Study of Neighborhood Air near Petroleum Sources (SNAPS) Lost Hills, California

Draft Summary Report

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Acknowledgements

The Study of Neighborhood Air near Petroleum Sources (SNAPS) in Lost Hills, CA would not have been possible without the continued input and assistance from community members and local and regional community groups. Their support and engagement have been invaluable throughout the SNAPS Lost Hills study, and staff would like to express their deepest appreciation for all of their work and interest.

Additionally, staff express gratitude to all stakeholders who participated in the public engagement process, and the Department of Water Resources for their willingness to host California Air Resources Board (CARB) monitoring equipment for the duration of air monitoring in Lost Hills.

Document Purpose

This document is intended to provide a summary of the complete Lost Hills Draft Final Report. ***CARB is accepting comments on the Lost Hills Draft Final Report through April 2, 2024. To submit comments, please call (279) 208-7687 or (279) 208-7749, email SNAPS@arb.ca.gov, or mail to 1001 I St, Sacramento, CA 95814 Attn: Jonathan Blufer.***

Information presented in the summary report includes:

1. Scope of SNAPS Monitoring Data
2. Key Lost Hills Air Monitoring Results, including answers to the following questions:
    a. How does meteorology impact air quality?
    b. What is the air quality in Lost Hills?
    c. Is Lost Hills disproportionally affected compared to other areas in the Central Valley?
    d. What are the potential sources of the measured air pollutants?
    e. Are there elevated health risks associated with air quality in the community?
3. Actions, Ongoing Work, and Next Steps
4. Resources

A brief overview of air quality results is also provided to further summarize the key findings from SNAPS Lost Hills air monitoring.

SNAPS Air Monitoring in Lost Hills, California

Overview of the SNAPS Program

The California Air Resources Board (CARB) developed the Study of Neighborhood Air near Petroleum Sources (SNAPS) to better characterize air quality in communities located near oil- and gas operations, with a focus on production facilities. The goals of SNAPS are to respond

to community concerns regarding air quality near oil and gas-related activities by improving our understanding of the pollutants the public may be exposed to, provide air quality information publicly in real-time, and inform possible measures to minimize exposure. This summary describes the most comprehensive air monitoring study near oil and gas operations in California to date and its results.

Motivation to develop SNAPS originated from a 2015 report released by the California Council on Science and Technology[1] that emphasized a lack of air quality information for communities located near oil and gas facilities and the need to assess potential health impacts resulting from exposure to air pollutants. SNAPS focuses on assessing the cumulative impacts from these oil and gas sources, as well as all other potential anthropogenic (human-driven) and biogenic[2] (natural) sources, on air quality in these communities.

Lost Hills is the first community to receive air monitoring under the SNAPS program. CARB and the Office of Environmental Health Hazard Assessment (OEHHA) developed and implemented the SNAPS program with input from and collaboration with Lost Hills community members. Lost Hills was selected based on several factors: its location downwind of oil and gas wells and areas of high well density and production volume, a CalEnviroScreen 3.0 score greater than 75 (deemed a disadvantaged community according to the criteria established under SB 535[3]), support from local community groups, and public suggestions. Through a public process that took into consideration technical and logistical requirements of SNAPS monitoring equipment, a monitoring site in Lost Hills was selected (Lost Hills Department of Water Resources substation located near the southwest corner of the community), and stationary and mobile air quality monitoring was conducted over the course of almost one year, from May 2019-April 2020.

Once CARB prioritized Lost Hills as the first community to receive air monitoring under the SNAPS program, CARB had frequent conversations with local community organizations, including but not limited to, the Central California Environmental Justice Network and Clean Water Fund. These organizations provided extensive support with outreach and information sharing to the Lost Hills community, including distribution of flyers detailing upcoming meetings, responding to community member inquiries regarding program goals, helping to schedule community meetings with CARB in Lost Hills, and meeting with the community on a regular basis to discuss the SNAPS program and other local issues.

CARB and OEHHA staff held a series of three meetings in Lost Hills to present details about SNAPS, including an overview of the program, monitoring site selection, and preliminary results. During these meetings, the residents of Lost Hills and other communities, as well as

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[1] California Council on Science and Technology (2015). "An Independent Scientific Assessment of Well Stimulation in California." https://ccst.us/reports/well-stimulation-in-california

[2] "Biological sources such as plants and animals that emit air pollutants such as volatile organic compounds." CARB. Glossary. https://ww2.arb.ca.gov/glossary?keywords=&page=2.

[3] Disadvantaged Community Designation. https://oehha.ca.gov/calenviroscreen/sb535

other stakeholders, provided valuable input and comment. Lost Hills community members made key recommendations that contributed to the development of the Lost Hills Air Monitoring Plan.[4] Community members helped determine the length of stationary monitoring in Lost Hills, when mobile monitoring took place, and how information would be displayed on the SNAPS website. In addition, community members interacted with CARB staff during a period of mobile monitoring as the vehicle drove on various streets in Lost Hills. One recommendation by community members and implemented during Lost Hills monitoring was the operation of two community reporting telephone lines, one in English and one in Spanish, available for the reporting of air quality concerns, including odors and health concerns. More information on community engagement can be found in the Lost Hills Draft Final Report.

Scope of SNAPS Air Monitoring Data

SNAPS air monitoring in Lost Hills was an intensive effort that included stationary and mobile measurements and constitutes the first-of-its-kind, comprehensive monitoring effort focused on communities near oil and gas facilities. Staff developed a monitoring plan[4], standard operating procedures (SOPs)[5], and a Quality Assurance Project Plan (QAPP)[6] to produce high quality monitoring data for characterization of air quality and health risks.

Staff deployed a stationary trailer containing air monitoring equipment to provide frequent measurements of over 200 pollutants, including criteria pollutants (particulate matter of diameter less than 2.5 microns [$PM_{2.5}$], ozone [O_3], carbon monoxide [CO], and lead), volatile organic compounds (VOCs), metals, greenhouse gases (GHGs), among others.[6] Some pollutants were directly measured at the trailer in near real-time, while others were collected as samples at pre-designated times and analyzed by several analytical laboratories. To supplement stationary monitoring, mobile monitoring captured "snapshots" of air quality in the community several times during the year-long monitoring period.

Data collection under the SNAPS program is significantly larger than many other regulatory monitoring or research projects (Figure 1). Figure 1 compares the typical range of pollutants and frequency of measurements per year for each site in several monitoring projects. SNAPS, in many cases, collected more than double the data collected from typical monitoring programs. The intensive nature of SNAPS monitoring was made possible by utilizing a wide range of available monitoring techniques, and the result is a comparatively large dataset for analysis.

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[4] SNAPS Lost Hills Air Monitoring Plan. CARB. https://ww2.arb.ca.gov/resources/documents/lost-hills-air-monitoring-plan-snaps.

[5] SNAPS Standard Operating Procedures. CARB. https://ww2.arb.ca.gov/resources/documents/study-neighborhood-air-near-petroleum-sources-snaps-monitoring-documents.

[6] SNAPS Quality Assurance Project Plan. CARB. https://ww2.arb.ca.gov/resources/documents/quality-assurance-project-plan-study-neighborhood-air-near-petroleum-sources.

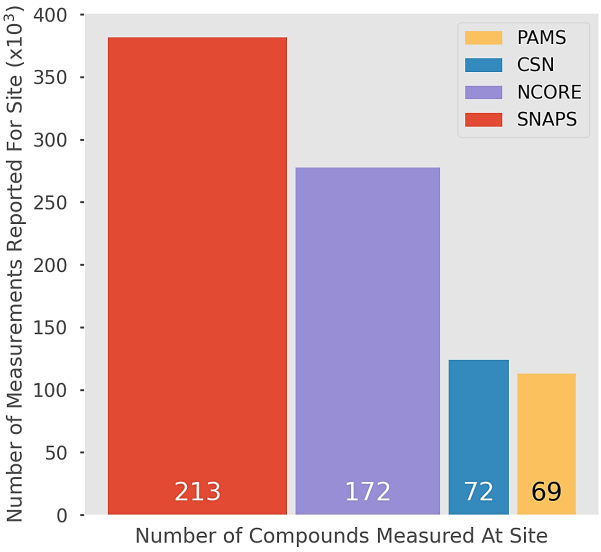

Figure 1. Comparison of the typical total number of measurements reported (vertical axis) and the number of compounds reported (horizontal axis) per year for different types of monitoring sites.[7]

Key Lost Hills Air Monitoring Results

How does meteorology impact air quality?

Meteorology, including wind speed and direction, plays an important role in the dispersion of pollutants from sources to communities and was an important consideration in where the monitoring trailer was located. In Lost Hills, wind measured at the SNAPS trailer frequently came from the west to west-northwest, meaning the Lost Hills community was often downwind of the Lost Hills Oil Field (Figure 2).

