Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

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

(November 22, 2007–November 21, 2011)

Annual Report
Prepared for

Planning Department, City of Los Angeles
Los Angeles, California

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

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Annual Report
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Cover photos depict monitoring stations located at the Sunshine Canyon Landfill (left) and Van Gogh Elementary School (right).

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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 quarterly and annually.

This Fourth Annual Report includes data summaries, accompanied by analysis and interpretation, drawn from four 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 last year's Third Annual Report, with updated content. Some sections, such as those covering methodology, are repeated 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.

The 4-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 3rd Annual Report, and reinforce 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 (eleven exceedances versus two exceedances, respectively, over four 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 during the four-year period.
  - 2010 was the only year in which there were no exceedances of the Federal 24-hr PM_{10}.
- 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 (N Main St., continuous monitor). During 2011, there were six monthly averages from the Landfill monitor that exceeded the Los Angeles average, with several occurring atypically during summer months of onshore wind flow.
  - 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 (N Main), Burbank (W Palm), and Santa Clarita. However, the neighborhood-scale impacts of the landfill are apparent during discrete time periods, which are typically characterized by high NW wind speeds.
- Wind direction and work activity level can impact the ambient concentrations of PM_{10} and BC. According to the four-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 average PM_{10} concentration.
    - When the wind is from the SoCAB, the Landfill and Community monitors measure about the same average BC concentration.
    - When the wind is from the SoCAB, the Community monitor measures almost twice the average concentration of PM_{10} and about three times the average 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 50% 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 3 when winds were from the landfill, and by a factor of 2 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. This additional contribution is estimated to be 4, 6, 9, and 5 $\mu g/m^3$, respectively, for the last four consecutive years. The 50% decrease from Year 3 to year 4 has reversed the former three year trend of increasing contributions.
    - The estimated Landfill PM_{10} contribution as measured at the Landfill site is, depending on year, a factor of 2 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 has increased each year, and for Years 3 and 4, has 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 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. 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).
    - 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 4. 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 BC contribution as measured at the Landfill site is, depending on year, a factor of 4 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 initially established by operators of the Sunshine Canyon Landfill in 2001 to monitor particulate matter less than 10 microns in aerodynamic diameter (PM_{10}), black carbon (BC), 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). The Conditions of Approval also required sampling of landfill gas (LFG) on four occasions throughout each year at each of the locations. In 2009, The County of Los Angeles adopted conditions (County Condition 81) very similar to the City's conditions, governing ambient air quality monitoring for the County portion of the landfill.

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).

A baseline year of continuous monitoring of PM_{10} and BC 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 a 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 evaluation of diurnal trends, day-of-week differences, seasonal differences, and annual trends in pollutant concentrations. LFG sampling, however, remained limited to four sampling events each year.

November 22, 2011, marked the completion of four 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

[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.

interruptions, however, annual completeness statistics for the four years indicate average data capture rates of 96%, 92%, and 96% for PM_{10}, BC, and winds, respectively (see Section 2). Less than 4% of all captured data were judged as invalid.

The high-quality, high-time-resolution data captured over the four years between November 2007 and November 2011 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).

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 South Coast Air Quality Management District (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.

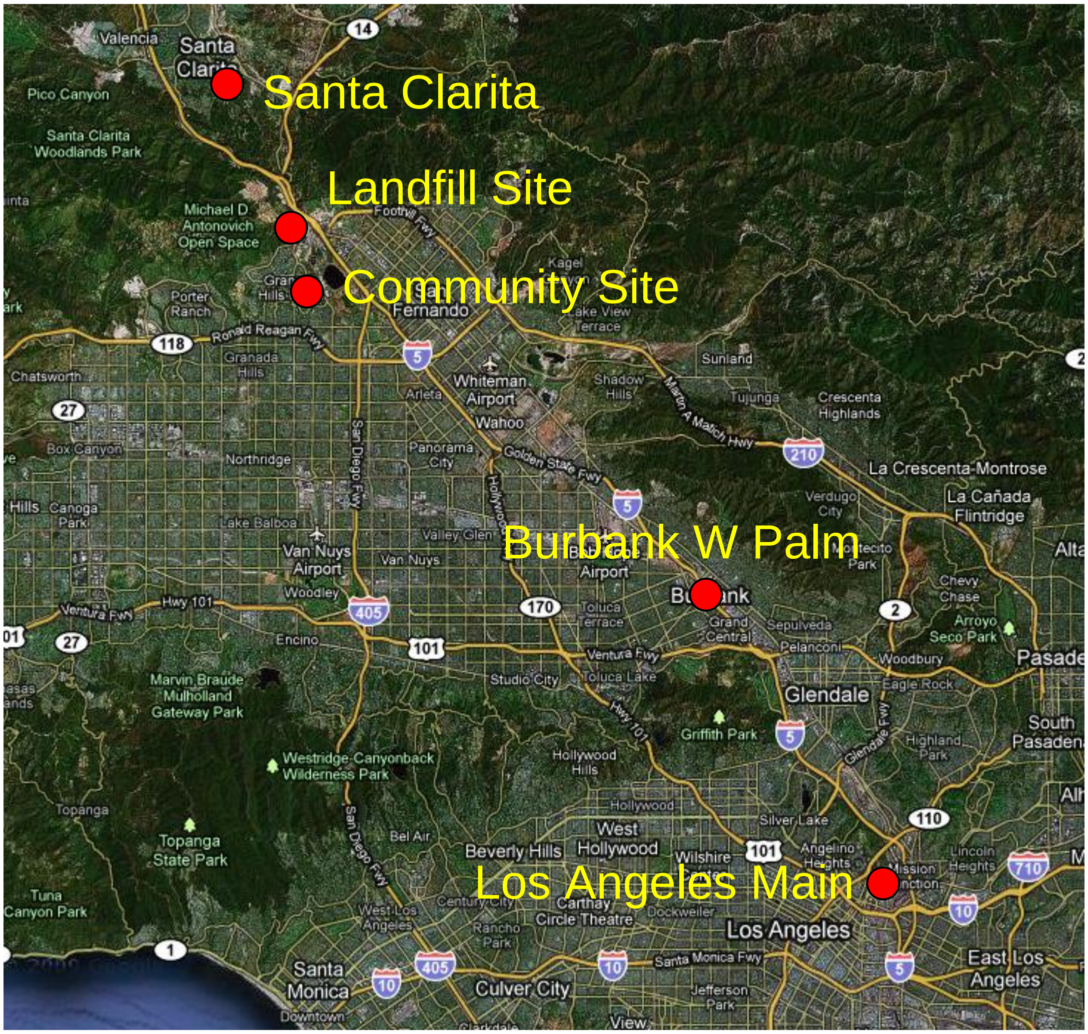

Figure 1-1. Locations of the Landfill and Community monitors in relation to the three SCAQMD sites that are used for regional comparisons.

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 description of the analytical method is presented in Section 5.

One area of concern to the residents of nearby communities is the occurrence of offensive odors. This has received considerable attention over the last three years. 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 volatile organic compounds (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. Beginning in June of 2012, STI will no longer be conducting 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 four years considered in this analysis. The percent data capture exceeded 90% for all site years, 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.

