Sixth Annual Report of Ambient Air Quality Monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School: A Six-Year Summary

November 22, 2007–November 21, 2013

Prepared for
Los Angeles County Department of Regional Planning
Los Angeles, California

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Sixth Annual Report of Ambient Air Quality Monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School: A Six-Year Summary November 22, 2007–November 21, 2013

Annual Report
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On the cover (clockwise from upper left): monitoring trailer and meteorological tower at Van Gogh School, auditing flow and temperature with DeltaCal NIST-traceable reference meter, aethalometer with Beta Attenuation Monitor and data acquisition system, monitoring trailer and meteorological tower at South Berm, and 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 Sixth Annual Report includes data summaries, accompanied by analysis and interpretation, drawn from six 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 sixth 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, and quantitative estimates of the contributions of landfill operations to ambient concentrations of PM_{10} and BC.

Combined with the previous five years of data, the sixth 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 (sixteen exceedances versus two exceedances, respectively, over six 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.
  - At the Landfill site, seven of the sixteen PM_{10} exceedances to date have occurred in the fall quarter (September through November), while six of the sixteen have occurred in the spring quarter (March through May). No exceedances have occurred in the summer quarter (June through August), although monthly median concentrations are highest during the summer.
- 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, six monthly averages from the Landfill monitor and three monthly averages from the Community monitor exceeded the Los Angeles average, with a majority occurring typically during summer months of onshore wind flow. During 2012, five monthly averages from the Landfill monitor exceeded the Los Angeles average; however, three months (July, August, and December) could not be compared due to incomplete data at one or both sites. During 2013, five monthly averages from the Landfill monitor exceeded the Los Angeles average, most of which occurred during warm weather.
  - Annual average PM_{10} concentrations at the Landfill site and the Community site are higher than those measured in Santa Clarita (one-in-six 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 six-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 70% lower) than when it was from the SoCAB (about 16% 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 to 4 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, 6, and 2 $\mu g/m^3$, respectively, for the last six consecutive years. The 61% decrease from Year 5 to Year 6 has reversed the former trend of increasing contributions observed from Year 1 to Year 3 and again from Year 4 to Year 5. A similar to decrease was measured 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 11 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 from 7.2 $\mu g/m^3$ in Year 1 to 26.3 $\mu g/m^3$ in Year 4, but decreased in Year 5. In Year 6, it increased again. For Years 3, 4, 5, and 6, 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, the decrease in Year 5, and the increase in Year 6, 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 at the Community site except for Year 4 and Year 5. In Year 4, the Landfill contribution to Community BC levels averaged close to zero (-0.01 $\mu g/m^3$, 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 six years of this study.
  - As measured at the Landfill BC monitor, the landfill contribution to ambient BC concentrations declined by 65% 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 site are assumed to be associated with a general increase in landfill activities or scope of operations. The landfill contribution to ambient BC concentrations dropped significantly from Year 5 to Year 6 at both the Landfill monitor and Community monitor. This may be due to changes in landfill activities and/or diesel equipment modifications, though no activity data or statistics on diesel equipment is presented in this report.
  - The estimated landfill contribution to BC concentrations as measured at the Landfill site is, depending on year, a factor of 3 to 11 times greater than the estimated contribution 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 in some years) 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

[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.

flows from the landfill to the Community receptor site at Van Gogh Elementary School, as well as for 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, 2013, marked the completion of six 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, data completeness statistics for the six years indicate average data capture rates of 94% at the Landfill site, and 97% at the Community 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 six years between November 2007 and November 2013 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 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.

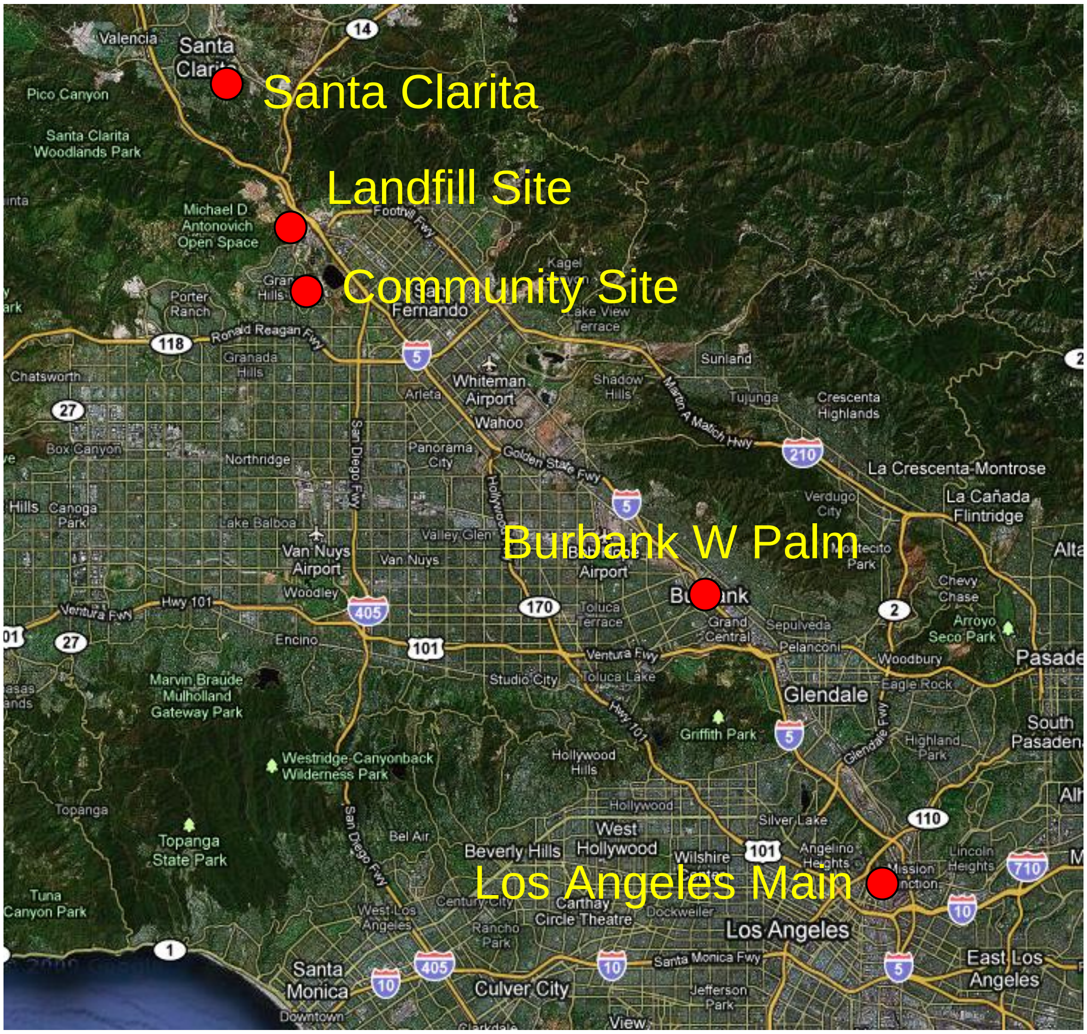


Figure 1-1. Locations of the Landfill and Community monitors in relation to the three SCAQMD sites that are used for regional comparisons.

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 6, with additional 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 conditions. One of the November 2011 abatement amendments directly affected STI's monitoring protocols. The landfill was required to conduct one-in-six day sampling of volatile organic compounds

(VOCs) for a minimum of one year, following established U.S. Environmental Protection Agency (EPA) schedules and protocols of SCAQMD's Multiple Air Toxics Exposure Study (MATES IV). 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 has not conducted any LFG sampling as previously required 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 six years considered in this analysis. Except for Year 2 at the Landfill monitoring site, the percent data capture exceeded 90% within each site-year for PM_{10}, and averaged over 97% over all years. 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, 5, and 6 of continuous monitoring, and overall six-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	91.0%	99.6%	100.0%	96.9%	99.9%	99.9%	0.0%	0.0%	4.2%
	Van Gogh Elementary School Site	100.0%	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	99.0%	97.6%	99.4%	95.4%	100.0%	100.0%	5.0%	0.0%	1.0%
	Van Gogh Elementary School Site	94.0%	99.8%	98.7%	98.1%	100.0%	96.1%	0.0%	0.0%	0.0%
Year 6 November 22, 2012–November 21, 2013	Sunshine Canyon Landfill Site	99.9%	92.0%	94.6%	97.4%	100.0%	100.0%	1.0%	0.0%	1.9%
	Van Gogh Elementary School Site	100.0%	95.7%	98.1%	97.4%	100.0%	98.7%	0.1%	0.0%	0.3%
Six-Year Average	Sunshine Canyon Landfill Site	95.1%	92.0%	94.6%	97.4%	100.0%	100.0%	1.0%	0.0%	1.9%
	Van Gogh Elementary School Site	97.8%	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 six 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 16 occasions at the Landfill site; on two of those 16 days the Community monitor also registered an exceedance. Note that the first exceedance reported in Table 3-1 occurred in October of 2007, after the equipment at the sites was refurbished and continuous monitoring began, but before the period covered by this report. These early concentration data are valid and thus included here for completeness. 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 $\mu g/m^3$ 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 one-in-six day schedule. Only one of the days listed in Table 3-1 happened to fall on the one-in-six day Santa Clarita sample schedule. This serves as a reminder of the utility of continuous monitoring: 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 $\mu g/m^3$. At the Landfill site on October 21, 12 of the 24-hourly PM_{10} values were invalid, because the measurements exceeded the maximum of the PM_{10} monitor (1,000 $\mu g/m^3$), causing the output to default to error values. 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 $\mu g/m^3$, with hourly average values ranging from 150 to 294 $\mu g/m^3$ 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 six 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 [d]	-- [b]
10/26/2012	227	49	31	40 [b]	-- [b]
3/21/2013	181	34	32	37	-- [b]
4/8/2013	174	64	53	-- [b]	-- [b]
10/4/2013	200	64	28	58	-- [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.