[7] Data are based on observations reported to U.S. EPA in 2019 for National Core (NCORE), Photochemical Assessment Monitoring Stations (PAMS), and Chemical Speciation Network (CSN). All data is for the duration of the SNAPS Lost Hills monitoring. Number of compounds is based on the number of parameter codes reported to U.S. EPA. All sub-hourly data from SNAPS is aggregated to hourly measurements for the purpose of comparison.

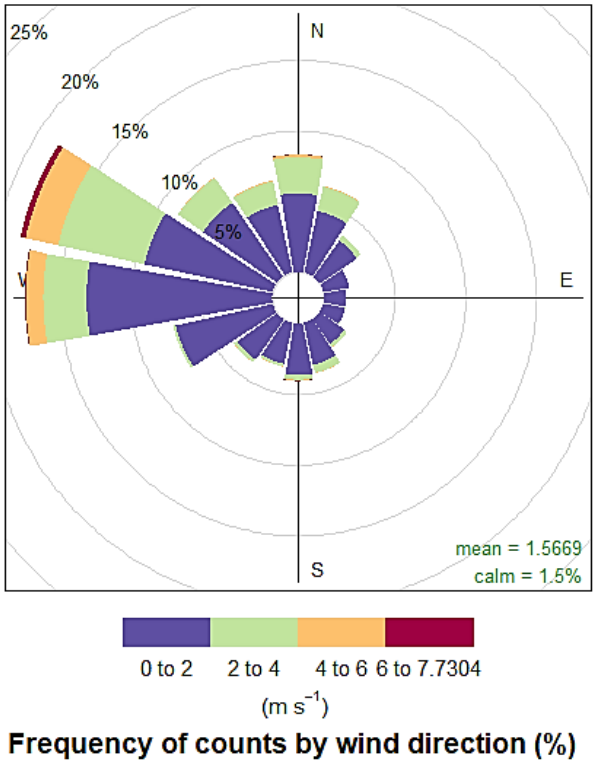

Figure 2. Wind speed (in meters per second (m/s)) and direction at the SNAPS trailer from May 2019 – April 2020. Wind speed is represented by various colors while the length of each colored slice corresponds to the percentage of time wind was measured at that speed from that specific direction.

What is the air quality in Lost Hills?

The Air Quality Index (AQI) is a useful tool to describe pollution levels in outdoor air. The AQI is a numerical value that can be calculated using measured PM and ozone concentrations and is associated with health protective actions.[8] When the AQI is below 100 ("Good" or "Moderate" air quality), the outdoor air corresponds to ambient air concentrations less than or equal to the short-term National Ambient Air Quality Standard and the majority of the population is unlikely to be affected by negative health impacts. When the AQI is 101 to 150, the outdoor air may be unhealthy for sensitive groups, including those with underlying health conditions. An AQI above 150 indicates that the air is considered unhealthy for everyone. Based on SNAPS measurements, the AQI in Lost Hills was considered "Good" or "Moderate" (i.e., satisfactory or acceptable) 98.9% of the time, and "Unhealthy for Sensitive Groups" or "Unhealthy" 1.1% of the time (Figure 3). AQI in the "Unhealthy for Sensitive Groups" or "Unhealthy" range, indicating more polluted air, occurred due to elevated $PM_{2.5}$

[8] AQI Basics. https://www.airnow.gov/aqi/aqi-basics/

concentrations during late October and early November 2019, as discussed later in this summary.

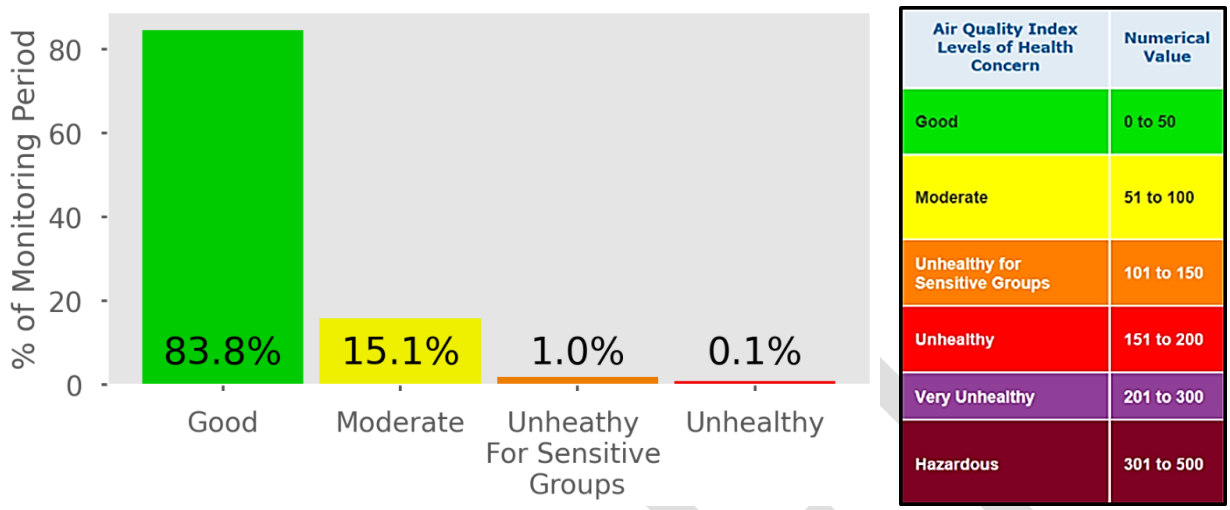

Figure 3. The Air Quality Index (AQI) in Lost Hills during the SNAPS monitoring period (May 2019 – April 2020), based on a rolling 24-hr average for $PM_{2.5}$ and rolling 8-hr average for O_3.

Concentrations of many pollutants measured at the SNAPS trailer followed clear trends likely influenced by atmospheric conditions, including but not limited to wind speed and direction. For example, stable atmospheric conditions, which often occur overnight, can trap emissions, causing increased concentrations of air pollutants. Changing atmospheric conditions over time can dilute or concentrate air pollutant concentrations. Figure 4 illustrates the atmospheric influence on air quality in Lost Hills; concentrations of black carbon (BC), BTEX (benzene, toluene, ethylbenzene, and xylenes), methane (CH_4), CO, and hydrogen sulfide (H_2S) were elevated overnight and in the early morning hours.

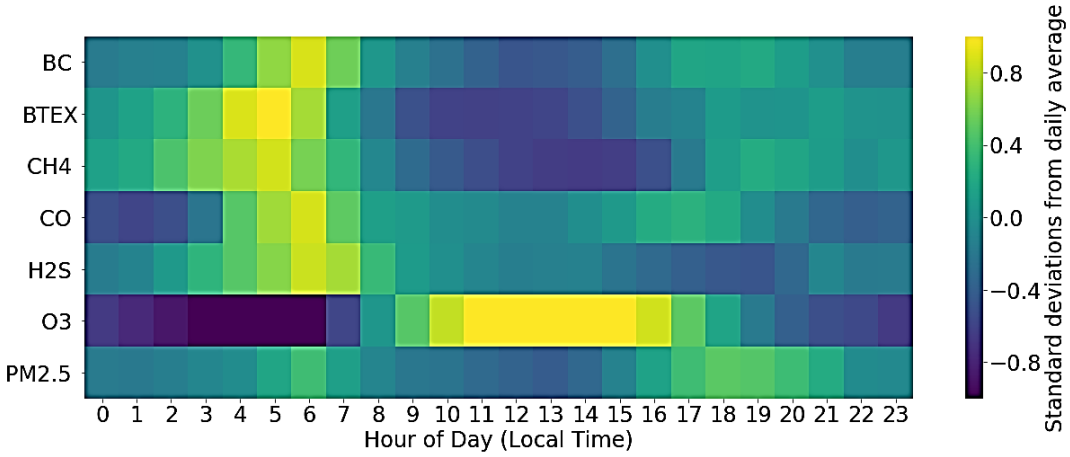

Figure 4. Heat map denoting the relative hourly concentrations of black carbon (BC), BTEX (benzene, toluene, ethylbenzne, and xylenes), methane (CH_4), carbon monoxide (CO), hydrogen sulfide (H_2S), ozone (O_3), and $PM_{2.5}$.

Similarly, higher overnight and early morning pollutant concentrations were observed during the fall and winter compared to the spring and summer, also likely due to stable atmospheric conditions.[9]

In addition to the overall trend of increasing overnight pollutant concentrations, Figure 4 shows $PM_{2.5}$ and ozone have other distinguishing concentration profiles. $PM_{2.5}$ concentrations peaked in both the early morning and evening hours. Peak concentrations of ozone occurred during the middle of the day, consistent with photochemical (sun-driven) processes.

Is Lost Hills disproportionally affected compared to other areas in the Central Valley?

Based on the current analysis of SNAPS data, for most pollutants measured in Lost Hills, the air quality was comparable to other areas in the Central Valley. A notable exception was acrolein, the concentrations of which were elevated in Lost Hills compared to other areas in the Central Valley. More information regarding air quality comparisons is discussed below.