Table 2-1. Data completeness statistics for hourly data during Years 1, 2, 3, and 4 of continuous monitoring. 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%	89%	88%	99%	100%	100%	0%	0%	0%
	Van Gogh Elementary School Site	96%	91%	94%	96%	100%	100%	0%	0%	0%
Year 2 November 22, 2008–November 21, 2009	Sunshine Canyon Landfill Site	87%	86%	87%	98%	100%	100%	0%	0%	0%
	Van Gogh Elementary School Site	99%	99%	100%	97%	100%	100%	0%	0%	0%
Year 3 November 22, 2009–November 21, 2010	Sunshine Canyon Landfill Site	100%	88%	98%	98%	100%	100%	0%	0%	4%
	Van Gogh Elementary School Site	98%	88%	98%	97%	100%	100%	0%	0%	0%
Year 4 November 22, 2010–November 21, 2011	Sunshine Canyon Landfill Site	91%	99%	100%	96%	99%	99%	0%	0%	4.2%
	Van Gogh Elementary School Site	100%	99%	99%	99%	99%	98%	0%	0%	1.6%

[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 8760 hourly data values are expected per year, 8784 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 four 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 11 occasions at the Landfill site, and on two of those 11 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 $\mu g/m^3$ 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 a synergistic effect between landfill contributions and regional concentrations that helped push the Community site's PM$_{10}$ concentrations over the federal standard. Note that the opposite is not true; that is, the high 24-hr concentrations seen during three days in 2011 at the Landfill monitor had no apparent effect on Community or regional 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 $\mu g/m^3$. 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 (1000 $\mu g/m^3$), causing the output to default to error values of 995 $\mu g/m^3$. 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 $\mu g/m^3$, 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 are notable because they exceeded the federal PM$_{10}$ standard by a substantial amount, while concentrations at the community site and at the regional monitoring sites were low on all three of those days. This finding lends confidence to one conclusion drawn from previous years' data: PM$_{10}$ exceedances at the Landfill site are more common than they are in the Community or at regional monitoring sites. This outcome suggests that surface material being entrained at high wind speeds and detected by the Landfill monitor is diluted by the time an air parcel reaches the Community or regional monitors.

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]

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

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 on 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 was 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.

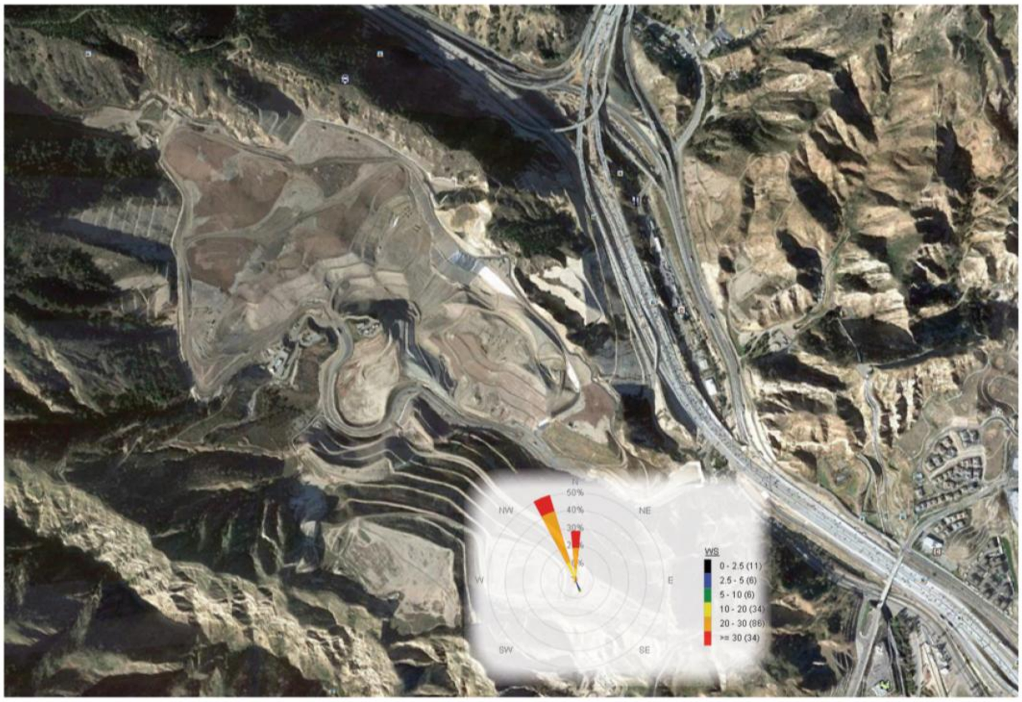

Figure 3-1. Wind rose from exceedance days during four continuous monitoring years at the Landfill monitoring site, illustrating the fetch that encompasses working portions of the landfill. Wind speed units are mph. The wind rose center point is directly over the location of the monitoring site.

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 South Coast Air Basin, 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 the three regional locations, for 2008, 2009, 2010, and 2011. For the first three years of continuous monitoring, the SCAQMD monitor at the downtown Los Angeles location had, on average, the highest PM_{10} concentrations, with exceptions noted in May of 2009 and June/July of 2010. (These exceptions were discussed in the Third Annual Report.) 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, had, 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 March data for the Landfill site and for the Los Angeles location are not shown in the 2011 panel. The Landfill PM_{10} monitor had ~65% data capture for the March-May quarter of 2011, due to a capstan motor failure in the PM_{10} monitor, and a subsequent pump failure. The monthly percent valid PM_{10} data for March did not meet the 75% completeness criteria at that location.)

The 2011 monitoring year exhibited an excursion from this observed pattern, with the Landfill monitor exhibiting the highest average monthly concentrations during the summer and early fall periods. 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; 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. However, the 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 and July of 2010, approximately 75% and 60%, respectively, of the winds were from the due south sector. Note that during these months in 2011, a notable shift to the south-southeast sector occurred.

Similarly, in August and September of 2011, the Landfill monitor recorded higher PM_{10} concentrations than did Los Angeles, and the Community monitor registered concentrations similar to, or slightly higher than, those in downtown Los Angeles. Note that the shift in wind direction mentioned above for June and July of 2011, compared to 2010, remained in effect for August and September of 2011, as shown in Figure 4-2. Greater than 90% of the associated hourly wind speeds during these time periods, in both 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. However, wind roses for these months from 2008 and 2009 indicate that 2008 was nearly identical to 2011, 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-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.