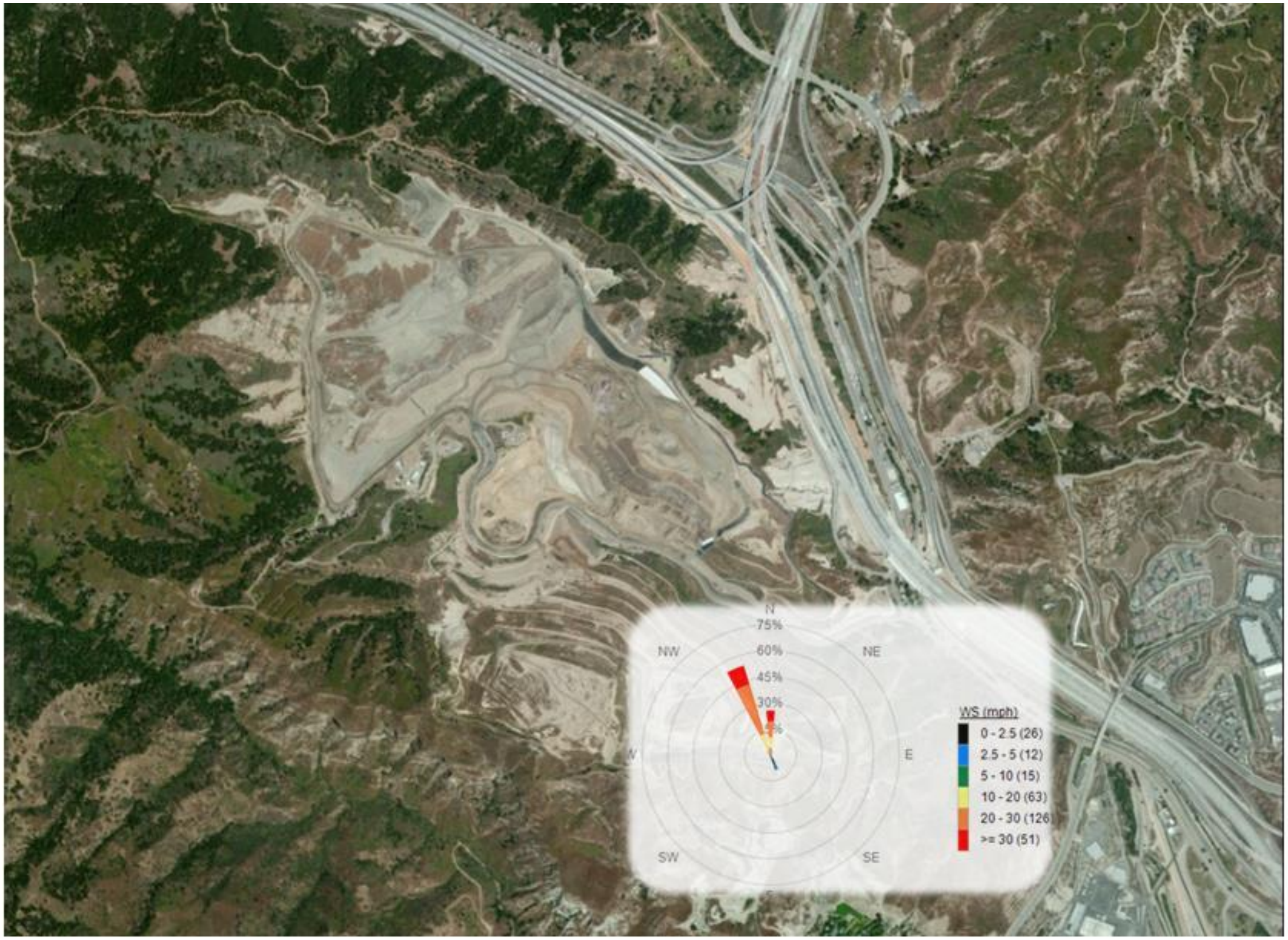


Figure 3-1. Wind rose from exceedance days during six continuous monitoring years at the Landfill monitoring site, illustrating the fetch that encompasses working portions of the landfill. Wind speed units are mph. The wind rose center point is directly over the location of the landfill monitoring site.

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 2013. 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 through 2013 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 in **Figure 4-2** for the years 2010, 2011, 2012, and 2013; 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 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, 2012, and 2013, 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 four years, were less than 5 mph, implying that entrainment of crustal material from the landfill 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.

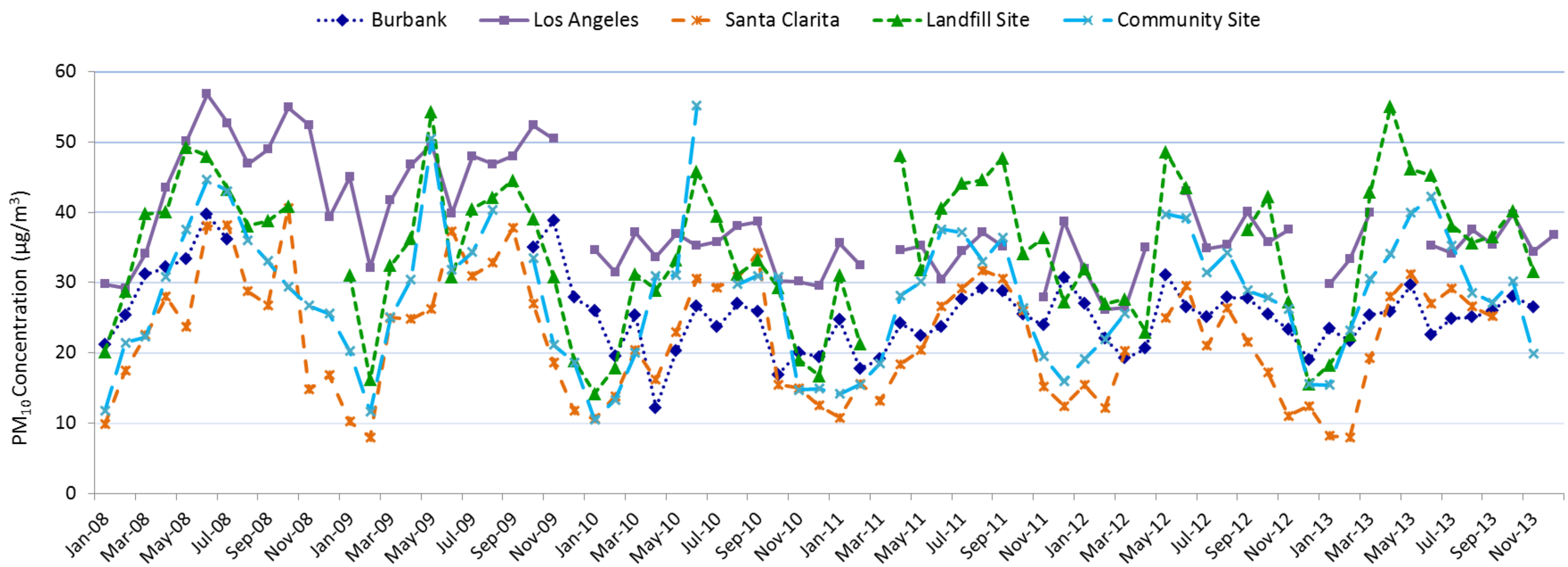


Figure 4-1. Monthly average PM_{10} concentrations for the Landfill and Community sites and three regional monitoring sites for 2008–2013.

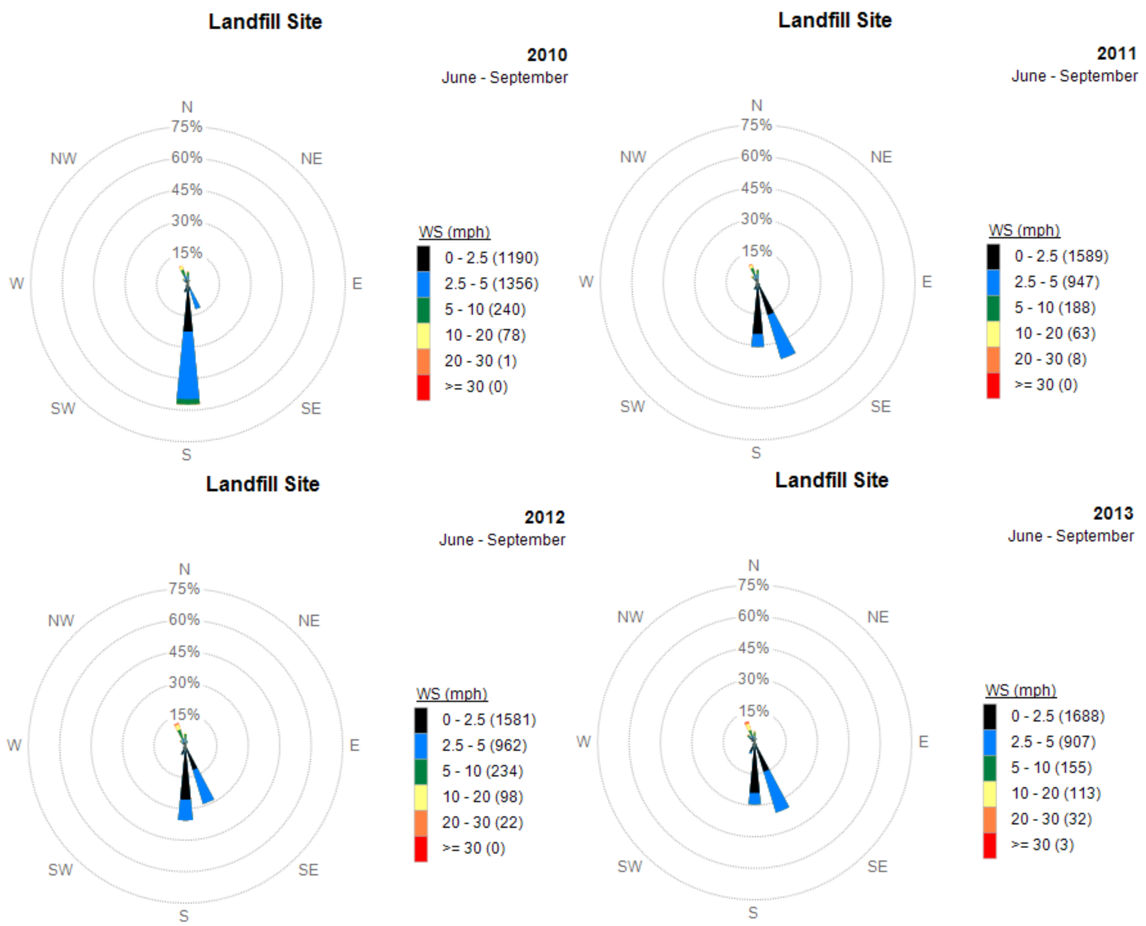


Figure 4-2. Wind roses of hourly data from the Landfill monitor for the months of June through September for 2010, 2011, 2012, and 2013 show the dominance of onshore wind flows in the summer, coupled with relatively low hourly averaged wind speeds, and illustrate the shift to SSE winds during 2011, 2012, and 2013 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 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 six-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 six-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, fourth, and fifth 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 Community 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).