$PM_{2.5}$ and Ozone

$PM_{2.5}$ concentrations in Lost Hills were relatively stable throughout the year, with a sharp increase in concentrations seen across the Central Valley and in Lost Hills in October and November 2019, coinciding with a period of stronger winds (Figure 5). Elevated concentrations of metals were measured in Lost Hills and throughout the Central Valley, suggesting that wind-blown dust was one contributor to the increase in $PM_{2.5}$.[10] Additional analysis showed a large increase in inorganic aerosols, likely from mobile and agricultural sources, and is typical for the fall/winter in the Central Valley. Organic $PM_{2.5}$ also increased in October and November, likely from wildfire smoke (such as the Kincade Fire in Sonoma County) and the transition to wood burning heat sources as the temperature dropped toward the end of the year.

Thereafter, concentrations of $PM_{2.5}$ sharply decreased regionally by December 2019, with smaller increases and decreases observed through May 2020. $PM_{2.5}$ concentrations in Lost Hills tended to follow the levels seen at other regional monitors, though concentrations in Lost Hills were, on average, lower than those observed across the Central Valley.

[9] To interpret Figure 4, note that the hour of day is located on the horizontal (x-) axis, with the pollutant labeled on the vertical (y-) axis. Each box shaded in warm colors (i.e., yellow) denotes concentrations higher than the average observed during that hour throughout the year of monitoring, while a box shaded in cool colors (i.e., blue) denotes concentrations lower than the average. For reference, midnight is the zeroth hour and noon is the 12th hour.

[10] Based on speciated filter measurements and analysis.

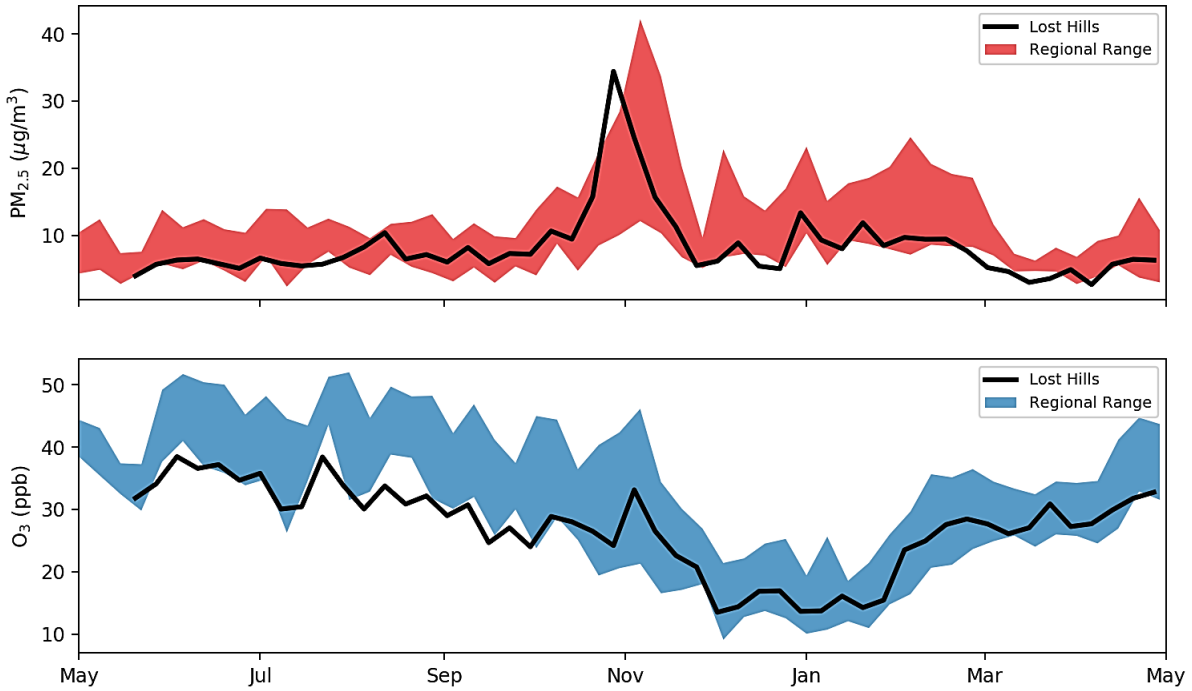

Figure 5. Seven-day average of $PM_{2.5}$ (top) and O_3 (bottom) at the Lost Hills monitoring site (black line) and the range for other sites in the region (shaded area).[11]

Ozone concentrations in Lost Hills and across the Central Valley gradually decreased from summer 2019 through winter 2019-20. Minimum ozone concentrations occurred in December-February then gradually increased across the region through May 2020. This summer maximum and winter minimum were expected, consistent with increased temperatures and sunlight resulting in greater ozone formation during the summer, and less ozone formation during the cooler winter months. Like $PM_{2.5}$, ozone concentrations in Lost Hills followed similar trends as the rest of the Central Valley but were on average lower.

Acrolein

Further characterization of air quality was carried out by comparing the concentrations of toxic pollutants in Lost Hills with those at other sites in the Central Valley. Acrolein and BTEX are shown in Figure 6. These sites were selected based on their geographic proximity to Lost Hills.

[11] $PM_{2.5}$ and O_3 regional data include 10 sites from the Central Valley (Manteca, Tracy, Modesto, Turlock, Visalia, Hanford, Corcoran, Porterville, Oildale and Bakersfield).

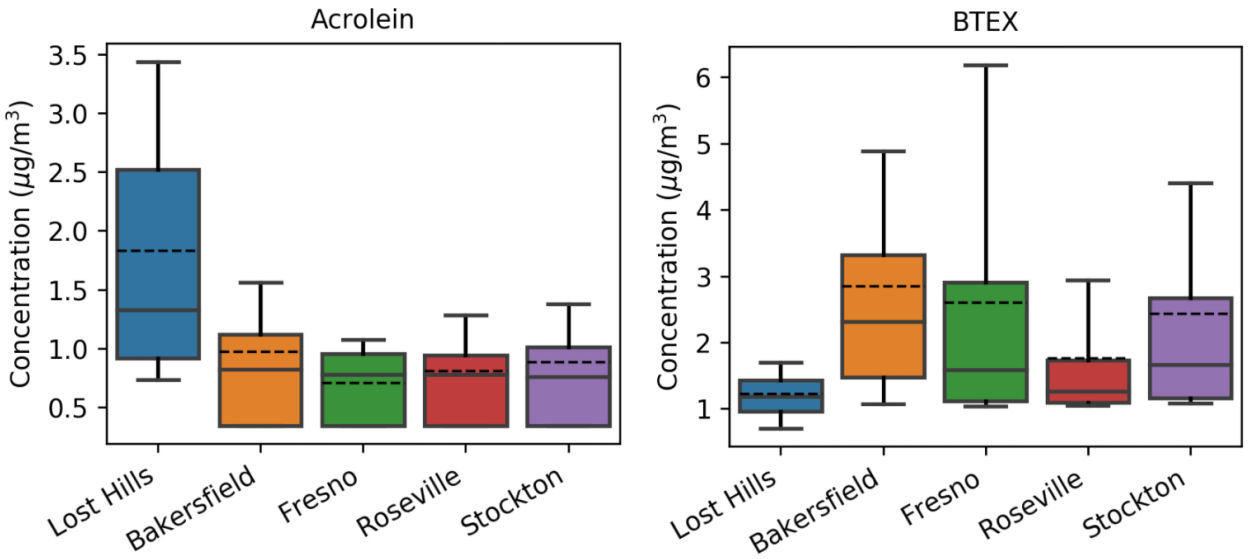

Figure 6. Concentrations of acrolein (left) and BTEX (right) measured in Lost Hills vs. at four regional sites in the Central Valley. Data for other regional sites are from the iADAM dataset[12] for the years 2016-2019. The median concentration at each site is denoted by individual solid lines within each box while the mean (average) concentration is denoted by individual dashed lines within each box.

Benzene (a component of BTEX) ranked as one of top four contributors to cancer risk in Lost Hills; however, benzene concentrations did not pose a substantial noncancer health risk. Concentrations of many compounds measured in Lost Hills, such as BTEX, were comparable to or less than concentrations across the Central Valley. However, acrolein was significantly elevated. Acrolein was the largest contributor to the noncancer risk, with potential health effects including eye irritation and damage to the respiratory tract.[13] To provide a holistic picture of health risk of toxics pollutants, OEHHA conducted a cumulative health risk assessment. A more detailed analysis on the health impacts of acrolein measured in Lost Hills, particularly noncancer health impacts, is discussed later in this document.

