Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

Fifth Annual Report of Ambient Air Quality Monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School: A Five-Year Summary November 22, 2007–November 21, 2012

Annual Report Prepared for
Planning Department, City of Los Angeles
Los Angeles, California

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Fifth Annual Report of Ambient Air Quality Monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School: A Five-Year Summary November 22, 2007–November 21, 2012

Annual Report
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On the cover: Sunshine Canyon Landfill.

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Executive Summary

Continuous monitoring of meteorological and air quality parameters began at the Sunshine Canyon Landfill (Landfill) and at Van Gogh Elementary School (Community) in the nearby community of Granada Hills in fall 2007. Ambient concentrations of particulate matter less than 10 microns in aerodynamic diameter (PM_{10}) are determined by integrated hourly measurements employing a beta attenuation monitor (BAM). Wind speed and wind direction are measured as 1-minute averages, and black carbon (BC)—a surrogate for diesel particulate matter (DPM)—is measured as 5-minute averages. All data are reported as hourly averages. The collected data undergo quarterly validation and are evaluated for completeness. PM_{10} concentrations are compared with federal and state PM_{10} standards and with the historical, regional, and annual ambient PM_{10} concentrations. The PM_{10} and BC data undergo further analysis to characterize the impact of landfill operations on ambient air quality on a neighborhood scale. The validated hourly data and a summary of the analytical results and field operations are reported to the Planning Department of the City of Los Angeles, and to the Los Angeles County Department of Regional Planning, quarterly and annually.

This Fifth Annual Report includes data summaries, accompanied by analysis and interpretation, drawn from five complete years of continuous monitoring of PM_{10}, BC, and meteorological data at the Landfill and Community monitoring sites. This represents an extensive repository of highly temporally resolved data. These annual data sets, characterized by high data quality, increase the level of confidence for inferences made from comparisons with standards, from comparisons between the two sites, from observed seasonal or annual trends, and from comparisons with regional observations reported by South Coast Air Quality Management District (SCAQMD) monitoring sites in the South Coast Air Basin (SoCAB). Baseline-year data, collected between November 22, 2001, and November 21, 2002, at the Landfill and Community monitoring sites, can provide additional historical perspective. This annual report uses the available data to characterize ambient PM_{10} and BC concentrations on a neighborhood scale and in the context of the SoCAB, and to continue to evaluate the impact of landfill operations on air quality in the community.

This report is parallel in format to previous years' Annual Reports, with analysis and discussion based on multiple years of sampling, but updated with results from the fifth year. Some sections, such as those covering methodology, are repeated from previous years for clarity and to keep discussion of results within the framework of the ongoing monitoring program. The specific analytical approaches include evaluation of PM_{10} exceedances, regional comparisons of PM_{10}, effects of meteorology and work activity level on ambient concentrations of PM_{10} and BC, quantitative estimates of the contributions of landfill operations to ambient concentrations of PM_{10} and BC, and landfill gas (LFG) sampling.

Combined with the previous four years of data, the fifth year of monitoring results reinforces the following general conclusions, by category:

- PM_{10} exceedances
  - The Landfill site is more prone to exceeding the Federal 24-hr PM_{10} standard than is the Community site (thirteen exceedances versus two exceedances, respectively, over five years).
  - PM_{10} exceedances at the Landfill site are accompanied by high average wind speeds within a narrow wind direction sector over the landfill from the northwest.
  - PM_{10} exceedances at the Community site are accompanied by exceedances at the Landfill site and by elevated regional PM_{10} concentrations, suggesting a synergy between regional concentrations and landfill impacts.
  - PM_{10} exceedances at the Landfill site and Community site cannot be attributed to regional PM_{10} concentrations alone, since there were no exceedances recorded at the nearby regional sites on days with exceedances at the Landfill site.
  - 2010 was the only year in which there were no exceedances of the Federal 24-hr PM_{10} standard at the Landfill site.
- Regional comparisons of PM_{10}
  - For 2008, 2009, and 2010, monthly average PM_{10} concentrations at the Landfill site and at the Community site were lower than those measured in downtown Los Angeles (North Main Street, continuous monitor). During 2011, there were six monthly averages from the Landfill monitor and four monthly averages from the Community monitor that exceeded the Los Angeles average, with a majority occurring atypically during summer months of onshore wind flow. During 2012, there were five monthly averages from the Landfill monitor that exceeded the Los Angeles average; however, three months (including July, August, and December) could not be compared due to incomplete data at one or both sites.
  - Annual average PM_{10} concentrations at the Landfill site and the Community site are higher than those measured in Santa Clarita (1-in-6 day Federal Reference Method [FRM]).
  - On average, regional influences remain large compared to landfill impacts. The observed patterns in seasonal or monthly average PM_{10} concentrations, within years, are similar among the Landfill site, the Community site, downtown Los Angeles (North Main Street), Burbank (West Palm), and Santa Clarita. However, the neighborhood-scale impacts of the landfill are apparent during discrete time periods, which are typically characterized by high wind speeds from the northwest.
- Wind direction and work activity level can impact the ambient concentrations of PM_{10} and BC. According to the five-year averages,
  - During the highest activity levels (working hours on working days),
    - When the wind is from the SoCAB, the Landfill and Community monitors measure about the same median PM_{10} and BC concentrations.

- When the wind is from the SoCAB, the Community monitor measures almost three times the median concentration of PM_{10} and about four times the median concentration of BC as when the wind is from the landfill.
- When wind is from the landfill, the Community PM_{10} and BC concentrations are about one-half of those measured at the landfill.

– During the lowest activity levels (non-working days),

- Ambient concentrations of PM_{10} and BC are lower on non-working days, but the extent of the decrease is influenced by wind direction:
  – For PM_{10}, the proportional decrease in daytime (working hours) ambient concentrations between working and non-working days was larger when wind direction was from the landfill (approximately 67% lower) than when it was from the SoCAB (about 17% lower), reflecting the larger regional PM_{10} influence of the SoCAB under these wind conditions.
  – For BC, the proportional decrease in daytime (working hours) concentrations between working and non-working days was larger than that observed for PM_{10}. Compared to working hours, BC concentrations during non-working hours decreased by a factor of 2 or 3 when winds were from the landfill, and by a factor of 1 when winds were from the SoCAB.

- Quantitative estimates of landfill impacts on ambient concentrations of PM_{10} and BC during working days when wind direction is from the landfill suggest that

– For PM_{10}

- The landfill is contributing small amounts of PM_{10} to concentrations monitored at the Community site, except during Year 3. This additional contribution is estimated to be 4, 6, 9, 5, and 6 μg/m^3, respectively, for the last five consecutive years. The 23% increase from Year 4 to Year 5 has continued the former trend of increasing contributions from Year 1 to Year 3, which was reversed by the decrease between Year 3 and Year 4.
- The estimated landfill PM_{10} contribution as measured at the Landfill site is, depending on year, a factor of 1 to 6 times greater than the estimated contribution to PM_{10} concentrations at the Community site. As measured at the Landfill monitor only, the Landfill's contribution to hourly average PM_{10} concentrations increased until Year 4, but decreased in Year 5. For Years 3, 4, and 5, the landfill has still accounted for the majority of the PM_{10} recorded by the monitor there. This trend is not seen in the Community monitor's data.
- The substantial increases in PM_{10} attributed to the landfill from Year 1 through Year 4, and the decrease in Year 5, at the Landfill site are not duplicated at the Community monitor; this suggests that the Landfill is a local source that minimally impacts neighborhood- or regional-scale measurements.

– For BC

- Annual landfill contributions to ambient BC concentrations are substantial at the Landfill monitor, but low and stable in the Community till Year 4. In Year 4, the

Landfill contribution to Community BC levels averaged close to zero (-0.01 µg/m^3, within the monitor's measurement error). In Year 5, the landfill contribution at the Community site increased significantly and became the highest among three categories for the first time in the five years of this study.

- As measured at the Landfill BC monitor, the landfill contribution to ambient BC concentrations declined by 50% from Year 1 to Year 2, but then increased from Year 2 to Year 3 and from Year 3 to Year 5. These increases in measured BC concentrations at the Landfill are assumed to be associated with a general increase in landfill activities or scope of operations.
- The estimated landfill contribution to BC concentrations as measured at the Landfill site is, depending on year, a factor of 3 to 10 times greater than the estimated contribution at the Community site.

- LFG sampling
  - Ambient concentrations of LFG in samples collected over the last four years have generally been either within range of Los Angeles regional levels or below the method detection limits (MDLs). Methane levels have been near the global average ambient concentrations of ~1.8 ppmV. A few isolated short-term spikes in volatile organic compounds (VOCs) have been detected, but to date no strong correlation is evident between spikes in concentrations measured at the Landfill site and those measured at the Community site.

1. Introduction

Two air quality monitoring sites were established by operators of the Sunshine Canyon Landfill in 2001. One monitoring site is located on a high-elevation ridge on the southern edge of the Sunshine Canyon Landfill (Landfill site). The second site is located at Van Gogh Elementary School in the nearby community of Granada Hills (Community site). These sites were established to monitor particulate matter less than 10 microns in aerodynamic diameter (PM_{10}), black carbon (BC) as a surrogate for diesel particulate matter (DPM), wind direction, and wind speed, in fulfillment of the stipulations set forth in the City of Los Angeles' Conditions of Approval for the expansion of the Sunshine Canyon Landfill in the City of Los Angeles (Section C.10.a of Ordinance No. 172,933). In 2009, The County of Los Angeles Department of Regional Planning and Public Works adopted conditions (County Condition 81) very similar to the City's conditions, governing ambient air quality monitoring for the County portion of the landfill. The original Conditions of Approval also required sampling of landfill gas (LFG) on four occasions throughout each year at each of the locations. The LFG sampling requirement was subsequently eliminated as part of the routine monitoring contract. Since April 2010, BFI/Republic has been operating the Sunshine Canyon Landfill under a Stipulated Order for Abatement (SOA) issued by the Air Quality Management District (AQMD) Hearing Board (a quasi-judicial body separate from AQMD). The SOA includes many operational provisions, and one of the subsequent amendments to the SOA required BFI/Republic to move to one-in-six day sampling of volatile organic compounds (VOCs). As a result of this required higher frequency sampling of VOCs, the four LFG samples are no longer required as part of the City and County Conditions of Approval.

1.1 Baseline Year and Continuous Monitoring

A baseline year of continuous monitoring of PM_{10}, BC, and meteorology occurred between November 22, 2001, and November 21, 2002, and a report of the baseline year results was produced by ENVIRON International Corporation.[1] A baseline study of LFG was conducted in 2003 and served as the basis for the establishment of an LFG monitoring protocol.[2] Between the time that the baseline studies were completed and November 2007, when continuous monitoring began, ambient sampling for PM_{10}, BC, and LFG was planned to be conducted at a nominal frequency of four times each year by ENVIRON International Corporation. Data from those years are not included in this report.

Beginning in 2007, ambient monitoring of particulate matter and LFGs at the Landfill and Community sites became the responsibility of Sonoma Technology, Inc. (STI). STI's technical approach to monitor PM_{10} and BC was based on continuous monitoring (hourly, year-round), whereas previous monitoring was limited to four events per year. Continuous all-year monitoring of PM_{10} and BC allows greater potential for evaluation of times when air flows from the landfill to the Community receptor site at Van Gogh Elementary School, as well as for

[1] ENVIRON International Corporation. (2003) Results of the baseline ambient air monitoring program for the Sunshine Canyon Landfill. Final report prepared for Browning-Ferris Industries of California, Inc., by ENVIRON International Corporation, Contract No. 03-9660A, June 6.
[2] ENVIRON International Corporation. (2003) Proposed landfill gas baseline ambient air monitoring protocol for the Sunshine Canyon Landfill. Report prepared for Browning-Ferris Industries of California, Inc., by ENVIRON International Corporation, Contract No. 03-9660A, March 27.

evaluation of diurnal trends, day-of-week differences, seasonal differences, and annual trends in pollutant concentrations in comparison with regional monitors operated by the South Coast Air Quality Management District (SCAQMD) and the California Air Resources Board (CARB).

November 22, 2012, marked the completion of five full years of continuous monitoring of PM_{10}, BC, and meteorology at the two monitoring locations. Data capture rates and the quality of the captured data have generally been very high. A few discrete events have interrupted data capture at one or both sites; for example, the Sayre Fire in late 2008 took out power at the Landfill monitoring site for several weeks. In addition, equipment upgrades in 2010 caused some loss of data because instruments were temporarily removed. Even with these interruptions, however, annual completeness statistics for the five years indicate average data capture rates of 94.1%, 92.0%, and 94.6% for PM_{10}, BC, and winds, respectively, at the Landfill site, and 97.4%, 95.7%, and 98.1% for PM_{10}, BC, and winds, respectively, at the Van Gogh School site (see Section 2). On average, less than 3% of all captured data were judged as invalid.

1.2 Report Overview

In this report, the high-quality, high-time-resolution data captured over the five years between November 2007 and November 2012 are analyzed and summarized to offer a realistic characterization of ambient air quality concentrations at the two monitoring locations, and to provide perspective on air quality at the landfill and the local community in the context of the greater South Coast Air Basin (SoCAB). Some additional preliminary analyses are provided in **Appendix A**.

Regulatory standards for pollutants are commonly used to judge the compliance status of air districts and air basins. Currently, the only federal health-based standard for PM_{10} is the daily (24-hr) average concentration of (150 $\mu g/m^3$). The State of California's PM_{10} 24-hr standard (50 $\mu g/m^3$) is more stringent than the federal standard. (The previously existing federal annual standard of 50 $\mu g/m^3$ was revoked because of the lack of substantial evidence of health effects attributable to long-term exposures.) In this report, the 24-hr federal standard of 150 $\mu g/m^3$ is used as a benchmark metric for evaluating the specific monitoring locations in relation to each other and to the federal standard.

Regional comparisons of ambient PM_{10} concentrations are used to place the Landfill and Community monitors within the larger context of regional concentrations. For these comparisons, three of the closest regional monitoring sites, operated by the SCAQMD, were chosen: downtown Los Angeles (North Main Street); Burbank (West Palm), and Santa Clarita. **Figure 1-1** shows the relative locations of the sites.

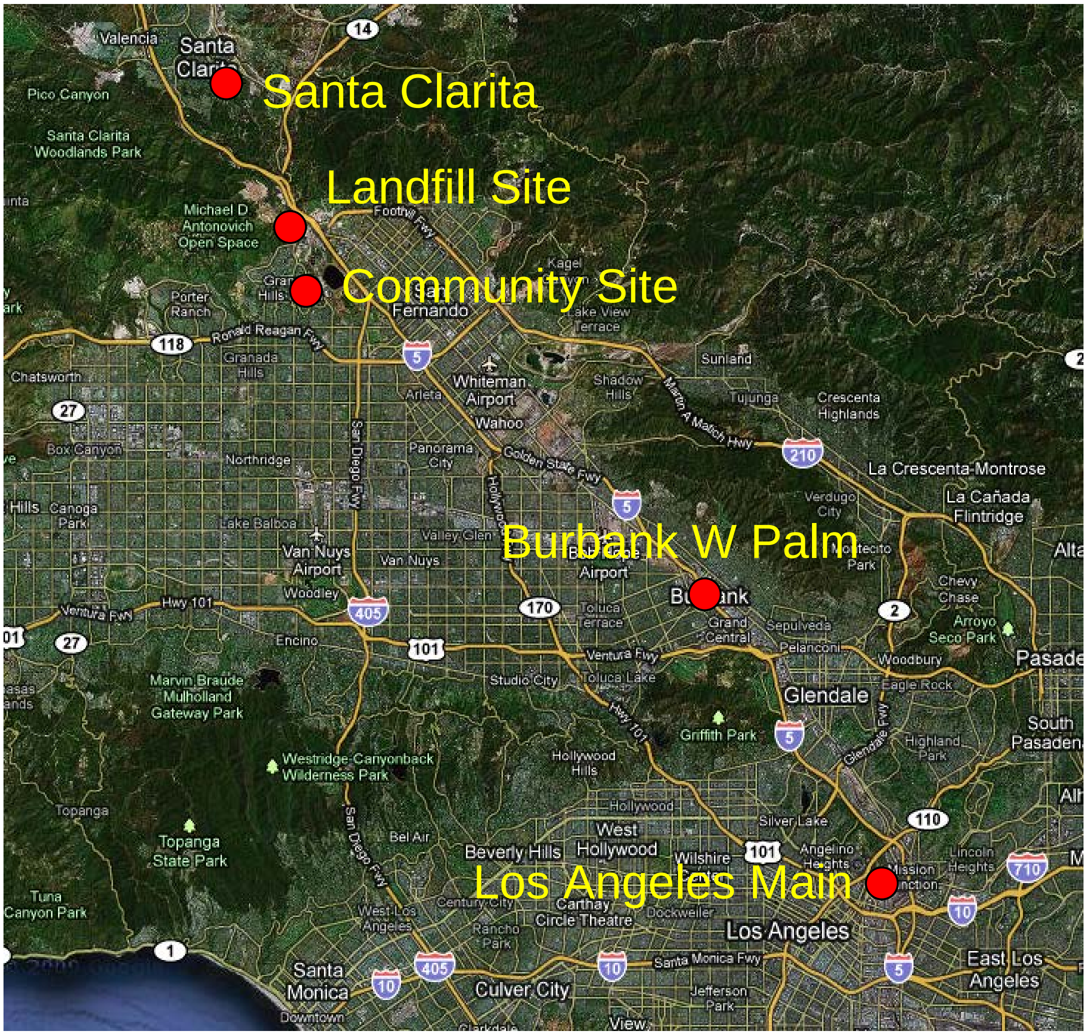


Figure 1-1. Locations of the Landfill and Community monitors in relation to the three SCAQMD sites that are used for regional comparisons.

