

ALISO CANYON GAS LEAK

Public Health Assessment



May 13, 2016

Environmental Conditions and Health Concerns in Proximity to Aliso Canyon Following Permanent Closure of Well SS-25

OVERVIEW

On February 18, 2016, the California Department of Conservation's Division of Oil, Gas and Geothermal Resources confirmed that the largest natural gas leak in United States history was permanently sealed. In the days following confirmation that Well SS-25 in the Aliso Canyon Storage Facility was sealed, marked reductions were observed in the levels of methane in ambient air, and other contaminants of concern returned to background levels for the region. Given the improvements in environmental conditions, the expectation was that reports of odors and symptoms would diminish, and residents could return home without experiencing further symptoms.

Some residents, however, continue to report symptoms similar to those experienced throughout the 16-week period that gases were being released from Well SS-25; these symptoms include headaches, nasal congestion, sore throat, respiratory complaints, nausea, dizziness, skin rashes and nosebleeds. These symptoms commence upon returning to their homes and cease once they return to their temporary relocation housing. During this time, independent research conducted by researchers from the University of California at Los Angeles (UCLA) and the University of California at Berkeley (UC Berkeley) observed marked differences in the temporal patterns of particles at locations near the leak site and downwind compared to those farther away or in an upwind direction. The temporal patterns suggest that the population living near Well SS-25 could have been exposed to particles or aerosol oil droplets from the well. As a continuation of this independent study, an indoor dust swab sampling was completed in seven homes, which found volatile organic compounds (VOCs) in two of the homes. The reemergence of adverse health symptoms reported by the community and preliminary results of this independent research prompted the Los Angeles County Department of Public Health (DPH) to conduct a series of rapid surveys and testing to investigate the scope of the health effects and possible exposure to contaminants related to gas and oil field activities.

This report presents an overview of the findings, and provides conclusions and recommendations from the recent public health activities. In summary, many commonly found priority chemicals of concern, including benzene, polycyclic aromatic hydrocarbons (commonly known as black soot), and sulfur compounds, were not elevated in the air and/or dust in Porter Ranch area homes. However, further analysis of household dust samples revealed a characteristic "fingerprint" of metals that indicates a common source. There is evidence that metals were emitted from Well SS-25 during the leak. While levels of these metals are not expected to pose a long-term health risk, they may have been generated as a result of operations during the gas leak, and in turn may be contributing to the short-term symptoms being observed. To reduce the exposure to these metals and potential other contaminants in homes, DPH recommends adequate ventilation of homes to flush out residual contaminants, deep cleaning of surfaces, regular change-out of HVAC filters, and proper maintenance of air purifiers.

ASSESSMENT PROCESS AND DATA SOURCES

This Public Health Assessment consists of two key components – an indoor exposure evaluation and a health effects evaluation. To review and interpret findings from these evaluations, DPH coordinated a multi-disciplinary health workgroup consisting of experts from the State Office of Environmental Health Hazard Evaluation (OEHHA), United States Environmental Protection Agency (US EPA), California Environmental Protection Agency Air Resources Board (CARB), California Department of Public Health (CDPH), South Coast Air Quality Management District (SCAQMD) and the Los Angeles County Fire - Health Hazmat Division. US EPA and researchers from UCLA and UC Berkeley also provided guidance and technical assistance.

Indoor Exposure Evaluation

In developing its indoor exposure evaluation, DPH and its partners drew from experience based upon testing protocols and analysis utilized in other environmental incidents in the United States. The first step in the indoor exposure evaluation was to review a comprehensive list of over 200 chemicals that may be associated with the gas leak and components of the drilling materials to determine which of these to include in the analysis. Given the history of the Aliso Canyon Storage Facility as a petroleum oil extraction field, DPH determined that it was necessary to test for more than those chemicals that might have been emitted from Well SS-25 as a result of the gas leak and related operations. Metals, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and petroleum hydrocarbons analyses were performed. As a result of a review of available environmental information, DPH identified the following as *priority chemicals of potential concern*: sulfur compounds, benzene and other volatile organic compounds, barium, petroleum hydrocarbons, and polycyclic aromatic hydrocarbons (see Table 1).