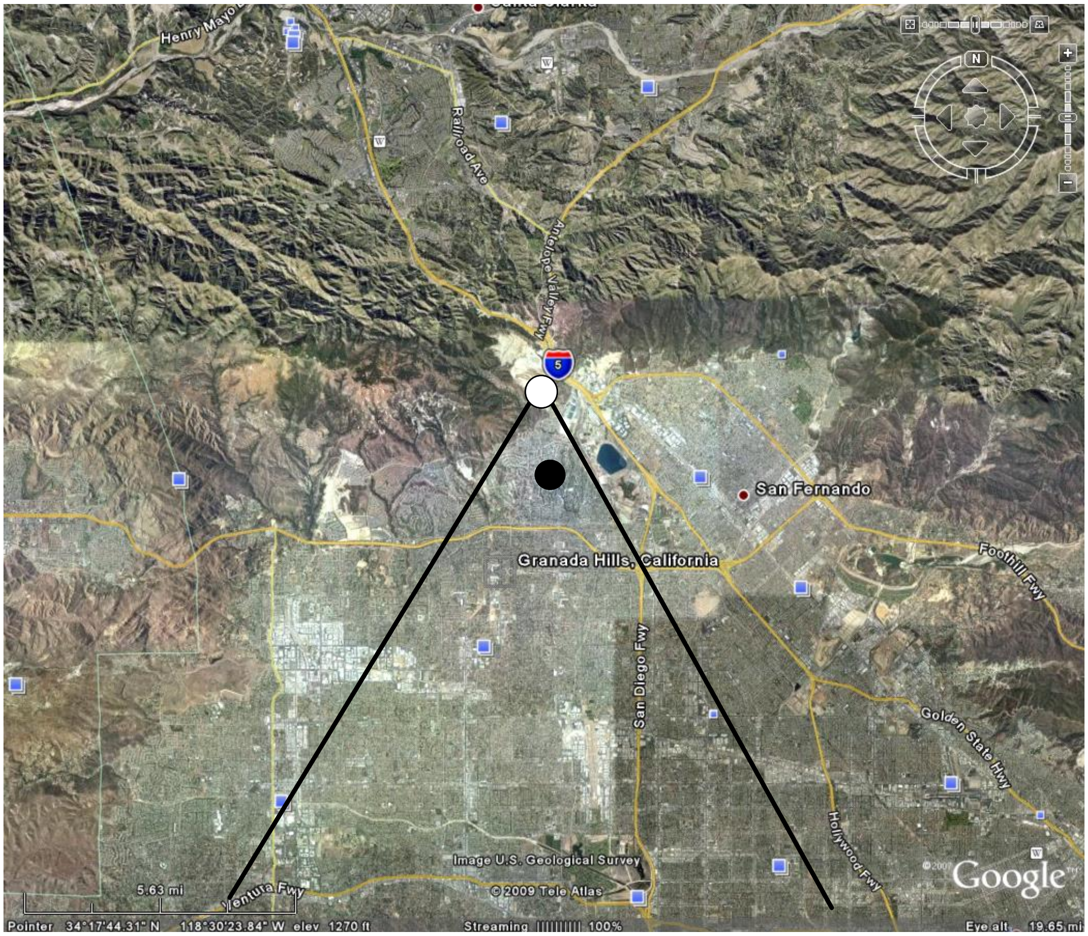


Figure 5-2. Aerial image of the Sunshine Canyon Landfill and the northern portion of the SoCAB, showing the wind direction sector representing the SoCAB source used for selecting data for analysis to compare with the landfill wind direction sectors depicted in Figure 5-1. The white dot represents the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

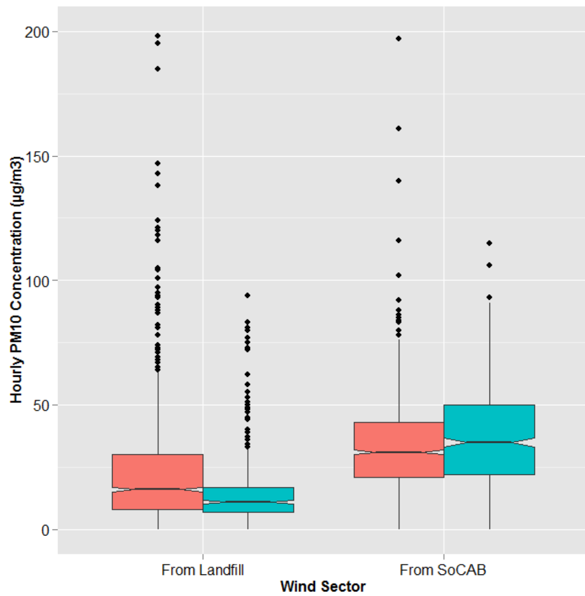
5.3 PM_{10} Concentrations

Figure 5-3 summarizes the six-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 diamonds.

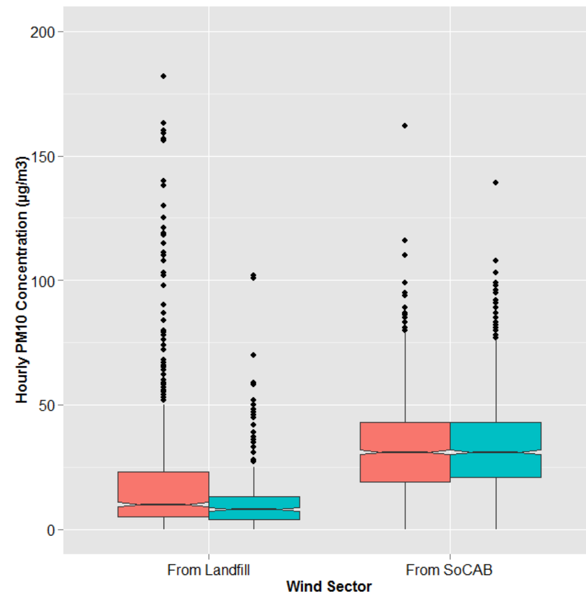
The following general conclusions are based on the median values presented in Figure 5-3. Note that these conclusions are nearly identical to those reached in the Fifth Annual Report (delivered in 2013), as are the proportions cited in the following bullets:

- 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 70% lower) than on non-working days when wind came from the SoCAB (approximately 16% lower), reflecting the larger regional PM_{10} influence of the SoCAB on non-working days.

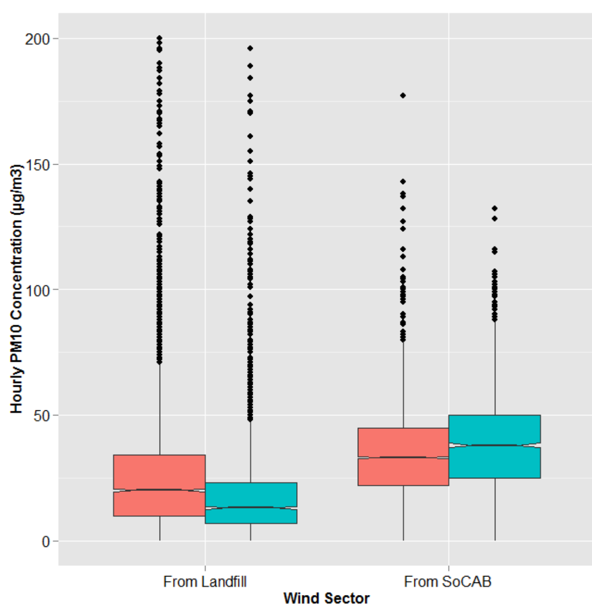
[3] A notched box-whisker plot shows the entire distribution of concentrations for each year. In box-whisker plots, each box shows the 25th, 50th (median), and 75th percentiles. The boxes are notched (narrowed) at the median and return to full width at the 95% lower and upper confidence interval values. 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).