Meteorological factors and work activity levels are known to have an impact on local and regional pollutant concentrations. An analysis based on wind direction and landfill working versus non-working days and hours is used to quantify the relationship of these factors to PM_{10} and BC concentrations. This analysis also provides quantitative estimates of landfill contributions to ambient concentrations of PM_{10} and BC. A summary of the analytical method is presented in Section 5, with additional preliminary analyses in Appendix A.

One area of concern to the residents of nearby communities is the occurrence of offensive odors. An abatement hearing in March 2010 (SCAQMD Case 3448-13) resulted in several stipulated requirements being placed on landfill operations to help to address the odor problems. However, the frequency of odor complaints continued to increase, and the original Order for Abatement was amended in November 2011 to add several additional stipulated conditions. One of the November 2011 abatement amendments directly affected STI's monitoring protocols. The landfill is now required to conduct 1-in-6 day sampling of VOCs, following established U.S. Environmental Protection Agency (EPA) schedules and protocols. This program, conducted separately from STI's monitoring, effectively made the LFG sampling required under City Conditions of Approval C.10.a redundant. Since June 2012, STI no longer conducts LFG sampling in fulfillment of City Condition C.10.a and County Condition 81.

2. Data Completeness

Table 2-1 gives completeness statistics for all measured variables for the five years considered in this analysis. The percent data capture exceeded 90% for all site years for PM_{10}, except for Year 2 at the Landfill monitoring site. Because the Sayre fire shut down the Landfill monitoring site data collection effort from November 15, 2008, through January 8, 2009, data capture rates were lower for Year 2. Note that the values in this table are based on valid hourly averages and may differ slightly from percentages based on 1-minute or 5-minute data which are presented in the quarterly reports.

Table 2-1. Data completeness statistics for hourly data during Years 1, 2, 3, 4, and 5 of continuous monitoring, and overall five-year averages. The begin and end dates for each year are chosen to allow comparison with the baseline year data collected from November 22, 2001, through November 21, 2002.

Years	Monitoring Location	Percent Data Capture[a] (%)			Percent Data Valid or Suspect (%)[b]			Percent Data Suspect (%)[c]		
		PM_{10}	BC	WS/WD[d]	PM_{10}	BC	WS/WD	PM_{10}	BC	WS/WD
Year 1 November 22, 2007–November 21, 2008	Sunshine Canyon Landfill Site	94.2%	89.0%	88.3%	98.5%	100.0%	100.0%	0.0%	0.0%	0.0%
	Van Gogh Elementary School Site	95.8%	91.5%	93.8%	96.0%	100.0%	100.0%	0.0%	0.0%	0.0%
Year 2 November 22, 2008–November 21, 2009	Sunshine Canyon Landfill Site	86.6%	86.0%	86.8%	97.9%	100.0%	100.0%	0.0%	0.0%	0.0%
	Van Gogh Elementary School Site	98.7%	99.5%	99.9%	96.8%	100.0%	100.0%	0.0%	0.0%	0.0%
Year 3 November 22, 2009–November 21, 2010	Sunshine Canyon Landfill Site	99.7%	87.7%	98.4%	98.2%	100.0%	100.0%	0.0%	0.0%	4.3%
	Van Gogh Elementary School Site	98.4%	87.8%	98.3%	97.0%	100.0%	100.0%	0.3%	0.0%	0.0%
Year 4 November 22, 2010–November 21, 2011	Sunshine Canyon Landfill Site	91%	99.6%	100.0%	96.9%	99.9%	99.9%	0.0%	0.0%	4.2%
	Van Gogh Elementary School Site	100%	99.7%	99.9%	99.2%	99.9%	97.5%	0.0%	0.0%	1.6%
Year 5 November 22, 2011–November 21, 2012	Sunshine Canyon Landfill Site	99%	97.6%	99.4%	95.4%	100.0%	100.0%	5.0%	0.0%	1.0%
	Van Gogh Elementary School Site	94%	99.8%	98.7%	98.1%	100.0%	96.1%	0.0%	0.0%	0.0%
Five-Year Average	Sunshine Canyon Landfill Site	**94.1%**	**92.0%**	**94.6%**	97.4%	100.0%	100.0%	1.0%	0.0%	1.9%
	Van Gogh Elementary School Site	**97.4%**	**95.7%**	**98.1%**	97.4%	100.0%	98.7%	0.1%	0.0%	0.3%

[a] Percent Data Capture is the percent of hourly data values that were collected divided by the total number of expected data intervals in the date range (e.g., 24 hourly data values are expected per day, and 8,760 hourly data values are expected per year—8,784 during the 2008 leap year).
[b] Percent Data Valid or Suspect is the percent of data values that are either valid or suspect divided by the number of **captured** data values.
[c] Percent Data Suspect is the percent of data values that are labeled as suspect divided by the number of captured data values.
[d] Wind speed/wind direction.

3. PM$_{10}$ Exceedances

Table 3-1 lists all the days during the past five years of continuous monitoring on which there were exceedances of the Federal 24-hr PM$_{10}$ standard at one or both monitoring sites, along with 24-hr average concentrations from those days at the three comparative SCAQMD sites (Burbank, Santa Clarita, and downtown Los Angeles). The Federal standard was exceeded on 13 occasions at the Landfill site, and on two of those 13 days the Community monitor also registered an exceedance. The SCAQMD sites in Burbank, Santa Clarita, and Los Angeles did not report any exceedances on any of those days. However, the SCAQMD sites did report high 24-hr PM$_{10}$ concentrations on the two days during which the Community monitor recorded PM$_{10}$ exceedances. The downtown Los Angeles monitor was only 3 µg/m^3 below the PM$_{10}$ exceedance threshold on October 27, 2009, and the concentrations measured at Burbank were elevated. The elevated concentrations at other sites suggest that, when regional concentrations are high, a synergistic effect exists between landfill contributions and regional contributions that push the Community site's PM$_{10}$ concentrations over the federal standard. Note that when regional concentrations are low, high 24-hr concentrations at the Landfill monitor, such as those seen during three days in 2011, had no significant effect on Community PM$_{10}$ concentrations.

The Burbank and Los Angeles sites have continuous PM$_{10}$ monitors, like those at the Landfill and Community sites, which report hourly concentrations, but the Santa Clarita site employs Federal Reference Method (FRM) sampling (integrated 24-hr samples on filters) on a 1-in-6 day schedule. Only one of the days listed in Table 3-1 happened to fall on the 1-in-6 day Santa Clarita sample schedule. This serves as a reminder of the utility of continuous monitoring: Note that on October 22, 2007, there was a PM$_{10}$ exceedance at the Landfill site, and the PM$_{10}$ concentration at the downtown Los Angeles site was elevated, but there was no filter sample collected at the Santa Clarita station. It is also of interest to note that on the previous day, October 21, an FRM filter sample at Santa Clarita measured an exceedance of 167 µg/m^3. At the Landfill site on October 21, 12 of the 24 hourly PM10 values were invalid, because the measurements exceeded the maximum of the PM$_{10}$ monitor (1,000 µg/m^3), causing the output to default to error values of 995 µg/m^3. These were consecutive hourly samples between 2:00 a.m. and 1:00 p.m. Because this proportion (50%) of valid samples is below the 75% criteria for valid daily averages, the average for that day was reported as invalid. The 24-hr average PM$_{10}$ concentration at the Community site on October 21 was 115 µg/m^3, with hourly average values ranging from 150 to 294 µg/m^3 between the hours of 3:00 a.m. and noon.

The three exceedances at the Landfill site in 2011, and the October 26, 2012 occurrence, are notable because they exceeded the federal PM$_{10}$ standard by a substantial amount, while concentrations at the Community site and available regional monitoring sites were low on all of those days. After five years of continuous data collection, it is clear that PM$_{10}$ exceedances at the Landfill site are more common than they are in the Community or at regional monitoring sites, suggesting that surface material is being entrained at high wind speeds and subsequently detected by the Landfill monitor. By the time these air parcels reach the Community or regional monitors, they become diluted.

Table 3-1. Summary of 24-hr PM$_{10}$ concentrations at the two monitoring sites and at the Burbank, Santa Clarita, and Los Angeles regional sites operated by SCAQMD on days when a Federal PM$_{10}$ exceedance (more than 150 µg/m^3) occurred at the Landfill site.

Date	Landfill Site PM$_{10}$ (µg/m^3)	Community Site PM$_{10}$ (µg/m^3)	Burbank West Palm PM$_{10}$ (µg/m^3)	Los Angeles Main Street PM$_{10}$ (µg/m^3)	Santa Clarita PM$_{10}$ (µg/m^3)
10/22/2007	183	41	93	108	-- [b,c]
2/14/2008	167	48	19	30	-- [b]
5/21/2008	290	152	119	140	-- [b]
10/9/2008	158	104	-- [b]	59	91
11/15/2008	269 [a]	136	-- [b]	85	-- [b]
1/9/2009	185	71	-- [b]	68	-- [b]
5/6/2009	257	91	-- [b]	49	-- [b]
10/27/2009	239	165	130	147	-- [b]
1/20/2011	207	28	26	46	-- [b]
4/30/2011	221	32	25	40	-- [b]
11/2/2011	263	43	37	56	-- [b]
5/22/2012	186	61	34	76 [b,d]	-- [b]
10/26/2012	227	49	31	40 [b]	-- [b]

[a] Only 6 hours of data available.
[b] No data available.
[c] The previous day at Santa Clarita, 10/21/07, an exceedance of 167 µg/m^3 was recorded.
[d] Only 12 hours of data available.

The PM$_{10}$ exceedances listed in Table 3-1 were generally accompanied by high wind speeds, with wind direction falling within a narrow sector that encompasses the landfill. Wind data from the Landfill site for all exceedance days are plotted as a wind rose overlay in **Figure 3-1**, which is an aerial image of the Landfill. The majority of the winds were from the northwest, passing directly over working areas of the landfill. A smaller, but still significant, proportion of the winds were from the north sector. Wind speeds were highest when the wind direction was from the northwest and from the north. In Figure 3-1, the center point of the wind rose diagram is directly over the location of the monitoring trailer on the south berm site.

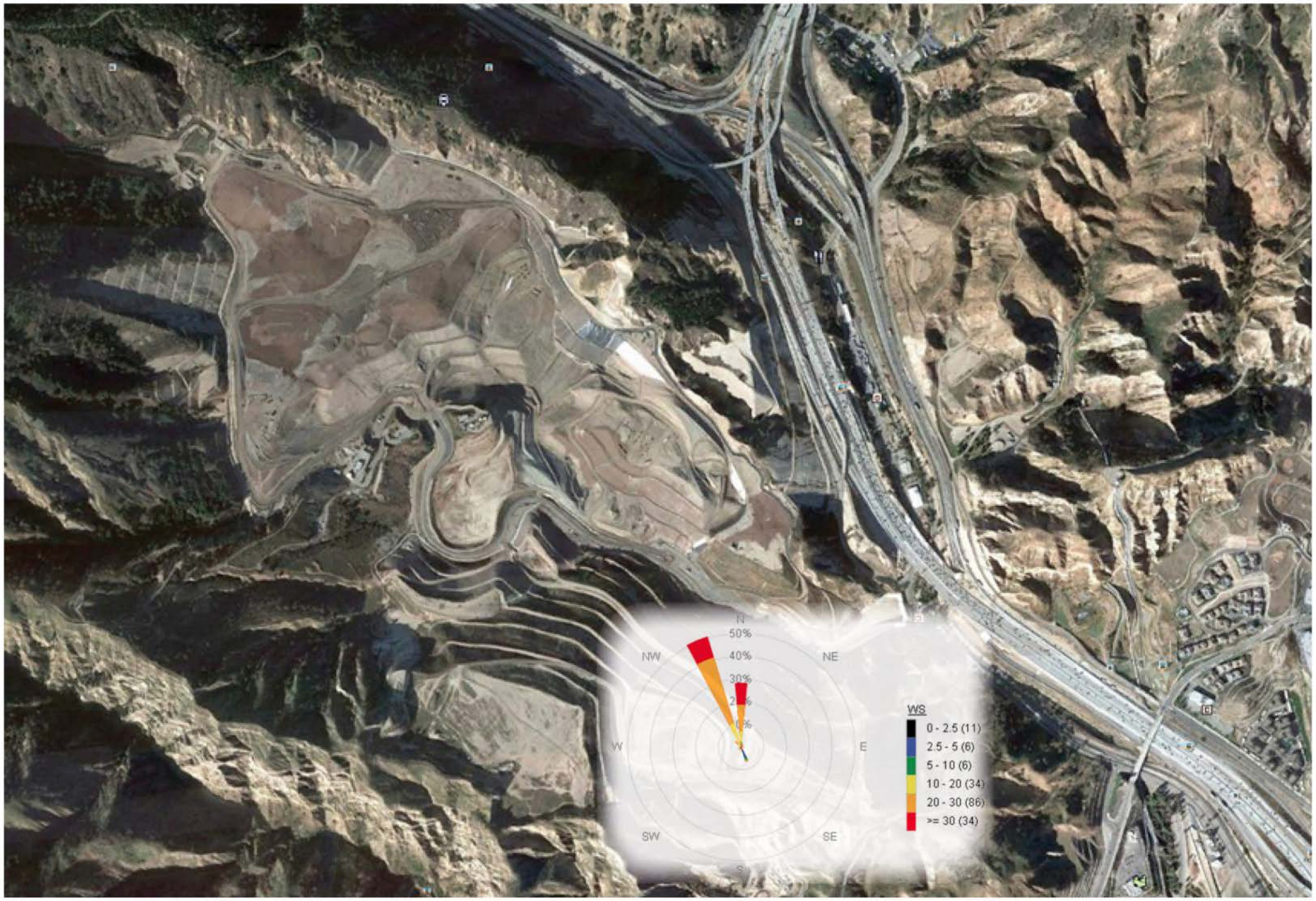


Figure 3-1. Wind rose from exceedance days during five continuous monitoring years at the Landfill monitoring site, illustrating the fetch that encompasses working portions of the landfill. Wind speed units are mph. The wind rose center point is directly over the location of the monitoring site.

4. Regional Comparisons of PM_{10}

Comparing the PM_{10} concentrations measured at the Landfill and Community monitoring sites with those measured at nearby regional monitoring sites places the locally collected data in a larger, more regional, context. The Landfill and Community sites are not isolated. These sites are directly affected by the large SoCAB, and by the nearby highly trafficked freeway system. The sites chosen for comparison, depicted earlier in Figure 1-1, are the closest regulatory sites that conduct routine PM_{10} monitoring. (Note: BC is not monitored at the regional locations.)

Figure 4-1 shows the monthly average PM_{10} concentrations for the Landfill and Community monitoring sites, and for the three regional locations, for 2008 through 2012. For the first three years of continuous monitoring, the SCAQMD monitor at the downtown Los Angeles location recorded, on average, the highest PM_{10} concentrations, with exceptions noted in May 2009 and June/July 2010. (These exceptions were discussed in the *Third Annual Report of Ambient Air Quality Monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School (June 1, 2009–May 31, 2010)*, delivered to the Los Angeles City Planning Department in March 2011.) The regional monitor in Burbank followed a month-to-month pattern similar to the Los Angeles pattern, but at a lower average PM_{10} concentration. The FRM monitor at Santa Clarita, on the very northern edge of the air basin, recorded, on average, the lowest PM_{10} concentrations of the regional sites. From 2008 to 2010, the Landfill and Community measurements tended to track between the Los Angeles and Santa Clarita data.

The 2011 and 2012 monitoring years exhibited a deviation from this pattern, with the Landfill monitor exhibiting the highest average monthly concentrations during the late spring to early fall period. To help understand this atypical pattern and to emphasize the importance of the effect of meteorology on measured pollutant levels, the June through September meteorological data are presented for the years 2010, 2011, and 2012; these data demonstrate that measurements at the two monitoring sites are dominated by regional PM_{10} concentrations originating in the SoCAB.

As shown in Figure 4-1, PM_{10} concentrations in June and July of both 2010 and 2011 at the Landfill and Community sites were higher than those recorded in Los Angeles. PM_{10} concentrations in May and June 2012 and in August and September 2011 were also higher at the Landfill site than at the Los Angeles site, and the Community monitor recorded concentrations similar to, or slightly higher than, those in downtown Los Angeles. (The July and August data for 2012 for the Landfill site are not shown. The landfill PM_{10} monitor recorded suspect data 18.5% of the time during the June through August quarter of 2012 due to a worn flow controller valve that led to erratic sample flow rates. The monthly percent valid PM_{10} data for July did not meet the 75% completeness criteria.) Wind roses in **Figure 4-2** show clearly that the mid-summer elevation in PM_{10} detected at the Landfill and Community monitors is driven by the onshore wind flow prevalent in those months, bringing pollutants from the SoCAB northward. During June through September 2010, nearly 60% of the winds were from the due south sector. Note that during these months in 2011 and 2012, a notable wind direction shift to the south-southeast sector occurred. Greater than 87% of the associated hourly wind speeds during the June to September time period, in all three years, were less than 5 mph, implying that entrainment of crustal material was not a major contributor to PM_{10} concentrations.