Acrolein can come from many sources including combustion processes (e.g., automobile and diesel exhaust), agriculture, photochemical reactions in the atmosphere, plants, and oil field operations. However, despite SNAPS localized monitoring and comprehensive data analysis, the relative contribution of these and other potential sources to the acrolein air concentration in Lost Hills remains unclear. CARB staff are working to develop novel sampling and analysis methods which will improve our understanding of acrolein levels in Lost Hills (see Next Steps section below).

[12] iADAM: Air Quality Data Statistics. CARB. https://www.arb.ca.gov/adam/
[13] Acrolein. OEHHA. https://oehha.ca.gov/chemicals/acrolein

What are the potential sources of the measured air pollutants?

There are several sources near the community of Lost Hills that may have an impact on air quality (Figure 7), including:

- Mobile sources (I-5 east of town and SR 46 traversing directly through the community)
- Lost Hills Oil Field (including wells [nearest active well roughly 5100 feet from monitoring site], storage tanks, compressors, separators, and the gas processing plant)
- Local natural gas distribution and transmission pipelines in Lost Hills
- Agriculture, landfills, composting facilities, and other regional sources not depicted in Figure 7

Staff monitored air quality using intensive monitoring approaches[6] and carried out source apportionment analysis (e.g., polar frequency plots and positive matrix factorization; Figures 8 and 9, detailed below) to investigate the contributions of these sources to the measured air pollutants. In addition, staff utilized results from other CARB programs to understand the effects of these sources on air quality in Lost Hills.

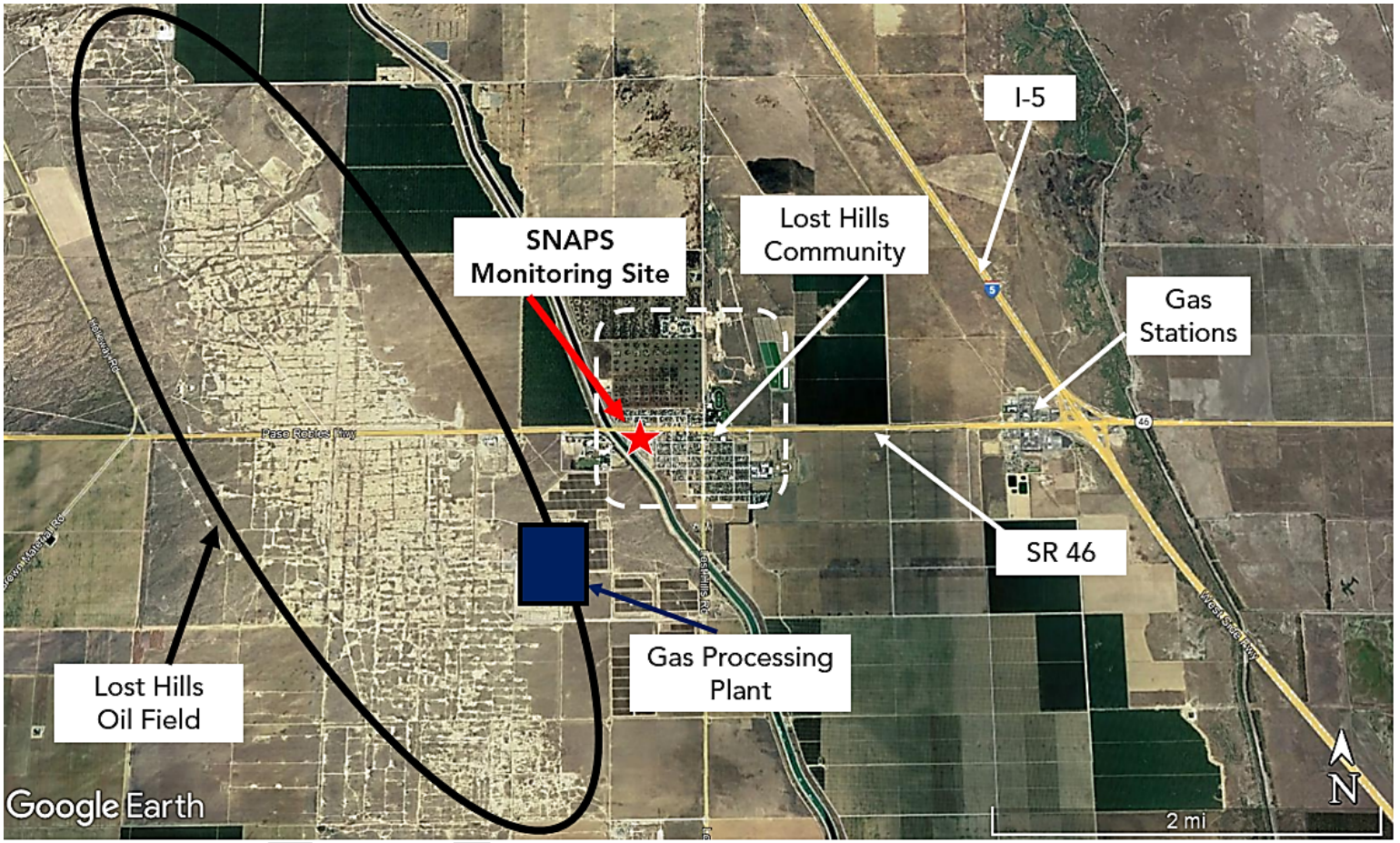

Figure 7. Map of the greater Lost Hills area showing the locations of the town of Lost Hills (white dashed line), the monitoring site (red star), and various potential sources of air pollution, including the Lost Hills Oil Field (black circle), the gas processing plant (blue rectangle), gas stations, and SR 46 highway and I-5 freeway.

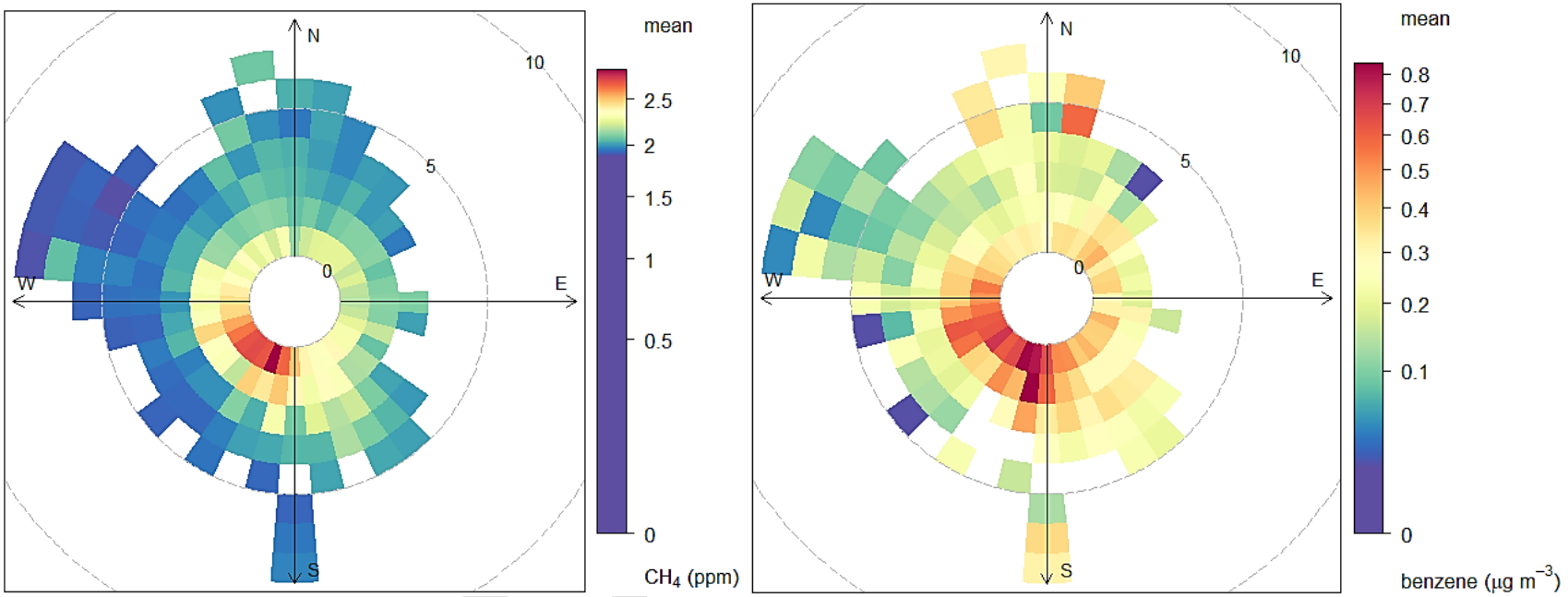

Figure 8. Polar frequency plots[14] for methane (CH_4) and benzene. Successively increasing wind speeds are shown further from the center of each plot, with the average value of each pollutant concentration at that specific wind speed and wind direction shaded according to the keys on the right.