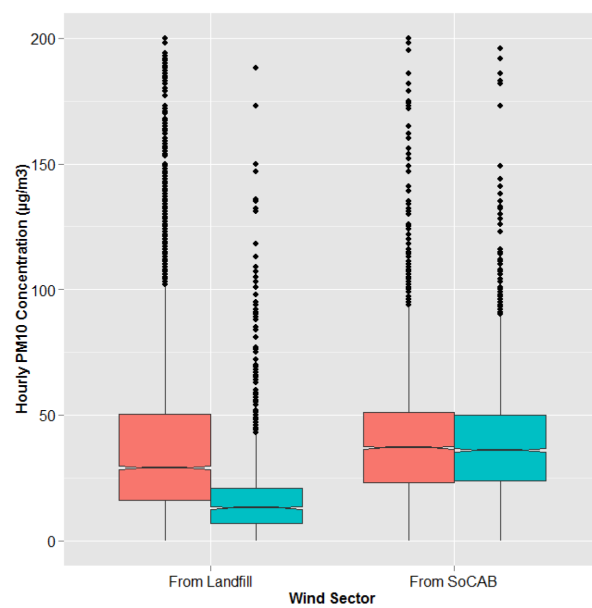
(a) Working hours on working days



(b) Non-working hours on working days



(c) Working hours on non-working days



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

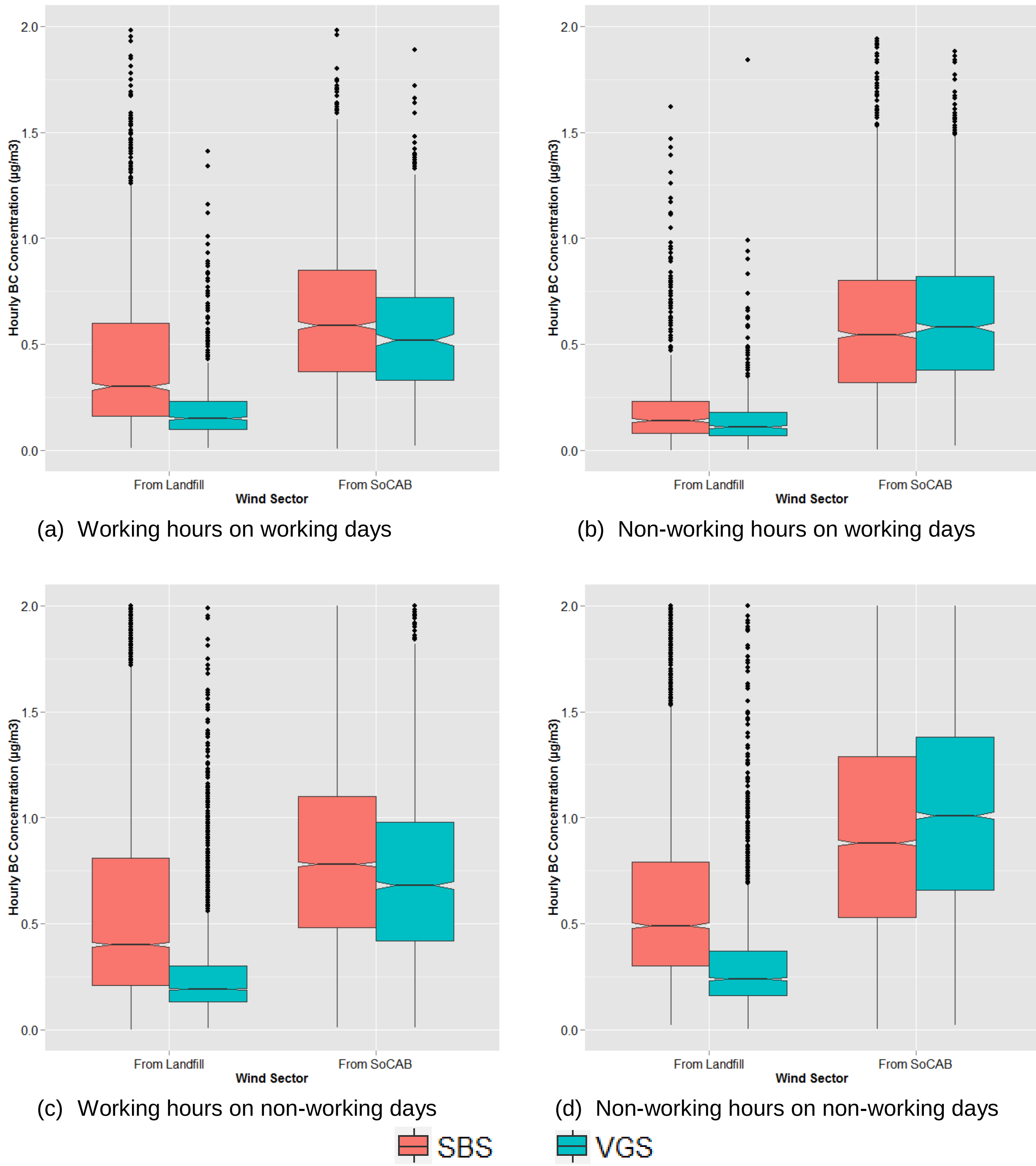
Figure 5-3. Notched box plot of six-year hourly average PM_{10} concentrations for northerly ("From Landfill") and southerly ("From SoCAB") wind sectors for working and non-working days and for working and non-working hours within those days for the Landfill (Sunshine Berm Site [SBS], pink box) and Community (Van Gogh School [VGS], turquoise box) monitor sites. Outliers over 200 μg/m^3 are not displayed in the box plot.

5.4 BC Concentrations

Figure 5-4 summarizes the six-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 Fifth 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 five 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) to 4 (Landfill site) when winds were from the landfill, and by a factor of 1 when winds were from the SoCAB. On working days, diesel powered vehicles (trucks and earth moving equipment) operating at the landfill increase the ambient concentrations of DPM, as determined by the BC measurements. However, the large metropolitan area of the SoCAB remains the dominant source of DPM.



(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 5-4. Notched box plot of six-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 the Landfill (SBS, pink box) and Community (VGS, turquoise box) monitor sites. Outliers over 2 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 one-in-six 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}, and wind direction often changes during the 24-hour period, meaning the 24-hour averages from Santa Clarita likely confuse any apportionment by wind direction.

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 the 2009 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.

[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.

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 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).

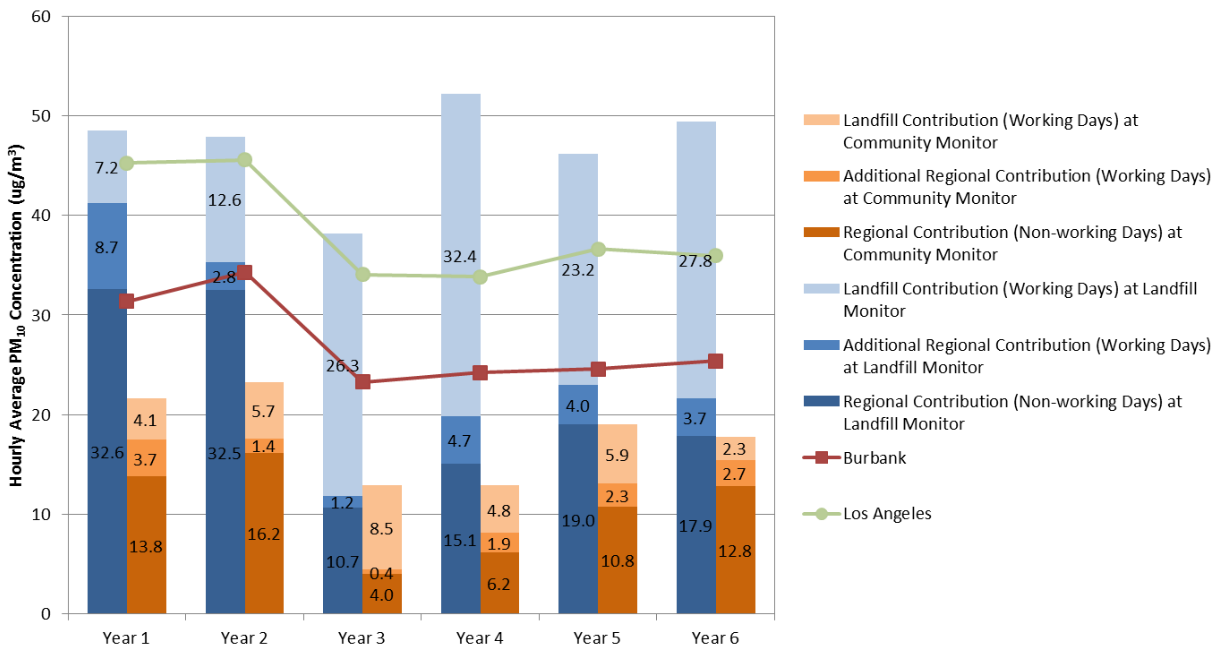


Figure 6-1. Summary of six consecutive years of quantitative estimates of the average regional contribution to ambient PM_{10} levels on non-working days (dark blue/orange bars), the additional regional contribution associated with increased activity levels on working days (medium blue/orange bars), and the average hourly landfill contribution on working days (light blue/orange bars) for the Landfill (blue bars) and Community (orange bars) monitor sites. 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. It decreased in in Year 5 but increased again in Year 6. 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 other years since Year 3.
- 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 that observed at the Community monitor (dark orange bars). 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 decreased by about 61% between Year 5 and Year 6.
- The additional regional contribution of PM_{10} associated with working days at the Landfill site (medium blue bars) decreased by 8% between Year 5 and Year 6, 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% but resumed in Year 6 with the PM_{10} attribution to the landfill increased by 20%
- 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.
- The estimated landfill contribution to PM_{10} concentrations measured at the Community monitor in Year 6 was the lowest of all measured years.

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 six 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 reported first three years of data.

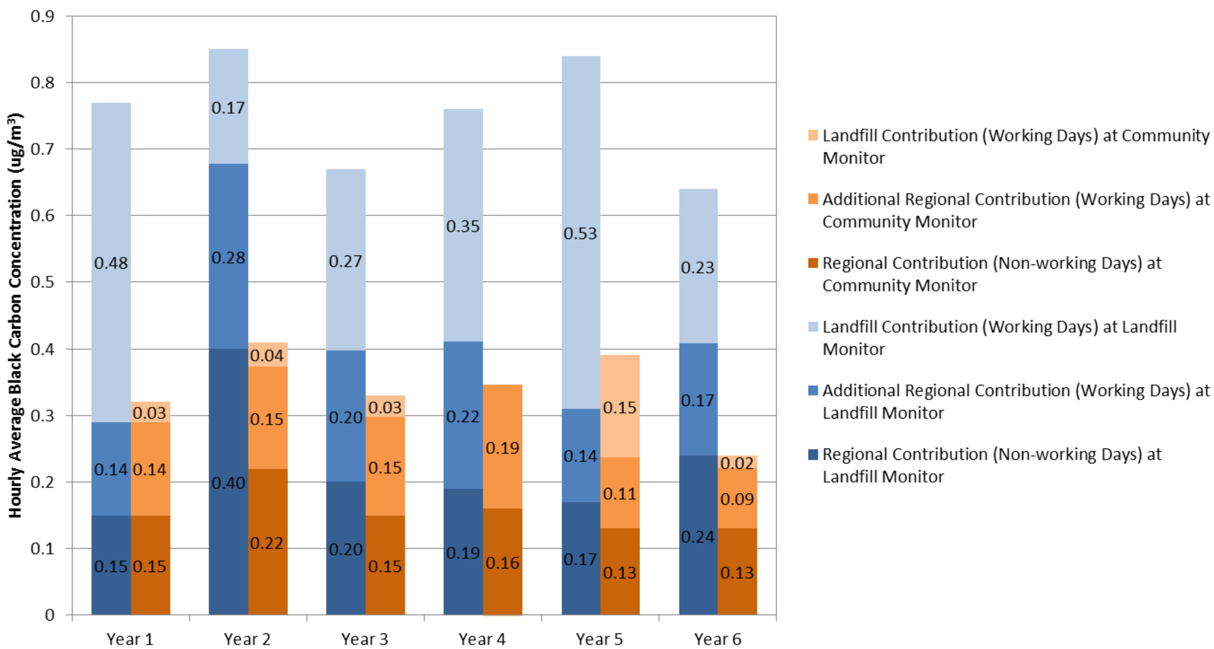


Figure 6-2. Summary of six consecutive years of quantitative estimates of the average regional contribution to ambient BC levels on non-working days (dark blue/orange bars), the additional regional contribution associated with increased activity levels on working days (medium blue/orange bars), and the 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 except for Year 4 and Year 5. In Year 4, the landfill contribution to Community BC levels averaged close to zero (-0.01 $\mu g/m^3$, 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 65% from Year 1 to Year 2, but then increased during Year 2 through 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. The landfill contribution to ambient BC concentrations dropped significantly from Year 5 to Year 6 at both the Landfill and Community monitors. Because tonnage has not decreased at the landfill, this decrease is probably not due to any decrease in landfill activities (no specific activity data is cited here.). A portion of this decrease might reflect ongoing efforts to better control DPM emissions from the truck fleet throughout the SoCAB, as well as landfill-based trucks and equipment.

7. 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 (BAM) and the Aethalometer. This protocol is in keeping with the recommended maintenance schedule recommended by Met One (manufacturer of the BAM) 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. **Tables 7-1 and 7-2** summarize all visits during December 1, 2012, through November 30, 2013, for the two monitoring sites, respectively.

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.

Table 7-1. Sunshine Canyon Landfill monitoring site visits and field maintenance and operations from December 1, 2012, through November 30, 2013.

