/hour)	25 times usual background
PM 2.5	> 35 µg/m ³	1482			389		954		378	Every minute	NAAQS 24-hours
PM 10	> 54 µg/m ³	0									
PM 10	> 54 µg/m ³	6268			2225		9251		3484	Every minute	PM 10 safe level
NO_x	> 53 ppb	5									
NO_x	> 53 ppb	6520	3319		3315	113			1037	Every minute	NAAQS 24-hours
		3	9						5		

Figure 1: Multiple Pollutant Exceedances (Helmig, 2023).

Figure 1 describes monitoring sites that include BRZ (Boulder Reservoir), LLG (Longmont Lykins Gulch), LUR (Longmont Union Reservoir), ECC (Erie Community Center), BSE (Broomfield Soaring Eagle), BNP (Broomfield North Pecos), CCF (Commerce City Fixed Site) and CCM (Commerce City Mobile Site). This highlights the diverse range of pollutants that were captured from the sensors over the course of the study. Ozone is not emitted directly from a single source but forms in the atmosphere when NO_x and VOCs react in sunlight. These findings indicate that the community is influenced by regional and local pollution sources that contribute to ozone formation. from a single source but forms in the atmosphere when NO_x and VOCs react in sunlight. These findings indicate that the community is influenced by regional and local pollution sources that contribute to ozone formation. These high-level occurrences from the study



are shown below in **Figure 2**. **Figure 3** shows benzene levels measured once per week over one year, resulting in about 50 data points per site, reported as weekly averages. Mean benzene concentrations varied by more than 50% between monitoring sites. In 2022, the number of one-minute readings above 35 $\mu\text{g}/\text{m}^3$ — the EPA’s 24-hour health standard for PM_{2.5}—was calculated for two monitoring sites. At Broomfield (BSE), pollution exceeded that level for 380 minutes (about 6 hours total). At Commerce City (CCF), it exceeded that level for 12,800 minutes (nearly 9 full days). This means CCF experienced about 40 times more high-pollution minutes than BSE, indicating far more frequent spikes above the daily health benchmark (Helmig, 2023). This is shown on the next page on **Figure 4**.

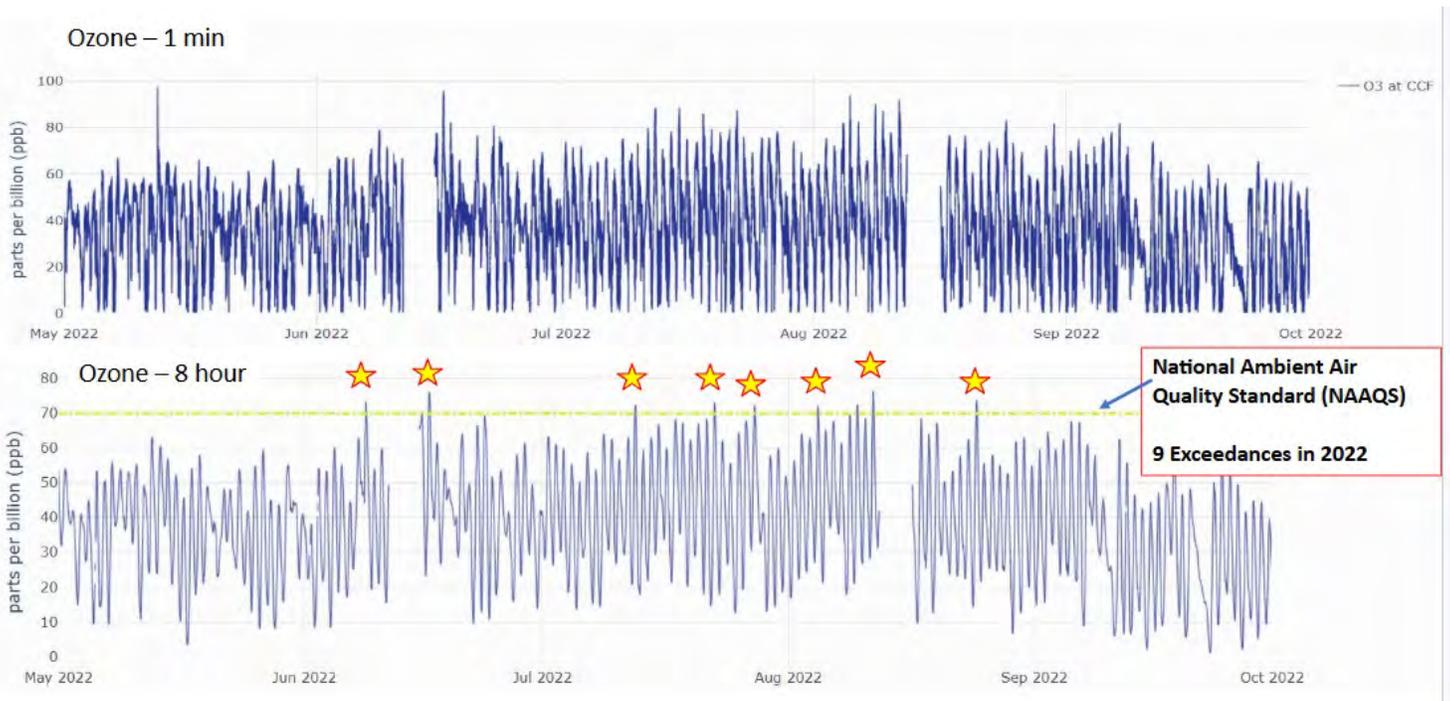


Figure 2: Ozone High Level Occurrences (Helmig, 2023).