[14] Openair. Tools for the Analysis of Air Pollution Data. https://www.rdocumentation.org/packages/openair/versions/2.8-1

Stationary and mobile monitoring results indicated increased hydrocarbons and VOCs when the wind was coming from the direction of the gas processing plant. As shown in Figure 8, when winds were light and from the southwest, concentrations of methane and benzene (and several other hydrocarbons/VOCs, not pictured) were measured at their highest average concentrations. While it is possible fugitive emissions from wells, storage tanks, and compressors may have contributed to these observations, corroborating evidence from other monitoring projects, including FluxSense[15], JPL methane source finder[16], and SNAPS mobile monitoring, indicate the gas plant as a likely source of emissions.

Additional analysis of SNAPS data with oil field activity (e.g. well stimulation ("fracking"), workover, drilling events) indicated these activities are not well correlated with air pollutant concentrations measured at the trailer. However, this does not preclude oil field activities from impacting air quality in Lost Hills.

Mobile monitoring detected two natural gas leaks in residential areas of Lost Hills: one on October 30, 2019 and the second on January 15, 2020, at separate locations. CARB staff immediately reported these leaks to the Southern California Gas Company (SoCalGas) to have the equipment quickly inspected and repaired.

In response to community and stakeholder feedback, CARB staff conducted additional source apportionment analysis[17] to evaluate how various source types and source categories contribute to the air quality in the Lost Hills community. The source apportionment analysis focused on a group of VOCs and BC, which are important contributors to health risk and bear the information necessary to identify potential sources. Note, only the data collected in near real-time were used for source apportionment analysis. The analysis indicated that BC was mostly from mobile sources, VOCs were mostly from oil and gas-related sources (including, but not limited to, gas stations, natural gas distribution lines, and oil production and processing), and BTEX was from both mobile sources and oil and gas-related sources (Figure 9).

[15] FluxSense. Toxic Air Contaminant and Greenhouse Gas Measurements near Oil and Gas Operations and Proximate Communities. https://ww2.arb.ca.gov/resources/documents/toxic-air-contaminant-and-greenhouse-gas-measurements-near-oil-and-gas.

[16] CARB. Methane Source Finder. https://msf.carb.arb.ca.gov/map.

[17] Positive Matrix Factorization model for environmental data analyses. U.S. EPA. https://www.epa.gov/air-research/positive-matrix-factorization-model-environmental-data-analyses

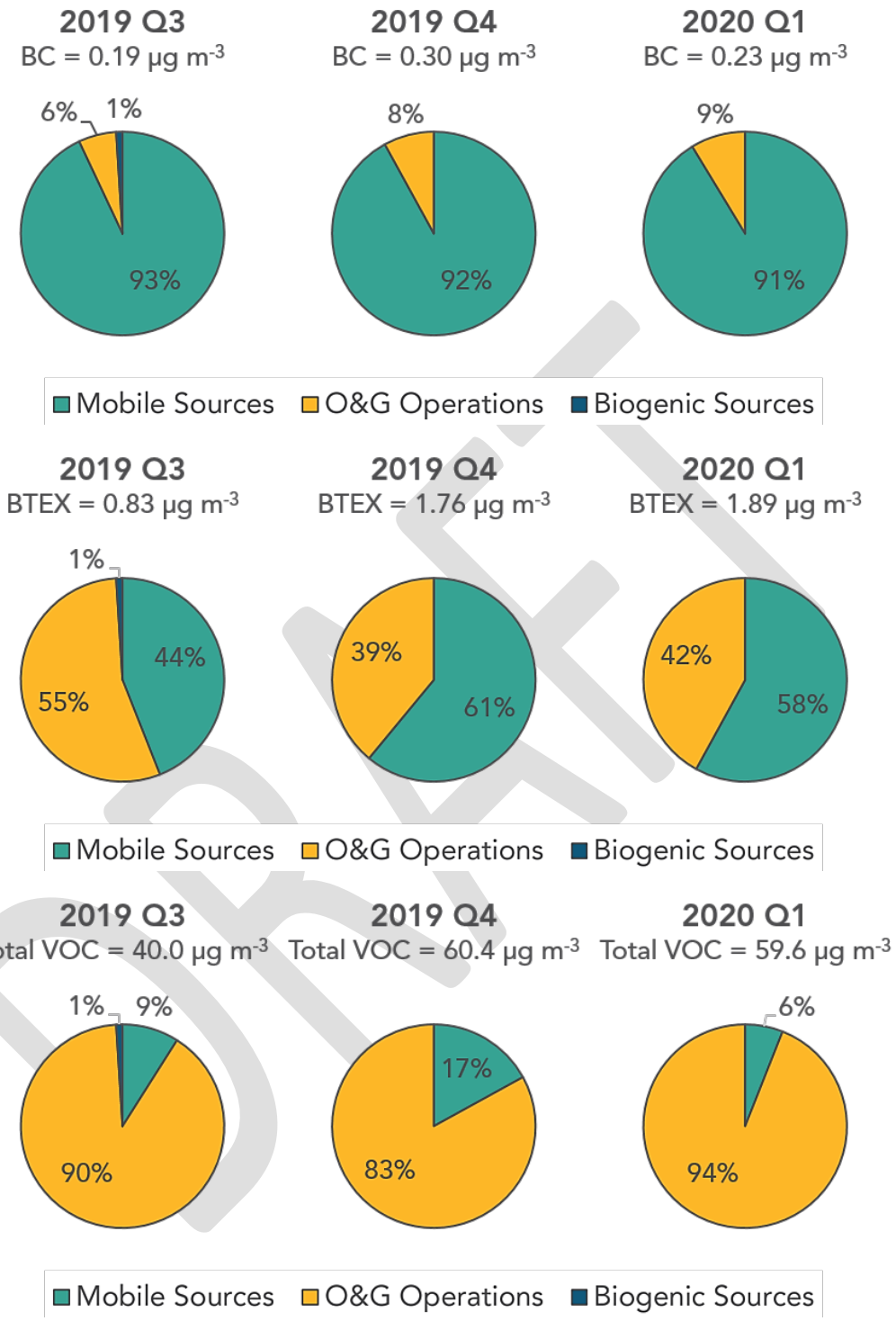

Figure 9. Summary of quarterly SNAPS source apportionment results, showing BC (top), BTEX (middle), and VOCs (bottom) contributions from mobile sources, oil- and gas- related (O&G) sources, and biogenic sources. The concentrations represent the quarterly sum.

There was also a small, but discernable contribution of biogenic emissions[2] in the third quarter of 2019, which was expected and is consistent with the detection of isoprene as reported in the scientific literature.

It is important to note that this source apportionment analysis cannot differentiate between BC, BTEX, and VOC emissions from vehicles on the highway versus vehicles/equipment operating within or near the oil field. As a result, the mobile source category includes emissions from vehicles on the roadways and within the oil field. BC is often used as a surrogate for diesel PM, which is important from a health perspective as covered in the health analysis below. This analysis also indicates a large majority of VOC emissions are from oil and gas-related operations. However, many of the individual VOCs driving this result are not at concentrations at which health impacts are expected (see below).

Are there elevated health risks associated with air quality in the community?

Cancer Risk

The cumulative cancer risk from all carcinogenic (cancer-causing) compounds measured in Lost Hills, both anthropogenic and biogenic[2], was estimated to be 710 per million (Figure 10). The cumulative cancer risk estimate means that breathing Lost Hills air over a lifetime is estimated to increase cancer risk by as many as 710 cases per million exposed individuals. As a percentage, this risk represents a 0.071% chance of getting cancer, or nearly 1/10th of 1%. It is possible that the cumulative cancer risk from ambient air pollution in Lost Hills may be higher, as acrolein, a recently identified carcinogen[18], was not evaluated quantitatively in the assessment due to lack of a cancer potency value. OEHHA is exploring the development of a cancer potency value for acrolein, which would facilitate assessment of acrolein in future SNAPS risk assessments.

These risk estimates are referred to as excess cancer risk, meaning they represent an increase in risk on top of the cancer risk already present due to other factors such as age, genetics, diet, obesity, and smoking[19]. Risk estimates for 13 of the 17 carcinogens evaluated exceeded a threshold of concern for cancer risk among the general population of one in a million (0.000001). After diesel PM (65%), the next greatest contributors to cancer risk were carbon tetrachloride (9%)[20] and formaldehyde (9%).[21] The risk calculation was estimated using approximately one year of air monitoring data but assumes continuous lifetime exposure to these concentrations for 70 years; as a result, the true risk may be different from the estimate. Diesel PM exposure often drives cancer risk assessments of ambient air pollution across the United States and in California, as it did in this assessment, contributing 65% of the cancer risk. An air monitoring study of the Inglewood Oil Field in Los Angeles (the Baldwin Hills Air Quality Study)[22], estimated diesel PM levels based on BC (as in this study) and found that ~74% of the excess cancer risk from ambient air from all sources was

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[18] International Agency for Research on Cancer. 2021. Carcinogenicity of acrolein, crotonaldehyde, and arecoline. Lancet Oncol 22(1):19-20.

