

SNAPS LOST HILLS AIR MONITORING RESULTS OVERVIEW



Background

The California Air Resources Board (CARB) and California's Office of Environmental Health Hazard Assessment (OEHHA) developed the Study of Neighborhood Air near Petroleum Sources (SNAPS) to characterize air quality and corresponding health risks in communities near oil and gas operations. CARB staff monitored air quality in Lost Hills, CA for nearly one year, from May 2019 through April 2020, using a suite of instruments housed in a stationary trailer. CARB staff also conducted mobile monitoring to supplement the stationary monitoring. SNAPS air monitoring constitutes the first-of-its-kind, comprehensive monitoring effort focused on communities near oil and gas operations, with over 200 compounds quantified, including criteria pollutants, toxic air contaminants, and other pollutants. Using the measured concentrations from air monitoring, OEHHA estimated the health risks for people in Lost Hills exposed to the pollutants. This document summarizes air monitoring results from Lost Hills and the health risk assessment presented in the Lost Hills Final Report. Data obtained from the SNAPS Lost Hills monitoring study was released with this report and can be found on the SNAPS website.

Lost Hills Air Quality

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 particulate matter (PM) and ozone (O₃) concentrations and is associated with health protective actions.¹ 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 1). AQI in the "Unhealthy for Sensitive Groups" or "Unhealthy" range, indicating more polluted air, occurred due to elevated PM_{2.5} concentrations in Lost Hills and across the Central Valley in October and November 2019.



Key Conclusions

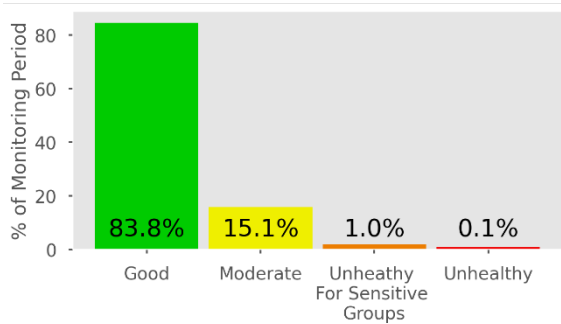
- Pollution levels in Lost Hills generally mirrored other Central Valley locations, except for acrolein concentrations. Because SNAPS was not able to identify specific acrolein sources in Lost Hills, staff are currently collecting additional acrolein measurements with more sensitive instruments.
- The Air Quality Index 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.
- Monitoring results indicated increased hydrocarbons and volatile organic compounds (VOCs) during times when the wind was coming from the direction of the Cahn 3 Gas Processing Plant.
- The evaluated carcinogens, notably diesel particulate matter, were detected in Lost Hills air at concentrations that were concerning, but similar to other areas of California not directly associated with oil and gas production.
- Noncancer health risks of concern for the respiratory system, eyes, and nervous system were identified. Acrolein was the primary driver of impacts to the respiratory system and eyes, and acrolein concentrations measured in Lost Hills were generally higher than those in other areas of California.
- Concentrations of PM_{2.5}, ozone, carbon monoxide, lead, and hydrogen sulfide in Lost Hills met ambient air quality standards.
- Source apportionment results show oil and gas-related sources contributed 39% to 55% of BTEX and over 80% of other VOCs included in the analysis, while black carbon was mostly from mobile sources.

¹ AirNow. AQI Basics. <https://www.airnow.gov/aqi/aqi-basics/>.

SNAPS LOST HILLS AIR MONITORING RESULTS OVERVIEW

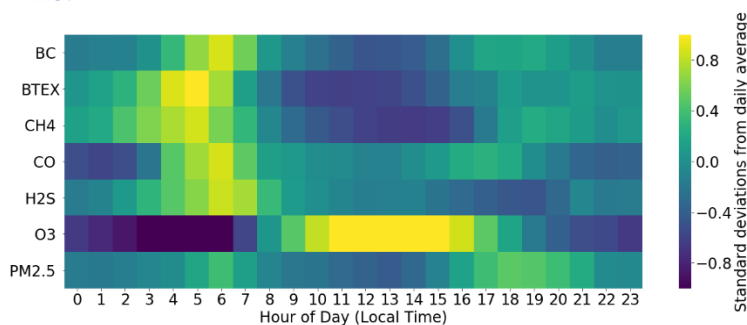


Figure 1. AQI in Lost Hills during the SNAPS monitoring period (May 2019-April 2020), based on a rolling 24-hr average for PM_{2.5} and rolling 8-hr average for O₃.