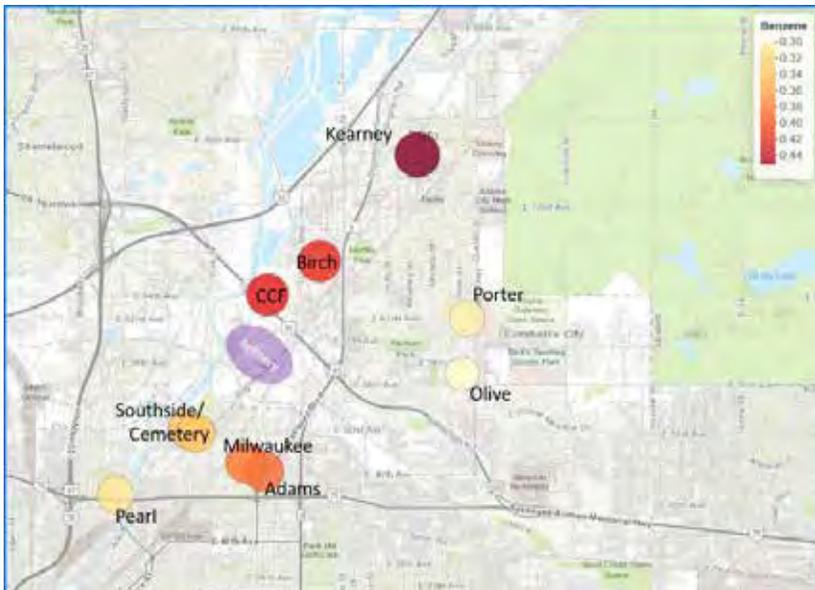


Figure 3: Benzene Levels (Helmig, 2023)..



Figure 4: Comparison of Particulate Matter (Helmig,

Figure 5 highlights Methane, Propane and H₂S levels that were monitored near Suncore. Each map shows pollutant concentrations displayed using a color gradient, where dark blue represents lower concentrations and colors transition through green and yellow to red, which indicates the highest measured levels. The circular patterns reflect wind-directional analysis centered on the monitoring site, illustrating how concentrations vary depending on wind speed and direction. Warmer colors clustered in specific directional sectors suggest elevated pollutant levels when winds originate from those areas. Monitoring results documented refinery-related pollutants beyond the facility boundary. The detection of these compounds in community air samples reinforced concerns that emissions associated with refinery operations may be extending into nearby residential areas.

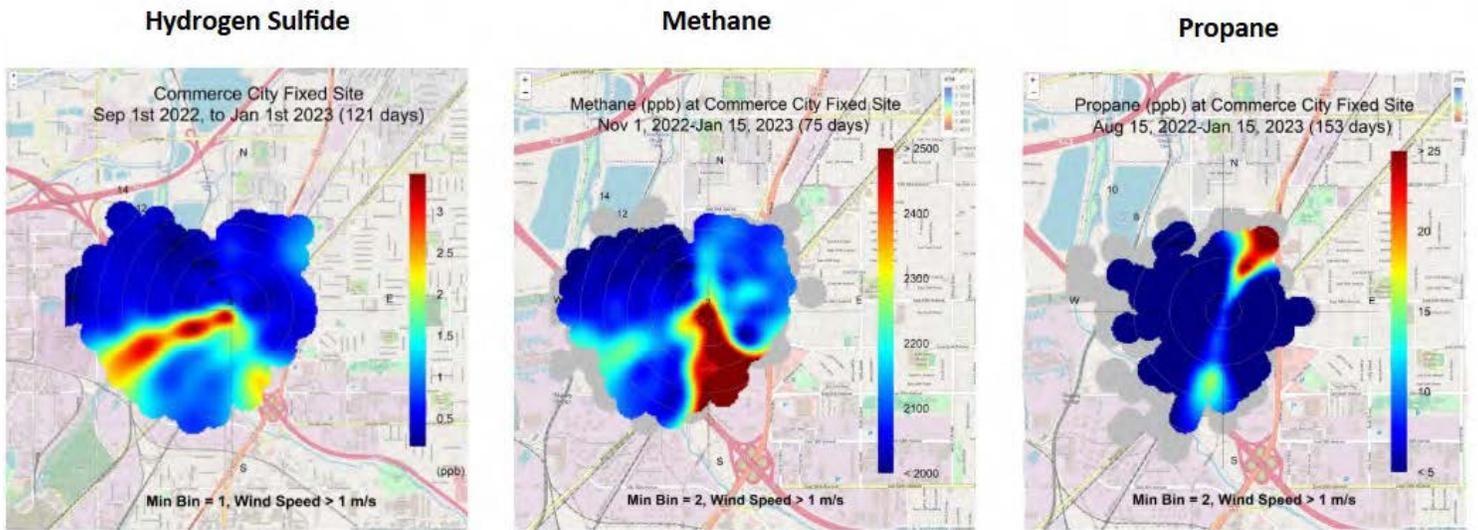


Figure 5: Commerce City Measurements (Helmig, 2023).

Today, CDPHE operates a combined fence-line and community air toxics monitoring program that requires certain industrial facilities to continuously measure pollutants such as benzene, H₂S and hydrogen cyanide at their perimeters, while also conducting mobile and fixed-site monitoring in surrounding neighborhoods. Cultivando's work has also contributed to

ongoing policy conversations around emergency notification and rapid response protocols in Commerce City. Their advocacy has supported efforts to strengthen community alert systems, improve transparency around industrial upsets and advance clearer protocols for notifying residents during chemical releases or operational malfunctions at Suncor.

These efforts generate publicly accessible data designed to improve transparency, support rapid response to emissions events and strengthen health protections for communities living near major point sources of industrial pollution (CDPHE, 2025). When paired with resident testimony describing health symptoms, the resulting data has provided critical evidence to inform advocacy and regulatory engagement (CDPHE, 2025).