The dominance of low speed, south-southeasterly winds from June 2011 through September 2011 was coupled with PM_{10} concentrations at the Landfill monitor that consistently exceeded those of the downtown Los Angeles monitor. This might suggest that the shift in direction in 2011 could account for the higher PM_{10} concentrations. Missing PM_{10} concentrations for July and August 2012 limit the comparison between the two years. However, wind roses for June through September for 2008 and 2009 indicate that the prevailing winds in 2008 were nearly identical to 2011 and 2012, exhibiting the greater proportion of south-southeasterly winds, while 2009 was similar to 2010, with a larger proportion of the winds from due south (data not shown). During those earlier two years, the downtown Los Angeles monitor consistently exhibited the highest PM_{10} concentrations during the June through to September period. The main conclusion drawn from these periods of low-speed, southerly winds is that summertime elevations in PM_{10} concentrations measured at the Landfill and Community sites are not attributable to Landfill activities. The cause for the shift in site rankings between years is not discernible from available data, but hypotheses include additional generation of PM_{10} by activities occurring north of downtown Los Angeles, but south of the Landfill monitor. Alternatively, lower concentrations of PM_{10} might exist at ground level during certain periods in downtown Los Angeles, compared to what was entrained at higher altitudes and carried to the higher elevation sites.

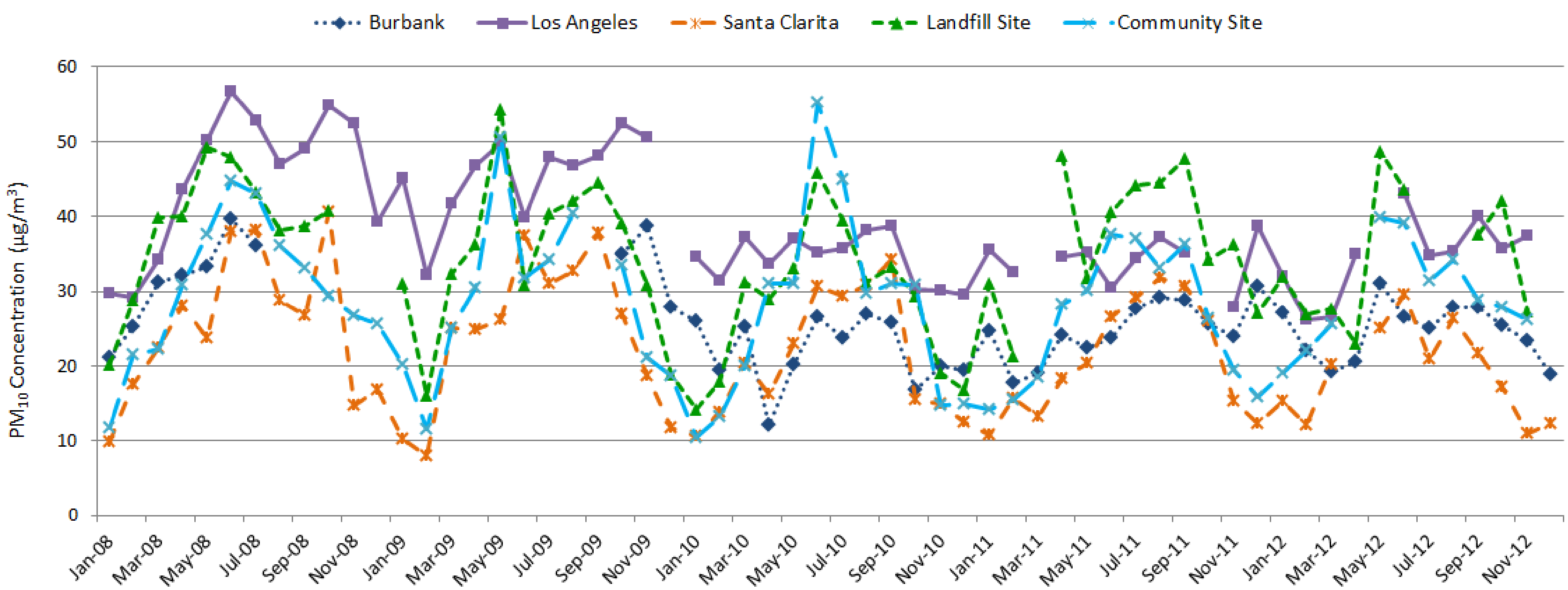


Figure 4-1. Monthly average PM_{10} concentrations for the Landfill and Community sites and three regional monitoring sites for 2008–2012.

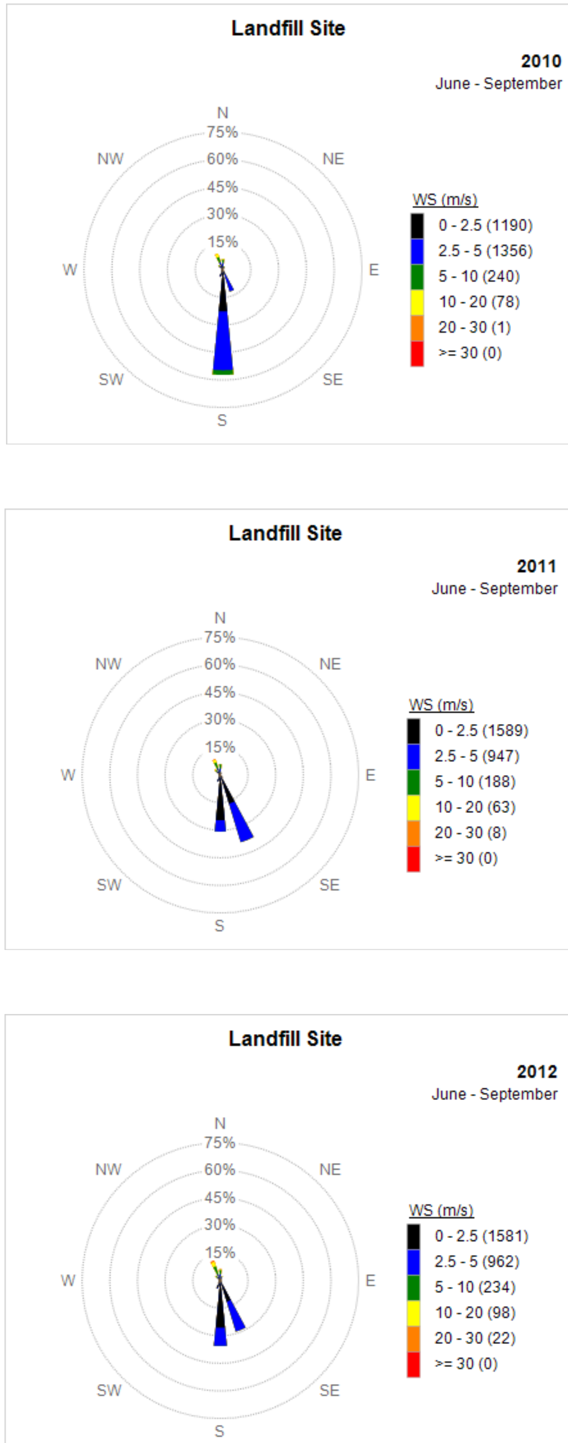


Figure 4-2. Wind roses of hourly data from the Landfill monitor for the months of June through September for 2010, 2011, and 2012 show the dominance of onshore wind flows in the summer, coupled with relatively low hourly averaged wind speeds, and illustrate the shift to SSE winds during 2011 and 2012 compared to 2010.

5. PM_{10} and BC: Effects of Wind Direction and Work Activity Levels

Wind direction and landfill work activity levels affect PM_{10} and BC concentrations measured at the Landfill and Community monitoring sites. As just demonstrated, winds coming from the south, for example, will transport pollutants from densely populated areas of the SoCAB and have a major effect on local pollutant concentrations. Similarly, observations of landfill contributions to neighborhood-scale PM_{10} and BC concentrations are expected under northerly wind flow or under calm conditions, such as early morning, when downslope flows or airflow through canyons and around elevated landforms can have an effect. PM_{10} and BC concentrations would also be expected to vary diurnally, and from day to day, as source strengths increase and decrease with changing activity levels. These activity levels vary with different times of day (e.g., daytime versus nighttime) or between working days and holidays, both regionally and at the local (landfill operations) scale.

The five-year data archive is used here to compare, with long-term averaging, the concentrations of PM_{10} and BC that characterize the Landfill and Community monitoring sites under northerly and southerly wind flows and under differing activity levels. Activity levels are binned according to landfill working and non-working days and working and non-working hours. The five-year averaged results presented in this report concerning the effect of work activity levels on concentrations of PM_{10} and BC are, overall, consistent with those presented in STI's third and fourth annual reports.

5.1 Wind Direction Sectors for Categorizing Data

Data for this analysis were selected using a wind sector to represent the landfill source and areas to the north and a wind sector to represent the area from which pollutants travel from the SoCAB. **Figure 5-1** is an aerial image of the area showing the wind sectors representing the landfill source in black for the Landfill monitor and in green for the Community monitor. Hourly pollution data corresponding to hourly wind direction data that fall within the boundaries of these sectors are used to compute the pollution metrics for working and non-working days (hours). Note that the Landfill monitor's wind sector (greater than or equal to 303 degrees and less than or equal to 360 degrees from true north) is broader than the Community monitor's (greater than or equal to 325 degrees and less than or equal to 355 degrees from true north). The analysis is based only on direction, not on matching times between records. The underlying premise is that long-term averages calculated in this manner more accurately represent true average landfill-derived contributions than do those calculated from matched hourly records, because of the frequent poor wind direction correlation between the two sites. The wind direction correlation between sites is poor due to problems with the siting of the meteorological tower at the Van Gogh School, elevation differences between the sites, and the geographic distance of about one mile. At Van Gogh School, nearby obstructions (e.g., tall trees) deflect the wind, causing localized turbulence and eddies that preclude accurate wind measurements. As a rule of thumb, wind measurements should be made at a minimum horizontal distance of three times the height of any obstruction There are no obstructions at the landfill monitoring site. The landfill site is at 1,722 feet above sea level (ASL), 440 feet higher than the elevation of the Van Gogh School site (1,282 feet ASL). Thus, some hourly records included in an individual monitor's averages do not appear in the other monitor's averages. For average concentrations calculated from the wind sector targeting the SoCAB, both monitors are in the same sector (greater than or equal to 150 degrees and less than or equal to 210 degrees from true north; **Figure 5-2**).

Figure 5-1. Aerial image of the Sunshine Canyon Landfill and the surrounding area, showing the wind direction sectors representing the landfill source used for selecting data for analysis from the Landfill monitor (in black) and the Community monitor (in green).

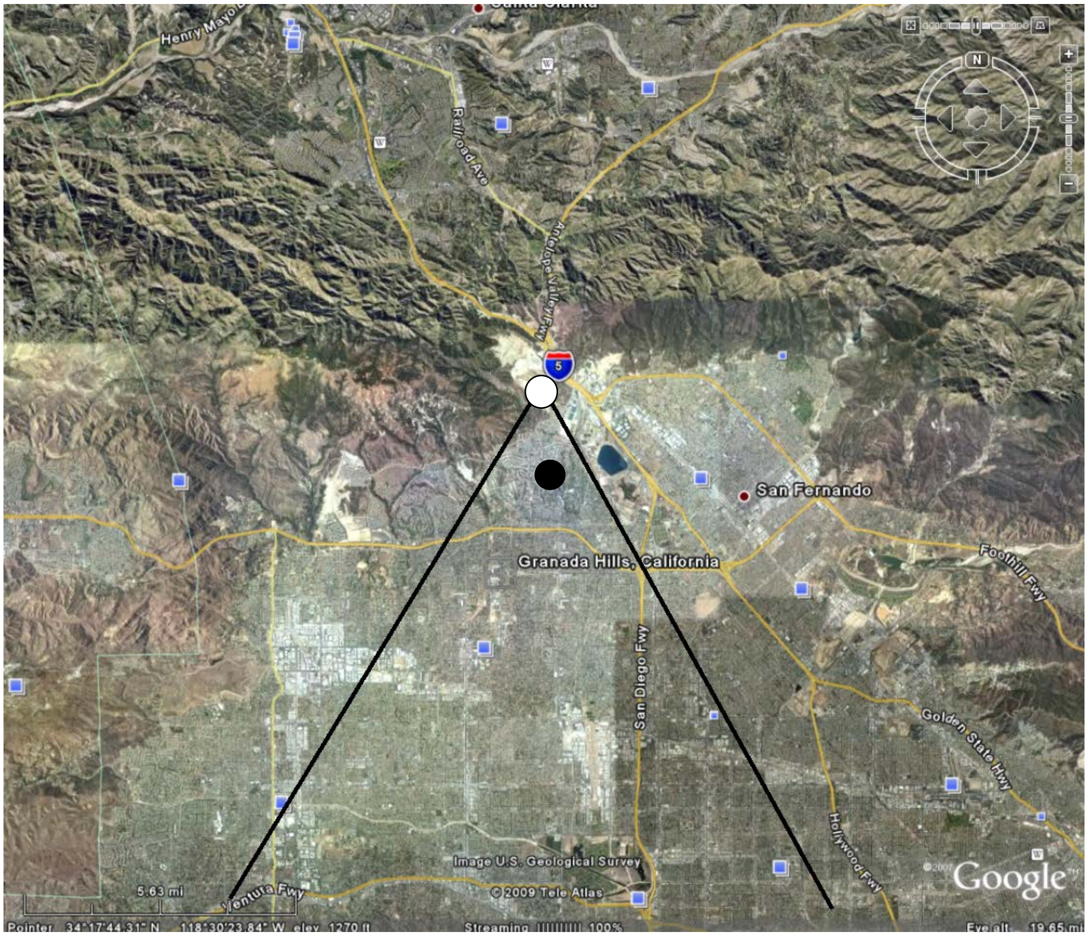


Figure 5-2. Aerial image of the Sunshine Canyon Landfill and the northern portion of the SoCAB, showing the wind direction sector representing the SoCAB source used for selecting data for analysis to compare with the landfill wind direction sectors depicted in Figure 5-1. The white dot represents the Landfill monitor, and the black dot represents the Community monitor.

5.2 Working and Non-Working Days and Hours for Categorizing Data

After the hourly data have been initially binned by the wind direction sectors described above, hourly PM_{10} and BC concentrations are categorized into landfill working and non-working days, and working and non-working hours within those days (based on landfill operations). Working days at the landfill are defined as Monday through Friday, excluding federal holidays. Non-working days are considered Sundays and federal holidays, including New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day; operations occurring on those days would confound the averages to an unknown degree. Additional non-Sunday holidays during which the landfill is closed, but operating, would similarly be incorrectly binned and thus slightly skew the resulting estimated concentration for that category. Saturdays are categorized "mixed use" at the landfill; thus, they do not fit easily into either category. The non-Sunday holidays and Saturdays are excluded from the analysis.

5.3 PM_{10} Concentrations

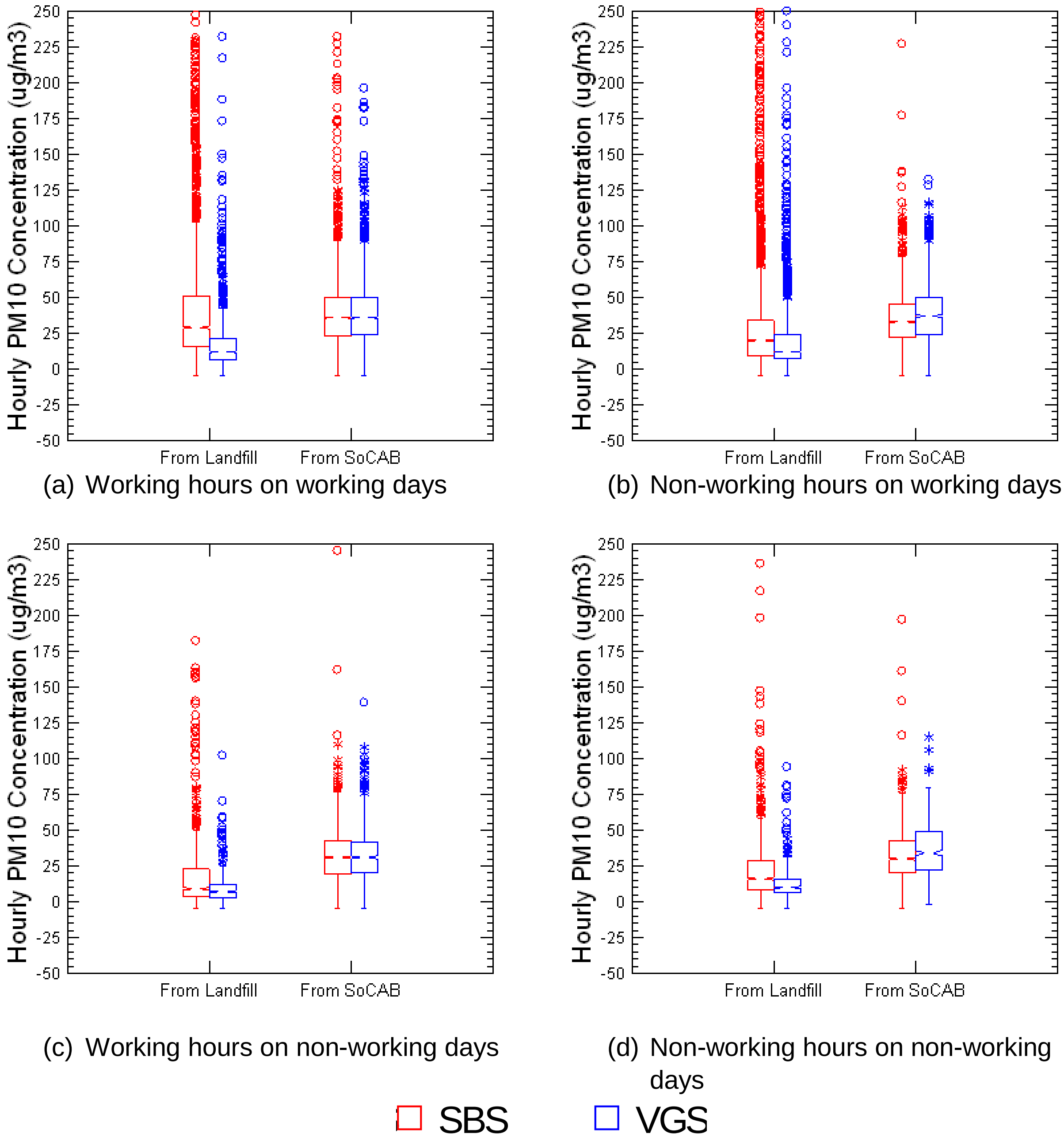
Figure 5-3 summarizes the five-year hourly average PM_{10} concentrations for the northerly and southerly wind sectors for working and non-working days and for working and non-working hours within those days in a notched box-whisker plot.[3] Each box indicates the interquartile range (IQR), where 50% of the data lie, with the notch at the median. If notches do not overlap, this indicates the data are statistically different at the 95% confidence level. The whiskers go to 1.5 times the IQR; points beyond this are shown individually as asterisks, or as circles if they are more than three times the IQR.

