San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

Compost VOC Emission Factors

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I. Introduction

This report provides the basis for the District's organic material composting volatile organic compound (VOC) emission factors (EFs). The organic material composting EFs contain the following categories: green waste, food waste, and grape pomace. However, the focus will be on green waste, since the San Joaquin Valley's inventory of organic material compost is primarily green waste. The EFs will be used for Rule 4566 (*Organic Material Management*) development and permitting applications in the San Joaquin Valley. These organic material composting EFs are not applicable to biosolids, animal manure, or poultry litter, which have been attributed a separate EF.

Accurate emission factors are required for the proper implementation of applicable air quality regulations and also for the evaluation of appropriate technologies and practices to reduce emissions. The VOC EFs proposed in this report are based on a detailed review of the available science. As would be the case with EFs for other sources, the District's EF should reflect the best scientific information that is currently available.

The District composting EFs are summarized below.

Table 1: Summary of District Composting EFs.

Compost Type	Stockpile (lb-VOC/wet ton/day)	Windrow EF Per composting cycle (lb-VOC/wet ton)
Green Waste, Food Waste, Grape Pomace	1.063	5.71
Co-Composting Biosolids, Animal Manure, Poultry Litter	-	1.78

II. Background

A. Air Quality

The San Joaquin Valley air basin has an inland Mediterranean climate characterized by hot, dry summers and cool, foggy winters. The San Joaquin Valley is surrounded by mountains on the east, west, and south sides. This creates stagnant air patterns that trap pollution, particularly in the south of the San Joaquin Valley. Additionally, the sunshine and hot weather, which are prevalent in the summer, lead to the formation of ozone (photochemical smog). Because of the San Joaquin Valley's geographic and meteorological conditions, it is extremely sensitive to increases in emissions and experiences some of the worst air quality in the nation.

The San Joaquin Valley Air Basin is now classified as an extreme non-attainment area for the health-based, Federal eight-hour ozone standard because of the inability to reach attainment of the standard by the earlier serious and severe classification attainment dates. The air basin is also classified as a non-attainment area for the Federal PM-2.5 (ultra-fine particulate matter) standard.

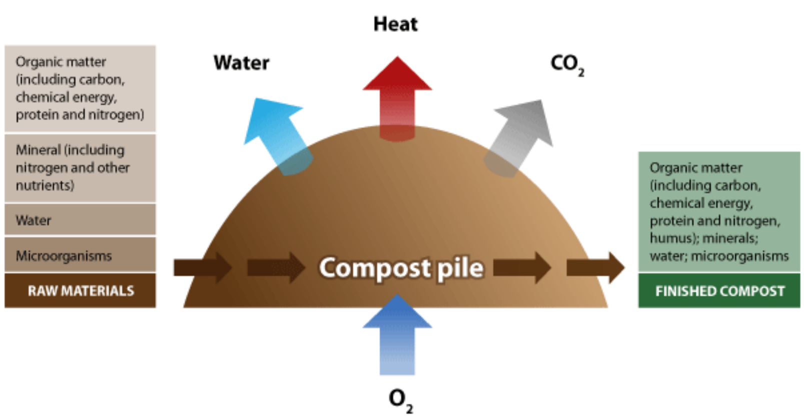
B. Composting

Compost operations can be sources of smog-forming VOCs, fine particulate matter, ammonia (NH_3), and greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4). The emissions are directly emitted from the decomposition of organic material in the San Joaquin Valley. Composting is a process that involves the biological break down of organic matter, typically into marketable products (soil amendments, animal bedding, and alternative daily cover at landfills). Composting uses wastes from a wide-variety of sources, such as curb-side green waste, landscaping, agricultural processing, crop harvesting, food consumption, and forest management.

There are two general categories of composting, aerobic and anaerobic:

Aerobic composting is the decomposition of organic material by microbiological organisms (microbes) in the presence of oxygen (O_2). This oxidation process theoretically results in CO_2, water (H_2O), and organic matter, including nitrates, sulphates and other minerals. Figure 1 below is a visual presentation of theoretic aerobic composting:

Figure 1: Aerobic Compost. [1]



Anaerobic composting is the decomposition of organic matter by microbes in the absence of O_2. During this digestion process, a gas primarily composed of CH_4 and CO_2, known as biogas, waste gas or digester gas is produced. Biogas also consists of nitrogen (N_2), O_2, NH_3, hydrogen sulfide (H_2S), and various VOCs. However, these additional products are generated in relatively small amounts when compared to the amount of CH_4 and CO_2 produced.

[1] http://www.londonfoodrecycling.co.uk

C. Purpose of the San Joaquin Valley Air Pollution Control District

The San Joaquin Valley Air District is a public health agency whose mission is to improve the health and quality of life for all Valley residents through efficient, effective and entrepreneurial air quality management strategies. To protect the health of Valley residents, the District works toward achieving attainment with health-based ambient air quality standards as required under State and Federal law. To achieve this goal, the District develops and adopts air quality attainment plans that include control measures aimed at further reducing emissions from a broad range of sources, commercial, industrial, and agricultural.

As mandated by Federal Law, the San Joaquin Valley Air District adopted its 8-hr ozone attainment plan to demonstrate how the Valley would reach attainment with the Federal eight-hour ozone standard. In developing the ozone attainment plan every feasible measure to reduce emissions of ozone precursors (VOC and NOx) was explored. Green waste composting was a control measured identified in the ozone plan. As such, plans to develop Rule 4566 (*Organic Material Management*) are in place. However, even though the District will be requiring every practical VOC and NOx control, and will be relying on the state and federal governments to significantly reduce emissions from mobile sources of pollution, the San Joaquin Valley will still need the development and adoption of future, not-yet-developed, clean air technologies to reach attainment by the 2023 deadline. Achieving the goal of attainment with air quality standards will require continued contributions from all industries, businesses, and individuals in the San Joaquin Valley.

D. Permitting Requirements

A critical tool that the air districts use to limit increases in emissions of air pollutants and to assure compliance with air quality regulations is the issuance of conditional construction and operating permits to commercial, industrial, and agricultural sources of air pollution. Since the 1970s, the San Joaquin Valley Air Pollution Control District and its predecessors have issued tens of thousands of conditional permits that are being used to assure compliance with air pollution control requirements throughout the Valley. District permits address the requirements of federal standards, state regulations, and District rules that specifically apply to a source of air pollution. New and modified sources of air pollution are also subject to the more protective requirements of "New Source Review", which are determined on a case-by-case basis and are also included in the permit. Permit holders, District Inspectors, and others use these District permits, rather than directly reference the complex and voluminous underlying regulations, to verify compliance with applicable air quality requirements.

For new sources, the District begins permitting them as we become aware of their emissions. The permitting threshold for these types of operations is 2 lb-pollutant/day. Currently the District quantifies VOC and NH_3 emissions to composting operations. Therefore, any organic material composting operation which has the potential to emit more than 2 lbs of either VOC or NH_3 per day is subject to District permitting.

III. EF Determination Analysis

Many factors, which are related, affect the composting process that makes it difficult to scientifically analyze composting from an air emissions standpoint. The major factors affecting compost are oxygen, moisture, seasonal temperature fluctuation, temperature increases resulting from microbial respiration, nutrients (especially carbon and nitrogen), feedstock variability and pH. As such, the District will rely heavily on actual test data for this emission factor determination.

A. Green Waste Composting EFs

The chosen EFs are based on the available source test data for organic material composting sites. The District contracted a review of this data to Charles E. Schmidt with the goal of establishing green waste EFs for rule making purposes. The report was intended to identify the tests that utilized appropriate sampling and analytical methods and that were statistically relevant. As a result, the following report was prepared: "Organic Material Composting and Drying focusing on Greenwaste Compost Air Emissions Data Review", by Thomas R. Card and Charles E. Schmidt, June 2008 (see the Appendix A for the full report). This report will be referred to as the "green waste report" hereafter within this document.

The tests were based on the concept of flux emissions escaping the green waste piles. In this context, flux means the rate of mass flow of fluid gases through a given surface area. For example, the flux emissions may be measured in units of mg-VOC/min-m^2. Knowing the total composting period of time, surface pile area, and pile mass, the flux emission factors may be converted to typical EFs used for permitting and rule making, such as in units of lb-VOC/ton. The flux emissions were primarily sampled using the SCAQMD Modified USEPA surface emission isolation flux chamber method, and analyzed using SCAQMD Method 25.3 for total VOCs.

Table 5.1 of the green waste report summarizes the most relevant green waste composting data. The relevant test locations identified in Table 5.1 are Site X, CIWMB Modesto, NorCal, CIWMB Tierra Verde, and two at SCAQMD Inland. Since the compilation of the green waste report, another relevant test was performed at the Northern Recycling Zamora Compost Facility. This test was also conducted by Card and Schmidt. The summary is contained in Tables 2 and 3 below.

1.) Green Waste Stockpile EF

The green waste EFs shown in the Table 2 below are based on a one day stockpile period. While a one day stockpiling period may not be how every facility in the SJV operates, the EF can be applied on a case-by-case basis when stockpiling time periods are known. Also of note, the source test reports do not show the Table 2 numbers directly. The source tests each reported the stockpile EF based on their own site-specific stockpile period. For example, the Northern Recycling Zamora stockpile test assumed the EF for a 90-day stockpile time. The Northern Recycling Zamora stockpile sampling was performed on days 1 and 7, which is representative of normal SJV stockpiling. To arrive at the 90-day stockpile EF, it was assumed the average rates measured on days 1 and 7 were emitted for 90 days. The District reduced the EF to a one-day basis for this EF report. Each of the other stockpile EFs were normalized to a one day basis as well.

Table 2: Green Waste Stockpile VOC EF

Site	Sampling Age of Material	Season Samples Taken	EF (lb-VOC/wet ton/day)
Northern Recycling Zamora	Day 1 & Day 7	Spring	0.126
NorCal Jepson Prairie (Vacaville)	Day 1	Summer	0.422
SCAQMD Inland	Day 2	Fall	0.907
SCAQMD Inland	Day 2	Fall	2.798
Average			1.063

The District surveyed the green waste composting facilities in the San Joaquin Valley. The result of the survey indicates an average stockpile time of 3.85 days, and ranged from 0-21 days. The Site X stockpile EF was based on sampling at day 45, and is not representative of stockpiling in the San Joaquin Valley. As such, the Site X stockpile test was not included in the stockpile EF. The test at CIWMB (Modesto) contained no stockpile data and does not factor into the green waste stockpile EF. The test at CIWMB Tierra Verde contained no uncontrolled stockpile data and does not factor into the green waste stockpile EF.

2.) Green Waste Windrow EF

Table 3: Green Waste Windrow VOC EF

Site	Sampling Age of Material	Season Samples Taken	EF (lb-VOC/wet ton/day)
CIWMB (Modesto)	Over the Active + Curing Phase (days not sampled were interpolated)	Spring	0.85*
Site X		Summer	6.30
NorCal Jepson Prairie (Vacaville)		Fall	5.65
Northern Recycling (Zamora)		Fall	10.03
Average			5.71

*1.54 was identified in the green waste report after a recalculation to better represent other sites; however, 0.85 was the actual value reported from this test site and will be used in the EF determination.

The test results for CIWMB Tierra Verde indicate the testing was performed for other management strategies, not a typical baseline facility; therefore, does not factor into the green waste windrow EF. The two test results for SCAQMD Inland indicate the windrows tested were extremely small; therefore, does not factor into the green waste windrow EF.

Please note, the values are based on the input material (as wet tons), not finished material. The green waste windrow composting EF is based on a typical active + curing phase composting life cycle (minimum 60 days). The active-phase has been defined at a minimum 22 days for District purposes. The District has also examined the VOC profile split over the course of a windrow cycle. The results are summarized below.

Table 4: Green Waste Windrow VOC EF Active-Phase vs Curing-Phase.

Windrow Phase	Overall EF Active + Curing (lb-VOC/wet ton)	VOC Profile Split (%)	Phase EF (lb-VOC/wet ton)
Active-Phase	5.71	90%	5.14
Curing-Phase		10%	0.57

B. Food Waste Composting EFs

The District has not been able to identify an emission factor for uncontrolled food waste composting. Source tests from controlled composting operations have yielded emission factors ranging from 3.4 lb VOC per ton food waste composted (micropore cover) to 37.1 lb VOC per ton food waste composted (Ag Bag). In addition to the wide range of values observed, it is also unlikely that emissions from a covered system would accurately represent emissions from the open windrow commonly used by facilities in the District. This is because covered systems offer many process control advantages including weather protection and water retention.

Source testing was conducted at the City of Modesto compost facility as a field test study for the California Integrated Waste Management Board (CIWMB). Two goals of this test were to determine VOC emissions from green waste composting and food waste composting. The food waste composting windrows contained approximately 15% food waste (from local food processing plants (e.g. peppers, tomatoes, peaches, and syrup) and 85% ground green waste. The resulting EFs were 0.85 lb-VOC/ton and 1.95 lb-VOC/ton for green waste and food waste respectively. As predicted, the food waste EF was higher than the green waste EF, 2.3 times higher for this test site. Since the average green waste EF has been established at 5.71 lb-VOC/ton, the District considers the food waste EF to be too low to be usable as a stand-alone food waste composting EF since it would be lower than the green waste EF. However, if more data were to become available for food waste composting, the food waste EF from the City of Modesto test site may be used in combination with the new data.