Suncor Air Pollution Monitoring

The Commerce City–North Denver (CCND) Air Monitoring Program was developed by Suncor Energy (U.S.A.) Inc. in response to community feedback received in late 2020. Designed in coordination with existing regional monitoring networks, the program was shaped through engagement with regulators and local governments, including the CDPHE, Commerce City, the City and County of Denver, Adams County and Tri-County Health Department, as well as public meetings held in May 2021. Suncor selected Montrose Air Quality Services to deploy, operate and maintain the monitoring network (Commerce City–North Denver Air Monitoring, 2026).

The CCND program operates multiple fixed stations that provide continuous public reporting of key pollutants. A mobile monitoring van is periodically deployed to detect additional VOCs and hydrogen cyanide. In 2026, the system was updated to align with Suncor’s Title V permit and now includes six stations equipped with FEM instruments (Suncor Energy, 2025).

Permitting, Rulemaking and Regulatory Accountability

Cultivando’s AIRE monitoring and community research helped strengthen the evidence base supporting expanded air toxics oversight in Colorado. By pairing high-resolution community data with formal regulatory engagement, the organization contributed to policy discussions that coincided with concrete state and federal actions affecting the Suncor refinery and other major point sources. Under Colorado’s 2021 Regulate Air Toxics Act, certain industrial facilities, including Suncor, became subject to required fence-line monitoring for priority pollutants, with partial operation of its fence-line system in 2023, and full system operation by the end of 2024, along with strengthened public notification provisions (CDPHE, 2025). Together, these state and federal actions illustrate a shift in how regulatory systems respond to industrial pollution, as shown [here](#). For point source monitoring projects, aligning neighborhood-scale data with state datasets and regulatory standards can make findings more actionable in rulemaking, permit review and enforcement processes. Community monitoring adds another layer — real-world exposure data that can reveal patterns not fully captured in permit documents or annual inventories. When integrated into enforcement reviews, settlement agreements and air toxics rulemaking, this data strengthens oversight, improves transparency and accelerates corrective action.

“Community monitoring gave residents something they never had before— independent data that validated their lived experience and strengthened their voice in state rulemaking.” — Olga Gonzalez, Executive Director, Cultivando



For residents living near the facility, these developments matter in practical terms. Expanded fenceline monitoring, strengthened public notification requirements and enhanced enforcement mechanisms increase the likelihood that emissions events are detected, documented and addressed promptly — reinforcing risk management and emergency response planning for residents living near industrial facilities. They create clearer pathways for public engagement and regulatory response. More broadly, they signal that environmental protection is not solely a technical exercise conducted within agency walls, but a shared process in which community evidence can shape how permits are written, how compliance is evaluated and how health protections are defined. When regulatory authority and community-generated data operate in tandem, monitoring shifts from a passive record of pollution to an active instrument of governance.

“Community-collected data has directly informed state rulemaking in Colorado. These datasets have been used to support testimony and shape air-quality regulations adopted by the Air Quality Control Commission.” — Michael Olgetree, Senior Director of State Air Quality Programs, CDPHE

Data-to-Decision Pathways

Cultivando advanced a data-driven advocacy strategy by pairing rigorous air quality monitoring with structured regulatory engagement. By generating time-resolved and location-specific data, the organization created an evidence base that could be introduced into public hearings, agency meetings and rulemaking processes. The study underscored major gaps in environmental health tracking. Cancer and other health indicators are typically reported at the county level, which can mask neighborhood-scale disparities in communities such as Commerce City. Researchers at the University of Colorado Denver worked with Cultivando to align community-collected monitoring data with state datasets to identify localized pollution hotspots and strengthen analysis at the census tract and neighborhood scale (Cultivando, 2024a). This alignment helped translate community data into formats compatible with state regulatory frameworks, making it more actionable within formal decision-making processes. Monitoring findings were used to inform testimony, support comments on rulemakings and engage regulators under Colorado’s Regulate Air Toxics Act, which requires the identification and control of priority air toxics. Community-generated data, when combined with resident documentation of symptoms and exposure events, strengthened calls for expanded fenceline monitoring, improved notification requirements and enhanced oversight.

“Fenceline monitors revealed pollution patterns the community had reported for years. Data made those stories impossible to dismiss.”

— Olga Gonzalez, Executive Director, Cultivando

Durability Through Collaboration

Local engagement was central to how data was used. Cultivando invested in community capacity-building by hosting workshops, distributing educational materials and training residents on the health risks associated with air pollution. Promotoras played a central role in the model, supporting sensor deployment and maintenance, translating technical



findings into accessible information, documenting odors, flaring events and related health symptoms and serving as trusted messengers within the community. Community-generated data and lived experience were brought into public meetings, press events and regulatory discussions, strengthening advocacy and informing recommendations to state decision-makers. These efforts equipped residents with the tools to interpret air quality data, engage in public processes and advocate effectively for stronger environmental protections (Cultivando, 2024b).

As part of a Latino-led organization, Cultivando prioritized culturally relevant outreach and multilingual materials, ensuring that air quality information was available and understandable to Spanish-speaking residents and families. This approach strengthened trust, built local expertise and supported long-term engagement, enabling community members to use air quality data to inform decisions and participate effectively in public processes over time. Cultivando also strengthened the durability of its monitoring and advocacy efforts through sustained collaboration with grassroots residents, technical experts and cross-sector partners. By working alongside organizations such as GreenLatinos and Earthjustice, the initiative combined community-generated data with legal expertise and policy advocacy, reinforcing that durable environmental health protections often require coordinated action across community, scientific and legal spheres (Cultivando, 2023).