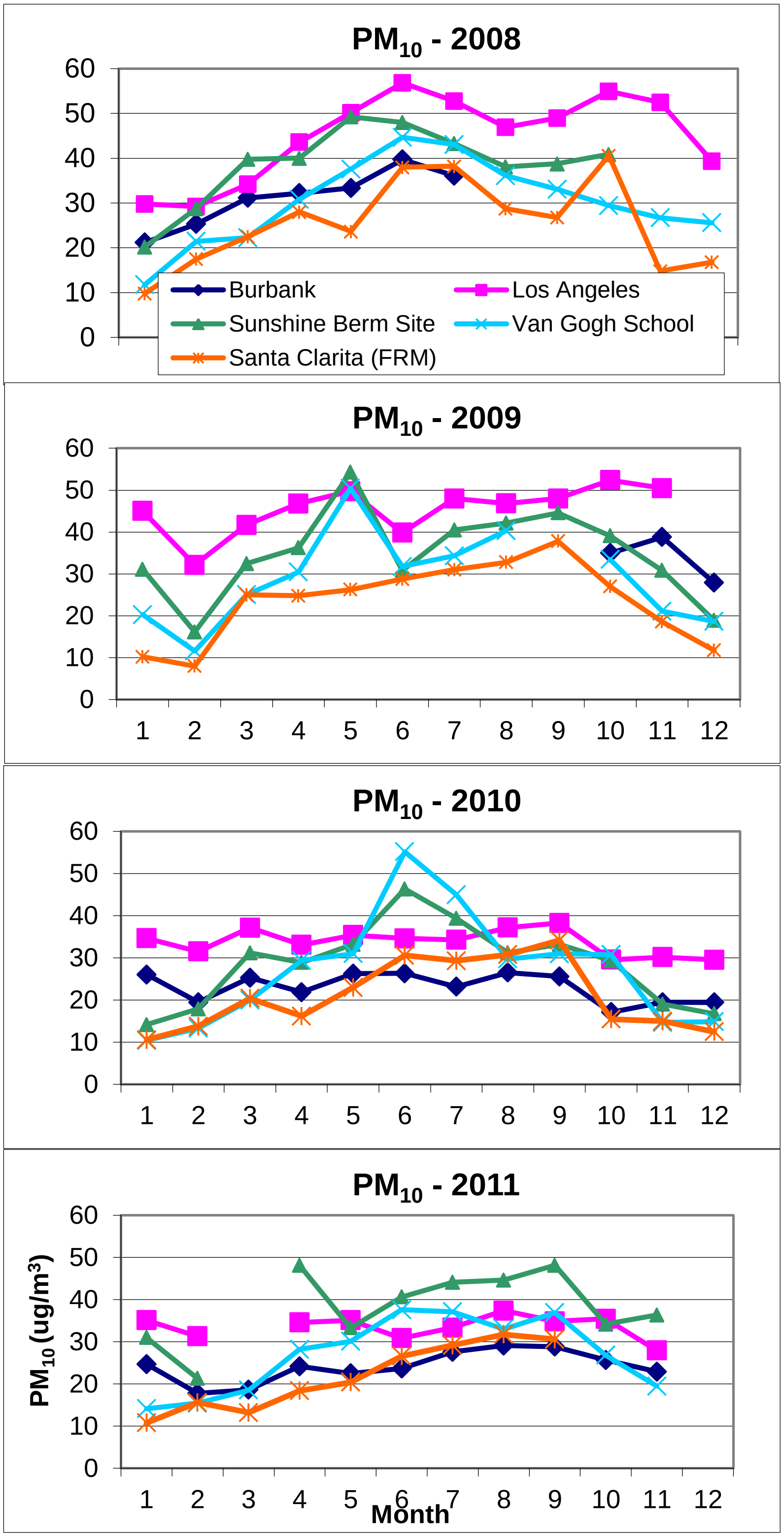

Figure 4-1. Monthly average PM_{10} concentrations for the Landfill and Community sites and three regional monitoring sites for 2008, 2009, 2010, and 2011.

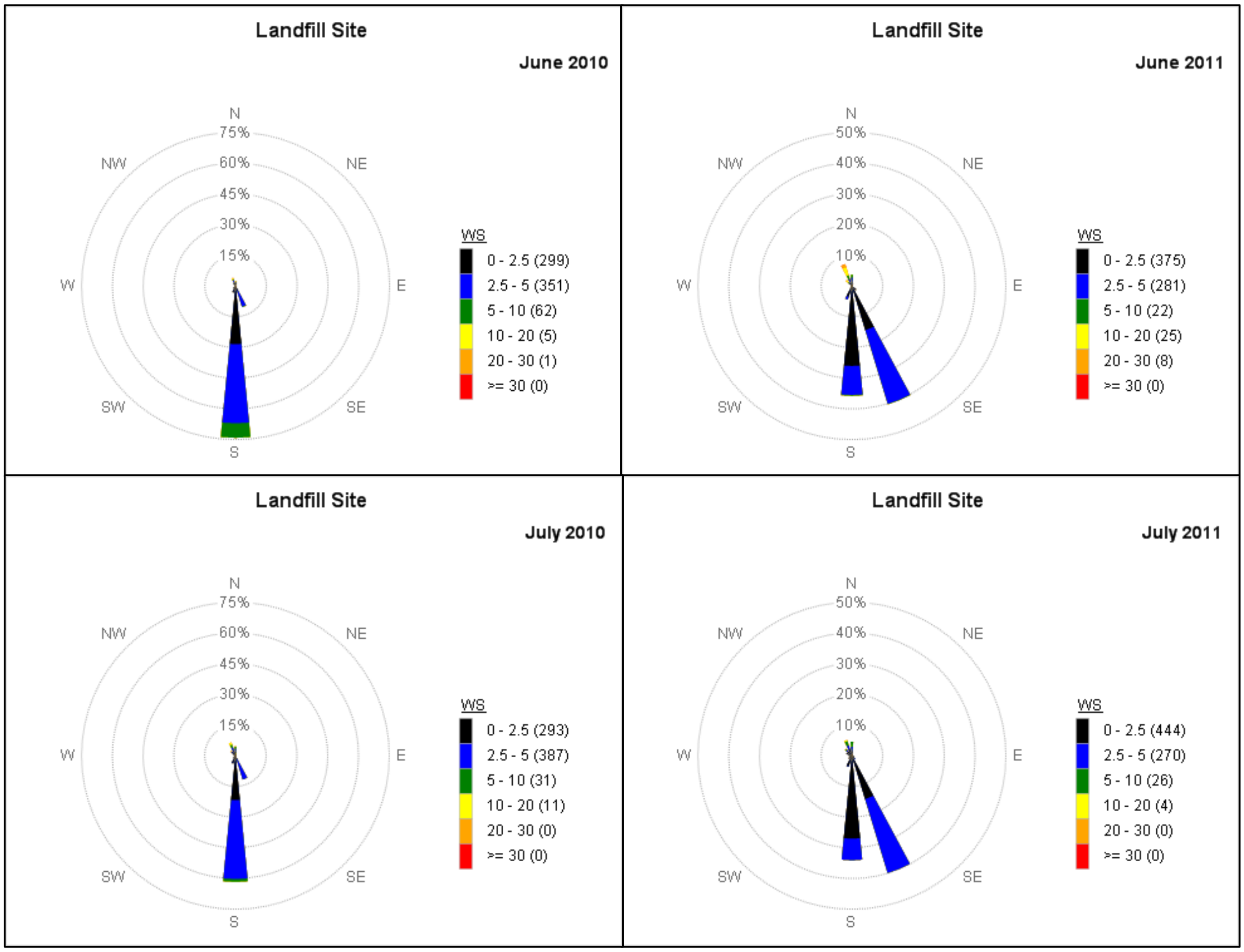

Figure 4-2. Wind roses of hourly data from the Landfill monitor for the months of June and July in 2010 and 2011 show the dominance of onshore wind flows in the summer, coupled with relatively low hourly averaged wind speeds. In these figures, the scale of the frequencies is different between 2010 and 2011.