For these reasons, the District will use the green waste composting emission factor to represent this feed stock until a more representative emission factor can be identified.

C. Grape Pomace Composting EFs

The District has not been able to identify an emission factor for grape pomace composting. Therefore, the District will use the green waste composting emission factor to represent this feed stock until a more data is available.

D. Biosolids, Animal Manure, Poultry Litter Composting EFs

Biosolids and animal manure composting emission factors were taken from source tests conducted by the South Coast Air Quality Management District (SCAQMD) in support of their Rule 1133 (Emission Reductions from Composting and Related Operations). These emission factors were calculated as an average of emissions from three co-composting facilities (SCAQMD, 2002) as presented in the Table below.

The District has not been able to identify an emission factor for poultry litter composting. The District will use the biosolids composting emission factor to represent this feed stock until a more representative emission factor can be identified.

Table 5: Biosolids, Animal Manure, and Poultry Litter EFs.

Summary of Co-Composting Emission Factors Developed by SCAQMD		
Location	Emission Factors (lb/wet-ton)	
	VOC	NH_3
RECYC Inc	0.53	2.70
EKO Systems	1.70	3.28
San Joaquin Composting	3.12	2.81
Average	1.78	2.93

Summary

The District composting EFs are summarized below.

Table 6: Summary of District Composting EFs.

Compost Type	Stockpile (lb-VOC/wet ton/day)	Windrow EF Per composting cycle (lb-VOC/wet ton)
Green Waste, Food Waste, Grape Pomace	1.063	5.71
Co-Composting Biosolids, Animal Manure, Poultry Litter	-	1.78

Appendices

Appendix A: "Organic Material Composting and Drying focusing on Greenwaste Compost Air Emissions Data Review", by Thomas R. Card and Charles E. Schmidt, June 2008

Appendix B: Comments and Responses to the "Organic Material Composting and Drying focusing on Greenwaste Compost Air Emissions Data Review"

Appendix C: "Northern Recycling Zamora Compost Facility Air Emissions Source Test", by Thomas R. Card and Charles E. Schmidt, May 2009

Appendix A

"Organic Material Composting and Drying focusing on Greenwaste Compost Air Emissions Data Review", by Thomas R. Card and Charles E. Schmidt, June 2008

San Joaquin Valley
Air Pollution Control District

Organic Material Composting and Drying
focusing on

Greenwaste Compost

Air Emissions Data Review

Report

June 2008

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Executive Summary

Useful information regarding air emissions from compost sites can be obtained by assessing the flux (mass transfer from the test surface) of hydrocarbon compounds and other compounds such as ammonia, and then expressing these data as emission factors. An emission factor is obtained by taking representative flux data for an operable unit at a compost site, such as a greenwaste in windrow, multiplying the average flux from the windrow by the surface area of the windrow, and generating an emission factor (mass emitted per time per source). These data can be expressed on a per ton basis, and the site air emissions can be obtained by summing the emission per operable unit, which are obtained by multiplying the mass or surface area of each unit by the respective emission factor. As such, the goal of any air pathway analysis intended to assess air emissions from a compost facility, is to obtain representative emission factor data.

The focus of this research effort is to provide to the District a report of relevant and useful emission factors that can be used in the regulatory process to assess air emissions from a variety of compost facilities. Compost emission factor data from 14 reports were reviewed and prioritized for data quality and completeness. These data consisted of emissions test data from greenwaste, biosolids-greenwaste co-composting, and food waste. All the reports were summarized and critiqued with the individual critiques attached in this report's appendix. A summary table was prepared by San Joaquin Valley Air Pollution Control District (SJVAPCD) staff and is provided in the same attachment.

This report is focused on total VOC emissions as measured by South Coast Air Quality Management District (SCAQMD) Method 25.3. This method is a comprehensive total VOC method and is generally not comparable to other total VOC methods including USEPA Method 25 series and USEPA Method TO-12. Ammonia and some methane data is reported as well, but in general is not discussed further. All VOC data reported here, unless otherwise noted, is VOC per SCAQMD Method 25.3.

The green waste composting data was looked at specifically for data that would be both complete and accurate enough to provide a rule making basis. Three data sets were found to be both complete enough and used the appropriate sampling an analytical methods to generate full site emissions. However, one of the data sets did not have stockpile emissions.

The data from these greenwaste composting sites is summarized below in Table ES 1. The data are averaged for reference only with no implication that the average is representative of green waste compost emissions for the SJVAPCD jurisdiction. The California Integrated Waste Management Board's (CIWMB) values are from their Modesto report and were recalculated to be more comparative to the other data (see attached Technical Memorandum). The emission factor was calculated by taking the total process emissions and dividing that by the mass of material that was in the compost process. For most situations, a facility can estimate their annual emissions using these factors by multiplying the factor times the total annual throughput (compost substrate and amendment). All mass values are for input, not output. There is normally significant mass loss during the composting process.

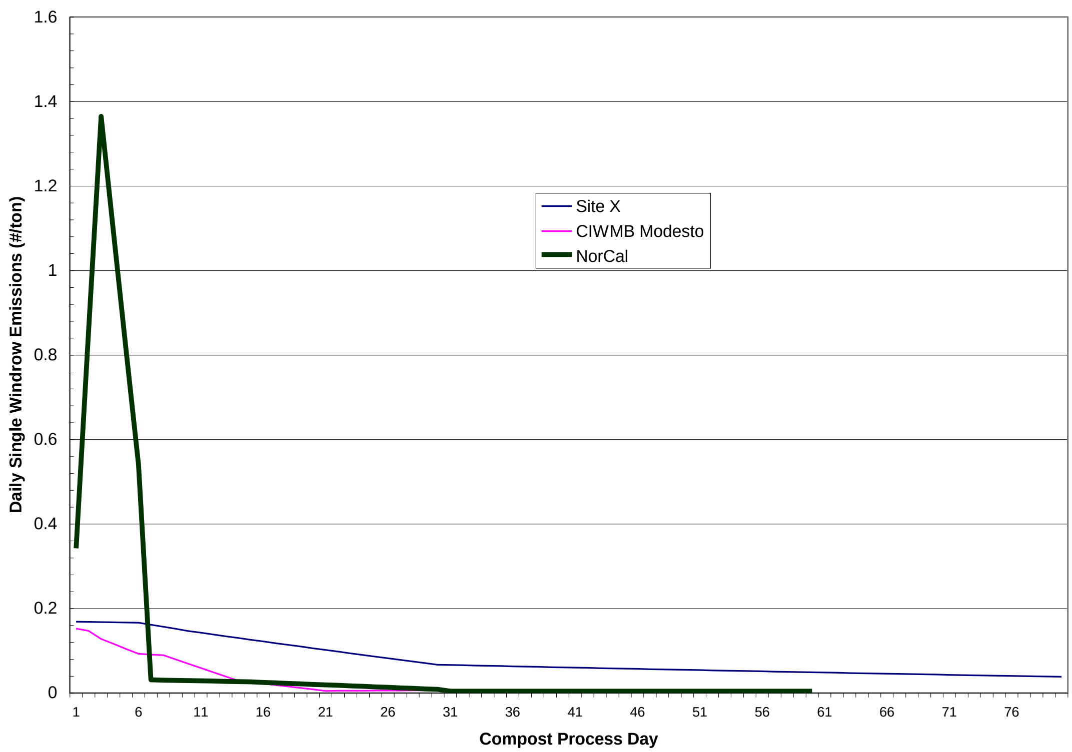
Table ES 1 Summary of greenwaste composting full site VOC emission data (#/ton of feedstock).

Source	Site X	CIWMB	NorCal	Average
Stockpile	7.76		2.95	5.36
Windrow	6.30	1.54	5.65	4.50
Total	14.06		8.60	9.85

These data are even more diverse than this table may indicate. Figure ES-1 shows the daily compost windrow emissions for each of these data sets. The NorCal profile particularly shows a unique characteristic initial cycle VOC spike.

There were other important data sets. The CIWMB Tierra Verde data shows the likely range of unit flux values that will be encountered in California green waste composting facilities. These values bracket the data from the three complete sites suggesting that the complete sites may represent the likely working range of emissions from these types of sites.

Figure ES 1 VOC emission profile for each of the three complete data sets (#VOC/ton feedstock per compost day).



SCAQMD emission factors, currently the only official regulatory values, are briefly discussed noting that they mostly represent stockpile emissions and not compost emissions. The compost emissions from their data appear unrealistically low and are significantly outside the bounds of all the other data sets.

The most relevant food waste composting data was from only one site and provided emissions for various covered compost technologies. The food waste compost technologies were Ag-Bag®, Compostex®, and micropore covers. These cover technologies are described in more detail in the report text. Food waste windrow emission factors ranged from 1.7 to 36.7 pounds VOC per ton of throughput. Food waste stockpile emission factors ranged from 0.42 to 1.8 pounds VOC per ton of throughput.

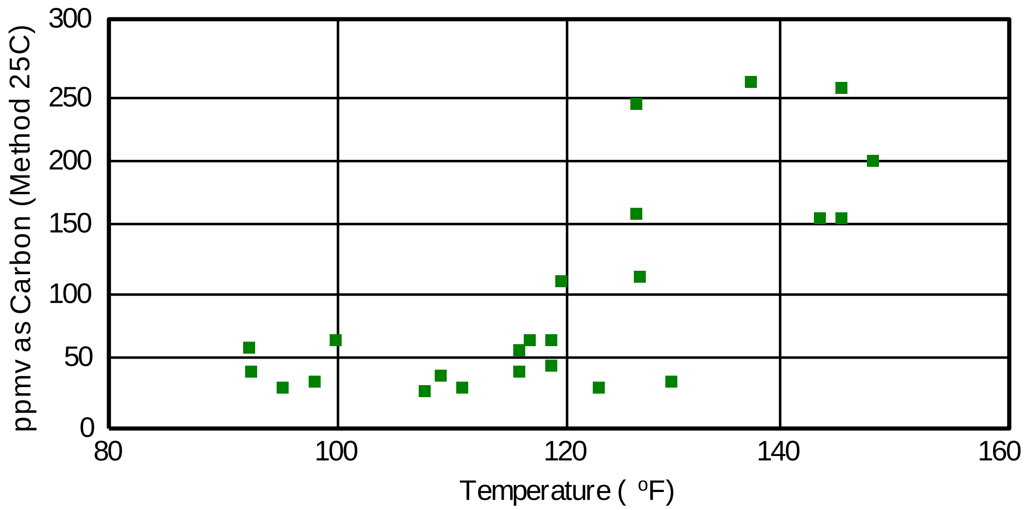
The most relevant biosolids composting data came from two sites. A third site (Las Virgenes) was reported but did not present complete system emissions. One of the sites (LACSD) reported data from both on top of, and underneath, a micropore cover system. The under the cover measured emissions are likely not representative of a normal uncovered process because the affect that the cover has temperature and moisture. In addition, this was a pilot scale facility. The other site was a compliance test for a very large aerated static pile biosolids facility near Bakersfield. The biosolids composting emission factors ranged from 0.2 to 3.7 pounds VOC per ton of total (biosolids plus amendment) throughput.

There is some discussion in this report as to why there is a large variability of emissions found in the compost industry. There are several reasons for this:

- Regional differences is feed stock materials processed at compost facilities
- Seasonal differences in feed stock materials
- Seasonal metrological differences
- Differences in operating procedures and facility management practices
- Size and age of feedstock piles
- Size, shape and orientation of windrows to dominant wind direction
- Solid waste handling equipment
- Control of parameters in the composting process such as aeration or mixing, water content, and temperature
- Compost composition, specifically ratio of carbon-to-nitrogen

The most significant sources of variability in emission factors is likely mostly due to windrow size, feedstock characteristics, waste pile and windrow temperature, and operating characteristics. There was not sufficient data to determine the magnitude of most of these variables, including seasonal emissions variability. Said another way, it is not possible to generate seasonal emission factors for these sources. Seasonal variability likely has both a temperature and feedstock component, which further complicates the determination of emission factor as a function of variable. There has been some previous work showing that the carbon–nitrogen ratio significantly affects air emissions, but again, insufficient information is available to define this effect. Temperature has been studied and there are some data available showing increased air emissions or greater emission factors with increased compost temperature as shown below. This figure shows how temperature affected VOC emissions from an aerated static pile composting biosolids in Philadelphia (Hentz *et al* 1996).

Figure ES 2 The effect of pile temperature on VOC emissions (from Hentz et al 1996).



The data set can not at this time be used to assess the impact of these variable on emission factors or compost site air emissions expressed on an annual basis. However, these limited data do justify the range of emission factors reported herein.

In summary, this report serves to:

1) Present the status quo of the industry air emission data base for the Central Valley;
2) Define the range of emission factors measured;
3) Define the key variables that effect air emissions from compost facilities;
4) Describe current and recommended testing protocols used to assess air emissions at compost facilities;
5) Provide an annotated bibliography of the relevant research with commentary on testing protocols, frequency of sample collection, analytical method, and emission factor generation; and
6) Present the emission factors supported by the data base.