Date of Site Visit	Description of Work
January 19, 2013	Performed flow check on BC and BAM samplers. Collected PM_{10} and BC data. Changed tape supply in BAM and conducted BAM self-test; passed. Removed plastic bag from RMY wind speed monitor mast.
March 15, 2013	Performed flow check on BC and BAM samplers. Collected PM_{10} and BC data. Adjusted BAM ambient temperature; changed BAM tape.
April 20, 2013	Performed flow check on BC and BAM samplers. Collected PM_{10} and BC data. Cleaned dust settled in BAM cabinet; cleaned BAM roller vane and nozzle.
May 11, 2013	Performed flow check on BC and BAM samplers. Collected PM_{10} and BC data. Cleaned BAM cabinet, roller and vane; blew out BAM nozzle with can air.
June 22, 2013	Installed and calibrated new temperature sensor for BAM. Backed up BC data. Changed BAM tape; cleaned roller and vane; backed up PM_{10} data. Calibrated wind sensors.
July 24, 2013	PM_{10} data collected; cleaned cabinet, performed BAM flow/leak check. BC data collected; performed Aethalometer flow check. Repaired trailer door.
August 27, 2013	Replaced BAM tape, ran BAM self-test; backed up data.
September 3, 2013	Collected BC data; performed Aethalometer flow check. Collected PM_{10} data; backed up PM_{10} data; performed BAM flow/leak check.
September 20, 2013	Collected BC data; backed up BC data; performed Aethalometer flow check. Collected PM_{10} data; backed up PM_{10} data. Cleaned BAM roller, vane, and nozzle. Performed BAM flow/leak check.

Date of Site Visit	Description of Work
October 5, 2013	No communication; power cycled router and communications were re-established.
November 1, 2013	Replaced BAM tape, ran BAM self-test; backed up data.
November 25, 2013	Collected BC data; backed up BC data; performed Aethalometer flow check. Collected PM_{10} data; backed up PM_{10} data. Cleaned BAM roller, vane, and cabinet. Performed BAM flow/leak check.

Table 7-2. Van Gogh monitoring site visits and field maintenance and operations from December 1, 2012, through November 30, 2013.

Date of Site Visit	Description of Work
January 19, 2013	Performed flow check on BC and BAM samplers. Collected PM_{10} and BC data.
January 24, 2013	Fixed BAM.
March 7, 2013	Performed flow check on BC sampler. Collected BC data.
March 15, 2013	Performed flow check on BAM sampler. Collected PM_{10} data. Changed BAM tape.
April 19, 2013	Performed flow check on BC and BAM samplers. Collected PM_{10} and BC data. Adjusted BAM ambient temperature; cleaned BAM roller and vane; changed BC tape.
May 10, 2013	Performed flow check on BC and BAM samplers. Collected PM_{10} and BC data. Changed BAM tape; cleaned BAM roller and vane; blew out BAM nozzle with can air.
June 20, 2013	Aethalometer stuck on flow stabilization; restarted and data recovered. Installed and calibrated new temperature probe for BAM; adjusted configuration. Changed BAM tape, performed flow/leak check. Calibrated wind sensors; replaced anemometer bearings.
July 7, 2013	Problem with AC unit discovered.
July 24, 2013	PM_{10} data collected; cleaned roller and nozzle; performed BAM flow/leak check. BC data collected; performed aethalometer flow check. Added insulation around AC unit.
August 26, 2013	Replaced BAM tape; backed up data.
September 3, 2013	Collected BC data; backed up BC data; performed Aethalometer flow check. Collected PM_{10} data; backed up PM_{10} data; performed BAM flow/leak check.

Date of Site Visit	Description of Work
September 20, 2013	Collected BC data; backed up BC data; performed Aethalometer flow check. Possible Aethalometer cabinet fan failure. Collected PM_{10} data; backed up PM_{10} data; performed BAM flow/leak check. Cleaned BAM cabinet, roller, and vane.
October 11, 2013	Replaced cooling fan in Aethalometer.
October 14, 2013	Found BAM data error; reseated inlet hose at pump and BAM; ran BAM self-test; cleared data error.
November 1, 2013	Replaced BAM tape, ran BAM self-test; backed up data. Took compass readings and measured heights for three trees on east side of school.
November 25, 2013	Collected BC data; backed up BC data; performed Aethalometer flow check. Collected PM_{10} data; backed up PM_{10} data; performed BAM flow/leak check.

Appendix A: Additional Analyses

This appendix contains discussions of the temporal variability in BC, PM_{10}, and wind direction (Section A.1), and of the effects of wind direction, wind speed 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 6 (November 22, 2012, through November 21, 2013) are consistent with the previous five years.

As shown in the box-whisker plots[5] (**Figure A-2**), both the Community and Landfill monitors experience higher median concentrations of BC and PM_{10} during the warm season, approximately May through September.

During May through September, the predominant wind direction at the Landfill site is from the SoCAB (56% to 78% of the time), whereas during the other months of the year it's from the Landfill sector (38% to 69% of the time) (**Figure A-3**). However, at the Community site from May through September, the predominant wind direction is from neither the Landfill nor the SoCAB sectors, although winds are more often from the SoCAB than the Landfill (Figure A-3). Perturbation of winds caused by large nearby trees at the Community substantially increases the variability in wind direction. A calculated variable, called sigma theta (based on the standard deviation of wind direction measurements), is normally used to quantify this variability. Sigma theta values at the Community monitor are higher than at the Landfill monitor (data not shown).

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).

[5] A notched box-whisker plot shows the entire distribution of concentrations for each year. In box-whisker plots, each box shows the 25th, 50th (median), and 75th percentiles. 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).

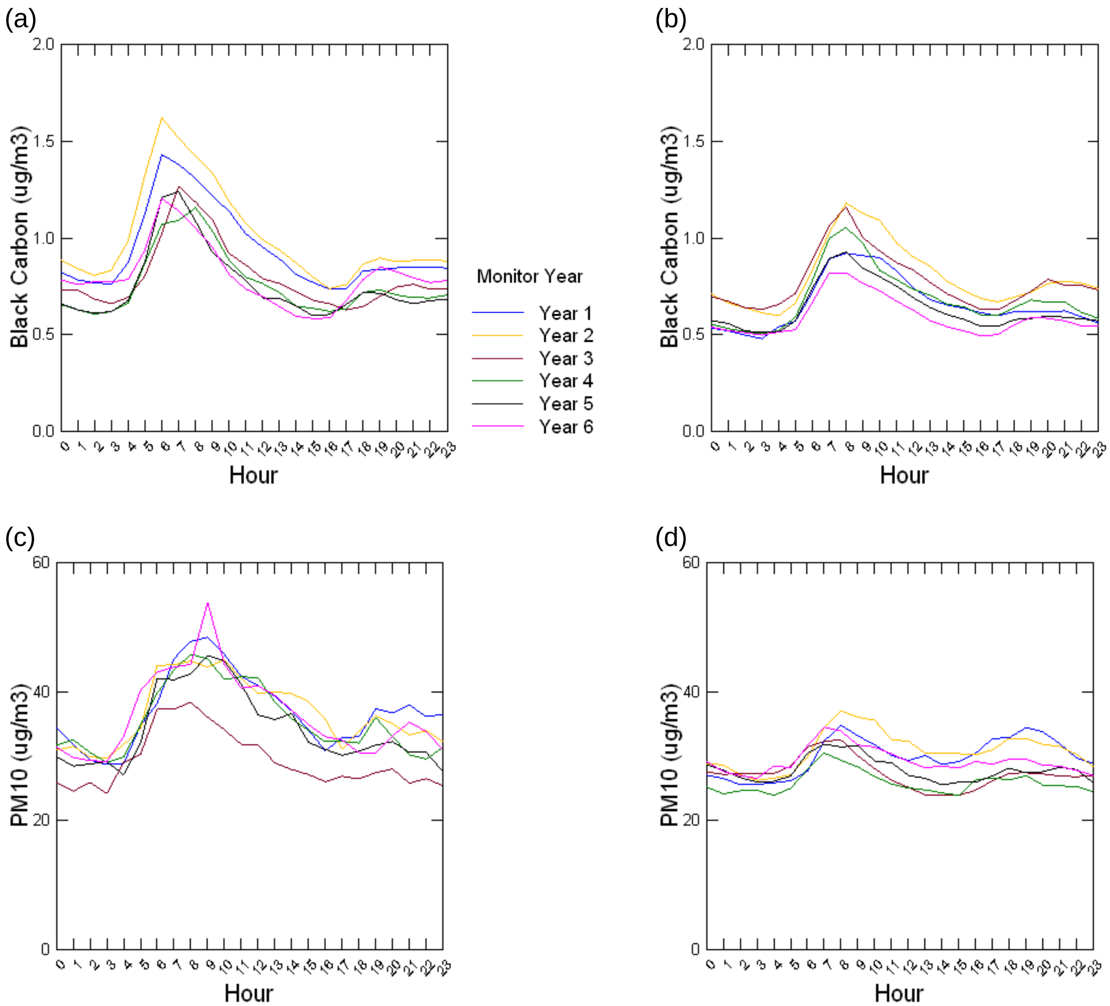


Figure A-1. Mean BC and PM_{10} concentrations by hour for the six monitoring years at the Landfill (a, c) and Community (b, d) sites.

