South Coast Air Quality Management District

ALISO CANYON NATURAL GAS LEAK: AIR MONITORING RESULTS

Final Report

January 2018

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Executive Summary

Background and Results Highlights

On October 24, 2015, the South Coast Air Quality Management District (SCAQMD) received the first air quality complaints resulting from sulfur type odors associated with the natural gas leak at Well SS-25 of the Southern California Gas Company's (SoCalGas) Aliso Canyon Facility (Facility). In response to these complaints and to characterize the ambient (outdoor) levels of air pollutants resulting from this massive leak, the SCAQMD and the California Air Resources Board (CARB) commenced air monitoring measurements on October 26, 2015. These air monitoring efforts included extensive stationary and mobile air measurements in and around the Facility, both in the Porter Ranch residential neighborhood and other nearby communities. Through February 11, 2016, SCAQMD received over 2,300 complaints regarding odors from the leak. The odors were predominantly from compounds added to natural gas (including mercaptans) to identify leaks that can be smelled even at very low concentrations (around or below 1 part per billion - ppb). The human nose is very sensitive and has the ability to detect odors that are below the detection level of any currently available monitoring device.

Notable results from the air monitoring efforts include:

- Ambient (outdoor) methane levels in the Porter Ranch community near the Aliso Canyon Facility were periodically higher than typical levels while the ruptured well was actively leaking (October 2015 to February 2016);
- Methane daily average levels, maximum daily hourly maximum, and frequency of samples exceeding 5 ppm significantly reduced after the leaking well was sealed in February 2016;
- Ambient air results were shown to be consistently within the SCAQMD's and CARB's air quality criteria (established specifically for this study) for over a year after the well was sealed;
- With a few exceptions, levels of air toxics measured from 24-hr time-integrated samples were comparable to typical levels for the Los Angeles Basin
- Levels of air toxics measured after the leaking well was sealed were within the range or lower than the typical air toxics levels measured elsewhere in the Los Angeles Basin;

- Long-term concentrations of air toxics were found to be substantially lower than the health-based reference exposure levels (REL) for long-term exposures; and
- Mobile air monitoring surveys conducted throughout the Porter Ranch community for more than one year after the closure of the leaking well detected methane concentrations similar to background levels.

Pursuant to the Aliso Canyon air monitoring plan[1], some fixed monitoring sites were removed in late July 2016, but SCAQMD continued its stationary and mobile air monitoring efforts until July 2017.

SoCalGas has installed eight permanent infrared monitors on the southern perimeter of the Aliso Canyon Facility and will continue monitoring methane concentrations in real-time. The data from these fence-line monitors are displayed on a publicly-available website[2].

SCAQMD efforts that will continue include:

- Consistently review data from existing continuous methane monitors
- Respond to air quality concerns. To report an air quality concern, a person may call 1-800-CUT-SMOG
- Re-deploy monitoring efforts, if warranted
- Periodic on-site SCAQMD inspections
- Fund and oversee a health study
- Participate with community member discussions on air monitoring

Methodology and Approach

In order to thoroughly characterize the spatial and temporal variations of methane and other air contaminants of concern, a combination of fixed-site and mobile air measurements were conducted inside the SoCalGas Aliso Canyon Facility and within the neighboring communities from October 2015 through July 2017. The monitoring plan, sampling equipment, and measurement techniques

[1] http://www.aqmd.gov/docs/default-source/compliance/aliso-cyn/aliso-canyon-monitoring-plan.pdf?sfvrsn=4
[2] https://socalgas.esriemcs.com/MethaneMonitoring/

used in this study have been thoroughly discussed in a separate document which can be found here[1].

In collaboration with CARB, a combination of continuous, short-term, and time-integrated air monitoring was conducted at eight community locations and one background sampling location (Figure (I)). Table (I) summarizes the air pollutants that were measured in near-real time at each site within the Porter Ranch community and at the background station in Reseda.

Table (I). List of continuous measurements at different sampling locations.

Air Pollutants	Sampling site #
Methane	1,2,3,4,5,6,7,8, Reseda
Hydrogen Sulfide	3
Benzene	4,5,7
Total Sulfur	4

Time-integrated and triggered air samples were collected at Sites #3, #4, #6 and analyzed to measure the concentrations of volatile organic compounds (VOCs), methane (CH_4), carbon monoxide (CO), carbon dioxide (CO_2), ethane (C_2H_6), sulfur odorant additives (t-Butyl Mercaptan and tetrahydrothiophene), and carbonyls.

[1] http://www.aqmd.gov/docs/default-source/compliance/aliso-cyn/aliso-canyon-monitoring-plan.pdf?sfvrsn=4

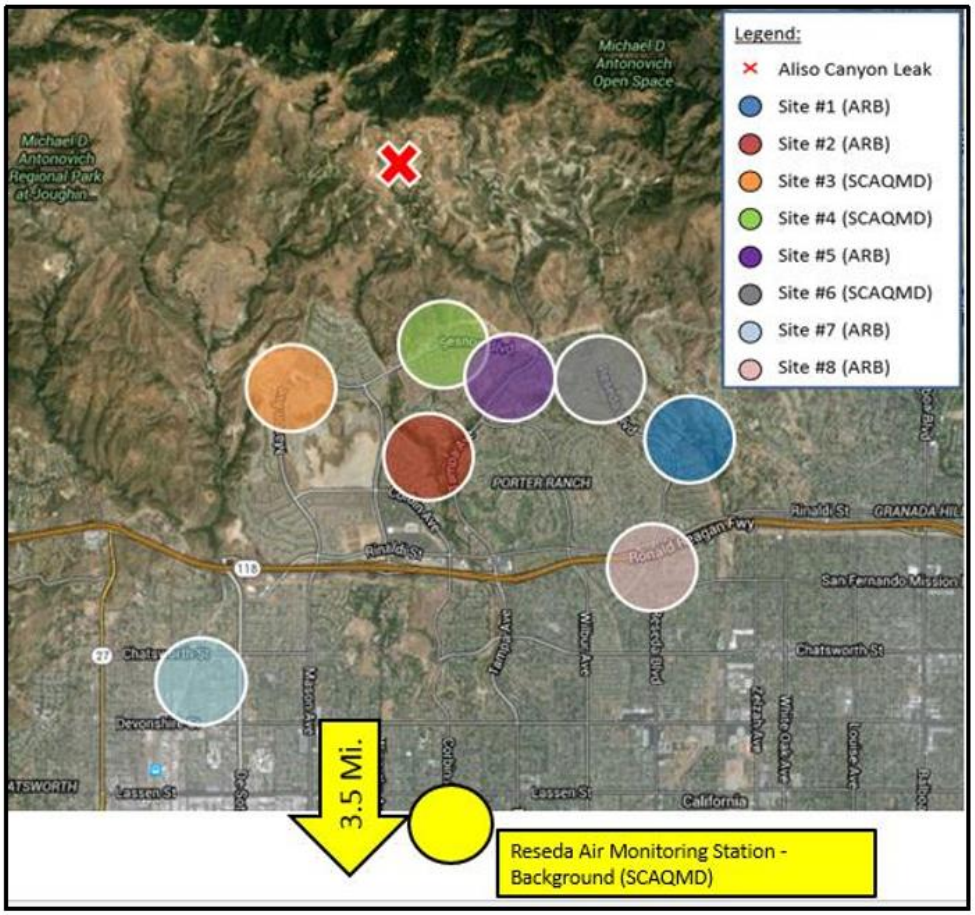

Figure (I). Fixed-site air monitoring locations operated by the SCAQMD and CARB.

Starting on December 21, 2015, SCAQMD initiated extensive mobile methane monitoring surveys in communities near the Facility and throughout the San Fernando Valley (SFV) to better characterize methane concentrations and gradients and to support the fixed-site methane monitoring efforts.

Results

Methane was the main air pollutant released as a result of the natural gas leak. During the leak, concentrations of methane measured from the stationary monitors showed strong fluctuations. While concentrations were mostly within the typical levels, there were occasional episodes that methane in ambient air were up to 15 times higher than the background levels (on a daily-average basis). However, the daily-average concentrations of methane did not exceed the criteria

established by SCAQMD and CARB (i.e., 3 ppm) at any of the monitoring locations after the leaking SS-25 Well was sealed on February 18, 2016 (Figure (II)).

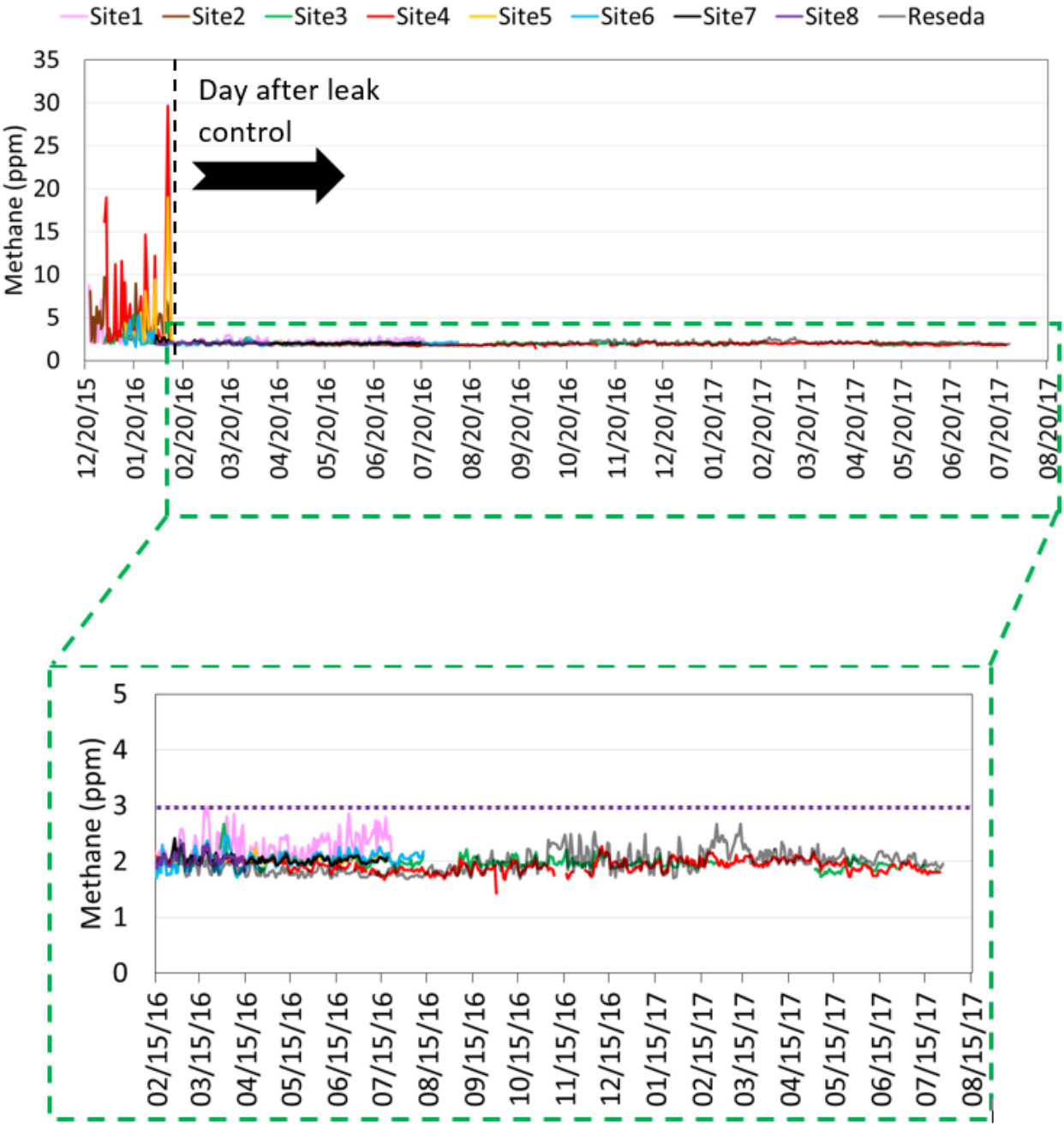

Figure (II). 24-hr average concentrations of methane measured at all monitoring locations. The dotted purple line represents the 24-hr average methane concentration criteria (3 ppm) set by CARB and SCAQMD for this study.

Results from the mobile surveys also indicated that when the leak was on-going, elevated levels of methane (sometimes as high as 70 ppm) were observed over short intervals (e.g., seconds to minutes) on the northern portion of this community. After the Well SS-25 was sealed, methane levels measured by the mobile platform south of the Facility and throughout the SFV were almost always close to background levels (~2 ppm). Figure (III) shows three representative maps of methane concentration measured by the mobile platform in the Porter Ranch area during the leak and two days and three months after the leak was controlled.

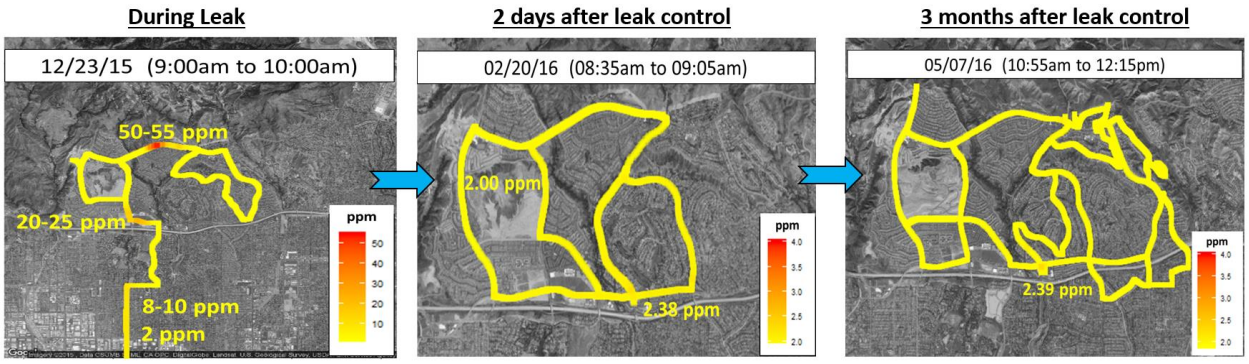

Figure (III). Three representative maps of methane concentrations measured by the mobile platform in Porter Ranch.

Similar to methane, marked reductions in the ambient concentrations of toxic VOCs (e.g., benzene, toluene, ethylbenzene, xylene, styrene) were observed after the leaking Well was sealed. While detectable, the measured concentrations of the aforementioned species from nearly all of the collected time-integrated air samples were always below the chronic RELs even during the leak. Figure (IV) shows the concentrations of selected toxic VOCs detected in the majority of air samples at Sites #3, #4, #6, and the Reseda station after the closure of the SS-25 Well. A more detailed discussion on the levels and trends of the measured VOCs can be found in the following sections.

Hourly concentrations of hydrogen sulfide (H_2S) were mostly at or below the detection limit for this compound, and the highest hourly H_2S ambient levels measured during this monitoring campaign were always below 5 ppb, which is substantially lower than the acute REL for this compound (30 ppb). The other two sulfur odorant additives to natural gas (i.e., t-Butyl mercaptan and tetrahydrothiophene) were below detection limits in all of the air samples collected by the SCAQMD at multiple locations throughout the Porter Ranch community during and after the leak.

Sulfur odorants can be detected by the human nose at very low levels, and odors can cause health symptoms at levels below the detection limits of any currently available monitoring device. The long-term average concentrations of all of measured air toxics during this event, including the carbonyl compounds formaldehyde and acetaldehyde, were substantially lower than the chronic RELs. Additionally, a comparison of the air toxic levels following the full closure of the SS-25 Well with the fourth Multiple Air Toxics Exposure Study (MATES IV[1]) measurements indicate that the concentrations of all air toxics measured in Porter Ranch and other part of the SFV were either within the range or lower than what was measured elsewhere in the Los Angeles Basin (Figure (IV)). A more detailed discussion on the comparison between the ambient levels of all VOCs measured during this study and the corresponding MATES IV concentrations is provided in the following sections.

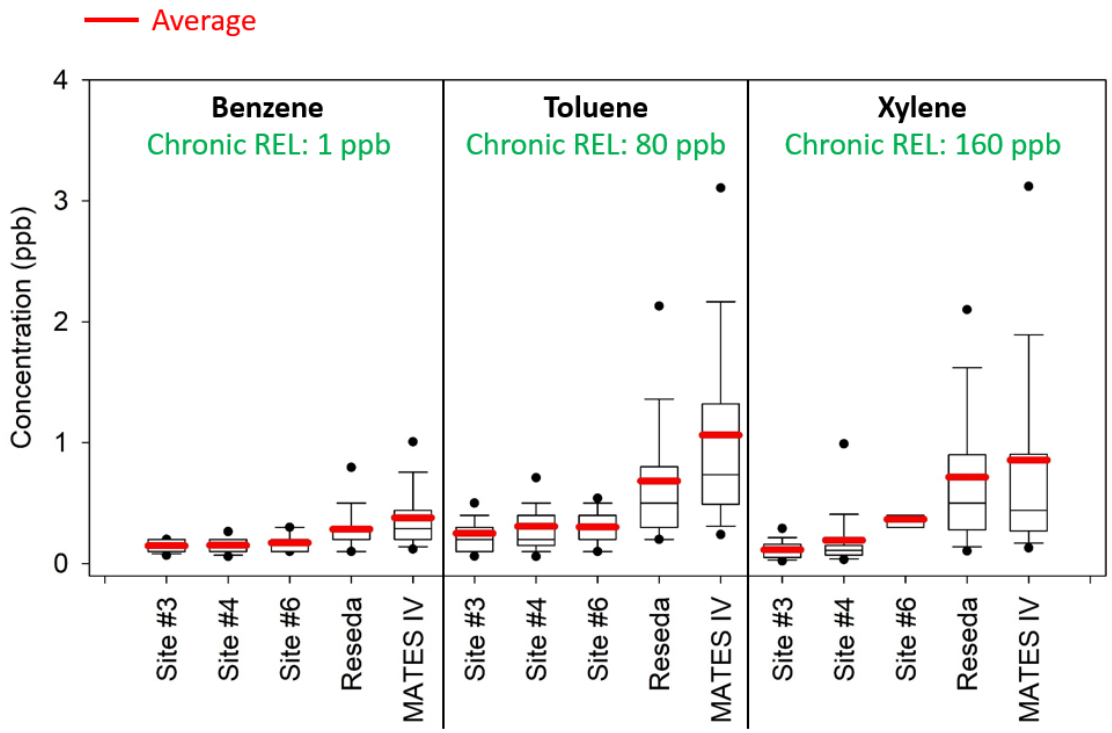

Figure (IV). Concentrations of selected toxic VOCs from MATES IV and the 24-hr integrated samples collected at Sites #3, #4, #6, and the Reseda Station after the closure of the SS-25 Well. A Reference Exposure Level (REL) is the level of a chemical in the air that is not anticipated to pose a significant non-cancer health risk. In California, RELs are established by the California Office of Environmental Health Hazard Assessment. Black dots represent the 5th and 95th percentiles.