1.0 Introduction

This report provides a comprehensive review of greenwaste composting air emissions data with focus on total hydrocarbon and ammonia emissions. Methane emissions are also presented to a limited extent. The report also presents some limited data on composting biosolids and food waste.

All raw data and original data reports were provided by San Joaquin Valley Air Pollution Control District (SJVAPCD) Staff. Since the method of analysis of total hydrocarbon is regulatory important, and SJVAPCD has adopted South Coast Air Quality Management District (SCAQMD) Method 25.3 as their standard, data is limited to recently tested California sources.

2.0 Background

The air emissions assessment of composting operations is both complicated and resource intensive. Composting can take place either in windrows or in aerated static piles (ASP). Windrows are naturally ventilated and normally mechanically turned on a process schedule. Typical compost windrow dimensions are 3 to 7 feet high, 8 to 20 feet wide, and 50 to 500 feet long. ASP's are large piles that are 8 to 16 feet high with plan form areas of 2,500 to 25,000 ft^2. They are normally underlain with an air distribution system that provides air by either suction or pressure. There also are some hybrid technologies that use a cover on a windrow that also have forced air ventilation systems. Most, if not all, greenwaste in California is composted in windrows that are mechanically turned.

A normal compost cycle lasts from 45 to 90 days. Most greenwaste is on a 60 day cycle. The first half of the cycle can be designated as composting and the last half as curing.

In addition to the windrows, there are also material stockpiles on composting sites that store feedstock and product. The size of these stockpiles is widely variable and is a significant factor in overall site emissions variability.

The emissions from these facilities are difficult to quantify. The emissions from a windrow change daily over the compost cycle. Testing is conducted using approved area source assessment technologies with the goal of collecting representative flux data (mass per time-area) that can be used to calculate emission factors for sources found on compost sites, or operable units (e.g., feed stock piles, windrows, product piles, etc.) Emission factors from operable units or sources are expressed as emissions per ton of materials received, and these data are used to estimate emissions (mass per time) for the facility on an annual basis.

Figure 2.1 shows a daily emissions profile from windrow greenwaste composting. In order to generate this curve, the windrow has to be sampled on several of the 60 process days. As shown on the curve, this sampling should be more intensive at the start of the compost cycle because most of the emissions occur at the start of the cycle and the daily emissions are the most temporally variable. In windrows that are less well mixed there can be significant spatial variability as well. For each compost day, from 2-to-8 individual samples should be taken to assure that the spatial variability is accommodated.

Emissions from these sources tend to be variable. The likely important factors in variability are seasonal temperatures, feedstock variability (regionally and seasonally), and operating parameters. Not a lot is known about how these factors affect emissions. The only quantitative data available are the affects that pile temperature has on VOC emissions. Figure 2.2 shows how temperature affected VOC emissions from an aerated static pile composting biosolids in Philadelphia (Hentz *et al* 1996).

Figure 2.1 Example daily emissions from a greenwaste composting windrow (VOC and ammonia).

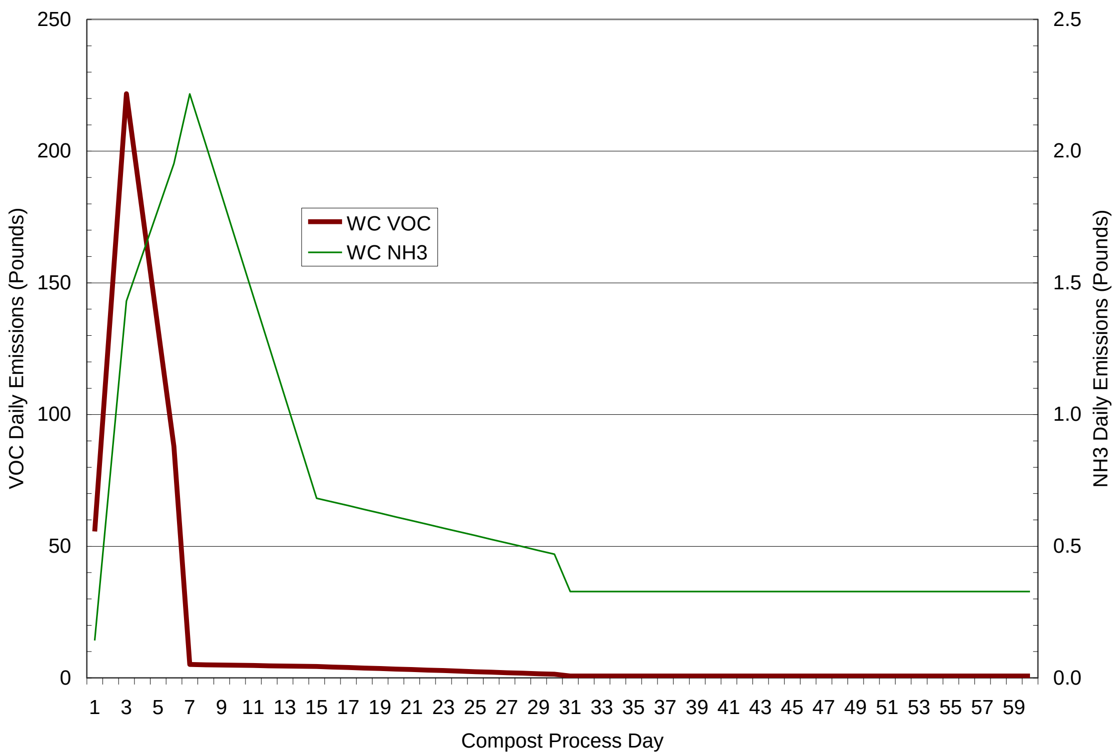
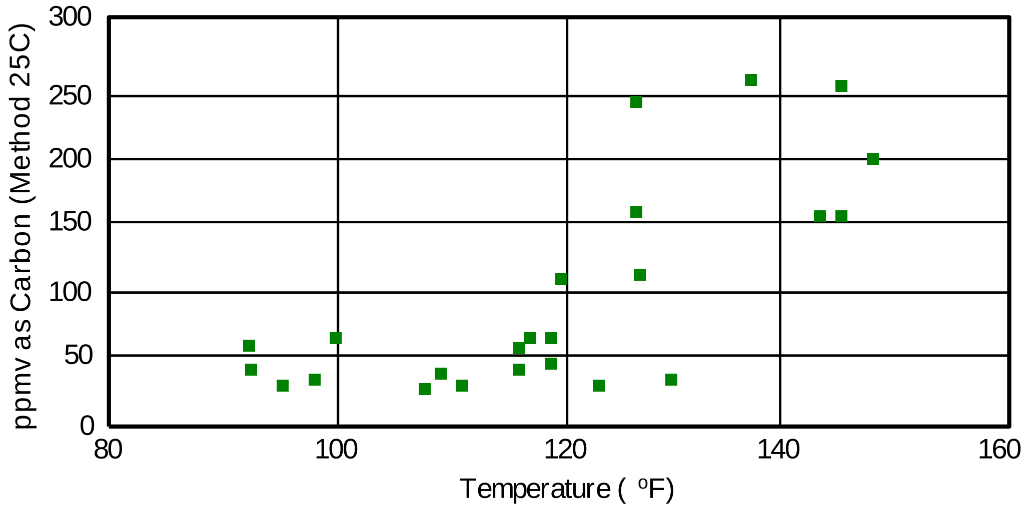


Figure 2.2 The effect of pile temperature on VOC emissions (from Hentz et al 1996).



3.0 Data Evaluation Methodology

This section covers the methodology for the sampling phase of the air emissions assessment and how the data sets were evaluated.

Target Species

The selection of target species was evaluated as best representing VOC emissions. For compost sites, all work was compared to SCAQMD Method 25.3 since it has been shown that this method is capable of collecting and analyzing for all condensable and volatile hydrocarbon species believed to exist on greenwaste, food waste, and biosolids compost facilities. Data representativeness will be discounted in the review for other methods, including SCAQMD 25.1 and USEPA Method TO-15 as compared to SCAQMD Method 25.3.

Sample Collection Methods

As demonstrated by the SCAQMD and indicated in Rule 1133, the preferred method for sample collection or assessment of compound emissions from sources at compost sites is the SCAQMD Modified USEPA surface emission isolation flux chamber technology. All the research reviewed used this technology except one, and this work (Hanaford Compost Site) was discounted as non-applicable and non-representative. On occasion, the USEPA technology was used without the SCAQMD modification, in which case a bias in emission may have been encountered.

Analytical Methods

The appropriate analytical methods for this research are SCAQMD Method 25.3 for VOCs (or total non-methane non-ethane organic compounds) and SCAQMD Method 207.1 for ammonia. Other methods fall short and are identified as such.

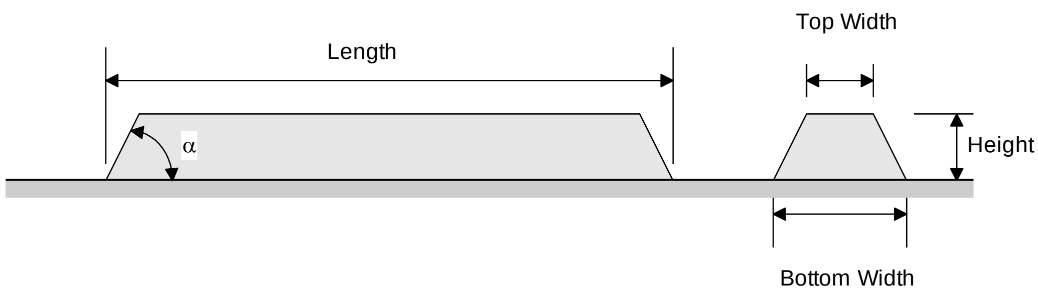
4.0 Emission Factor Development

Once the unit flux data has been obtained, the full cycle emissions are then estimated by the following procedures.

4.1 Compost Pile Configuration

Compost pile dimensions have a high degree of variability. However, they all match the shape shown in Figure 4.1. The key property for the configuration is the surface area to volume ratio. Figure 4.2 shows how this varies for different cross sections. There is over a factor of two difference in surface area to volume ratio between shallow and deep windrows. For the same unit surface flux rate, the smaller row will have twice the emissions on a per ton input basis.

Figure 4.1. – Compost Windrow Configuration.



Mensuration formulas

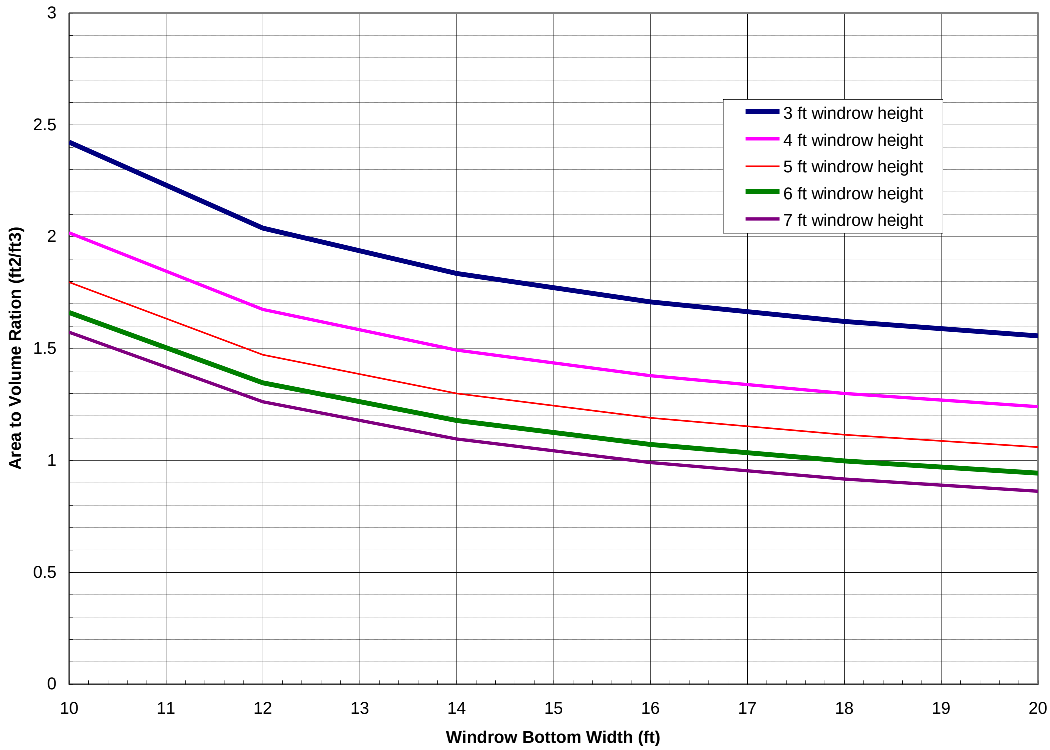
$$S = \frac{p_1 + p_2}{2} s + A_2$$

$$V = \frac{h(A_1 + A_2 + \sqrt{A_1 A_2})}{3}$$

$$s = \sqrt{h^2 + ((W_B - W_T)/2)^2}$$

where S = total surface area, p_1 = bottom perimeter, p_2 = top perimeter, s = slant height, V=volume, h=vertical height, A_1 = bottom area, A_2 = top area, α = bottom angle

Figure 4.2. – Range of area to volume ratios for typical windrow cross-section dimensions.