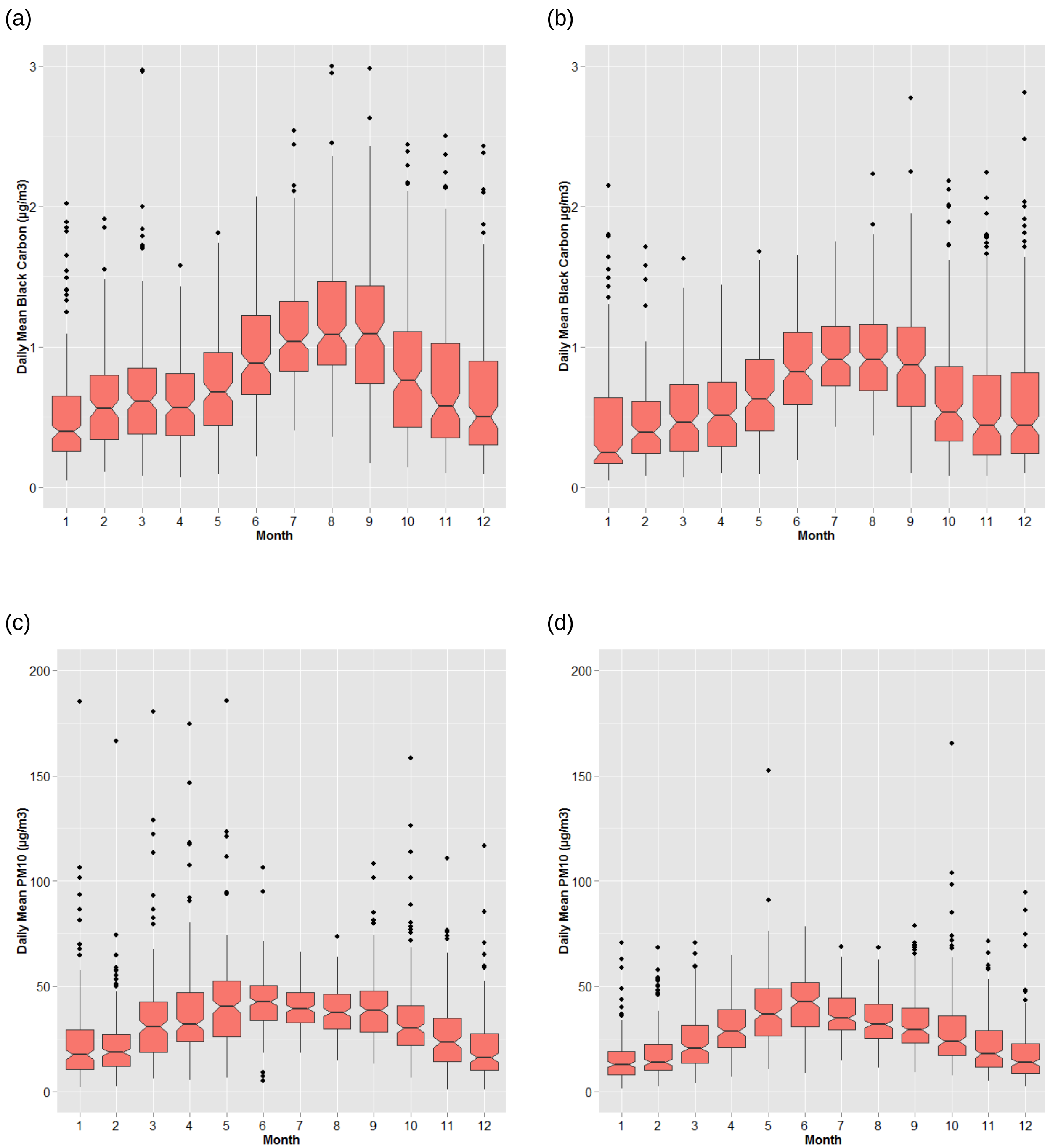
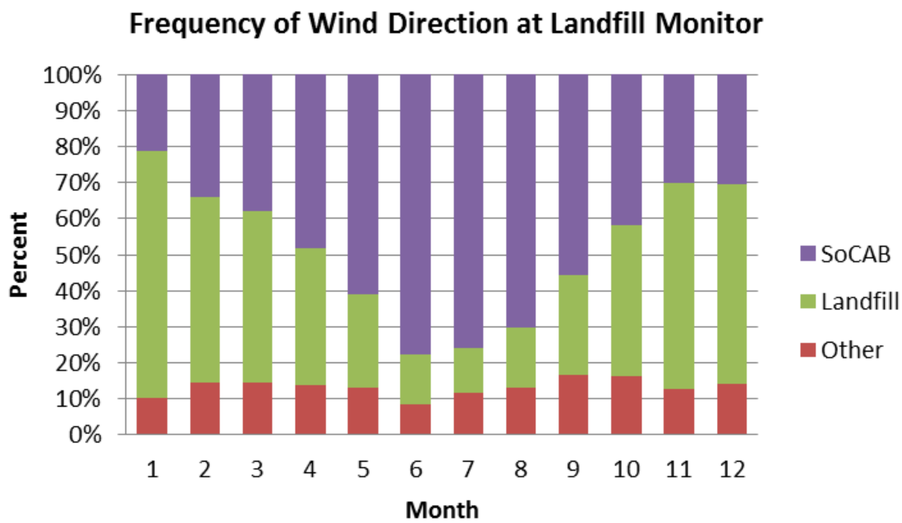
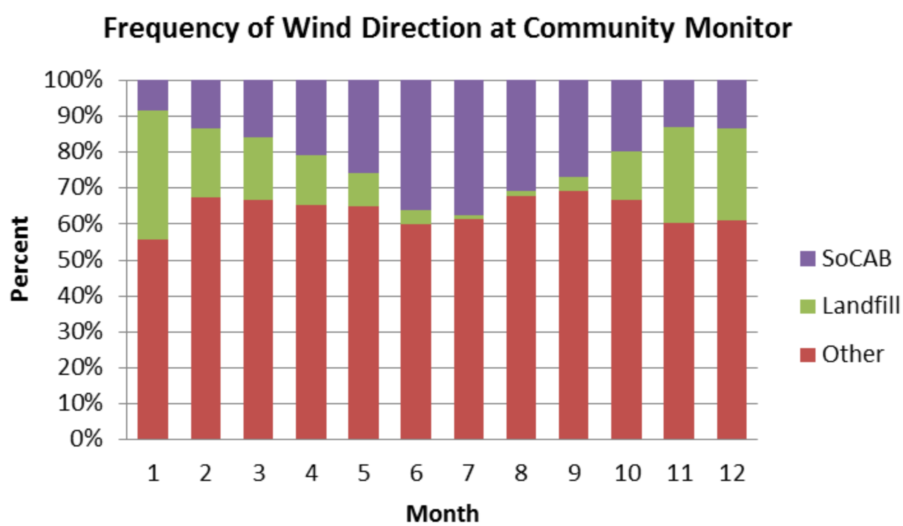


Figure A-2. Distribution of daily mean BC and PM_{10} concentrations by month at the Landfill (a, c) and Community (b, d) sites, during all six monitor years (2007–2013). BC data >3 is excluded.



(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 2007–2013.

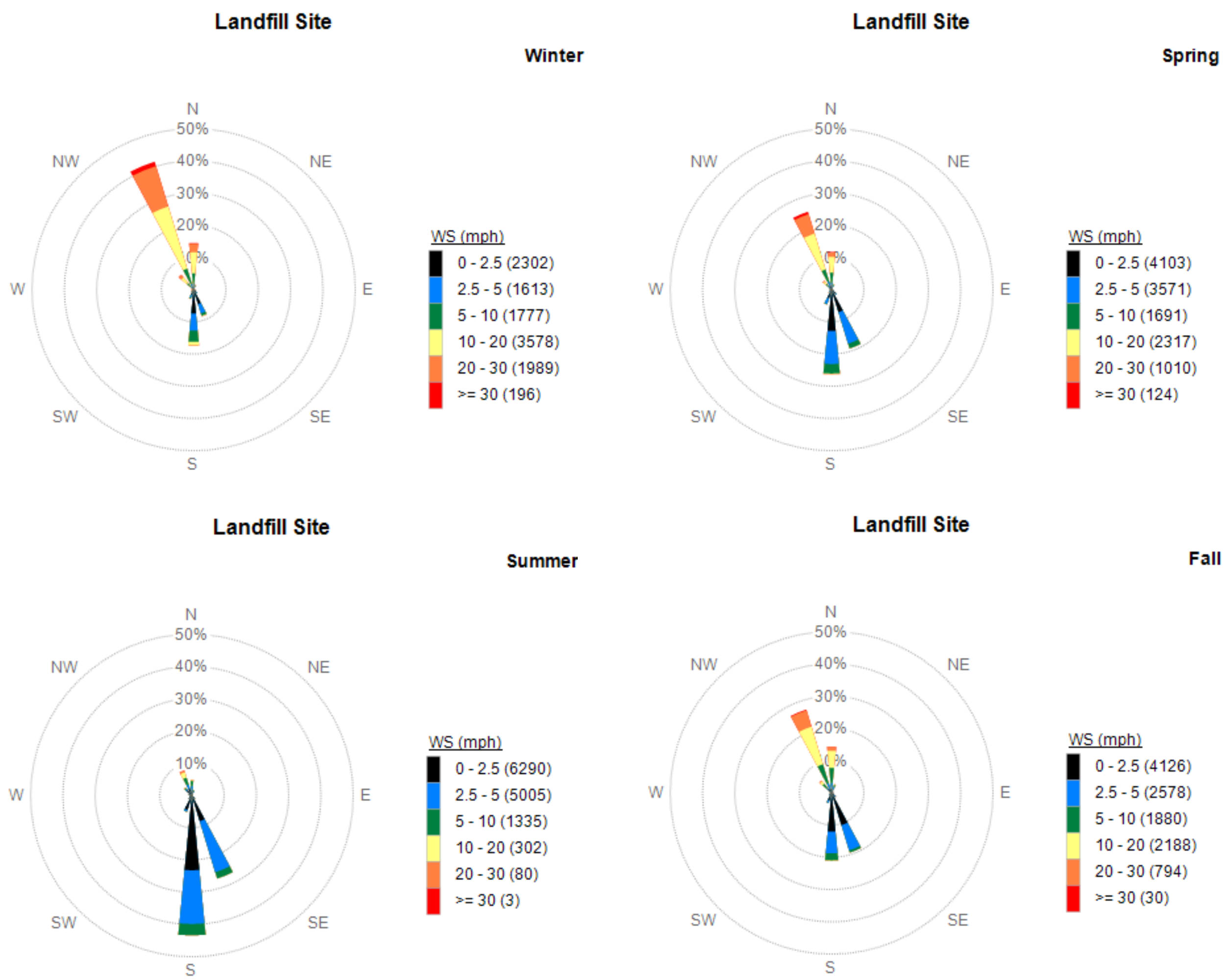


Figure A-4. Seasonal wind roses of hourly data collected at the Landfill monitor during 2007-2013.