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 air pollutant concentrations. Figure 2 illustrates the atmospheric influence on air quality in Lost Hills; concentrations of black carbon (BC), BTEX (benzene, toluene, ethylbenzene, and xylenes), methane (CH₄), carbon monoxide (CO), and hydrogen sulfide (H₂S) were elevated overnight and in the early morning hours.

Figure 2. Heat map denoting the relative hourly concentrations of several pollutants measured in Lost Hills.



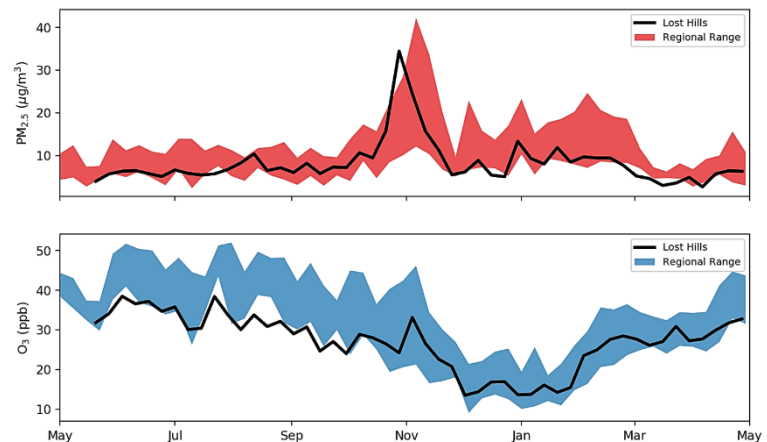
Higher overnight and early morning pollutant concentrations were also observed during the fall and winter, also likely due to stable atmospheric conditions.

Figure 2 shows PM_{2.5} and O₃ had other distinguishing trends. PM_{2.5} concentrations peaked in both the early morning and evening hours. Peak concentrations of O₃ occurred during the middle of the day, consistent with photochemical (sun-driven) processes.

Lost Hills Air Quality Compared to Other Central Valley Locations

For most pollutants measured in Lost Hills, the air quality was comparable to other areas in California and the Central Valley (Figure 3).

Figure 3. Seven-day average of PM_{2.5} (top) and O₃ (bottom) at the Lost Hills monitoring site (black line) and the range for 10 other sites in the region (shaded area).



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. Elevated concentrations of metals were also measured in Lost Hills and throughout the Central Valley during this time, suggesting wind-blown dust was one contributor to the increase in PM_{2.5}. Additional analysis showed a large increase in inorganic aerosols, likely from mobile and agricultural sources, and is typical for fall/winter in the Central Valley. Organic PM_{2.5} also increased in October and November, likely from wildfire smoke and the transition to wood-burning sources as the temperature dropped toward the end of the year.

O₃ 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. Similar to PM_{2.5}, ozone concentrations

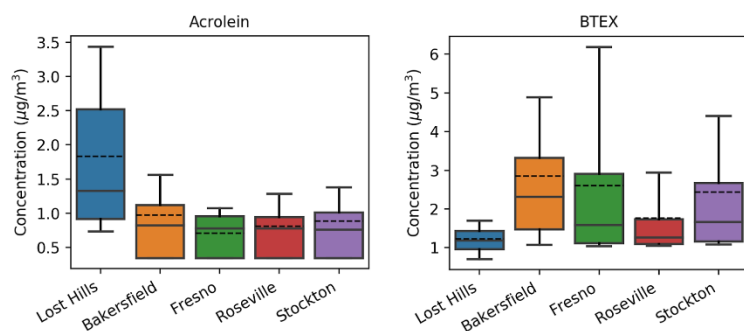
SNAPS LOST HILLS AIR MONITORING RESULTS OVERVIEW



in Lost Hills followed similar trends to the rest of the Central Valley but were on average lower.

Further characterization of air quality was carried out by comparing concentrations of toxic pollutants in Lost Hills with those at other sites in the Central Valley. BTEX and acrolein, are shown in Figure 4.

Figure 4. Concentrations of acrolein and BTEX in Lost Hills (2019-20) and at other monitoring sites in the Central Valley from 2016-2019.



Benzene (a component of BTEX) ranked as one of the top four contributors to cancer risk in Lost Hills. 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 locations in the Central Valley. However, acrolein concentrations were distinctly elevated. Acrolein can come from many sources including combustion processes (e.g., automobile and diesel exhaust on and off oil fields), reactions in the atmosphere, plants, and as a pesticide/biocide in agriculture, water systems, and oil field operations.