Sensing Air Justice in Rubbertown: Louisville, Kentucky

Rubbertown is a historic industrial corridor along the Ohio River in West and Southwest Louisville, located in Jefferson County, Kentucky. Developed during World War II to support synthetic rubber and chemical production, the area now contains a dense concentration of large-scale chemical, plastics, refrigerant, ammonia and waste treatment facilities.

According to Louisville’s Air Pollution Control District, 12 Title V facilities operate in Rubbertown, with a total of 31 Title V facilities operating across the Louisville Metro (Air Justice Louisville, 2025). The EPA’s TRI identifies 57 hazardous waste treatments, storage and disposal facilities in the metropolitan region as well, with many located directly adjacent to residential neighborhoods (Air Justice Louisville, 2025). This proximity creates complex, overlapping mixtures of hazardous air pollutants at the fenceline, where homes, schools and community gathering spaces often sit with little to no buffer from industrial activity. Rubbertown is home to approximately 5,000 residents, and the surrounding neighborhoods include a high proportion of low-income households, with over 75% of residents in West and Southwest Louisville identifying as Black (Sarr et al., 2021). These patterns reflect broader conditions across these areas, where poverty rates are elevated and average life expectancy is seven years shorter in West and Southwest Louisville than in East Louisville (Air Justice Louisville, 2025). These neighborhoods have long experienced disproportionate exposures to industrial pollution due to the concentration of chemical plants, waste facilities and power generation infrastructure located directly adjacent to residential areas (Sarr et al., 2021).



Image of Rubbertown Facilities (Louisville Metro Air Pollution Control District [APCD], 2026).

These neighborhoods have long experienced disproportionate exposures to industrial pollution due to the concentration of chemical plants, waste facilities and power generation infrastructure located directly adjacent to residential areas (Sarr et al., 2021).

There have long been community complaints about air pollution in neighborhoods bordering Rubbertown, and federal and local assessments have documented elevated concentrations of carcinogenic pollutants in these areas. According



to the American Lung Association’s “State of the Air” 2025 report, Louisville was ranked the 29th worst metropolitan area in the nation for ground-level ozone pollution and second worst in its region for ozone pollution. Louisville also ranked 88th worst for short-term particle pollution out of 225 metropolitan areas and ranked the worst 15% of metropolitan areas for annual particle pollution.

As a result of increasing pollution concerns, Rubbertown Emergency ACTION (REACT) was established in April 2003 by residents living near the fenceline of the plants that make up Louisville’s Rubbertown industrial area. Originally formed as a campaign of the Justice Resource Center, REACT became an independent grassroots organization later that year (Environmental Justice for All, 2024). Through collaboration with REACT, University of Louisville researchers and the Environmental Health Literacy Coalition, the Sensing Air Justice monitoring project began in 2021. Former University of Louisville faculty members Dr. Megan Poole and Professor Shavonnie Carthens partnered with community advocate Eboni Neal Cochran to engage scholars, students, local residents and community partners in developing research-informed solutions. The project focused on reducing toxic emissions and advancing legislative change in neighborhoods bordering Rubbertown.

A core element of community-driven monitoring is starting with the questions residents want answered. Instead of relying solely on technical assumptions, this project began with extensive in-person surveys across West and Southwest Louisville, reaching nearly 2,000 residents. An overwhelming 92% identified air pollution as a high-priority concern, with 50% of respondents reporting asthma or other lung conditions and 16% reporting cancer (Air Justice Louisville, 2025). In Louisville, 62% of young patients hospitalized for asthma are Black children, while asthma is more prevalent and severe in zip codes that border Rubbertown.

Health assessments further show the West and Southwest corridor residents are three to four times more likely to develop cancer than those in East Louisville, alongside elevated rates of asthma and heart disease. **Figure 6** highlights rates of asthma from the Sensing Air Justice report. **Figure 7** displays modeled cancer risk from industrial air pollution across Louisville using EPA’s 2020 AirToxScreen data, averaged by Council District. The color gradient represents average industrial source cancer risk per million residents, with darker purple and blue areas indicating higher estimated risk and lighter green to yellow areas indicating lower estimated risk. Red dots mark the locations of Title V industrial facilities.

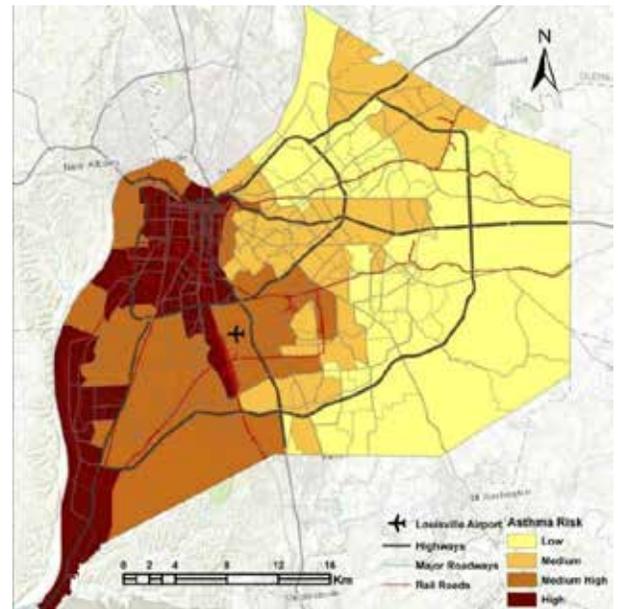


Figure 6: Louisville Asthma Rates (created by Air Justice Louisville) (Air Justice Louisville, 2025).

“Public health and environmental harms are not just scientific issues —they are legal and policy issues. Law and policy tools can elevate these harms and make them visible in decision-making spaces.”