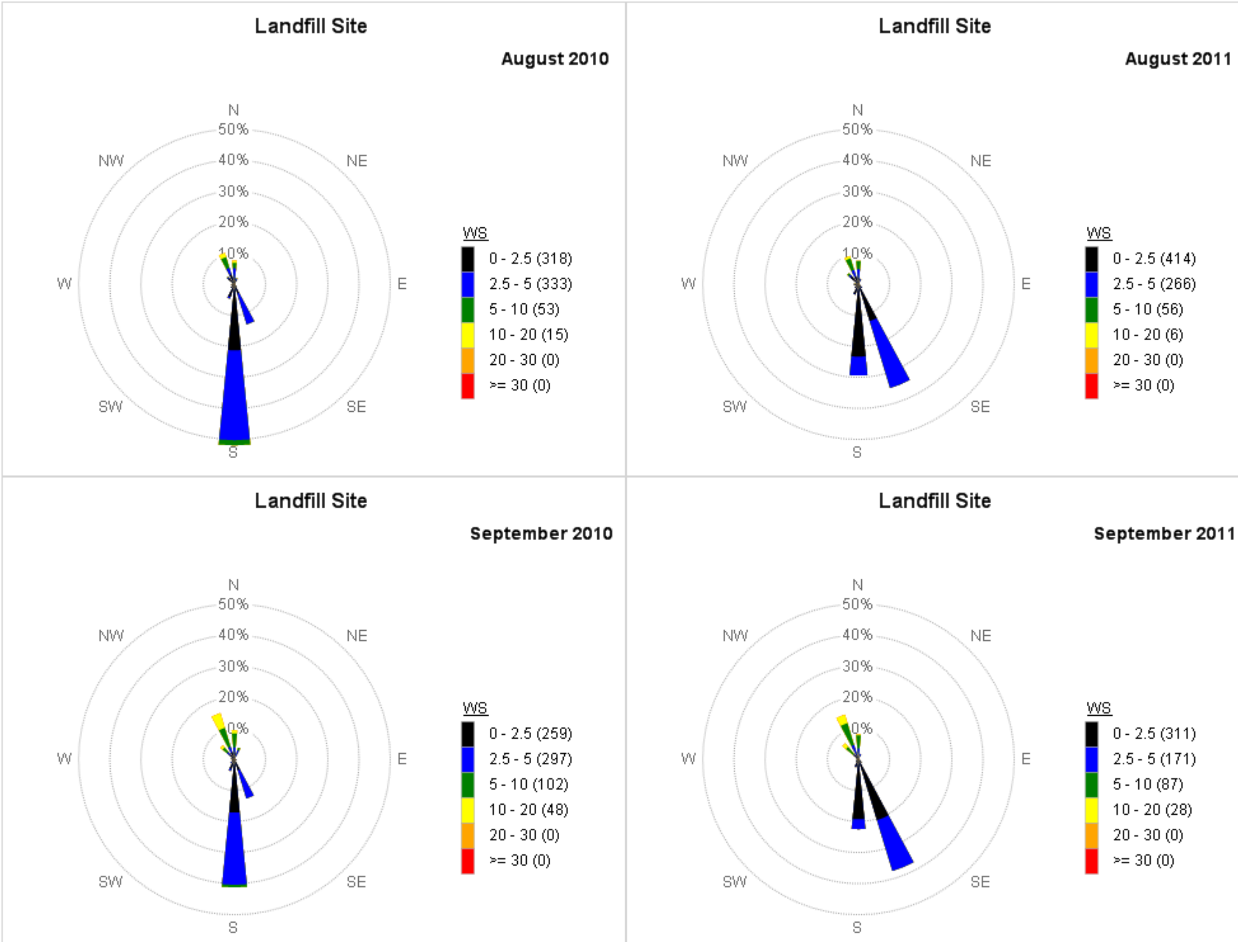

Figure 4-3. Wind roses of hourly data from the Landfill monitor for the months of August and September in 2010 and 2011 show the dominance of onshore wind flows in the summer, and illustrate the shift to SSE during 2011 compared to 2010.

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

The statement that wind direction and landfill work activity levels affect PM_{10} and BC concentrations measured at the Landfill and Community monitoring sites is not unexpected: 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 impact. 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 four-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 4-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 Annual Report.

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. 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).

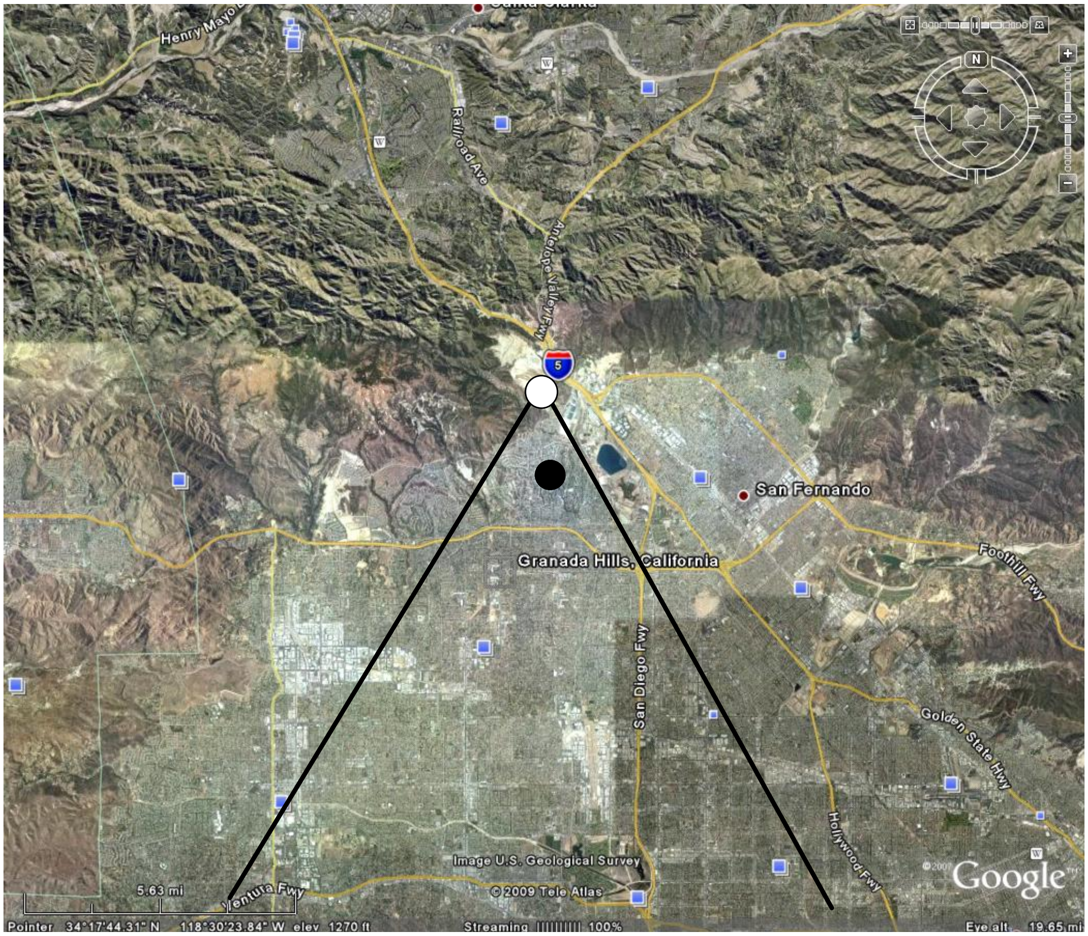

Figure 5-2. Aerial image of the Sunshine Canyon Landfill and the northern portion of the SoCAB, showing the wind direction sector representing the SoCAB source used for selecting data for analysis to compare with the landfill wind direction sectors depicted in Figure 5-1. The white dot represents the 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 4-yr 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. The Landfill and Community monitors are represented on the bar graphs; the error bars represent the standard error of the 4-yr mean for each category.

The following general conclusions are based on the average values presented in Figure 5-3. Note that these conclusions are nearly identical to those reached in last year's Third Annual Report. The number statistics in the graphs are very similar to the previously reported 3-year averages, 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 average concentrations of PM_{10}.
  - When the wind is from the SoCAB, the average concentration of PM_{10} at the Community site is about twice as high as when the wind is from the landfill.
  - When wind is from the landfill, 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 the lowest activity levels (non-working days, lower panel):
  - Ambient concentrations of PM_{10} are lower on non-working days, but the extent of the decrease is influenced by wind direction. 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 50% 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.