The following general conclusions are based on the median values presented in Figure 5-3. Note that these conclusions are nearly identical to those reached in the Fourth Annual Report (delivered in 2012), as are the proportions cited in the following bullets:

- During the highest activity levels (working hours on working days, top panel, left side):
  - When the wind is from the SoCAB, the Landfill and Community monitors measure about the same median concentrations of PM_{10}.
  - When the wind is from the SoCAB, the median concentration of PM_{10} at the Community site is about three times as high as when the wind is from the landfill.
- When wind is from the landfill, median PM_{10} concentrations at the Community site are less than one-half of those measured at the landfill itself, suggesting that although the landfill-derived PM_{10} concentrations are significant, they remain mostly localized to the landfill.
- During non-working hours on working days (top panel, right side):
  - When the wind is from the SoCAB, the Community monitor measures higher PM_{10} concentrations than when wind is from the Landfill. When the wind is from the Landfill, PM_{10} concentrations are lower at both monitoring sites than when the wind is from the SoCAB, and the Community is characterized by lower concentrations than the Landfill monitor, illustrating a localized Landfill contribution during times of low activity (nighttime).
- During the lowest activity levels (non-working days, lower panel):
  - Median ambient concentrations of PM_{10} are lower on non-working days, but the extent of the decrease is influenced by wind direction. At the Landfill site, median ambient PM_{10} concentrations in daytime (working hours) showed a greater proportional decrease on non-working days when wind direction was from the landfill (approximately 67% lower) than on non-working days when wind came from the

[3] A notched box-whisker plot shows the entire distribution of concentrations for each wind sector. In box-whisker plots, each box shows the 25th, 50th (median), and 75th percentiles. The whiskers have a maximum length equal to 1.5 times the length of the box (the interquartile range, IQR). If data are outside this range, the data points are shown on the plot. These "outliers" are further identified with asterisks (representing the points that fall within three times the IQR from the end of the box) and circles (representing the points beyond). These plots also include notches that mark confidence intervals. The boxes are notched (narrowed) at the median and return to full width at the 95% lower and upper confidence interval values. These plots indicate that we are 95% confident that the median falls within the notch. If the 95% confidence interval is beyond the 25th or 75th percentile, then the notches extend beyond the box (hence a "folded" appearance).

SoCAB (approximately 17% lower), reflecting the larger regional PM_{10} influence of the SoCAB on non-working days.



(a) Working hours on working days

(b) Non-working hours on working days

(c) Working hours on non-working days

(d) Non-working hours on non-working days

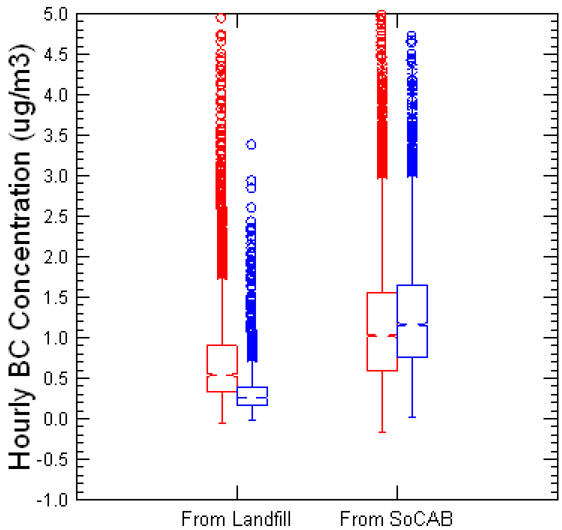
Figure 5-3. Notch box plot of five-year hourly average PM_{10} concentrations for northerly ("From Landfill") and southerly ("From SoCAB") wind sectors for working and non-working days and for working and non-working hours within those days for Landfill monitor site (Sunshine Berm Site [SBS], red box) and Community monitor site (Van Gogh School [VGS], blue box). Outliers over 250 μg/m^3 are not displayed in the box plot.

5.4 BC Concentrations

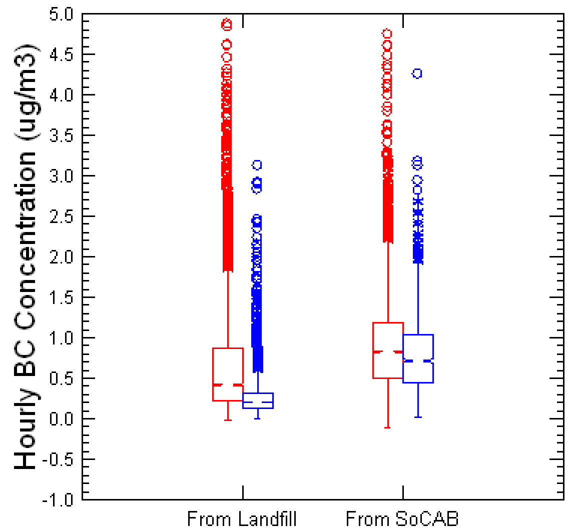
Figure 5-4 summarizes the five-year hourly average BC concentrations for the northerly and southerly wind sectors during working and non-working days and during working and non-working hours within those days in a notched box-whisker plot.

The following general conclusions are based on the median values presented in Figure 5-4. These conclusions are similar to those reached in the Fourth Annual Report, as are the proportions cited in the following bullets:

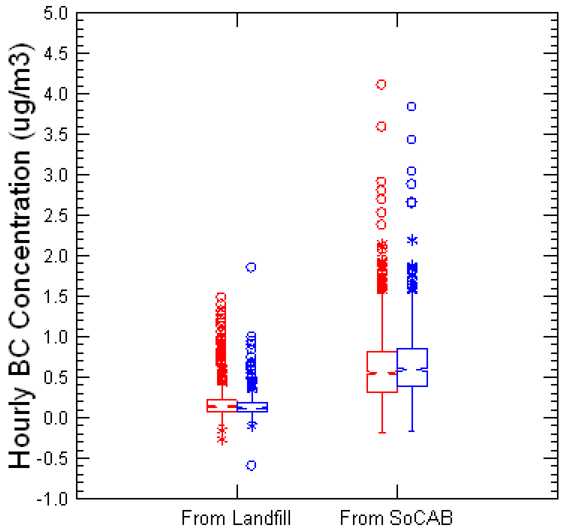
- During the highest activity levels (working hours on working days, top panel, left side):
  - When the wind is from the SoCAB, the Landfill and Community monitors measure similar median BC concentrations.
  - When the wind is from the SoCAB, the Community monitor measures roughly four times the median concentration of BC as when the wind is from the landfill.
  - When wind is from the landfill, the Community BC levels are about one-half of the BC levels measured at the landfill itself.
- During the lowest activity levels (non-working days, lower panel):
  - Median ambient concentrations of BC are lower on non-working days in all categories, but the extent of the decrease is influenced by wind direction. The proportional decrease in BC concentrations on non-working days was larger than the decrease observed for PM_{10}. Compared to working days, BC concentrations on non-working days decreased by a factor of 2 (Community site) or 3 (Landfill site) when winds were from the landfill, and by a factor of 1 when winds were from the SoCAB.



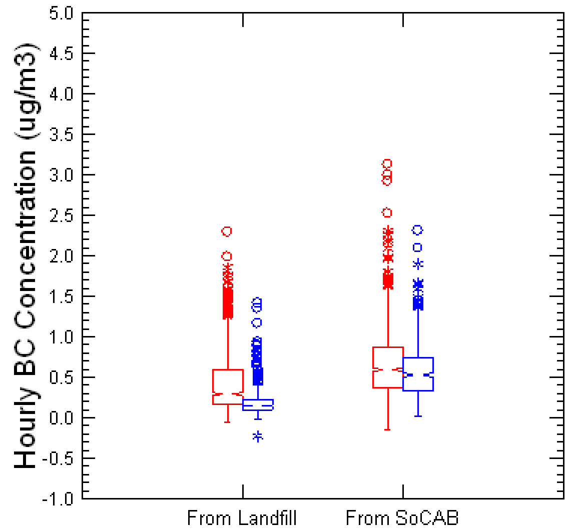
(a) Working hours on working days



(b) Non-working hours on working days



(c) Working hours on non-working days



(d) Non-Working hours on non-working days

SBS VGS

Figure 5-4. Notch box plot of five-year hourly average BC concentrations for northerly and southerly wind sectors for working and non-working days and for working and non-working hours within those days for Landfill monitor site (SBS, red box) and Community monitor site (VGS, blue box). Outliers over 5 µg/m^3 are not displayed in the box plot.

6. Quantitative Estimates of Landfill Impacts on Ambient Concentrations of PM_{10} and BC

Quantitatively estimating the impact of landfill operations on neighborhood-scale ambient air quality is required by the original Conditions of Approval (C.10.a) and the nearly identical County Condition 81. Specifically, the Conditions require determination of “whether air quality near the Landfill is consistent with the supporting environmental documentation for the City Project (i.e., the City’s Final Supplemental Environmental Impact Report or ‘FSEIR’).” The FSEIR reported the emissions estimates of pollutants likely to result from landfill operations, modeled by the Industrial Source Complex Short Term (ISCST3) regulatory model. Beginning with baseline year data (November 22, 2001–November 21, 2002) and continuing through 2008, no attempt was made to specifically address this requirement, probably because there is no way to *directly* calculate an appropriate metric. The primary reason is that no pollutant monitoring data are gathered immediately upwind of the landfill to enable accurate estimates of the regional concentrations north of the landfill (and thus unaffected by landfill contributions). While the SCAQMD operates a BAM-1020 monitor at the Santa Clarita station, it is configured for $PM_{2.5}$ sampling. These $PM_{2.5}$ data are not directly comparable to the PM_{10} data provided by the BAM-1020 instruments currently deployed at the Landfill and Community monitoring sites. The Santa Clarita station does employ FRM measurements of PM_{10} (integrated 24-hr samples on filters) on a 1-in-6 day schedule. While 24-hr averaged data from the Landfill PM_{10} monitor could be compared with the 24-integrated data from the FRM samples every sixth day, the low frequency sampling supports only minimal statistical power for calculating upwind (background) PM_{10} concentrations. Additionally, the location of the Santa Clarita station relative to the landfill and nearby freeways further minimizes the potential for direct application of that data for calculating landfill contributions of PM_{10}.

Beginning with STI’s Second Annual Report[4] in 2009, a data analysis method for approximating landfill contributions to neighborhood-scale PM_{10} and BC concentrations, intended to address City Ordinance C.10.a and County Condition 81, was developed. The method was used to assess regional concentrations and provide estimates of landfill contributions above the regional contributions. It uses long-term averaging to maximize the sample size (hourly values) to be sufficiently representative. In 2009’s Second Annual Report, rolling averages were used to maximize the sample size. Since the Third Annual Report, rolling averages are no longer used because full years of continuous data are available for calculating the yearly averages used in the analysis. The results of the analysis have an undefined level of uncertainty because, in lieu of directly measured concentrations upwind of the landfill, regional pollutant concentrations are estimated from a southerly wind direction sector, isolating the SoCAB, to provide an estimate of regional pollutant levels during working days and non-working days.

The method involves using the same specific wind direction sectors and activity level bins for selecting the BC and PM_{10} data as described above for the annual average regional

[4] Vaughn D.L. and Roberts P.T. (2009) Second annual report of ambient air quality monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School. Prepared for the Planning Department, City of Los Angeles, CA, by Sonoma Technology, Inc., Petaluma, CA, STI-907032-3671-AR, August.

comparisons. Although presented in previous reports, the method is described again here for completeness.

6.1 Justification of the Method

As illustrated in Section 5, when the wind is from the south, bringing pollutants northward from the SoCAB, the long-term average pollutant concentrations measured at the Community and Landfill monitoring sites are similar. When the wind is from the north, bringing pollutants southward, the pollutant concentrations measured at the two monitoring sites are much less similar. This observation provides the framework to

- Calculate regional pollutant concentrations not affected by contributions from the landfill.
- Calculate differences in regional pollutant concentrations between regular working days and non-working days. The data from non-working days provide estimates of baseline or background pollutant levels, and the data from working days provide estimates of any additional regional contribution associated with regular work days.
- Estimate regional contributions and use this estimate to assess landfill contributions to neighborhood-scale pollutant concentrations when winds are from the north (i.e., when landfill impacts, if any, would be measurable at both monitoring sites). In the absence of a monitor north of the landfill, the application of this estimate results in an undefined degree of uncertainty, since it is unknown how well this estimate of regional concentrations truly reflects the impact of concentrations from areas north of the landfill.

6.2 Specific Steps of the Method

Implementation of this analytical approach involves the following basic steps, using only validated and quality assured data:

- From the two monitoring sites, select the hourly pollutant concentration data for the analysis based on wind direction sectors, as described in Section 5.1.
- Categorize the data from the two sites into landfill-operating days (referred to as "working days") and non-operating days (referred to as "non-working" days), as described in Section 5.2.
- Categorize the data from the two sites into working hours (chosen to reflect the main operating hours of the landfill) and non-working hours (non-operating periods), as described in Section 5.2.
- Calculate average pollutant concentrations for each data category.
- Using only the average concentrations derived from data attributed to the SoCAB, calculate the difference in regional concentrations between working days and non-working days.
- Compare the average concentrations measured on working days when the wind direction is from the landfill with the regional estimates and calculate an estimate of

landfill contributions. Under these sampling conditions, the working day concentrations are assumed to have three components:

(1) A regional contribution, estimated using data from non-working days when winds are from the landfill

(2) An additional regional contribution, estimated by multiplying the estimate in (1) by the proportional increase in concentrations observed during times of southerly winds on working days compared to non-working days

(3) Average concentrations, measured when winds blow from the landfill on working days, in excess of the sum of (1) and (2), which are attributed to the landfill. If average concentrations measured when winds are from the landfill increase proportionally with the regional increases associated with working days, no contribution from the landfill would result from this calculation.

The hours within each of these working and non-working day categories are additionally binned into working hours (defined as beginning at 0600 PST and ending at 1700 PST) and non-working hours. While the level of activity may vary within each timeframe, reliance on long-term averaging of pollutant concentrations will help to integrate the effect of these varying activity levels.

6.3 Estimates of Landfill Contributions of BC and PM_{10}

The results of the analyses are presented in two figures: **Figure 6-1** for PM_{10} and **Figure 6-2** for BC. The bar charts shown for each parameter depict the measured average concentration at both monitoring sites for working days during daytime hours, apportioned among three components: a component attributable to a background regional concentration estimated from non-working days, an additional regional component attributable to working days, and a component estimated as the landfill contribution on working days.

6.3.1 PM_{10} Impacts

Figure 6-1 shows the estimated apportionment of average PM_{10} concentrations to regional, non-working day levels; additional regional inputs on working days; and landfill contributions associated with working days (calculated by difference).