— Shavonnie Carthens, JD, Assistant Professor of Law, University of Kentucky, J. David Rosenberg College of Law



Residents consistently raised air quality concerns and the questions below represent a deliberate effort by residents to examine the gaps between regulatory reporting and on-the-ground exposure conditions. Residents consistently identified air pollution as a top concern and raised specific questions that existing regulatory monitoring could not answer:

<p>Were particulate matter exposures near Rubbertown higher than reported by official sources?</p>	<p>Whether pollution varied block by block rather than uniformly across neighborhoods?</p>	<p>How do community-collected data compare with measurements from the local Air Pollution Control District (APCD) and the EPA?</p>
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The program deployed 11 PurpleAir sensors across West and Southwest Louisville to provide real-time neighborhood-level PM data. Eight were placed in Parkland and Park DuValle based on survey findings, with three in Shively as a comparison site. Sensors were co-located with EPA monitors at Bowman Field for validation, and data collected from October 2023 to April 2024 was reviewed by a panel of residents, students and independent experts (Air Justice Louisville, 2025). The sensors continuously measured PM_{2.5} and identified consistent early-morning spikes in West and Southwest Louisville that did not align with traffic patterns. Compared to East Louisville, these areas recorded higher average PM_{2.5} levels, with several sensors reaching or exceeding health-based Air Quality Index (AQI) thresholds. Heat map analysis revealed repeated daily spikes and localized exposure disparities not visible in weekly trends.

Figure 8 on the next page shows daily average PM_{2.5} concentrations from multiple PurpleAir monitors in Louisville between November 2023 and March 2024. Each line represents an individual sensor, grouped by east and west locations. The data show frequent short-term spikes in fine particle pollution throughout the monitoring period, with concentrations regularly fluctuating between low levels and peaks approaching 25–30 µg/m³. Although pollution levels vary day to day, the overall pattern indicates recurring episodes of elevated PM_{2.5} across multiple sensors simultaneously, suggesting area-wide influences rather than isolated site-specific events. Seasonal variation is also visible, with higher variability during winter months, when colder temperatures and atmospheric stagnation can trap fine particles near the ground.

These findings do more than document episodic spikes; they demonstrate how distributed, neighborhood-scale monitoring can reveal patterns that regional networks may overlook. The themes that emerged from this project offer a practical framework for other communities seeking to translate localized air quality data into stronger public health insight and accountability.

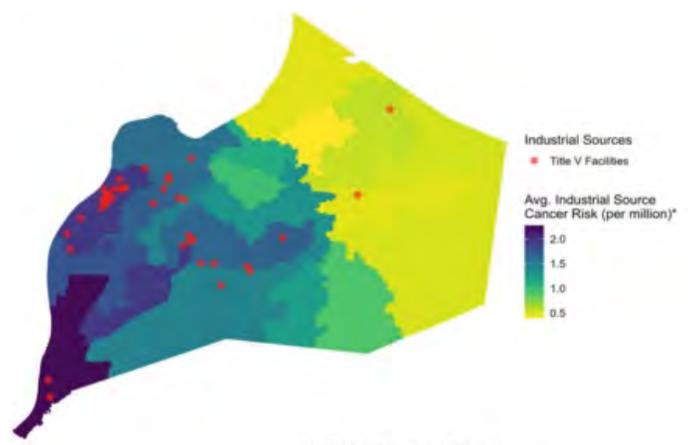


Figure 7: Title V facilities in the Louisville Metro area over AirToxScreen data.

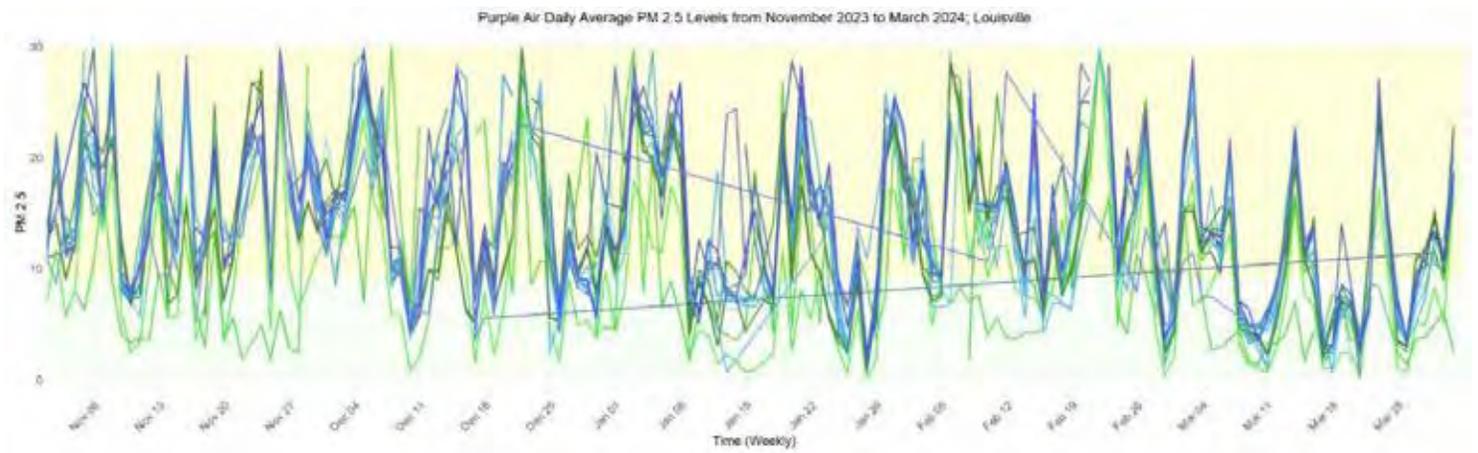
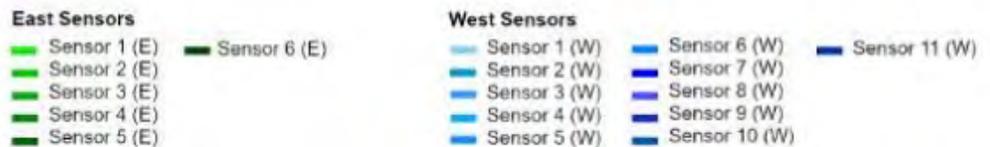