[19] NCI (National Cancer Institute). 2015. Risk Factors for Cancer. National Cancer Institute, National Institutes of Health https://www.cancer.gov/about-cancer/causes-prevention/risk

[20] Carbon tetrachloride was produced in large quantities to make refrigerants and propellants for aerosol cans.

[21] Potential sources of formaldehyde include vehicle emissions, pesticides, and oil and gas production.

[22] STI (Sonoma Technology Inc.). 2015. Baldwin Hills Air Quality Study. https://planning.lacounty.gov/assets/upl/project/bh_air-quality-study.pdf

attributable to diesel PM. Similarly, a study of the South Coast Air Basin (which includes Los Angeles) found that diesel PM contributed 68% of the cancer risk based on air monitoring data and 76% based on computer-modeled concentrations[23].

Beyond diesel PM, a comparison of data from other California locations (Figure 11), including the Central Valley, showed similar cancer risk estimates for three of the other top four pollutants contributing to risk in the Lost Hills study (carbon tetrachloride, formaldehyde, and benzene). Note that while similar, the estimated cancer risks for these three pollutants in all of the locations (including Lost Hills) exceed one in a million and are thus of concern. The Bakersfield, Fresno, Roseville, and Stockton sites were selected based on their geographic proximity to Lost Hills, while the statewide average is presented for context at a larger scale, the South Coast Air Basin MATES IV study is presented as an example of an ambient air assessment for a region (Los Angeles area), and the Baldwin Hills Air Quality Study as the only available air monitoring study of an oil field in California identified. An advantage of the Bakersfield, Fresno, Roseville, and Stockton data is that these compounds (carbon tetrachloride, formaldehyde, and benzene) were measured using the same methods as in SNAPS.

[23] SCAQMD 2015. Final Report: Multiple Air Toxics Exposure Study in the South Coast Air Basin. MATES-IV. https://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-iv

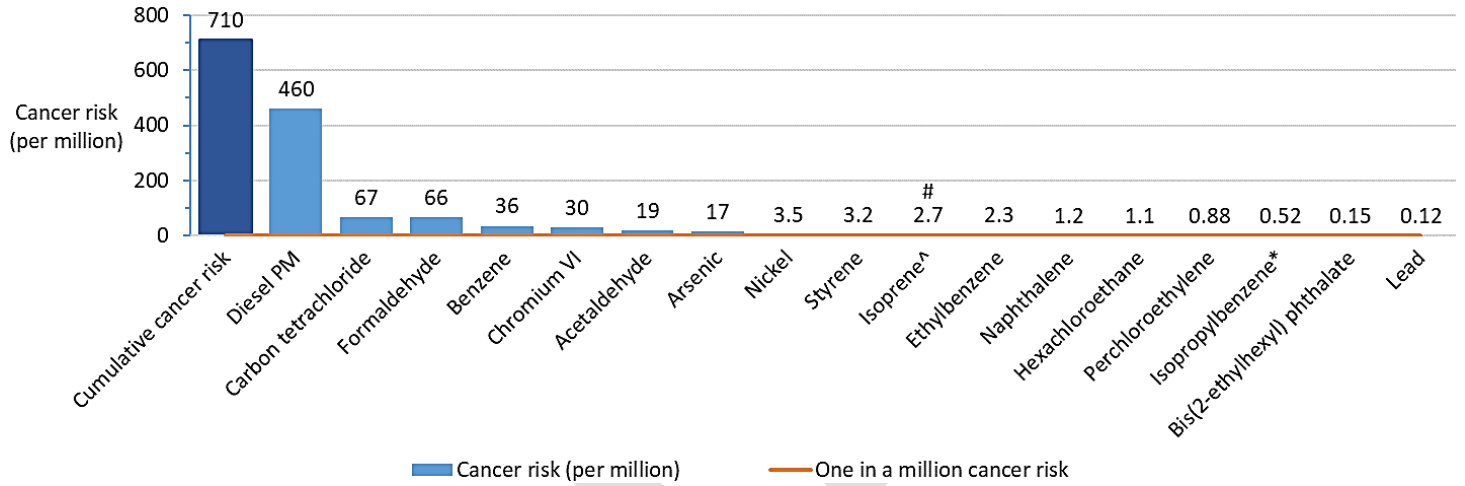


Figure 10. Cancer risk estimates for carcinogens measured in Lost Hills air.[24]

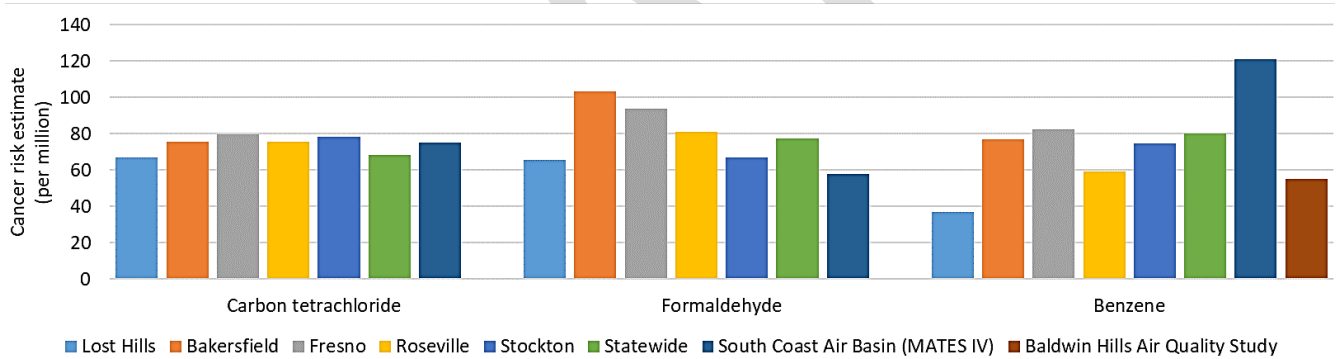


Figure 11. Cancer risk estimate comparisons for carbon tetrachloride, formaldehyde, and benzene.[25]

[24] Cumulative cancer risk (dark blue bar) and cancer risk estimates for each compound (lighter blue bars) are arranged by cancer risk in decreasing order. The orange horizontal line represents one in a million cancer risk, which is a threshold of concern for cancer among the general population. ^Indicates that the health guidance value used to calculate risk for isoprene is a draft value and is under review by the California Scientific Review Panel on Toxic Air Contaminants. *Indicates that the health guidance value used to calculate risk for isopropylbenzene is provisional (not derived by OEHHA). #Indicates that isoprene is likely from biogenic sources.

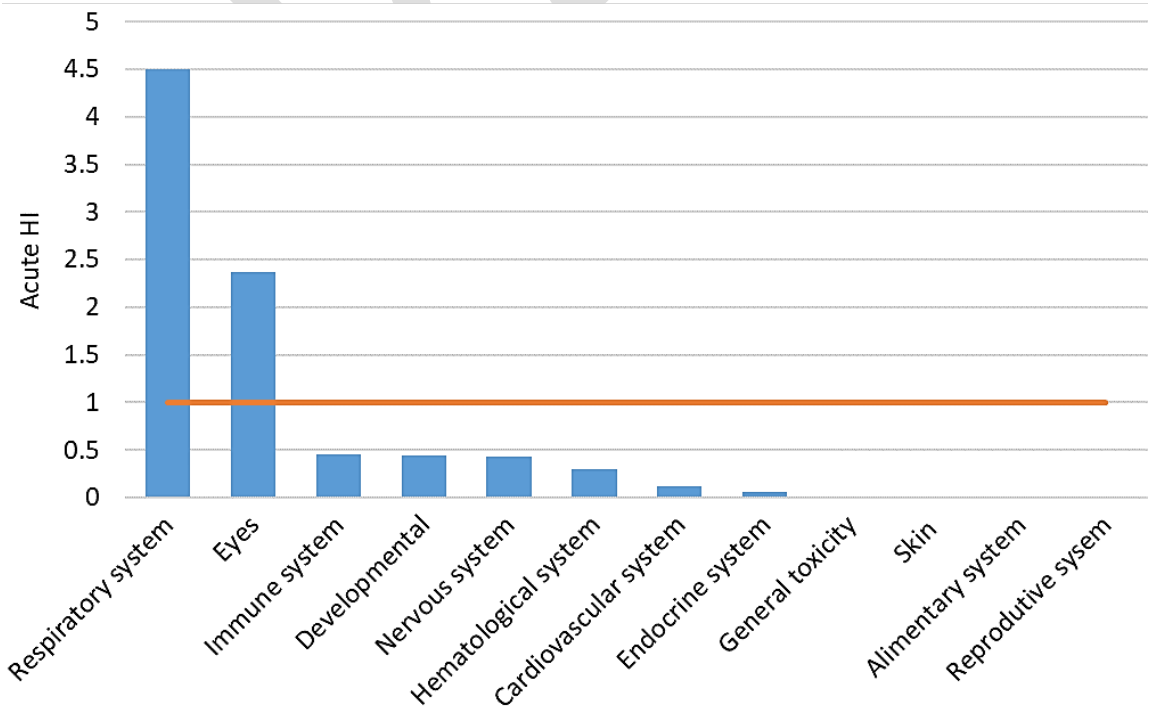
[25] Based on average concentrations from: (1) SNAPS discrete data for Lost Hills (2019-2020), (2) various Central Valley sites (2016-2019)[12], (3) Statewide (2017 for formaldehyde and 2018 for carbon tetrachloride and benzene)[12], (4) MATES IV (2012-2013)[23], and (5) the Baldwin Hills Air Quality Study (2013)[22].