[1] http://www.aqmd.gov/home/library/air-quality-data-studies/health-studies/mates-iv

Conclusions

The results from this extensive air monitoring campaign indicate that the ambient concentrations of measured air pollutants related to natural gas in the residential communities near the Aliso Canyon Facility decreased substantially following the full closure of the SS-25 Well and then gradually returned to background levels. The mobile monitoring data collected inside of the Facility showed a steady decrease of ambient methane levels around the SS-25 Well after the leak was fully certified sealed on February 18, 2016. Despite these reductions, the measured levels of methane have occasionally been elevated above what would be expected in the area, suggesting there could be other local sources of natural gas being released. These ephemeral events did not result in any considerable methane increase in the ambient air within the adjoining communities.

Overall, the results from this nearly 20-month air monitoring effort demonstrate that an excessive amount of methane was present in ambient air in communities near the Aliso Canyon Facility during the leak. After the SS-25 well was sealed, air quality in the Porter Ranch area and surrounding communities has returned to typical background levels for over a year and the measured air toxics in this community have been within the typical levels observed elsewhere in the Los Angeles Basin and substantially lower than the RELs.

Overview

This report summarizes the results from nearly 20 months of air monitoring activities conducted jointly by the South Coast Air Quality Management District (SCAQMD) and the California Air Resources Board (CARB) throughout the Porter Ranch and nearby communities during and after the Aliso Canyon natural gas leak incident. The air monitoring results presented in this report indicate that while an excessive amount of methane was present in ambient air in communities near the Aliso Canyon Facility during the leak, hourly- and daily-average methane concentrations decreased substantially following the full closure of Well SS-25 on February 18, 2016. Daily-average concentrations of methane never exceeded the 3 ppm criteria (set by the SCAQMD and CARB for this study) at any of the monitoring locations after Well SS-25 was sealed. While methane was the main air pollutant released as a result of the natural gas leak, other air contaminants including various volatile organic compounds (VOCs) and other air toxics were detected in communities near the Facility. Similar to methane, after the leaking well was contained, marked reductions were observed for the ambient concentrations of benzene, toluene, ethylbenzene, xylenes, styrene and other VOCs. While detectable, the measured concentrations of the aforementioned species from nearly all of the air samples collected during the leak and after closure of the well were below the acute and chronic RELs. Ambient concentrations of the measured toxic carbonyl compounds (i.e., formaldehyde and acetaldehyde) were always substantially lower than the acute and chronic RELs even during the leak. Hourly concentrations of hydrogen sulfide (H_2S) were mostly at or below the detection limit for this compound; the highest hourly H_2S ambient levels measured during this monitoring campaign were always below 5 ppb (the acute and chronic RELs for H_2S are 30 ppb and 5ppb, respectively). The other two sulfur odorant additives to natural gas (i.e., t-Butyl mercaptan and tetrahydrothiophene) were below the detection limits in all of the air samples collected by the SCAQMD at multiple locations throughout the Porter Ranch community during and after the leak. The long-term average concentrations of all of measured air toxics during this campaign were substantially lower than the chronic RELs.

The air monitoring results indicate that after the full closure of Well SS-25, the ambient concentrations of all measured air pollutants in the communities near the Aliso Canyon Facility gradually returned to background levels. As a result, after several months of recording typical ambient levels of methane and meeting the health-based criteria for other air contaminants

associated with the incident (e.g., VOCs), the SCAQMD concluded its air monitoring campaign in Porter Ranch in July 2017.

It should be noted that Southern California Gas Company (SoCalGas) has installed eight permanent infrared monitors on the southern perimeter of the Aliso Canyon Facility and will continue monitoring methane concentrations in near-real time. The data from these fence-line monitors are displayed on a publicly available website[1] where users can view a chart showing the methane levels in parts per million (ppm), reported in near-real time over the previous 24 hours. While SoCalGas does not intend to use these monitors as the primary means for detecting potential leaks in its pipelines and wells, this fence-line system will allow nearby residents to continuously observe the methane concentrations in their community.

1. Background

On October 23, 2015, SoCalGas informed the State of California of the natural gas leak from well SS-25 at its Aliso Canyon natural gas storage facility (hereafter referred to as Facility). After numerous attempts to stop the leak which was ongoing for about four months, on February 11, 2016, SoCalGas reported that the leaking well had been temporarily sealed. On February 18, 2016, the Division of Oil, Gas and Geothermal Resources (DOGGR) confirmed that Well SS-25 had been permanently sealed.

In response to this major gas leak incident, SCAQMD commenced an air monitoring campaign on October 26, 2015 and since that time, in conjunction with CARB, installed and operated nine fixed monitoring stations and conducted extensive mobile air monitoring throughout the Porter Ranch and other nearby communities. In accordance to the air monitoring plan, CARB removed their air quality monitors in late July 2016, while SCAQMD continued its stationary and mobile air monitoring efforts until July 2017 to confirm that the Facility was not adversely impacting local air quality and that the ambient concentrations of methane and other air pollutants associated with the gas leak decreased to typical background levels. The scope of this report is to summarize the results of the stationary and mobile air monitoring efforts conducted by the SCAQMD and CARB to characterize the ambient air pollution levels in the Porter Ranch community near the Facility during and after the gas leak incident. It is noteworthy that a series of monitoring efforts (e.g.,

[1] https://socalgas.esriemcs.com/MethaneMonitoring/

aircraft studies, indoor sampling, stored gas inventory analysis, etc.) were conducted by multiple agencies to fully address the emissions from the SS-25 Well and its impact on the nearby communities. While this report focuses only on the air monitoring efforts conducted by the SCAQMD and CARB, a comprehensive report [1] published by the Interagency Task Force on Natural Gas Storage Safety has summarized all of the monitoring efforts carried out by different agencies.

2. Methodology

In order to fully characterize the spatial and temporal variations of the ambient concentrations of methane and other air contaminants of concern, a combination of fixed-site and mobile air monitoring activities were carried out on-site at the Facility and in the neighboring communities from October 2015 through July 2017. The monitoring plan, sampling equipment, and measurement techniques used in this study have been thoroughly discussed in a separate document which can be found here[2]. In the following sections, the applied methodology will be briefly discussed.

2.1. Fixed-site Air Monitoring

Since the onset of the air monitoring campaign in October 2015, a combination of continuous, short-term, and time-integrated air monitoring was conducted at eight community locations and one background sampling site (Figure 1). The SCAQMD's Reseda air monitoring station is located approximately 8 miles south of Well SS-25 and outside the area of odor complaints reported to SCAQMD related to this incident. Thus, this sampling site is representative of a "background" location for the air pollutants measured in this study.

[1] https://energy.gov/under-secretary-science-and-energy/downloads/report-ensuring-safe-and-reliable-underground-natural

[2] http://www.aqmd.gov/docs/default-source/compliance/aliso-cyn/aliso-canyon-monitoring-plan.pdf?sfvrsn=4

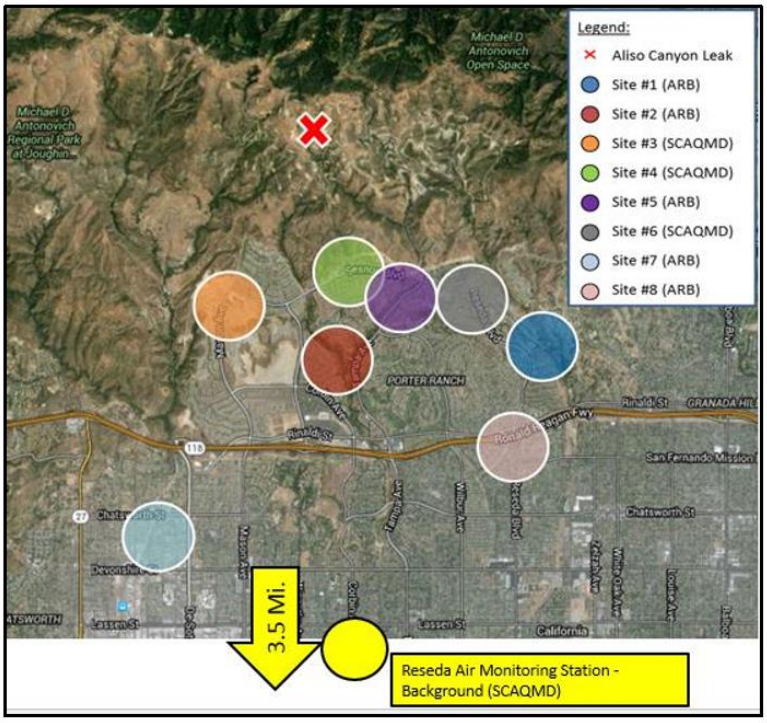

Figure 1. Fixed-site air monitoring locations operated by the SCAQMD and CARB.

Table 1 summarizes the air pollutants that were measured continuously at multiple locations within the community adjacent to the Facility perimeter and at the Reseda background station.

Table 1. List of continuous measurements at different sampling locations.

Air Pollutants	Sampling site #
Methane	1,2,3,4,5,6,7,8, Reseda
Hydrogen Sulfide	3
Benzene	4,5,7
Total Sulfur	4

When a continuous methane monitor measured levels above a pre-set concentration threshold, it automatically triggered the collection of an instantaneous "grab" sample in SUMMA canister. In addition to canister sampling, triggered samples for sulfur species analysis were collected using Tedlar bags. These samples were then retrieved and brought back to the SCAQMD's laboratory for the analysis of air contaminants that were not measured continuously. Before February 18, 2016, methane trigger levels were set at 20 ppm, 30 ppm and 20 ppm at Sites #3, #4 and #6,

respectively. After the closure of Well SS-25 on February 18, 2016, these levels were changed to 5 ppm for all three sites. Instantaneous grab samples were also collected from multiple locations throughout the Porter Ranch community as a result of odor investigations or routine surveillance activities during the leak and after the closure of the SS-25 Well. Triggered and grab samples provide an instantaneous snapshot of the area during times when an odor was detected or ambient methane levels, as detected by the continuous monitors, were substantially higher than background. Thus, the results from the analysis of these samples provide valuable information for short-term exposure assessment. It should be noted that these triggered/grab samples were not intended to be representative of typical levels in the air, but rather, reflect the levels of these air pollutants at times when the methane levels were high. These triggered samples were not intended to be used to assess long-term exposures.

In addition to the continuous monitoring and the collection of grab samples, 24-hour integrated canister samples were collected at Sites #3, #4, #6, and the Reseda station on a daily, 1-in-3-day, or 1-in-6-day schedule from midnight to midnight. These samples were primarily collected for assessing daily exposure and long-term health impacts.

Time-integrated and triggered canister samples were analyzed to measure the concentrations of volatile organic compounds (VOCs), methane (CH_4), carbon monoxide (CO), carbon dioxide (CO_2), and ethane (C_2H_6). The triggered Teldar bags were analyzed to measure the levels of sulfur species and odorant additives (t-Butyl Mercaptan and tetrahydrothiophene) in the ambient air. Additionally, at Sites #3 and #4, a few 24-hr integrated samples were collected by drawing air through a DNPH (2,4-Dinitrophenylhedrazine) cartridge for carbonyls measurement.

2.2. Mobile Platform Measurements

In conjunction with the air monitoring at fixed sampling sites, starting on December 21, 2015, SCAQMD initiated extensive mobile methane monitoring surveys in communities near the Facility and throughout the San Fernando Valley (SFV) to better characterize methane concentrations and gradients and to support the fixed-site methane monitoring efforts. For this purpose, a state-of-the-art methane analyzer (LI-COR 7700) and a Global Positioning System (GPS) were mounted on top of a hybrid vehicle and driven inside the Facility, around the Porter Ranch neighborhood, and other surrounding areas of the SFV. The LI-COR 7700 is an open-path instrument capable of measuring methane concentrations as low as single parts per billion (ppb) at rates as fast as 40

times per second with high accuracy and precision. Daily mobile methane monitoring maps for the community of Porter Ranch and other parts of the SFV can be found on the SCAQMD's website[1].

This mobile platform assessed methane concentrations and gradients in real-time at a higher spatial resolution than those provided by the fixed monitoring sites. Several routes in and around Porter Ranch and neighboring communities were selected for these surveys and monitoring was conducted during different times of the day (e.g., morning, afternoon, evening, and night) and under different meteorological conditions. Figure 2 illustrates the map of the highest methane concentrations measured by the SCAQMD's mobile platform between 12/21/2015 and 1/29/2016 around the Facility. Sites # 3, #4, and #6 are located in the areas where the peak methane levels were usually measured by the mobile monitor. The mobile methane monitoring results thus further supported the representativeness of the selected fixed monitoring sites and the fact that these sampling locations would provide appropriate coverage for the long-term assessment of air quality in nearby communities.

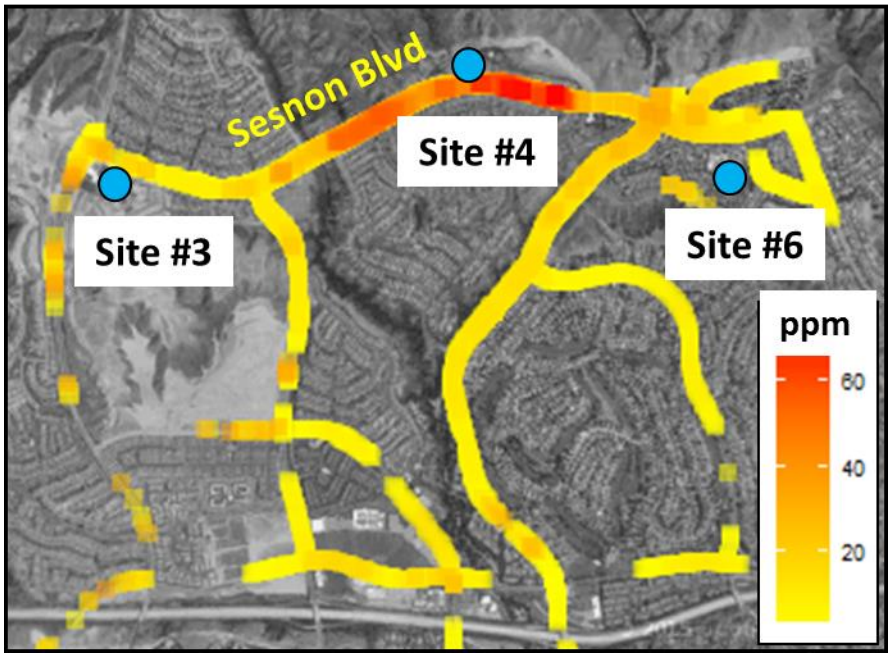

Figure 2. Map of the highest methane concentrations measured by the SCAQMD's mobile monitor between 12/21/2015 and 1/29/2016.

[1] http://www.aqmd.gov/home/regulations/compliance/aliso-canyon-update/air-sampling/mobile-methane-measurement-surveys

The mobile platform also enabled targeted methane monitoring surveys at locations such as schools and outlying communities that reported potential impacts. Since October 2015, SCAQMD received more than 2,300 complaints from residents in the communities near the Facility. Using the mobile platform, SCAQMD's staff were able to respond to the public's concerns and odor complaints related to the Facility in a timely manner. Figure3 shows the cumulative map of all routes surveyed with the mobile monitor. Using this mobile platform, SCAQMD's staff were able to monitor nearly the entire area where complaints were received. Since a substantial and persistent increase in the levels of methane was not observed outside of the Porter Ranch neighborhood, the fixed-site monitoring activities remained focused on the communities adjoining the Facility, while periodic mobile surveys continued throughout the SFV for any unforeseen changes in circumstances that could potentially cause elevated levels of pollutants from the Facility.

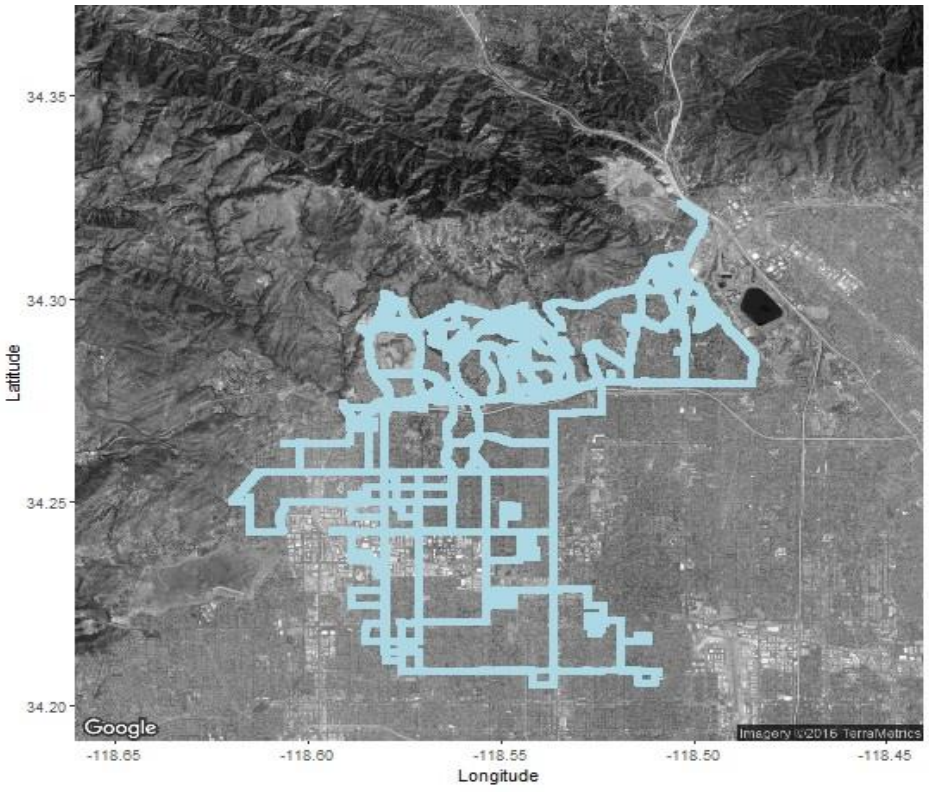

Figure 3. Cumulative map of all routes covered by the SCAQMD's mobile methane monitoring platform.

