Making the Most of Air Monitoring

Strategies for Communities and Regulators Adopting Real-Time Monitoring

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The Danger of Too Much Air Monitoring

As recently as twenty-five years ago, there was scarcely any air monitoring in communities next to large industrial emitters of air toxins, such as oil refineries. Today, thanks to advances in sensor technology and decades of environmental justice activism, real-time measurement of chemical concentrations is increasingly widespread in frontline communities adjacent to industrial sources of air pollution. In the United States, some regulatory agencies have even passed regulations requiring real-time fenceline monitoring at industrial facilities and set up new community air monitoring initiatives.

However, expanded monitoring programs may not necessarily translate into improved air quality, health, or empowerment for these frontline communities. This report builds on findings from the Meaning from Monitoring project, led by the Fair Tech Collective at Drexel University and conducted in collaboration with residents of San Francisco Bay Area communities affected by refinery pollution. The project aimed to improve the relevance and usability of data from two of the oldest and most extensive real-time monitoring systems in the United States: at the Phillips 66 refinery in Rodeo, California, where fenceline monitors have been in operation since 1996, and at the Chevron refinery in Richmond, California, where fenceline and community monitors were installed in 2013.

The project showed that it is difficult to make sense of or mobilize the large quantities of data these monitors produce, and it exposed a series of other deficiencies that communities hoping to use real-time monitoring have to overcome. In the absence of *context, interpretive innovation, infrastructure,* and *proactive pollution prevention*, real-time monitoring does less to protect communities from air pollution than it could.

Findings from the Meaning from Monitoring project can help communities and regulators design expanded air monitoring programs that avoid overwhelming residents with data or distracting from underlying environmental and equity issues. Our findings help to identify where complementary investments are needed to create context, foster innovation in metrics, build infrastructure, and ultimately even change the political climate to be more hospitable to initiatives that would prevent pollution in the first place.

There are sound reasons to continue to expand air monitoring at industrial facility fencelines and in neighboring communities, including to:

- Manage and prevent industrial accidents
- Understand and improve air quality
- Improve knowledge about the health effects of chemical exposures
- Move in the direction of equitable access to air quality information for all communities and neighborhoods

Regulators should not simply curtail monitoring for fear that too much data could overwhelm or distract those they intend to help. Instead, they should invest in the infrastructure and innovation necessary to enhance its usefulness, while continuing to prioritize pollution prevention.

How to Make the Most of Air Monitoring

To ensure that *expanded* monitoring does not become *too much* monitoring, communities and regulators need to address deficiencies of context, interpretive innovation, infrastructure, and proactive pollution prevention. Taking the following steps helps data from expanded real-time air monitoring have a positive impact in frontline communities:

Collect contextualizing information as part of air monitoring programs.

This includes meteorological data, health data, information about facility operations (including dates of facility shutdowns, startups, and incidents), and firsthand observations of smells, residues, and health impacts.

Encourage and support innovation in metrics and interpretation.

Make available resources to calculate averages and other familiar metrics, as well as develop new ones that take full advantage of the extensive data real-time monitoring produces, with the help of advances in artificial intelligence-supported interpretation techniques. Enlist data scientists and social scientists to help create these new metrics. Ensure that metrics represent the experiences and concerns of community members—not just those of scientists.

Expand infrastructure in advance of monitoring.

Scaled-up monitoring requires additional infrastructure for data storage, access, and interpretation. Public agencies should scale infrastructure to anticipate the increasing scale of monitoring data, as more communities and regulators adopt real-time monitoring.

Actively pursue pollution reduction alongside monitoring.

Monitoring is a means to an end: protecting communities from industrial pollution. In cases where other means are available to reduce pollution directly, regulators and activists should prioritize these over monitoring. When there are no other means, they should use monitoring programs, including innovations in metrics, to strategically advance campaigns for community health and safety.

Learn from experience.