4.2 Full Compost Cycle Simulation

The unit emission data should be extended to estimate emissions from the full compost cycle using linear interpolation and averaging. Full cycle emissions for each day of the compost process, should then added and the sum of the individual daily emissions should be totalized. The emission factor consists of the full total cycle emissions (in pounds) divided by the incoming feedstock weight (in tons).

4.5 Emissions from Feedstock and Product Storage

The emissions from feedstock and product storage typically are calculated by taking unit flux data (apportioned to different types of materials) and multiplying by the average annual storage surface area. For some data sets, there was more area in storage than in windrows.

5.0 Most Relevant Green Waste Compost Data

This section presents the data found to be most relevant in characterizing greenwaste emissions in the State of California. Table 5.1 presents a summary of this data in both an emission factor and unit emission rate form. The paragraphs below discuss the data points in detail.

Table 5.1 Summary of most relevant green waste composting data.

			VOC							NH3						
			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)		
Location	**Material**	**Activity**	**(#/ton)**	**Peak**	**Avg**	**Min**	**Peak**	**Avg**	**Min**	**(#/ton)**	**Peak**	**Avg**	**Min**	**Peak**	**Avg**	**Min**
Site X	Landscape	Stockpiles	7.76	186	111	37	2.30	1.38	0.46	0.03	0.62	0.39	0.16	0.01	0.00	0.002
	Waste	Windrows	6.30	23	11	3	0.29	0.13	0.04	2.34	26.56	12.07	0.20	0.33	0.15	0.003
		Total	14.06							2.37						
CIWMB Modesto		Windrows	1.54	42	9	0.1	0.51	0.11	0.001							
NorCal		Stockpiles	2.95	110	54	4	1.36	0.66	0.046	0.08	2.1	1.21	0.61	0.03	0.01	0.008
		Windrows	5.65	376	73	1	4.65	0.90	0.010	0.54	7.29	1.68	0.22	0.09	0.02	0.003
		Total	8.60							0.62						
CIWMB TV		Mix HCN		124	42	2	1.53	0.52	0.02							
		Mix LCN		443	110	1	5.48	1.36	0.02							
		UnMix HCN		23	6	1	0.28	0.07	0.01							
		UnMix LCN		38	10	1	0.47	0.13	0.01							
SCAQMD Inland Summer		Stockpiles	4.75		24			0.30		0.01		6.55			0.081	
		Windrows	0.3		6			0.08		1.31		0.32			0.004	
		Total	5.05							1.32						
SCAQMD Inland Winter		Stockpiles	1.96		20			0.25		0.29		2.67			0.033	
		Windrows	0.5		6			0.08		0.03		0.32			0.004	
		Total	2.47							0.32						

5.1 Confidential Site (Site X)

This is the most recent data set, taken in the Spring of 2008. This is a confidential source composting greenwaste in the SJVAPCD. The data set consists of about 20 measurements, all collected with the newly modified SCAQMD flux method and acceptable laboratory method and practice. This site had large stockpiles with about one half the emissions coming from the stockpiles. The stockpiles had about 50% of the surface area as the windrows. The windrow emissions from this site were about an order of magnitude (10 times) the emissions measured by the SCAQMD in 2001, but were not the highest measured of this data group. The site was very well operated with significant attention to process control. This site uses very small windrows with a high surface area to volume ratio.

5.2 California Integrated Waste Management Board (CIWMB) Modesto

This data set was taken in 2006 using the current state of the art methods for that time. The emission factor in this table (1.5 # VOC per ton) was recalculated to better represent the other projects and is about twice the factor presented in their report (see attached TM). Note that the average unit flux value is the same as Site X (about 10 mg/min-m^2), but the emissions are a factor of 4 lower. This is due to a combination of the larger windrows used on this site and the rapid fall off of emissions after initial composting. This was also a well run site. The data set consisted of 36 measurements.

5.3 NorCal Waste Systems

This site is located near Vacaville, CA. The data was taken in 2006. It is a well operated site with larger windrows. The data set consisted of a total of 12 measurements, which is a small number for use in estimating life-cycle emissions. This site had VOC emissions that were about four times greater than the CIWMB Modesto report. The average flux rate was about eight times higher.

5.4 CIWMB Tierra Verde

This data was not sufficient to develop a full site emission factor. What it does provide is a range of unit flux rates for the various process management strategies tested, including carbon/nitrogen ratio and mixing. These average unit flux values, ranging from 6 to 100 mg/min-m^2, completely bracket the previous data sets and appear to provide a valid range of emission rates for the greenwaste composting process. However, the data are insufficient to draw specific conclusions about mixing because there could be high emissions from either handling or stockpiling compost from the non-mixed process.

5.5 SCAQMD Data

The SCAQMD data are provided purely for reference. However, it should be noted that the windrow emissions are extremely small (5 times lower than CIWMB Modesto) and most of the emission factor is from stockpiles. The windrow data is derived from a total of four measurements.

5.6 Discussion

Figure 5.1 presents the daily emission profile for VOC for the three sites that had complete data. Note that the NorCal emissions are dominated by a severe emissions peak that occurred early in the process followed by lower emissions that the other sources immediately after the peak.

Table 5.2 presents a summary of the valid data points with the average value shown. This does not imply that the average value is representative, is only shown for reference.

Table 5.2 Summary of greenwaste VOC emission factors (#/ton feedstock).

Source	Site X	CIWMB	NorCal	Average
Stockpile	7.76		2.95	5.36
Windrow	6.30	1.54	5.65	4.50
Total	14.06		8.60	9.85

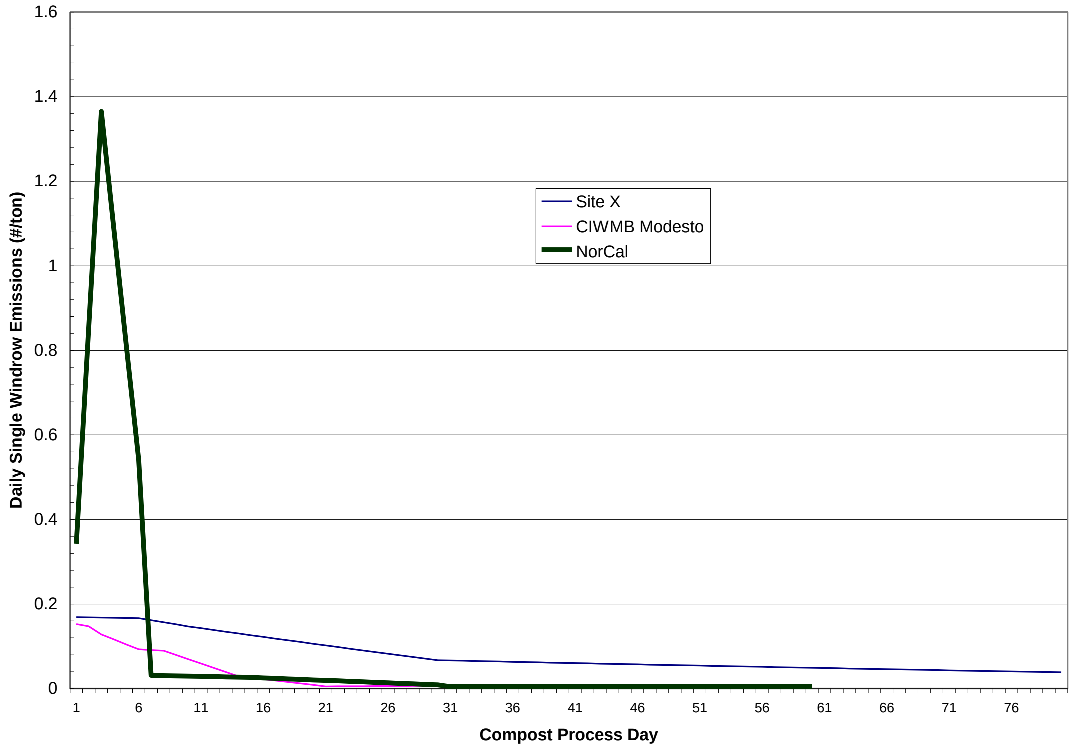


Figure 5.1 Daily VOC emissions profile from Site X, CIWMB Modesto, and NorCal.

6.0 Most Relevant Food Waste Compost Data

This section presents the data found to be most relevant in characterizing food waste emissions in the State of California. Table 6.1 presents a summary of this data in both an emission factor and unit emission rate form. The paragraphs below discuss the data points in detail.

All the food waste data was taken from the NorCal site near Vacaville, CA. The emissions data consists of very comprehensive tests on four food waste composting technologies. All the data utilized SCAQMD Method 25.3 and used the current state of the art flux chamber techniques at the time of the sampling.

The first technology tested was the use of the AgBag® vessel reactor. This consists of a polyethylene bag encapsulated compost windrow that has a small amount of forced air (100 – 300 cfm) into it. The bag is vented by small (5 cm dia) port placed every 20 feet along the bags length on each side. The compost cycle consists of 30 days in the bag and then 30 days of curing out of the bag. During the cure phase, the windrow is mixed every three days using the standard Rotoshredder/Scarab windrow mixer.

The second technology used was the Compostex cover technology. This consists of a standard windrow that is placed and mixed, then covered with the Compostex®

polypropylene cover. The cover is very porous, but does supply insulation and some water retention.

Table 6.1 Summary of most relevant food waste composting data.

			VOC							NH3						
			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)		
Location	**Technology**	**Activity**	**(#/ton)**	**Peak**	**Avg**	**Min**	**Peak**	**Avg**	**Min**	**(#/ton)**	**Peak**	**Avg**	**Min**	**Peak**	**Avg**	**Min**
NorCal	AgBag	Stockpile	0.42	9	4	0.5	0.12	0.06	0.01	0.02	1.05	0.39	0.03	0.01	0.01	0.000
		Windrow	36.7	9,603	1,729	1	119	21.38	0.01	0.7	98.84	13.82	0.01	1.22	0.17	0.000
		Total	37.1							0.7						
	Compostex	Stockpile	1.5	31	12	0.33	0.38	0.15	0.00	0.002	0.02	0.01	0.01	0.000	0.000	0.000
		Windrow	25.4	899	143	0.4	11.11	1.76	0.01	8.1	173	12	0.01	2.14	0.15	0.000
		Total	26.9							8.1						
	Micropore 30	Stockpile	1.8	27	13	8	0.34	0.17	0.10	0.1	6.48	1.45	0.10	0.08	0.02	0.001
		Windrow	9.0	195	32	0.1	2.41	0.39	0.00	14.1	370	21.3	0.00	4.57	0.26	0.000
		Total	10.8							14.2						
	Micropore 45	Stockpile	1.7	27	13	8	0.34	0.17	0.10	0.1	6	1	0.1	0.08	0.02	0.001
		Windrow	1.7	622	33	0.1	7.70	0.40	0.00	1.3	56.4	2.87	0.00	0.70	0.04	0.000
		Total	3.4							1.4						

The last two technologies were micropore covers. These covers are expanded polytetrafluoroethylene (PTFE) membranes encased in a polyester protective covering. The pore size of the PTFE membrane is controlled to maximize oxygen transfer while minimizing water vapor loss. This pore size is a barrier to most non-methane hydrocarbons but not in general to ammonia. The cover provides an opportunity for superior process control due to weather protection and moisture control. The covering system is substantially more costly than the Compostex® system. For the micropore cover system, two cases were evaluated. The first case was for covering the windrow for 30 days, followed by a 30 day uncovered cure period. The second case was for covering the windrow for 45 days, followed by a 15 day cure period. Both cure periods had mechanical mixing every three days. While covered, the micropore windrow received about 300 cfm of forced air on a 10 minute on/20 minute off cycle.

There is really no baseline/no control data for food waste. All the data consists of some level of control technology. The micropore cover system provides the highest level of control at the highest cost. From a regulatory standpoint at NorCal, the AgBag technology was considered baseline. Note that for food waste, better process control that lowers VOC emissions may actually increase ammonia emissions.

7.0 Most Relevant Biosolids Compost Data

This section presents the data found to be most relevant in characterizing biosolids composting emissions in the State of California. Table 7.1 presents a summary of this data in both an emission factor and unit emission rate form. The paragraphs below discuss the data points in detail.

Table7.1 Summary of most relevant biosolids composting data.

			VOC							NH3						
			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)		
Location	Technology	Activity	(#/ton)	Peak	Avg	Min	Peak	Avg	Min	(#/ton)	Peak	Avg	Min	Peak	Avg	Min
LACSD/ Cedar Grove	Uncovered	ASP	3.7	74	15	0.3	0.92	0.46	0.00	4.6	200	27.94	1.56	2.47	1.24	0.019
	Micropore	ASP	0.2	21	2.9	0.3	0.26	0.13	0.003	1.8	279	17.72	1.40	3.44	1.73	0.02
SKIC	ASP/Biofilter	Whole Site	0.2	3.0	0.8	0.2	0.04	0.010	0.002	0.1	5	1.81	0.18	0.06	0.02	0.002
SCAQMD Las Virgenes		Biofilter In	0.8		3.1			0.04		0.7		2.9			0.04	

There were only four biosolids data sets that utilized a VOC test method (SCAQMD 25.1/25.3) that would provide meaningful regulatory data for SJVAPCD. All biosolids composting utilizes some bulking agent or amendment that is almost always greenwaste. So essentially almost all biosolids composting is co-composting with greenwaste.