Figure 8: Purple Air Daily Average PM2.5 Levels



Strengthening Public Process

Public participation in environmental decision-making depends on more than the availability of technical documents. It depends on whether residents can understand, access and act on the information that shapes regulatory outcomes. In many industrial communities, pollution data and permitting materials are technically public but practically inaccessible — buried in complex language, lengthy applications or poorly publicized comment periods. Health information is also inaccessible when distributed only through channels that many residents do not regularly use, limiting awareness of comment opportunities and hearings.

Through the Air Justice work, monitoring data became a bridge between lived experience and regulatory systems. Community-generated air measurements were translated into plain language summaries, visual tools and workshop discussions that helped residents understand what pollutants were present, how they related to refinery operations and where those findings intersected with permit conditions or rulemaking processes (Air Justice Louisville, 2025). Rather than positioning data as an endpoint, the program used it as a participation tool— equipping residents to submit informed public comments, ask targeted questions during hearings and engage more confidently with regulators. The research also identified practical steps to strengthen participation more broadly, including improving the readability of permit materials, using plain-language standards and translation checklists, extending public comment periods to allow adequate review time and expanding distribution of public notices beyond traditional channels to reach a wider audience.

By connecting monitoring results to permitting timelines and emergency notification systems, the effort helped shift public engagement from reactive testimony to evidence-based participation. In this model, transparency is not just disclosure. It is the ability of community members to interpret data, connect it to regulatory mechanisms and influence decisions before permits are finalized or rules are adopted.



Data-to-Decision Pathways

The monitoring effort did not end with data collection. Results were intentionally connected to regulatory, permitting and emergency preparedness systems to create actionable pathways for change. Community-generated air data informed public comments during permit review processes, strengthening resident participation with site-specific evidence. Findings were shared with local regulators to support calls for improved odor investigations, expanded toxic air studies and stronger enforcement practices. The documented presence of refinery-related pollutants beyond facility boundaries also reinforced recommendations for permanent, independent monitoring rather than reliance on self-reported industry data. Monitoring results were further used to advocate for structural improvements in regulatory systems, including extending public comment periods, increasing accessibility of permit materials and expanding distribution of public notices. In this way, data moved beyond awareness and into process reform.

“Data has to be digestible at a glance—otherwise people can’t use it to advocate for stronger permits, better monitoring, or safer operations.” — Megan Poole, Ph.D., Assistant Professor of Rhetoric & Writing, University of Texas at Austin & co-creator of Air Justice

Air Justice also advances emergency response and notification efforts by advocating for more transparent, timely communication during industrial incidents and linking residents to Louisville Metro Emergency Services alerts for chemical spills and releases. The project’s findings supported broader emergency preparedness discussions, highlighting the need for clearer communication protocols, updated risk management planning and collaborative preparedness strategies for communities living near industrial facilities.

Finally, the data contributed to broader accountability conversations around enforcement. By pairing measured air conditions with patterns in regulatory response, the effort highlighted gaps between compliance on paper and exposure in practice, strengthening calls for more effective oversight and enforcement that discourages future violations. In this model, monitoring served as both documentation and leverage — connecting lived experience to regulatory decision points and creating clearer pathways from data to policy action.

Permitting, Rulemaking and Regulatory Accountability

The Air Justice project used monitoring results to engage directly in permitting and regulatory processes affecting refinery operations. By documenting the presence of refinery-related pollutants beyond the facility boundary, the data provided concrete evidence that could be referenced during Title V permit reviews, public comment periods and discussions with local regulators. This shifted community participation from general concern to evidence-based engagement tied to specific regulatory decisions. The project also identified structural barriers within the permitting system — including technical permit language, limited public notice distribution and constrained comment timelines that made meaningful participation difficult. In response, monitoring findings were translated into plain-language summaries and shared through community workshops to help residents understand how measured pollutants intersected with permit conditions, reporting requirements and enforcement mechanisms. Beyond individual permits, the findings supported



broader discussions about regulatory reform. Results reinforced calls for permanent, independent toxic air monitoring rather than reliance on self-reported industry data, more transparent enforcement practices and regulatory systems that respond to documented exposure patterns. By connecting community-generated data to concrete regulatory touchpoints, Air Justice demonstrated how monitoring can inform both immediate permit decisions and longer-term rulemaking discussions.

“There is often a gap between community concerns and the government’s response. A response does not always meet the needs expressed by the community.” — Megan Poole, Ph.D., Assistant Professor of Rhetoric & Writing, University of Texas at Austin & co-creator of Air Justice

The data also informed conversations about emergency management. The project reinforced calls for stronger coordination between regulators and residents during incidents and for preparedness planning that accounts for those living closest to facilities, especially updating risk management plans at the local facilities.

In this model, permitting, rulemaking and emergency response were not distant administrative processes. They became accessible pathways for accountability—where measured air conditions, public participation and oversight intersect.

Conclusions

Point-source pollution remains one of the most persistent and unevenly addressed air-quality challenges in the United States, particularly for communities living at the fenceline of refineries and chemical manufacturing corridors. The case studies of Commerce City, Colorado and Louisville’s Rubbertown demonstrate that meaningful change often begins at the fenceline, where residents confront emissions firsthand and where conventional monitoring systems are least capable of capturing short-term spikes and facility-specific impacts.