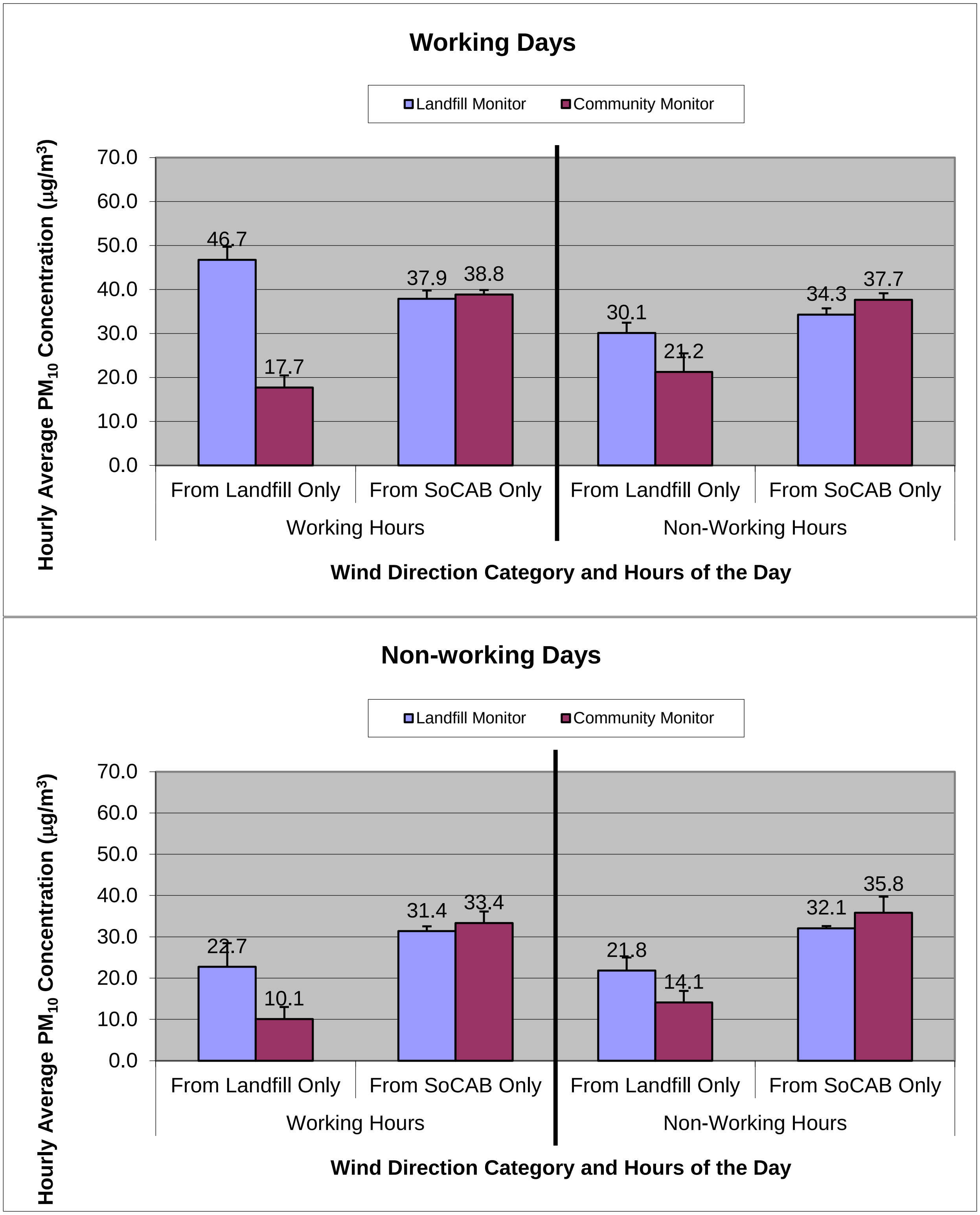

Figure 5-3. 4-yr average PM_{10} concentrations for northerly ("From Landfill Only") and southerly ("From SoCAB Only") wind sectors for working and non-working days and for working and non-working hours within those days.

5.4 BC Concentrations

Figure 5-4 summarizes the 4-yr 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. The Landfill and Community monitors are represented on the bar graphs; the error bars represent the standard error of the 4-year mean for each category.

The following general conclusions are based on the average values presented in Figure 5-4. These conclusions are similar to those reached in last year's Third Annual Report, as are the number statistics in the graphs, and 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 average BC concentrations.
  - When the wind is from the SoCAB, the Community monitor measures roughly three times the average 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):
  - 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 2 when winds were from the SoCAB.

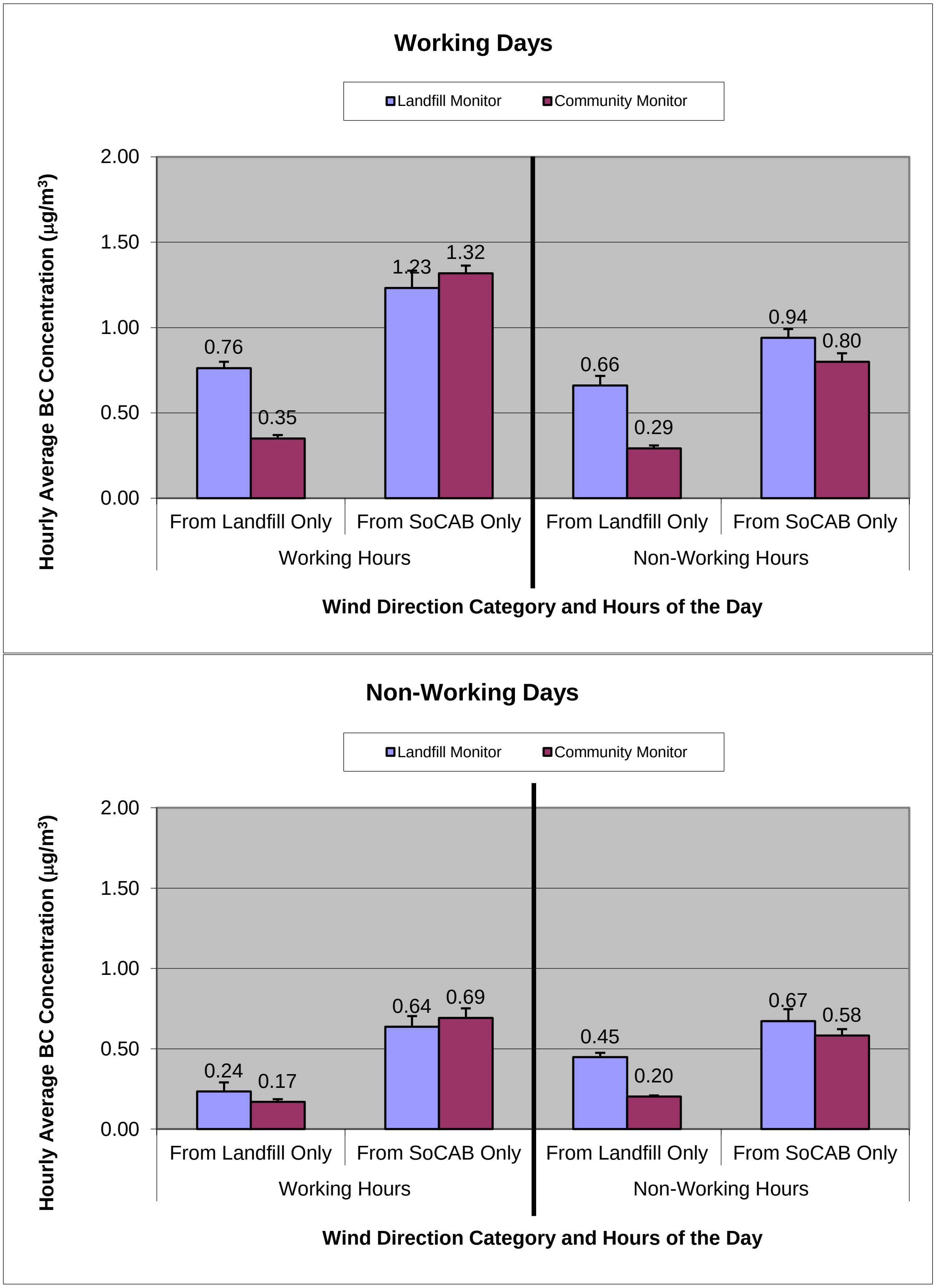

Figure 5-4. 4-yr average BC concentrations for northerly and southerly wind sectors for working and non-working days and for working and non-working hours within those days.

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 Federal Reference Method 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 calculation of 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 calculation of landfill contributions of PM_{10}.

Beginning with STI's Second Annual Report[3] in 2009, a data analysis method to approximate 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 utilizes 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. In last year's Third Annual Report and in this Fourth Annual Report, rolling averages are not used because full years of continuous data are available for calculation of 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 the use of 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

[3] 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-907032.19-3671-AR, August.