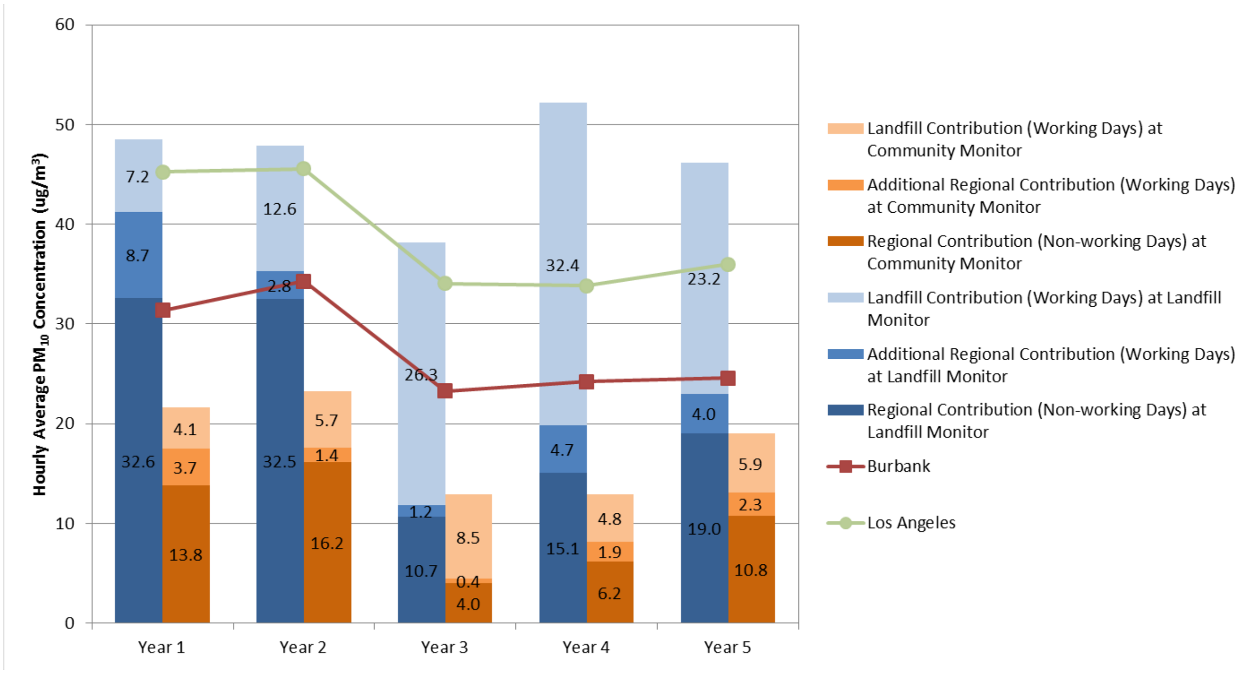


Figure 6-1. Summary of five consecutive years of quantitative estimates of the average regional contribution to ambient PM_{10} levels on non-working days (dark blue/orange bars), the additional regional contribution associated with increased activity levels on working days (medium blue/orange bars), and the average hourly landfill contribution on working days (light blue/orange bars) for Landfill monitor (blue bars) and Community monitor (orange bars). Line graphs show annual averages for Los Angeles and Burbank (January through December).

The following comments are offered about the estimates of regional and landfill contributions of PM_{10} shown in Figure 6-1:

- As measured at the Landfill monitor only, the landfill's contribution (light blue bars) to hourly average PM_{10} concentrations increased until Year 4. Though the landfill's contribution decreased in Year 5, it still accounted for the majority of the PM_{10} recorded by the monitor there, similar to Years 3 and 4.
- This trend is not seen in the Community monitor's data. Estimates of landfill contributions to community levels of PM_{10} remain comparatively low, with no trend.
- Ambient PM_{10} concentrations at the Landfill and Community monitoring sites have tracked regional concentrations fairly well, except for in Year 4 at the Landfill monitor, where increased landfill contributions contributed to higher average levels, while the Community and regional sites remained about the same as Year 3. (Note: the annual averages shown by the line graphs are meant to illustrate the degree of agreement in regional trends of annual average PM_{10} concentrations between the SCAQMD sites and the two local monitoring sites. They are January-through-December averages, and thus not directly comparable to the November-to-November averages shown for the Landfill and Community monitoring sites.)

- In any given year, the “background” PM_{10} concentration, estimated from non-working days when wind direction is from the landfill (dark blue bars), is about twice as that observed at the Community monitor. This non-working day background value is a direct measurement, bound by the “from landfill” wind direction sector on Sundays and holidays. The confidence level in this measurement is high. This finding suggests that, even on non-working days, the landfill is contributing PM_{10} that is measured by the Landfill monitor, but which is not detected by the Community monitor. Note, however, that the background concentration attributed to non-working days, as measured by the Community monitor, has continued to increase since Year 3 as well.
- The contribution of the landfill to average PM_{10} concentrations in the Community increased by about 23% between Year 4 and Year 5.
- The additional regional contribution of PM_{10} associated with working days at the Landfill site (medium blue bars) decreased by 15% between Year 4 and Year 5, while that at the Community site (medium orange bars) increased by 17%. The regional contribution associated with working days remained the smallest contributor among the three categories for all years.
- The substantial trend of increases in PM_{10} attributed to the landfill from Year 1 through Year 4 at the Landfill site may be associated with increased activity at the landfill. The trend stopped in Year 5 when PM_{10} attribution to the landfill decreased by 28%. The substantial increases in PM_{10} attributed to the landfill from Year 1 through Year 4 are not duplicated at the Community monitor; this suggests that the landfill is a local source that minimally impacts neighborhood- or regional-scale measurements. A 23% increase in PM_{10} attribution to the landfill at the Community site between Year 4 and Year 5 could be due to a change in meteorology (i.e., strong northerly wind on non-working days) or changes at the landfill facility.

6.3.2 Black Carbon Impacts

Figure 6-2 shows the estimated apportionment of average BC concentrations to regional non-working day levels, additional regional inputs on working days, and landfill contributions associated with working days (calculated by difference) for each of the four monitoring years. Note that some of the data values shown in Figure 6-2 are a few hundredths of a microgram per cubic meter different than those reported in the Fourth Annual Report, due to a few hours of data that were previously incorrectly binned. The main effect of this correction was to lower the estimate of Landfill contributions of BC for each of the previously reported three years’ data.

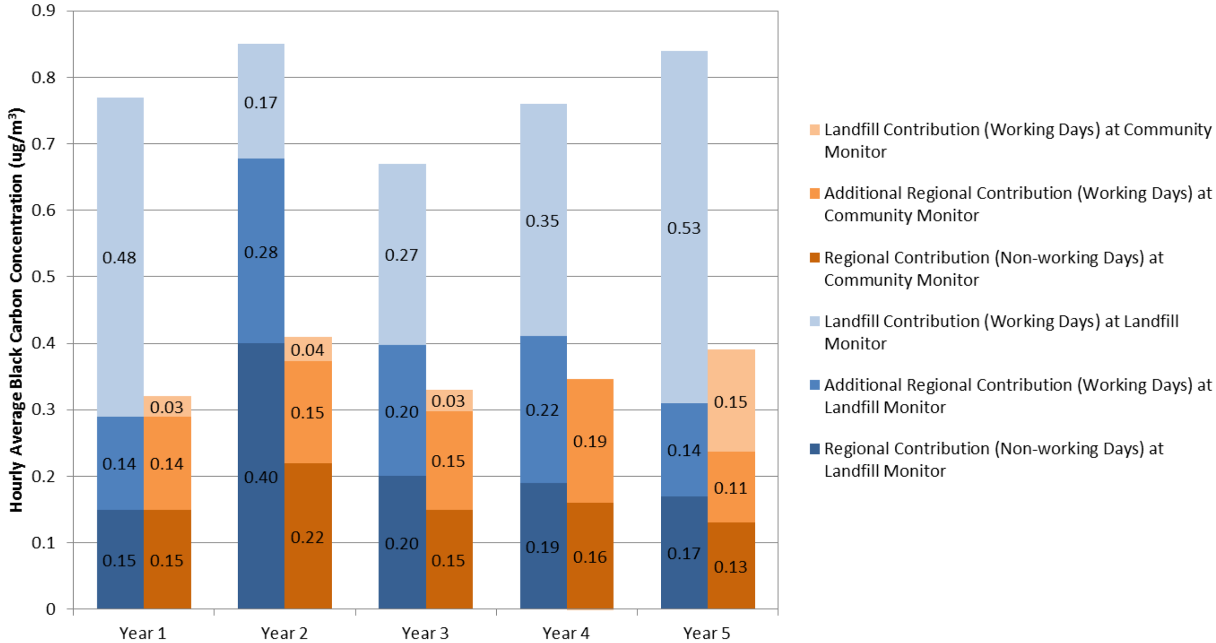


Figure 6-2. Summary of five consecutive years of quantitative estimates of the average regional contribution to ambient BC levels on non-working days (dark blue/orange bars), the additional regional contribution associated with increased activity levels on working days (medium blue/orange bars), and the average hourly landfill contribution on working days (light blue/orange bars).

The following comments are offered about Figure 6-2:

- As shown previously with PM_{10}, annual landfill contributions to ambient BC concentrations (light blue bars) are substantial at the Landfill monitor, but low and stable at the Community monitor until Year 4. In Year 4, the landfill contribution to Community BC levels averaged close to zero (-0.01 µg/m^3, within the monitor's measurement error). In Year 5, the landfill contribution at the Community site increased significantly and became the highest among the three categories for the first time. The reason for this increase is unknown.
- As measured at the Landfill BC monitor, the landfill contribution to ambient BC concentrations (light blue bar) declined by 50% from Year 1 to Year 2, but then increased from Year 2 to Year 3 and from Year 3 to Year 5. These increases in measured BC concentrations at the landfill are assumed to be associated with a general increase in landfill activities or scope of operations, but no metric of that level of activity is provided.

7. Landfill Gas and Hazardous Air Pollutants

As a courtesy to the reader, this section of the five year summary report repeats the brief overviews of LFGs and hazardous air pollutants (HAPs) that were offered in the Fourth Annual Report. Discussion of odors *per se* is not included here, though an overview was presented in the Fourth Annual Report. Monitoring of odors is outside the scope of STI's monitoring, as dictated by City Condition C.10.a and County Condition 81. Most of the general information regarding LFGs presented here is taken from a publication from the Agency for Toxic Substances and Disease Registry (ATSDR),[5] and readers are directed to the web link in the footnote to obtain additional information. In the following sections, readers will find a brief review of HAPs, those compounds known to have carcinogenic, teratogenic, or other serious health effects, and the role that they play in the LFG sampling strategy. The LFG sampling strategy and methodology which has been used over the last four years is described, and the results of the LFG sampling conducted to date are qualitatively summarized. Detailed quantitative data summaries of the LFG ambient air sampling are contained in the quarterly reports covering the periods when the samples were taken. A few examples (one typical, one less so) are presented in this report for illustrative purposes.

Note that the amendments to the original Abatement Order that were stipulated in November of 2011 included provision for 1-in-6 day sampling of VOCs. Because of this increased frequency of VOC sampling, which is being conducted by Republic Services, the contract for the sixth year of STI's monitoring responsibilities excludes any continued VOC sampling, effective June 21, 2012.

7.1 LFG Overview

While LFG can include hundreds of compounds, it is typically composed of 45% to 60% methane and 40% to 60% carbon dioxide. It may include small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen, carbon monoxide, and non-methane organic compounds (NMOCs) such as trichloroethylene, benzene, and vinyl chloride.

Landfill gases are derived from three processes: bacterial decomposition, volatilization, and chemical reactions. Bacterial decomposition of organic matter proceeds through four phases, moving from aerobic to anaerobic processes, producing acidic compounds and carbon dioxide and hydrogen, to anaerobic methane production, and finally to a steady state where methane and carbon dioxide gas production remains more or less constant. This latest stage can last 20 years or more. Any or all of these stages may be proceeding simultaneously in different parts of the landfill. **Figure 7-1**, taken from the ATSDR publication, illustrates the gas production at each of the four stages of microbial degradation.

Volatilization is the process of a compound changing from a solid or liquid to a gaseous state. Some NMOCs can come directly from this process if chemicals are disposed of in a

[5]Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services (2001) Landfill Gas Primer - An Overview for Environmental Health Professionals, available at http://www.atsdr.cdc.gov/HAC/landfill/html/intro.html.

landfill. (Many chemicals are prohibited from being disposed of in landfills.) Chemical reactions can also produce NMOCs if chemicals are deposited and react with each other.

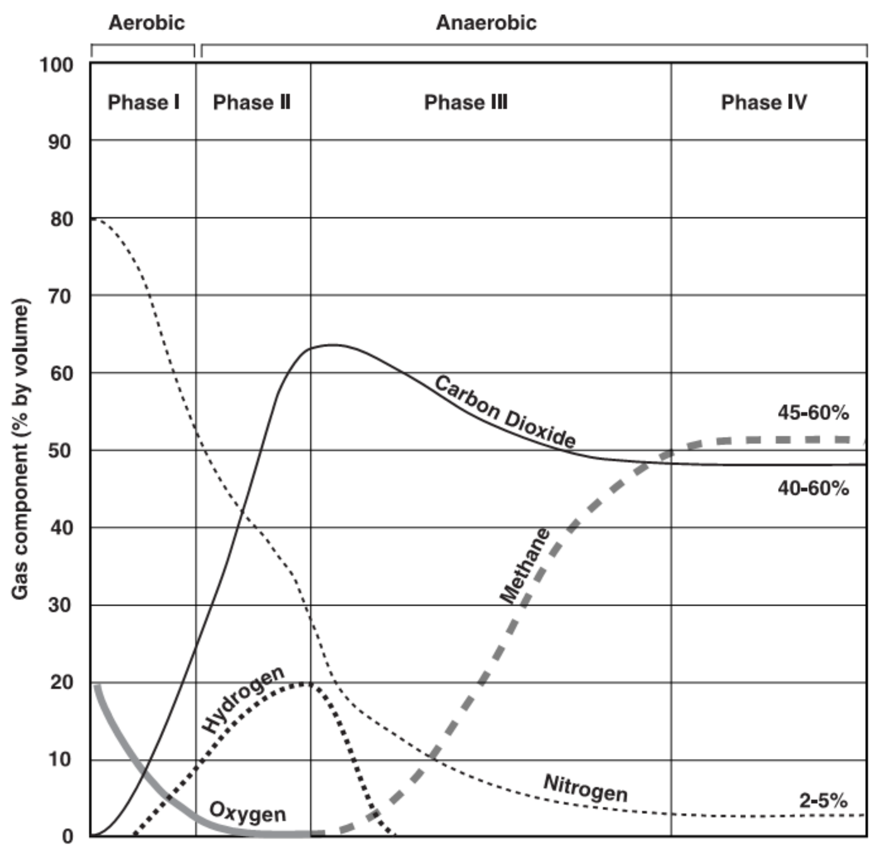


Figure 7-1. Generalized scheme of landfill gas production during the bacterial decomposition process in municipal landfills. Figure from ATSDR.

Site characteristics determine the rate and volume of gas production. The composition of the waste (the balance of organic matter and chemical compounds), the age of the refuse (fresh material produces more LFG than does older waste), the presence of oxygen (methane is produced only when no oxygen is available), the moisture content (increased moisture increases bacterial decomposition), and temperature are all critical factors that interact to influence the gas production.

The Sunshine Canyon Landfill likely has areas ranging from old sections in the equilibrated methane-producing stage to newly deposited refuse that is added daily and is in the aerobic stage of microbial degradation. The measurement and control of LFG from all these areas represents one of the major tasks of the landfill operators. Independent measurements of LFG are required by SCAQMD Rule 1150.1 and include integrated and instantaneous landfill surface monitoring and periodic ambient air sampling (nominally monthly) at landfill property boundaries. This monitoring is undertaken by an independent contractor and is separate from monitoring required by City Conditions of Approval C.10.a and County Condition 81. These latter two conditions govern the ambient air sampling conducted by STI at the southern edge of the landfill and in the neighboring community of Granada Hills.

7.2 Hazardous Air Pollutants (HAPs)

Some NMOCs are known to cause serious environmental and health effects and are known as HAPs. Some of the compounds associated with landfill emissions have been classified by the EPA as environmental and health hazards, and cancer and non-cancer health benchmarks have been established for many of them. A cancer benchmark means that exposure to concentrations at this level for 70 years would be expected to result in one additional case of cancer per million people. Concentrations below this level would result in a lower rate, and concentrations above, a higher rate. Non-cancer benchmarks are also based on a 70-year exposure, with health effects such as asthma or neurological or reproductive effects

HAPs have many sources. They can occur in LFG as a result of the physical process of volatilization of chemicals deposited in the landfill, or they may be derived from chemical and biological reactions. Some HAPs are additionally classified as mobile source air toxics (MSATs) that are associated with motor vehicles (e.g., benzene, 1,3-butadiene, xylene, and toluene). Many industrial processes produce HAPs as by-products. While most HAPs do not occur naturally, some do (1,2-dibromomethane produced by algae and kelp; ethylbenzene and xylenes in coal tar). Thus, the mere presence of a compound in a sample of ambient air does not indicate that it is derived from a landfill. Attributing ambient concentrations of NMOCs to landfill emissions requires care in sampling technique and information about the factors affecting transport, such as meteorology and topography. Worldwide ambient concentrations of methane are about 1.8 ppmV; thus, methane exists at these levels in most ambient air samples. Determining which compounds should be targeted in an analysis is one important aspect of sampling for LFG in ambient air.

7.3 LFG Sampling Strategy—When to Sample

LFG sampling in ambient air normally uses “grab sample” techniques. Using an appropriate collection mechanism (e.g., Tedlar bags, Summa canisters), air samples are acquired over a specific time period, ranging from several minutes to several hours. The duration of the sample period is dictated by the objective of the sampling. Typically, 24-hr average concentrations are used to assess seasonal variability or annual averages. Shorter duration samples (1- to 3-hr) are used to determine diurnal variability. Once the sampling objective and sample duration are determined, a sufficiently large number of samples must be obtained to assure statistical rigor. For example, 1-in-6- or 1-in-12-day samples of 24-hr duration on a continuing basis are sufficient to delineate seasonal differences. (Continuous monitoring, on the scale of minutes to hours, of LFG is possible with automated gas chromatography, but such monitoring involves large investments in equipment and frequent site visits by trained personnel.)