Noncancer Risk

For noncancer health effects, risk from individual pollutants is summed to give the hazard index (HI), which reflects the likelihood that a target organ (such as the respiratory system) will be affected by exposure. Noncancer health risk is determined with a hazard quotient (HQ), which is the ratio between the exposure and the health guidance value (HGV). Health-protective assumptions are built into the HGVs such that adverse outcomes may not occur even when they are exceeded, though harm from the compounds cannot be ruled out. In addition, lifestage (pregnancy, infancy, elderly), health status, genetics, lifestyle choices, and other factors can influence risk. HGVs take these factors into account so that the most sensitive individuals in a population will be protected.

The risk to the respiratory system, in terms of both acute and chronic noncancer risk, was largely driven by acrolein. For acute (short-term) exposures, acrolein and dimethyl disulfide (DMDS) were the only pollutants detected at a maximum concentration with the potential to cause adverse noncancer health effects, specifically, eye irritation (acrolein) and damage to the respiratory tract (acrolein and DMDS). For chronic (long-term) exposures, acrolein was the only pollutant detected at an average concentration with the potential to cause adverse noncancer health effects, specifically, effects to the respiratory system.

Beyond acrolein and DMDS, individual pollutants by themselves do not appear to pose a noncancer health risk in Lost Hills. Results did indicate, however, that due to cumulative exposure to multiple chemicals there is the potential for health effects to the respiratory system and eyes from acute (short-term) exposures as well as health effects to the respiratory and nervous systems from chronic (long-term) exposures (Figure 12).



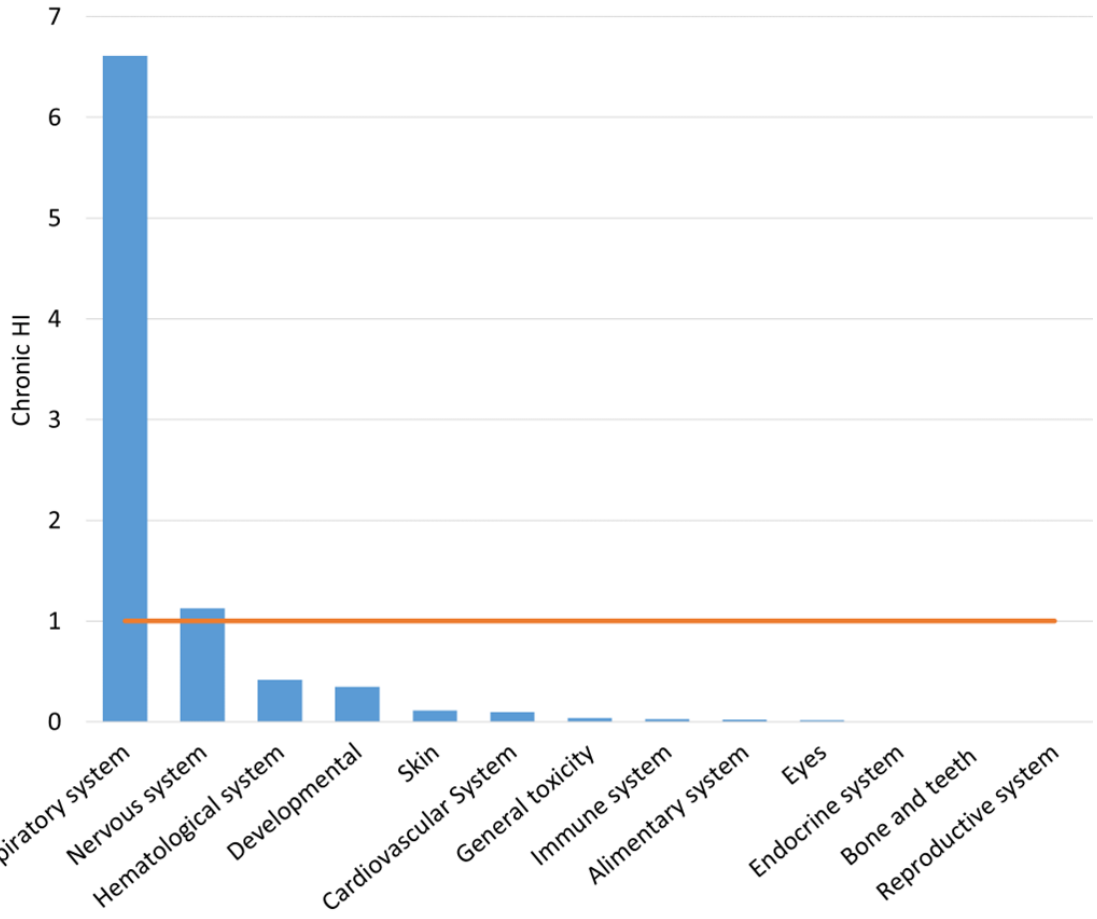
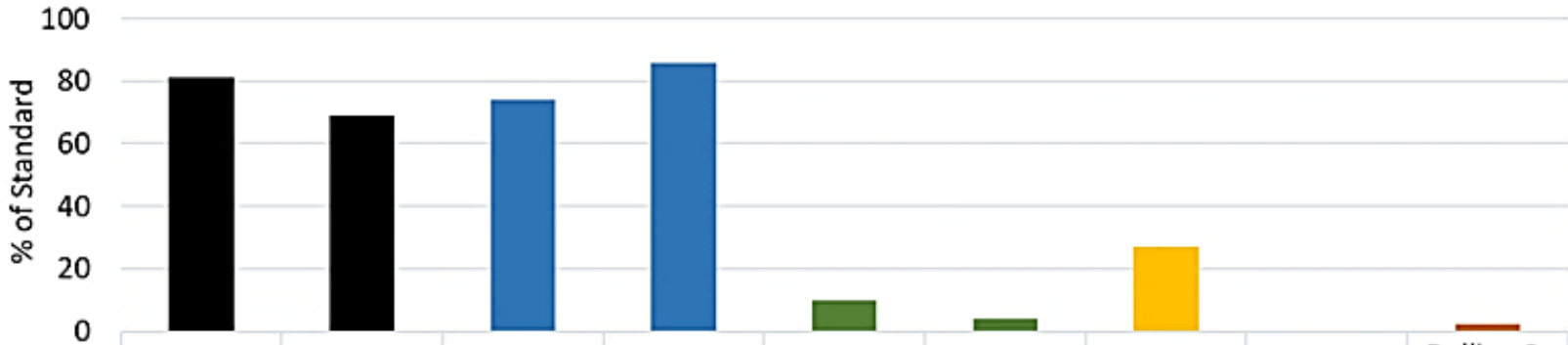


Figure 12. Acute (top) and chronic (bottom) hazard indices (HIs) which combine hazard quotients (HQs) for compounds with the same target organ. The orange horizontal line indicates an HI of one, below which health effects are not expected to occur.

Health Analysis for Criteria Pollutants and Hydrogen Sulfide

Concentrations of all criteria pollutants and hydrogen sulfide measured in Lost Hills met ambient air quality standards for $PM_{2.5}$, ozone (O_3), CO, hydrogen sulfide (H_2S), and lead (Figure 13). However, exposures to these pollutants at levels below the standards can add to the health risks for the air toxics evaluated in this assessment. As shown in Figure 13, the $PM_{2.5}$ and O_3 levels were measured closest to the standards, with concentrations representing 81% of the 24-hr National Ambient Air Quality Standards ($PM_{2.5}$) and 86% of the 8-hr California Ambient Air Quality Standards (O_3).



% of Standard	81	69	74	86	10	4.1	27	0.27	2.4

Figure 13. Concentrations of criteria air pollutants and hydrogen sulfide measured in Lost Hills as a percent (%) of relevant ambient air quality standards (California or National). The values plotted relative to the standard are (from left to right) the daily 24-hr 98th percentile for $PM_{2.5}$, average of hourly data over the monitoring period for $PM_{2.5}$, daily 1-hr and 8-hr maximum values for ozone, daily 1-hr maximum and rolling 8-hr maximum for carbon monoxide, daily 1-hr maximum for hydrogen sulfide, and the maximum 30-day average and maximum rolling 3-month average for lead.