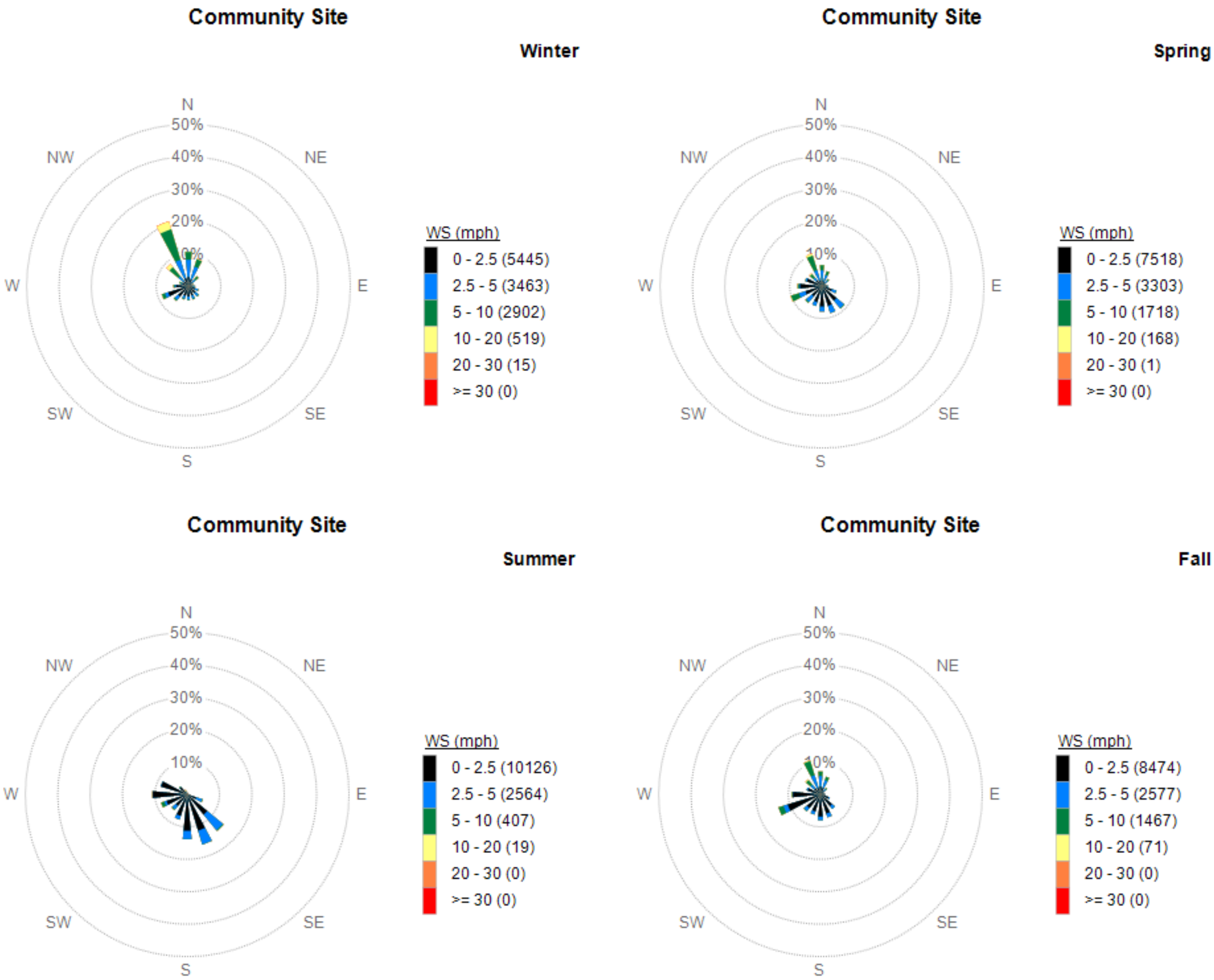


Figure A-5. Seasonal wind roses of hourly data collected at the Community monitor during 2007-2013.

A.2 BC and PM_{10}: Effects of Wind Direction, Wind Speed, 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 more potential vehicles on the roads throughout the SoCAB. Concentrations of BC and PM_{10} are higher on Saturdays than Sundays at the Landfill site, though median PM_{10} is barely higher on Saturdays compared to Sundays at the Landfill site. 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.

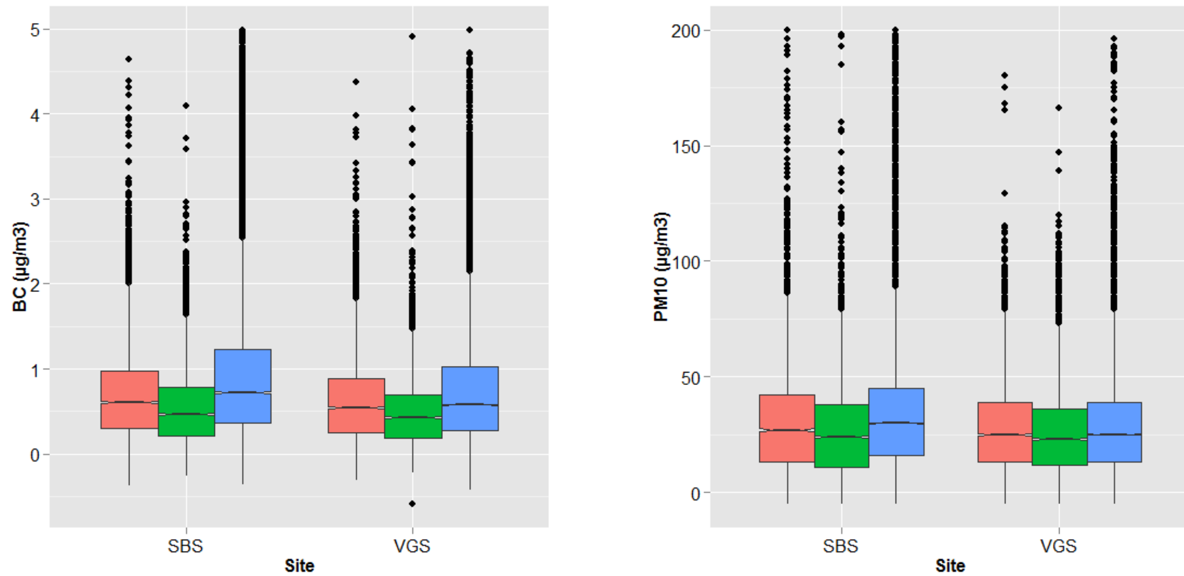


Figure A-6. Hourly BC and PM_{10} concentrations at the Landfill (SBS) and Community (VGS) monitoring sites on weekdays (blue), Saturdays (salmon), and Sundays (green). Only data from November 22, 2012, through November 21, 2013, are included. BC data >5 are excluded; PM_{10} data >200 are excluded from the plot.

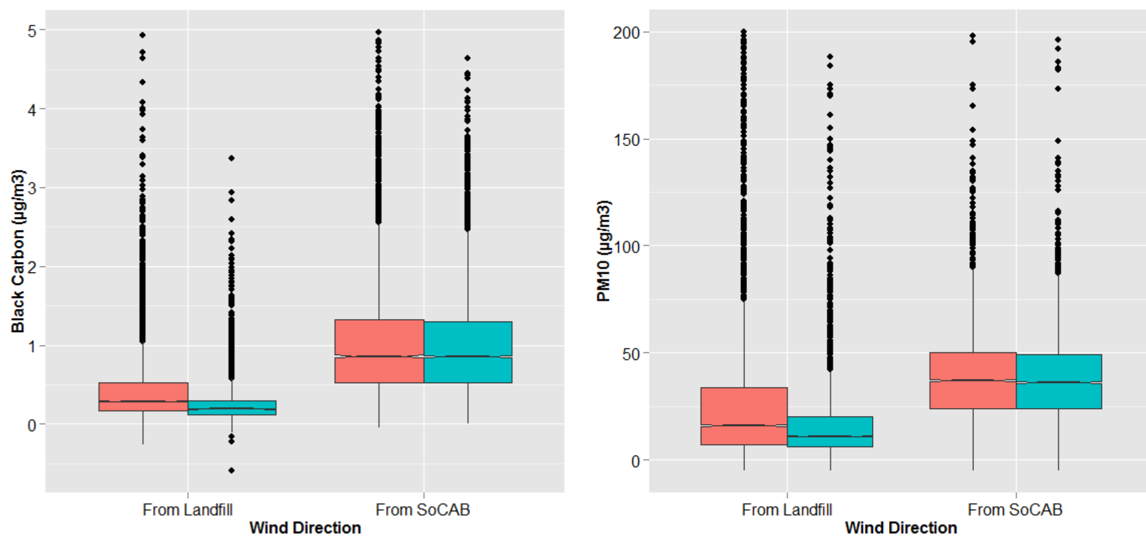


Figure A-7. BC and PM_{10} concentrations at the Landfill (salmon) and Community (turquoise) monitors during November 22, 2012, through November 21, 2013, when winds originate from the Landfill versus when they originate from the SoCAB. Results are based on hourly data points where both sites experienced winds from the same sector. BC data >5 are excluded and PM_{10} data >200 are excluded from the plot.

Figures A-8 through A-11 show bivariate polar plots[6] of mean hourly BC and PM_{10} concentrations at the Landfill and Community sites for each of the six monitoring years. The plots show the variation of BC and PM_{10} concentrations by wind direction and wind speed. In these plots, hourly wind speed, wind direction and concentration data are partitioned into wind speed-direction bins and the mean concentration is calculated for each bin (e.g., wind direction intervals of 10 degrees and 30 wind speed intervals). Using the average concentration in each bin, a surface of concentration is modeled via a General Additive Model (GAM). For each of the two pollutants at both sites, the distribution of mean concentrations shows similar patterns among the six monitoring years. For both sites, high PM_{10} concentrations tend to occur along with high wind speeds because strong wind gusts blow dust particles through the air. In contrast, high BC concentrations tend to occur along with low wind speeds because DPM accumulates and is less diluted by wind. At the Landfill site, the highest PM_{10} concentrations 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 are higher when winds are from the south, while the PM_{10} concentrations are less dependent on wind direction.

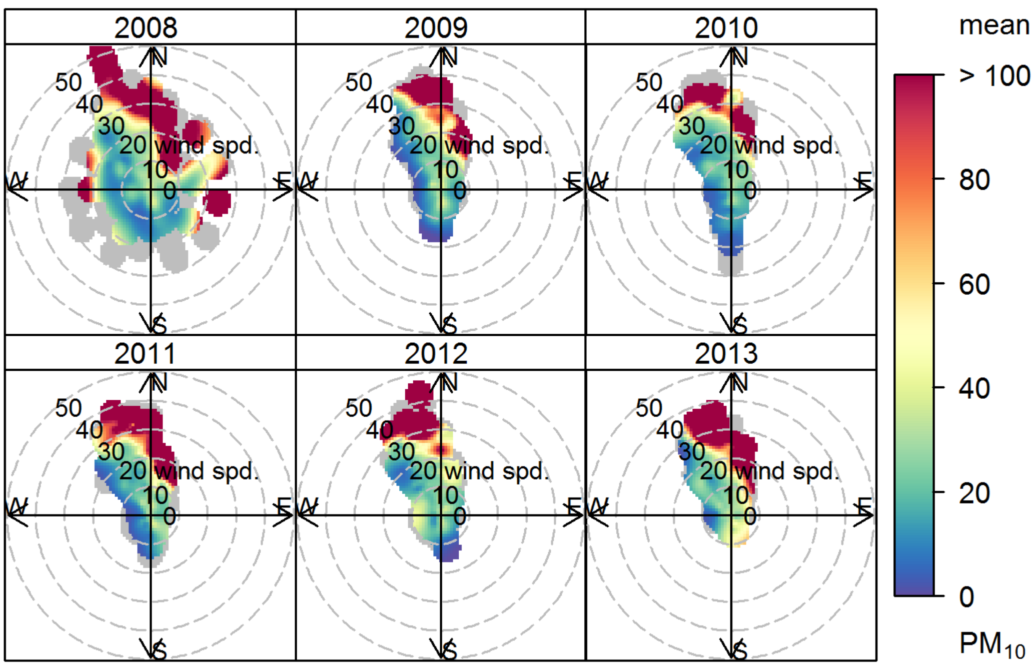


Figure A-8. Mean PM_{10} concentrations (µg/m^3) at the Landfill site by wind direction and wind speed (mph) for each of the six monitoring years.