Up until the amendments to the Abatement order (SCAQMD case number 3448-13) were stipulated in November 2011, the minimum sample frequency imposed by the Conditions of Approval precluded a statistically based LFG sampling strategy. Thus, the four sampling times were targeted to the "worst case scenario" by sampling during those times when the probability of landfill emissions influencing neighborhood-scale ambient concentrations is highest. Beginning in 2010, the LFG sampling strategy was changed to reflect patterns seen in the SCAQMD's 2009 and 2010 registry of complaints attributed to landfill operations. These complaints tended to peak in the fall and winter months. This peak coincided with the seasonal change in prevailing wind patterns from onshore (southerly) to offshore (northerly) flow, and suggested strongly that it would be during these time frames that any impacts of LFG on the community would be most likely to be detected. Currently, all four LFG sampling periods fall within the fall and winter months.

The sample times for LFG samples collected to date were chosen on the basis of real-time wind data, coupled with anecdotal knowledge derived from reported odor complaints suggesting that transport to the community may be occurring during early morning hours. For each designated sample day, two samples are taken at each location. The first integrated sample is taken from 7 a.m. to 8 a.m. and is immediately followed by a second sample from 8 a.m. to 9 a.m.

The sampling times could be further refined so that the samples more closely correspond to maximum levels of LFG. Published accounts of diurnal variation in concentrations of air toxics can help in this process. McCarthy et al (2007)[6] evaluated the temporal variability of selected air toxics in the United States. Sufficient data were available to analyze diurnal variability for 14 air toxics, and the authors were able to identify four diurnal variation patterns: invariant, nighttime peak, morning peak, and daytime peak. Carbon tetrachloride was the only air toxic fitting the invariant pattern. The nighttime and morning peak patterns were similar to each other, with high evening/nighttime concentrations and low midday concentrations driven primarily by meteorology. Concentrations build up during the night because of lower mixing heights. As the sun rises and heating occurs, turbulence develops and results in dispersion and lower concentrations. The morning pattern has an additional mid-morning rush-hour peak attributable primarily to mobile sources. The daytime peak pattern is driven by photo-oxidation of other VOCs. If the temporal variability of ambient LFG concentrations near the landfill is meteorologically driven, then the nighttime peak pattern may be the most applicable, suggesting that the best time to sample maximum concentrations may be the middle of the night. Sampling during this window would also minimize mobile source contributions.

7.4 LFG Sampling Strategy—How to Sample

Samples for NMOCs are collected in evacuated Summa canisters. A Summa canister is a stainless steel vessel which has had the internal surfaces specially passivated using a "Summa" process. This process combines an electropolishing step with chemical deactivation to produce a surface that is chemically inert. The canisters used for the ambient sampling undergo a 100% certification process that ensures no contamination in the canister. In combination with the canister is a flow controller with a critical orifice, calibrated specifically for

[6] McCarthy M.C., Hafner H.R., Chinkin L.R., and Charrier J.G. (2007) Temporal variability of selected air toxics in the United States. *Atmos. Environ*. **41**(34), 7180-7194 (STI-2894). Available at http://dx.doi.org/10.1016/j.atmosenv.2007.05.037.

the duration of the sample, to allow the can to fill gradually over the intended sample period so the sampled air represents a properly integrated sample. Flow controllers calibrated for 1-hr samples are currently being used for the Sunshine Canyon ambient LFG sampling.

On the designated sampling day, one STI staff person is located at each monitoring site to manually control the sample collection process. Once collected, the samples are immediately shipped to an independent lab for analysis.

7.5 LFG Sampling Strategy—Target Compounds

The list of NMOCs targeted in the laboratory analysis of collected samples includes those compounds that were sampled during the baseline study. This ensures continuity and allows direct comparison with the results of the baseline study should that be desired. The list also includes other NMOCs commonly associated with landfills, in particular those compounds specified in SCAQMD's Core Group of "Carcinogenic and Toxic Air Contaminants" listed in the District's Rule 1150.1. The ATSDR also provides a list of NMOCs commonly found in LFG, and a few of these compounds are included in the list as well.

In the baseline study, one objective was to identify compounds found in LFG but not typically found in background air, thereby allowing the identified compounds to act as tracers specific to the landfill. An analysis was performed on LFG collected directly from the onsite LFG collection and control system. The most prevalent components of LFG found in these landfill samples, in decreasing order of concentration, were xylenes, toluene, dichlorobenzenes, benzene, perchloroethene, dichloromethane, and vinyl chloride. The measured concentrations of these compounds were compared to the average concentrations reported by the California ARB for the SoCAB for the year 2001.[7] These ratios were used to help identify appropriate tracer compounds, based on the notion that compounds exhibiting the highest ratio would be the best marker compounds. Xylenes, benzene, and toluene were excluded as target compounds because they are found in motor vehicle exhaust, confounding the ability to pinpoint emission sources. Perchloroethene and dichloromethane were excluded because they exhibited low landfill gas-to-ambient air ratios.

The baseline study identified the three isomers of dichlorobenzene and vinyl chloride as the most appropriate target NMOC compounds. These compounds are included in the target list of compounds in the ongoing monitoring work so that direct comparisons to baseline concentrations can be made. However, the average concentration of the three isomers of dichlorobenzene reported for the SoCAB in 2001 (0.31 ppbv) in the Baseline Monitoring Report[8] does not agree with published CARB data.[9] All Southern California stations with available data on any of the three isomers of dichlorobenzene had reported concentrations of 0.15 ppbv for the

[7] ENVIRON International Corporation (2003) Proposed landfill gas baseline ambient air monitoring protocol for the Sunshine Canyon Landfill. Report prepared for Browning-Ferris Industries of California, Inc., by ENVIRON International Corporation, Contract No. 03-9660A, March 27. Table 1.
[8] ENVIRON International Corporation (2003) Results of the baseline ambient air monitoring program for the Sunshine Canyon Landfill. Final report prepared for Browning-Ferris Industries of California, Inc., by ENVIRON International Corporation, Contract No. 03-9660A, June 6.
[9] California Air Resources Board (2008) Annual toxics summaries. Available at http://www.arb.ca.gov/adam/toxics/statesubstance.html.

2001 calendar year, which is one-half the Method Detection Limit (MDL) of 0.3 ppbv (1.8 $\mu g/m^3$). A value of one-half the MDL value is commonly used for reporting data below detection.

Several other NMOCs are included in the ongoing monitoring. Information about concentrations of other landfill-associated gases affords comparison with other NMOC data sets collected in the Los Angeles air basin or at other landfills. **Table 7-1** lists the compounds included in the ongoing monitoring and whether they (1) were included in the baseline study, (2) are listed in the Core Group of toxic substances in Rule 1150.1, or (3) are listed as a common constituent of landfill gas by the ATSDR. The table also contains information on the odor characteristics of the target compounds, and, when available, the odor threshold concentration.

Two compounds are being assayed in the current sampling strategy that were not monitored in the baseline study and do not appear in either the SCAQMD's Core Group or the ATSDR's list of common LFGs. The compound 1,1,2,2-tetrachloroethane is not commonly found in ambient air samples, but it is one of the most commonly monitored air toxics because of its high toxicity. It was previously used as an industrial solvent or as an ingredient in paints and pesticides, but commercial production for these uses in the United States has ended. It is currently used only as an intermediate in production of other chemicals. A second commonly measured air toxic, 1,3-butadiene, was added not because of its strong association with municipal solid waste landfills, but because it serves as a good tracer for motor vehicles. Other compounds in the ongoing monitoring list can be attributable to either motor vehicles or to LFG (e.g., benzene, toluene, xylenes); if these compounds are detected in an LFG sample, but 1,3-butadiene is not, then the landfill is the most likely source of those species.

Table 7-1. A listing of the NMOCs included in the current monitoring program, the baseline monitoring program, SCAQMD's Core Group of air toxics from Rule 1150.1, and ATSDR's list of common LFGs. Odor characteristics and odor threshold concentrations from references as noted in table footnotes.

Compound	Ongoing Monitoring	Base-line	SCAQMD Core Group	ATSDR	Odor	Odor Threshold (mg/m^3)
1,1,2,2-Tetrachloroethane	✓				Sweet, chloroform-like	11.2 [a]
1,1-Dichloroethane	✓		✓	✓	Mildly aromatic, similar to ether	523 [a]
1,1-Dichloroethene	✓		✓		Sweet, mild, chloroform-like	811 [a]
1,2-Dichlorobenzene	✓	✓	✓		Pleasant, aromatic	324 [b]
1,3-Butadiene	✓				Mild, gasoline-like	3.8 [a]
1,3-Dichlorobenzene	✓	✓	✓		Odorless	[c]
1,4-Dichlorobenzene	✓	✓	✓		Mothball-like	1.2 [a]
Benzene	✓		✓	✓	Sweet	5.2 [a]
Benzyl chloride	✓		✓		Pungent, unpleasant, irritating	0.25 [a]
Carbon tetrachloride	✓		✓		Sweet	67.7 [a]
Chlorobenzene	✓		✓		Aromatic, almond-like	5.0 [a]
Chloroform	✓		✓		Pleasant, non-irritating	447 [a]
cis-1,2-Dichloroethene	✓			✓	Ether-like, slightly acrid	72.6 [d]
Dichloromethane	✓		✓	✓	Sweet, mild, chloroform-like	767 [a]
Ethylbenzene	✓			✓	Gasoline	10.8 [a]
Ethylene dibromide	✓		✓		Slightly sweet, chloroform-like	82.7 [d]
m- and p-Xylene	✓		✓	✓	Sweet	5.1 [a]
Methyl chloroform	✓		✓		Sweet, sharp, chloroform-like	705 [a]
n-Hexane	✓			✓	Faint, peculiar	493 [a]
o-Xylene	✓		✓	✓	Sweet, balsam-like, distinct	5.1 [a]
Tetrachloroethylene	✓		✓	✓	Sharp, sweet	7.3 [a]
Toluene	✓		✓	✓	Sweet, pungent	11.8 [a]
Trichloroethylene	✓		✓	✓	Sweet; ether- or chloroform-like	162 [a]
Vinyl chloride	✓	✓	✓	✓	Mild, sweet	8,260 [a]

[a] Technology Transfer Network Air Technical Website, EPA, http://www.epa.gov/ttn/atw/
[b] Spectrum Laboratories Inc., http://www.speclab.com/
[c] ATSDR – Toxprofile: Toxicological Profile Information Sheet, http://www.atsdr.cdc.gov/toxprofiles/index.asp
[d] http://www.osha.gov/SLTC/healthguidelines/

7.6 Summary of LFG Sampling

As stated previously, the LFG sampling that occurs under the auspices of City Condition C.10.a and County Condition 81 is limited to four samples per year and is not statistically robust for making any general inferences. Sampling has been targeted at those times when meteorology and odor complaint registry records indicate that landfill impacts may be most likely. Under this scenario, the LFG data collected to date has fit into one of three cases:

- Case I: sampling problems or unidentified laboratory issues return methane concentrations below the global average concentration of 1.8 ppmV, and are thus suspect.
- Case II: methane and NMOC concentrations fall within the historical range of Los Angeles and Ventura County values (the most common result).
- Case III: a few compounds above the 90th percentile of historical concentrations have been detected in a few samples, but usually these compounds are also associated with mobile sources and not directly attributable to landfill operations.

There were four VOC sample days between November 22, 2011 and November 21, 2012: December 7, 2011, and January 13, February 3, and March 7, 2012. Analytical results from the December 7, January 13, and February 3 sample days are available and presented in the 17th Quarterly Report, which covers the December 2011 through February 2012 period. Analytical results from the March 7, 2012, sample date were included in the 18th Quarterly Report, which covers March through May 2012.

Two examples are provided to illustrate Case II (Section 7.6.1) and Case III (Section 7.6.2) that were described above. These illustrative data are from the samples collected during 2012.

7.6.1 Example of Case II: Typical LFG Sampling Results

Figure 7-2 depicts the LFG data collected on February 3, 2012, compared to annually averaged Los Angeles and Ventura County data from 2008 through 2010, obtained from the EPA's Airdata system. Averages are based on methodology described by McCarthy et al. (2007).[10] MDLs are also provided in the figure. The February 3, 2012 results typify the most common range of LFG concentrations that have been observed over the prior years of sampling at the Landfill site and the Community site.

[10] McCarthy M.C., Hafner H.R., Chinkin L.R., and Charrier J.G. (2007) Temporal variability of selected air toxics in the United States. *Atmos. Environ*. **41**(34), 7180-7194 (STI-2894). Available at http://dx.doi.org/10.1016/j.atmosenv.2007.05.037.

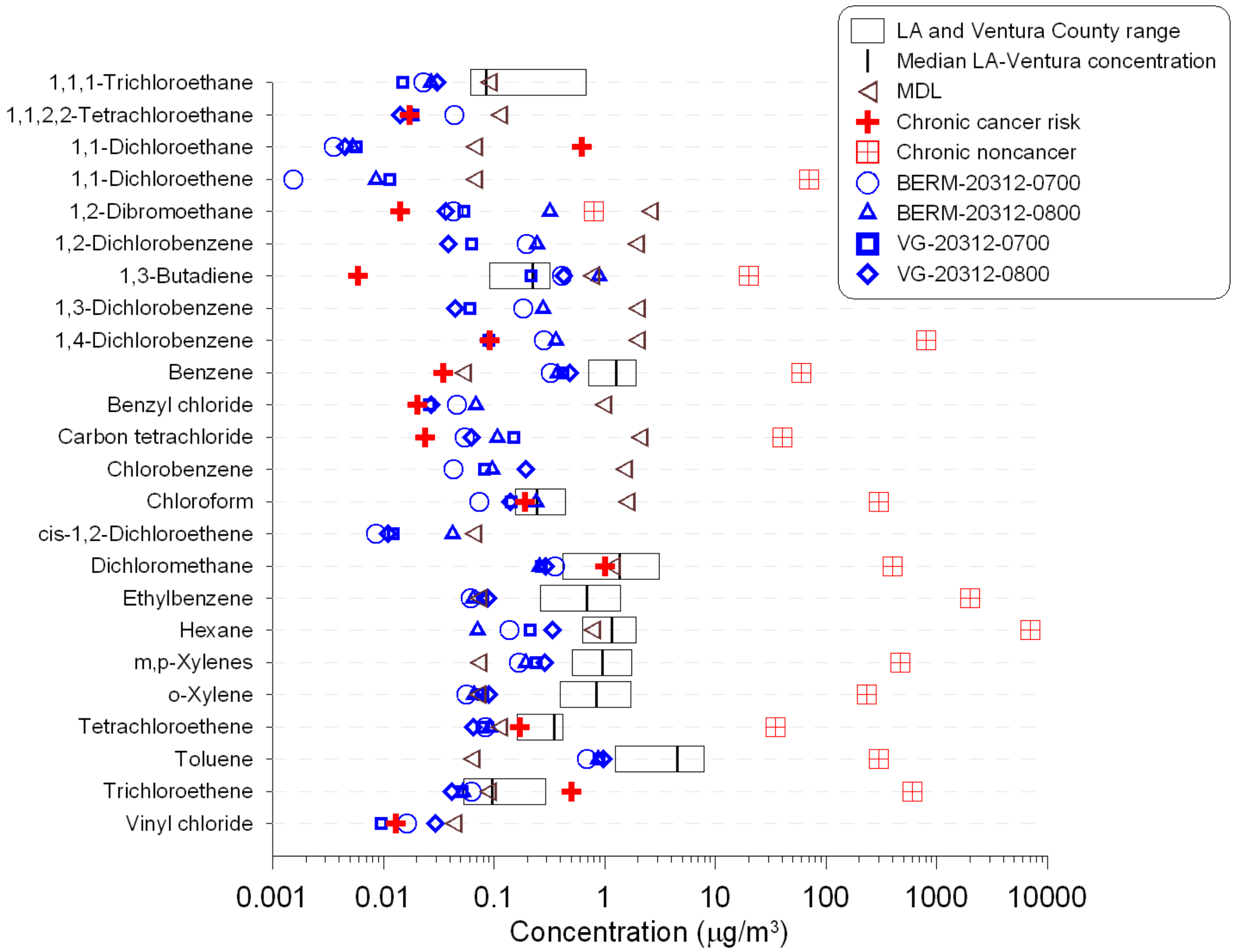


Figure 7-2. Ranges of the 10th to 90th percentile quarterly averages and median values for Los Angeles and Ventura County NMOC data from 2008 through 2010, as available. Concentrations determined from the February 3, 2012, samples collected at the Landfill site (BERM) and the Community site at Van Gogh Elementary School site (VG); MDLs; chronic cancer risk; and chronic noncancer hazard levels. Any data not shown were not detected by the analytical laboratory. Data below the MDL that were reported are shown.