The Meaning from Monitoring project experimented with multiple techniques for making real-time monitoring data more useful to frontline communities. The following pages describe how its results can inform and improve subsequent efforts. However, further experimentation is needed to develop sustainable infrastructures and provide robust means of managing and interpreting contextual data. To continue to increase the benefit of expanded real-time monitoring, communities and regulators developing real-time monitoring programs should treat their efforts as experiments and share reflections on their successes and failures widely.

Context

Without context, it's hard to interpret data. Finding appropriate contexts for understanding real-time air monitoring data is far from straightforward. The Meaning from Monitoring project created additional contexts for air monitoring data, to increase communities' ability to make use of those data. Our efforts increased the volume of data that project partners had to manage and process. They also increased the difficulty of interpreting the data, making the need for additional innovation and infrastructure even more apparent.

Standards as Context

Measurements of chemical concentrations at a particular place and time take on meaning only by comparison. Government agencies encourage communities to compare data to regulatory standards, like the National Ambient Air Quality Standards, and to health-based screening levels, like the Agency for Toxic Substance and Disease Registry's minimal risk levels. They see the standards as the line dividing concentrations that are safe to breathe and those that are potentially hazardous. Communities exposed to industrial pollution criticize the standards for not being protective enough, and for not taking into account the effects of breathing multiple chemicals at once. The standards can also vary a great deal from one source to another, which suggests that even scientists are uncertain exactly where to draw the line. As a context for air monitoring data, standards and screening levels are helpful but far from definitive.

Like expanding monitoring programs, expanding context comes with a risk of overwhelming potential users of the data—especially if it does not address deficiencies in infrastructure and interpretive innovation.

	OEHHA	ATSDR
	ppb	ppb
Benzene	1	3
Ethylbenzene	400	60
Hydrogen Sulfide	8	20*
Toluene	70	1000
Xylene	200	50

Comparison of California Office of Environmental Health Hazard Assessment (OEHHA) chronic reference exposure levels (RELs) for inhalation and Agency for Toxic Substance and Disease Registry (ATSDR) chronic minimal risk levels (MRLs) for inhalation of selected chemicals measured by real-time air monitors in Rodeo and Richmond, California.

**no chronic MRL; intermediate listed instead.*

Expanding Context

There are other ways to address the question of whether a given level of pollutants is harmful to human health. There are also other questions one might ask of monitoring data, including whether local levels of pollution are worsening, or whether pollution is worse at some times of year than others. The Meaning from Monitoring project expanded the contexts for monitoring data in several ways:

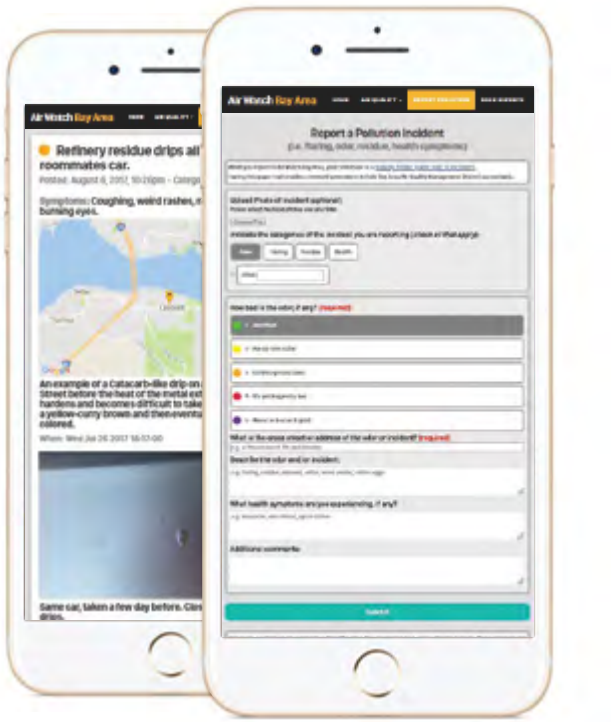
Historical Context: We made monitoring data from as far back as 2015 available on the Air Watch Bay Area website (airwatchbayarea.org). The growing repository enables users to compare current levels of pollution to past levels.