Three data sets do not really represent baseline/uncontrolled emissions. The Cedar Grove data set utilized an under-the-cover measurement to establish control efficiency for a micropore cover system. The micropore cover does influence the entire compost process so even the under the cover measurement is likely lower in emissions than an uncovered pile or windrow. The Las Virgenes data is from a compost structure, so it represents the uncontrolled emissions from composting in a building, not outdoor composting.

The SKIC data set is from a compliance test at the South Kern Industrial Complex near Bakersfield. The facility was a very large aerated static pile (ASP) facility that had induced air flow controlled by biofilters.

The Cedar Grove data is from the test of a micropore cover for Los Angeles County Sanitation District’s biosolids from the Joint Water Pollution Control Plant in Carson, CA. The actual test occurred in Everett, Washington at a facility that was designed to compost greenwaste under micropore covers. As mentioned earlier, under the cover measurements were utilized to estimate cover control efficiency. However, it is unlikely that an uncovered system would perform even as well as the under the cover micropore system. This is because the micropore system offers many process control advantages including weather protection and water retention.

8.0 References

Hentz Jr, L. H., W. E. Toffey, and C. E. Schmidt. 1996. **Understanding the Synergy Between Composting and Air Emissions.** BioCycle. 37(3):67-75.

Appendix A
SJVAPCD Literature Table
and
Individual Report Summaries

TECHNICAL MEMORANDUM

Date: May 9 2008
To: SJAQMD Staff
From: CE Schmidt

RE: Annotated Bibliography in Support of the SJVAPCD Greenwaste Baseline Composting Document

The core documents collected and reviewed by the SJVAPCD staff supporting the baseline document preparation as foundational to the proposed Rule 4566 have been reviewed with a focus on: project objective, sample collection technology, analytical methodology, and representativeness of the reported and tabulated flux or emission rate data. Each of the research reports has been reviewed, and an annotated bibliography has been prepared, and is contained herein.

The purpose of this effort was to provide council to the SJVAPCD staff with regard to using the available information regarding the compost industry in rule making. A companion document has been prepared in a similar vein with regard to the flux data use in these documents, emission calculation algorithm and assumptions used in the process, and the overall usability of the emission rate data. These two documents, constitutes the contracted support to the SJVAPCD staff for the purpose of rule making.

The annotated bibliographies are provided as an attachment to this memorandum.

Note that three studies have been added to the reference list for your review.

CE Schmidt

SUMMARY OF ANNOTATED BIBLIOGRAPHY ATTACHMENTS

SITE: Cedar Grove Composting, Everett, WA;
TITLE: "Full Scale Evaluation of Gore Technology On LACSD Biosolids at Cedar Grove Composting, Everett, WA"

SITE: Inland Composting and Organic Recycling Facility, Colton, CA; City of LA Anchorage Green Material Facility, San Pedro, CA; City of LA Van Norman Green Material Mulching Facility, San Fernando Valley, CA, and Scholl Canyon Landfill Site (alternative daily cover application)
TITLE: "Air Emissions Tests Conducted at Green Material Processing Facilities"

SITE: Jepson Prairie Organics Compost Facility, Vacaville, CA
TITLE: "Air Emissions Source Test- Emissions Evaluation of Complete Compost Cycle VOC and Ammonia Emissions"

SITE: City of Modesto Compost Facility, Modesto, CA
TITLE: "Emissions Testing of Volatile Organic Compounds from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley"

SITE: Inland Empire Composting, Colton, CA
TITLE: "Ammonia and Volatile Organic Compound (VOC) Emissions From A Greenwaste Composting Facility "

SITE: Westlake Farms Co-Composting Facility, Stratford, CA
TITLE: "Assessment of Volatile Organic Compound and Ammonia Emissions from a Bulking Agent Stockpile"

SITE: Intravia Rock and Sand, Inc. Upland, CA
TITLE: "Ammonia and Volatile Organic Compound (VOC) Emissions From A Non-Curbside Greenwaste Chipping and Grinding Facility "

SITE: Rancho Las Virgenes Municipal Water District, Calabasas, CA
TITLE: "Characterization of Ammonia, Total Amine, Organic Sulfur Compound, and Total Non-Methane Organic Compound Emissions from Composting Operations "

SITE: Little Hanaford Farms, Centralaia, WA
TITLE: "Technical Support Document Little Hanaford Farms"

SITE: EKO Systems, Corona, CA
TITLE: "Characterization of Ammonia, Total Amine, Organic Sulfur Compound, and Total Non-Methane Organic Compound (TGNMOC) Emissions From Composting Operations "

SITE: San Joaquin Composting, Inc, Lost Hills, CA
TITLE: "Characterization of Ammonia, Total Amine, Organic Sulfur Compound, and Total Non-Methane Organic Compound (TGNMOC) Emissions From Composting Operations "

SITE: Tierra Verde Industries, Irvine, CA
TITLE: "Technical Report- Best Management Practices for Greenwaste Composting Operations: Air Emissions Tests vs. Feedstock Controls and Aeration Techniques"

SITE: Jepson Prairie Organics Compost Facility, Vacaville, CA
TITLE: "Jepson Prairie Organics Facility Compostex Cover System- Air Emissions Report"

SITE: Jepson Prairie Organics Compost Facility, Vacaville, CA
TITLE: "Jepson Prairie Organics Facility Micropore Cover System- Air Emissions Report"

SITE: South Kern Industrial Complex (SKIC) LLC, Taft, CA
TITLE: "SKIC Air Emissions Compliance Report"

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Biosolids

SITE: Cedar Grove Composting, Everett, WA

PAPER TITLE: "Full Scale Evaluation of Gore Technology On LACSD Biosolids at Cedar Grove Composting, Everett, WA"

AUTHORS: Tom Card, CE Schmidt

DATE: August, 2007 (testing conducted 01/07 to 03/07)

PROJECT OBJECTIVE:
Evaluate VOC and ammonia emissions for biosolids composting using the Gore micropore/ASP cover system, and to determine the control efficiency for the cover system.

FACILITY OPERATIONS:
Cedar Grove composting utilizes a three-phase compost operation with a 28 day active phase (covered), a 13 day maturation phase (covered) and a 14 day cure phase (uncovered).

TARGET SPECIES:
Methane, ethane, $CO2$, CO, Total non-methane organic carbon (condensable and volatile), and ammonia.

SAMPLE COLLECTION METHODS:
SCAQMD Modified (6" port, tracer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:
SCQAMD Method 25.3, SCAQMD Method 207.1, and USEPA Method TO-14/GC-ECD for the tracer SF6.

SCOPE OF WORK:
Over 100 flux measurements conducted over a 43-day time period. Test locations were selected to represent side and top of pile with test locations, and top and side under the cover test locations. Testing was conducted on head space under the cover, from flux chambers under the cover, on the cover (top and side locations), during phase transitions and mixed compost, on cover seams, and repeat testing on different portions of the covered compost.,

Phase 1, Day 2- three flux tests on cover per round per day, two rounds, two buried flux
Phase 1, Day 4- Same, plus full replicate tests

Phase 1, Day 7- Same
Phase1, Day 14- Same
Phase 1,Day 28- Same
Transition P1/P2- breakdown compost, mixed compost, covered compost tests; multiple
Phase 2, Day 1- Same as covered
Phase 2, Day 13- Same as covered
Phase 3, Day 1- Same as covered

QC DATA:
Work plan was prepared and is available.
Adequate frequency of blank, replicate, and repeat samples are reported.
QC data indicated overall acceptable method performance.

FINDINGS:
Biosolids Uncontrolled test pile)- 1.8 #VOC/ton and 4.0 #NH3/ton

Fugitive Emissions with Gore Cover- 0.2 #VOC/ton and 1.8 #NH3/ton

Note- Uncontrolled emissions, as well as the control efficiency estimate reference measurements taken from two flux chambers under the cover during the life-cycle testing effort.

CONCLUSIONS:
The appropriate sample collection and analytical techniques were employed, with the exception that recent SCAQMD Modified USEPA flux chamber techniques were not used (redesigned sweep air inlet system and stack testing in extended stack), although the flow rates were probably low enough so that the sample collection technique was not biased.

COMMENTS:
Climatic conditions may have influenced the composting operations, in particular the beginning of the cycle. The LACSCD biosolids arrived in a semi-frozen state, and this may have hampered complete mixing of the biosolids with bulking agent, and delayed the starting of the composting process. The cool winter weather with light precipitation for the area probably had little effect on the composting operations. The testing effort was not hampered by the weather.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Greenwaste

SITE: Inland Composting and Organic Recycling Facility, Colton, CA; City of LA Anchorage Green Material Facility, San Pedro, CA; City of LA Van Norman Green Material Mulching Facility, San Fernando Valley, CA, and Scholl Canyon Landfill Site (alternative daily cover application)

PAPER TITLE: "Air Emissions Tests Conducted at Green Material Processing Facilities"

AUTHORS: CIWMB Brenda Smyth, CE Schmidt

DATE: February 22, 2002 (testing conducted 12/03/01, 12/06/01, and 12/07/01)

PROJECT OBJECTIVE:
Evaluate baseline VOC and ammonia emissions for greenwaste composting operations in the SCAQMD.

FACILITY OPERATIONS:
All three compost facilities receive, grind, static pile compost, and screen product in similar fashion. The landfill uses greenwaste mulch as alternative daily cover.

TARGET SPECIES:
Methane, ethane, CO2, CO, and Total non-methane organic carbon (condensable and volatile), and ammonia.

SAMPLE COLLECTION METHODS:
USEPA surface emission isolation flux chamber, standard chamber. Side-by-side open path optical remote sensing by SCAQMD at the Inland Empire

ANALYTICAL METHODS:
NMAM 6015 for ammonia, EPA Method 25C for methane and TNMHC, Method TO-15 for VOC species, and SCQAMD Method 25.3 for condensable and non-condensable organic compounds (by SCAQMD Lab).

SCOPE OF WORK:
Inland Composting and Organics Recycling Facility
14 Flux chamber tests: raw greenwaste, Day 17 compost, Day 45 compost, Day 90 overs material, screened product fines.
Anchorage Facility
18 Flux chamber tests: Day 1 compost, Day 3 compost, and Day 7 compost, Day 14 compost, Day 28 compost, Day 80 compost, Day 90 overs.

Van Norman Facility
24 Flux chamber tests: Day 1 compost, Day 3 compost, Day 5 compost (raw, coarse mulch, fine mulch, superfine mulch)

QC DATA:

Work plan was prepared and is available.
Adequate frequency of blank samples reported; no replicate samples.
QC data indicated overall acceptable method performance.

FINDINGS:

Greenwaste- 0.186 #VOC/hr-1000ft2 and 0.002 #NH3/hr-1,000ft2 (mean values for the collective data set).

Note- The frequency of testing is limited in that there are many different area sources in a compost cycle and life cycle emission estimates must include operational considerations, spatial variability, and time-dependent emissions per source. 54 data points collected at three different facilities does not constitute a robust program.

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed, with the exception that recent SCAQMD Modified USEPA flux chamber techniques were not used (redesigned sweep air inlet system and stack testing in extended stack), although the flow rates were probably low enough so that the sample collection technique was not biased. The use of the flux data, estimate of surface area, and representativeness of the emissions estimate should be reviewed.

COMMENTS:

The results of these test show much lower ammonia emissions and lower VOC emissions from facilities located in the SCAQMD area compared the SCAQMD published values of 0.224 #VOC/hr-1,000ft2 and 0.091 #NH3/hr-1,000ft2 from the Inland Empire site. This is suggested to be related to the difference in seasonal flux and the analytical methods: higher emissions in the summer and more compound detection with SCAQMD Method 25.3 as compared to Method 25C.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Food Waste with Ag Bag Cover and Greenwaste

SITE: Jepson Prairie Organics Compost Facility, Vacaville, CA

PAPER TITLE: "Air Emissions Source Test- Emissions Evaluation of Complete Compost Cycle VOC and Ammonia Emissions"

AUTHORS: Tom Card, CE Schmidt

DATE: May, 2006 (testing conducted 08/23/05 to 08/25/05)

PROJECT OBJECTIVE:
Evaluate VOC and ammonia site wide baseline emissions for food waste composting using the Ag Bag cover system and the static greenwaste windrow compost system.

FACILITY OPERATIONS:
Jepson Prairie Organics Compost facility utilizes a two-phase compost operation with a 30-day active phase (food waste in the Ag Bag, covered) and ASP system, and a 30 day cure phase (uncovered).

TARGET SPECIES:
Methane, ethane, CO_2, CO, Total non-methane organic carbon (condensable and volatile), and ammonia.

SAMPLE COLLECTION METHODS:
SCAQMD Modified (6" port, tracer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:
SCQAMD Method 25.3, SCAQMD Method 207.1, and USEPA Method TO-14/GC-ECD for the tracer SF_6.

SCOPE OF WORK:
Over 46 flux measurements conducted over a 3-day time period. Test locations were selected to represent Ag Bag ports, and the side and top of curing or greenwaste piles. Receiving and finish was also tested.