Across both cases, industrial exposure is experienced at the neighborhood level — uneven, episodic and deeply felt by those living closest to major facilities. Community-led monitoring did not simply confirm what residents already suspected; it documented patterns and intensity in ways that regional systems could not resolve. By situating monitors within residential blocks and along facility boundaries, these initiatives transformed localized concern into concrete evidence, grounding policy conversations in measurable community conditions rather than distant compliance summaries.

The case studies demonstrate that community-generated monitoring is most effective when supported by rigorous technical design and embedded within durable partnerships. Clearly defined objectives, strong quality-assurance protocols, transparent data platforms and collaboration with state agencies, academic institutions and technical experts were critical to ensuring findings were credible, actionable and trusted. When these elements were in place, localized monitoring informed rulemaking, strengthened enforcement conversations, guided inspections and supported more responsive emergency planning.



At the same time, these efforts underscore a broader truth: while community monitoring can expose gaps in oversight and reveal when and where emissions occur, it cannot replace strong, enforceable regulatory frameworks. Only robust federal and state standards, permit conditions and enforcement mechanisms can reduce emissions at their source. In the absence of comprehensive fence-line monitoring requirements across industrial sectors, many communities remain reliant on their own systems to understand and expose risks that regulatory networks do not consistently track. Embedded within collaborative governance structures, these partnerships reframed monitoring from a compliance exercise into a shared public-health tool—one that strengthens accountability while respecting community knowledge and leadership. Point-source emissions are not only chronic but episodic, and these characteristics make emergency preparedness a central concern. Short-duration releases of hazardous air pollutants can pose acute risks, particularly when residents lack timely alerts, clear response guidance or confidence that agencies are aware of conditions on the ground. The experiences documented here show how localized monitoring can support faster detection, more informed emergency response and clearer communication during industrial incidents—but only when data systems are designed with emergency management in mind.

As point-source corridors continue to overlap with densely populated neighborhoods—often communities of color and low-income households—the need for both localized monitoring and systemic regulatory reform becomes increasingly urgent. The combined approach reflected in these case studies recognizes lived experience, addresses long-standing monitoring inequities and strengthens the ability of communities to participate meaningfully in decisions that affect their health and safety (Madrigal et al., 2024).

Looking Forward

The recommendations above are already taking shape in several regions through next-generation monitoring frameworks and public-facing data tools that show how community data, regulatory oversight and transparency can function together at scale, with fence-line and community monitoring evolving beyond pilot efforts into standardized, enforceable systems that provide real-time data, clear accountability and independent verification.

Next-Generation Facility Monitoring

Across the country, refinery fence-line and community-monitoring programs are evolving toward real-time, publicly accessible data systems, and one of the clearest examples is South Coast Air Quality Management District's (AQMD) Rules 1180 and 1180.1 in Southern California. In the South Coast Air Basin, covering Los Angeles, Orange, and parts of Riverside and San Bernardino counties, refineries are now required to operate continuous air-monitoring systems at their fence-lines and in surrounding neighborhoods. The air district also runs its own community monitoring network through a Community Air Monitoring Plan (CAMP) and a Quality Assurance Project Plan (QAPP), documents that describe how monitors are sited, how data is validated and how results are communicated. Together, these systems provide real-time detection of emission changes, public alerts when pollutants exceed thresholds and clear expectations for facility response. AQMD is also developing an Independent Audit Protocol to ensure that refinery-reported data are independently verified and consistent with regulatory and public-health standards (South Coast Air Quality Management District, 2025).



This protocol represents a shift in how community monitoring is being built across the country. It introduces regular third-party audits, detailed document and data reviews, on-site verification tests and formal corrective action plans that reinforce accuracy, transparency and continuous improvement. Key priorities include clear roles among refineries, auditors and regulators; consistent QA/QC procedures tied to public dashboards; strong data-management systems; and a repeatable process for identifying and resolving issues. As more regions adopt similar approaches, community monitoring will increasingly rely on independently validated, high-frequency networks that give residents trustworthy information, support health-protective decision-making and strengthen accountability for point-source emissions.

Together, these elements show how fence-line monitoring can evolve into a durable regulatory and public-health tool—one that aligns facility responsibility, agency oversight and community trust through validated, real-time data. In parallel with advances in facility-level monitoring, new public-facing data platforms are reshaping how industrial air pollution information is accessed, understood and acted upon by communities and decision-makers. These tools demonstrate how transparent, map-based dashboards can complement regulatory monitoring by making localized risks visible, contextualizing health impacts and revealing where monitoring coverage remains insufficient. The recommendations and examples in this report reflect approaches already underway across the country.

Public-Facing Air Quality Data Tools

Recent tools point toward a shift in industrial air-quality monitoring toward integrated, public-facing dashboards that link facility locations, emissions, health-risk indicators and monitoring coverage. In 2025, the Environmental Defense Fund (EDF) launched the Petrochemical Air Pollution Map, an interactive tool that shows where petrochemical facilities operate, which nearby communities face the highest modeled health risks and where monitoring gaps persist. Tools like this illustrate how transparent, map-based dashboards can complement regulatory monitoring and improve visibility into localized risks near industrial corridors (EDF, 2025).



Recommendations

Communities living near point-source facilities are already generating the data needed to understand and respond to local emissions, but the durability of these efforts depends on stronger policy frameworks, sustained funding, clear emergency-response pathways and consistent integration of community data into regulatory systems. To ensure that localized monitoring translates into meaningful public-health protection, the American Lung Association offers the following calls to action.