7.6.2 Example of Case III: Some Concentrations Above the Historical 90th Percentile

The results from the sample collected on March 7, 2012, are representative of the Case III scenario, in which some compounds, in this case hexane, toluene, and methane, are measured above the typical range of Los Angeles and Ventura County values. **Figure 7-3** presents the LFG NMOC analytical results from the samples collected on March 7, 2012, compared to annually averaged Los Angeles and Ventura County data from 2008 through 2010, obtained from the EPA's Airdata system. Averages are based on methodology described by McCarthy et al. (2007). MDLs are also provided in the figure. The two samples at the Community site both had high hexane concentrations, while only one sample at the Landfill site had high hexane concentrations, suggesting the landfill is less of a contributor. Toluene concentrations were high at the landfill site in one sample. Both toluene and hexane are associated with mobile sources, so it is difficult to attribute elevated concentrations to landfill operations. The methane levels reported for the March 7, 2012, samples are given in **Table 7-2**. The values are higher than usual, but within the normal range. Global ambient concentrations are near 1.8 ppmV

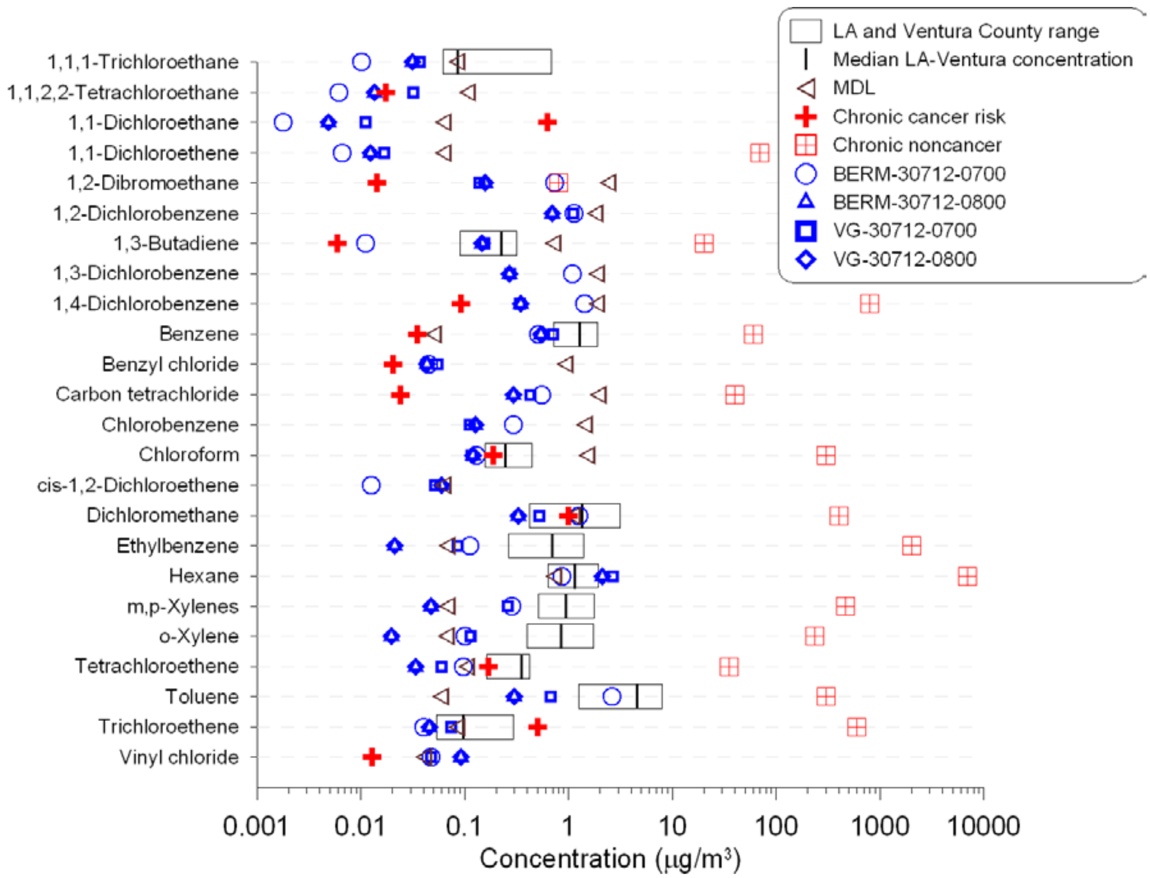


Figure 7-3. Ranges of the 10th to 90th percentile quarterly averages and median values for Los Angeles and Ventura County NMOC data from 2008 through 2010, as available. Concentrations determined from the March 7, 2012, samples collected at the Landfill site (BERM) and the Community site at Van Gogh Elementary School site (VG); MDLs; chronic cancer risk; and chronic noncancer hazard levels. Data not shown were not detected by the analytical laboratory. Data below the MDL that were reported are shown.

Table 7-2. Ambient concentrations of methane measured at the Landfill monitoring site and the Van Gogh School on March 7, 2012.

Site	Methane Concentration (ppmV)	
	7:00–8:00 a.m.	8:00–9:00 a.m.
Landfill	2.33	2.35
Community	1.96	2.03

8. Field Operations

Field operations include regular visits to both monitoring sites. During the first four years of the study, these visits were scheduled at two-week intervals. We have changed this interval to monthly because the experience gained over the recent years has demonstrated that monthly visits suffice to meet the routine maintenance operations associated with the Beta Attenuation Monitor and the Aethalometer. This protocol is in keeping with the recommended maintenance schedule recommended by Met One (manufacturer of the Beta Attenuation Monitor) and Magee Scientific (manufacturer of the Aethalometer). This protocol is accompanied by daily review of data that allows problems to be detected quickly. Many times the detected problems can be addressed remotely via cellular connection to the site instruments. Occasionally, non-scheduled onsite visits by an STI technician are required and occur as soon as reasonably possible.

Each quarterly report contains tables with the dates and times of each site visit and a summary of activities that took place.

In 2010, STI upgraded the site infrastructure and equipment, using funds provided by Republic Services. Since then, the continuity and reliability of the monitoring sites has improved.

Appendix A: Additional Preliminary Analyses

This appendix contains discussions of the temporal variability in black carbon (BC), PM_{10}, and wind direction (Section A.1), and of the effects of wind direction and work activity on BC and PM_{10} (Section A.2).

A.1 Temporal Variability in BC, PM_{10}, and Wind Direction

As shown in **Figure A-1**, the diurnal profiles of BC and PM_{10} are characterized by a morning peak in concentrations at both monitoring locations. The peak in BC occurs between 6 a.m. and 8 a.m., while the peak in PM_{10} is broader, occurring between 6 a.m. and 10 a.m. Overall, the mean hourly concentrations of both BC and PM_{10} are lower at the Community monitor than at the Landfill monitor. The diurnal profiles in year 5, November 22, 2011, through November 21, 2012, are consistent with the previous four years.

As shown in **Figure A-2**, both the Community and Landfill monitors experience higher concentrations of BC and PM_{10} during the warm season, approximately May through September. A notched box-whisker plot shows the entire distribution of concentrations for each year. In box-whisker plots, the box shows the 25th, 50th (median), and 75th percentiles. The whiskers have a maximum length equal to 1.5 times the length of the box (the interquartile range, IQR). If data are outside this range, the data points are shown on the plot. These “outliers” are further identified with asterisks (representing the points that fall within three times the IQR from the end of the box) and circles (representing the points beyond). These plots also include notches that mark confidence intervals. The boxes are notched (narrowed) at the median and return to full width at the 95% lower and upper confidence interval values. These plots indicate that we are 95% confident that the median falls within the notch. If the 95% confidence interval is beyond the 25th or 75th percentile, then the notches extend beyond the box (hence a “folded” appearance). Confidence intervals are a function of sample size; small sample size will increase these intervals.

At the Landfill site during these months, the predominant wind direction is from the South Coast Air Basin (SoCAB) (58% – 78% of the time) whereas during the other months of the year, the predominant wind direction is from the Landfill sector (50% – 70% of the time) (**Figure A-3**). However, at the Community site during these months, the predominant wind direction is from neither the Landfill nor the SoCAB sectors, but winds are more often from the SoCAB than the Landfill than during other months of the year (Figure A-3).

Figures A-4 and A-5 show seasonal wind roses of hourly data collected at the Landfill and Community sites, respectively. At the Landfill site, winds are predominantly from the northerly and southerly directions during all seasons, with a larger proportion of winds from the north during the winter and from the south during the summer (Figure A-4). The prevailing wind direction at the Community site is variable during all seasons (Figure A-5).

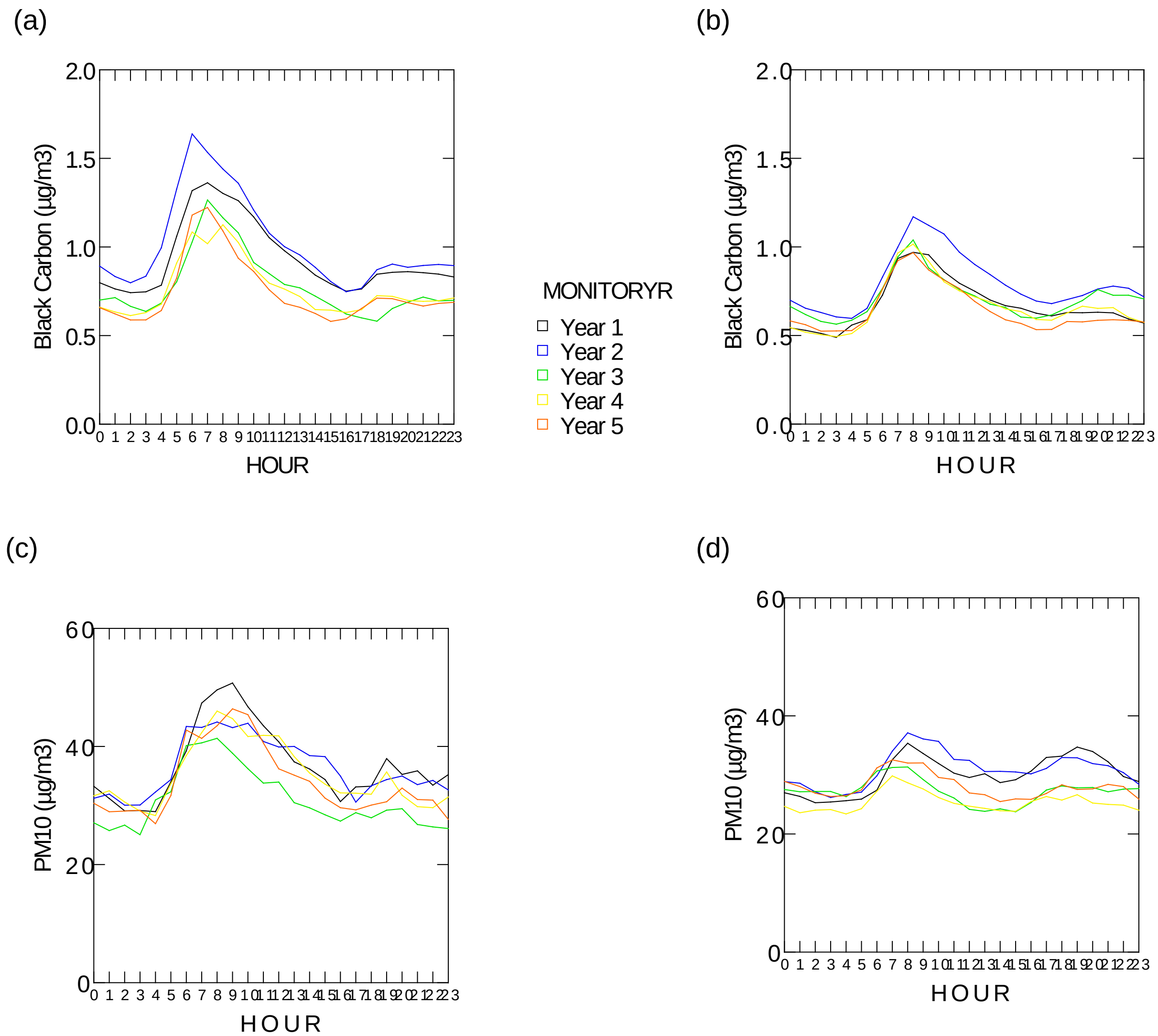


Figure A-1. Mean BC and PM_{10} concentrations by hour for the five monitoring years at the Landfill (a, c) and Community (b, d) sites.

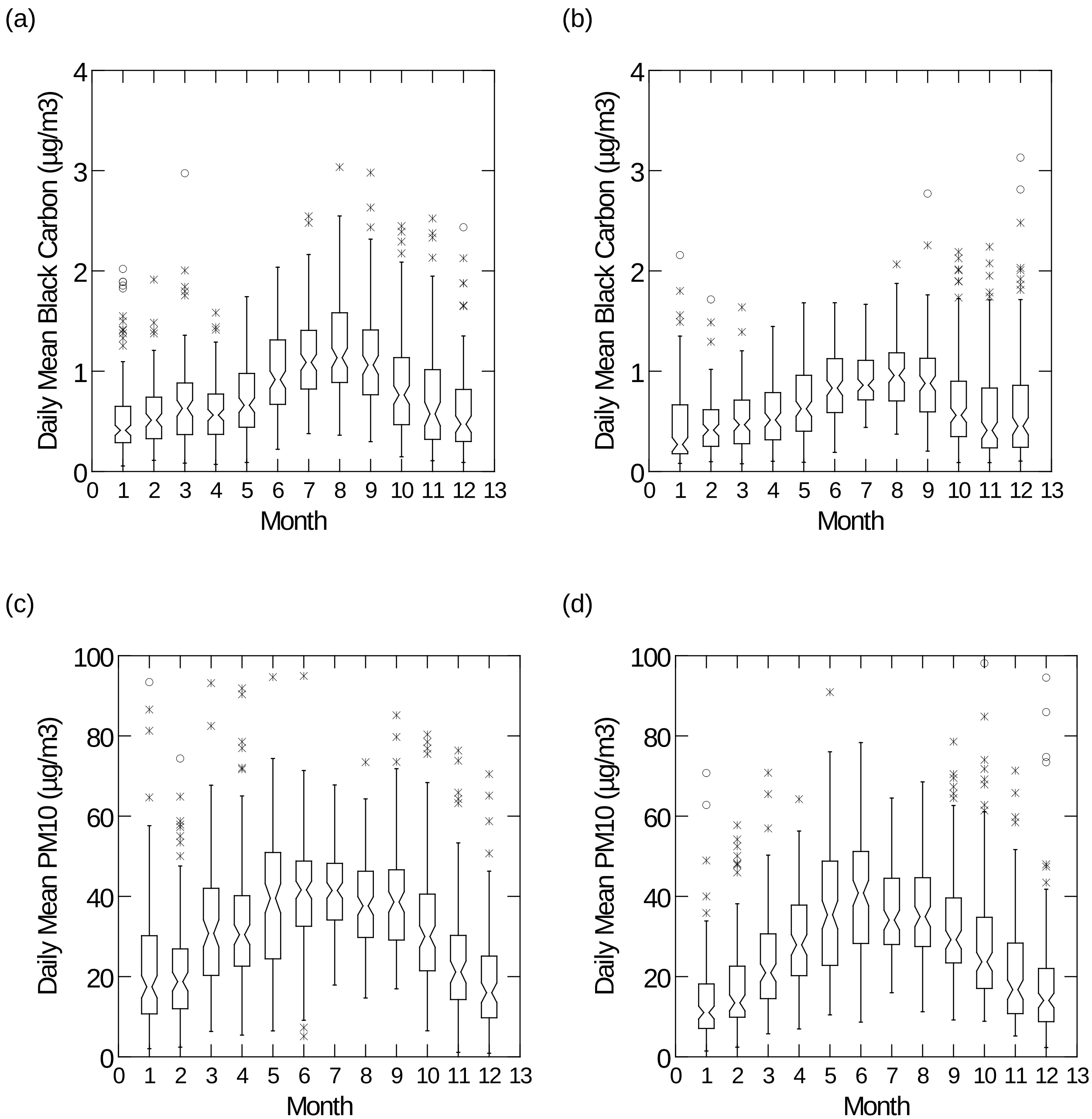
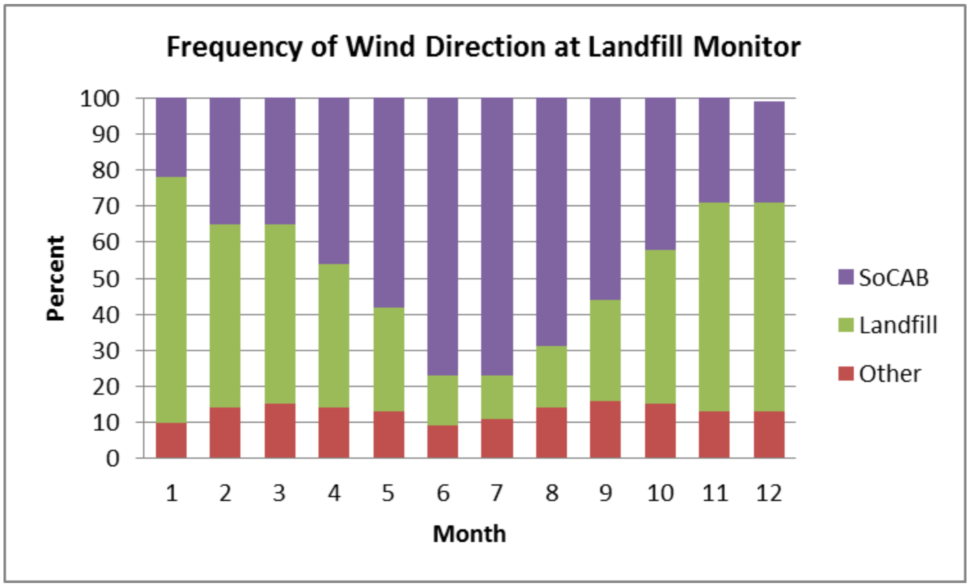
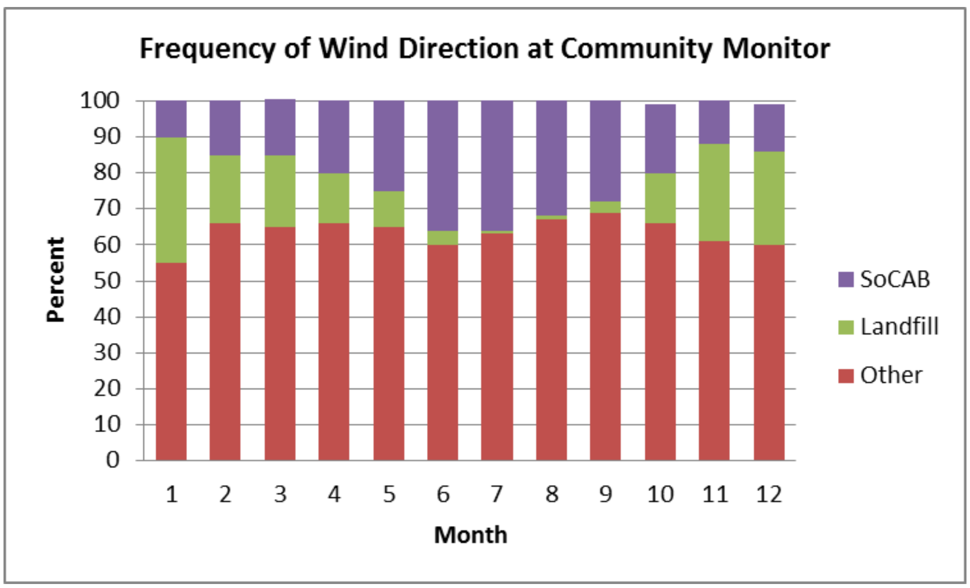


Figure A-2. Daily mean BC and PM_{10} concentrations by month at the Landfill (a, c) and Community (b, d) sites, during all five monitor years (2007–2012).