Food Waste/Ag Bag
Phase 1 Compost, Day 1- Two flux tests on bag ports
Phase 1, Compost, Day 4- Same
Phase 1, Compost, Day 5- Same
Phase 1, Compost, Day 8- Same
Phase 1, Compost, Day 10- Same

Phase 1, Compost, Day 22- Same
Phase 1, Compost, Day 30- Same
Phase 2, Cure, Day 0 unmixed, one flux test
Phase 2, Cure, Day 3, unmixed and mixed- three flux tests
Phase 2, Cure, Day 7- unmixed, one flux test
Phase 2, Cure, Day 10, unmixed and mixed- two flux tests
Phase 2, Cure, Day 13- one flux test
Phase 2, Cure, Day 19, unmixed and mixed- two flux tests
Phase 2, Cure, Day 25- one flux test
Phase 2, Cure, Day 31, unmixed and mixed- two flux tests
Finish- three flux tests

Greenwaste Static Pile
Phase 1, Compost, Day 3- one flux test
Phase 1, Compost, Day 6- Same
Phase 1, Compost, Day 7- three flux tests
Phase 1, Compost, Day 15- one flux test
Phase 1, Compost, Day 30- Same
Phase 2, Cure, Day 50 unmixed, one flux test
Finish- three flux tests

Phase 3, Day 1- Same as covered

QC DATA:
Work plan was prepared and is available.
Adequate frequency of blank, replicate, and repeat samples are reported.
QC data indicated overall acceptable method performance.

FINDINGS:
Food Waste in Ag Bag- 37 #VOC/ton and 0.7 #NH3/ton

Static Pile Greenwaste Composting- 14 #VOC/ton and 0.5 #NH3/ton

CONCLUSIONS:
The appropriate sample collection and analytical techniques were employed, with the exception that recent SCAQMD Modified USEPA flux chamber techniques were not used (redesigned sweep air inlet system and stack testing in extended stack), although the flow rates were probably low enough so that the sample collection technique was not biased.

COMMENTS:
The Ag Bag showed very low emissions during the in-vessel phase with little emissions from the open ports and little effect by the blower fans. Most of the emissions occurred during the curing phase. The greenwaste static pile was occasionally watered and mixed.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Greenwaste and Greenwaste with Food Waste

SITE: City of Modesto Compost Facility, Modesto, CA

PAPER TITLE: "Emissions Testing of Volatile Organic Compounds from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley"

AUTHORS: Brenda Smyth, Fatih Buksonamez, CE Schmidt

DATE: October 31, 2007 (testing conducted 10/19/06 to 12/14/06)

PROJECT OBJECTIVE:
Evaluate baseline VOC emissions during greenwaste composting and greenwaste that includes food waste, and to assess VOC emissions reduction potential of Best Management Practices (BMP) including application of a finished compost blanket on top of the greenwaste windrow and application of two chemical additives to greenwaste windrow.

FACILITY OPERATIONS:
City of Modesto- 250 to 300 tons of greenwaste per day, some paper and residential food waste; 30 acre site with maximum 500 tons per day capacity. Greenwaste source is residential, landscape business, and municipal pruning. The process is static composting in windrows: greenwaste is tipped on a concrete pad, processed in a grinder, shaped in windrows, and mixed by Scarab-type turner approx. once per week with infrequent watering.

TARGET SPECIES:
Methane, ethane, CO2, CO, and Total non-methane organic carbon (condensable and volatile) with CO used as a tracer species.

SAMPLE COLLECTION METHODS:
SCAQMD Modified (6" port, tracer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:
SCQAMD Method 25.3.

SCOPE OF WORK:
Over 100 flux measurements conducted over a 57-day time period. Test locations were selected to represent bottom, middle and top of pile with test locations selected by real time instrument data.

Greenwaste (control test pile)

Day 1- Three-to-four flux tests per pile per day
Day 2- Same
Day 3- Same
Day 6- Same
Day 8- Same
Day 14- Same
Day 21- Same
Day 30- Same
Day 44- Same
Day 57- Same
Greenwaste with 15% food waste- Same

Greenwaste capped with finished compost blanket- Same

Greenwaste inoculated with two chemical additives- Same

QC DATA:

Work plan was prepared and is available.
Adequate frequency of blank samples reported; no replicate samples.
QC data indicated overall acceptable method performance.

FINDINGS:

Greenwaste (control test pile)- 0.8 to 0.9 #VOC/ton

Greenwaste with 15% food waste- 1.3 to 2.6 #VOC/ton

Greenwaste capped with finished compost blanket- 0.1 to 0.4 #VOC/ton

Greenwaste inoculated with two chemical additives- 0.5 to 0.6 #VOC/ton

Note- surface area of vented sources estimated at 10% for all piles except biofilter finish-covered pile, which was estimated by screening to be 1% to 2%. Fall season and frequent site watering my have influenced the flux data.

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed, with the exception that recent SCAQMD Modified USEPA flux chamber techniques were not used (redesigned sweep air inlet system and stack testing in extended stack), although the flow rates were probably low enough so that the sample collection technique was not biased. The use of the flux data, estimate of surface area, and representativeness of the emissions estimate should be reviewed.

COMMENTS:

None.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Greenwaste

SITE: Inland Empire Composting, Colton, CA

PAPER TITLE: "Ammonia and Volatile Organic Compound (VOC) Emissions From A Greenwaste Composting Facility "

AUTHORS: SCAQMD, Wayne Stredwick

DATE: Testing conducted 09/27/01 and 10/04/01)

PROJECT OBJECTIVE:

Evaluate VOC and ammonia emissions during greenwaste composting including: tipping pile, static piles, and windrows.

FACILITY OPERATIONS:

The site processes 350 tons of greenwaste per day. The waste is received and stored up to two days, stored in a static pile after grinding for up to 14 days, placed in windrow for up to 45 days and screened. The process is static composting in windrows: greenwaste is tipped on a concrete pad, processed in a grinder, shaped in windrows, and mixed by Scarab-type turner approx. once per week with infrequent watering.

TARGET SPECIES:

Methane, ethane, CO_2, CO, and Total non-methane organic carbon (condensable and volatile) with helium used as a tracer species and ammonia.

SAMPLE COLLECTION METHODS:

SCAQMD Modified (6" port, 10% helium tracer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:

SCQAMD Method 25.3 and SCAQMD Method 207.1.

SCOPE OF WORK:

Over 30 flux measurements conducted over a two-day time period.
Tipping pile- 10 tests; 0-2 day old tested.
Static piles- 10 tests; 7 day old tested.
Windrow- 10 tests; day 7 and day 30 tested.

QC DATA:

It is not known if a work plan was prepared or is available.

Blank samples and replicate sample data were not reported or commented on, with the exception of problems encountered. Note that all 25.3 samples were taken in duplicate as per the method.

FINDINGS:

	Ammonia	**Methane**	**TNMNEOC**
	(lb/hr-1000ft2)	(lb/hr-1000ft2)	(lb/hr-1000ft2)
Tipping Pile	0.091	0.079	0.368
Static, Fines and ADC Pile	0.071	0.024	0.226
Windrow	0.004	0.005	0.079
Site Total (lb/ton)	1.32 #/ton	0.83 #/ton	5.05 #/ton

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed including the SCAQMD Modified USEPA flux chamber technique. No discussion was provided about specific surface area testing, designation of sub area per type of source, and no QC data was provided. The use of the flux data, estimate of surface area, and representativeness of the emissions estimate should be reviewed.

COMMENTS:

None.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Bulking Agent Stockpile

SITE: Westlake Farms Co-Composting Facility, Stratford, CA

PAPER TITLE: "Assessment of Volatile Organic Compound and Ammonia Emissions from a Bulking Agent Stockpile"

AUTHORS: LACSD, CH2MHill, Tom Card, CE Schmidt

DATE: April 27, 2005 (testing conducted 03/24/ 2005)

PROJECT OBJECTIVE:
Evaluate VOC and ammonia emissions for the Westlake Farms Co-Composting site bulking agent, shredded almond wood waste (orchard waste).

FACILITY OPERATIONS:
The Westlake Farms Co-Composting facility ATC includes utilizing orchard waste as a bulking agent for a negative ASP/biofilter biosolids composting operation. The emissions from the bulking agent are part of the site emissions estimate.

TARGET SPECIES:
Methane, ethane, CO2, CO, Total non-methane organic carbon (condensable and volatile), ammonia, and total hydrocarbon species.

SAMPLE COLLECTION METHODS:
USEPA surface emission isolation flux chamber (standard chamber design- no significant advective flow from the source) and tracer recovery (CO).

ANALYTICAL METHODS:
SCQAMD Method 25.3, SCAQMD Method 207.1, and USEPA Method TO-12. Real time instrument data was used to select sample collection from test locations (FID/PID) and CO tracer recovery.

SCOPE OF WORK:
Eight flux measurements were conducted over a 1-day time period, where four of the eight locations were selected for sample collection by Methods 25.3 and 207.1. All screening data was similar, and based on field screening data the two highest flux and the two lowest flux locations were selected for testing.

QC DATA:
Work plan was prepared and is available.
Adequate frequency of blank, replicate, and repeat samples are reported.

QC data indicated overall acceptable method performance.

FINDINGS:

Static Pile Flux- 0.00000073 #VOC/hr,ft-1 and 0.0000000079 #NH3/hr,ft-1

Advective flow was calibrated based on a field test that generated recovery of CO tracer (36%) from a thin layer of wood chips divorced from the static pile (not composting).

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed. The SCAQMD Modified USEPA flux chamber techniques were not used given that advective flow was not anticipated. All data were at or below MDL for the methods and the emissions could potentially overestimate the emissions from the source based on demonstrated adsorption of the CO tracer species. The non-detect TO-14 results supported the very low/non-detect Method 25.3 results.

COMMENTS:

The flux from the orchard waste showed very low VOC and even lower ammonia emissions.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Greenwaste

SITE: Intravia Rock and Sand, Inc. Upland, CA

PAPER TITLE: “Ammonia and Volatile Organic Compound (VOC) Emissions From A Non-Curbside Greenwaste Chipping and Grinding Facility ”

AUTHORS: SCAQMD, Mei Wang

DATE: Testing conducted 07/12/02)

PROJECT OBJECTIVE:

Evaluate VOC and ammonia emissions during greenwaste composting including: tipping pile, static piles, and windrows.

FACILITY OPERATIONS:

The site receives non-curbside greenwaste, stores the wastes, grinds the waste, and ships the waste off site. Composting is not conducted on site. The material stays on site for about 30 days. Little information was available regarding the site operations.

TARGET SPECIES:

Methane, ethane, CO2, CO, and Total non-methane organic carbon (condensable and volatile) with helium used as a tracer species and ammonia.

SAMPLE COLLECTION METHODS:

SCAQMD Modified (6” port, 10% helium tracer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:

SCQAMD Method 25.3 and SCAQMD Method 207.1.

SCOPE OF WORK:

Over 20 flux measurements conducted over a one-day time period.
Tipping pile- 10 tests.
Ground material pile- 10 tests.

QC DATA:

It is not known if a work plan was prepared or is available.
Blank samples and replicate sample data were not reported or commented on. Note that all 25.3 samples were taken in duplicate as per the method.

FINDINGS:

	Ammonia	**Methane**	**TNMNEOC**
	(lb/hr-1000ft2)	(lb/hr-1000ft2)	(lb/hr-1000ft2)
Tipping Pile	0.0030	0.0029	0.228
Ground Piles	0.0006	0.0097	0.153
Site Total (lb/ton)	0.017 #/ton	0.058 #/ton	1.5 #/ton

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed including the SCAQMD Modified USEPA flux chamber technique. No discussion was provided about specific surface area testing, designation of sub area per type of source, and no QC data was provided. The use of the flux data, estimate of surface area, and representativeness of the emissions estimate should be reviewed.

COMMENTS:

None.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Biosolids Bulked with Wood Chips

SITE: Rancho Las Virgenes Municipal Water District, Calabasas, CA

PAPER TITLE: "Characterization of Ammonia, Total Amine, Organic Sulfur Compound, and Total Non-Methane Organic Compound Emissions from Composting Operations "

AUTHORS: SCAQMD, Carey Willoughby

DATE: Testing conducted 12/19/95 and 12/20/95)

PROJECT OBJECTIVE:
Verify the flux chamber sampling method for assessing emission from compost operations, and evaluate air emissions from the biosolids compost operations.
Method verification was accomplished by flux testing on the compost in an enclosed building, then comparing those emissions to the mass loading on the biofilter inlet line from the enclosure.

FACILITY OPERATIONS:
The site receives dewatered biosolids, mixes the biosolid waste with wood chips, constructs windrows on subsurface vents in an enclosure structure, supplies positive air flow to the piles for 45 days, and collects the enclosure air and runs the air through a biofiltration system.

TARGET SPECIES:
Methane, Total non-methane organic carbon (condensable and volatile) with helium used as a tracer species and ammonia, CO_2, O_2, amines, and organic sulfur compounds.

SAMPLE COLLECTION METHODS:
SCAQMD Modified (6" port, 10% helium tracer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:
SCQAMD Method 25.1, SCAQMD Method 207.1, and non-specified methods for total amines and organic sulfur.