Sensory Context: Community members can now report smells, flares, symptoms, and other observable effects of refinery emissions through the website or the Air Watch app. These reports appear alongside measurements from the monitors, making it possible to associate a particular smell or symptom with high readings of a chemical or chemicals.

Health Context: Residents of Crockett and Rodeo—communities on either side of the Phillips 66 refinery—collected personal health metrics, including heart rate and pulse oximetry (SpO_2). They were then able to investigate how variation in their personal data set did (or did not) correspond to variations in chemical concentrations that fenceline monitors measured at the refinery.

The Danger of Too Much Context

Creating new contexts for understanding air quality measurements involved collecting even more data, and the data we collected included a mix of quantitative and qualitative data: biological markers, photos, and first-person observations. The new information gave us more ways to look at air monitoring data, but it also increased the complexity of figuring out how to compare disparate kinds of information, as well as the difficulty of storing and managing the data. Like expanding monitoring programs, expanding contexts for data comes with a risk of overwhelming potential users—especially if it does not address deficiencies in infrastructure and interpretive innovation.



RIGHT. *User reports submitted through the Air Watch app help put monitoring data in the context of residents' experience.*

Innovations in Interpretation

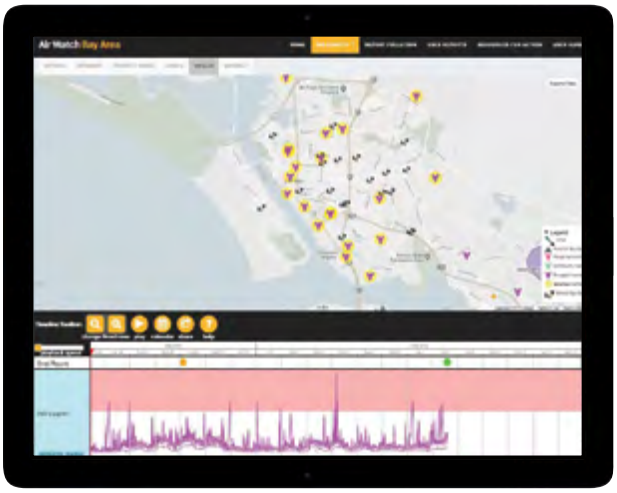
Expanded real-time monitoring is unlikely to lead to new understandings of air quality without innovative metrics, or new ways of boiling down large data sets into a few comprehensible numbers. In the Meaning from Monitoring project, we experimented extensively with new metrics for real-time monitors. One result was a metric that represents the "toxic soup" of chemicals that frontline communities breathe. Another result was learning that creating new metrics requires multiple kinds of experts working together.

New Monitors Need New Metrics

Regulatory agencies usually assess air quality by calculating the average concentrations of several chemicals over a specified period of time. Averages are metrics that regulators or communities could calculate from real-time air monitoring data. However, one advantage of measuring air quality with real-time monitors (over taking and analyzing air samples) is that it captures information about fluctuations in chemical concentrations. To frontline communities, the fluctuations matter just as much as the average concentrations, so using an average as a metric obscures important information.

Similarly, regulators usually calculate averages on a chemical-by-chemical basis, whereas residents also worry about the effects of breathing a toxic soup of multiple chemicals simultaneously. Real-time monitoring contains information about how levels of different chemicals may (or may not) rise and fall together, in ways that existing metrics cannot capture.

Our new metric quantifies something that residents have long understood intuitively, to which existing air quality metrics simply don't call attention.



ABOVE: *Data from real-time monitors show short-term fluctuations in pollutant concentrations—information that is lost when calculating averages.*

Representing the Toxic Soup

The Meaning from Monitoring project experimented with new metrics to take advantage of the data real-time monitors provide. In particular, we tried to find metrics that represented phenomena that were visible in the data and would also represent concerns community members expressed about air quality, such as periodic spikes in pollution levels.