Actions and Ongoing Work

SNAPS monitoring and analysis has characterized air quality and its potential health effects on the Lost Hills community. Actions that were and are being taken based on the results include the following:

1. Staff immediately responded to two separate natural gas leaks detected in Lost Hills by calling SoCalGas to have the leaking equipment inspected and repaired.
2. SNAPS stationary and mobile monitoring indicate that the gas processing plant is a potential source of pollution to the community. This finding is consistent with previous monitoring projects such as the JPL methane source finder and FluxSense. In January 2021, the local air pollution control district conducted an inspection of the facility as part of their annual inspections and issued a Notice of Violation for a component leak exceeding 50,000 parts per million (ppm) VOCs. There was also a separate leak for a component subject to California's Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities regulation cited under the registration for facility S-2010 near the gas plant. The operator fixed these leaks on the same day they were discovered, and they were reinspected by District staff to confirm compliance. The air district also conducted inspections of S-55 in November and December 2022. Two NOVs were issued as a result of the inspections. The first NOV was for three leaks exceeding 50,000 ppm, which were repaired and re-inspected by the facility and confirmed repaired by air district staff. The second NOV was issued for a leak exceeding 50,000 ppm, which was repaired and re-inspected the same day. Additionally, as part of the California Environmental Protection Agency's (CalEPA) Environmental Justice Task Force, compliance information and coordination of inspections of facilities like the gas processing plant near Lost Hills are underway and include US Environmental Protection Agency, California Environmental Protection Agency, CARB, local Air Districts, state and local Water Boards, Department of Toxic Substances Control, and California Geologic Energy Management Division (CalGEM). Coordinated multiagency inspections of other facilities have been conducted in other communities in the San Joaquin Valley such as Shafter, Arvin, Maricopa, Fellows, and Bakersfield. At a joint inspection of the Cahn 3 gas processing plant in December 2021, the task force noted a violation on a gas separator with a leak concentration of 90,000 PPM methane. The leak was immediately fixed, and the team checked and confirmed repair before leaving the site.
3. SNAPS data indicates mobile sources and oil- and gas-related operations are substantial pollution sources with potential health impacts to the Lost Hills community. The State of California recently passed legislation to address some of these pollution sources. Recently signed legislation included locking in a pathway to

carbon neutrality by no later than 2045[26] and establishing a 3200-foot buffer zone between sensitive populations and oil and gas-related operations[27].

4. CARB, and the State of California, continue to make progress reducing pollution from mobile sources. To continue California's history of leadership in reducing pollution from mobile sources, Governor Newsom issued an Executive Order (EO) in 2020 that requires all new cars and passenger trucks sold in California to be zero emission by 2035. On August 25, 2022, CARB approved the trailblazing Advanced Clean Cars II rule, which establishes a year-by-year roadmap so that by 2035, 100% of new cars and light trucks sold in California will be zero-emission vehicles, including plug-in hybrid electric vehicles.[28,29] The regulation realizes and codifies the light-duty vehicle goals set out in the Governor's EO. The EO also sets a goal for all medium and heavy-duty trucks to transition to zero emission by 2045, where feasible (with drayage trucks transitioning to zero-emission by 2035). Additionally, the EO sets a zero-emission goal for off-road vehicles and equipment by 2035. Implementation of this EO and the Advanced Clean Cars II rule, as well as additional regulations and incentive programs adopted by CARB, will mean substantial air quality improvements for the Lost Hills community and the Central Valley more broadly.
5. Oil and gas-related sources are also a major source category impacting Lost Hills. In April 2021, Governor Newsom directed CalGEM to stop issuing new hydraulic fracturing permits by 2024 and requested that CARB analyze pathways to phase out oil extraction by 2045.[30] CARB's 2022 Scoping Plan for Achieving Carbon Neutrality lays out a path to achieve targets for carbon neutrality and reduce anthropogenic GHG emissions by 85 percent below 1990 levels no later than 2045, as directed by Assembly Bill 1279. The actions and outcomes in the plan will achieve: significant reductions in fossil fuel combustion by deploying clean technologies and fuels, further reductions in short-lived climate pollutants, support for sustainable development,

[26] Muratsuchi. 2022. AB 1279. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1279.
[27] Gonzalez and Limon. 2022. SB 1137. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB1137.
[28] CARB. "California moves to accelerate to 100% new zero-emission vehicle sales by 2035." https://content.govdelivery.com/accounts/CARB/bulletins/329a48c.
[29] CARB. Advanced Clean Cars II. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.
[30] Office of Governor Gavin Newsom. "Governor Newsom Takes Action to Phase Out Oil Extraction in California." https://www.gov.ca.gov/2021/04/23/governor-newsom-takes-action-to-phase-out-oil-extraction-in-california/.

increased action on natural and working lands to reduce emissions and sequester carbon, and the capture and storage of carbon.[31,32]

Next Steps

1. While the local air district conducts annual inspections of oil and gas facilities, additional inspections may be conducted as a result of public complaints and equipment breakdowns.
2. Acrolein concentrations were found to pose noncancer health risks to the Lost Hills community and were substantially increased compared to other regional sites. A recently identified carcinogen, acrolein was not included in the cancer risk assessment due to lack of a cancer potency value. OEHHA is exploring the development of a cancer potency value for acrolein, which would facilitate assessment of acrolein in future SNAPS risk assessments. In addition, source identification for acrolein in this report was limited by the available analytical method, which had a low sampling frequency and low time resolution. CARB staff are now working on new monitoring approaches which employ state-of-the-art techniques. These new techniques will enable ambient measurements of acrolein with hourly time resolution (i.e., more frequent measurements) and allow improved source apportionment analysis. Further investigation of acrolein sources will focus on two sampling periods (summer and winter) when the elevated acrolein concentrations were observed during SNAPS in Lost Hills. CARB staff will carry out monitoring of acrolein and other VOCs for a period of time in each of these seasons. After this additional data is collected, source apportionment analysis will be performed to explore the major sources contributing to acrolein concentrations in Lost Hills.
3. Furthermore, OEHHA is currently undergoing the formal process to develop a cancer potency value for isoprene. The draft value is under review by the California Scientific Review Panel on Toxic Air Contaminants. As this value may differ from the draft value used in this draft report, updates to the cancer risk assessment will be performed after the new HGV is established.
4. While Lost Hills was the first community to receive SNAPS monitoring, monitoring in the second community located near oil and gas facilities is currently underway. In June 2023, staff began air monitoring in the next community selected for the SNAPS program, communities near the Inglewood Oil Field. Staff will monitor air quality at two stationary sites, and deploy the mobile monitoring vehicle, to characterize air quality near the Inglewood Oil Field for approximately one year. CARB and OEHHA staff will analyze the final data obtained from the Inglewood Oil Field communities'

[31] CARB. AB 32 Climate Change Scoping Plan. https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan.
[32] CARB. 2022 Scoping Plan Documents. https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents.

monitoring study, allowing for a comparison between the rural Lost Hills site and the urban Inglewood Oil Field communities sites. Additional communities will be considered for SNAPS monitoring in future years.

Data obtained from the SNAPS Lost Hills monitoring study will be released, potentially for further analysis by regulatory agencies and interested parties, after public comment on this draft report has been considered.

Resources

SNAPS

- **For comments on the Lost Hills Draft Final Report:**
  - **Call: (279) 208-7687 or (279) 208-7749**
  - **Email: *SNAPS@arb.ca.gov***
  - **Mail: 1001 I St, Sacramento, CA 95814 Attn: Jonathan Blufer**
- Website: *https://ww2.arb.ca.gov/our-work/programs/study-neighborhood-air-near-petroleum-sources* (Full list of relevant SNAPS links in Appendix A of full draft report)
  - Quality Assurance Project Plan
    - *https://ww2.arb.ca.gov/resources/documents/quality-assurance-project-plan-study-neighborhood-air-near-petroleum-sources*
  - Lost Hills Air Monitoring Plan
    - *https://ww2.arb.ca.gov/resources/documents/lost-hills-air-monitoring-plan-snaps*
- For general questions, call (279) 208-7749

Reporting air quality and odor complaints (Kern County)

- Visit IVAN Kern[33]: *https://www.kernreport.org/*
- Call SJVAPCD[34] at (800) 926-5550

CARB Community Air Protection Program Resource Center

- Website: *https://ww2.arb.ca.gov/ocap_resource_center*
  - *Introduction to Community Air Quality*
    - *https://ww2.arb.ca.gov/introduction-community-air-quality*
  - *Community Health*
    - *https://ww2.arb.ca.gov/our-work/programs/community-health*
  - *Related State Agency Efforts*
    - *https://ww2.arb.ca.gov/related-state-agency-efforts*

[33] IVAN Kern. https://www.kernreport.org/
[34] SJVAPCD. File a Complaint. https://ww2.valleyair.org/file-a-complaint