After Well SS-25 was temporarily sealed on February 11, 2016, SCAQMD's staff started mobile methane surveys inside the Facility, the results of which can be found here[1].

While most of the LI-COR measurements inside the Facility focused on quantifying methane emissions around Well SS-25, mobile methane surveys were also conducted in other parts of the Facility to identify other potential emission sources of natural gas.

3. Air Quality Criteria and Health-Based Reference Exposure Levels

The California Office of Environmental Health Hazard Assessment (OEHHA) has identified a list of air toxics that are known to cause health effects, and has established Reference Exposure Levels (RELs) for these air toxics. An REL is the level of a chemical in the air that is not anticipated to pose a significant non-cancer health risk. The acute RELs are designed to be protective for infrequent short-term exposures. The chronic RELs are designed to be protective for continuous exposure for at least a significant fraction of a lifetime. Some of the measured ambient species in this study are among the known air toxics identified by the OEHHA, including hydrogen sulfide (H_2S), some of the VOCs (e.g., benzene, toluene, ethylbenzene, xylenes, and styrene), and carbonyls (e.g., formaldehyde and acetaldehyde). Table 2 summarizes the OEHHA's acute and chronic REL standards for the aforementioned species. Throughout this report, concentrations of the air toxics that were measured in this air monitoring campaign will be compared to the RELs.

Table 2. OEHHA's acute and chronic reference exposure levels (RELs) for relevant air toxics measured during this study.

Air toxics	Acute REL (ppb) [1-hour average]	Chronic REL (ppb) [long-term average]
Benzene	8	1
Toluene	9800	80
Ethylbenzene	-	460
Xylenes	5000	160
Styrene	4900	200
Acetaldehyde	260	80
Formaldehyde	44	7
Hydrogen Sulfide	30	7

[1] http://www.aqmd.gov/home/regulations/compliance/aliso-canyon-update/air-sampling/xxx

Moreover, SCAQMD and CARB jointly established more protective criteria for some of the air pollutants of concern measured during this study (Table 3).

Table 3. Air quality criteria established by SCAQMD and CARB for some of the air pollutants measured during this air monitoring campaign.

Air pollutants	Measurement type/period			Unit
	Triggered/grab	1-hr	24-hr	
Methane	5	4	3	ppm
Hydrogen sulfide	10	10	-	ppb
Mercaptans	5	5	-	ppb
Benzene	2	2	1	ppb

To assess whether the concentrations of the air toxics measured during this air monitoring campaign are consistent with the air toxics levels across the region, the long-term air toxic monitoring results were compared to the findings from the fourth Multiple Air Toxics Exposure Study (MATES IV), which provides a regional estimate of the "background" or expected levels of air toxics in 2012-2013 from 10 locations in the Los Angeles Basin.

4. Results and Discussions

4.1. Fixed-site Air Monitoring

4.1.1. Continuous Monitoring

Methane

Figure 4 illustrates the hourly-average methane concentrations at nine monitoring locations between December 2015 and July 2017. Prior to February 18, 2016, some of the measured 1-hr daily maximum methane concentrations were significantly higher than the typical background level (~2 ppm), while substantially lower than the lower flammability limit (50,000 ppm). The highest 1-hr average methane concentration (96 ppm) was measured at Site #4 (the closest monitoring location to Well SS-25) on February 11, 2016, which was the day that the well was temporarily sealed.

Following the full closure of the SS-25 Well, hourly-average concentrations of methane at all monitoring locations never exceeded the CARB's/SCAQMD's conservative 4 ppm threshold, except during a few occasions. These exceedances were mostly observed at Site #1 and only once at the Reseda station. At Site #1, the hourly methane concentrations exceeded the 4 ppm criteria

for a total of 21 times after February 18, 2016, with a maximum daily hourly maximum level of 8.4 ppm on July 11, 2016 at 1:00 pm. Since July 2016, only one exceedance was observed among the monitoring sites at the background Reseda station on April 10, 2017 (at 8:00 pm), when the methane concentration reached 5.2 ppm. An assessment of wind data measured at the same monitoring station indicated that at that time light wind (~2-4 mph) was blowing from west/southwest (Figure 5), suggesting that emissions from the Aliso Canyon Facility did not contribute to this increased concentration. Moreover, during that time, a concurrent increase in methane concentration was not observed at Site #4, which is the closest monitoring location to the Facility. Thus, this spike in the methane concentration was most likely due to a local source close to the Reseda station rather than emissions from the Aliso Canyon Facility.

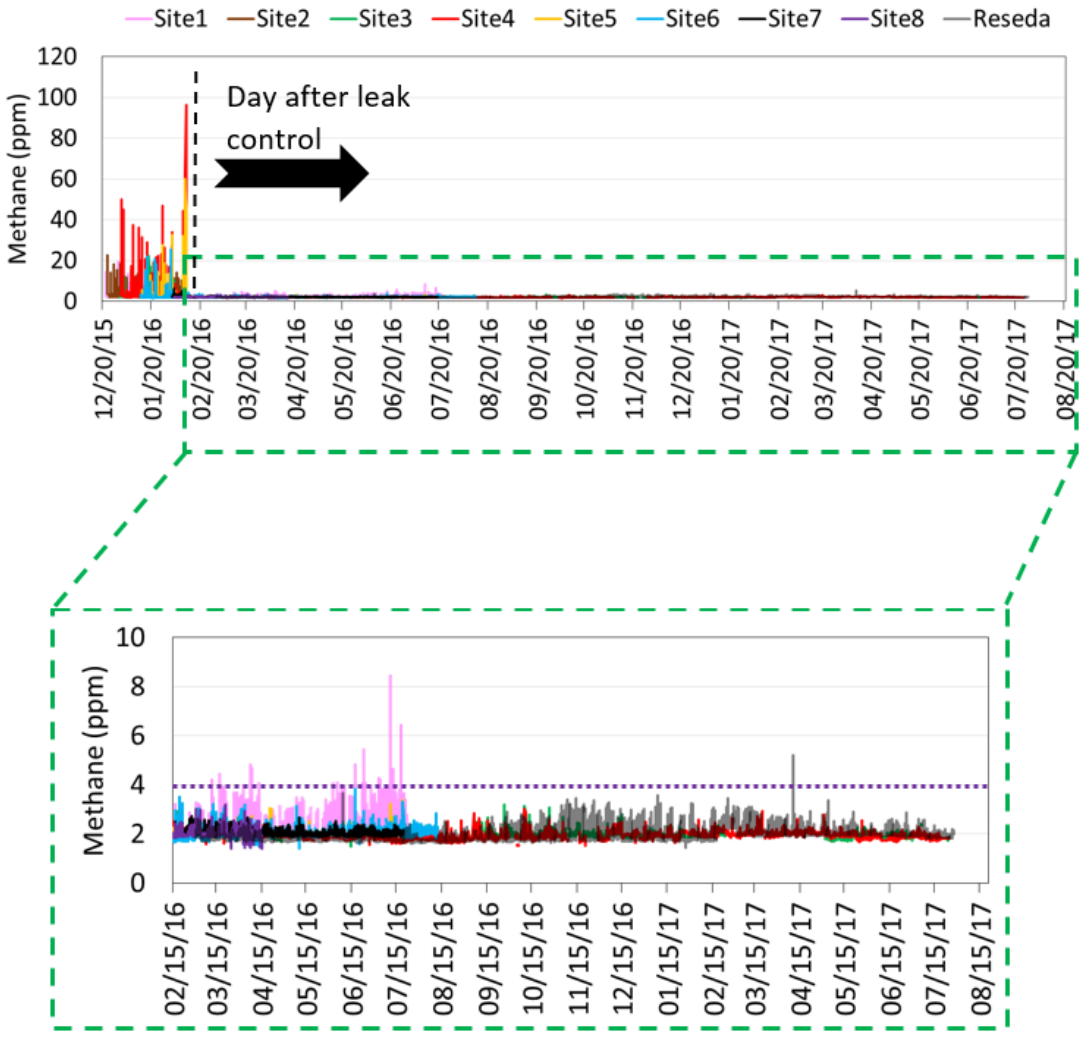

Figure 4. Hourly-average concentrations of methane measured at all monitoring locations. The dotted purple line represents the hourly methane concentration criteria (4 ppm) set by CARB and SCAQMD for this study.

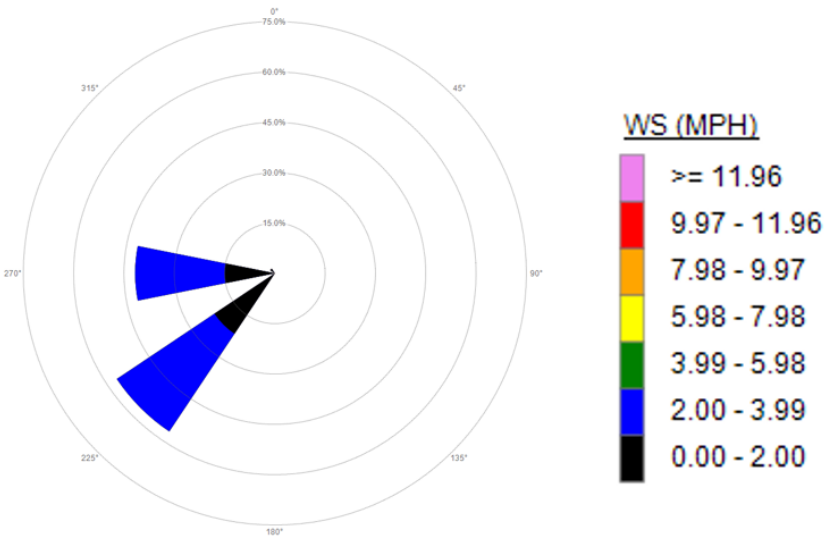

Figure 5. Wind speed/direction on April 10, 2017 (at 8:00 pm) at the Reseda station.

Figure 6 shows the 24-hr average methane concentrations at all monitoring locations, and illustrates a drastic reduction in the measured levels after February 18, 2016. Also, these 24-hr averages never exceeded the CARB's/SCAQMD's 3 ppm criteria (dotted purple line) at any of the monitoring locations since the SS-25 Well was fully sealed.

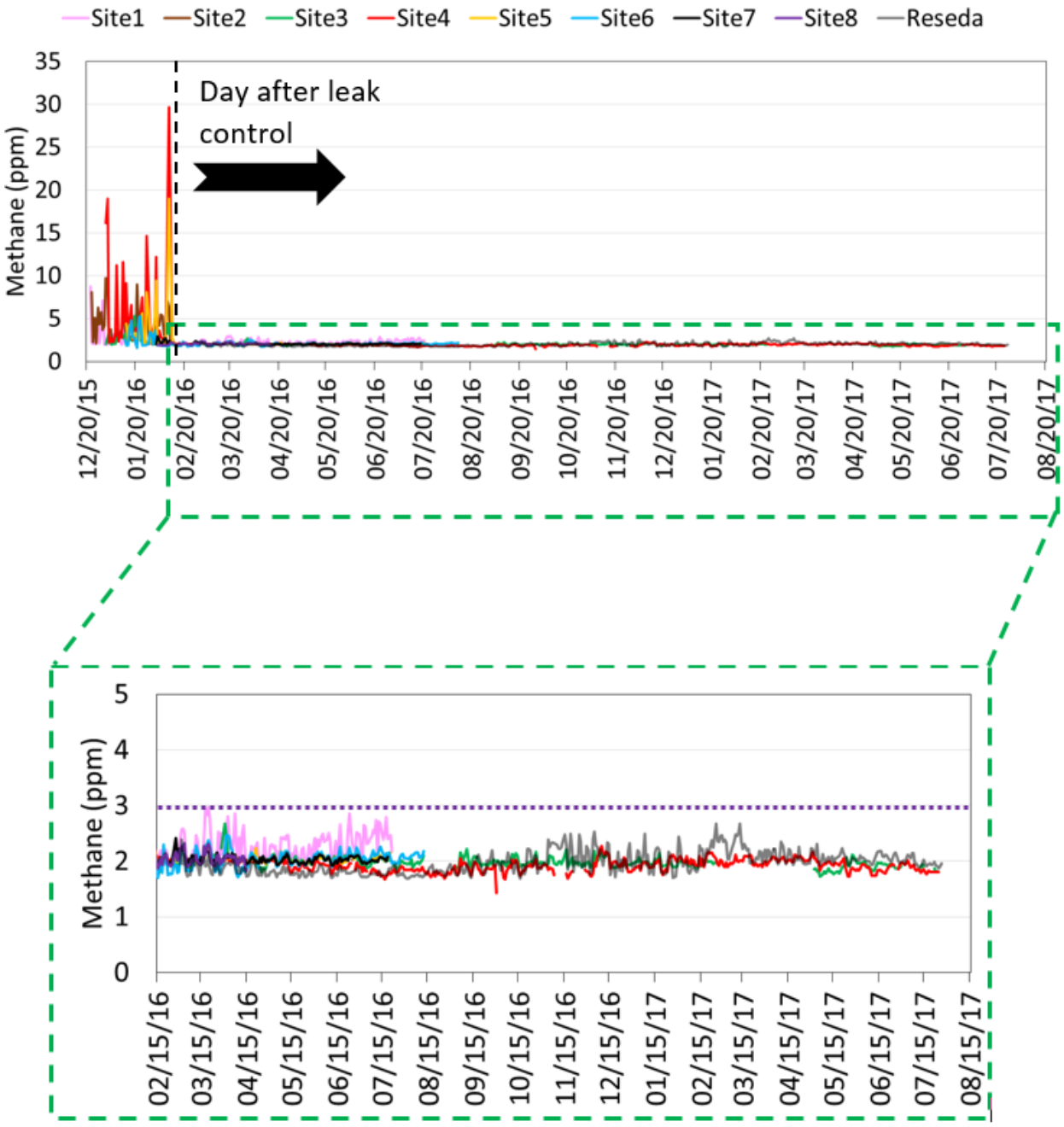

Figure 6. 24-hr average concentrations of methane measured at all monitoring locations. The dotted purple line represents the 24-hr average methane concentration criteria (3 ppm) set by CARB and SCAQMD for this study.

Benzene

Near real-time benzene levels were measured by CARB at Sites #5 and #7 from early February through late June, 2016, and by SCAQMD at Site #4 starting mid-October, 2016. As shown in Figure 7, hourly-average benzene concentrations at all three locations were substantially lower than the acute REL of 8 ppb. However, on a few occasions, benzene concentrations exceeded the more conservative criteria set by CARB and SCAQMD for this study (i.e., 2 ppb; reported as hourly average). The 24-hr average concentrations of benzene, on the other hand, were consistently below the 1 ppb criteria (also set by CARB and SCAQMD) throughout the monitoring campaign (Figure 8).

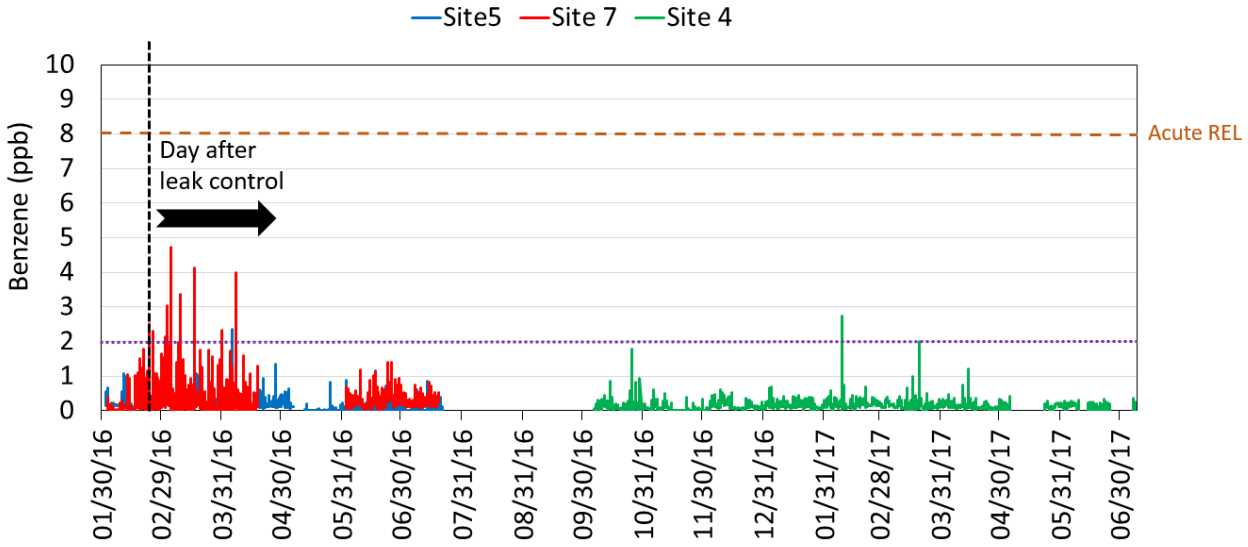

Figure 7. Hourly-average concentrations of benzene measured at Sites #5, #7, and #4. The dotted purple line represents the hourly benzene concentration criteria (2 ppb) set by CARB and SCAQMD for this study, and the dashed orange line represents the acute REL.