By calculating the percentage of time residents are breathing multiple chemicals, we were able to validate their suspicions that they regularly breathe toxic soup. For example, we found that about 25 percent of the time residents of Richmond are breathing at least four chemicals simultaneously—and often more. The metric quantifies something that residents have long understood intuitively, to which existing air quality metrics simply don't call attention.

Creating this new metric demonstrated that innovation in this area is a time- and resource-intensive process. The Meaning from Monitoring project's team of programmers, data scientists, anthropologists, and community members invested hundreds of hours over two years, and drew equally on knowledge of data analysis techniques and local knowledge about patterns of emissions from oil refineries.

Fostering Innovative Interpretations

Our new metric is but one example of the kind of information that could be uncovered in the large data sets that real-time monitoring produces. To realize the full potential of expanded monitoring, community groups and regulators need to work with data scientists, computer scientists, and social scientists—and take advantage of ever-improving artificial intelligence-supported interpretation techniques—to invent additional metrics that can offer insight into health effects or help regulators make an argument for stricter controls on industrial emissions. They also need robust infrastructures for storing and processing data, especially as data sets grow larger.

Infrastructure

Building context or innovating new ways of looking at data requires robust infrastructure to access, store, and analyze large quantities of data. The existing infrastructures for real-time monitoring data in the Bay Area enabled only limited access and almost no analysis. In response, the Meaning from Monitoring project pulled together new elements to better understand fenceline monitoring data. It became clear that it is unsustainable for local-level groups to create and maintain infrastructure. Governments and other established institutions should make long-term investments in infrastructure instead.

Community groups should not be expected to create and maintain the infrastructure necessary for making sense of real-time monitoring data without substantial support from government, foundations, or other well-established institutions.

Limited Access to Public Data

Communities can't access data from monitors without infrastructure, including servers that store data, websites that present data, and code that moves data from one platform to another—or allows users to download it. Equipment manufacturers and operators often provide infrastructure for *viewing* monitoring data, but not for exploring, manipulating, or downloading data. Fenceline.org, which provides public access to data from real-time monitors in Rodeo and Richmond, is one example: users can view current data but cannot easily export a month's worth of data if they want to analyze or correlate the data with contextualizing information.

ABOVE: *The original site for accessing data from community monitors in Richmond allows users to view only the past 24 hours of readings and offers no way to add comments or context.*

Building Information Infrastructure

Airwatchbayarea.org expands the infrastructure for monitoring data by creating a way to view historical data and annotate them with smell reports from individuals in the community. The process of building the website revealed the many other aspects of infrastructure necessary to expand public access to fenceline and community monitoring data. The project relied on:

- Open source code from the CREATE Lab at Carnegie Mellon University to develop the website and app
- CREATE Lab servers there to store air monitoring data and user reports
- Server space rented from Heroku to host the website and from Cloudinary to store pictures submitted with user reports
- The Environmental Sensor Data Repository (ESDR, also a CREATE Lab project) to download data for analysis in other platforms
- The beta version of Intel's Data Sense to support data exploration and analysis

This model of cobbled-together infrastructure—made possible by the generosity of colleagues at the CREATE Lab and Intel—is not one that can be scaled up. Incorporating data from many more monitors, or handling considerably more user reports, would require investing heavily in servers and redesigning the ESDR interface. The program's platform is also vulnerable to decisions by other organizations to discontinue their investment in projects on which it relies, such as Intel's decision to discontinue new development on Data Sense. Community groups should not have to create and maintain the infrastructure necessary to make sense of real-time monitoring data without substantial support from government, foundations, or other well-established institutions.

ABOVE: *Spreadsheets can't handle the millions of data points that real-time monitoring creates. Data Sense, designed by Intel Labs to find patterns in large data sets, became an important part of our infrastructure for exploring and interpreting monitoring data.*

Public Investment in Infrastructure

The current approach to providing access to monitoring data, which relies on the disparate efforts of multiple instrument manufacturers, is not conducive to fostering innovation or creating context for data. As air monitoring initiatives scale up, and communities' efforts to contextualize data from their monitors increase, the need for more robust infrastructure will grow. Those demands will quickly outpace what university labs can germinate out of research projects. Long-term, sustainable investments in a coordinated information infrastructure are necessary. While it makes sense for the public sector to take the lead in creating infrastructure, philanthropic organizations should also address the need for long-term investment in this area.