In designing the indoor exposure evaluation, DPH also considered the possible ways in which people may be exposed to these chemicals. During interviews, residents revealed that they reported developing symptoms after spending time inside their homes. Realizing that symptoms could result from exposure to contaminants in indoor air or from surfaces in the home (and given the preliminary particle data analysis), DPH determined to collect samples from both media. The indoor environmental assessment performed in Porter Ranch consisted of testing for chemical contaminants in both household surface dust and indoor air. DPH developed an Indoor Environmental Assessment protocol and sampled dust and air inside 114 homes and 2 schools (Leighton, 2015). Eleven of the homes located six miles southeast of Well SS-25 were selected as a comparison group. In addition to the indoor environmental sampling results, DPH evaluated several other data sources to characterize potential emissions during the gas leak incident: outdoor air and soil samples collected near Well SS-25 and review of Material Safety Data Sheets that provide information on the ingredients of drilling fluids used at the Aliso Canyon Storage Facility (see Attachment 1).

Health Effects Evaluation

The second component of the assessment was the collection of information on the health effects experienced by residents in the Porter Ranch community. This part of the evaluation focuses on primary data collected in the Porter Ranch community during two surveys. The first survey used the Community Assessment for Public Health Emergency Response (CASPER) tool to collect information from a representative sample of 210 households within a 3-mile radius of Well SS-25. The second survey used the Assessment of Chemical Exposure (ACE) tool to collect health-related information from households selected for indoor sampling where ongoing symptoms were experienced.

FINDINGS

Indoor Exposure Evaluation

Attachment 2 provides a detailed report of results and findings from the indoor environmental sampling program.

Surface Wipe Samples:

Thirteen of the 16 metals tested for in the surface wipe samples of household dust were detected in the Porter Ranch area while only four metals were found in the comparison homes. The most frequently detected metal was barium, which was found in 19% of the Porter Ranch homes and ranged in concentration from 0.05 to 1.0 $\mu\text{g}/\text{cm}^2$. Overall, levels of aluminum, barium, cobalt, iron, manganese, nickel, strontium and vanadium were higher in the Porter Ranch group than the comparison group (see Figure 1). These levels of metals found in household dust in Porter Ranch are not expected to pose a long-term health risk, however it is possible that metals at these low levels could cause short-term symptoms. For example, barium can cause eye, nose, throat, skin irritation. The existence of these chemicals on surfaces where they can be touched, absorbed or ingested is a plausible explanation for the symptoms people are experiencing. People have varying degrees of sensitivity, which is why some people may react and others may not.

Further modeling by scientists at GIS HEAL Labs showed that five metals (barium, manganese, vanadium, aluminum and iron) appear together consistently. There is also additional evidence that strontium, nickel and cobalt appear together with the main mixture, though less consistently (see Attachment 3). This consistency, in the mixture of elements, suggests a common single source. A barium sulfate mixture was used in three of the seven well kill attempts. There are indications that the kill fluids were ejected from the well under high pressure and as aerosols, which was evidenced by elevated concentrations of barium found in soil and petroleum product near Well SS-25 (see Figure 2). Taken together, these findings suggest that barium and other metals detected in Porter Ranch homes may have been generated as a result of well kill operations during the gas leak, emitted into the air and settled as dust in homes which could cause the reported symptoms.

Of the 67 SVOCs tested in household dust, four SVOCs were detected in the Porter Ranch group of homes and five SVOCs were detected in the comparison group. The most frequently detected SVOC was bis(2-ethylhexyl)phthalate, which was detected in 15% of the Porter Ranch group and 18% of the comparison group. Bis(2-ethylhexyl)phthalate is the most common phthalate and is used as a plasticizer. It was not found in soil or outdoor air near Well SS-25; therefore it does not appear to be related to the gas leak emissions, but further analyses are ongoing to further evaluate the evidence for this conclusion. Other SVOCs, butyl benzyl phthalate, di-n-butyl phthalate, and dimethyl phthalate, were found in less than 5% of the Porter Ranch homes sampled.