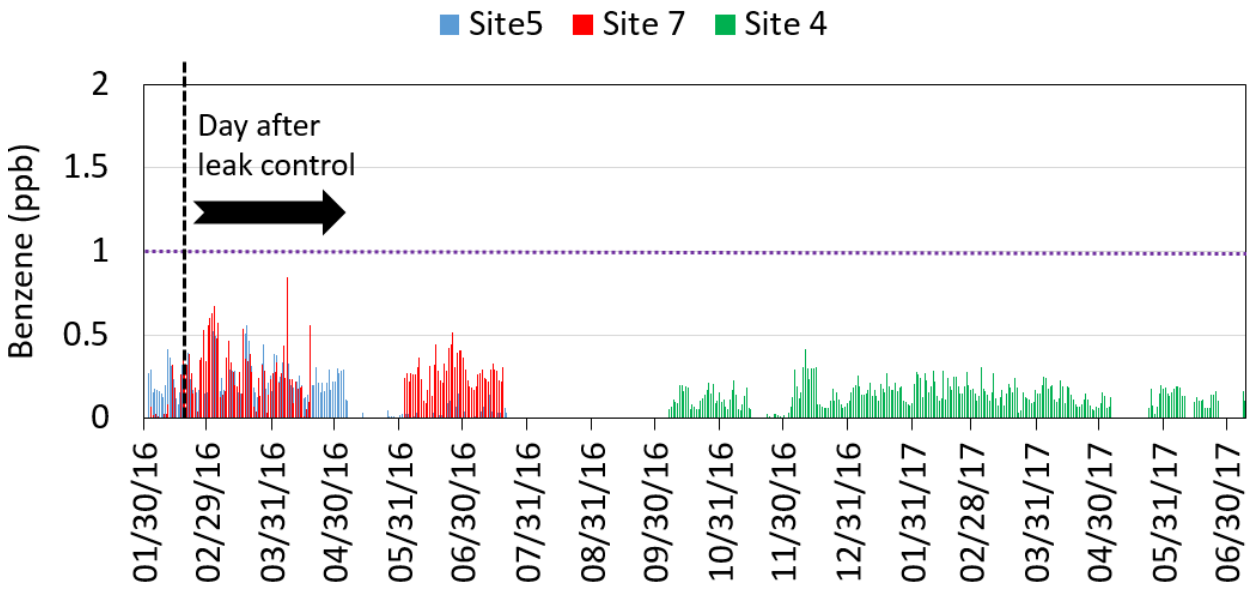

Figure 8. 24-hr average concentrations of benzene measured at Sites #5, #7, and #4. The dotted purple line represents the chronic REL as well as the 24-hr benzene concentration criteria (1 ppb) set by CARB and SCAQMD for this study.

Hydrogen Sulfide

The SCAQMD operated a continuous H_2S monitor at Site #3 from early December 2015 to late February 2017. Values from this instrument were mostly non-detect and the highest levels observed were always lower than 5 ppb (Figure 9). These concentrations are well below the 10 ppb criteria established for this study and also substantially lower than both the acute REL (30 ppb) and chronic REL (8 ppb) for H_2S.

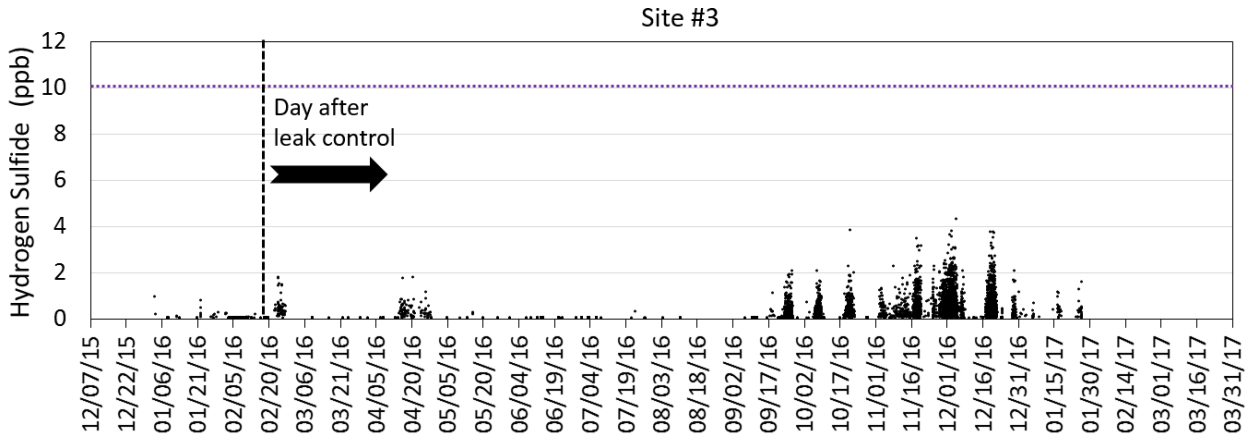

Figure 9. 5-minute average concentrations of hydrogen sulfide (H_2S) measured at Site #3. The dotted purple line represents the H_2S concentration criteria (10 ppb) set by CARB and SCAQMD for this study.

Total Sulfur

Odorizing compounds such as tetrahydrothiophene and t-Butyl mercaptan are added to natural gas to provide an alert that natural gas is present in the ambient air. To detect the concentrations of these and other sulfur-containing compounds near real-time, in addition to the continuous measurements of H_2S at Site #3 (Figure 9), total sulfur concentrations were continuously measured at Site #4 since March 2016 through April 2017 (Figure 10). Similar to H_2S, the hourly-average concentrations of total sulfur were consistently low throughout the measurement period and never exceeded 5 ppb.

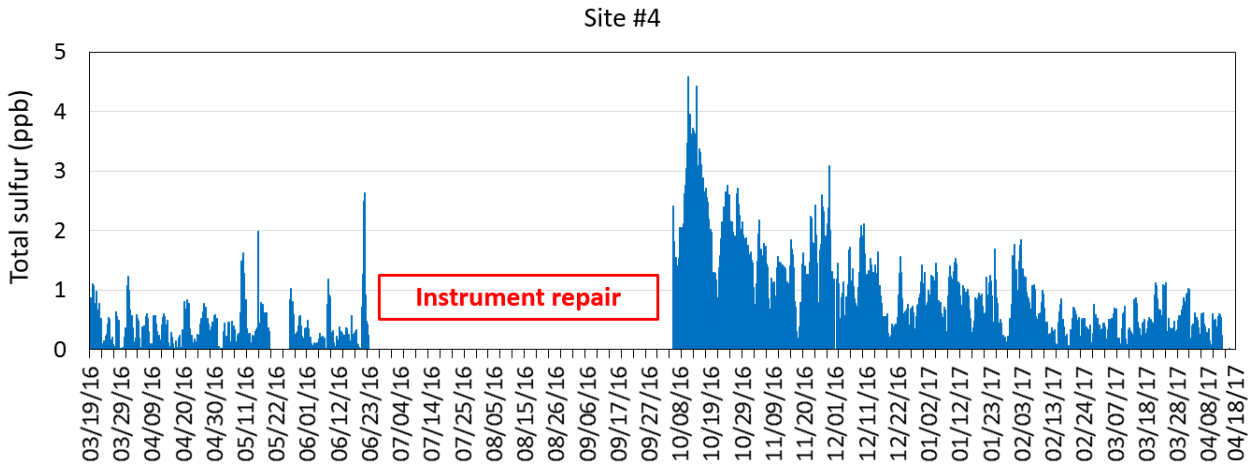

Figure 10. Hourly-average concentrations of total sulfur measured at Site #4.

4.1.2. 24-hr Integrated Samples

Methane

Concentrations of methane from the analysis of the 24-hr integrated canister samples collected at Sites #3, #4, #6, and the Reseda station are illustrated in Figure 11. In concert with the trends observed from the continuous measurements (Figure 6), methane concentrations measured from the time-integrated canister samples along with the frequency of the samples exceeding the 3 ppm criteria (set by CARB and SCAQMD) decreased substantially after February 18, 2016.

Figure 11. Methane concentrations from 24-hr integrated canister samples at Sites #3, #4, #6, and Reseda station. The dotted purple line represents the 24-hr methane concentration criteria (3 ppm) set by CARB and SCAQMD for this study.

Volatile Organic Compounds (VOCs)

While a wide range of VOCs were measured from the time-integrated canister samples, the concentrations of several compounds were at or below their corresponding detection limits in the majority of the collected samples. In this report, the focus will be on those VOCs that are known to cause health effects and for which the OEHHA has established RELs (Table 2). These compounds include benzene, toluene, ethylbenzene, xylenes (abbreviated as BTEX) and styrene. The complete VOC dataset can be found in the Appendix.

Figures 12-19 show the concentrations of the selected VOCs from the analysis of valid time-integrated samples collected at Sites #3, #4, #6 and the Reseda station. Values in parentheses next to each compound in the plots' legends indicate the percentage of samples with levels below the method detection limits. In addition, to compare the levels of the selected VOCs at the aforementioned monitoring locations with their "background" or typical ambient levels, a statistical summary of the concentrations of these compounds measured during MATES IV is provided in Table 4.

Table 4. Statistical summary of the concentrations of selected VOCs measured during MATES IV.

	MATES IV VOCs				
	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylenes (ppb)	Styrene (ppb)
Avg	0.37	1.02	0.21	0.86	0.04
SD	0.08	0.3	0.17	0.75	0.03
Median	0.29	0.75	0.12	0.46	0.02
Min	0.02	0.10	0.00	0.06	0.00
Max	1.77	6.15	4.75	19.39	0.85

With the exception of a few samples that were collected at Sites #3 and #4 prior to February 18, 2016, concentrations of the selected toxic VOCs were overall comparable to or even lower than the corresponding levels found elsewhere in the Basin (also refer to Figure (IV) in Executive Summary). Ethylbenzene and styrene were mostly non-detect with respectively 51-97% and 63-97% of samples containing concentrations below their corresponding method detection limits among the monitoring locations. At the monitoring sites in the Porter Ranch community (i.e., Sites #3, #4, and #6), concentrations of toluene decreased substantially following the closure of the leaking SS-25. The concentrations of benzene were below the 24-hr 1 ppb criteria at all monitoring locations even during the leak. The average concentrations of benzene among all time-integrated samples were 0.15, 0.15, 0.18, and 0.28 ppb at Sites #3, #4, #6 and Reseda, respectively. These averages which are well below the 1ppb chronic REL, more appropriately represent the chronic, long-term exposure in the community than any single measurement value. Moreover, the estimated averages are based solely on the samples with a detectable level and, therefore, are higher than the actual averages if non-detects were to be taken into account. Yet, these levels are below the basin-wide one-year average of benzene as measured during MATES IV (i.e., 0.37 ppb).

It is noteworthy that under typical conditions (i.e., after the leak was controlled), higher concentrations of BTEX and styrene were measured at the Reseda station compared to the monitoring sites in the Porter Ranch community. This is most likely due to the close proximity of this monitoring site to major surface streets (e.g., Ventura Blvd) with relatively higher emissions from vehicles, which are important sources of VOCs.

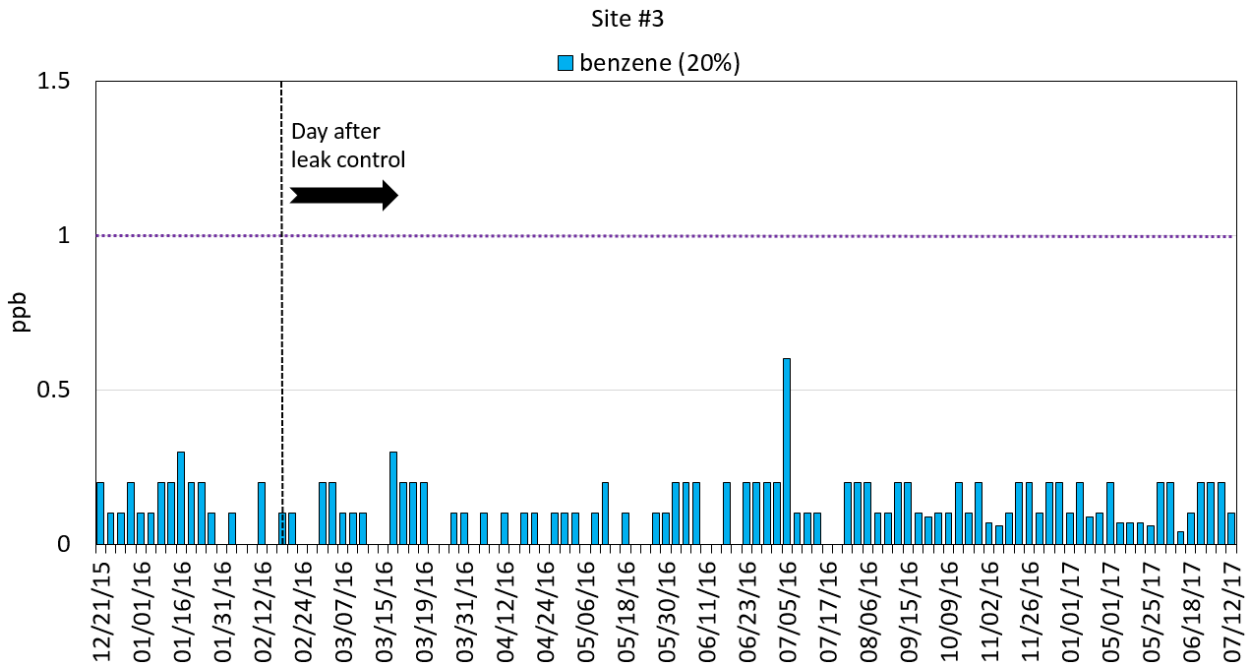

Figure 12. Concentrations of benzene from the 24-hr integrated samples collected at Site #3. Value in parenthesis represents the percentage of samples with concentrations below the method detection limit. The dotted purple line represents the chronic REL as well as the 24-hr benzene concentration criteria (1 ppb) set by CARB and SCAQMD for this study.

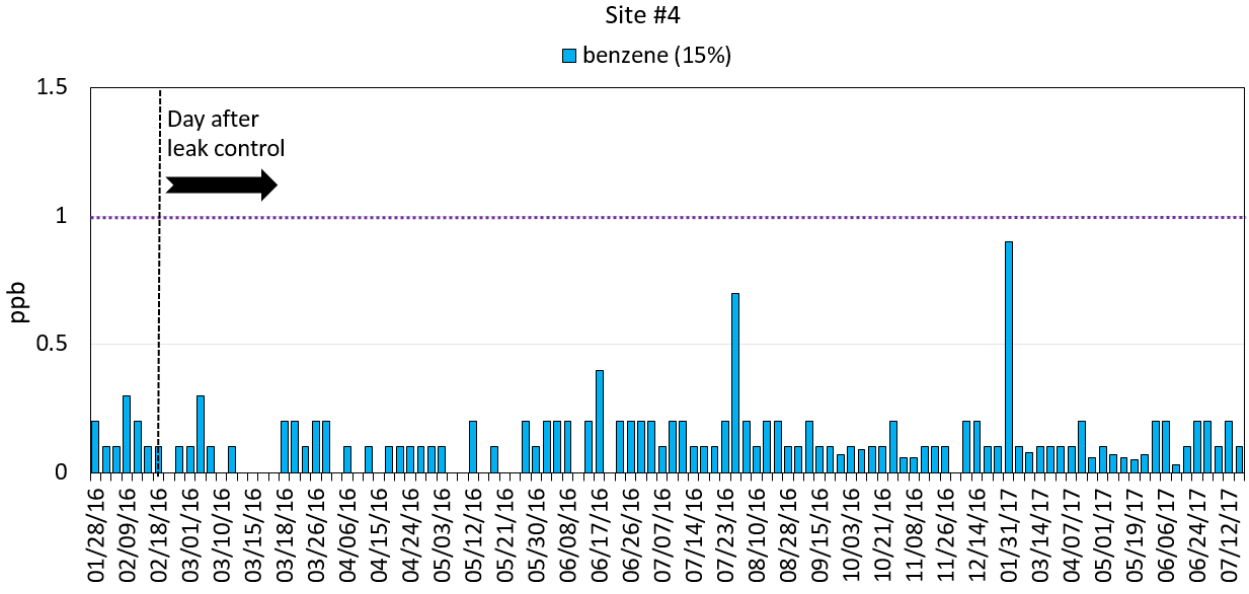

Figure 13. Concentrations of benzene from the 24-hr integrated samples collected at Site #4. Value in parenthesis represents the percentage of samples with concentrations below the method detection limit. The dotted purple line represents the chronic REL as well as the 24-hr benzene concentration criteria (1 ppb) set by CARB and SCAQMD for this study.

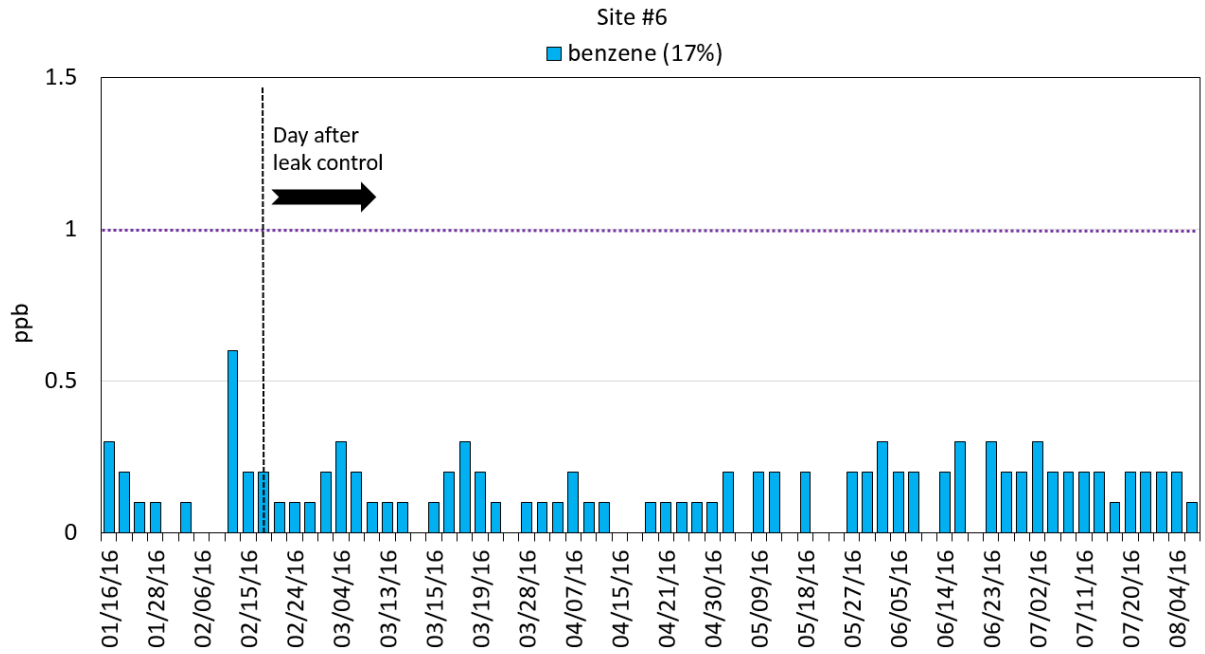

Figure 14. Concentrations of benzene from the 24-hr integrated samples collected at Site #6. Value in parenthesis represents the percentage of samples with concentrations below the method detection limit. The dotted purple line represents the chronic REL as well as the 24-hr benzene concentration criteria (1 ppb) set by CARB and SCAQMD for this study.