Pollution Prevention

Air monitoring is a means to an end: protecting communities from potentially harmful effects of industrial emissions. It is not the only way to achieve that end. Stricter regulations or denials of permits could curtail emissions directly, reducing the threat of poor air quality, but regulators are often unwilling to take these steps. In the absence of political will to rein in industry, monitoring can be an important resource for communities—provided they can turn to appropriate metrics that represent data in ways that resonate with their grievances and correlate with their goals. Innovation and infrastructure can play an important role in facilitating political change by adding to the tools that are available to activists.

Putting Monitoring in Its Place

During the years of the Meaning from Monitoring project (2016–18), Bay Area activists did advocate for expanded real-time monitoring near oil refineries. However, more of their efforts focused on measures that would prevent emissions and accidents in the first place: legally binding caps on refinery emissions, an industrial safety ordinance that would apply to the Valero oil refinery in Benicia, denial of a permit to allow the Phillips 66 refinery in Rodeo to process dirtier crude oil. In none of these campaigns did they need air monitoring data to make their case: it is straightforward to argue that emissions caps would improve air quality, an industrial safety ordinance would help protect residents from accidents, and further investments in fossil fuel infrastructure would harm communities and the climate.

Activists know that air monitoring is at best a reactive strategy, a second line of defense when their efforts fail to secure regulatory decisions that would prevent pollution.

Paying attention to activists' priorities puts air monitoring in its place as just one among several possible responses to pollution. Activists know that air monitoring is at best a reactive strategy, a second line of defense when their efforts fail to secure regulatory decisions that would prevent pollution. At worst, monitoring is a distraction from fights that get to the heart of the issue: will we do what is necessary to stop exposing communities to industrial emissions? Too often, the answer is, "No." Many lawmakers are unwilling to adopt measures that would be unpopular with industry, and regulators may not have the authority to take steps that would curtail pollution, such as denying permits for new emissions sources.

Leveraging Monitoring Data

In a political climate stacked against communities, real-time air monitoring can be a secondary strategy for addressing industrial emissions. Monitoring data can potentially help activists work within the system to influence regulatory decisions, or work outside formal administrative processes to change the political climate. Both approaches depend on the kind of infrastructure, innovation, and context that the Meaning from Monitoring project attempted to create.

Working the System: Air monitoring can help community groups participate in regulatory processes that value quantitative data over residents' local and experiential knowledge. Communities can offer monitoring data as evidence that they are suffering from the cumulative impact of multiple facilities, or that a facility's flaring or accidental releases are significantly affecting air quality. While having data may still not be enough to sway regulators to decide in favor of a community, it nonetheless increases the likelihood that residents will be heard and taken seriously.

To bring real-time monitoring data to a public hearing, however, community groups need to be able to download data, assemble them into reports, and cite metrics meaningful to regulators. They require reliable infrastructure that allows them to mobilize data in regulatory processes.

Changing the Climate: Outside of formal governmental processes, activism around environmental health and justice can change the political climate, and even change the law, by telling a compelling story about the harm communities suffer when exposed to industrial pollution and the fact that some communities are exposed much more than others. Activists have, for example, coined terms like toxic soup, "Cancer Alley," and "sacrifice zone," to force these problems onto the political agenda.

Air monitoring data can help make activists' rhetoric more compelling by revealing the truths that underlie the slogans, such as the number of chemicals in the toxic soup. Contextualizing information and innovative metrics are important aspects of leveraging monitoring data in this way: changing the metric can change the political conversation.

Air monitoring cannot substitute for organizing and direct action. However, strategic ways of representing monitoring data, supported by robust infrastructure, can enhance these efforts, and ultimately increase the likelihood that an ethic of pollution prevention will prevail.

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