Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

FIRST ANNUAL REPORT OF AMBIENT AIR QUALITY MONITORING AT SUNSHINE CANYON LANDFILL AND VAN GOGH ELEMENTARY SCHOOL

(MAY 10, 2007–MAY 30, 2008)

Annual Report
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EXECUTIVE SUMMARY

ES.1 BACKGROUND

Monitoring of ambient air quality at the Sunshine Canyon Landfill and in the nearby community of Granada Hills is required pursuant to the Conditions of Approval (Condition C.10.a of Ordinance No. 172,933) for the expansion of the Sunshine Canyon Landfill in the City of Los Angeles. The City of Los Angeles Planning Department contracted with Sonoma Technology, Inc. (STI) in May 2007 to undertake monitoring of particulate matter less than 10 microns (PM_{10}), black carbon (BC) as a surrogate for diesel particulate matter (DPM), and meteorology at two sites, at the Sunshine Canyon Landfill and in neighboring Granada Hills, for a period of three years. BC is a component of PM_{10}. Periodic (four times annually) sampling of ambient air for landfill gas (LFG) at the two sites is also required by the Conditions of Approval. Monitoring began in August 2007. PM_{10}, BC, and LFG data collected during the first year (May 2007-May 2008) were compared to (1) baseline PM_{10} and BC data collected between November 2001 and November 2002, (2) baseline LFG data collected in 2003, (3) state and federal standards where applicable, (4) other regional data, and (5) health benchmarks where applicable.

ES.2 PARTICULATE MATTER

The metrics used to compare particulate matter concentrations with the baseline study results were calculated for compass-based source sector activity types (landfill, freeway, urban) and time-of-day and day-of-week activity levels (landfill or freeway activity) and were identical to those used in the baseline study. In nearly all comparisons with baseline data, the hourly averaged and 24-hour averaged PM_{10} and BC concentrations have remained below the levels measured in the baseline year. This result parallels the regional decline in ambient PM_{10} levels reported for nearby Santa Clarita, where annual ambient PM_{10} concentrations have decreased each year between 2002 and 2006 (latest available California Air Resources Board [ARB] data). Average annual PM_{10} levels at the Santa Clarita station were about one-third lower in 2006 compared to 2002 levels.

One exceedance of the federal 24-hr PM_{10} standard (150 $\mu g/m^3$) occurred during high winds on May 21, 2008, at both monitoring sites. Two additional exceedances were recorded at the landfill site. One of the latter two was associated with an exceptional event (Santa Ana winds and wildfires), and the second is believed to be attributable to high winds entraining crustal material from the barren and disturbed surface of the area immediately surrounding the landfill monitoring site.

ES.3 LANDFILL GAS

Ambient air samples were obtained in April and May 2008 at the two monitoring sites and analyzed for methane and 24 non-methane organic compounds (NMOC). Four NMOCs on the analyte list were those chosen as tracer compounds in the baseline study, allowing direct comparison with baseline data.

Methane concentrations were normal and within the range of the average ambient global concentration that averages approximately 1.8 ppmv, indicating no direct impact by the landfill. Similar concentrations were measured during the baseline study.

NMOC concentrations in the LFG baseline study in 2003 were all less than the method detection limit (MDL) for the laboratory analysis method. MDLs in the current study are lower than baseline MDLs (the methods are more sensitive). All NMOC results were compared to quarterly averaged data, available since 2005, for Los Angeles and Ventura Counties. The NMOC concentrations measured in the spring quarter were lower or within the range of the reported values for the Los Angeles/Ventura area. Many of the compounds are listed as air toxics by the U.S. Environmental Protection Agency (EPA), so comparisons were also made to cancer and non-cancer, or chronic hazard, benchmarks. Some compounds were above cancer benchmarks, but within range of reported levels for the Los Angeles area. All concentrations were below chronic hazard benchmarks.

ES.4 RECOMMENDATIONS

Based on the first year of field operations and validated data, a few recommendations are being made.

1. BFI should consider applying a soil stabilization treatment to the barren and disturbed surface that lies around and especially to the north of the landfill monitoring site. The data suggest that, under high wind conditions, wind-blown dust from this area is contributing to high ambient PM_{10} levels recorded at this site, and the data do not represent (in fact, overestimate) the true landfill contribution to ambient PM_{10} levels.
2. We recommended that the Aethelometers™ at the two sites be sent to Magee Scientific for refurbishment and collocated testing. This action is important to keep any instrument bias to a quantifiable minimum.
3. BFI should consider upgrading the wind sensors at both monitoring sites. It is estimated that, to date, the expense of labor hours and shipping charges associated with troubleshooting and repairing the Met One 034B wind sensors exceeds the costs of higher priced, but more reliable, wind monitors ($1,000 to $1,200 list price).

1. INTRODUCTION

Monitoring of ambient air quality at the Sunshine Canyon Landfill (Landfill site) and at the Van Gogh Elementary School (School site) in the nearby community of Granada Hills is required pursuant to the Conditions of Approval (Condition C.10.a of Ordinance No. 172,933) for the expansion of the Sunshine Canyon Landfill in the City of Los Angeles. As part of the Conditions of Approval, required baseline studies for particulate matter and for landfill gas (LFG) were undertaken in 2001 and 2003, respectively. The baseline results are summarized here to provide some context for the current monitoring efforts.

The baseline study of particulate matter less than 10 microns (PM_{10}) and black carbon (BC) concentrations was conducted between November 22, 2001, and November 21, 2002, at the Landfill and School sites. BC is a component of PM_{10}. The baseline PM_{10} measurements were made with a Beta Attenuation Monitor (BAM) that reports hourly PM_{10} concentrations. The BC concentrations were measured with a Magee Scientific Aethalometer™ that reports 5-minute average BC concentrations which were post-processed for hourly averages. Analysis of these baseline PM_{10} and BC data included comparisons with federal and state PM_{10} standards (average annual and 24-hr), comparisons with other regional monitors measuring PM_{10} and BC, and a detailed evaluation of source sector contributions (landfill, freeway, and urban sectors based on compass direction) in different time-of-day and day-of –week classifications.

No exceedances of federal PM_{10} standard were observed at either site during the baseline year, while exceedances of California (state) standard were recorded at both sites. Currently the only federal, health-based standard for PM_{10} is the daily average concentration of 150 $\mu g/m^3$. The previously existing federal annual standard of 50 $\mu g/m^3$ was revoked, based on the lack of substantial evidence of health effects attributable to long-term exposures. The state PM_{10} standard is more stringent than the federal standard, and the number of exceedances of the state PM_{10} standard at the two monitoring locations was comparable to those measured by other monitors in the South Coast Air Quality Management District (SCAQMD). Based on the source sector (compass based sectors) analysis, the baseline study concluded that nearby freeways and urban sources were the dominant contributors to PM_{10} and BC concentrations measured at the Landfill and School sites. Comparisons between the baseline data and ongoing ambient monitoring data use the same metrics as the baseline study.

The hourly particulate matter data from the baseline study suffered from substantial gaps in the data record. The rule of thumb for minimum data completeness in ambient air pollution studies is 75% validity. An hourly average constructed from 5-minute data must have 9 valid data points, and a 24-hr average must have at least 18 valid hourly data points. Based only on data gaps greater than 24 hours, the percentages of missing baseline PM_{10} data at the Landfill and School sites were 26% and 45%, respectively, and the percentages of missing BC data at the Landfill and School sites were 25% and 28%, respectively.[1] Neither site met the completeness criteria for annual averages. The data gaps impose an additional restriction for completeness in

[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.

the directional analysis, since that analysis is based only on data where time-matched records are valid at both monitoring locations.

A baseline study of LFG was conducted in 2003. Before the baseline LFG sampling was undertaken, a review of existing ambient LFG concentration data collected at the Landfill was conducted to examine whether LFG concentrations vary seasonally. The historical data that were reviewed represented quarterly samples of ambient air collected between June 2000 and November 2002 at the Landfill, under the requirements of SCAQMD Rule 1150.1. The conclusion reached from this review was that methane and non-methane organic compounds (NMOCs) at the Landfill do not vary seasonally, and that samples taken during any time of the year would be sufficiently representative of baseline Landfill emissions.[2] Historical measurements of total hydrocarbons in the South Coast Air Basin (SoCAB) were also reviewed and showed that higher concentrations of hydrocarbons exist during the winter months; the implication is that landfill-based emissions may be harder to detect under those conditions. Based on these conclusions drawn from the historical data record, it was decided that baseline LFG sampling would be conducted with four evenly spaced sampling events during the spring and summer months of 2003, and that the sampling would adhere to Rule 1150.1 recommendations that samples be collected under conditions that maximize concentrations (e.g., low wind speeds). While sample times may have been chosen to meet this requirement, these short duration grab samples (several minutes) taken four times annually are not sufficient to characterize seasonal variations.

Target compounds for the baseline study were chosen by identifying NMOCs characteristic of LFG but found at low concentrations in ambient air. LFG samples collected at the landfill flares were compared with ambient NMOC concentrations reported by the California Air Resources Board (ARB). Compounds with high LFG-to-ambient air ratios were considered candidates for tracer compounds signifying the landfill as a source. Common NMOCs associated with other sources, such as mobile source air toxics (MSAT), were excluded from consideration as marker compounds. Identified in the baseline study as the most appropriate target NMOC compounds were three isomers of dichlorobenzene and vinyl chloride. The results from the four baseline LFG sampling periods in 2003 showed that all ambient samples of these specific NMOCs were below the method detection limits (MDLs) for the analytical methods that were used.

Since the baseline studies were completed, ambient sampling for PM_{10}, BC, and LFG has presumably been undertaken at a nominal frequency of four times each year, as specified in the Conditions of Approval. The results of those sampling events are not discussed here.

Beginning in 2007, ambient monitoring of particulate matter and LFGs at the Landfill and School sites became the responsibility of Sonoma Technology, Inc. (STI). A three-year contract was initiated on May 10, 2007, between the City of Los Angeles Planning Department and STI, and the first on-site visit occurred on July 31, 2007.

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[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.

The technical approach of the continuing monitoring effort differs from those of previous monitoring: monitoring for particulate matter (PM_{10} and BC) is continuous (hourly) year round, whereas previous monitoring of particulate matter was limited to four events per year. Continuous all-year sampling of PM_{10} and BC allows greater potential for evaluation of those times when air flows from the landfill to the receptor site at Van Gogh Elementary School, as well as an evaluation of diurnal trends, day-of-week differences, seasonal differences, and annual trends. LFG sampling is still limited to four sampling events each year.

STI submitted a technical memorandum dated September 7, 2007, that covered the initial on-site evaluations and audits of the ambient air quality and meteorological monitoring resources located at the Landfill and School sites. Subsequent reports include "Start-up Summary and First Quarterly Report of Ambient Air Quality Monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School (August 2, 2007–February 29, 2008)" submitted on April 15, 2008, and "Second Quarterly Report of Ambient Air Quality Monitoring at Sunshine Canyon Landfill and Van Gogh Elementary School (March 1, 2008–May 30, 2008)" submitted on June 30, 2008. These reports should be consulted for data analyses specific to the reporting periods.

This document summarizes the results of field operations during the first year, data from the continuous monitoring of PM_{10} and BC, and results from the LFG sampling events that were conducted in April and May 2008.

2. PARTICULATE MATTER

Project startup tasks delayed the onset of continuous monitoring of PM_{10}, BC, and wind until August 2007; thus, a complete year of hourly data is not yet available. Data collected from August 2007 through May 2008 have been validated and compared to a year of baseline values collected between November 2001 and November 2002. Average 1-hr PM_{10} and BC concentrations and wind speeds are the nominal measures used for comparing baseline continuous data to those of the current monitoring period. To allow direct comparison with baseline study data, metrics identical to those of the baseline study are used. These metrics are based on sector source activity type and time-of-day/day-of-week activity levels.

Also of interest is the comparison of the data to state and federal standards and the magnitude of average and maximum 24-hr concentrations.