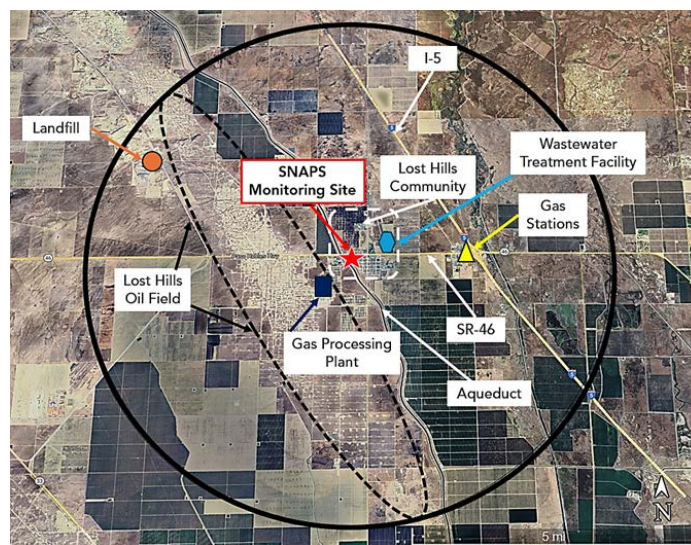
To provide a holistic picture of health risk of toxic pollutants, OEHHA conducted a cumulative health risk assessment. Acrolein was the largest contributor to the noncancer risk, with potential health impacts including eye irritation and damage to the respiratory tract.

Lost Hills Air Quality and the Lost Hills Oil Field

The Lost Hills site has several notable sources that may have an impact on air quality (Figure 5). The site was located downwind of the Lost Hills Oil Field, roughly 5100 feet from nearest active oil and gas well and less than 1 mile from the gas processing plant. Other sources near the site include mobile source emissions, particularly from two highways, natural gas distribution

and transmission pipelines, agriculture, and landfills and composting facilities. CARB also used mobile monitoring to complement and supplement the measurements made at the stationary trailer, with CARB staff performing mobile monitoring in Lost Hills approximately once every two months.

Figure 5. Map of the greater Lost Hills area.



Stationary and mobile monitoring results indicated increased hydrocarbons and volatile organic compounds (VOCs) during times when the wind was from the direction of the nearby gas processing plant, occurring across all four seasons and most often during the evening to overnight hours. While fugitive emissions from wells, storage tanks, and compressors might have been potential sources of pollutants in the community, corroborating evidence from other air monitoring, including FluxSense,² JPL methane source finder,³ and SNAPS mobile monitoring, indicate the gas plant as a likely source of methane and VOCs. The gas plant is inspected annually by the local Air District.

Further analysis of oil field activity (e.g., well stimulation, workover, drilling events) and SNAPS data did not indicate these activities alone played a role in increasing overall pollutant concentrations in Lost Hills. Beyond oil and gas sources located directly on the Lost Hills Oil Field, mobile monitoring detected two separate natural gas leaks in residential areas of Lost Hills. Staff immediately responded by calling the gas

² FluxSense. <https://www.fluxsense.com/>.

³ CARB. Methane Source Finder. <https://msf.carb.arb.ca.gov/map>.

SNAPS LOST HILLS AIR MONITORING RESULTS OVERVIEW



utility, SoCalGas, to have the equipment quickly inspected and repaired.

Using near real-time data, additional source apportionment analysis was performed on a select group of VOCs, including BTEX, to further determine the impacts of oil and gas sources on Lost Hills air quality. Results show that oil and gas-related sources contributed 39% to 55% of BTEX and over 80% of other VOCs included in the analysis, while BC was mostly from mobiles sources.

Source apportionment analysis is detailed further in the Lost Hills Draft Final Report and Appendix C.

Limited source information could be determined for acrolein with SNAPS data collected in Lost Hills. CARB staff have since worked on new methods to substantially improve the sampling frequency of acrolein to collect sufficient data for source apportionment analysis.

Evaluation of Health Risks

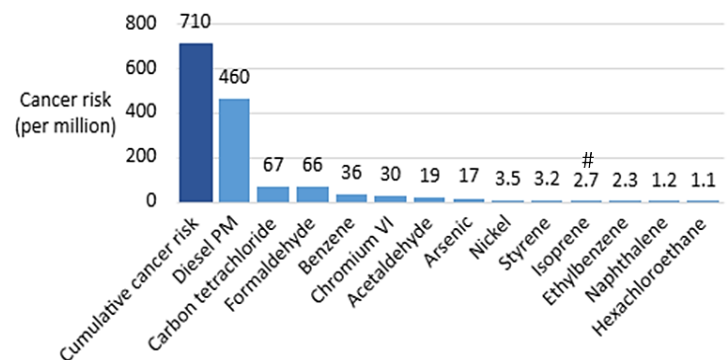
This risk assessment evaluated the potential for adverse health effects including the risk of getting cancer over a lifetime (known as lifetime cancer risk), and the risk of facing health effects other than cancer (known as noncancer effects, for example, eye irritation). Noncancer health risks from acute (short-term) and chronic (long-term) exposure to a chemical were assessed. Health risk depends on how toxic a chemical is as well as the amount and duration of the exposure. OEHHA used health guidance values (HGVs) and CARB's air monitoring data, to evaluate toxicity and exposure, respectively.