Air Samples:

Of the 250 chemicals tested in indoor air, 143 chemicals were detected in at least one sampling location in Porter Ranch and the comparison group. Overall, levels of chemicals in indoor air in the Porter Ranch group are similar to those in the comparison group and found to be within normal ranges for indoor home environments (USEPA 2009). Figure 3 illustrates the average concentrations of priority chemicals of concern, including benzene and other gases that can be associated with natural gas. These priority chemicals of concern detected in indoor air in the Porter Ranch area were found at lower levels than the comparison area and normal ranges for indoor home environments (USEPA 2009).

Key Findings:

- Metals in dust were detected more frequently and at higher concentrations in Porter Ranch homes than in the comparison homes. While levels of these metals are not expected to present a significant long-term health risk, they may be responsible for short-term symptoms.
- Data analysis of the *surface wipe samples* indicated a pattern in which barium tended to appear together with other metals in the Porter Ranch homes; this pattern is not observed in the comparison homes. The fact that barium sulfate was used in drilling fluids and was found in soil from Well SS-25, suggests that emissions during well kill attempts may have contributed to the presence of metals in household dust.
- Data analysis of *indoor air samples* indicates that chemicals detected in Porter Ranch homes are at levels similar to those in the comparison homes, and are also consistent with US EPA published background levels in home environments (USEPA 2009). While it is possible that higher levels of key contaminants of concern were present at earlier periods and that volatile and semi-volatile chemicals have broken down and/or dissipated and are no longer present at elevated levels, the results of the indoor air sampling indicate that the current indoor air environment in Porter Ranch is likely no longer impacted by the gas leak emissions.

Health Effects Evaluation

Findings from the CASPER survey revealed that during the month after the gas leak was sealed, 63% of sampled households reported health symptoms believed to be related to the leak (see Attachment 4). These findings indicate only a moderate reduction from the level of 81% of sampled households reporting any symptoms during the gas leak from October 23, 2015 – February 11, 2016. The most commonly reported symptoms were eye, nose, and/or throat irritation (59%), headache/migraine (52%), and respiratory symptoms (51%). These symptoms were also the most commonly reported during the leak.

The majority of households (61%) sought medical care for symptoms experienced after the well was sealed, mainly from family doctors and urgent care centers.

Households commonly reported alleviation of their symptoms upon leaving their homes, both before and after the leak was sealed.

Households closer to Well SS-25 reported greater frequencies of any health symptoms as well as specific health symptoms both during the gas leak and after the well was sealed.

During the month after the gas leak was sealed, 41% of sampled households reported smelling “gas-like” odors and 35% noticed the appearance of oily residue. During this same period, the percentage of households that reported symptoms believed to be related to the leak was 43% among households reporting no odors or oily residue, 59% among households reporting odors only, 61% among households reporting oily residue only, and 95% among households reporting both odors and oily residue. Households that smelled odors and observed oily residue were significantly more likely to report having symptoms than those that did not ($p_{trend} < 0.001$).

Prevalence of symptoms in surveyed households in month after Well SS-25 was sealed
Eye, nose, throat irritation – 59%
Headache/migraine – 52%
Respiratory symptoms – 51%
Stress – 43%
Nausea/Vomiting – 41%
Dizziness/Lightheaded – 40%
Skin irritation/rash – 37%
Nosebleeds – 31%

The majority of households (66%) reported regular use of either in-duct air cleaning devices or portable air purifiers in the month after the well was sealed: 22% of households used them 1 to 6 days per week and 45% of households used them daily. During the month after the well was sealed, more households that regularly used devices to improve the indoor air quality in their homes reported experiencing symptoms (62 and 74%, respectively) compared to households that did not use any air cleaning devices (45%). Although the assessment did not determine whether device use affected the frequency of reported symptoms, the majority of households (68%) reported that using methods such as air cleaning devices to air out their home did help to reduce “gas-like” odors smelled inside their home.

Key Findings:

- The majority of households in the communities near the Aliso Canyon Storage Facility experienced health symptoms in the month after the well was sealed.
- Households most likely to report symptoms were those that were closer to Well SS-25, had reported odors in the last month, and/or reported the presence of oily residue.
- The majority of households (66%) are using air filters or purifiers, typically daily.
- 64% of relocated households reported airing out their home upon returning home. Only half of relocated households (49%) reported both airing out and cleaning their home upon returning home.