2.1 BASELINE COMPARISONS

Table 2-1 compares the hourly average PM_{10} and BC concentrations of continuous monitoring at the School site (through May 2008) with the concentrations reported for the baseline monitoring period. In nearly all comparisons, the hourly averaged PM_{10} and BC concentrations observed in the current year have remained below the levels measured in the baseline year. An exception occurred in the comparison for the landfill non-operating rush hours when winds measured at the School site were from the landfill: PM_{10} concentrations at the school were 50% higher than baseline values (24.2 versus 16.6 $\mu g/m^3$). More needs to be learned about landfill activities during this time period (3 p.m. to 7 p.m. weekdays). The data suggest that "non-operating" may inaccurately describe potential PM_{10} generating activities that may be occurring during that time frame at the landfill.

The annual summary presented in Table 2-1 masks some differences noted in previous quarterly data evaluations. The data collected from August 2007 through February 2008 showed that the 1-hr average ambient concentrations of PM_{10} and BC were lower than baseline levels, while in the following three months of March, April, and May 2008, some of the PM_{10} metrics exceeded baseline levels. This observation may be a result of seasonal differences in wind patterns or some other factor. This result reinforces the importance of maintaining a year-round monitoring effort.

Overall, the hourly average PM_{10} concentrations remain low, reflecting the regional decline in ambient PM_{10} levels reported for Santa Clarita, where annual ambient PM_{10} concentrations have decreased each year between 2002 and 2006 (latest available data). Average annual PM_{10} levels at the Santa Clarita monitor were about one-third lower in 2006 compared to those in 2002.

The hourly average concentration of BC has remained below baseline levels for all wind directions at the School monitor. Highest BC concentrations remain associated with winds from the freeway for all temporal classifications.

Table 2-1. Hourly average PM_{10} and BC concentrations within spatial and temporal categories as measured at the School site in Granada Hills for the period August 2007 through May 2008. Eligible data are limited by wind direction as determined at the School site; these data correspond to matching valid data from the Landfill site. Averages are weighted by the frequency of matched, validated hourly data between sites.

	Average 1-Hr PM_{10} ($\mu g/m^3$)					
	All Validated Hours		Landfill Operating, Non-Rush Hours[a]		Landfill Non-Operating, Rush Hours[b]	
Wind Direction at School	Baseline at School[c]	Current year data at School[d]	Baseline at School[c]	Current year data at School	Baseline at School[c]	Current year data at School
All winds	33.7	22.8	38.2	21.6	34.4	27.3
Winds from Landfill[e]	20.1	20.7	22.5	14.2	16.6	24.2
Winds not from Landfill[f]	38.0	23.5	41.7	23.7	38.9	27.9
Winds from freeway[g]	38.1	25.6	33.4[h]	26.3	35.2[h]	29.8
	Average 1-Hr BC ($\mu g/m^3$)					
	All Validated Hours		Landfill Operating, Non-Rush Hours		Landfill Non-Operating, Rush Hours	
Wind Direction at School	Baseline at School[c]	Current year data at School	Baseline at School[c]	Current year data at School	Baseline at School[c]	Current year data School
All winds	1.08	0.46	1.37	0.53	1.14	0.54
Winds from Landfill	0.47	0.24	0.59	0.24	0.40	0.31
Winds not from Landfill	1.19	0.55	1.49	0.62	1.23	0.58
Winds from freeway	1.17[h]	0.58	1.61[h]	0.68	1.20[h]	0.64

[a] 10 a.m.–2 p.m. weekdays; 6 a.m.–12 p.m. Saturdays
[b] 3 p.m.–7 p.m. weekdays
[c] November 22, 2001 to November 21, 2002; data extracted from 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.
[d] July 31, 2007 to May 30, 2008
[e] Winds from landfill are >= 303° or <=19°.
[f] Winds not from landfill are <303° and >19°.
[g] Winds from freeway are <=180° and >19°.
[h] These values were calculated by STI from summary data in Baseline report (footnote [c]).

2.2 COMPARISON WITH STATE AND FEDERAL STANDARDS

The federal 24-hr PM_{10} standard of 150 $\mu g/m^3$ was exceeded at *both* monitoring sites on only one day (May 21, 2008) during this period (**Table 2-2**). At the Landfill site on that day, northerly winds with speeds exceeding 25 mph were strongly correlated with high hourly PM_{10} concentrations. Wind speeds measured at the School site were about half the magnitude of those measured at the Landfill site. Preliminary data (non-validated) reported to AIRNow for 12 SCAQMD monitoring sites for that day showed maximum 24-hr concentrations less than 75 $\mu g/m^3$, suggesting that these exceedances were localized and associated with landfill emissions. A discussion of wind conditions and PM_{10} concentrations for this day was presented in the recent report "Second Quarterly Report Of Ambient Air Quality Monitoring at Sunshine

Canyon Landfill and Van Gogh Elementary School (March 1, 2008–May 30, 2008)", June 30, 2008.

The Landfill site exceeded the standard on two additional days. The exceedance at the landfill on October 27, 2007, occurred under Santa Ana wind conditions, which were simultaneous with widespread wildfires throughout Southern California. Under U.S. Environmental Protection Agency (EPA) guidelines, these conditions would be considered exceptional circumstances (if applied for and justified), and ambient PM_{10} concentrations of this magnitude, had they been recorded at a regulatory monitoring site, would likely not be considered an exceedance of the standard.

Table 2-2. Comparison of baseline and current period (August 1, 2007 through May 30, 2008) exceedances of federal and state PM_{10} standards.

Regulatory Level	Averaging Period	PM_{10} Standard	School Baseline	School Current Period	Landfill Baseline	Landfill Current Period
Federal	24-hr	150 μg/m^3	0	1[a]	0	3[b]
	Annual	Revoked	--	--	--	--
State	24-hr	50 μg/m^3	38/182 (21%)	20/234 (9%)	125/264 (47%)	46/237 (19%)
	Annual	20 μg/m^3	Yes	Insufficient data	Yes	Insufficient data

[a] Exceedance occurred on 5/21/08

[b] Exceedances occurred on 10/22/07 (Santa Ana winds), 2/14/08, 5/21/08

The third exceedance occurred at the Landfill site (but not the School site) on February 14, 2008. This event is thought to have been local and associated only with the landfill, resulting in a 24-hr average PM_{10} concentration at the Landfill site of 167 μg/m^3. The School site monitor reported a 24-hr average PM_{10} concentration of 48 μg/m^3. The concentration measured at the School site is similar to those reported at other ARB monitoring sites in Southern California on that day, where all but one (in Imperial County) reported concentrations below the state standard of 50 μg/m^3.

In the recent quarterly report (March 1 through May 30, 2008), it was suggested that elevated PM_{10} concentrations measured at the Landfill site may be due in part to the condition of the area immediately surrounding the trailer that houses the monitoring equipment on the southern berm of the old city landfill. The data shown in **Figure 2-1** provide a foundation for this hypothesis. The strong northerly winds caused six consecutive hourly PM_{10} concentrations in excess of 400 μg/m^3 at the Landfill site. (One of these hourly values was invalidated because it was above the maximum scale of the BAM instrument, 1,000 μg/m^3.) The School site monitor shows somewhat elevated PM_{10} readings during these hours, and the readings may have been influenced by the emissions from the barren area surrounding the Landfill monitoring site. The time series of PM_{10} data also shows a few elevated readings at the landfill on February 12, with similar strong northerly winds, but with little impact at the school. On February 15, winds approaching the same magnitude as those of February 14 caused no spike in measured $PM_{10.}$ The immediate area may have been swept clean of loose crustal material. If the hypothesis of this localized effect is true, the event misrepresents the magnitude of the contribution of the landfill proper to local ambient PM_{10} concentrations under high wind conditions. BFI should consider the application of a surface stabilization treatment on the area immediately surrounding the monitoring trailer and restricting vehicles traversing the area to specific routes.

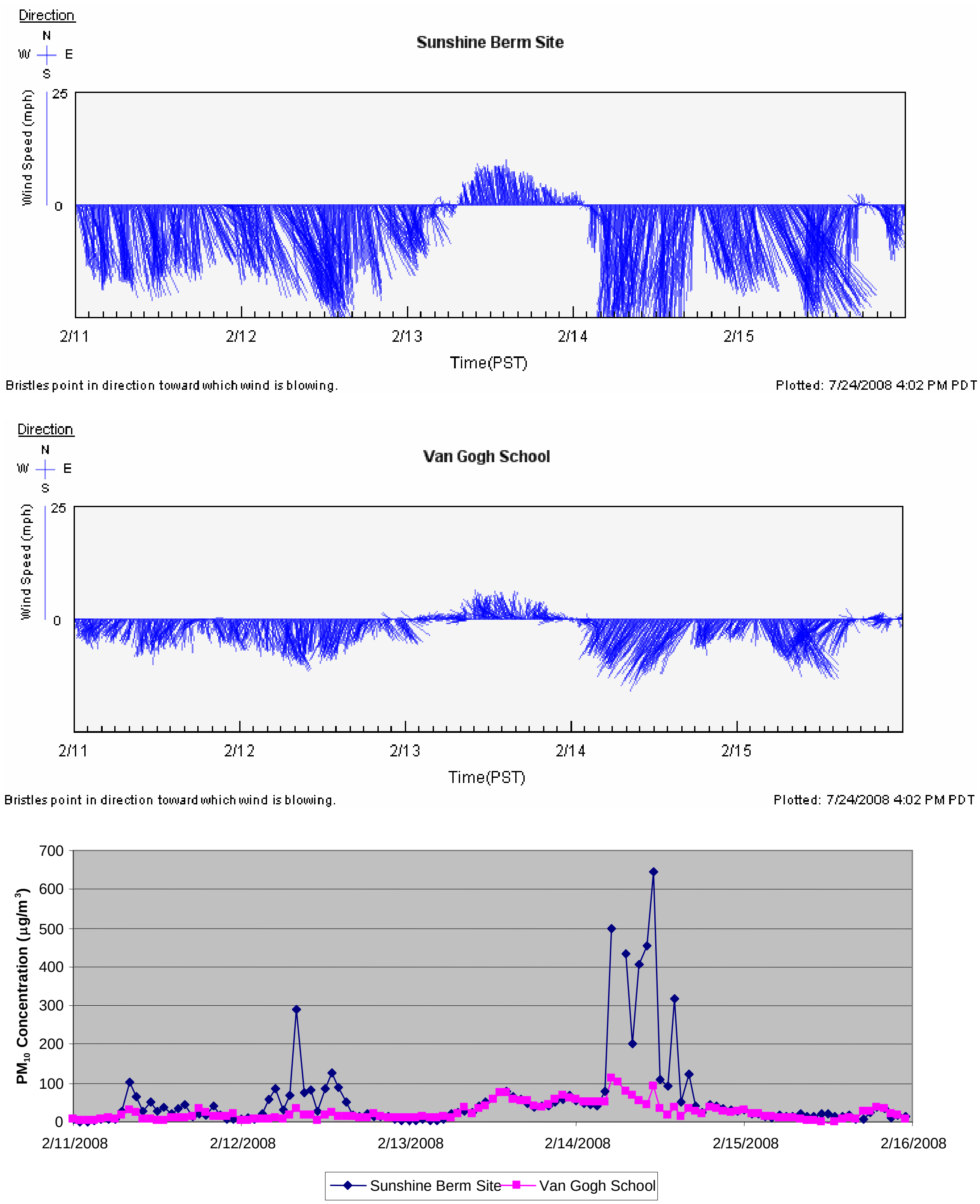

Figure 2-1. The federal 24-hr PM_{10} standard was exceeded only at the Landfill site on February 14, 2008. The top panel is a vector plot of the 5-minute wind speeds at the School site. (The bristles point in the direction toward which the wind is blowing, and the length of the bristles indicate wind speed.) High hourly concentrations also occurred on February 12.

2.3 24-HR METRICS

Baseline-versus-current period values of average 24-hr and maximum 24-hr PM_{10} and BC concentrations are shown in **Table 2-3**. Based on all validated data collected in the current monitoring program through May 30, 2008, the average 24-hr PM_{10} concentrations at the Landfill and School sites are lower than the baseline values. The maximum 24-hr values at both sites are higher, but the higher values are considered either the result of an exceptional event, or realistically attributable to crustal contributions from the disturbed soil surface surrounding the landfill monitoring trailer.

Table 2-3. Comparison of baseline and current period (August 1, 2007, through May 30, 2008) values of average 24-hr and maximum 24-hr PM_{10} and BC concentrations.