[6] More information about bivariate polar plots is available at: http://www.openair-project.org/PDF/OpenAir_Manual.pdf.

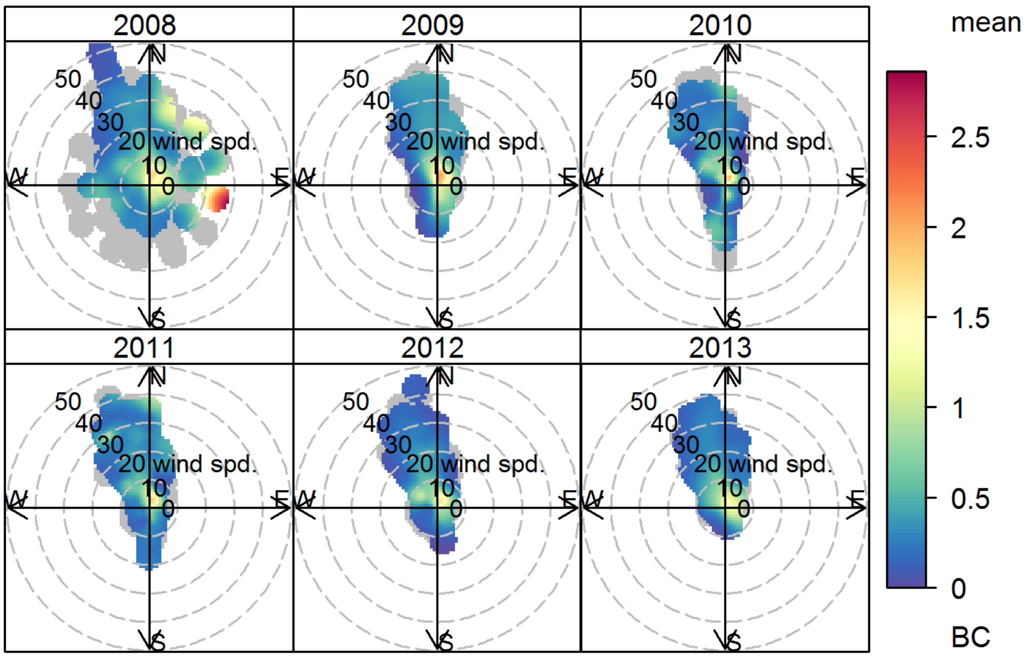


Figure A-9. Mean BC concentrations (μg/m^3) at the Landfill site by wind direction and wind speed (mph) for each of the six monitoring years.

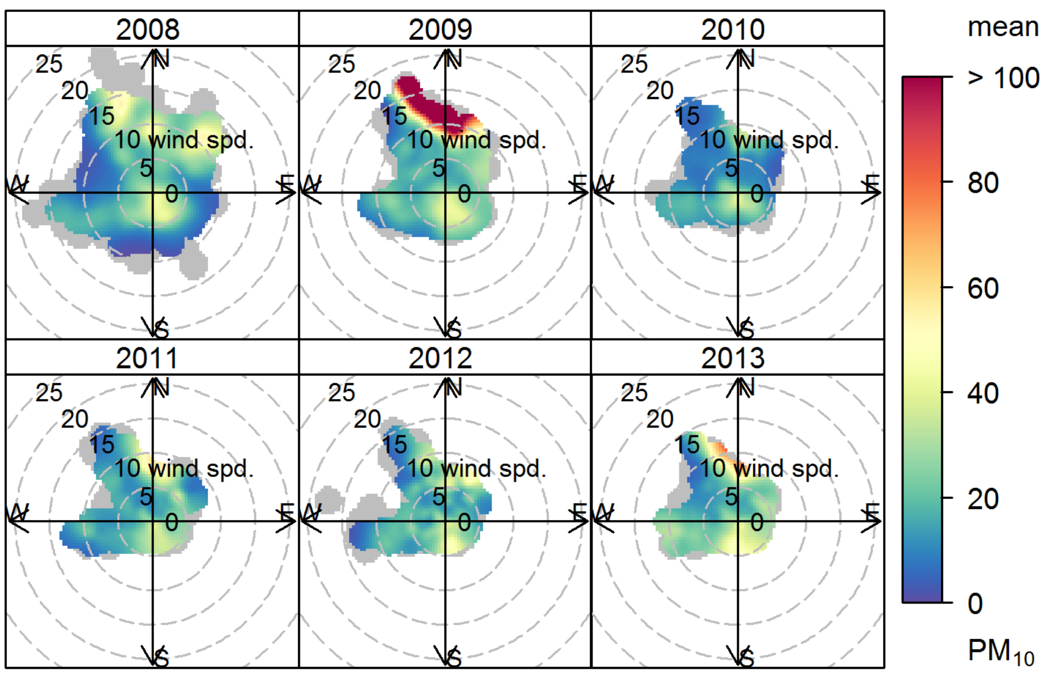


Figure A-10. Mean PM_{10} concentrations (μg/m^3) at the Community site by wind direction and wind speed (mph) for each of the six monitoring years. Note wind speed scale is different than in A-8 and A-9.

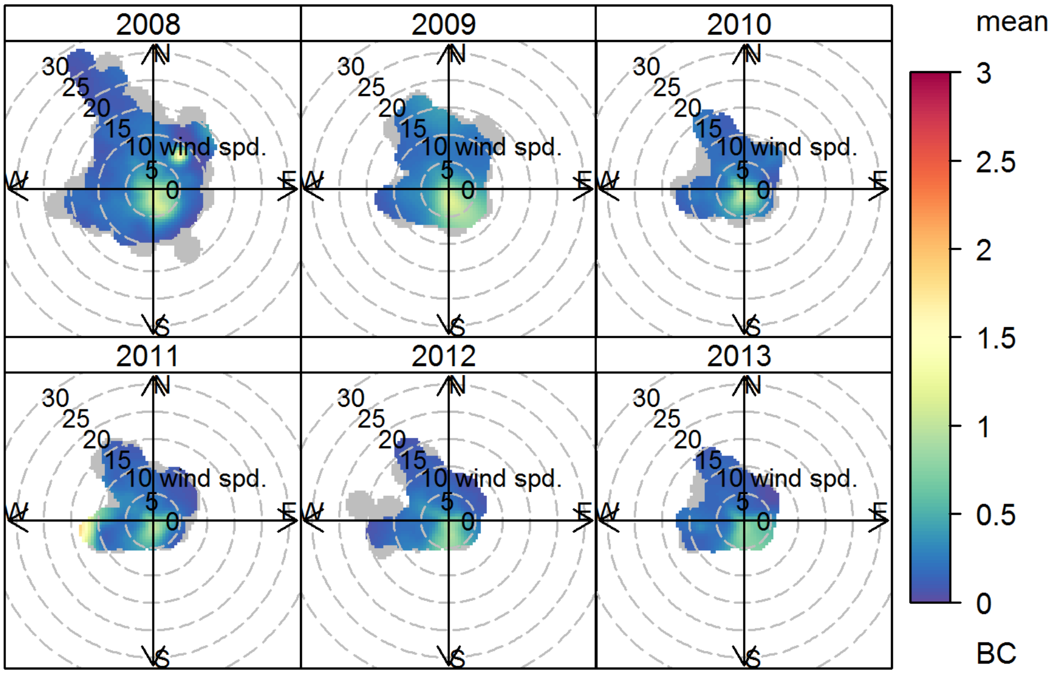


Figure A-11. Mean BC concentrations (µg/m^3) at the Community site by wind direction and wind speed (mph) for each of the six monitoring years. Note wind speed scale is different than in A-8 and A-9.

A.3 BC and PM_{10}: Trends of Monthly Mean Concentrations

The general trends of measured BC and PM_{10} levels are depicted by the smooth trend plots[7] in **Figure A-12,** which show the smooth trends of monthly mean BC concentrations measured from 2008 to 2013. For both sites, the BC level has decreased since 2010, which may be due to the phase-in of the cleaner trucks and automobiles. The smooth trend plots of PM_{10} are not presented here because no trends were observed for both sites.

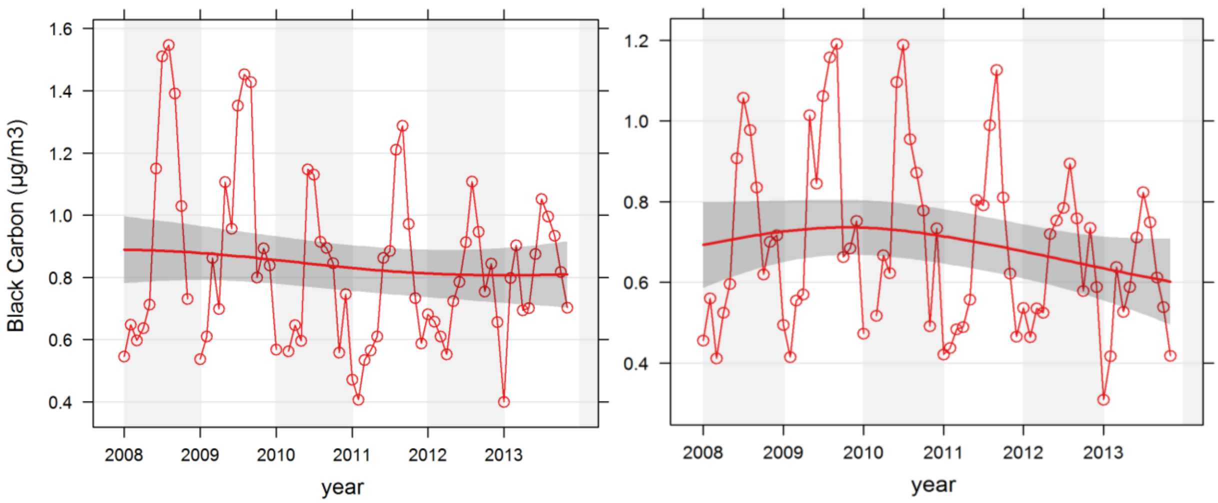


Figure A-12. Smooth trends of BC concentrations (µg/m^3) at the Landfill (left) and Community (right) sites. Monthly mean concentrations (red circles), mean concentrations (bold red line), and the 95% confidence interval (dark gray fill) are shown.

[7] More information about smooth trend plots is available at: http://www.openair-project.org/PDF/OpenAir_Manual.pdf.