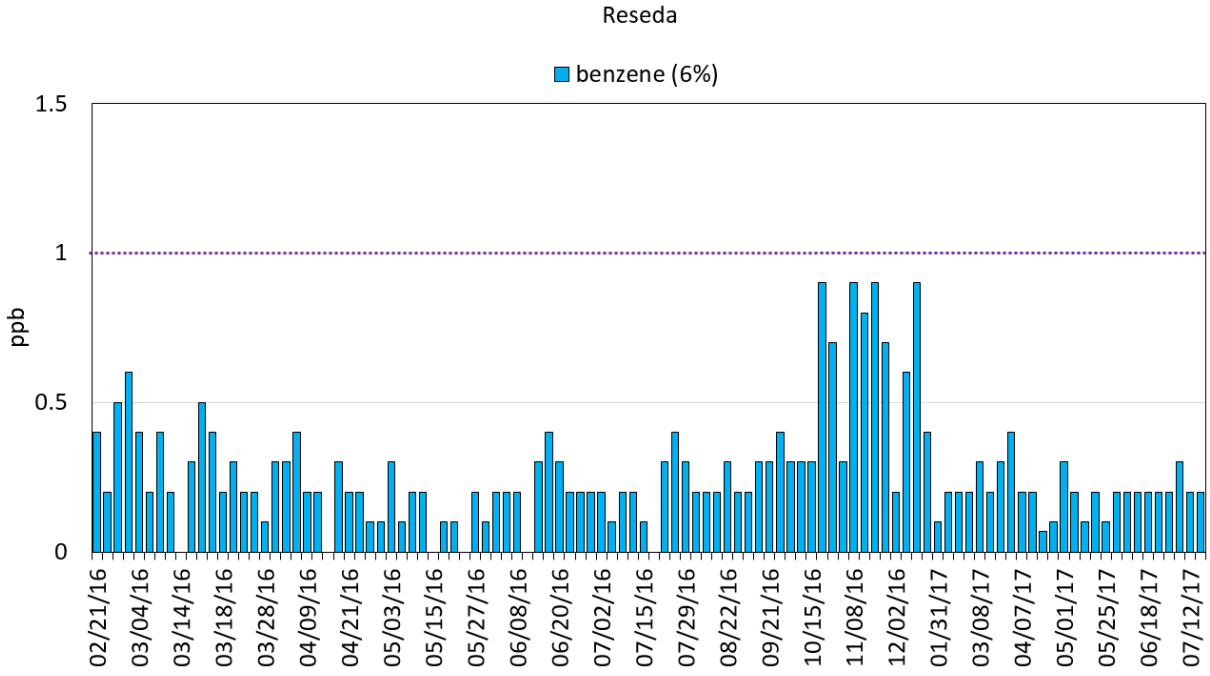

Figure 15. Concentrations of benzene from the 24-hr integrated samples collected at the Reseda station. Value in parenthesis represents the percentage of samples with concentrations below the method detection limit. The dotted purple line represents the chronic REL as well as the 24-hr benzene concentration criteria (1 ppb) set by CARB and SCAQMD for this study.

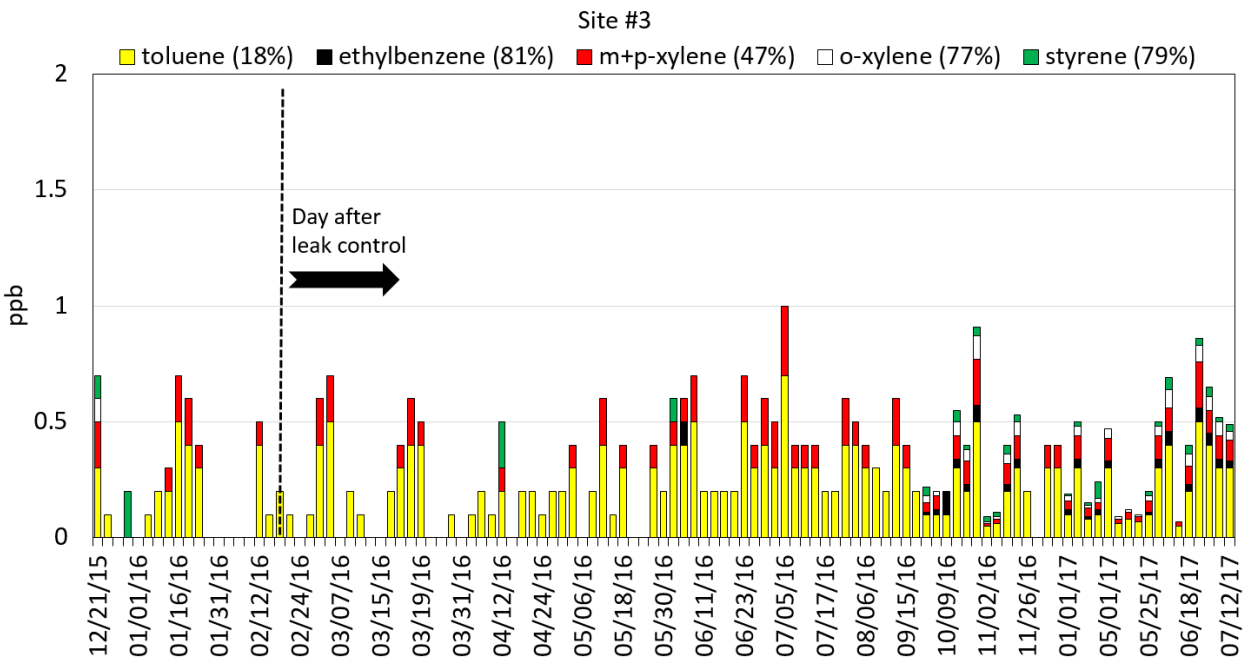

Figure 16. Concentrations of selected VOCs from the 24-hr integrated samples collected at Site #3. Values in parentheses represent the percentage of samples with concentrations below the method detection limit.

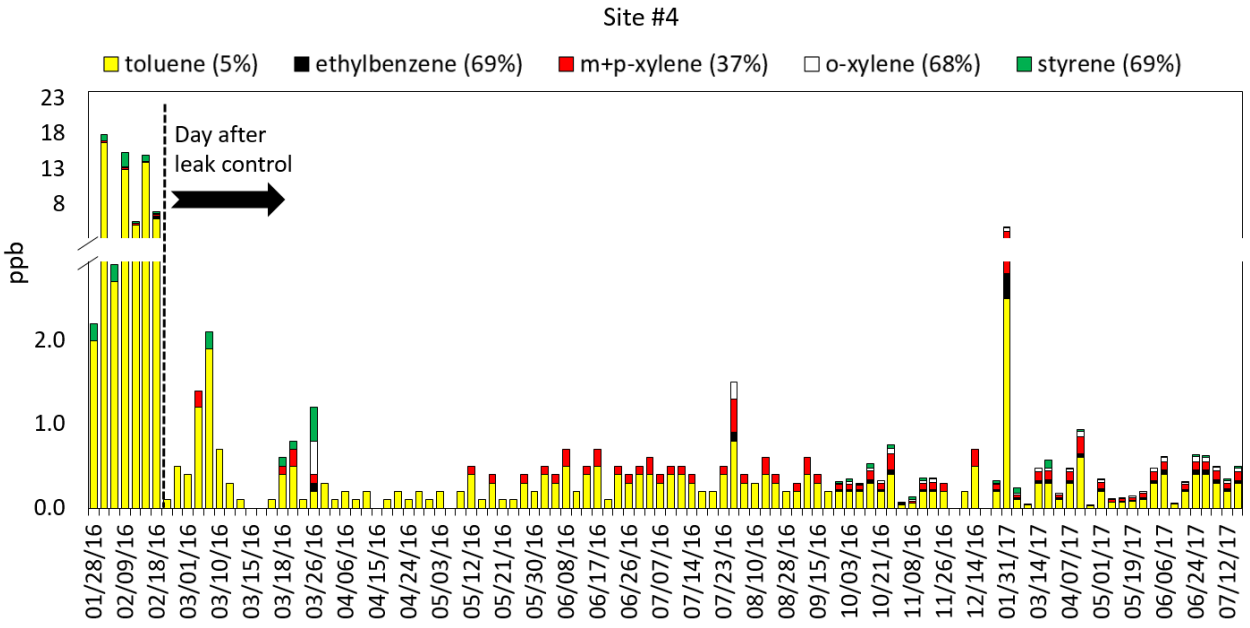

Figure 17. Concentrations of selected VOCs from the 24-hr integrated samples collected at Site #4. Values in parentheses represent the percentage of samples with concentrations below the method detection limit.

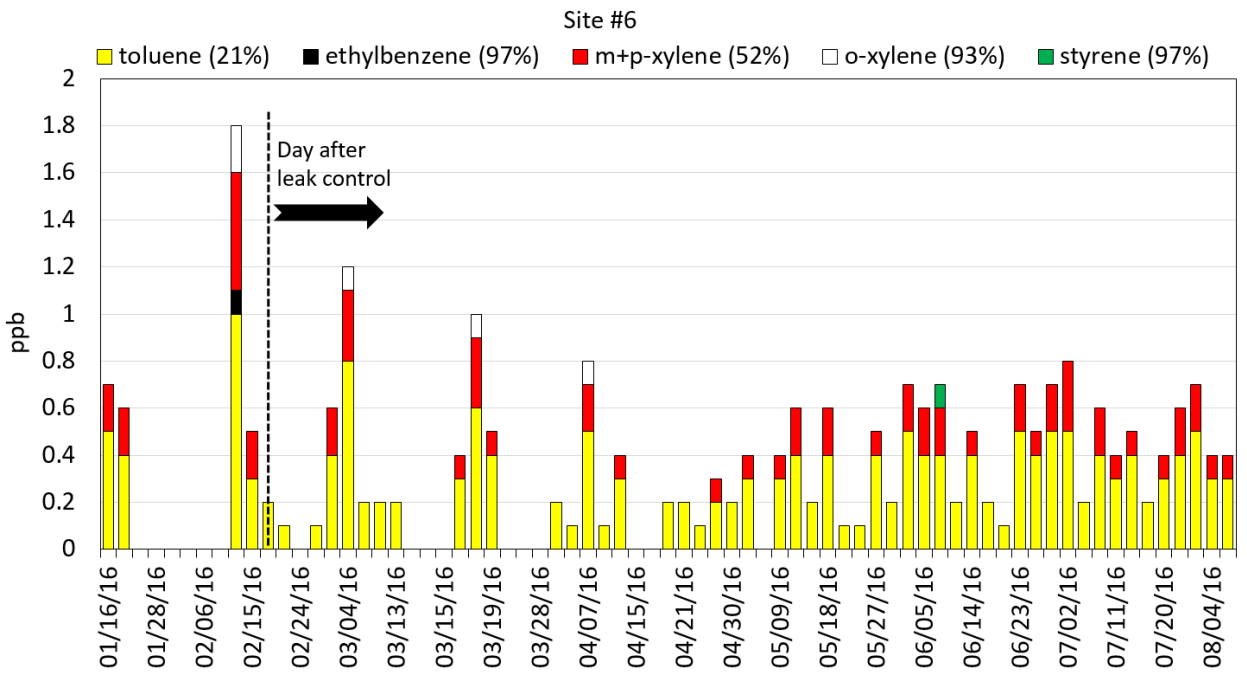

Figure 18. Concentrations of selected VOCs from the 24-hr integrated samples collected at Site #6. Values in parentheses represent the percentage of samples with concentrations below the method detection limit.

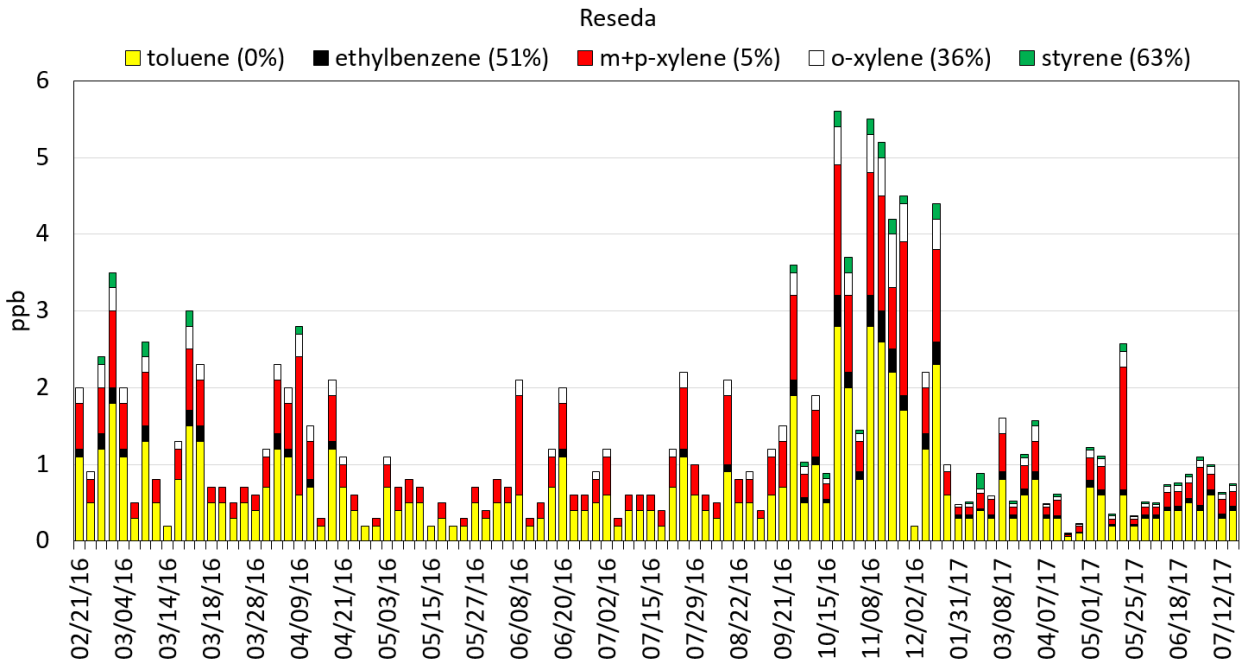

Figure 19. Concentrations of selected VOCs from the 24-hr integrated samples collected at the Reseda station. Values in parentheses represent the percentage of samples with concentrations below the method detection limit.

Carbonyl Compounds

Time-integrated concentrations of the carbonyl compounds (formaldehyde, acetone, and acetaldehyde) which were measured at Site #3 in February 2016 (prior to the sealing of the Well) and at Site #4 in April-May 2017 are shown in Figures 20 and 21, respectively. Concentrations of all measured carbonyl compounds were within the levels observed during MATES IV (Table 5). More importantly, all measured concentrations from the time-integrated samples are well below the chronic REL standards of 80 ppb and 7 ppb for acetaldehyde and formaldehyde, respectively. This means that the long-term exposure to these compounds at the levels found in the Porter Ranch even during the leak area are not expected to cause any long-term non-cancer health effects.

Table 5. Statistical summary of the concentrations of selected carbonyl compounds measured during MATES IV.

	MATES IV Carbonyls		
	Formaldehyde (ppb)	Acetaldehyde (ppb)	Acetone (ppb)
Avg	2.24	0.90	1.69
SD	0.59	0.20	0.47
Median	2.20	0.77	0.88
Min	0.12	0.02	0.02
Max	6.32	3.07	21.79

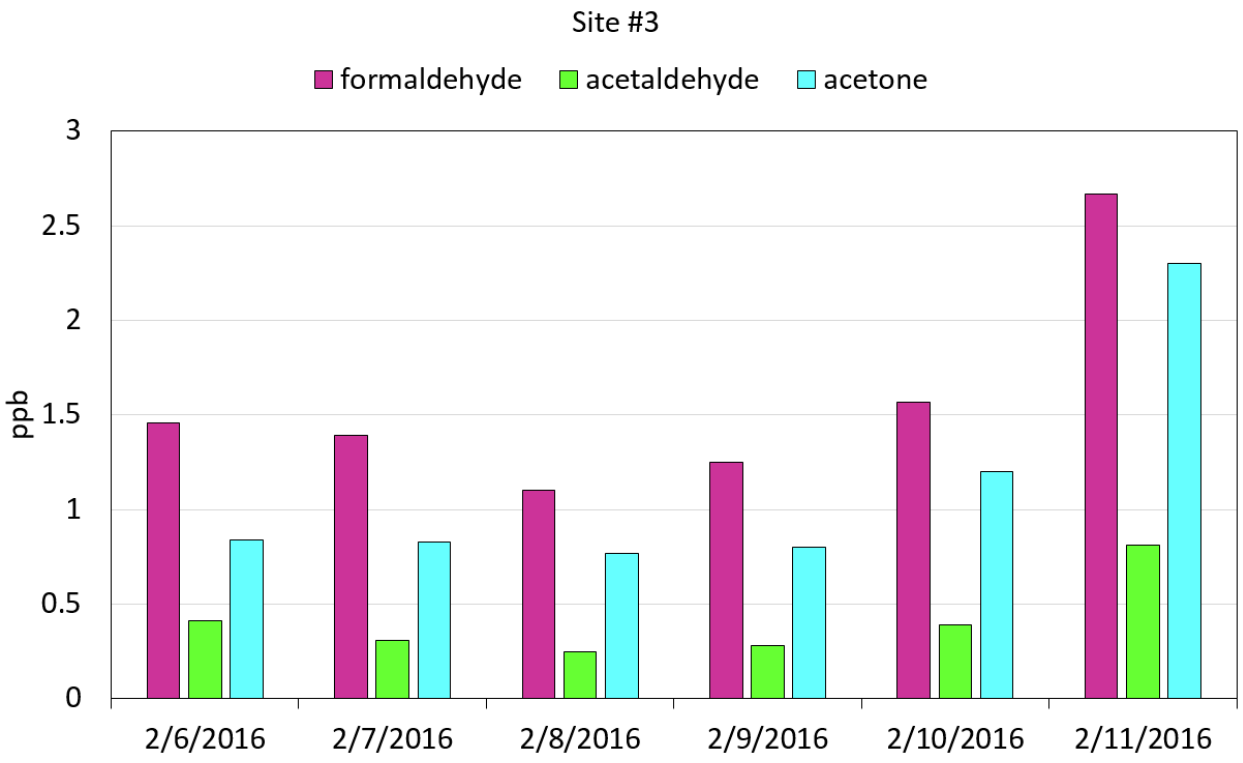

Figure 20. Concentrations of selected carbonyl compounds from the 24-hr integrated samples collected at Site #3.