Metric	PM_{10} Concentration (μg/m^3)			
	School Baseline	School Current Period	Landfill Baseline	Landfill Current Period
Average 24-hr	33.2	28.2	49.3	36.2
Maximum 24-hr	112.5	152.5	135.3	290.4
Metric	**BC Concentration (μg/m^3)**			
	School Baseline	School Current Period	Landfill Baseline	Landfill Current Period
Average 24-hr	0.98	0.64	0.99	0.75
Maximum 24-hr	3.72	2.85	3.49	3.35

2.4 PM_{10} AND BC DATA COMPLETENESS

Ambient air quality data must meet certain data completeness criteria to meet EPA reporting standards. While the current monitoring effort is neither regulated nor intended for submission to EPA, meeting minimum data completeness guidelines ensures that conclusions drawn from the data are representative. The generally accepted data completeness requirement is 75%.

Percent data capture is the percent of non-missing data values that were collected over the total number of data intervals in the date range (e.g., for the raw BC 5-minute data, 12 data values are expected per hour, and 288 data values are expected per day). As indicated in **Table 2-4**, the percent data capture for PM_{10} and BC has shown steady improvement from the time continuous monitoring started in August 2007, with data capture rates greater than 97% for the most recent quarter. Lower data capture rates during the startup months were attributable to equipment problems that either required that instruments be sent back to the factory, or to the failure of an integral component, such as a pump. Details of the equipment problems are discussed in the earlier quarterly reports. The percent of valid or suspect data (all data that are included in the calculation of metrics and statistics) has remained good to excellent from the beginning of the field study. The high percentage of valid/suspect data is attributable to daily quality assurance (QA) procedures that are apart of STI's standard operating procedures (SOP) for air monitoring projects. Data from all monitors are viewed daily, usually several times a day. Interruptions in data streams, or data that appear atypical or suggest a problem are given priority. Many times these anomalies are merely glitches in the monitoring and telemetry network that can be addressed remotely. Other problems require site visits. Data completeness statistics for the meteorological data are discussed in Section 4.4.

Table 2-4. A summary of data completeness statistics of the continuous particulate matter monitoring through May 30, 2008.

Monitoring Location (Site)	Dates	Percent Data Capture[a]		Percent Data Valid or Suspect [b]		Percent Data Suspect[c]	
		PM_{10}	BC	PM_{10}	BC	PM_{10}	BC
Sunshine Canyon Landfill	7/31/01–11/30/07	60	76	99	100	0	0
	12/1/07–2/29/08	94	87	84	100	0	0
	3/1/08–5/30/2008	100	97	97	100	0	0
	Cumulative	82	86	97	100	0	0
Van Gogh Elementary School	8/1/01–11/30/07	63	57	95	100	0	0
	12/1/07–2/29/08	93	91	85	100	0	0
	3/1/08–5/30/2008	100	97	100	100	0	0
	Cumulative	83	79	95	100	0	0

[a] Percent Data Capture is the percent of non-missing data values that were collected over the total number of data intervals in the date range (e.g., for the raw BC 5-minute data, 12 data values are expected per hour, and 288 data values are expected per day).
[b] Percent Data Valid or Suspect is the percent of data values that are 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.

3. LANDFILL GAS

Management of LFGs is a major component of any municipal solid waste (MSW) landfill. Landfills that fall within the jurisdiction of the SCAQMD must comply with Rule 1150.1, "Control of Gaseous Emissions from Municipal Solid Waste Landfills". All landfills are required to have an LFG collection and control system meeting the requirements of the rule. Specifications of frequency and suitable methods for instantaneous and integrated surface monitoring, as well as ambient monitoring, are stated explicitly. The regularly scheduled measurements required by Rule 1150.1 provide the data necessary to judge the operational status and effectiveness of the LFG collection and control system.

The Conditions of Approval that govern the community-based ambient air monitoring program being operated by STI are independent of Rule 1150.1, and stipulate that LFG sampling in ambient air be undertaken four times each year at the perimeter of the landfill and in the community of Granada Hills.

3.1 LANDFILL GAS BACKGROUND

The term LFG encompasses a wide variety of compounds, but LFG is typically dominated by methane (45% to 60%) and carbon dioxide (40% to 60%).[3] The balance of the LFG mixture is made up of small amounts of nitrogen, oxygen, hydrogen, ammonia, sulfides, carbon monoxide, and NMOCs.

Some NMOCs are known to cause serious environmental and health effects and are known as hazardous air pollutants (HAPs). 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 the chemical and biological reactions that occur in MSW landfills. Some HAPs are additionally classified as MSATs that are associated with motor vehicles (e.g., benzene, 1,3-butadiene, xylene, and toluene). Many industrial processes produce HAPs as by-products. While most HAPs do not occur naturally, some do (1,2-dibromomethane produced by algae and kelp; ethybenzene 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 infomation about the factors affecting transport, such as meteorology and topography. Worldwide ambient concentrations of methane are about 1.8 ppmv ; thus, methane will exist 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.

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

[3] Agency for Toxic Substances and Disease Registry (2002) Landfill gas basics. Available on the Internet at <http://www.atsdr.cdc.gov/HAC/landfill/PDFs/Landfill_2001_ch2mod.pdf>.

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 twice weekly site visits by trained personnel.) Unfortunately, obtaining only four samples annually precludes the ability to discern diurnal, seasonal, or annual trends. At best, these samples may reveal the maximum potential ambient concentrations of LFGs if the factors controlling the source strength and transport of landfill-based LFG emissions can be approximated, so that each sample may be targeted at times when maximum ambient concentrations are expected to occur.

3.2 LFG SAMPLING STRATEGY—WHEN TO SAMPLE

The limitations on sample frequency imposed by the Conditions of Approval preclude statistically based LFG sampling strategy. Sampling LFG only four times a year should target the “worst case scenario” by sampling during those times when the probability of landfill emissions influencing neighborhood-scale ambient concentrations is highest. Employing a method known as “triggered sampling” is one approach. Monitoring for sudden increases in concentration of a compound known to be associated with LFG could be used to trigger canister or cartridge sampling of ambient air. Methane or carbon dioxide may be appropriate triggering compounds for LFG sampling, since LFG is typically 45 to 60% methane and 40 to 65% carbon dioxide. This method would require additional monitors to track these compounds.

A less sophisticated approach using resources that already exist at the monitoring locations may be effective. Wind direction and wind speed are obvious factors to consider. For example, sampling when the wind is blowing from the south, over the SoCAB, would do little to ascertain the contribution of the landfill to neighborhood concentrations of LFG. Many compounds that occur in LFG can also occur in urban environments, from industrial or mobile sources. Similarly, sampling during periods of high winds introduces a dilution factor and lessens the potential for identifying sources. Real-time meteorological data are available from both monitoring locations and may be used to avoid sampling under unsuitable meteorological conditions.

In addition to real-time wind data, continuously logged 5-minute BC concentrations may be helpful in determining when transport from the landfill southward to nearby Granada Hills is occurring. An example of how paired BC and wind data may be used is illustrated in **Figure 3-1**, which depicts a time series of 5-minute wind and BC data from March 8 through March 12, 2008, at the two monitoring sites.

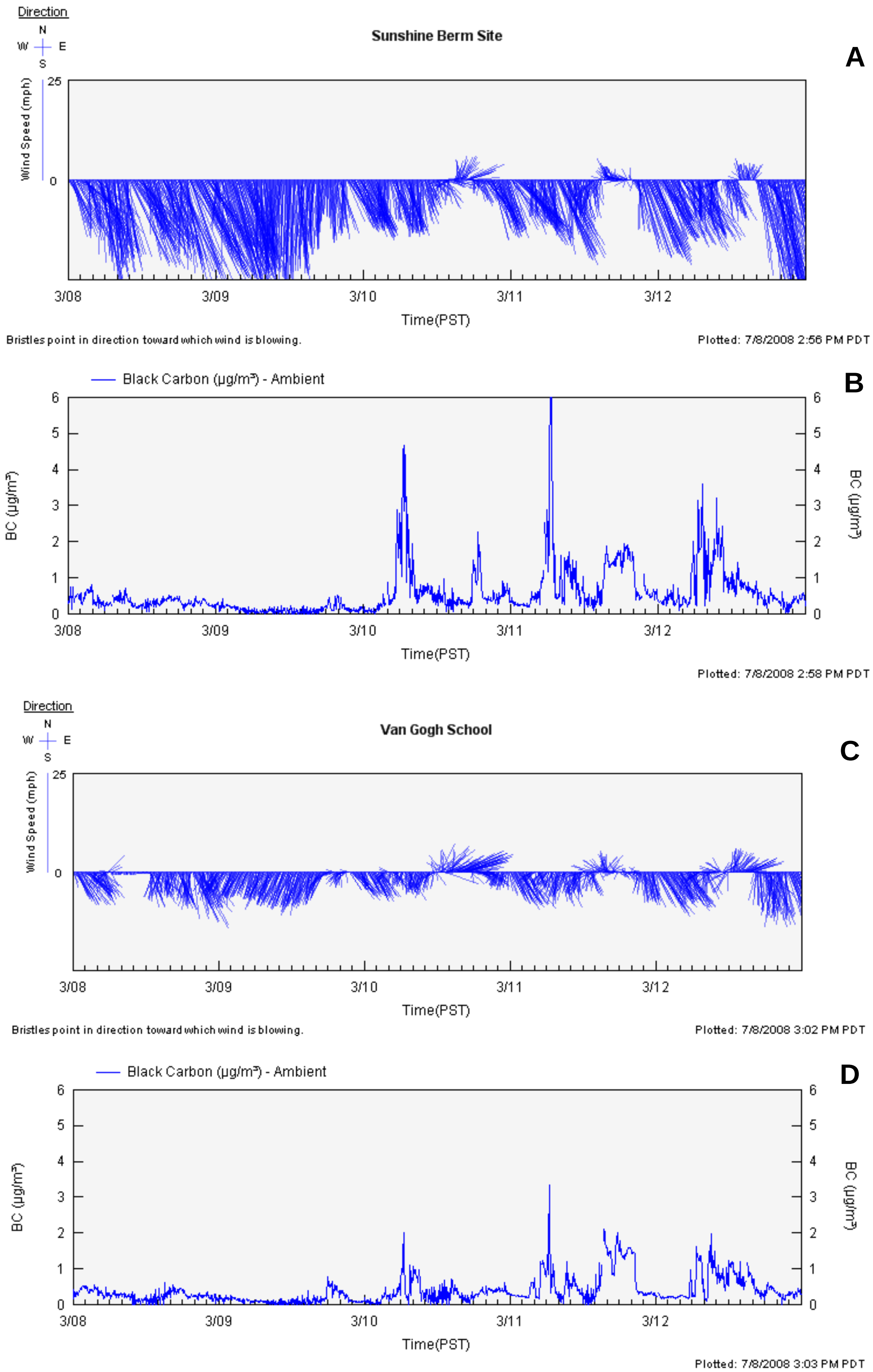

Figure 3-1. A time series of 5-minute wind and BC concentration data illustrate conditions under which the probability of landfill-based emissions impacting ambient concentrations in Granada Hills may be maximized.

In Figure 3-1, Panels A and C, the wind data are graphically presented as bristle plots. Each bristle represents a 5-minute average wind speed. The bristles point in the direction toward which the wind is blowing. The length of the bristle indicates the wind speed. Legends for wind speed and wind direction are depicted on the left side of the bristle plots. Panels B and D show the corresponding 5-minute average BC concentrations.

Several observations can be made:

- Wind speeds at the School site are lower than at the Landfill monitoring site.
- Substantially lower BC concentrations and higher wind speeds are depicted on March 8 and 9 (Saturday and Sunday) than on March 10 through March 12 (Monday through Wednesday). The low BC concentrations on the weekend days may be attributable to low activity levels at the landfill, or higher wind speeds during those days, or a combination of the two.
- Spikes in BC concentration on March 10 through March 12 correlate well between the two sites.
- The maximum weekday peaks in BC concentration in these days occur between 6 a.m. and 8 a.m.