SCOPE OF WORK:
Over 34 flux measurements conducted over a two-day time period.
Flux chamber testing on compost windrows in one cell or area, 17 locations per day, two days.
Simultaneous biofilter (replicate) inlet testing for the facility.

QC DATA:

It is not known if a work plan was prepared or is available.
Blank samples and replicate sample data were not reported or commented on.

FINDINGS:

Source	**Ammonia**	**Methane**	**TNMOC**	**CS**
	(lb/hr-1000ft2)	(lb/hr-1000ft2)	(lb/hr-1000ft2)	(lb/hr-1000ft2)
Inlet Sampling	0.036	0.025	0.038	0.038
Flux Chamber on Compost	0.012	NA	NA	NA
Site Total (lb/ton)	0.70 #/ton	0.50 #/ton	0.76 #/ton	0.69

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed including the SCAQMD Modified USEPA flux chamber technique. No discussion was provided about specific surface area testing, designation of sub area per type of source, and no QC data was provided. The use of the flux data, estimate of surface area, and representativeness of the emissions estimate should be reviewed.

The conclusion from the technical team indicated that the USEPA flux chamber method, for a variety of reasons, was 'the preferred method' for estimating and comparing emissions from compost sites.

COMMENTS:

None.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Waste material- not specified

SITE: Little Hanaford Farms, Centralaia, WA

PAPER TITLE: "Technical Support Document Little Hanaford Farms"

AUTHORS: Clint Lamoreaux, Southwest Clean Air Agency

DATE: April, 2005 (testing conducted 08/04)

PROJECT OBJECTIVE:
Comply with permit requirements.

FACILITY OPERATIONS:
75,000 Ton per year static pile windrow composting operation that receives solid waste of unspecified type and origin and produces compost and soil amendments.

TARGET SPECIES:
Eight amines plus ammonia, two sulfur compounds, and eight oxygenated compounds are listed. No total VOC.

SAMPLE COLLECTION METHODS:
None specified.

ANALYTICAL METHODS:
None specified.

SCOPE OF WORK:
None provided. Emission rate data provided as final number for amines, two sulfur compounds, ammonia, and a short list of oxygenated compounds. Sample collection technique not specified. Sample count and sampling strategy not specified. Analytical method not specified.

QC DATA:
None provided.

FINDINGS:
VOC Emissions factor- 0.10 #VOC/ton and 0.062#NH3/ton

Note- No method information, scope of work or test data was provided. These findings provide no useful information. Discount this reference.

CONCLUSIONS:
No useful information is provided. Discount this reference.

COMMENTS:
You have to be kidding me!

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Biosolids (20%) and Manure (80%)

SITE: EKO Systems, Corona, CA

PAPER TITLE: "Characterization of Ammonia, Total Amine, Organic Sulfur Compound, and Total Non-Methane Organic Compound (TGNMOC) Emissions From Composting Operations "

AUTHORS: SCAQMD, Carey Willoughby

DATE: Testing conducted 11/16/95, 01/24, and 01/26/96

PROJECT OBJECTIVE:

Evaluate VOC and ammonia emissions during greenwaste composting by testing three different ages of compost; Day 2, Day 20 and Day 50. Based in temperature, the peak emission was expected on Day 20.

FACILITY OPERATIONS:

The site receives biosolids and manure and produces compost by static pile windrow (50 day compost cycle) and a non-specified curing phase in larger piles. No mention was made regarding bulking agent, although it is likely that bedding or fiber was present in the manure.

TARGET SPECIES:

Methane, O2, CO2, CO, and Total non-methane organic carbon (condensable and volatile) with helium used as a tracer species, total sulfur compounds, ammonia and amines.

SAMPLE COLLECTION METHODS:

SCAQMD Modified (6" port, 10% helium tracer, mixing fan) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:

SCQAMD Method 25.1, Amines, Sulfur Compounds, and SCAQMD Method 207.1.

SCOPE OF WORK:

Nine sampling points per source (Day 2, 20, 50) prior to turning and five sampling points post turning per source. Note- number of samples is not specified, and the SCAQMD often collects composite samples. It is possible that only six composite samples were collected per these 42 flux tests (9 x 3 plus 5 x 3).

QC DATA:

It is not known if a work plan was prepared or is available.
Blank samples and replicate sample data were not reported or commented on. Note that all 25.3 samples were taken in duplicate as per the method.

FINDINGS:

Compounds	**Emission Factor**
	(lb/ton)
Ammonia	3.28
Amines	<0.0003
Methane	2.23
TGNMOC	1.7
Total Sulfur Compounds	0.015

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed including the SCAQMD Modified USEPA flux chamber technique. No discussion was provided about specific surface area testing, designation of sub area per type of source, and no QC data was provided. The use of the flux data, estimate of surface area, and representativeness of the emissions estimate should be reviewed.

COMMENTS:

None.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Biosolids (50%) and Greenwaste (50%)

SITE: San Joaquin Composting, Inc, Lost Hills, CA

PAPER TITLE: "Characterization of Ammonia, Total Amine, Organic Sulfur Compound, and Total Non-Methane Organic Compound (TGNMOC) Emissions From Composting Operations "

AUTHORS: SCAQMD, Carey Willoughby

DATE: Testing conducted 02/15/96, 03/01/96, and 03/11/96

PROJECT OBJECTIVE:

Evaluate VOC and ammonia emissions during greenwaste composting by testing three different ages of compost; Day3, Day 45 and Day 57. Based in temperature, the peak emission was expected on Day 45.

FACILITY OPERATIONS:

The site receives biosolids and manure and produces compost by static pile windrow (50 day compost cycle) and a non-specified curing phase in larger piles. No mention was made regarding bulking agent, although it is likely that bedding or fiber was present in the manure.

TARGET SPECIES:

Methane, O2, CO2, CO, and Total non-methane organic carbon (condensable and volatile) with helium used as a tracer species, total sulfur compounds, ammonia and amines.

SAMPLE COLLECTION METHODS:

SCAQMD Modified (6" port, 10% helium tracer, mixing fan) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:

SCQAMD Method 25.1, Amines, Sulfur Compounds, and SCAQMD Method 207.1.

SCOPE OF WORK:

Nine sampling points per source (Day 3, 45, 57) prior to turning and five sampling points post turning per source. Note- number of samples is not specified, and the SCAQMD often collects composite samples. It is possible that only six composite samples were collected per these 42 flux tests (9 x 3 plus 5 x 3). These locations were screened with an FID and these field data may have been used to select locations for sample collection, either composite or discrete samples.

QC DATA:

It is not known if a work plan was prepared or is available.
Blank samples and replicate sample data were not reported or commented on.

FINDINGS:

Compounds	Emission Factor
	(lb/ton)
Ammonia	2.81
Amines	0.19
Methane	33.49
TGNMOC	3.1
Total Sulfur Compounds	0.22

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed including the SCAQMD Modified USEPA flux chamber technique. No discussion was provided about specific surface area testing, designation of sub area per type of source, and no QC data was provided. The use of the flux data, estimate of surface area, and representativeness of the emissions estimate should be reviewed.

COMMENTS:

The compost site had experienced heavy rain prior the Day 3 testing resulting in higher emissions as per the authors. The greenwaste stockpile combusted during the 03/11/96 testing event.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Greenwaste Engineering Evaluation (Not Life Cycle)

SITE: Tierra Verde Industries, Irvine, CA

PAPER TITLE: “Technical Report- Best Management Practices for Greenwaste Composting Operations: Air Emissions Tests vs. Feedstock Controls and Aeration Techniques”

AUTHORS: Brenda Smyth, CE Schmidt

DATE: July 29, 2003 (testing conducted 10/29-30/02, 11/06-07/02, and 02/04-05/03)

PROJECT OBJECTIVE:
Evaluate baseline air emissions from feedstock blends (C:N) and aeration techniques and to determine how changing these variables affects air emissions from the compost.

FACILITY OPERATIONS:
Engineering evaluations were performed on four, custom-made windrow piles. Two piles were made with higher C:N and two with lower C:N. One of each type of blends were mechanically aerated while the others were not mixed at all. The resulting matrix was as follows: low C:N aerated and low C:N non-aerated; and high C:N aerated and high C:N non-aerated. Aeration was facilitated by turning three times per week. Of the 100 day cycle, testing was conduced on Day 3 and 4, and Day 11 and 12, and Day 101 and 102.

TARGET SPECIES:
Methane, ethane, CO2, CO, and Total non-methane organic carbon (condensable and volatile) with CO used as a tracer species.

SAMPLE COLLECTION METHODS:
Standard USEPA Flux Chamber (bottom and sides) and SCAQMD Modified (6” port, CO tracer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:
SCQAMD Method 25.3, SCAQMD 207.1, and ASTM Odor.

SCOPE OF WORK:
52 Flux measurements conducted over a 103-day time period. Test locations were selected to represent bottom, middle and top of pile with the top test location typically replicated.

QC DATA:

Work plan was prepared and is available.
Adequate frequency of blank samples and replicate samples reported in Tech Memo. QC data indicated overall acceptable method performance.

FINDINGS:

Ammonia emissions were generally below method detection limit.

VOC emissions by Method 25.3:

Test Pile	#VOC per day/ton
Static, Low C:N	0.055
Turned, Low C:N	0.848
Static, High C:N	0.038
Turned, High C:N	0.240
Total	0.247

CONCLUSIONS:

VOC emissions decreased with increasing C:N. Higher VOC emissions were observed for turned versus non-turned piles. VOC emissions peaked during the first week. It was not possible to determine if static verses turned piles were higher or lower VOC emitters. Life cycle for turned compost is shorter that static compost.

COMMENTS:

The engineering evaluation of C:N ratio and aeration provide useful operational information, but life-cycle emission factor data is difficult to extract from these data. Note that only one 6” diameter exhaust port chamber was used (top location) and a standard chamber was used for the middle and bottom-side locations. Although a tracer gas was used (CO), a bias in sampling could have resulted from back pressure in the standard chamber as related to advective flow.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Food Waste with Compostex Cover

SITE: Jepson Prairie Organics Compost Facility, Vacaville, CA

PAPER TITLE: "Jepson Prairie Organics Facility Compostex Cover System- Air Emissions Report"

AUTHORS: Tom Card, CE Schmidt

DATE: April 2008, (testing conducted 02/05-07/08)

PROJECT OBJECTIVE:

Evaluate VOC and ammonia site wide baseline emissions for food waste composting using the Compostex Cover System.

FACILITY OPERATIONS:

Jepson Prairie Organics Compost facility utilizes the Compostex cover system. The compost operation includes food waste grinding, mixing with a greenwaste bulking agent, a 45-day active compost phase (food waste covered) and a cure phase (uncovered).

TARGET SPECIES:

Methane, ethane, CO_2, CO, Total non-methane organic carbon (condensable and volatile), and ammonia.

SAMPLE COLLECTION METHODS:

SCAQMD Modified (6" port, 10% helium tracer with modified air introduction system and stack testing approach and mixer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:

SCQAMD Method 25.3, SCAQMD Method 207.1, and USEPA Method TO-14/GC-ECD for the tracer SF_6 (verification on tracer study).

SCOPE OF WORK:

Over 71 flux measurements conducted over a 3-day time period. Test locations were selected to represent the life-cycle emissions from the operations including uncovering, mixing, and time-dependent emissions post mixing. Receiving and finish was also tested.

Feedstock as received and aged	2 Flux tests- fresh and 24 hours old
Compost Day 1, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 3, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 7, covered	4 Flux tests, (T1, T2, S1, S2)

Variability Test, Day 7	4 Flux tests, (T1, T2, S1, S2)
Compost Day 15, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 28, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 28, uncovered and unmixed	4 Flux tests, (T1, T2, S1, S2)
Compost Day 28, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, S1, T1, S1)
Curing Day 45, uncovered and unmixed	4 Flux tests, (T1, T2, S1, S2)
Variability Test, Day 45	4 Flux tests, (T1, T2, S1, S2)
Curing Day 55, uncovered and unmixed	4 Flux tests, (T1, T2, S1, S2)
Curing Day 55, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, S1, T1, S1)
Finish Product- post screening	4 Flux tests- 2 fresh, 2 aged
Blank testing	9 Flux tests
Replicate testing	8 Flux tests
TOTAL	71 Flux tests

QC DATA:

Work plan was prepared and is available.
Adequate frequency of blank, replicate, and repeat samples are reported.
QC data indicated overall acceptable method performance.

FINDINGS:

Food Waste with Compostex- 27 #VOC/ton and 8.1 #NH3/ton

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed, including the recent, validated modifications to the SCAQMD Rule 1133 recommended procedure (6" port, 10% helium tracer). The modifications included the redesigned sweep air inlet system and stack testing in extended stack, backup tracer, and internal mixer. Data was collected without an adverse affect from high winds.