CONCLUSIONS

DPH conducted an indoor assessment of contaminants related to natural gas and oil emissions, and a comprehensive investigation of reported symptoms since the gas leak was sealed. The findings above support the following conclusions:

1. The majority of households near the Aliso Canyon Storage Facility experienced health symptoms after the well was sealed, and these symptoms were likely related to the gas leak and/or other emission sources from the Aliso Canyon Storage Facility.
2. Barium and several other metal contaminants found in household dust are common additives in the drilling fluids used at the Aliso Canyon Storage Facility. The findings suggest that metals were emitted during the leak and may have been distributed into the surrounding area and into the homes of residents. Metals in household dusts can cause respiratory and skin irritation and could be contributing to reported symptoms.
3. Overall, the indoor air testing did not detect chemicals at levels that present an elevated health risk. The occurrence of indoor air contaminants within the study area was found to be generally consistent with both the comparison area as well as with published background data on air contaminants in residential settings.
4. Adequate ventilation of homes to flush out residual contaminants, deep cleaning of surfaces, regular change-out of HVAC filters, and proper maintenance of air purifiers will minimize the potential for exposure that may produce symptoms. Such cleaning will also remove routine dust, pollens and molds, which may have accumulated during the period when people were not residing in their homes and practicing normal house cleaning.
5. It is possible that other contaminants, from the leak site and/or other sources, are present in the homes and the ambient air. For example, the Aliso Canyon Storage Facility is the largest single emitter of formaldehyde in the South Coast Air Quality Management District, releasing approximately 14054 pounds per year. SCAQMD reported that formaldehyde was not found at elevated concentrations in the community during the gas leak; however DPH will continue to consult with experts to monitor this issue.

6. Ongoing monitoring by CARB and SCAQMD indicates that methane levels in the area around the Aliso Canyon Storage Facility continue to be higher than expected and may indicate some additional source of methane in the area. Although these methane levels are not as high as during the leak periods, the elevated levels do indicate the need for continued monitoring. DPH will continue to work with its partners to understand why methane levels continue to be above normal at times.

RECOMMENDATIONS

Because residents continue to report symptoms three months after the gas leak was sealed, contaminants related to the gas leak were found in household dust, and there is a plausible biological explanation for how these contaminants could contribute to reported short-term symptoms, DPH recommends the following:

1. Several measures should be taken to clean and ventilate homes near the gas leak, including an extended period of ventilation, deep-cleaning of all surfaces, and routine replacement of HVAC filters. DPH recommends the detailed protocol for ventilation and cleaning included as Attachment 5.
This cleaning protocol is designed to reduce the potential for contaminants that may have entered the home and produced short-term symptoms.
2. Residents who continue to experience symptoms should inform DPH at 213-738-3220, and consult directly with their medical provider. DPH will closely monitor the health status of residents as they move back home.

To protect the future health and safety of the communities near the Aliso Canyon Storage Facility, DPH recommends the following as next steps:

3. DPH will continue, in consultation with partner agencies and scientific experts, to review available environmental data and monitor health surveillance activities, and will intervene as necessary to protect health in the communities near Aliso Canyon.
4. DPH will confer with appropriate regulatory agencies overseeing the integrity testing of facility infrastructure, and monitor efforts to address other potential sources of emissions in Aliso Canyon.

REFERENCES

Leighton Consulting Inc., 2016. Time Critical Indoor Environmental Sampling Work Plan, Aliso Canyon Natural Gas Incident, Porter Ranch Community, Los Angeles, CA. March.

USEPA, 2011. Background Indoor Air Concentrations of Volatile Organic Compounds in North American Residences (1990-2005): A Compilation of Statistics for Assessing Vapor Intrusion. EPA 530-R-10-001. June. Accessible via <https://www.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-background-report-062411.pdf>

FIGURES

Figure 1: Average Metal Concentrations in Surface Wipe Samples ($\mu\text{g}/\text{cm}^2$) - Porter Ranch Area Homes and Schools, and Comparison Area

Figure 2: Comparison of Metals Found Near Well SS-25, Porter Ranch Area Homes and Schools, and Comparison Area

Figure 3: Average Metal Concentrations in Air Samples ($\mu\text{g}/\text{cm}^3$) - Porter Ranch Area Homes and Schools, Comparison Area and U.S. EPA Background Indoor Air Reference Values.