Daily observation of the PM_{10}, BC, and wind data over several months suggests that when wind speeds are high (about 25 mph or greater) and from the north, BC concentrations are usually lower and PM_{10} concentrations at the Landfill site increase. The higher PM_{10} concentrations may or may not be seen at the School site. These observations suggest that high winds may entrain soil surface crustal material, while simultaneously blowing away combustion source BC.

Figure 3-1 illustrates one set of meteorological conditions under which the LFG sampling might be triggered: northerly winds at moderate speed at the landfill and lower speeds at the school, with little deviation from the northerly direction, and increased BC concentrations at both sites. This scenario occurs only a small proportion of the time. Other, more typical, scenarios would be *excluded* from potential LFG sampling::

- When winds are not blowing from the landfill towards the community
- When high winds tend to clean out BC (and also LFGs)
- When wind blow at very low wind speeds (calm periods) and are accompanied by large deviations in wind direction. This scenario is especially true at the School site, where nearby obstructions can affect the local wind pattern (see Section 4).

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)[4] 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 they were able to identify

[4] 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>.

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 volatile organic compounds (VOCs). If the temporal variability of ambient LFG concentrations near the landfill are 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.

In addition to basing LFG sampling times on real-time data and published information on diurnal trends of air toxics, experience or anecdotal knowledge may be helpful. For example, are odor complaints filed by neighborhood residents associated with a particular time of day? The SCAQMD maintains a smog hotline where the public can register complaints. A check of the Complaint Summary Report for complaints directed specifically towards the Sunshine Landfill was made for the period February 2007 through March 2008. There were 29 odor complaints registered during that time period when the caller suggested the Sunshine Canyon Landfill as the source. Of these 29 complaints, 20 were received between the hours of 7 a.m. and 9 a.m., one occurred at 2 a.m., and the rest were scattered throughout the day.

The sample times for LFG samples collected to date were chosen, based on the real-time wind and BC concentration patterns noted above, coupled with anecdotal knowledge derived from reported odor complaints, that suggested that transport to the community may be occurring during morning hours. Two samples were taken at each location on each of two days. The first sample ran from 7 a.m. to 8 a.m. and was immediately followed by a second sample from 8 a.m. to 9 a.m. Two separate hourly samples were collected in an effort to evaluate whether concentration differences existed during these morning hours. Section 3.5 discusses the results of the sampling.

The timing component of the sampling strategy remains open to modification. It differs from the baseline LFG monitoring because it is targeted, not random. Decisions about when to obtain LFG samples will continue to evolve as more is learned about landfill-related emissions and transport.

3.3 LFG SAMPLING STRATEGY—HOW TO SAMPLE

Some special accommodations are needed to implement the sample timing discussed in Section 3.2. Obtaining samples as described requires access to near real-time data to support the decision when to sample. It also requires sampling hardware that can be installed, left unattended, and triggered remotely.

The real-time meteorological and particulate matter data are uploaded from the monitors at Sunshine Canyon Landfill and Van Gogh Elementary School to STI's data server every

10 minutes, and graphical displays of the data are updated immediately and made available to in-house personnel working on the Sunshine Canyon project. This data processing routine allows on-the-fly decision-making needed for the triggered sampling.

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 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.

To enable remote triggering of the sample, a solenoid valve was added to the sample train. The on-site data logger controls this valve. When a decision to trigger a sample has been made, the user logs in remotely to the on-site computer and sends a signal to the data logger to open the solenoid valve. From this point forward the sampling process is controlled by the data logger. The start time of the sample is under the subjective control of the sampling technician, but once triggered moves forward to completion under data logger control. For the two samples obtained through May 30, 2008, the initial trigger was at 7 a.m PDT.

One of the four canisters in the first LFG sample was lost due to a leak that caused the can to fill partially during the days following deployment but before the triggering event. Because the evacuated canisters must be left unattended and will be triggered remotely, a mechanism to detect any leaks in the system was added to the sampling hardware setup. The added mechanism employs a pressure transducer that constantly monitors the Summa canister pressure and converts the pressure reading to an analog voltage signal that is recorded by the data logger, allowing real-time monitoring of Summa canister pressures. This continuous system pressure monitoring provides certainty that leaks are not occurring in the sampling system. If leaks occur, it provides the opportunity for an on-site visit to correct the problem.

3.4 LFG SAMPLING STRATEGY—TARGET COMPOUNDS

The list of NMOCs to be targeted in the laboratory analysis of collected samples should include those compounds that were sampled during the baseline study, since direct comparison with the results of the baseline study is one objective in the ongoing monitoring program. The list should also include other NMOCs commonly associated with landfills, in particular those compounds specified in SCAQMD’s Core Group of “Carcinogenic and Toxic Air Contaminants” listed in Rule 1150.1. The Agency for Toxic Substances and Disease Registry (ATSDR), part of the Centers for Disease Control (CDC), also provides a list of NMOCs commonly found in LFG.

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 on-site 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.[5] 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 dichloroethane 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[6] does not agree with published California ARB data.[7] 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 MDL of 0.3 ppbv (1.8 $\mu g/m^3$). Substituting a value of one-half the MDL value is commonly used for reporting non-detect data.

According to the ATSDR Division of Toxicology and Environmental Medicine ToxFAQs™,[8] 1,4-dichlorobenzene is the most recognizable isomer and considered the most important. It is a solid that changes from solid to vapor form (sublimation) when exposed to air, the most common means of exposure being through household products such as air fresheners, mothballs, and toilet-deodorizer blocks. These throw-away consumer items could have been the source for those LFG samples obtained from the landfill collection system in 2003. 1,2-dichlorobenzene is used to make herbicides, and 1,3-dichlorobenzene is used to make herbicides, insecticides, medicine, and dyes. These isomers are released into the environment when used during the manufacturing process or when people use the products that contain these chemicals. In the two LFG samples collected in spring 2008, 1,4-dichlorobenzene was the only isomer that came close to the detection limit, coming in just below the MDL for all samples. For the samples collected in 2008, dichlorobenzenes were analyzed with a Modified TO-15, low-level procedure that has an average MDL for the isomer 1,4-dichlorobenzene of 0.43 $\mu g/m^3$, more than five times lower than the baseline procedure MDL of 2.4 $\mu g/m^3$.

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[5] 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.

[6] 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.

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

[8] Agency for Toxic Substances and Disease Registry (2006) Dichlorobenzenes. Available on the Internet at <http://www.atsdr.cdc.gov/tfacts10.pdf>. August.

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 3-1** 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.

Table 3-1. 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.

Compound	Ongoing Monitoring	Baseline	SCAQMD Core Group	ATSDR
1,1,2,2-Tetrachloroethane	✓			
1,1-Dichloroethane	✓		✓	✓
1,1-Dichloroethene	✓		✓	
1,2-Dichlorobenzene	✓	✓	✓	
1,3-Butadiene	✓			
1,3-Dichlorobenzene	✓	✓	✓	
1,4-Dichlorobenzene	✓	✓	✓	
Benzene	✓		✓	✓
Benzyl chloride	✓		✓	
Carbon tetrachloride	✓		✓	
Chlorobenzene	✓		✓	
Chloroform	✓		✓	
cis-1,2-Dichloroethene	✓			✓
Dichloromethane	✓		✓	✓
Ethylbenzene	✓			✓
Ethylene dibromide	✓		✓	
M-&P- Xylene	✓		✓	✓
Methyl Chloroform	✓		✓	
N-Hexane	✓			✓
O-Xylene	✓		✓	✓
Tetrachloroethylene	✓		✓	✓
Toluene	✓		✓	✓
Trichloroethylene	✓		✓	✓
Vinyl Chloride	✓	✓	✓	✓

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-tetrachlroethane 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 MSW 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.

It should be noted that hydrogen sulfide (H_2S) is not currently on the list of target compounds and is not sampled , although it was included in the baseline analysis. This lack of sampling is a function of the current sampling technique. Hydrogen sulfide reacts with metal, so it is not possible to use the samples gathered in the Summa canisters for H_2S analysis. Samples for H_2S analysis must be collected in Tedlar bags and analyzed within 24 hours. Tedlar bag samples specifically for H_2S may be included in future sampling periods if this is deemed essential to the objectives of the monitoring.

3.5 LFG SAMPLING RESULTS TO DATE

Two LFG sampling events occurred during the spring 2008 evaluation period—the first on April 10 and the second on May 13. Between 7 a.m. and 9 a.m. on each of those days, two consecutive 1-hr samples (7 a.m. to 8 a.m. and 8 a.m. to 9 a.m., local time) were obtained at each monitoring site. The samples were obtained by passive flow through a calibrated flow controller into evacuated canisters certified for TO-15 low level (LL) and selected ion monitoring (SIM) analyses.

3.5.1 Methane

The average ambient global concentration of methane is approximately 1.8 ppmv. During the baseline monitoring period in 2003, four sampling events occurred (April 6, May 18, June 25, and July 29). Methane concentrations averaged 1.94 ±0.10 ppmv at the Landfill site, and 1.79 ±0.18 ppmv at the School site. The methane analysis by modified ASTM-D-1946 from the spring 2008 sampling events gave similar results. The Landfill and School sites yielded 2.3 and 1.9 ppmv methane on April 10, and 2.4 and 2.3 ppmv on May 13, respectively. These ambient concentrations of methane are considered normal and do not indicate a direct impact by the landfill. It should be noted that a small oil field, a potential additional methane source, exists between the landfill and the community of Granada Hills.

3.5.2 Non-methane Organic Compounds

Baseline samples were collected on April 6, May 18, June 25, and July 2 in 2003 at both the Landfill and School sites. The results for all samples indicated that ambient NMOC concentrations were all less than the MDL for the analysis method of the laboratory. The ambient concentrations of vinyl chloride, 1,2 dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene were less than the MDLs of 0.26, 1.8, 1.8, and 2.4 $\mu g/m^3$, respectively.

The results from the two recent sampling events in Spring 2008 are presented graphically. **Figures 3-2 through 3-8** illustrate the results of the May 13, 2008, LFG in a stepwise progression—each incremental figure overlays new information on previously shown data. The overlays facilitate interpretation of the plots since the final graph (Figure 6) is a bit complex. This is the same data that was presented in the most recent quarterly report.

Figure 3-2 shows the ranges of the 10^{th} to 90^{th} percentile quarterly averages for available Los Angeles and Ventura County data from 2005 forward. These quarterly averages are derived from 24-hr samples and are averaged over all sites.

Figure 3-3 shows an overlay of one of the samples collected on May 13, 2008, to illustrate how the sample compares to averaged Los Angeles and Ventura County data. Figure 3-4 overlays all the data collected on that sample day. Figure 3-5 overlays the MDL for the compounds, allowing a comparison of the sample data with the MDLs.

Some of the compounds associated with landfill emissions have been classified by the EPA as environmental and health hazards, or air toxics. Cancer and non-cancer health benchmarks have been established for many of these compounds. Figure 3-6 compares the sample concentrations to cancer benchmarks. If exposed to a concentration for 70 years, concentrations at this level would be expected to result in an additional case of cancer per million people. Concentrations below the chronic cancer benchmark would have a lower rate, and concentrations above would have a higher rate.

Figure 3-7 overlays the chronic hazard values. These values are also for a 70-year exposure, but the health effects are non-cancer, such as asthma, neurological, or reproductive effects.

It is important to note that these are 1-hr concentration values, and they are being compared to quarterly averages. Compared to the range of values in the Los Angeles and Ventura County areas, the concentrations are all lower or within those ranges. Some of the 1-hr values are above the benchmarks, but they are not high for Los Angeles County.

Figure 3-8 is the complete figure for the April 10, 2008, sampling event.