Federal Government

- Implement and enforce science-based, health-protective NAAQS, including the 2024 updated PM_{2.5} standard.
- Strengthen hazardous air pollutant standards and enforcement. Expand fenceline monitoring requirements to more stationary sources of hazardous air pollutants.
- Adequately fund state, local and tribal air agencies to sustain robust regulatory monitoring networks, including staffing, data platforms and infrastructure.
- Invest in dedicated, multi-year funding for community-led monitoring, supported across federal agencies (e.g., EPA, FEMA, USDA and others). Include investments in technical assistance hubs that provide calibration and collocation support, QA/QC protocols, quality assurance and data interpretation guidance. Support ongoing research into best practices.
- Develop guidance on minimum performance, documentation and transparency standards to integrate validated, community monitoring data into federal air quality decisions, including enforcement, inspections, permitting, compliance and rulemaking.
- Establish frameworks to utilize community-scale data for public health communications, emergency response and preparedness, and post-event evaluations.
- Building on the success of the EPA U.S. Fire and Smoke Map, improve and modernize federal data platforms to display validated and corrected community monitoring data alongside regulatory measurements. Permanently fund and expand federal wildfire smoke monitoring programs, including EPA's WSMART.
- Support cross-agency coordination among air agencies, transportation authorities, port and freight authorities and land-use and zoning regulators to integrate community monitoring into decision-making.

States

- Ensure stable, state-level funding streams, beyond short-term grants and projects, for community monitoring. Sustain cross-agency partnerships that build local expertise and tailor to local needs.
- Partner with universities, air agencies and research institutions to provide technical support – including sensor deployment, data hosting, calibration and validation, assessment and maintenance, data useability and hands-on training—for community, school and tribal monitoring programs.
- Integrate properly corrected community sensor data into dashboards, maps, public advisories and communication platforms that support incident-response systems, neighborhood-level messaging, school and outdoor activity guidance, emergency response decisions, post-event assessments and inclusion in state resilience planning.



- Establish frameworks that formalize community participation and transparency in air quality decision-making, including defining how community input informs agency actions and ensuring feedback loops between residents and decision-makers. Ensure a pathway for community-generated data to be used to identify high exposure areas.
- Use quality-assured community data to inform state permitting decisions, cumulative-impact analyses and targeted inspections, and formalize how neighborhood-scale monitoring feeds into state air quality programs to support enforcement screening, mitigation prioritization, emergency monitoring plans, transportation planning and land-use strategies. SIPs can remain anchored to regulatory monitoring for NAAQS compliance while using quality-assured community data to identify hotspots and better target where emission reductions can be applied.
- Support Tribal sovereignty in air monitoring by strengthening EPA State and Tribal Assistance Grant (STAG) support for tribal air programs, including sustained funding for staff, operations and data ownership and use.

Local Governments

- Commit sustained funding to support the full lifecycle of community air monitoring, including sensor maintenance and replacement, staff capacity and training, partnerships, public data platforms and ongoing engagement that links monitoring to public health and emergency response.
- Coordinate across cities, counties, regional agencies, public health and emergency planners and neighboring jurisdictions to align monitoring with pollution patterns, enabling residents and agencies to co-develop priorities, review data and guide mitigation strategies.
- Embed air quality monitoring into local emergency management and hazard-mitigation plans by establishing formal cross-department protocols that define how community sensor networks are used in public communications, emergency operations, recovery planning and future preparedness, require agencies to use real-time data to guide coordinated response during major pollution events, and document lessons learned to improve future decision making.
 - Wildfire smoke: Use data to guide decisions on outdoor activities, worker safety, school and childcare operations, ventilation and clean-air shelter activation.
 - Heavy-duty trucks: Apply data to inform truck routing, idling enforcement, curb management, port operations and roadway design.
 - Point-source pollution: Integrate data into investigations, permitting review, public comment processes and facility-level mitigation actions.
- Regularly review monitoring data to identify areas of elevated concentrations, dominant sources and exposure trends, and conduct after-action reviews following major events to refine communication, sensor placement, outreach and resource deployment.
- Preserve quality-assured community data for public comment and, when needed, legal review, strengthening the administrative record with real-world exposure evidence.
- Support community events and volunteer networks—including schools, faith-based organizations and health clinics—to engage residents as sensor hosts and data stewards.
- Use transparent, plain-language and multilingual reporting tools with visuals and maps to support public understanding and informed participation in policy discussions.



Individuals/Community Groups

- Collaborate with academic entities, public health organizations, government agencies and commercial vendors to secure multi-year grant funding support for deploying monitoring projects and sustaining staffing, data infrastructure and stewardship.
- Bolster community capacity and support through coordination with local schools, tribal, faith-based and neighborhood organizations in under-resourced or rural areas.
- Use publicly accessible air quality data, supported by cross-sector partnerships, to deliver clear findings, actionable requests and health-protective protocols to local municipal boards, school boards, commissions and decision-making bodies.
- Apply neighborhood-scale data to advocate for health-protective actions, including emergency alerts, clean-air shelter activation and smoke-day school and work adjustments, truck rerouting, idling restrictions, buffer zones near homes and schools, and stronger fenceline monitoring, permit modifications, targeted inspections, health symptom tracking and enforceable mitigation during permit renewals or expansions.
- Build data literacy by training local staff, volunteers, leaders and residents to interpret corrected data, document pollution events and communicate findings effectively, while establishing clear governance structures over roles, authority and data ownerships.
- Plan for the full data lifecycle and continuous improvement—from defining monitoring questions and selecting sensors to placement, calibration and maintenance; data collection, backup and useability; to quality assurance and sustained use of results.
- Document and apply lessons learned to improve communication strategies, locally tailored data models, resource deployment and long-term operation and sustainability.
- Maintain public-facing dashboards that integrate sensor data and forecasts with plain-language health guidance, designed to be mobile-friendly, multilingual and accessible to non-experts.
- Educate residents on local emergency preparedness and response protocols, including the communication channels used to deliver rapid public alerts during pollution events.

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Something in the Air

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