Cancer Risk Results

Some of the carcinogens evaluated were detected in Lost Hills air at concentrations that are concerning but similar to levels in other areas of California that are not directly associated with oil and gas production. A threshold of concern for cancer risk in the general population is one excess case of cancer per million

exposed individuals. Risk estimates for most of the carcinogens detected in Lost Hills air exceeded this threshold (Figure 6).⁴ The estimated cumulative cancer risk, which is the cancer risk of the evaluated carcinogens added together from anthropogenic (human-driven) and biogenic⁵, sources, is 710 cases per million individuals. Diesel PM is the main contributor to the cumulative cancer risk (65 percent), which is consistent with assessments of ambient air in other California locations not directly associated with oil and gas production.

Figure 6: Cancer risk estimates that exceed one excess cancer case in a million exposed individuals.



Cumulative cancer risk (left; dark blue) and cancer risk estimates for each carcinogen (lighter blue).⁶

Other key contributors to cancer risk were carbon tetrachloride, formaldehyde, and benzene, all of which may come from a number of possible sources. A comparison of these results to air monitoring data from other California locations (e.g., San Joaquin Valley locations not directly associated with oil and gas production) showed similar risk estimates for these top five contributors to cancer risk.

Noncancer Risk Results

In Lost Hills, short-term exposure to the highest measured acrolein and dimethyl disulfide (DMDS) concentrations has the potential to cause adverse respiratory effects (acrolein and DMDS) and eye

⁴ Acrolein, a recently identified carcinogen, 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.

⁵ 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>.

⁶ # Indicates that isoprene is likely from biogenic sources.

SNAPS LOST HILLS AIR MONITORING RESULTS OVERVIEW



irritation (acrolein). Long-term exposure to the average acrolein concentration has the potential for adverse respiratory health effects. Cumulative exposure to multiple chemicals that affect the same organ system has the potential to cause adverse health effects, even if the individual compounds would not. In Lost Hills, cumulative short-term exposure has the potential to cause adverse effects to the respiratory system and eyes (Figure 7). The risk to the respiratory system, including for people with asthma, is largely driven by exposure to acrolein and DMDS and the risk to the eyes is largely driven by exposure to acrolein. In Lost Hills, cumulative long-term exposure to multiple chemicals has the potential to cause adverse effects on the respiratory and nervous system (Figure 7).

Figure 7: Summary of cumulative noncancer risk results.

Length of exposure	Target organs with risks of concern	Compounds contributing most to cumulative risk
Short-term 	Respiratory system 	Acrolein, dimethyl disulfide
	Eyes 	Acrolein
Long-term 	Respiratory system 	Acrolein
	Nervous system 	Manganese*, aluminum*

**Compound by itself does not present a risk level of concern.*

The risk to the respiratory system is mostly attributable to acrolein and the risk to the nervous system is mostly attributable to manganese and aluminum. There is some uncertainty associated with the acrolein risk estimates due to technical challenges in accurately measuring acrolein. Using more sensitive instrumentation, CARB is currently collecting additional acrolein measurements in Lost Hills to investigate potential sources in the community. Acrolein commonly occurs in California and can arise from both natural and human-caused sources. The acrolein concentrations measured in Lost Hills were generally higher than ambient levels in other areas of California not directly associated with oil and gas production.

Does Lost Hills Air Meeting Ambient Air Quality Standards?

Concentrations of PM_{2.5}, O₃, CO, lead, and H₂S measured through SNAPS in Lost Hills were below their respective ambient air quality standards, indicating that the air in the community was at levels that meet state and federal standards. Attainment with ambient air quality standards is determined at a regional level. The Lost Hills community is within the San Joaquin Valley, a nonattainment area for federal ozone and PM_{2.5} standards.

Screening-Level Odor Assessment

Odor can affect quality of life and well-being. Eight compounds were measured in Lost Hills air at concentrations that may be detected by smell. During the sampling period, community members filed several complaints about unpleasant odors. Ozone concentrations were elevated around the time these complaints were made. However, it is not clear if ozone concentrations were the source of these odors, as the sources of odors can be difficult to identify.

Thank You

SNAPS would not have been possible without continued engagement with the Lost Hills community and local and regional community groups. Thank you!

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