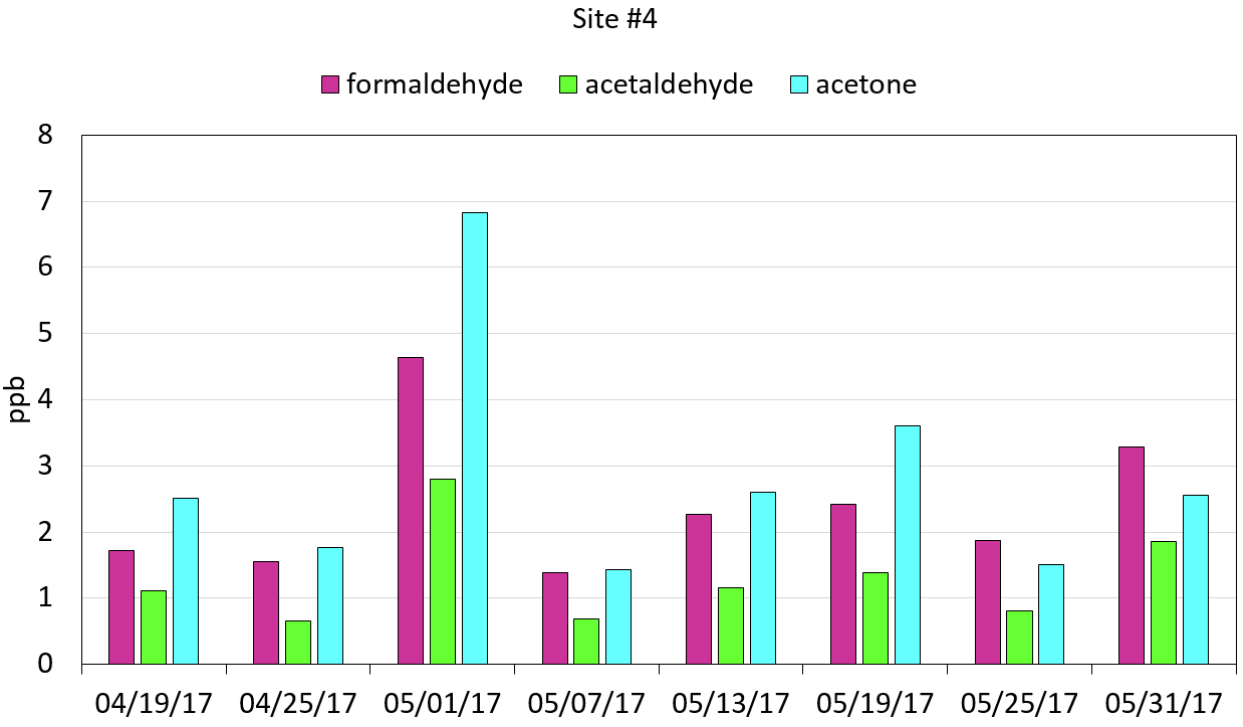

Figure 21. Concentrations of selected carbonyl compounds from the 24-hr integrated samples collected at Site #4.

4.1.3. Triggered Samples

Instantaneous grab samples were automatically collected for about 5 minutes when the measured methane concentrations from the continuous monitors exceeded the pre-set threshold levels. In this section, the results from individual trigged samples at Sites #3, #4, and #6 are presented and discussed. It should be noted that in some of the following plots (Figures 22-30), more than one data point is reported for some given days. This means that more than one triggered sample was collected on that day.

Methane

Concentrations of methane measured from the analysis of triggered samples collected at Sites #3, #4, and #6 are shown in Figures 22, 23, and 24, respectively. At Site #3, methane concentrations among the 30 collected triggered samples ranged between 2 to 48 ppm with a median value of 18 ppm. Additionally, no triggered samples were collected at this site after February 18, 2016, meaning that the concentration of methane measured by the continuous monitor at this site never exceeded the 5 ppm threshold following the permanent closure of Well SS-25. At Site #6, a total of 11 valid triggered samples were collected between January and April 2016. During the gas leak, concentrations of methane from the six triggered canister samples collected at this site ranged between 13 and 24 ppm. Concentrations of methane from the five triggered samples collected at Site #6 after the closure of Well SS-25 did not exceed the 5 ppm criteria (Figure 24). The largest number of triggered samples were collected at Site #4, which was the closest monitoring location to the Facility. Prior to February 18, 2016 more than 70 triggered samples were collected at this site and the median methane concentration among these samples was 33 ppm. The frequency of the triggered samples at this site, however, decreased substantially after February 18, 2016 and the measured methane concentrations from these samples never exceeded the 5 ppm criteria set by SCAQMD and CARB (Figure 23).

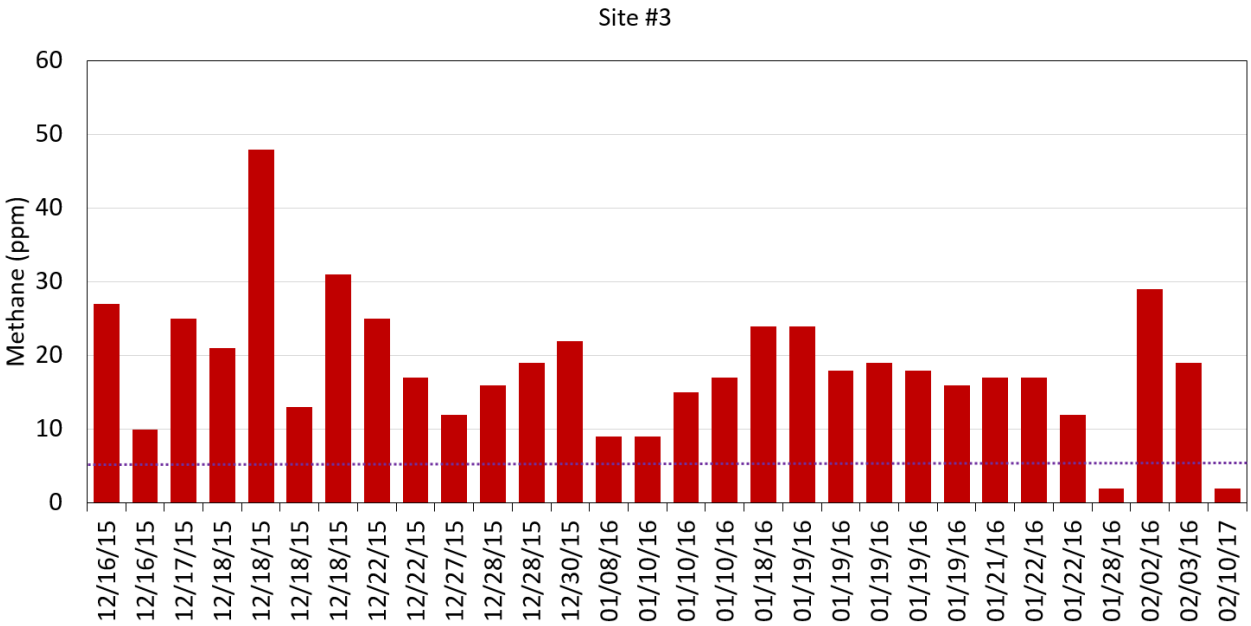

Figure 22. Concentrations of methane measured from the triggered samples collected at Site #3. The dotted purple line represents the methane concentration criteria (5 ppm) for triggered samples set by CARB and SCAQMD for this study.

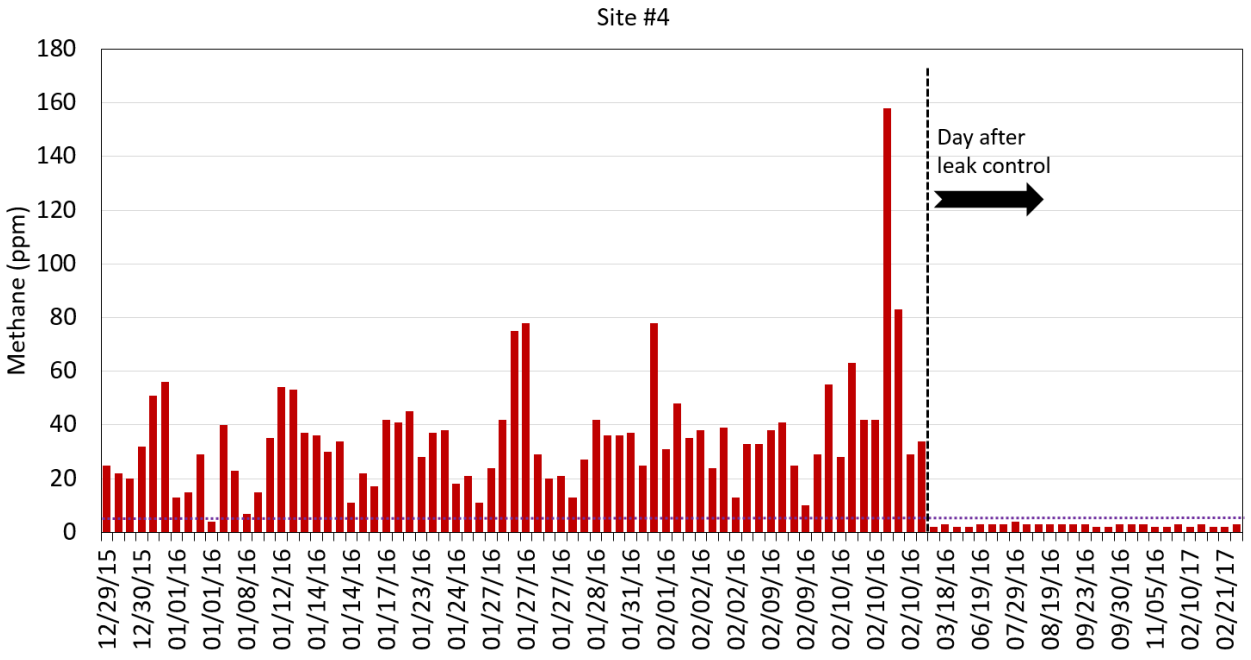

Figure 23. Concentrations of methane measured from the triggered samples collected at Site #4. The dotted purple line represents the methane concentration criteria (5 ppm) for triggered samples set by CARB and SCAQMD for this study.

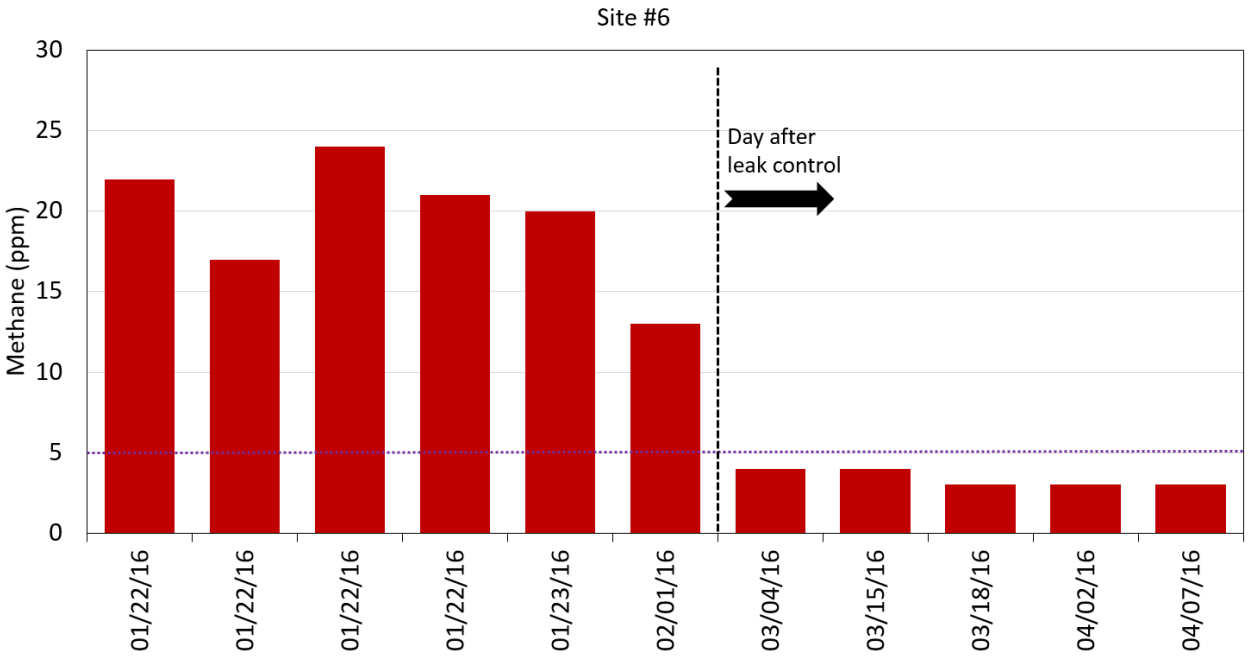

Figure 24. Concentrations of methane measured from the triggered samples collected at Site #6. The dotted purple line represents the methane concentration criteria (5 ppm) for triggered samples set by CARB and SCAQMD for this study.

Volatile Organic Compounds (VOCs)

Figures 25-30 illustrate the concentrations of the selected VOCs (benzene, toluene, ethylbenzene, xylenes, and styrene) from individual triggered samples collected at Sites #3, #4, and #6. At Site #3, VOC concentrations from all triggered samples were substantially lower than the OEHHA's acute RELs and the conservative 2 ppb benzene threshold set by SCAQMD and CARB for this study. This was also the case at Sites #4 and #6 with the exception of a small number of samples. At Site #4, three triggered samples contained benzene concentrations higher than 2 ppb but only one of them (collected on July 29, 2016) exceeded the OEHHA's 8 ppb acute REL standard. The corresponding methane concentrations from these three samples, however, did not exceed the 5 ppm criteria (Figure 23), suggesting a source other than natural gas. Similarly, at Site #6 only a single 5-minute measurement on March 4, 2016 had a benzene concentration higher than 2 ppb, but it did not exceed the OEHHA's acute REL threshold of 8 ppb. The concentration of methane from this sample did not exceed the 5 ppm criteria either (Figure 24). Even though a small of number of triggered samples exceeded the acute RELs, the long-term averages of benzene at these sites are expected to be far below the chronic RELs. It should be noted that the concentrations of

toluene, xylenes, and styrene measured from all of the triggered samples never exceeded the OEHHA's acute RELs at any of the monitoring locations.

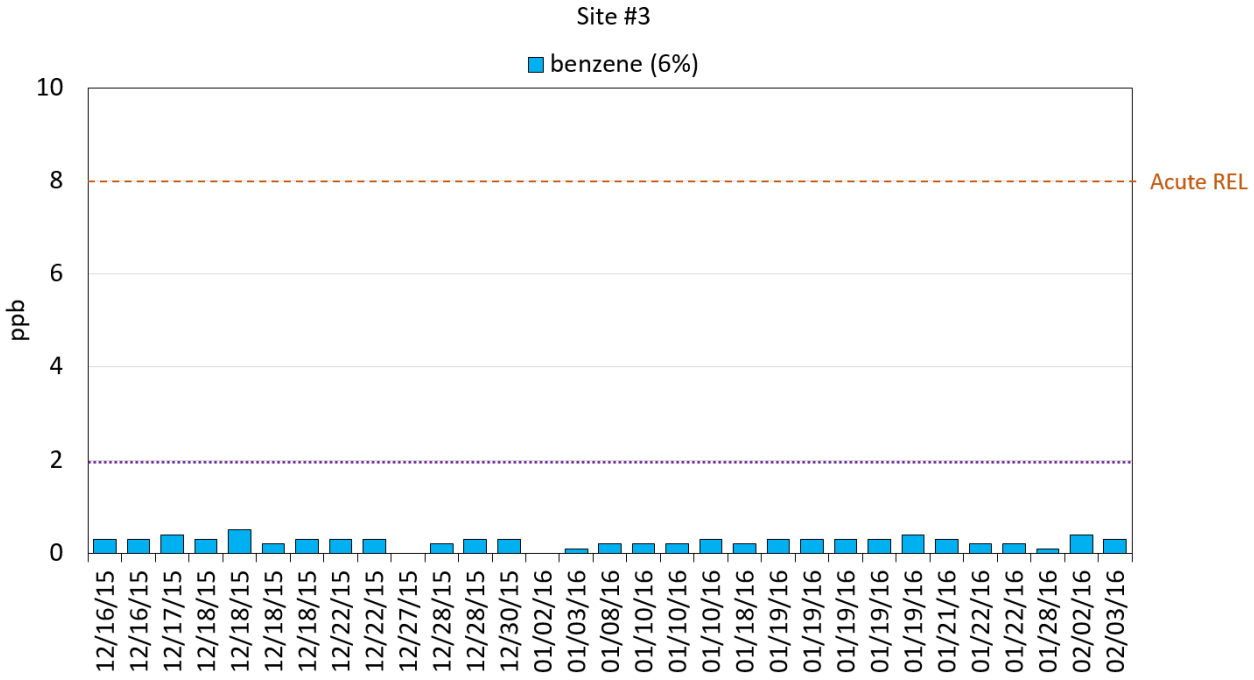

Figure 25. Concentrations of benzene from the triggered samples collected at Site #3. The dotted purple line represents the benzene concentration criteria (2 ppb) for triggered samples set by CARB and SCAQMD for this study, and the dashed orange line represents the acute REL (8 ppb). Value in parenthesis represents the percentage of samples with concentrations below the method detection limit.