TABLES

Table 1: Summary of Chemicals Potentially Associated with Well SS-25 Gas Leak and Drilling Activities

ATTACHMENTS

Attachment 1: Material Safety Data Sheet for Barite Drilling Mud

Attachment 2: Time Critical Indoor Environmental Sampling Summary Report

Attachment 3: Cluster Analysis of Metals and Organics in Dust Samples: Porter Ranch Area

Attachment 4: Community Assessment for Public Health Emergency Response

Attachment 5: DPH Guidelines for Cleaning and Ventilation

FIGURES

Figure 1. Average Metal Concentrations in Surface Wipe Samples (ug/cm²) - Porter Ranch Area Homes and Schools, and Comparison Area

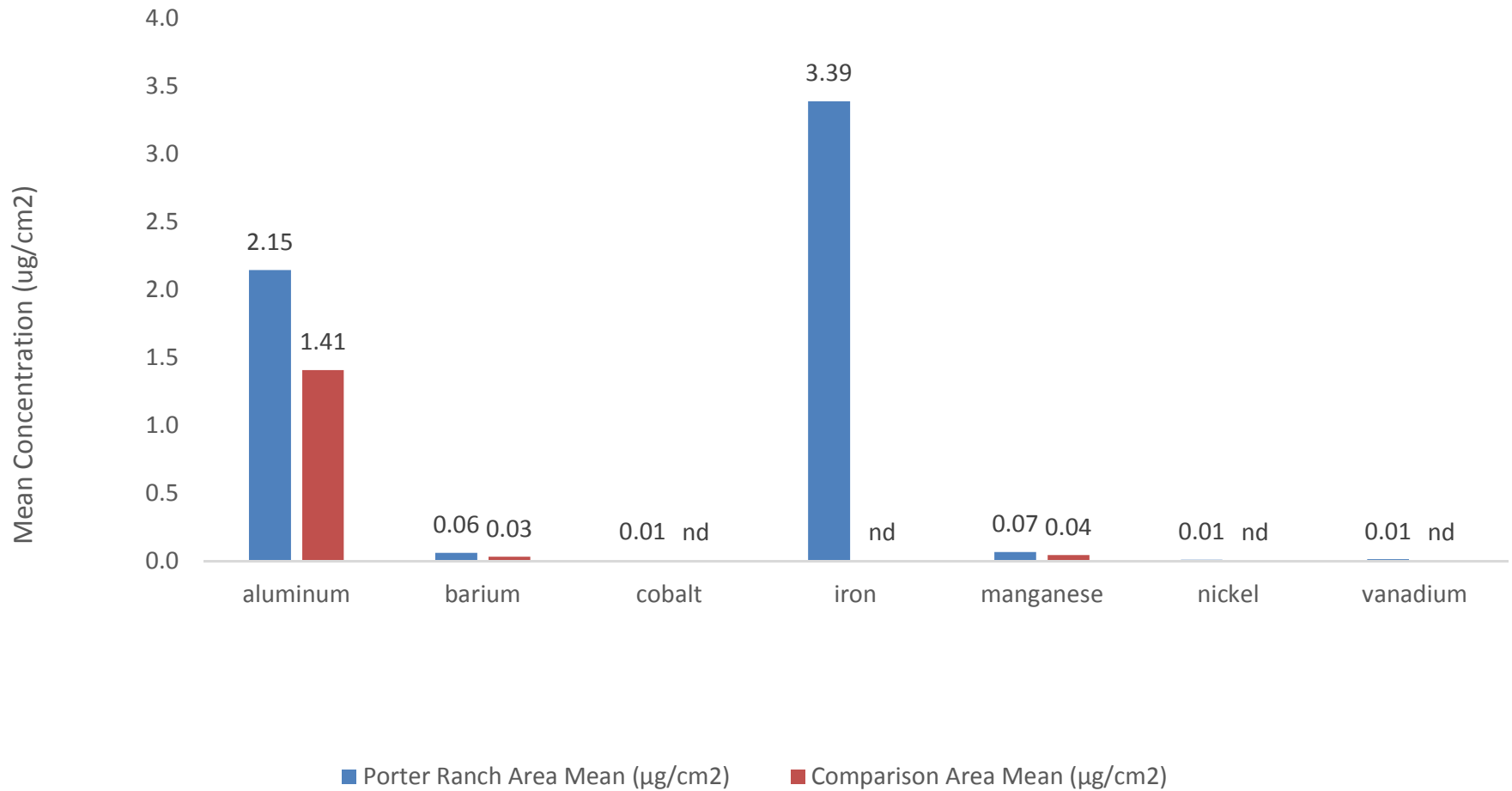


Figure 2. Comparison of Metals Found Near Well SS-25, Porter Ranch Area Homes and Schools, and Comparison Area

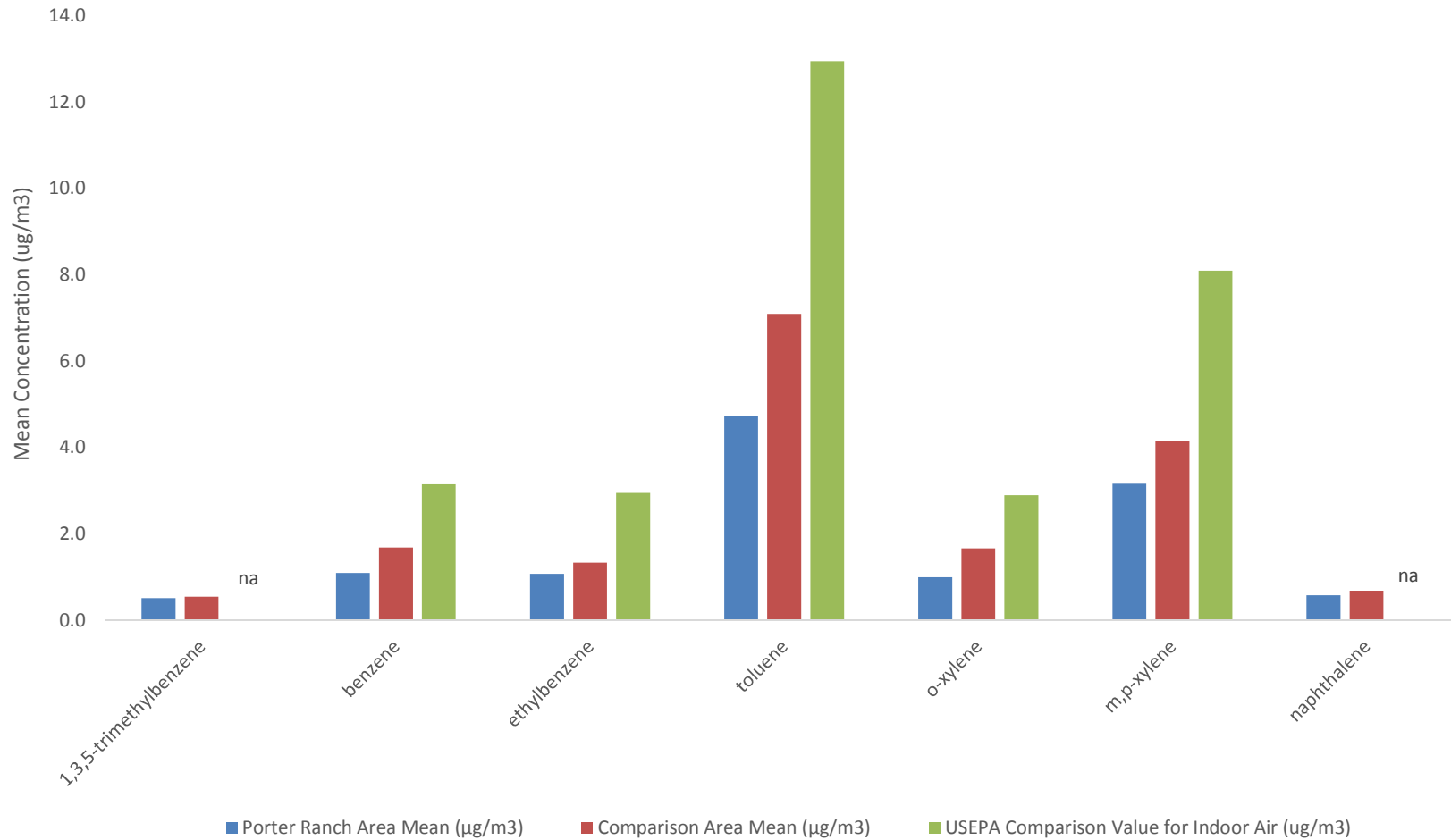
		Aluminum	Barium	Iron	Manganese
Source	Barite Drilling Mud	X	X	X	X
	Well SS-25 Soil	X	X	X	X
	Well SS-25 Air		X		
Porter Ranch Sampling Locations	Porter Ranch Sampling Location #1	X	X	X	X
	Porter Ranch Sampling Location #2	X	X	X	X
	Porter Ranch Sampling Location #3	X	X	X	X
	Porter Ranch Sampling Location #4	X	X		