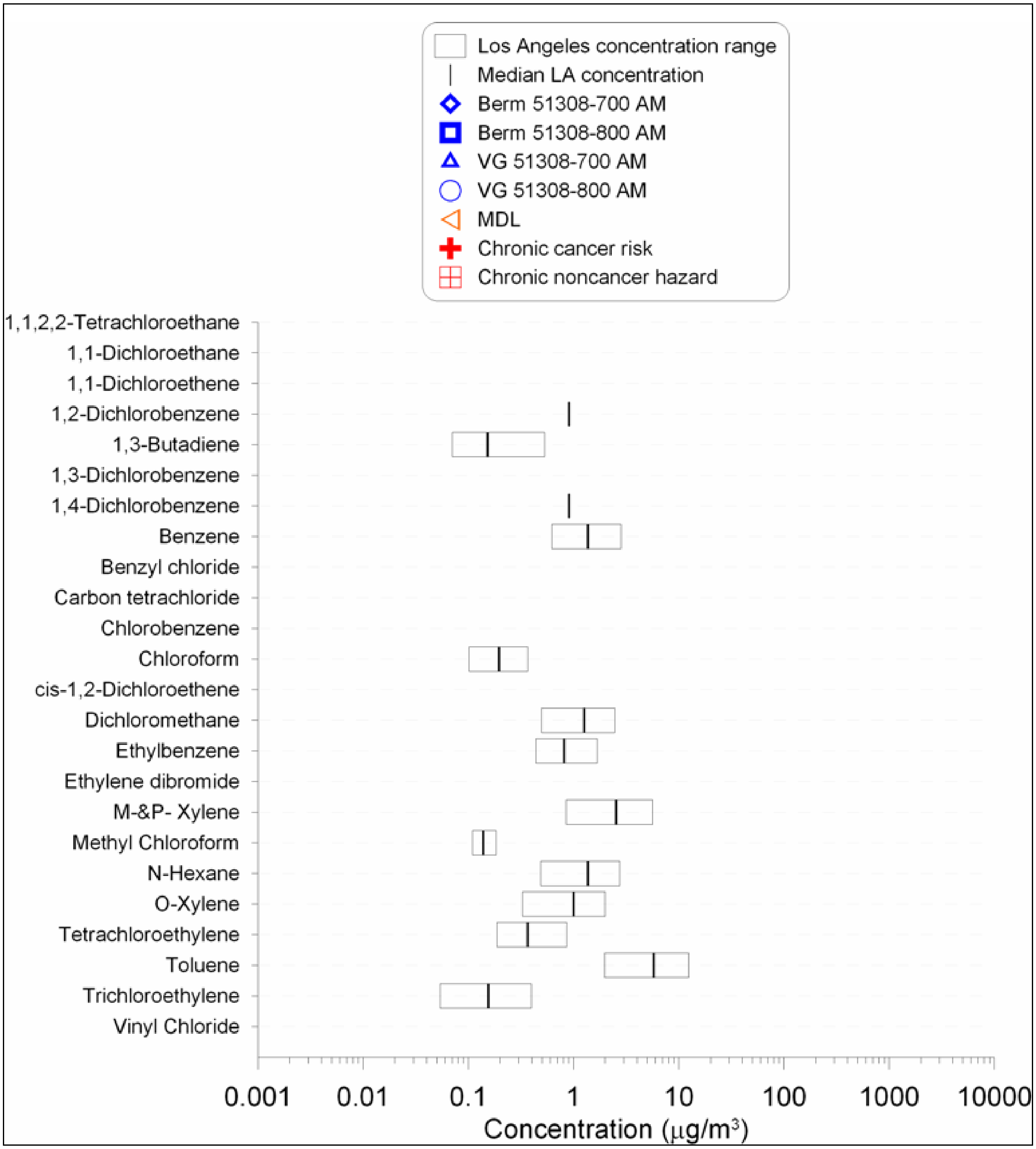

Figure 3-2. Ranges of the 10th to 90th percentile quarterly averages for available Los Angeles and Ventura county NMOC data from 2005 forward. The 24-hr sample data are averaged over all sites.

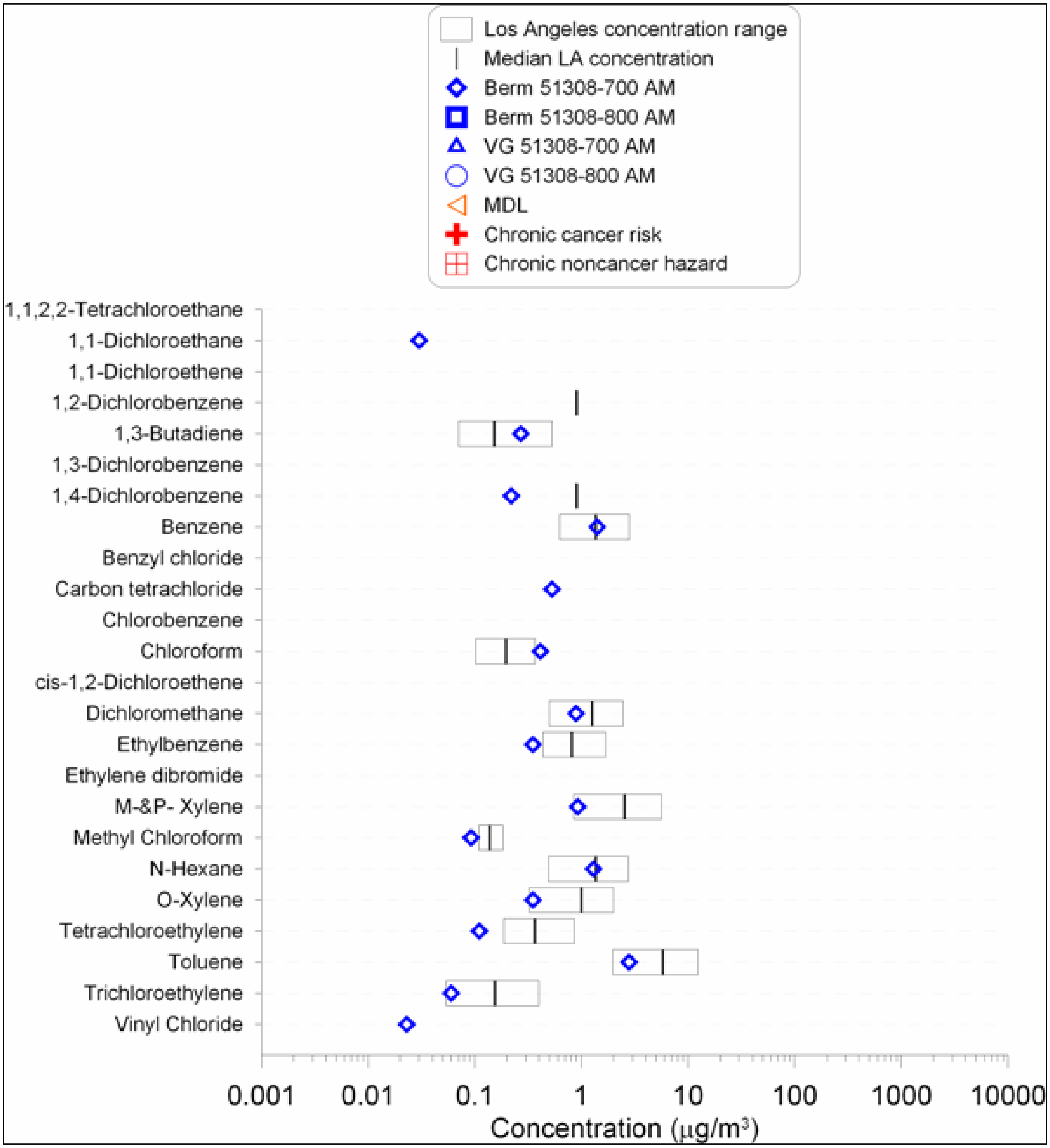

Figure 3-3. Overlay of one sample collected on May 13, 2008, to illustrate how the sample NMOC concentrations compare to averaged Los Angeles and Ventura county data.

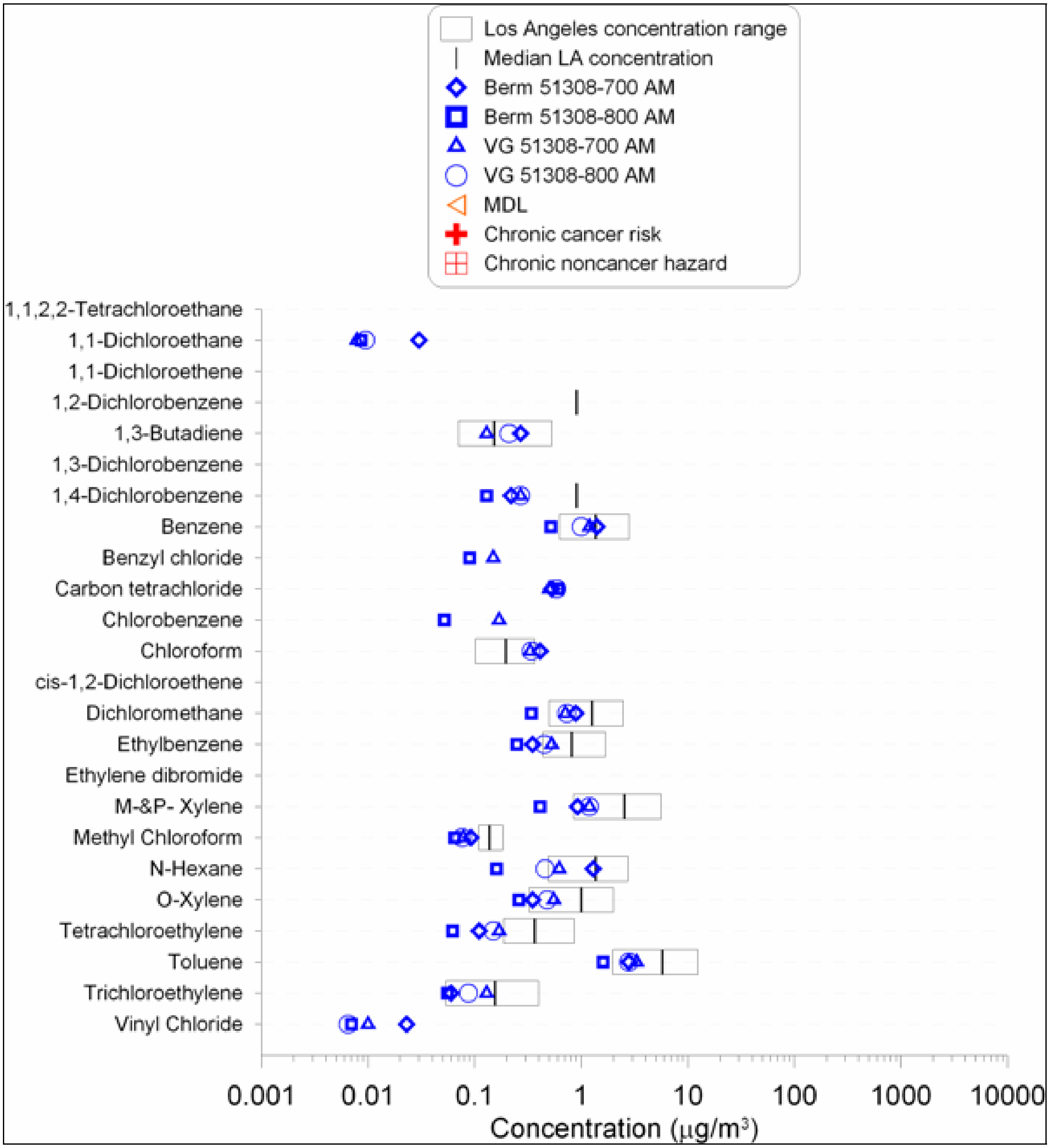

Figure 3-4. Overlay of all the NMOC samples collected on May 13, 2008.