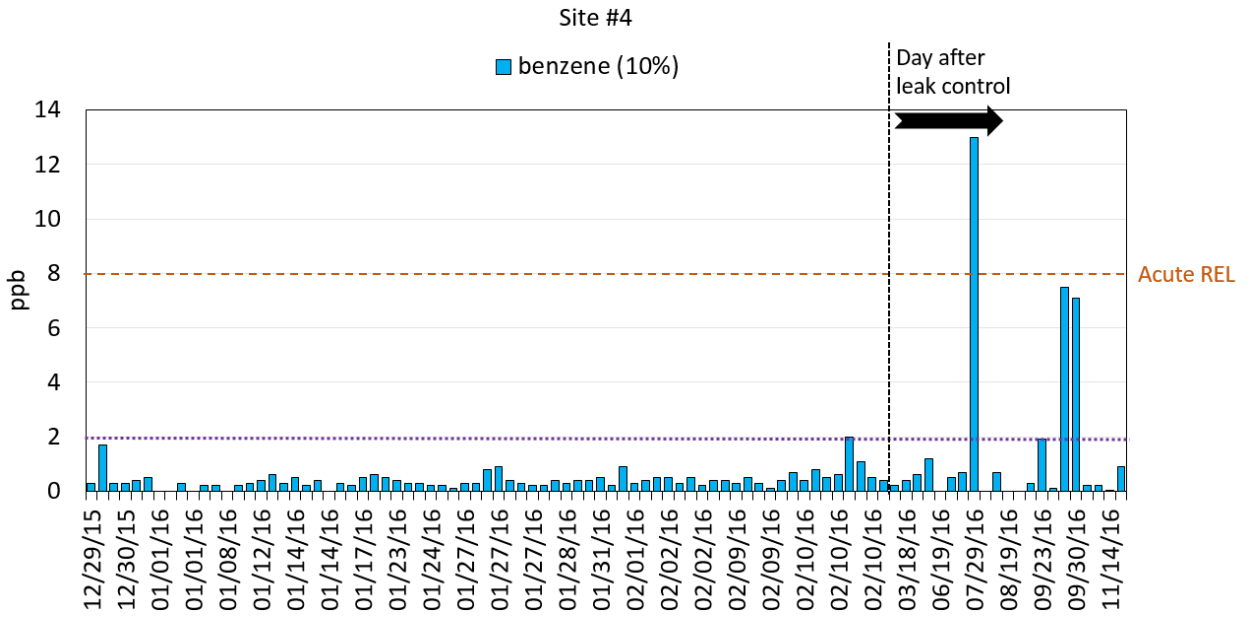

Figure 26. Concentrations of benzene from the triggered samples collected at Site #4. The dotted purple line represents the benzene concentration criteria (2 ppb) for triggered samples set by CARB and SCAQMD for this study, and the dashed orange line represents the acute REL (8 ppb). Value in parenthesis represents the percentage of samples with concentrations below the method detection limit.

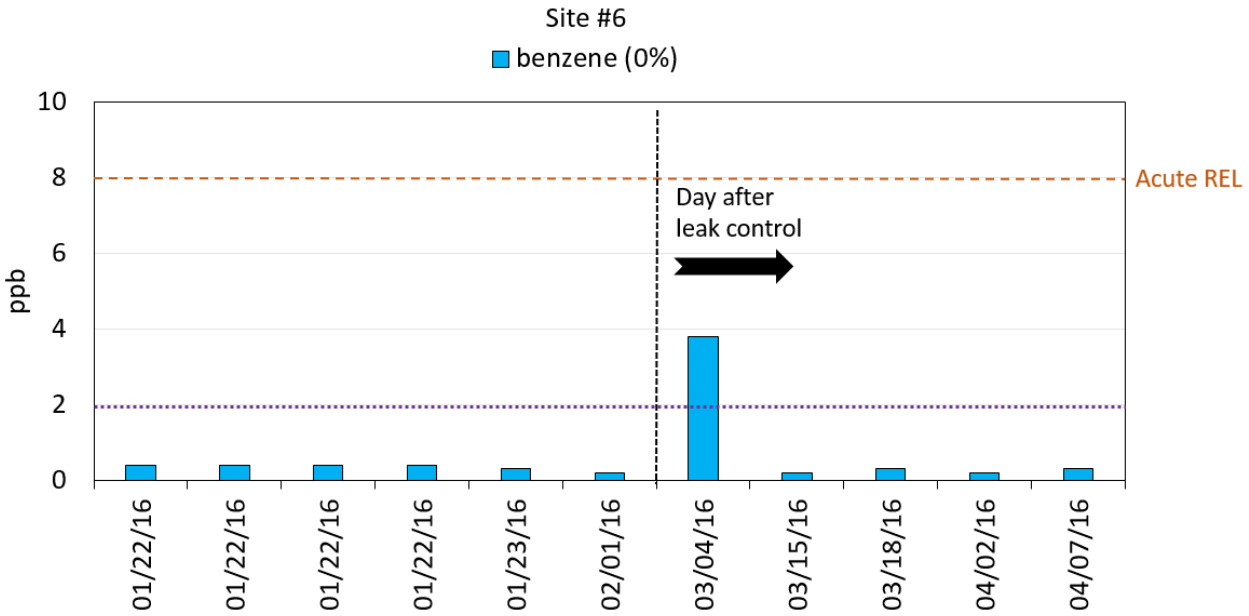

Figure 27. Concentrations of benzene from the triggered samples collected at Site #6. The dotted purple line represents the benzene concentration criteria (2 ppb) for triggered samples set by CARB and SCAQMD for this study, and the dashed orange line represents the acute REL (8 ppb). Value in parenthesis represents the percentage of samples with concentrations below the method detection limit.

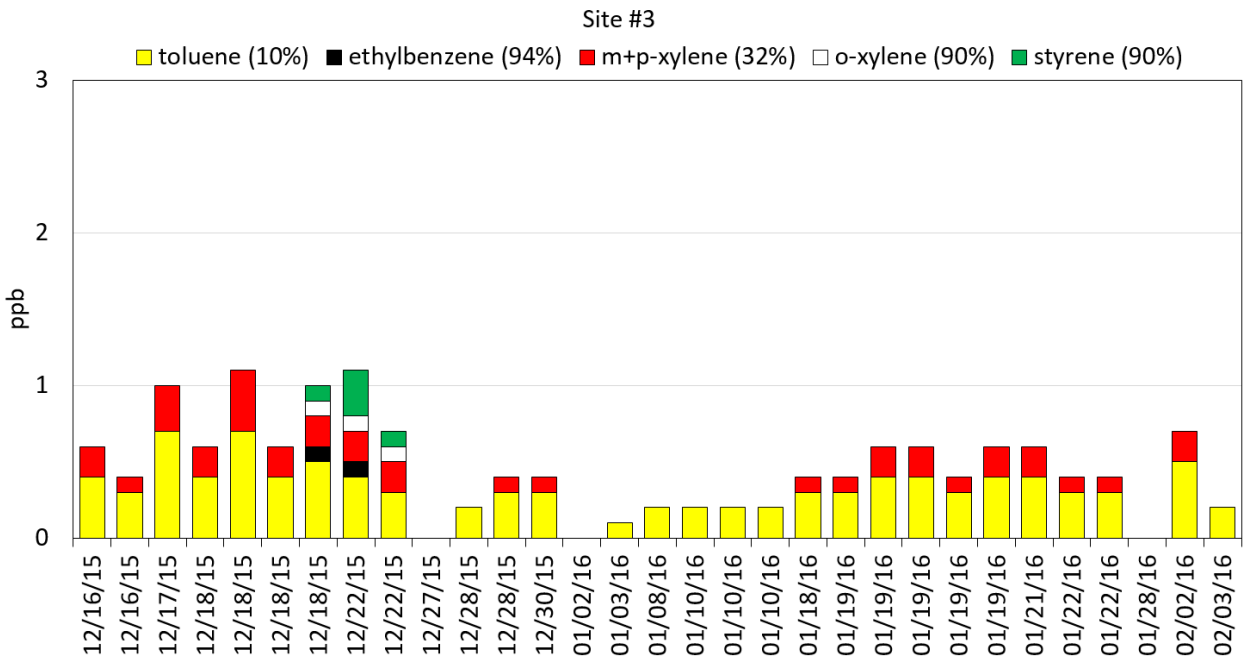

Figure 28. Concentrations of selected VOCs from the triggered samples collected at Site #3. Values in parentheses represent the percentage of samples with concentrations below the method detection limit.

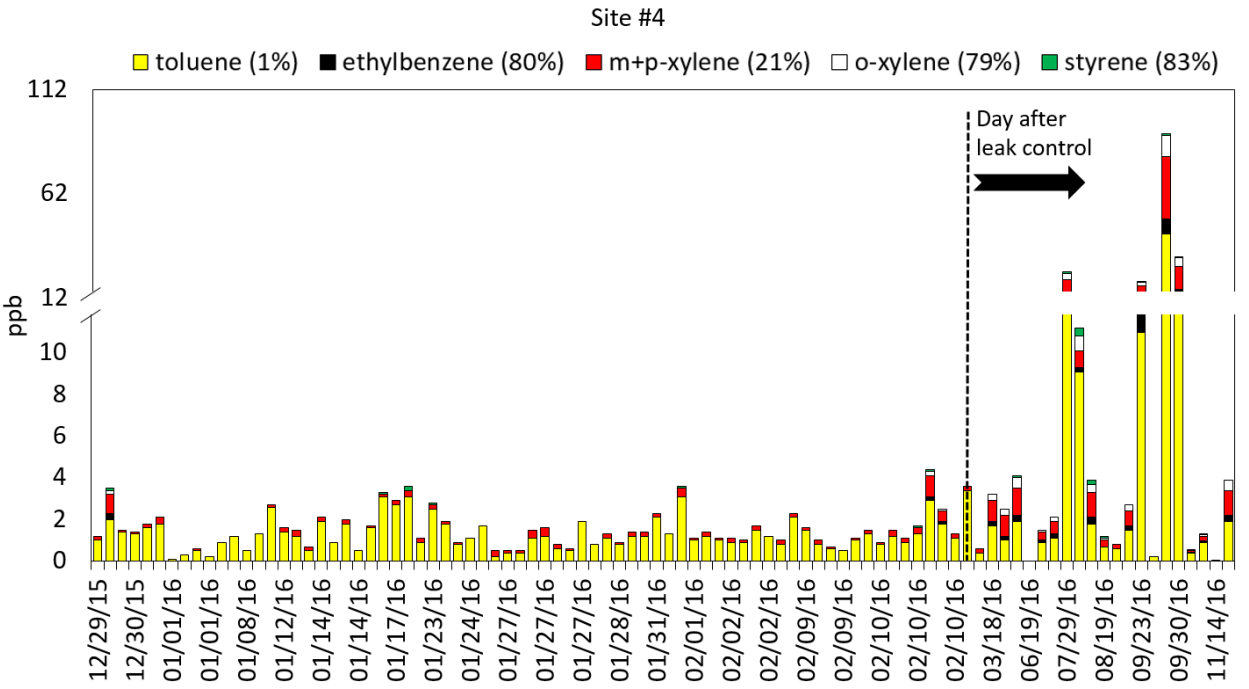

Figure 29. Concentrations of selected VOCs from the triggered samples collected at Site #4. Values in parentheses represent the percentage of samples with concentrations below the method detection limit.

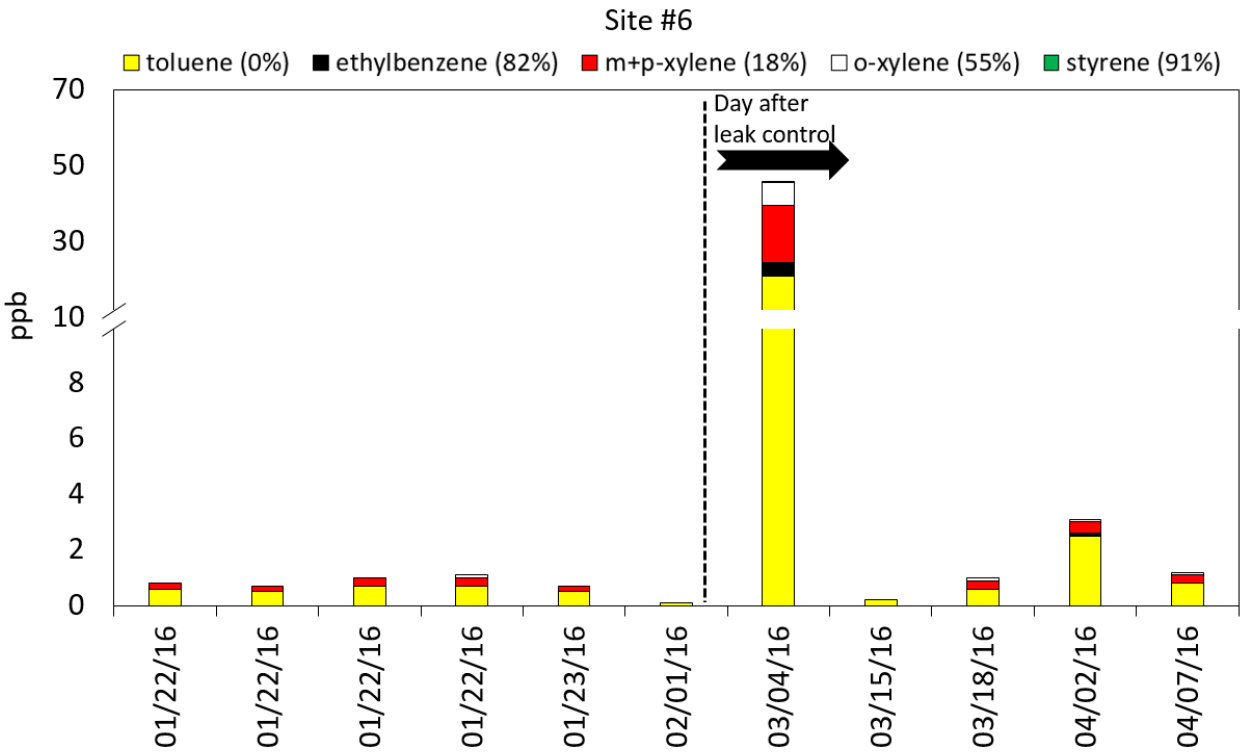

Figure 30. Concentrations of selected VOCs from the triggered samples collected at Site #6. Values in parentheses represent the percentage of samples with concentrations below the method detection limit.

Sulfur Odorants

Between January and October 2016, the SCAQMD collected near 50 triggered and grab samples inside the Facility and throughout the Porter Ranch community for sulfur species analysis. The sampling dates and locations are summarized in Table 6. Sulfur odorant additives (t-Butyl mercaptan and tetrahydrothiophene) were not detected in any of the samples, including those that were collected within the Facility perimeter. However, sulfur odorants can be detected by the human nose at very low levels, and odors can cause health symptoms at levels below the detection limits of any currently available monitoring device

Table 6. Concentrations of sulfur odorants (t-Butyl mercaptan and tetrahydrothiophene) from the triggered and grab samples collected inside the Facility and throughout the Porter Ranch community.

Sample Type	Sample Date	Location	t-Butyl mercaptan	Tetrahydrothiophene
Triggered	1/24/2016	Site #4	N.D.	N.D.
Triggered	1/27/2016	Site #4	N.D.	N.D.
Grab	1/27/2016	Site #4	N.D.	N.D.
Triggered	1/27/2016	Site #4	N.D.	N.D.
Grab	1/27/2016	Sesnon Blvd & High Glen Way	N.D.	N.D.
Triggered	1/27/2016	Site #4	N.D.	N.D.
Triggered	1/28/2016	Site #4	N.D.	N.D.
Triggered	2/1/2016	Site #4	N.D.	N.D.
Triggered	2/2/2016	Site #4	N.D.	N.D.
Grab	2/4/2016	Lurline Ave, Chatsworth	N.D.	N.D.
Triggered	2/9/2016	Site #4	N.D.	N.D.
Triggered	2/9/2016	Site #4	N.D.	N.D.
Triggered	2/10/2016	Site #4	N.D.	N.D.
Grab	2/16/2016	Site #6	N.D.	N.D.
Grab	2/16/2016	Site #4	N.D.	N.D.
Grab	2/16/2016	Site #3	N.D.	N.D.
Grab	2/17/2016	Site #4	N.D.	N.D.
Grab	2/17/2016	Site #3	N.D.	N.D.
Grab	2/17/2016	Site #6	N.D.	N.D.
Grab	2/18/2016	Site #4	N.D.	N.D.
Grab	2/18/2016	Site #3	N.D.	N.D.
Grab	2/18/2016	Site #6	N.D.	N.D.
Grab	2/19/2016	Site #4	N.D.	N.D.
Grab	2/19/2016	Site #3	N.D.	N.D.
Grab	2/19/2016	Site #6	N.D.	N.D.
Triggered	4/7/2016	Site #4	N.D.	N.D.
Grab	4/13/2016	Site #4	N.D.	N.D.
Grab	4/13/2016	Pesaro	N.D.	N.D.
Grab	4/13/2016	Index St	N.D.	N.D.
Grab	4/26/2016	So Cal Survey East SS-25 Storm Drain	N.D.	N.D.
Grab	4/26/2016	So Cal Survey East SS-25 Storm Drain	N.D.	N.D.
Grab	4/26/2016	So Cal Survey East SS-25 Storm Drain	N.D.	N.D.
Triggered	6/17/2016	Site #4	N.D.	N.D.
Triggered	7/10/2016	Site #4	N.D.	N.D.
Triggered	7/15/2016	Site #4	N.D.	N.D.
Triggered	7/21/2016	Site #4	N.D.	N.D.
Triggered	7/22/2016	Site #4	N.D.	N.D.
Triggered	7/29/2016	Site #4	N.D.	N.D.
Triggered	8/16/2016	Site #4	N.D.	N.D.
Triggered	8/19/2016	Site #4	N.D.	N.D.
Triggered	8/26/2016	Site #4	N.D.	N.D.
Triggered	9/2/2016	Site #4	N.D.	N.D.
Triggered	9/11/2016	Site #4	N.D.	N.D.
Triggered	9/23/2016	Site #4	N.D.	N.D.
Triggered	9/26/2016	Site #4	N.D.	N.D.
Triggered	9/30/2016	Site #4	N.D.	N.D.
Triggered	10/3/2016	Site #4	N.D.	N.D.
Triggered	10/8/2016	Site #4	N.D.	N.D.