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 above, 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) above 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) 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).

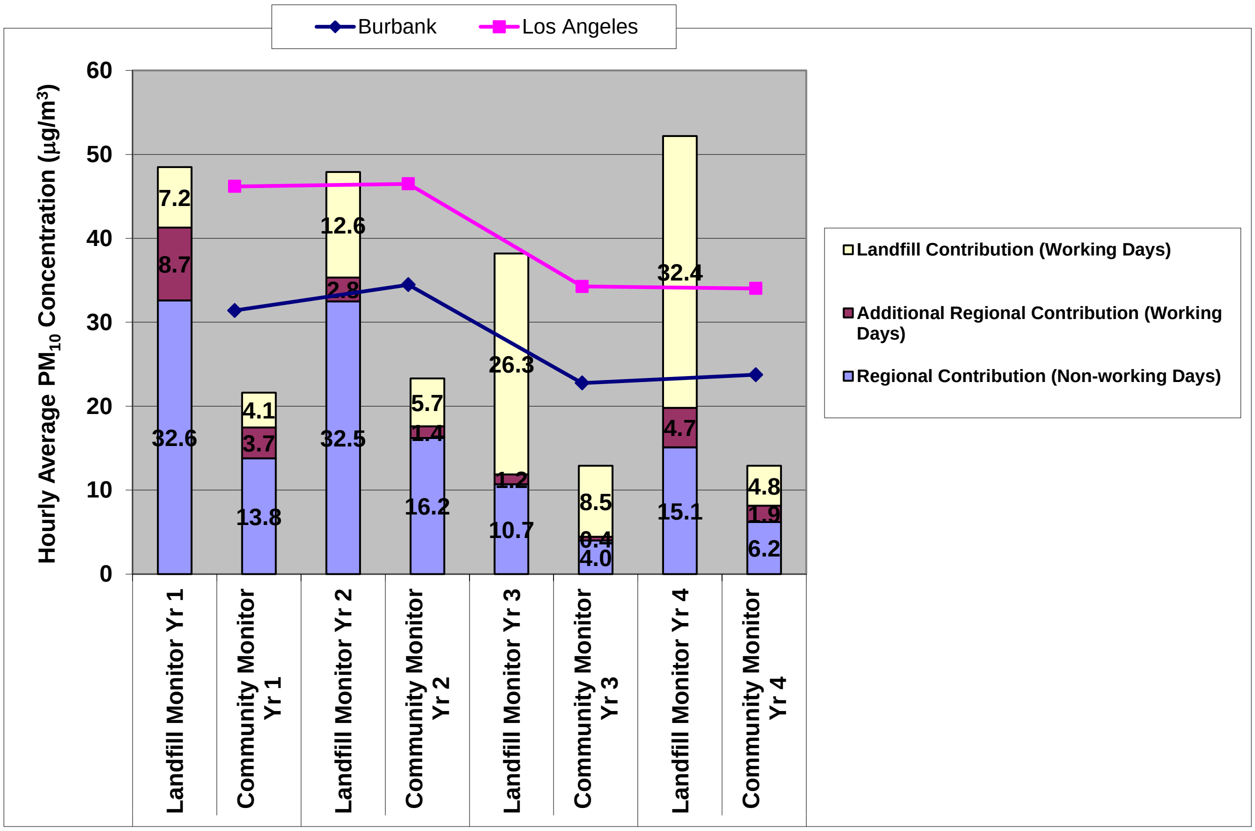

Figure 6-1. Summary of four consecutive years of quantitative estimates of the average regional contribution to ambient PM_{10} levels on non-working days (blue bars), the additional regional contribution associated with increased activity levels on working days (violet bars), and the average hourly landfill contribution on working days (yellow bars). Line graphs show annual averages for Los Angeles and Burbank (Jan-Dec).

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 (yellow bars) to hourly average PM_{10} concentrations has increased each year, and for Years 3 and 4, has accounted for the majority of the PM_{10} recorded by the monitor there.
- However, this trend is not seen in the Community monitor's data. Estimates of landfill contributions to community levels of PM_{10} remain comparatively low.
- 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 (blue bars), is more than twice 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, increased from Year 3 to Year 4 as well.
- The contribution of the Landfill to average PM_{10} concentrations in the Community decreased by about 50% between Year 3 and Year 4.
- The additional regional contribution of PM_{10} associated with working days (violet bars) increased by a factor of 4 between Year 3 and Year 4, but remained the smallest contributor among the three categories.
- The substantial increases in PM_{10} attributed to the landfill from Year 1 through Year 4 may be associated with increased activity at the Landfill. 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.

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 last year's Third 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.

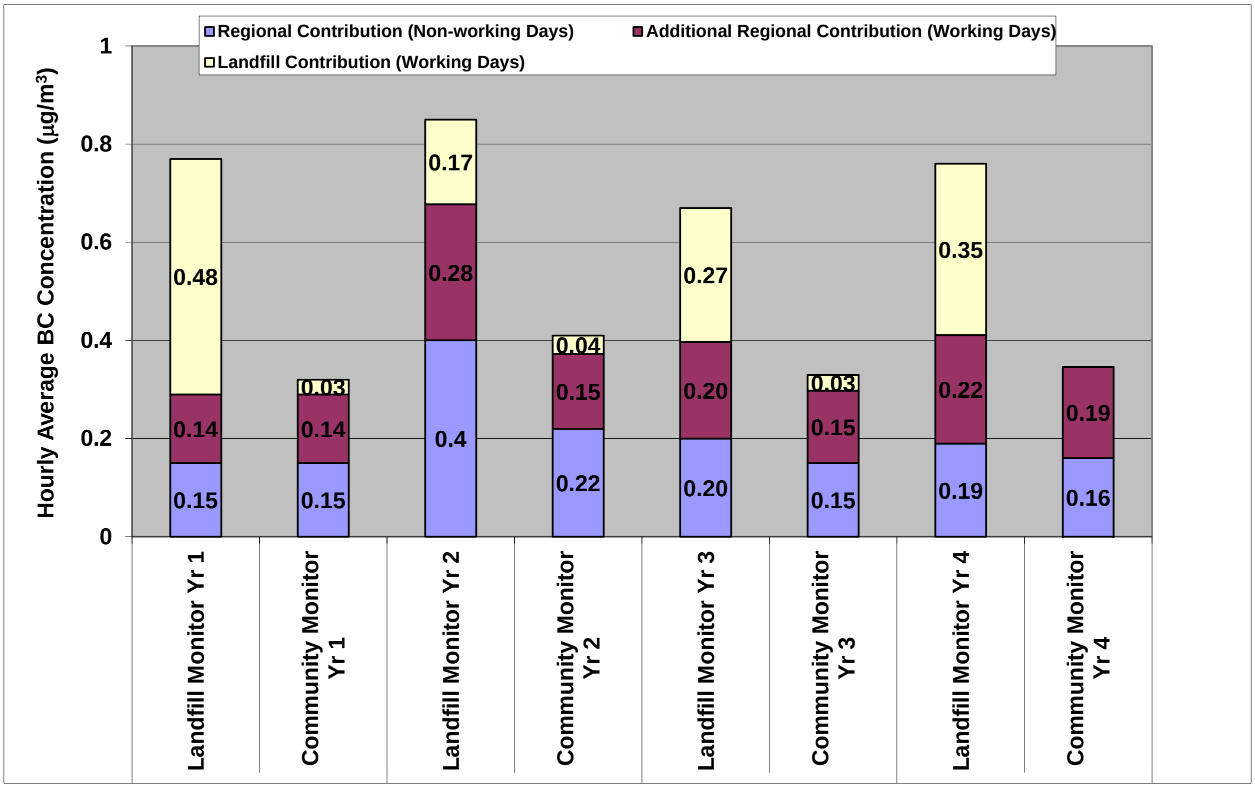

Figure 6-2. Summary of four consecutive years of quantitative estimates of the average regional contribution to ambient BC levels on non-working days (blue bars), the additional regional contribution associated with increased activity levels on working days (violet bars), and the average hourly landfill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

The following comments are offered about Figure 6-2:

- As shown previously with PM_{10}, annual landfill contributions to ambient BC concentrations (yellow bars) are substantial at the Landfill monitor, but low and stable in the Community. 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).
- As measured at the Landfill BC monitor, the landfill contribution to ambient BC concentrations (yellow 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 4. 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 gauging that level of activity is provided.