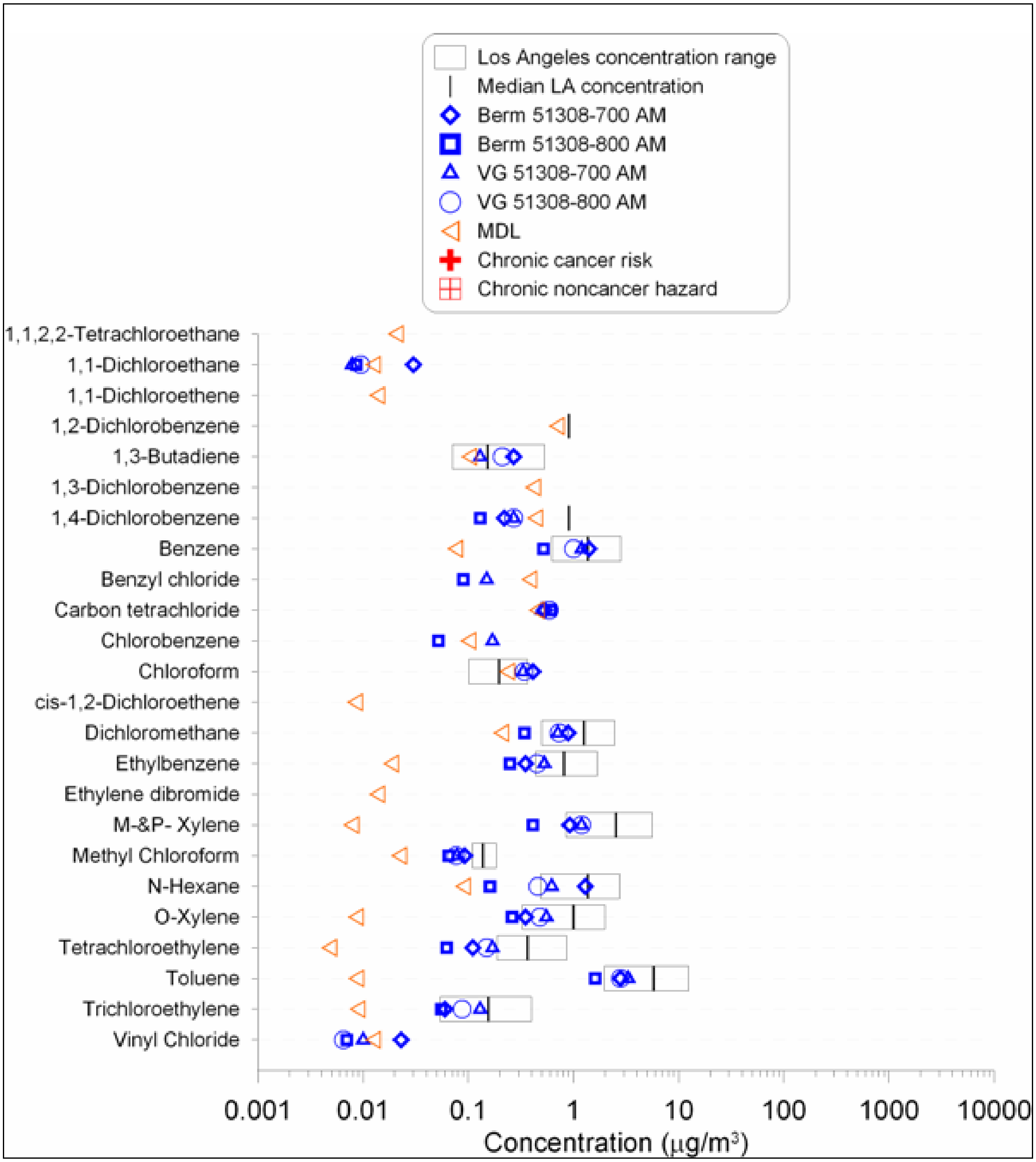

Figure 3-5. Comparison of all NMOC sample concentrations collected on May 13, 2008, to the MDLs.

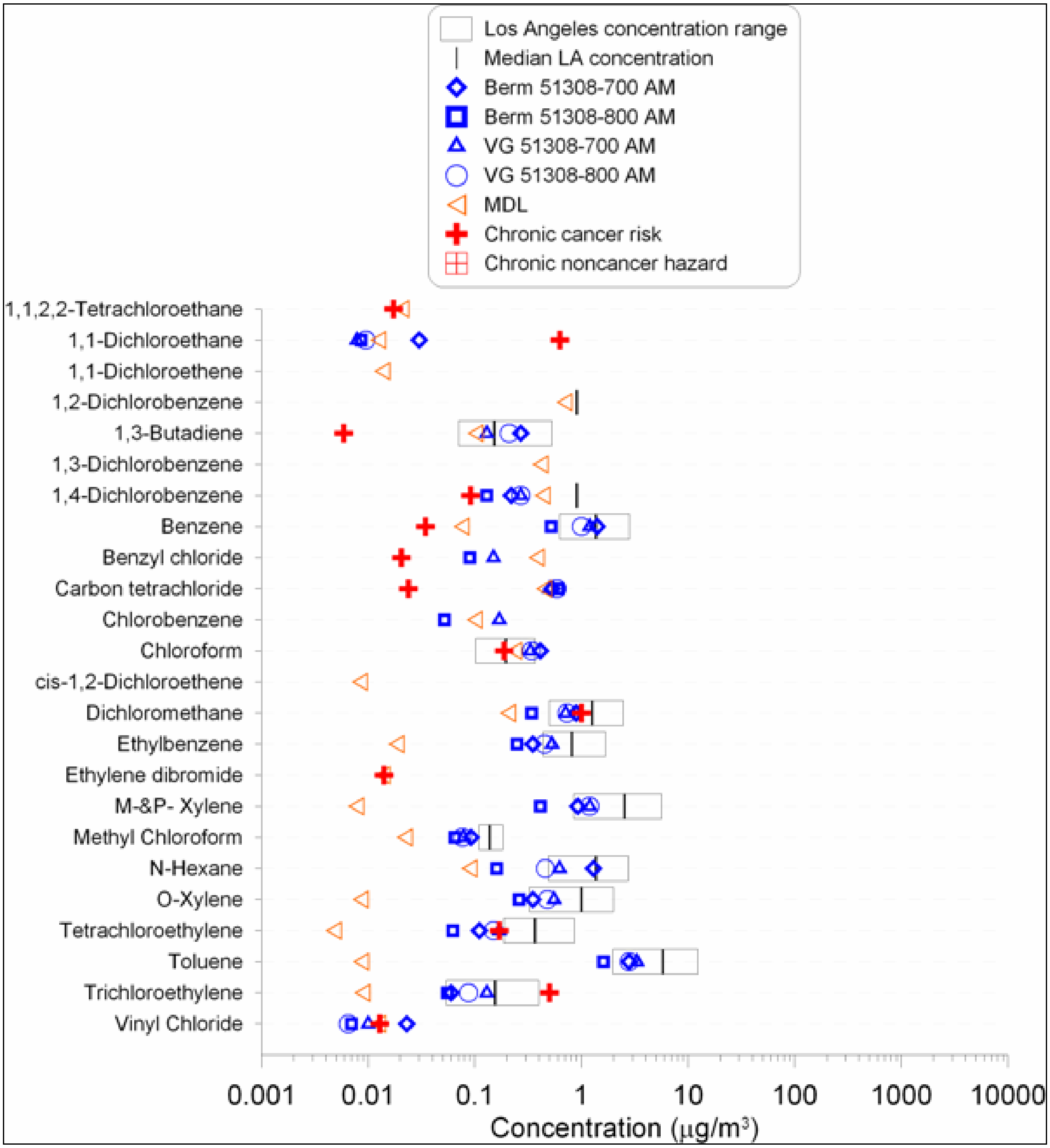

Figure 3-6. Comparison of the sample NMOC concentrations collected on May 13, 2008, to 10^{-6} cancer benchmarks.

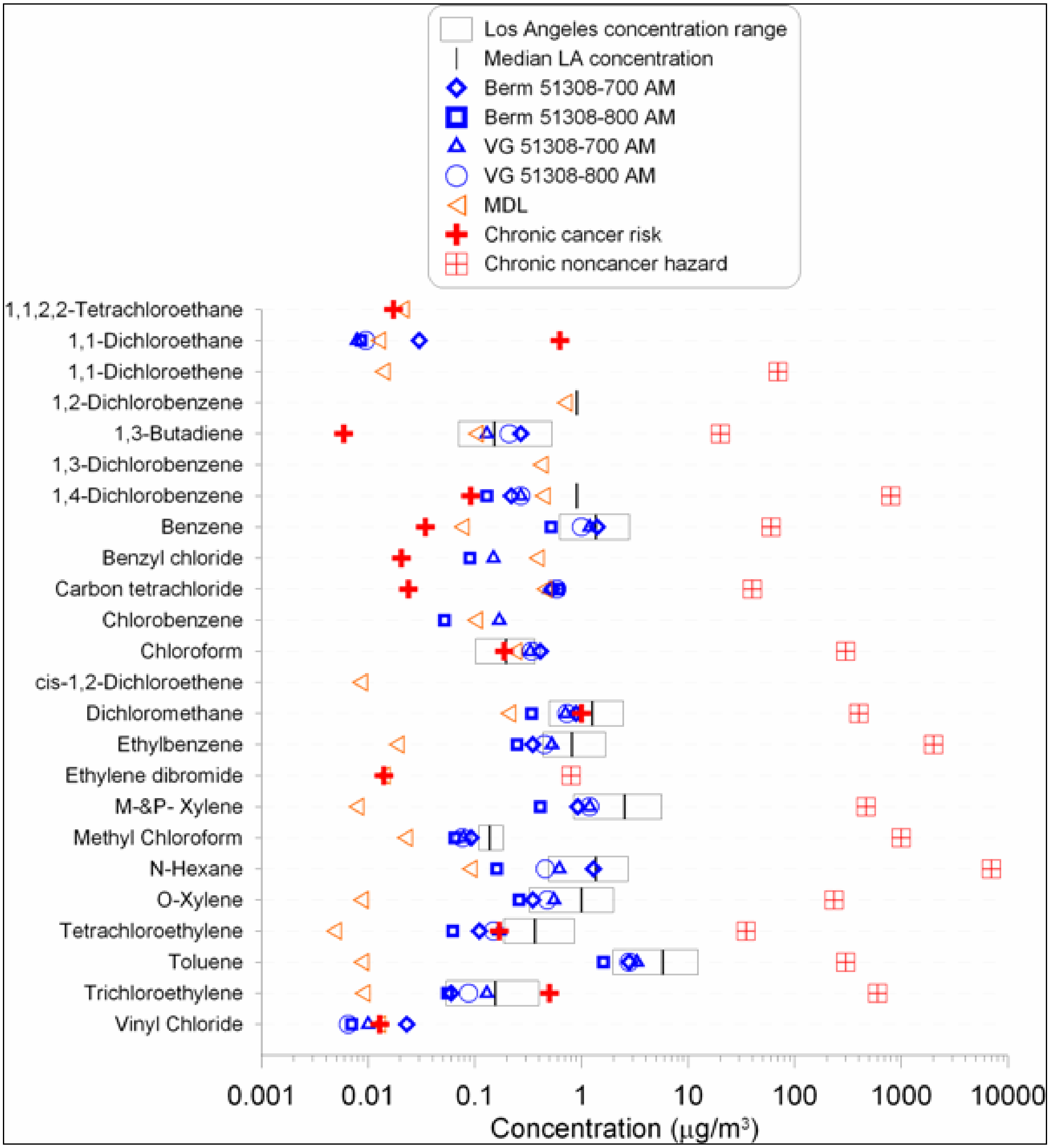

Figure 3-7. Comparison of 1-hr sample NMOC concentrations collected on May 13, 2008, to chronic hazard values for non-cancer health effects (asthma, neurological or reproductive effects).