N.D.= Non-detect, below method detection limit

4.2. Grab Samples

Table 7 summarizes the concentrations of methane and selected VOCs (i.e., BTEX and styrene) from the grab samples collected from several locations in the Porter ranch community. While the SS-25 Well was actively leaking, concentrations of methane were substantially higher (up to 616 ppm) than the typical levels (i.e., 2-3 ppm). Levels of methane from all of the grab samples collected after the full closure of the well were between 2-3 ppm. Concentrations of BTEX and Styrene from these samples were consistently below their corresponding acute RELs even during the period of the leak.

Table 7. Concentrations of methane and selected VOCs from the grab samples collected throughout the Porter Ranch community.

Sample Date	Location	methane (ppm)	benzene (ppb)	toluene (ppb)	ethylbenzene (ppb)	m+p-xylene (ppb)	o-xylene (ppb)	styrene (ppb)
10/26/15	19400 Block Kilfinen	616	3.0	3.4	0.2	1.2	0.2	0.1
11/03/15	19400 Block Kilfinen	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
11/12/15	20070 Block Sesnon Blvd.	14	0.2	0.2	N.D.	N.D.	N.D.	N.D.
11/13/15	20050 Block Sesnon Blvd.	67	0.7	0.9	N.D.	0.6	0.1	N.D.
11/17/15	19900 Block Crystal Hills Lane	49	0.2	0.2	N.D.	0.1	N.D.	N.D.
11/20/15	Crystal Springs Circle	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
11/22/15	Site #4	-	1.3	1.8	0.2	1.1	0.2	N.D.
12/08/15	19500 Block Turtle Ridge Ln.	17	0.3	1.1	0.2	0.8	0.2	N.D.
12/18/15	High Glen Way	37	0.3	0.7	N.D.	0.9	0.1	N.D.
12/18/15	Crystal Hills & Eagle Ridge Way	22	0.3	0.4	N.D.	0.2	N.D.	N.D.
12/18/15	Crystal Hills & Eagle Ridge Way	24	0.5	1.1	N.D.	1.1	0.2	0.2
12/23/15	19800 Block S. Falcon Crest	28	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
04/13/16	Killoch	2	0.2	0.5	N.D.	0.2	N.D.	N.D.
04/13/16	Site #4	2	0.2	0.6	N.D.	0.2	0.1	N.D.
04/13/16	Crystal Hills	2	0.2	0.4	N.D.	0.2	N.D.	N.D.
04/13/16	Pesaro	2	0.2	0.5	N.D.	0.2	N.D.	N.D.
04/13/16	Index St	2	0.2	0.4	N.D.	0.1	N.D.	N.D.
05/04/16	Site #4	3	0.2	0.5	N.D.	0.2	N.D.	N.D.

N.D.= Non-detect, below method detection limit

4.3. Mobile Platform Measurements

When the leak was on-going, mobile surveys often detected elevated levels of methane in Porter Ranch. The highest methane concentrations, sometimes reaching up to 70 ppm, were observed mostly on the northern portion of this community, along Sesnon Boulevard (Figure 2). After Well SS-25 was sealed, methane levels south of Aliso Canyon and throughout the SFV were almost always close to background (~2-3 ppm). Figure 31 shows three representative maps of methane

concentration measured by the mobile platform in the Porter Ranch area during the leak and two days and three months after the leak was controlled.

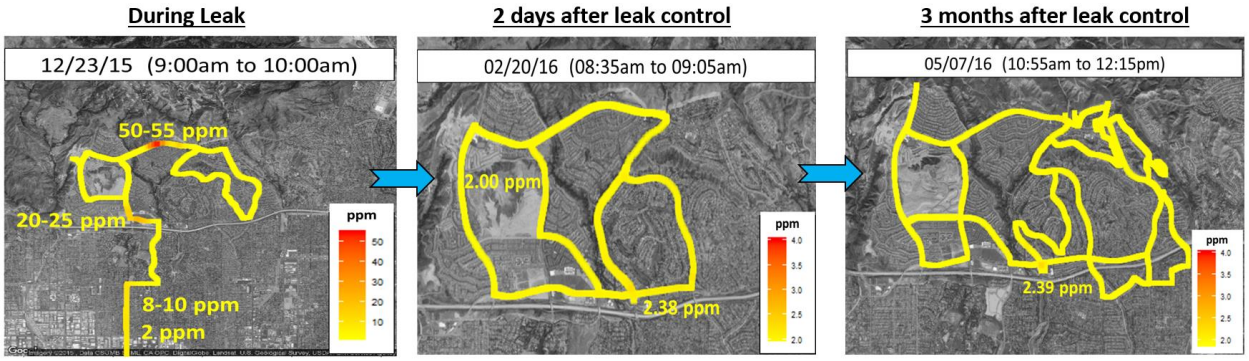

Figure 31. Three representative maps of methane concentrations measured by the mobile platform in Porter Ranch.

During this monitoring campaign, we also conducted numerous mobile methane surveys in the vicinity of schools in the SFV to evaluate whether these locations were impacted by gas emissions from the Aliso Canyon Facility. Figures 32 shows the methane concentration maps from two surveys conducted during the leak at 15 different schools throughout the SFV. The methane concentration was found to be close to or slightly above background levels at all of these schools.

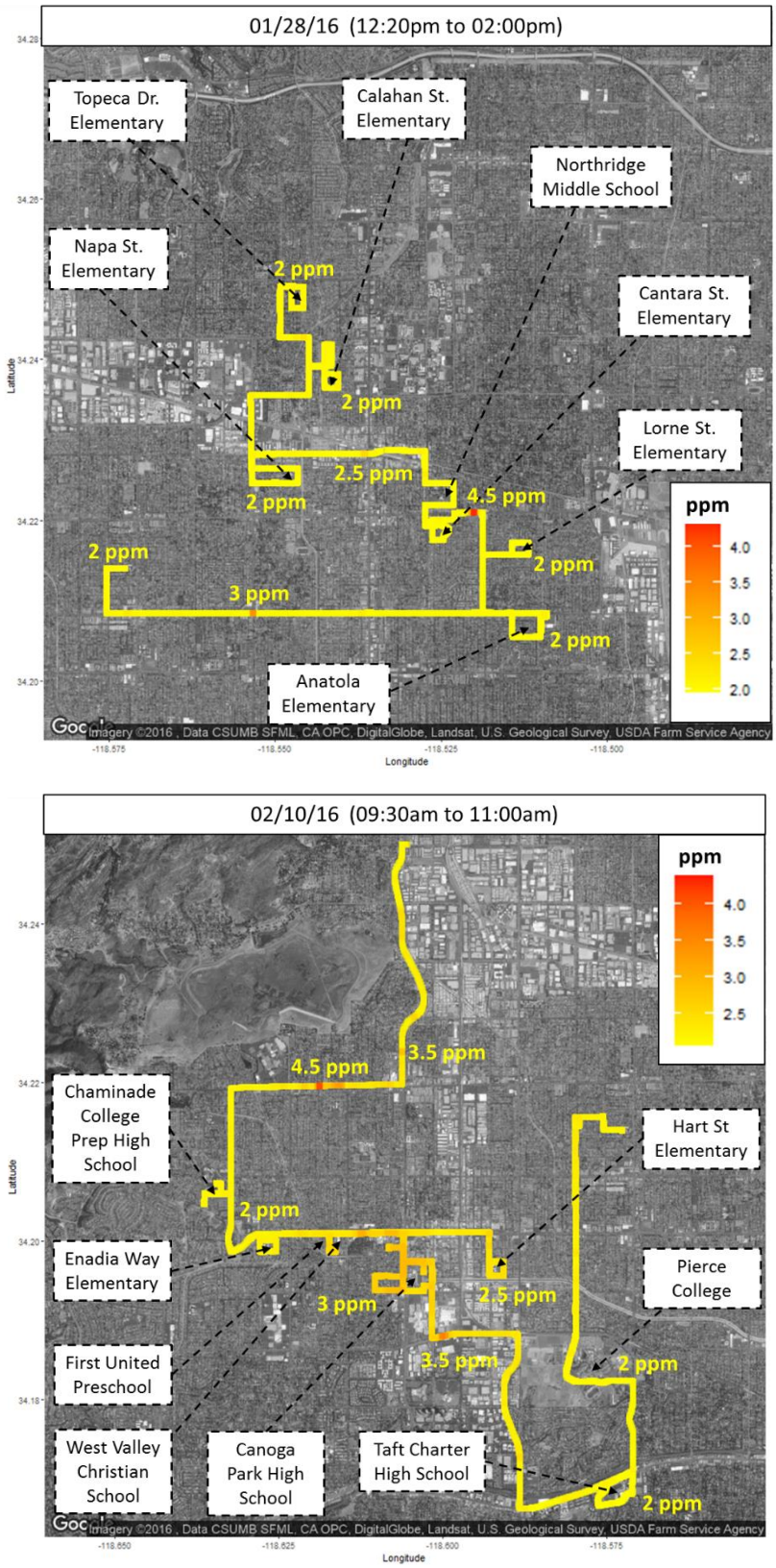

Figure 32. Maps of methane concentrations around different schools in the San Fernando Valley from two mobile surveys during the gas leak.

The mobile monitoring data collected inside the Facility documented steady decrease of ambient methane levels around SS-25 following the full closure of this Well on February 18, 2016 (Figure 33). However, likely due to off-gassing of residual methane from the soil, valves, and other equipment around the wellhead, our mobile surveys occasionally detected elevated methane concentrations in the vicinity of SS-25 for several months following the closure of the Well. These ephemeral events did not result in any considerable methane increase in the ambient air within the adjoining communities. The concentration maps from three representative surveys conducted in February, April, and June 2016 also show a clear downward trend in methane levels inside the Facility (Figure 34) over the months following the closure of the leaking well. As mentioned earlier, the results for all of the mobile surveys inside the Facility can be found on the SCAQMD's website[1].

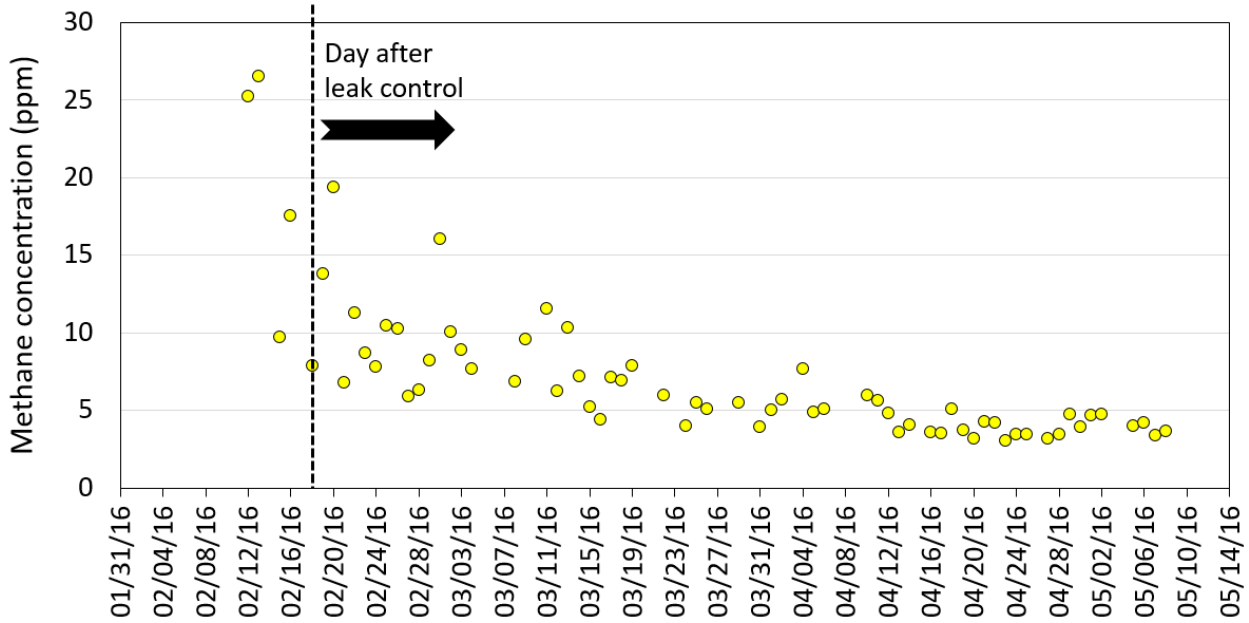

Figure 33. Average methane concentrations measured by the SCAQMD's mobile methane monitor near the SS-25 Well.

[1] http://www.aqmd.gov/home/regulations/compliance/aliso-canyon-update/air-sampling/xxx

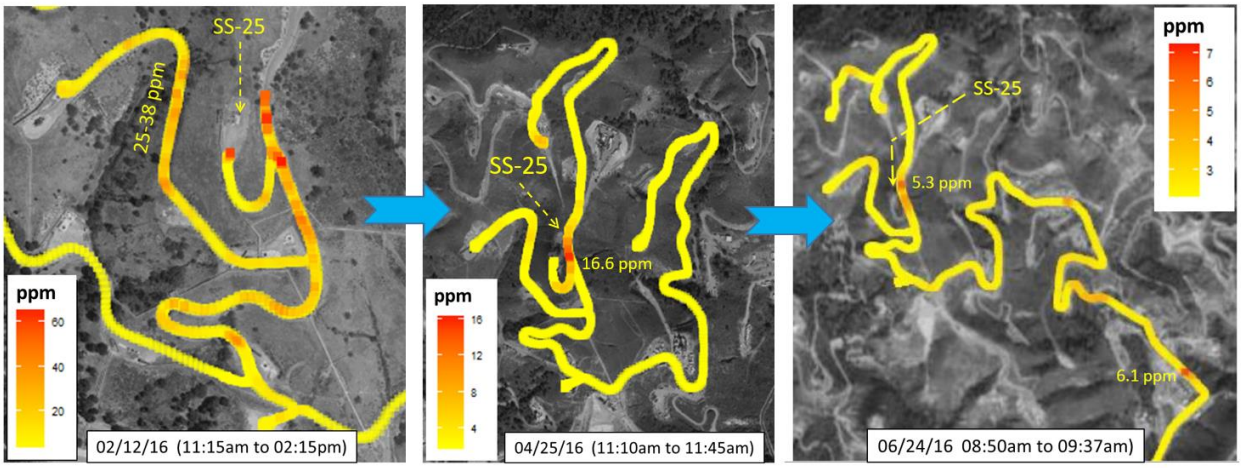

Figure 34. Maps of methane concentrations inside the Aliso Canyon Facility from three representative surveys conducted in February, April, and June 2016.

5. Conclusions

Shortly after the Aliso Canyon natural gas leak was discovered, SCAQMD and CARB began monitoring air quality throughout the nearby communities in October 2015 and SCAQMD continued its monitoring efforts until July 2017. Results from this 20-month long air monitoring campaign indicated that elevated levels of methane were measured in ambient air while the SS-25 Well was actively leaking, and that measured methane concentrations decreased substantially following the permanent sealing of the Well on February 18, 2016, and no longer exceeded the 24-hr average 3 ppm criteria (set by CARB and SCAQMD for this study) at any of the monitoring locations. The ambient concentrations of toxic VOCs (i.e., BTEX and styrene) measured from nearly all of the air samples collected at multiple locations in the Porter Ranch neighborhood were below the acute RELs during the active leak and after the well was sealed. Similarly, levels of sulfur-containing compounds as well as toxic carbonyls (i.e., formaldehyde and acetaldehyde) were below the acute RELs throughout the entire duration of this study. Moreover, the long-term average concentrations of the measured toxic air contaminants were substantially lower than their corresponding chronic RELs. Levels of benzene from 24-hr time-integrated samples during the leak period were comparable to typical levels for the South Coast Basin, as determined recently from the MATES IV study. Additionally, a comparison of the air toxic levels after February 18, 2016 with MATES IV measurements indicate that the concentrations of all of the air toxics

measured in Porter Ranch and other parts of the SFV were either within the range or lower than what was measured elsewhere in the Los Angeles Basin in 2012-2013.

Overall, results from this air monitoring campaign (October 2015 – July 2017) indicate that after the full closure of the SS-25 Well, air quality in the communities near the Facility returned to background levels. While SCAQMD concluded its stationary air quality monitoring in the Porter Ranch community, staff will continue to perform periodic mobile and on-site inspections. In addition, SCAQMD will consistently monitor the levels of methane from the existing monitoring network (established by SoCalGas) and re-deploy the monitoring efforts, if deemed necessary. Moreover, to further address the impacts of the well rupture at Aliso Canyon and resulting emissions, an independent health study will be conducted. This study will examine the unexplained health symptoms that were reported during and after the massive gas leak and address the potential toxicity of the species for which there is no established REL (e.g., mercaptan odorants).

Lastly, it is noteworthy that a series of monitoring, measurements, and analysis were conducted by other agencies (e.g., CARB, LADPH, OEHHA) as well. These efforts include but not limited to indoor air monitoring, aircraft studies, mobile tracer flux ratio studies, and satellite remote sensing. The report[1] published by the Interagency Task Force on Natural Gas Storage Safety has summarized all of these monitoring efforts.

[1] https://energy.gov/under-secretary-science-and-energy/downloads/report-ensuring-safe-and-reliable-underground-natural