7. Landfill Gas and Hazardous Air Pollutants

As a courtesy to the reader, this section of the four year summary report repeats the brief overviews of LFGs and hazardous air pollutants (HAPs) that were offered in last year's Third Annual Report. Discussion of odors *per se* is not included here, but an overview was presented in last year's 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),[4] and readers are directed to the web link in the footnote to obtain additional information. 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, is given. 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 (16 to date) 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 literally 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

[4]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.

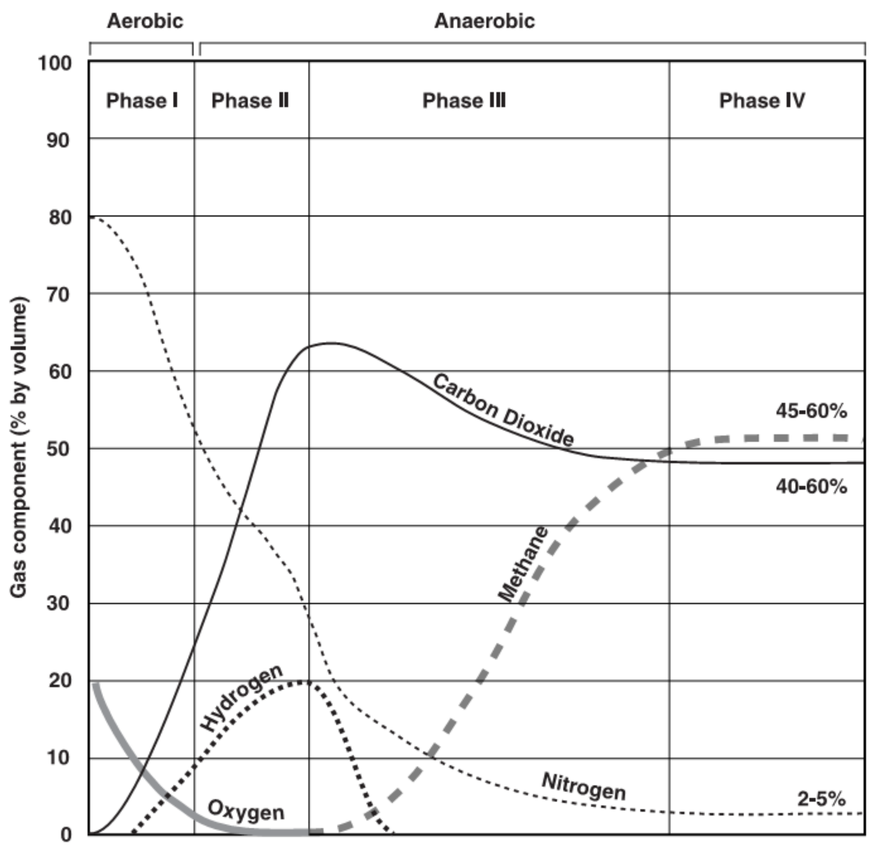

Figure 7-1. Generalized scheme of landfill gas production during the bacterial decomposition process in municipal landfills. Figure from ATSDR.

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 Sonoma Technology 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, but the health effects are such things as asthma or neurological or reproductive effects

HAPs have many sources. They may 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 byproducts. 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 utilizes “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. (It should be noted that 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, sampling LFG only four times a year was 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.

Published accounts of diurnal variation in concentrations of air toxics may also help refine a sampling strategy targeted to measure maximum levels of LFGs. Recently, McCarthy et al (2007)[5] 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, 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.

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.

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

[5] 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 on the Internet 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.[6] 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, it should be noted that the average concentration of the three isomers of dichlorobenzene reported for the SoCAB in 2001 (0.31 ppbv) in the Baseline Monitoring Report[7] does not agree with published California ARB data.[8] All Southern California stations with available data on any of the three isomers of dichlorobenzene had reported concentrations of 0.15 ppbv for the 2001 calendar year, which is one-half the Method Detection

[6] 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.

[7] 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.

[8] California Air Resources Board (2008) Annual toxics summaries. Available on the Internet at http://www.arb.ca.gov/adam/toxics/statesubstance.html.

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 non-detect data.

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 the odor threshold concentration, when available.

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, characteristic	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, characteristic	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	8260[a]

[a] Technology Transfer Network Air Technical Website, U.S. 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 in scope 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); and (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.

The four VOC sample days for the current contract year, which runs from June 21, 2011 to June 20, 2012, occurred on December 7, 2011, and on January 13, February 3, and March 7 of 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 sample date will be included in the 18th Quarterly Report, which will cover 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.

7.6.1 Example of Case II: Typical LFG Sampling Results

Figure 7-2 depicts the LFG data collected on December 29, 2009. These results typify the most common range of LFG concentrations that have been observed over the last three years of sampling at the Landfill site and the Community site.