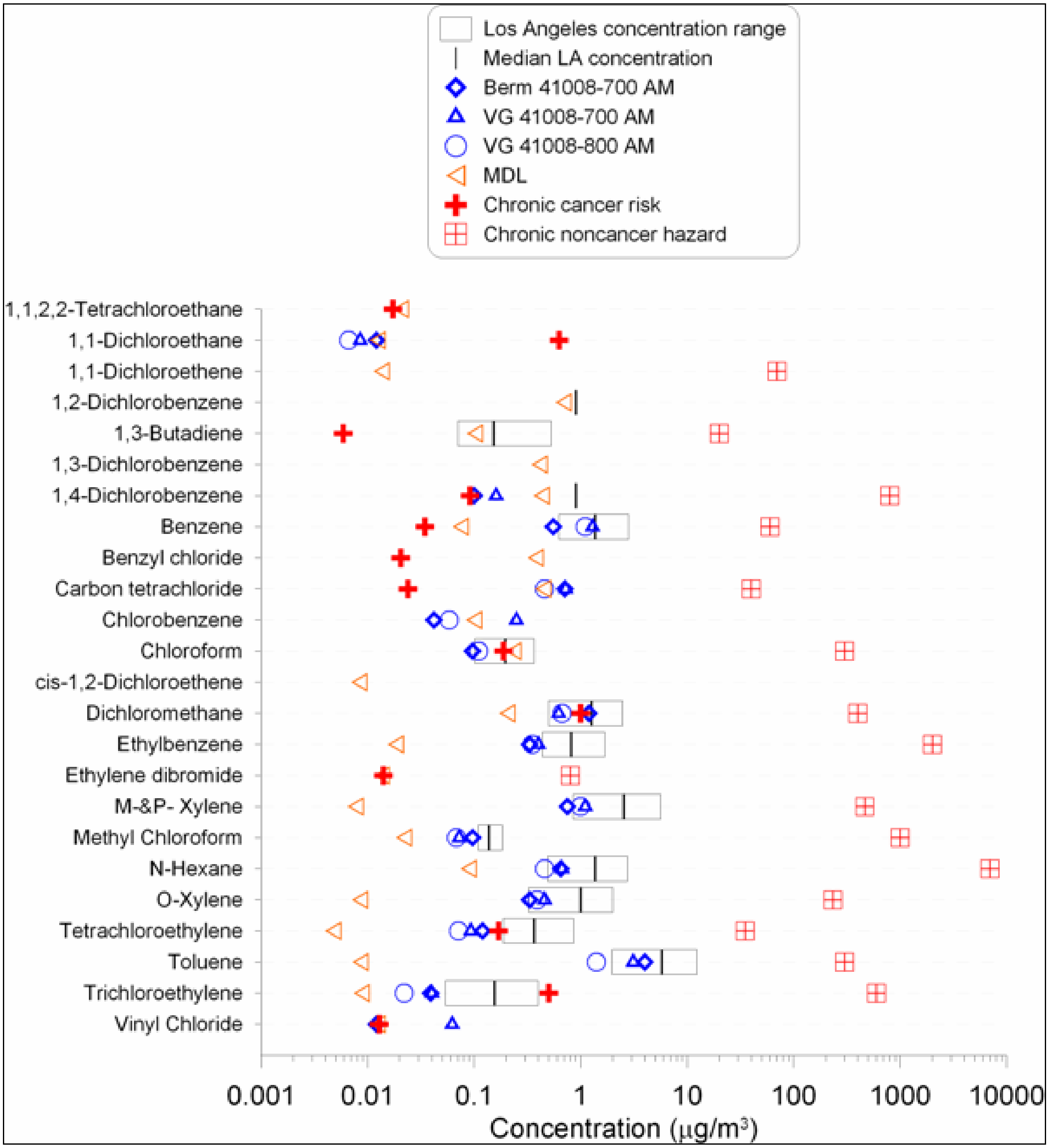

Figure 3-8. Ambient NMOC concentrations from the April 10, 2008, sampling event compared to the range of concentrations for Los Angeles and Ventura Counties, cancer benchmarks, and chronic hazard values.

4. METEOROLOGY

Pollution transport is governed largely by meteorological conditions, so meteorological monitoring is an integral part of ambient air pollution monitoring programs. Wind speed and direction are the two most important variables to measure, and these parameters are being continuously monitored at both monitoring sites. Even though the two sites are only one mile apart in a direct line, the wind parameters can vary substantially between the two points. Some examples of this variaton are discussed in the context of the PM_{10}, BC, and LFG data.

The wind monitors used at these sites are Met One Instruments Model 034B. In August 2007, it was deemed that the existing monitors were not functional and the cost of repairs approached the cost of new monitors, so new Model 034B monitors were purchased and installed. However, problems with the new sensors soon surfaced and required warranty repairs. Infrequent problems continue to negatively impact data completeness to some degree. These issues are discussed in context of the importance of these data and the long term monitoring that is being undertaken.

4.1 WIND PATTERNS

Wind speed and wind direction are often quite different between the two monitoring locations. The topography of the landfill and surrounding areas is complex: the mountain ranges and canyons can alter wind patterns, and make difficult any conclusions about overnight down-slope air flow that may exist. Large trees at the School site northeast of the wind sensor prohibit the site from meeting EPA siting requirements for meteorological sensors. The eddies created by such obstacles in the wind path add uncertainty to the wind direction measurements.

The analysis of the pollutant data collected during baseline monitoring and in the ongoing program to date has been driven largely by subjective categorization of pollutant data based on wind direction (and additionally by time of day and day of week); thus, it is important to understand how winds at the two sites are similar or dissimilar as affected by mesoscale meteorology, topography, or other factors.

The overall distribution of wind speed and wind direction since the continuous monitoring began in August of 2007 is illustrated in **Figures 4-1A and 4-1B**. This data set covers approximately late December 2007 through May 2008, so it reflects mostly the winter and spring seasons. (Data completeness for winds prior to December 2007 is very poor due to malfunctions of the wind speed sensor, and much of that early data have been invalidated; see Section 4.4). Winds at the Landfill site (Figure 4-1A) were northwesterly to northerly about 50% of the time, and were southeasterly to southerly about 40 % of the time. The northerly winds exhibit the highest wind speeds. The frequency of winds from other directions, as measured at the Landfill site, is low. The overall distribution of wind speeds at the School site is quite different (Figure 4-1B): no one sector exhibits a dominant frequency. Hourly average wind speeds at the School site infrequently exceeded 20 mph and never exceeded 30 mph. Wind speeds exceeding 20 mph are common at the Landfill site, occurring primarily from the northerly directions.

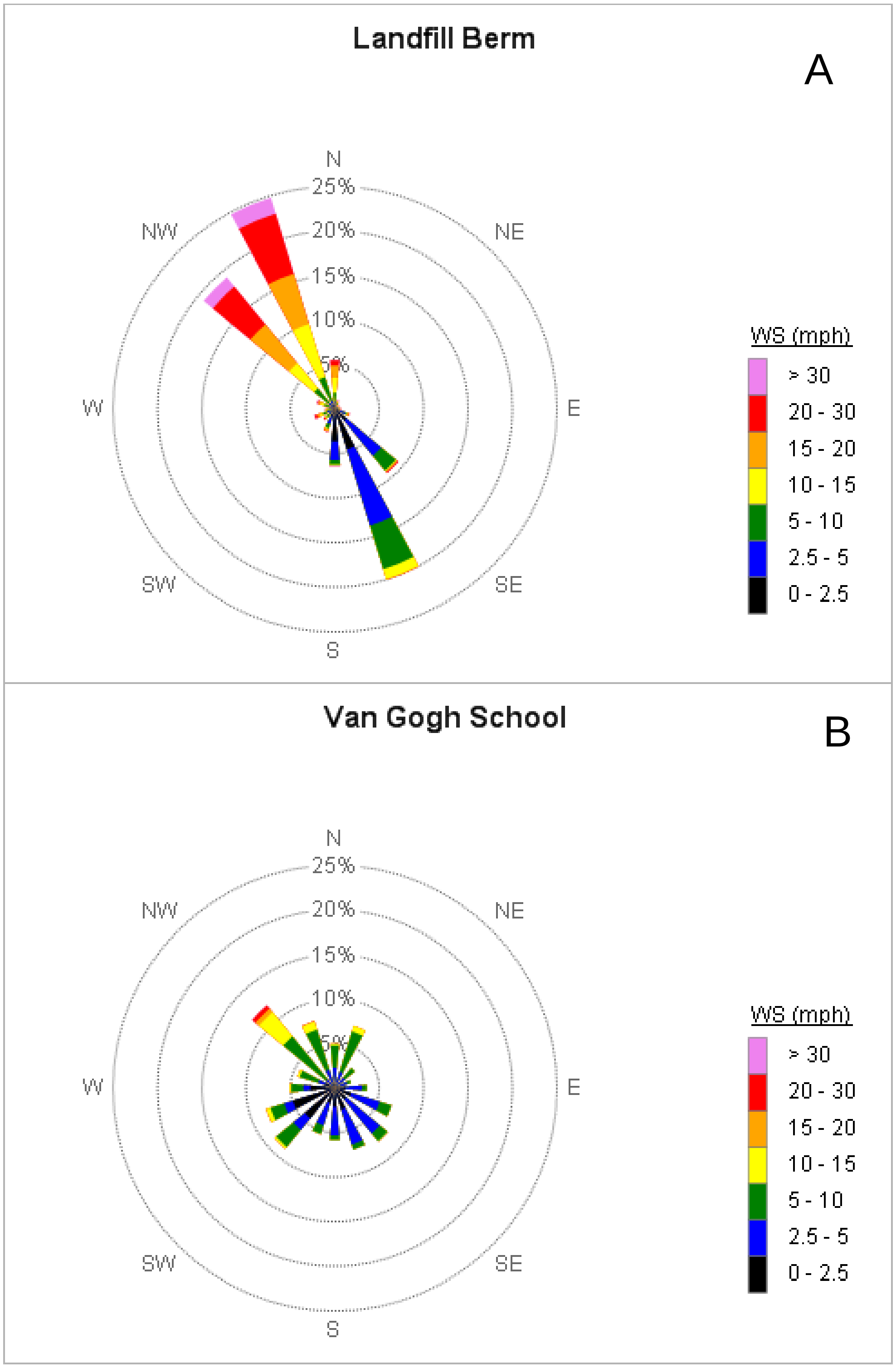

Figure 4-1. Comparison of the distribution of wind speed and wind direction measured at the Landfill site (Panel A) and at the School site (Panel B) between early December 2007 and the end of May 2008.

4.2 WIND SPEED

Wind speeds at the School site are generally lower than wind speeds at the Landfill site. The Landfill monitor is located on a berm on the southern edge of the inactive portion of the City landfill, at an elevation of 1,620 ft. The School monitor's elevation is 1,285 ft. The distance separating the monitors is 1.06 miles. **Figure 4-2** is a scatter plot of all validated hourly wind data collected since continuous monitoring began in August 2007. Wind speeds at the School site are about one-third the magnitude of those measured at the Landfill site. This statistic is weighted heavily by wind speeds above 8 to 10 mph. The School site occasionally exhibits higher wind speeds than Landfill site, but this only occurs when wind speeds are low. These lower wind speeds tend to be associated with southerly flow, and this flow is not perturbed by mountainous topography or local obstacles in that direction.

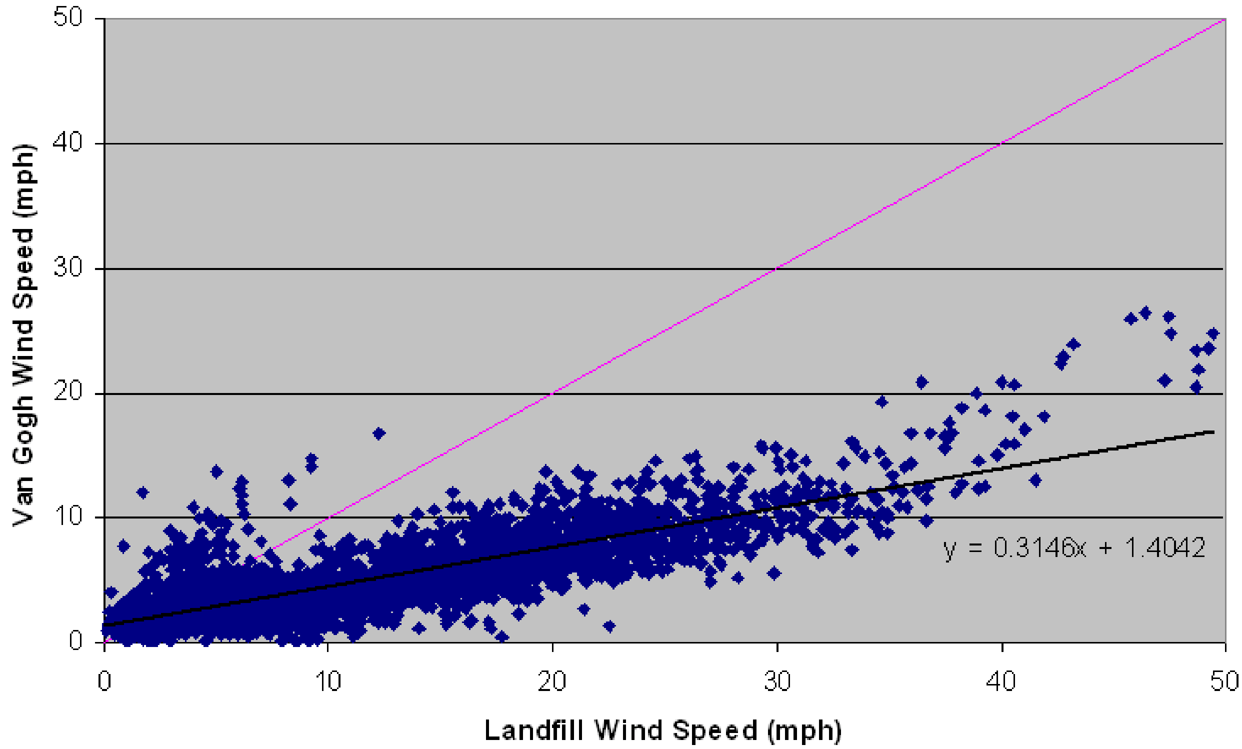

Figure 4-2. Comparison of hourly average wind speeds at the two monitoring sites demonstrates that the School site experiences substantially lower wind speeds compared to the Landfill site.