(a)



(b)

Figure A-3. Percent of time that the Landfill (a) and Community (b) monitoring sites experienced winds that originated from each wind direction sector (South Coast Air Basin, Landfill, Other) during each month from 2007–2012.

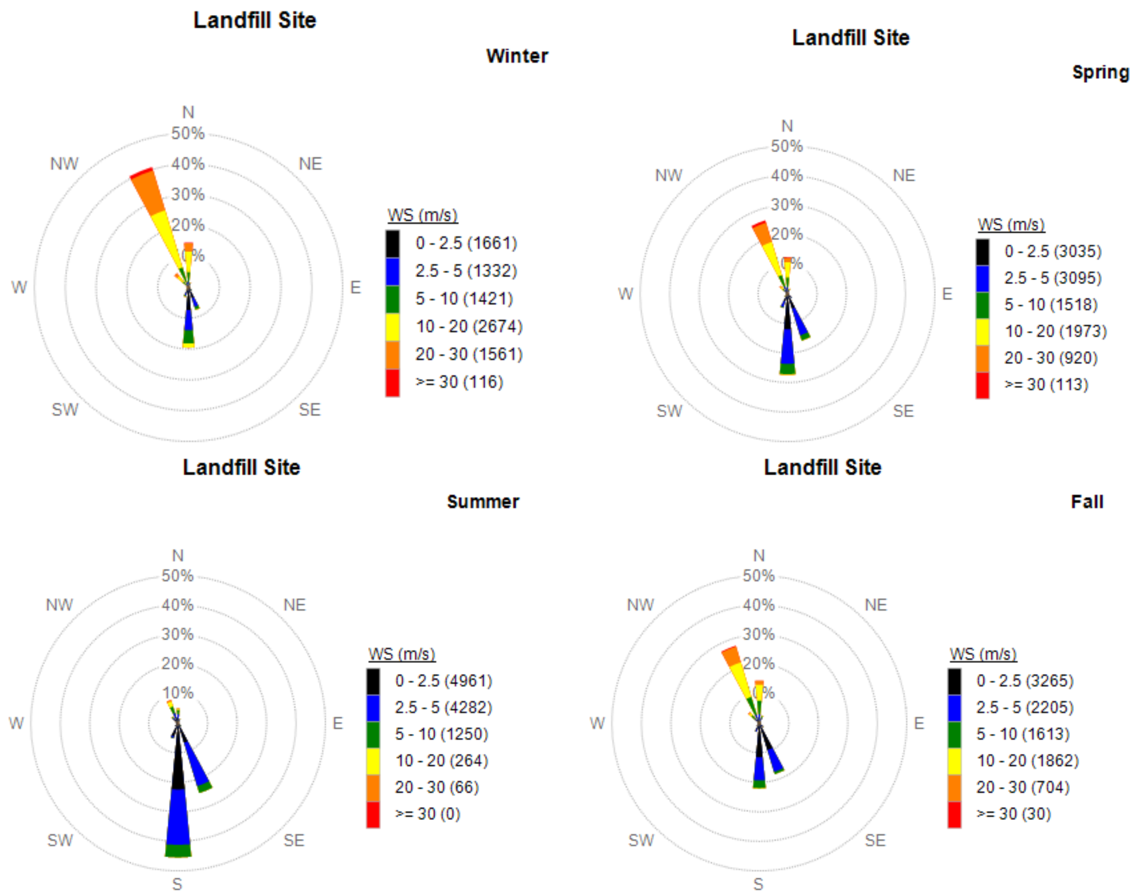


Figure A-4. Seasonal wind roses of hourly data collected at the Landfill monitor during 2007–2012.

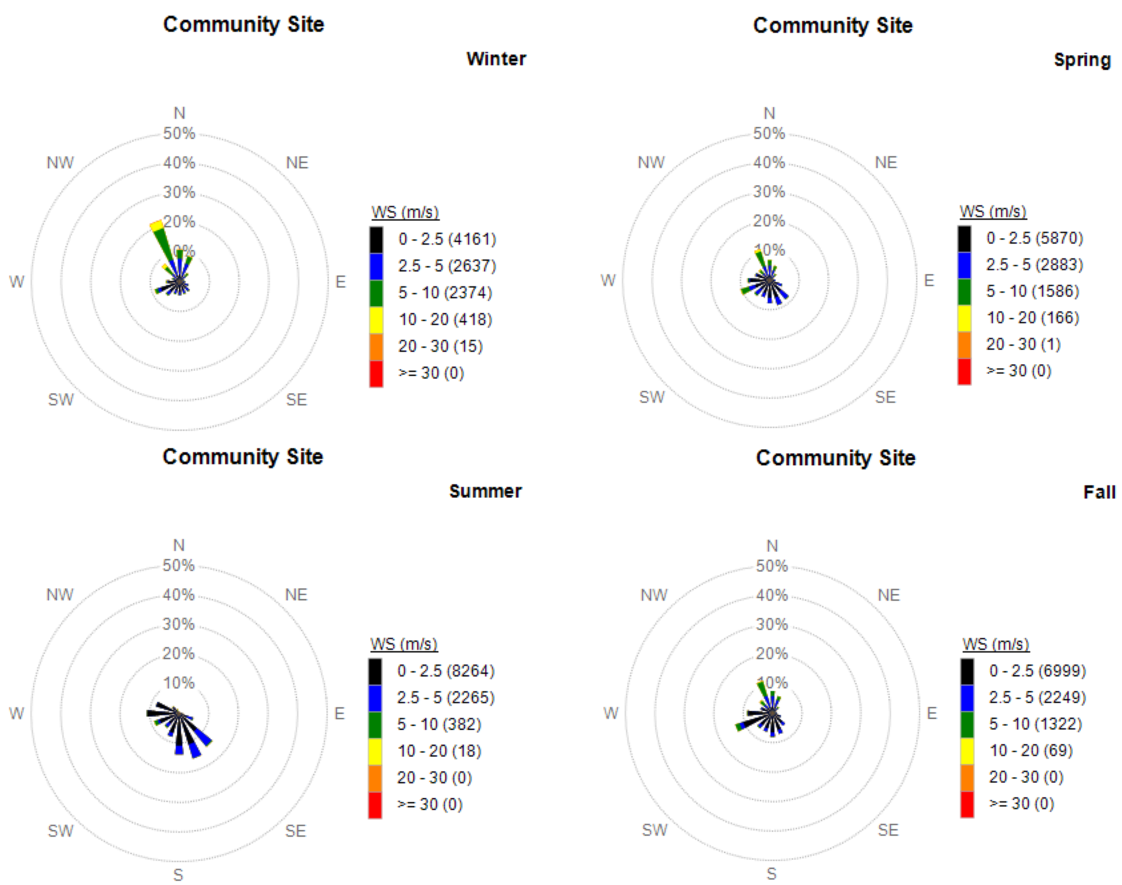


Figure A-5. Seasonal wind roses of hourly data collected at the Community monitor during 2007–2012.

A.2 BC and PM_{10}: Effects of Wind Direction and Work Activity Levels

As shown in **Figure A-6**, concentrations of BC and PM_{10} are higher on the weekdays than the weekends. Higher concentrations are consistent with greater activity at the landfill during the week, as well as with potentially more vehicles on the roads throughout the SoCAB. Concentrations of BC and PM_{10} are higher on Saturdays than Sundays at the Landfill site. Concentrations of BC are also typically greater on Saturdays than Sundays at the Community site; however, PM_{10} concentrations are not. Activity occurs at the Landfill on some Saturdays, but not on Sundays.

As shown in **Figure A-7**, concentrations of BC and PM_{10} are several times greater when wind conditions are from the south than from the north. In addition, concentrations are typically similar between the Landfill and Community sites when winds are from the SoCAB direction. Concentrations are greater at the Landfill site than the Community site when winds are from the north.

Figure A-8 shows the average BC and PM_{10} concentrations at the Landfill and Community sites by prevailing wind direction. At the Landfill site, the highest measured PM_{10} concentrations tend to occur on days when winds are from the north, while the highest BC concentrations are measured when winds are from the southeast. At the Community site, concentrations of BC and PM_{10} are highest when winds are from the south.

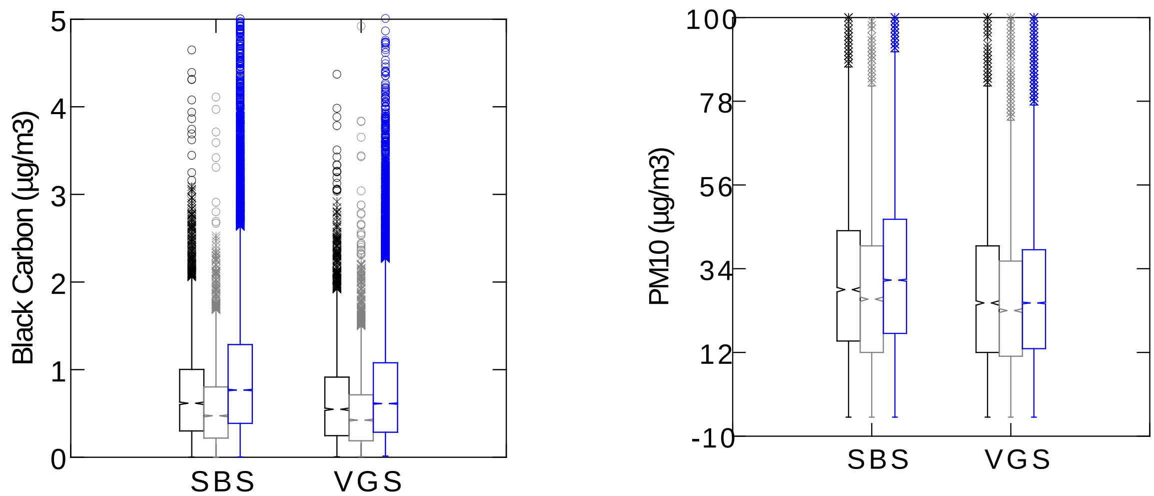


Figure A-6. Hourly BC and PM_{10} concentrations at the Landfill (SBS) and Community (VGS) monitoring sites on weekdays (blue), Saturdays (black), and Sundays (grey). Only data from November 22, 2011, through November 21, 2012, are included.

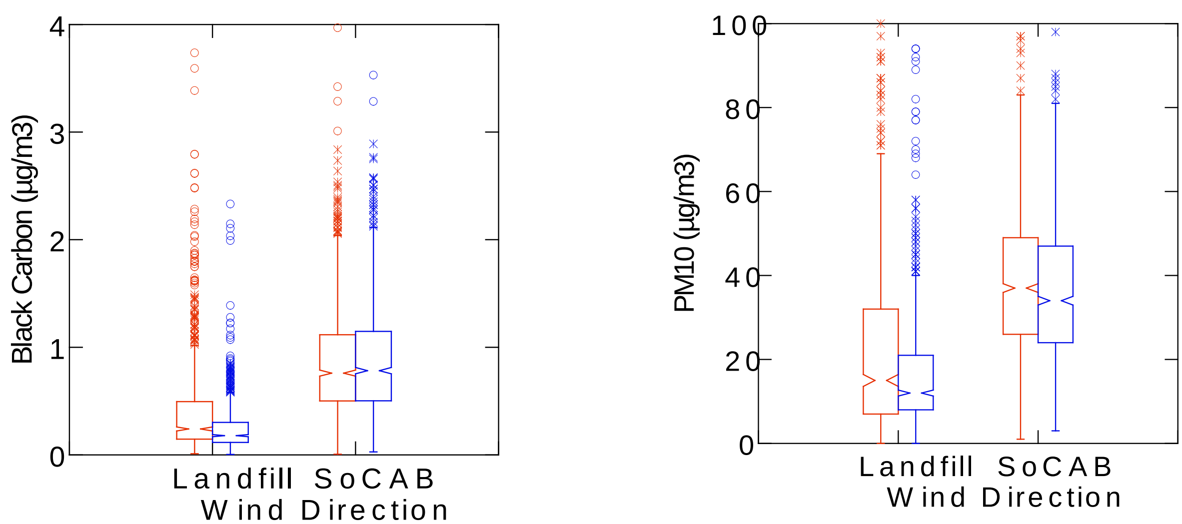


Figure A-7. BC and PM_{10} concentrations at the Landfill (red) and Community (blue) monitors during November 22, 2011, through November 21, 2012, when winds originate from the Landfill versus when they originate from the South Coast Air Basin (SoCAB). Results are based on hourly data points where both sites experienced winds from the same sector.

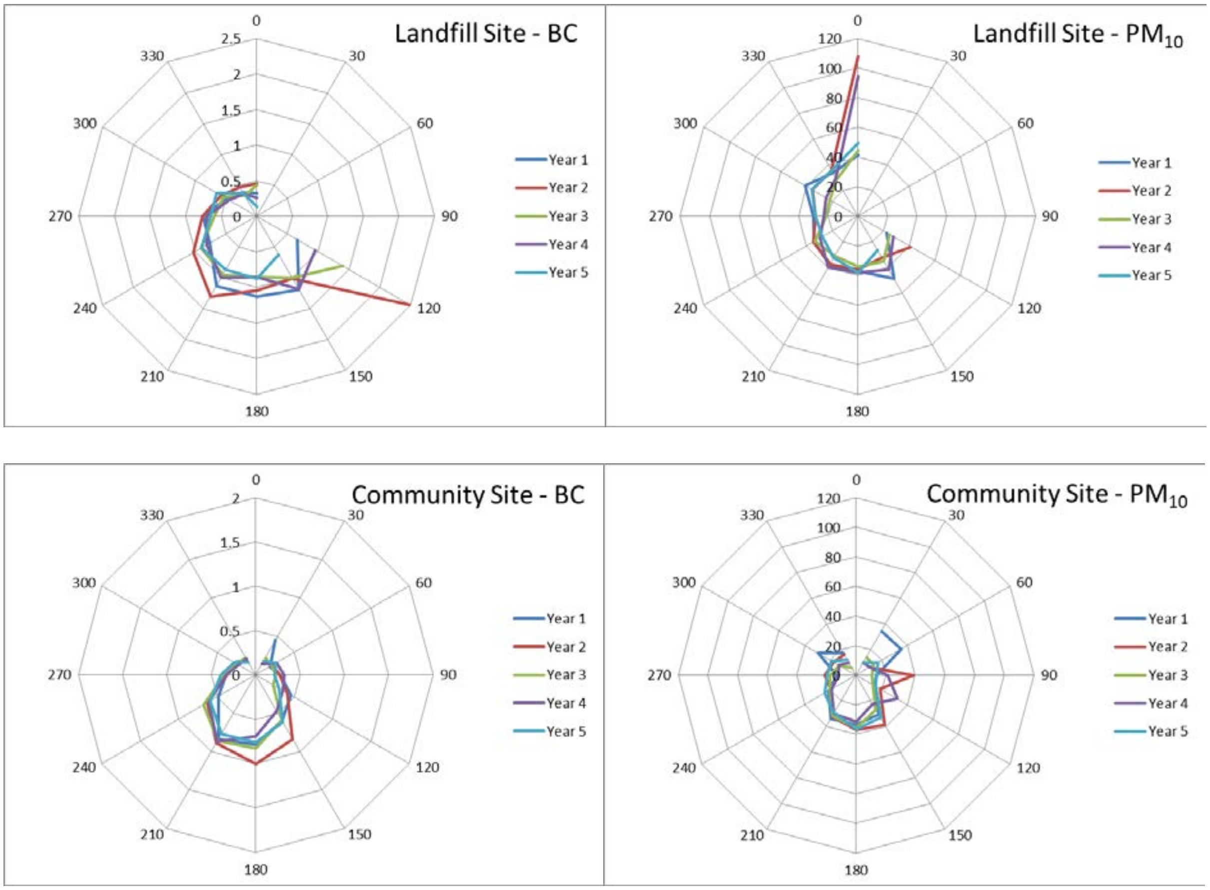


Figure A-8. Average daily BC and PM_{10} concentrations at the Landfill and Community sites, binned by prevailing wind direction for each of the five monitoring years.