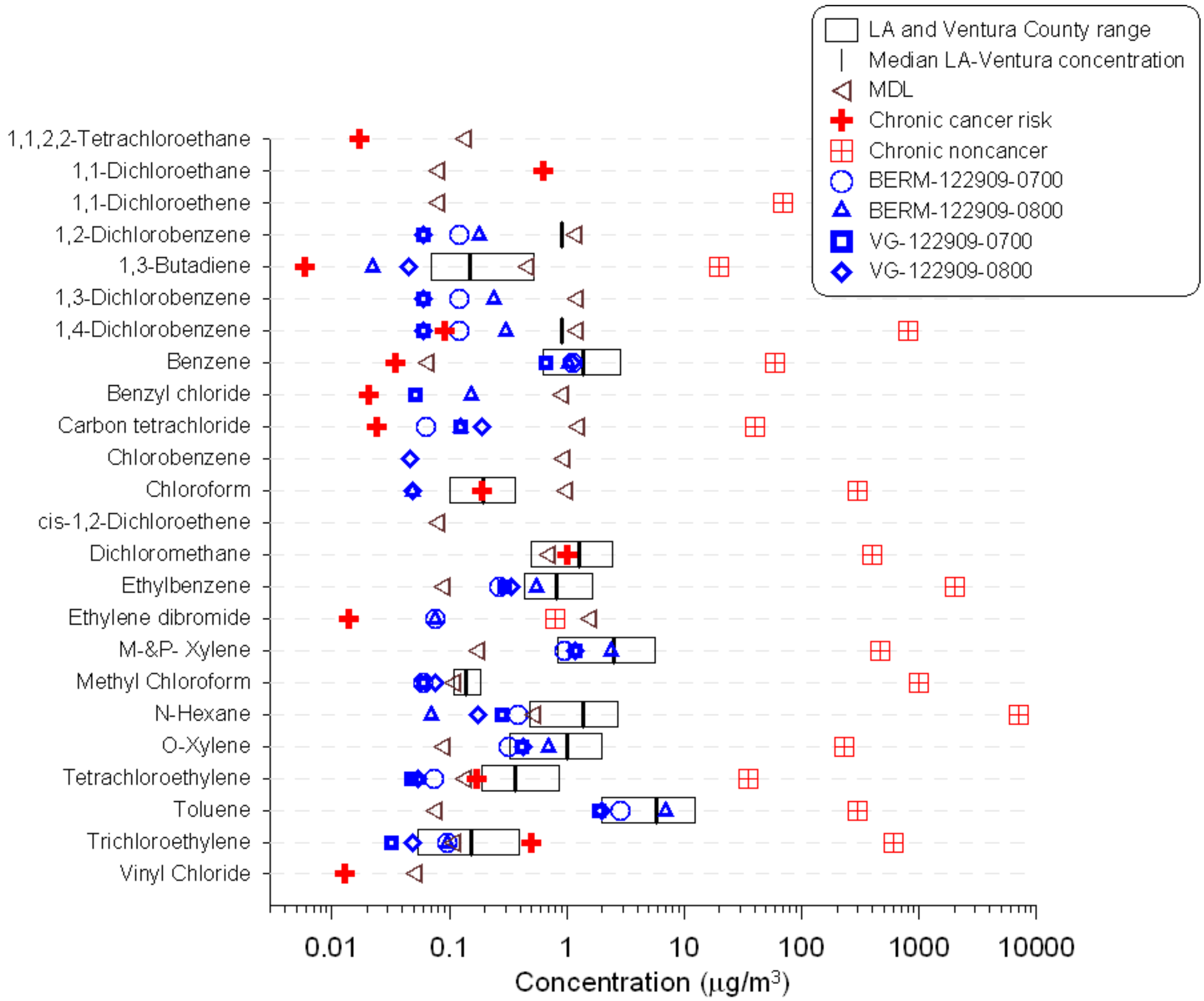

Figure 7-2. Illustration of a typical LFG sample data set. The plot depicts ranges of the 10th to 90th percentile quarterly averages and median values for available Los Angeles and Ventura County NMOC data from 2005 to 2009; concentrations determined from the December 29, 2009, samples collected at the Sunshine Canyon Landfill ("Berm") and Van Gogh School ("VG") sites; MDL; and chronic cancer risk and noncancer benchmarks. If data are not shown, the compounds were not detected.

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

The results from the sample, which was collected on November 18, 2010, are representative of the Case III scenario, in which some compounds are measured above the typical range of Los Angeles and Ventura County values, but the compounds are also associated with mobile sources and difficult to attribute to landfill operations. The results also contain one methane sample that is below the global average concentration and is thus suspect.

The methane levels reported for the November 18, 2010, samples are given in **Table 7-2**. The values are within the normal range. Global ambient concentrations are near 1.8 ppmV, so the 8:00 a.m. sample at the Landfill site is well below background level. It is at the borderline of laboratory Quality Control failure (1.26 ppmV).

Table 7-2. Ambient concentrations of methane measured at the Landfill monitoring site and the Van Gogh School on November 18, 2010.

Site	Methane Concentration (ppmV)	
	7:00–8:00 a.m.	8:00–9:00 a.m.
Landfill Site	3.8	1.3
Community Site	2.5	1.9

Figure 7-3 presents the LFG NMOC analytical results from the samples collected on November 18, 2010. The two samples at the Community site both had high benzene, high hexane, and somewhat high xylenes and toluene. The concentration of 1,3-butadiene also looks high, but it is below MDL. As explained above, this might suggest landfill contributions, since 1,3-butadiene was added to the target list to help segregate mobile sources. The concentrations at the Landfill, however, are at the low end of the expected range, suggesting that the landfill is not a contributor. No high concentrations were found at the Landfill monitoring location.

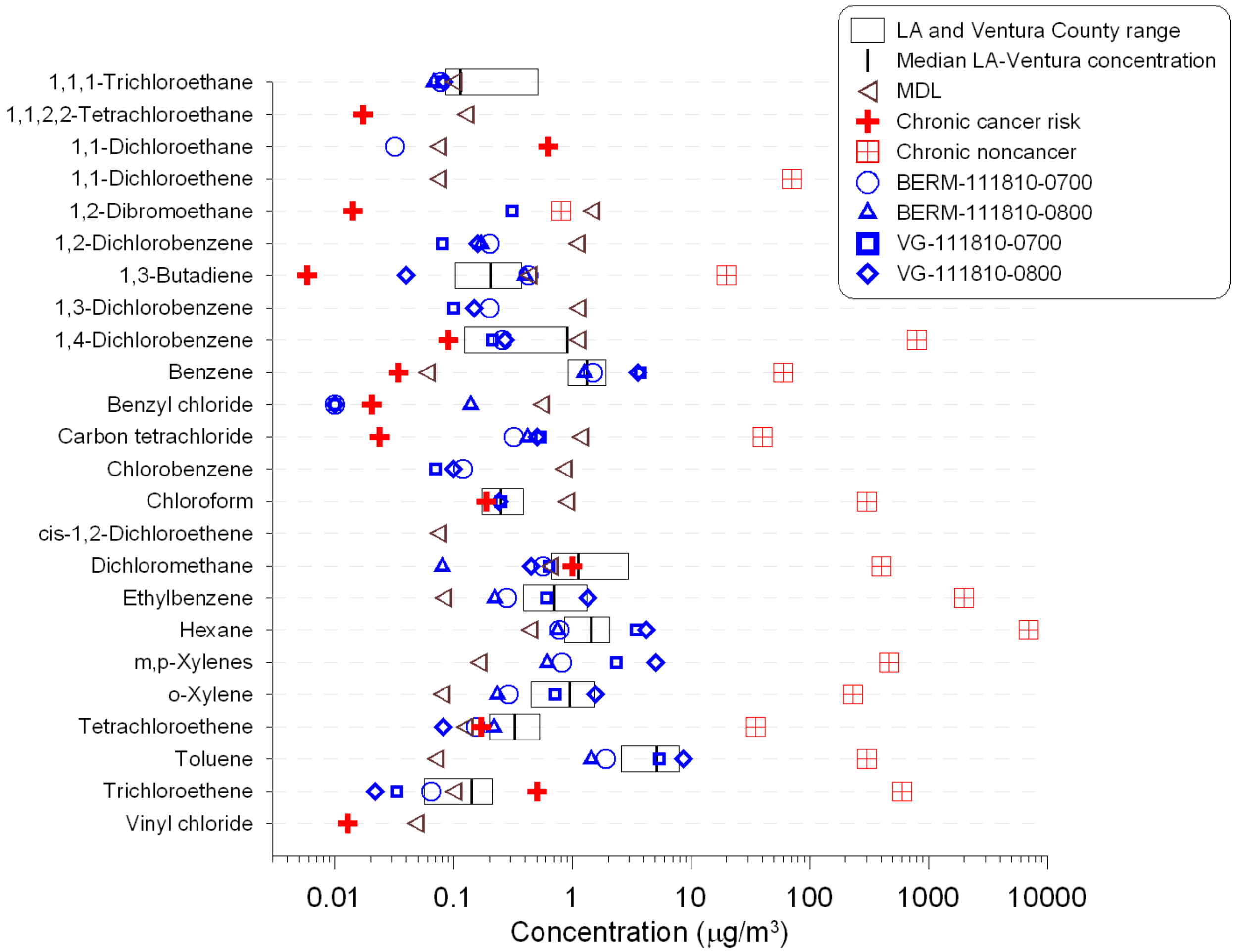

Figure 7-3. Ranges of the 10th to 90th percentile quarterly averages and median values for Los Angeles and Ventura county NMOC data from 2006 to 2009, as available; concentrations determined from the November 18, 2010, samples collected at the landfill site (BERM) and Van Gogh Elementary School site (VG); MDLs; chronic cancer risk; and chronic noncancer hazard levels. For the November 18 sample, any data not shown were not detected by the analytical laboratory. Data below MDL that were reported are shown.

8. Field Operations

Field operations include regular visits to both monitoring sites, scheduled for every second week. Problems are usually detected quickly (within a day) and addressed remotely when possible. 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. Since the site infrastructure and equipment were upgraded in 2010, the continuity and reliability of the monitoring sites has improved.