4.3 WIND DIRECTION

Wind direction data plays a major role in the analysis of the PM_{10} and BC data because, in the baseline analysis and the analyses conducted on the current year's data, the comparisons between the landfill-based data and the community-based data collected at the School site are classified by wind direction sectors. These sectors are rather broad, with winds at the Landfill site classified as either going toward the school (greater than or equal to 303° or less than or equal to 19°) or not going toward the school (less than 303° and greater than 19°). Winds at the School monitor are classified in three categories: from the landfill (greater than or equal to 303° or less than or equal to 19°); from the freeway (less than or equal to 180° and greater than 19°); or from other directions (less than 303° or greater than 180°). The objective is to try to apportion the temporal variability in pollutant concentrations by source sector type (landfill, freeway, and urban). This approach is a reasonable, but the efficacy of the analysis is confounded by the poor correlation between hourly averaged wind directions at the two sites.

Figure 4-3 compares wind direction data measured at the two locations in the current monitoring project (Panel A) with data from a separate project in San Rafael, California conducted in 2004 (Panel B). The San Rafael project had a similar deployment geometry for the meteorological measurements: there were two measurement sites, about a mile apart and a difference of few hundred feet in elevation. The point of this comparison is to illustrate that the correlation in wind direction between the Landfill and School sites is poorer than that observed under similar monitoring scenarios. Figure 4-3, Panel A, is a scatter plot of hourly averaged wind directions recorded at the Landfill monitoring site versus the School monitoring site for all data collected between late December 2007 and the end of May 2008. In Figure 4-3, Panel B, hourly averaged wind data from the San Rafael research project are shown for comparison.

The wind direction data in Panel A is the same wind direction data in the wind rose plots in Figure 4-1. By viewing the X-axis data in Panel A (wind direction at the landfill), the dominant northerly and southerly winds depicted in the wind roses can be visualized. The wide dispersion of wind direction data at the School monitor for those sectors is evident.

The poor correlation in wind direction data between the Landfill and School sites suggests that alternative approaches to the type of analysis applied to the meteorological and pollutant data should be considered. Employing a "case study" approach may be one alternative to help understand the environmental conditions under which landfill emissions impact neighboring communities. While it seems likely that the physical obstacles (trees) that exist near the School monitor contribute to the poor correlation of wind direction between the sites, there are few, if any, other options for siting that can be reasonably considered. The monitoring installation at the Van Gogh School will likely remain in its current location. The accuracy of the wind data measured at the school remains in question, that is, does it really represent the mesoscale wind patterns in the surrounding area?

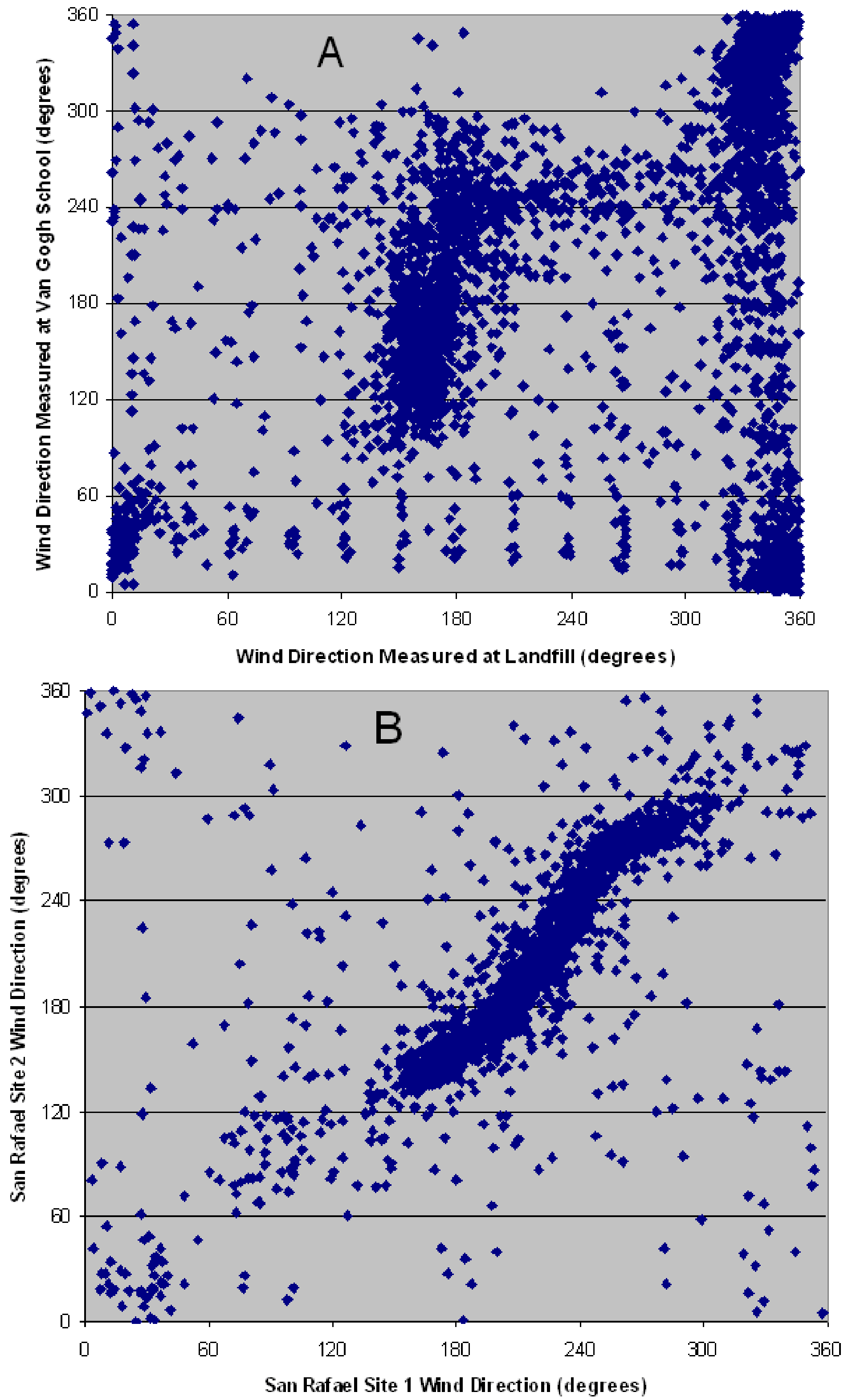

Figure 4-3. Scatter plot comparison of the wind direction data measured during the current Sunshine Canyon project (Panel A) with data collected from a project in San Rafael, California, (Panel B) that had similar wind sensor geometry.

4.4 METEOROLOGICAL DATA COMPLETENESS

Completeness statistics for meteorological data are presented in **Table 4-1**. Intermittent, but persistent, problems with newly purchased wind monitors in fall 2007 led to the invalidation of most wind data collected through November of that year. While the sensors were capturing nearly all the data, a large proportion of the data points were outliers in wind speed and/or wind direction. Because wind data are integral to the analysis of PM_{10} and BC (an analysis using compass-based source sectors), a conservative approach to the wind validation was taken.

Following factory service in November 2007, the wind sensor problems abated somewhat but were not eliminated. At the Landfill site, data capture for winds was 100% during the months of December, January, and February, but 11% of the data from that time period were still invalidated and 27% were considered suspect. Data capture rates were lower from March through May 2008 at both sites because the wind sensors were again removed and sent to the factory for evaluation (resulting in replacement of the internal reed switch mechanism that converts anemometer cup revolutions to a signal recognized by the data logger). Since that repair, the percent of valid data has been 100% at the Landfill site and 94% at the School site. A majority of the wind data at the School site from March through May 2008 have been deemed suspect. Suspect data are still used in the analyses.

Table 4-1. Completeness statistics for meteorological data. The date ranges are based on periods of sensor malfunction that led to substantial data invalidation during the startup months.

Monitoring Location (Site)	Dates	Wind speed and wind direction		
		Percent Data Capture[a] (%)	Percent Data Valid or Suspect (%)[b]	Percent Data Suspect (%)[c]
Sunshine Canyon Landfill	7/31/01-11/30/07	98%	0%	0%
	12/1/07-2/29/08	100%	89%	27%
	3/1/08-5/30/2008	90%	100%	0%
	Cumulative	96%	55%	7%
Van Gogh Elementary School	8/1/01-11/30/07	99%	0%	0%
	12/1/07-2/29/08	100%	89%	0%
	3/1/08-5/30/2008	89%	94%	67%
	Cumulative	96%	54%	18%

[a] Percent Data Capture is the percent of non-missing data values that were collected over the total number of data intervals in the date range (e.g., for the raw BC 5-minute data, 12 data values are expected per hour, and 288 data values are expected per day).
[b] Percent Data Valid or Suspect is the percent of data values that are 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.

4.5 WIND SENSORS

The Met One Instruments Model 034B wind sensors have exhibited repeated problems with the component that measures wind speed. This component is a reed switch, which is an electrical switch activated by an applied magnetic field. A magnet is mounted on the shaft of the anemometer, and as the anemometer spins in response to the wind, the rotating shaft momentarily closes the circuit when the magnet passes over the reed switch and the switch closure is logged by the data logger.

Newly purchased Met One 034B wind sensors were installed October 9, 2007 (School site) and October 10, 2007 (Landfill site). On numerous occasions at both sites over the following three weeks, wind data were missing; the duration of missing data would vary from a few hours to a few days. After extensive consultation with Met One Instruments' technical advisors, the wind sensors were removed, as were the BAM instruments that, at that time, were acting as the data logger for the wind measurements. All the equipment was returned to Met One for evaluation. While Met One technicians were unable to pinpoint the cause of the problem, they replaced the reed switches under warranty. The instruments were re-installed on December 6, 2007.

Unfortunately, the problem of intermittently missing wind data persisted. Field tests of the sensor signals during one of the periods of missing data indicated that the circuit carrying the wind speed signal was closed, suggesting that the reed switch was stuck in a closed position. The wind sensors from both sites were removed on March 31, 2008, and sent to Met One with a request for warranty replacement of the reed switch. While the factory found no problems with the reed switches, new ones were installed by request. The performance of the wind sensors since that time has been better, with only a few short periods of missing wind data.

Continuous and reliable wind information is necessary in any ambient air quality monitoring program where one primary objective is to ascertain the source contributions of pollutants from different compass directions. Upgrading the wind sensors to more reliable models should be considered as the monitoring program moves forward.

5. RECOMMENDATIONS

Based on the first year of field operations and a partial year of available validated data, we offer the following recommendations:

1. BFI should consider applying a soil stabilization treatment to the barren and disturbed surface that lies north of the Landfill monitoring site. The data suggest that circumstances in this area, under high wind conditions, are contributing to high ambient PM_{10} levels recorded at this site, and do not represent (overestimate) the true landfill contribution to ambient PM_{10} levels.
2. We recommended that the Aethelometers™ at the two sites be sent to Magee Scientific for refurbishment and collocated testing. This action is important to keep instrument bias to a quantifiable minimum.
3. BFI should consider upgrading the wind sensors at both monitoring sites. It is estimated that, to date, the expense of labor hours and shipping charges associated with troubleshooting and repairing the Met One 034B wind sensors exceeds the costs of higher priced, but more reliable, wind monitors ($1,000 to $1,200 list price).