	Porter Ranch Sampling Location #5	X	X	X	X
	Porter Ranch Sampling Location #6	X	X	X	X
	Porter Ranch Sampling Location #7	X	X	X	X
	Porter Ranch Sampling Location #8	X	X	X	X
	Porter Ranch Sampling Location #9	X	X	X	X
	Porter Ranch Sampling Location #10		X	X	X
	Porter Ranch Sampling Location #11		X	X	X
	Porter Ranch Sampling Location #12		X	X	X
	Porter Ranch Sampling Location #13		X		
	Porter Ranch Sampling Location #14		X		
	Porter Ranch Sampling Location #15		X	X	X
	Porter Ranch Sampling Location #16		X		
	Porter Ranch Sampling Location #17		X	X	X
	Porter Ranch Sampling Location #18	X	X	X	X
	Porter Ranch Sampling Location #19		X		
	Porter Ranch Sampling Location #20		X		
	Porter Ranch Sampling Location #21				
Porter Ranch Sampling Locations #22-104					
Comparison Area Locations	Comparison Area Site #1	X	X		X
	Comparison Area Site #2		X		
	Comparison Area Site #3				
	Comparison Area Site #4				
	Comparison Area Site #5				
	Comparison Area Site #6				
	Comparison Area Site #7				
	Comparison Area Site #8				
	Comparison Area Site #9				
	Comparison Area Site #10				
	Comparison Area Site #11				

KEY:

X = Detected

Note: The levels of barium detected in household dust at the two comparison sites were lower than the Porter Ranch area sites.

Figure 3. Average Concentrations of Priority Chemicals of Concerns in Air Samples (mg/cm²) - Porter Ranch Area Homes and Schools, Comparison Area and USEPA Background Indoor Air Reference Values



TABLES

Table 1. Summary of Chemicals Potentially Associated with Well SS-25 Gas Leak and Drilling Activities

Compound(s)	Potential Source	Data Supporting Compound as a Potential Source*
Sulfur compounds	Odorants & Reservoir	Soil near SS-25, air downwind of SS-25, ambient air
Benzene, toluene, ethylbenzene and xylenes (BTEX)	Reservoir	Soil near SS-25, air downwind of SS-25, ambient air
Barium	Well kill mud	Material safety data sheets, Soil near SS-25, air downwind of SS-25
Petroleum Hydrocarbons	Reservoir & Well kill solutions	Material safety data sheets, Soil near SS-25, air downwind of SS-25
Polycyclic Aromatic Hydrocarbons (PAHs)	Reservoir	Soil near SS-25, air downwind of SS-25
1,2,4 Trimethylbenzene	Reservoir	Soil near SS-25, air downwind of SS-25
Crystalline Silica	Well kill solids	Material Safety Data Sheets

**Various data sources were used to identify priority compounds of potential concern: Soil near Well SS-25 = seven samples collected on April 20, refer to Time Critical Indoor Environmental Report in Attachment 2; Air downwind of Well SS-25 = three air samples collected downwind of Well SS-25 during the gas leak in January 2015 and results are reported in DPH's Expanded Air Monitoring Report; Material safety data sheets = list compounds used in drilling materials during attempts to seal the well, and are included as Attachment 1; ambient air data = outdoor air data collected during the gas leak incident in the community and from the facility, which were collected by air agencies and the Southern California Gas Company.*