COMMENTS:

The Compostex cover system showed a reduced air emissions for VOC (27 #VOC/ton versus 37 #VOC/ton) as compared to the historic Ag Bag compost system, but higher ammonia emissions (8.1 #NH3/ton versus 1.0 #NH#/ton). The robust assessment produced representative life-cycle emissions from the Compostex cover system on food waste at this site.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Food Waste with Compostex Cover

SITE: Jepson Prairie Organics Compost Facility, Vacaville, CA

PAPER TITLE: "Jepson Prairie Organics Facility Micropore Cover System- Air Emissions Report"

AUTHORS: Tom Card, CE Schmidt

DATE: April 2008, (testing conducted 01/17/08 – 02/15/08)

PROJECT OBJECTIVE:
Evaluate VOC and ammonia site wide baseline emissions for food waste composting using the Micropore Cover System; 30 day and 45 day covered operations

FACILITY OPERATIONS:
Jepson Prairie Organics Compost facility typically utilizes the Compostex cover system, and a test was conducted using micropore fabric with forced air (Mor and GE covers). The micropore test used a compost operation that included food waste grinding, mixing with a greenwaste bulking agent, a 30-day and a 45-day active compost phase (food waste covered with micropore) and a cure phase (uncovered).

TARGET SPECIES:
Methane, ethane, CO_2, CO, Total non-methane organic carbon (condensable and volatile), and ammonia.

SAMPLE COLLECTION METHODS:
SCAQMD Modified (6" port, 10% helium tracer with modified air introduction system and stack testing approach and mixer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:
SCQAMD Method 25.3, SCAQMD Method 207.1, and USEPA Method TO-14/GC-ECD for the tracer SF_6 (verification on tracer study).

SCOPE OF WORK:
95 Flux measurements were conducted over multiple field trips. Test locations were selected to represent the life-cycle emissions from the operations including uncovering, mixing, and time-dependent emissions post mixing. Receiving and finish was also tested.

Feedstock as received and aged	2 Flux tests- fresh and 24 hours old

Compost Day 1, covered	4 Flux tests, (T1, T2, S1, S2)
Variability Test, Day 1, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 8, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 18, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 31, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 31, uncovered and unmixed	4 Flux tests, (T1, T2, S1, S2)
Compost Day 32, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, S1; T1, S1)
Compost Day 45, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 45, uncovered and unmixed	4 Flux tests, (T1, T2, S1, S2)
Compost Day 45, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, S1, T1, S1)
Compost Day 46, uncovered and unmixed	4 Flux tests, (T1, T2, S1, S2)
Compost Day 46, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, S1, T1, S1)
Compost Day 55, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, S1, T1, S1)
Compost Day 58, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 58, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, S1, T1, S1)
Compost Day 60, covered	4 Flux tests, (T1, T2, S1, S2)
Variability Test, Day 60, covered	4 Flux tests, (T1, T2, S1, S2)
Compost Day 60, Mix Decay (hr 1, hr 4)	4 Flux tests, (T1, T2, S1, S2)
Finish Product- post screening	4 Flux tests- 2 fresh, 2 aged
Blank testing	9 Flux tests
Replicate testing	8 Flux tests
TOTAL	95 Flux tests

QC DATA:

Work plan was prepared and is available.
Adequate frequency of blank, replicate, and repeat samples are reported.
QC data indicated overall acceptable method performance.

FINDINGS:

Food Waste with 30-Day Micropore Cover- 11 #VOC/ton and 14 #NH3/ton
Food Waste with 45-Day Micropore Cover- 3.4 #VOC/ton and 114 #NH3/ton

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed, including the recent, validated modifications to the SCAQMD Rule 1133 recommended procedure (6" port, 10% helium tracer). The modifications included the redesigned sweep air inlet system and stack testing in extended stack, backup tracer, and internal mixer. Data was collected without an adverse affect from high winds.

COMMENTS:

The 30-Day Micropore cover system showed a reduced air emissions for VOCs (11 #VOC/ton versus 27 #VOC/ton) as compared to the baseline Compostex cover system, but higher ammonia emissions (14 #NH3/ton versus 8.1 #NH#/ton). And, the 30-Day Micropore cover system showed a reduced air emissions for VOCs (3.4 #VOC/ton versus 11 #VOC/ton) as compared to the 30-Day Micropore cover system, and also lower ammonia emissions (1.4 #NH3/ton versus 14 #NH#/ton). The robust assessment produced representative life-cycle emissions from the Micropore cover system on food waste at this site.

SJVAPCD ANNOTATED BIBLIOGRAPHY FACT SHEET

COMPOST TYPE: Biosolids

SITE: South Kern Industrial Complex (SKIC) LLC, Taft, CA

PAPER TITLE: "SKIC Air Emissions Compliance Report"

AUTHORS: Tom Card, CE Schmidt

DATE: January 2008, (testing conducted 08/08-12/07 and 12/04-06/08)

PROJECT OBJECTIVE:

Determine the air emissions of VOCs and ammonia from the primary and secondary ASPs and the biofilters (mixing building, primary, and secondary biofilters); and determine the control efficiency of the biofilters for both VOCs and ammonia.

FACILITY OPERATIONS:

SKIC operates a co-composting facility that uses aerated static pile and biofilters. The biosolids are received in a building, mixed with greenwaste bulking agent, heap piled, placed in primary composting under negative aeration via subsurface ventilation and covered with a layer of finish biosolids (30 days), broke-down and transported to secondary curing which is also under negative aeration via subsurface ventilation but not covered with finish, screened, and sold as product. Gases collected from the mixing building, primary and secondary are routed though separate biofiltration consisting of wood chip media maintained by irrigation.

TARGET SPECIES:

Methane, ethane, CO2, CO, Total non-methane organic carbon (condensable and volatile), and ammonia.

SAMPLE COLLECTION METHODS:

SCAQMD Modified (6" port, 10% helium tracer with modified air introduction system and stack testing approach and mixer) USEPA surface emission isolation flux chamber.

ANALYTICAL METHODS:

SCQAMD Method 25.3, SCAQMD Method 207.1, and USEPA Method TO-14/GC-ECD for the tracer SF6 (verification on tracer study).

SCOPE OF WORK:

Approximately 103flux or stack measurements were conducted over two field trips. The primary composting and biofilter was tested in August and the secondary and biofilter along with the mixing building biofilter was tested in December. Test locations were selected to represent the life-cycle emissions from the operations. Biofilter inlet testing included triplicate stack testing in order to establish inlet concentrations and flow rates into the biofilters for destruction efficiency determinations.

Process	**Stack Tests**	**Flux Locations**
Primary Composting		
Compost Surface- Day 5, 11, 16	None	9
Secondary Composting		
Compost Surface- Day 22, 28, 36	None	9
Mixing Building Biofilter		
Biofilter In	3 + 3	None
Biofilter Surface- 16 cell grid	None	16
Primary Biofilter		
Biofilter In	3	None
Biofilter Surface- 16 cell grid	None	16
Secondary Biofilter		
Biofilter In	3	None
Biofilter Surface- 16 cell grid	None	16

QC DATA:

Work plan was prepared and is available.
Adequate frequency of blank, replicate, and repeat samples are reported.
QC data indicated overall acceptable method performance.

FINDINGS:

Facility Emissions- 0.31 #VOC/ton and 0.14 #NH3/ton

Biofilter Destruction Efficiency; VOCs- 88% to 97%, NH3- 81% to 97%

CONCLUSIONS:

The appropriate sample collection and analytical techniques were employed, including the recent, validated modifications to the SCAQMD Rule 1133 recommended procedure (6” port, 10% helium tracer). The modifications included the redesigned sweep air inlet system and stack testing in extended stack, backup tracer, and internal mixer. Data was collected without an adverse affect from high winds.

COMMENTS:

The ASP composting system complete with biofilter blanket on primary composting, negative aeration and biofilter control, and secondary curing negative aeration and biofilter control shows low emissions of VOCs and ammonia. Destruction efficiencies for both VOCs and ammonia from maintained wood chip biofiltration range from 81% to 97% or these species. The robust assessment produced representative life-cycle emissions from the negative ASP system and biofiltration control.

Appendix B
Technical Memorandum
CIWMB Modesto Data Recalculation

41125 278th Way SE, Enumclaw, WA 98022 USA
Phone: 360-802-5540 Fax: 360-802-5541
E-Mail: trcard@earthlink.net

TO: Chuck Schmidt

FROM: Tom Card

DATE: June 19, 2008

SUBJECT: CIWMB Modesto Composting Report Analysis

An analysis has been made of the California Integrated Waste Management Board's (CIWMB) report entitled **Emissions Testing of Volatile Organic Compounds from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley**. It was not possible to reproduce the calculations in the report to verify their accuracy. Instead, the emissions are recalculated using the quantitative and written descriptions of the site and the testing procedures. There can be many reasons why this calculation is different than the report's calculation. Those differences are discussed in detail below.

Table 1 summarizes the results of this analysis compared to the report's findings. The South Coast Air Quality Management District (SCAQMD) emission factor is presented for comparative purposes.

Table 1. Preliminary Results

Source	VOC (#/ton mix)
Recalculation of CIWMB Results	1.5
CIWMB Report	0.6 - 0.7
SCAQMD Emssion Factor	3.8

Basis of Recalculation

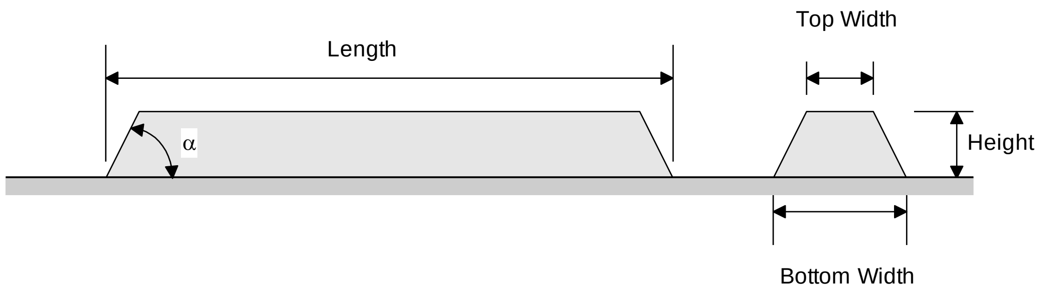
VOC Species

This report calculated VOC emissions as methane with no method bias factor applied. The SCAQMD presents VOC emissions as hexane carbon and includes a method bias factor. This report did not present the VOC data in this manner since most jurisdictions report VOC as methane with no method bias factor.

Compost Process

The compost process tested was greenwaste in windrows. The compost was placed in the windrow and mixed eleven times over a 60 day cycle. No attempt was made in the CIWMB report to quantify immediate mixing emissions. Previous work has shown that mixing emissions are irrelevant in well mixed aerobic windrows, but mixing emissions dominate in poorly mixed and poorly vented windrows. Based on the descriptions and data in the report, this windrow likely trends to the former condition. Figure 1 presents the windrow configuration that this report assumed along with the mensuration formulas used. Table 2 presents the windrow calculated data.

Figure 1. Assumed Windrow Configuration and Mensuration Formulas



Mensuration formulas

$$S = \frac{p_1 + p_2}{2} s + A_2$$

$$V = \frac{h(A_1 + A_2 + \sqrt{A_1 A_2})}{3}$$

$$s = \sqrt{h^2 + ((W_B - W_T)/2)^2}$$

where S = total surface area, p_1 = bottom perimeter, p_2 = top perimeter, s = slant height, V=volume, h=vertical height, A_1 = bottom area, A_2 = top area, α = bottom angle

The CIWMB reported the surface area as 206.4 m^2. This report calculates the surface area as 212 m^2. The CIWMB reports the initial bulk density as 360 kg/m^3. This report calculates the density as 510 kg/m^3. The density difference is significant and could be one of the primary causes of the differences in results. The CIWMB number is significantly lower than any density value for greenwaste compost seen by this author. The compost windrow normally shrinks during the cycle. This shrinkage was not incorporated in this calculation, but based on the emissions profile (late cycle emissions go to essentially zero) this should not have significant impact.

The compost windrow was sampled typically at two locations on the top of the windrow, on the middle of the side and at the bottom of the side. Figure 2 is taken directly out of the CIWMB report to show the portions of the windrow that these samples represent. Table 3 shows this report's allocation of the surface areas compared to the CIWMB allocation of surface areas. It was not possible to determine how the CIWMB calculated their area ratios.

Compost Venting

Compost often cracks and develops vent channels so that a large portion of the vent air goes through few channels. The CIWMB report discussed the phenomena extensively. However, the data suggest that the vent channels had no more emissions than the rest of the top surface. Many of the non-vented top surfaces had emissions exceeding the vented surfaces, which suggests that for the added volumetric flow even the field instrument screening data are not good indicators of VOC flux or emissions. Therefore, for this report all top surface values are averaged

Table 2. Windrow Dimensions and Capacities

Property	Units	Value
Length	ft	102.0
Height	ft	6.8
Bottom Width	ft	14.4
Top Width	ft	5.6
Top Length	ft	93
alpha	R	1.00
	o	57
Top Perimeter	ft	198
Top Area	ft2	522
Bottom Perimeter	ft	233
Bottom Area	ft2	1,469
Slant height	ft	8.1
Surface Area	ft2	2,265
	m2	212
Volume	ft3	6,497
	yd3	241
	m3	184
Conversion Factors	ft2/m2	10.7
	ft3/yd3	27
	ft3/m3	35.31
Top Area Ratio		0.230
Mass	Tons	103
Density	*#/yd3*	856
	kg/m3	509

Figure 2. CIWMB Windrow Cross Section (Figure 1. from the CIWMB report).

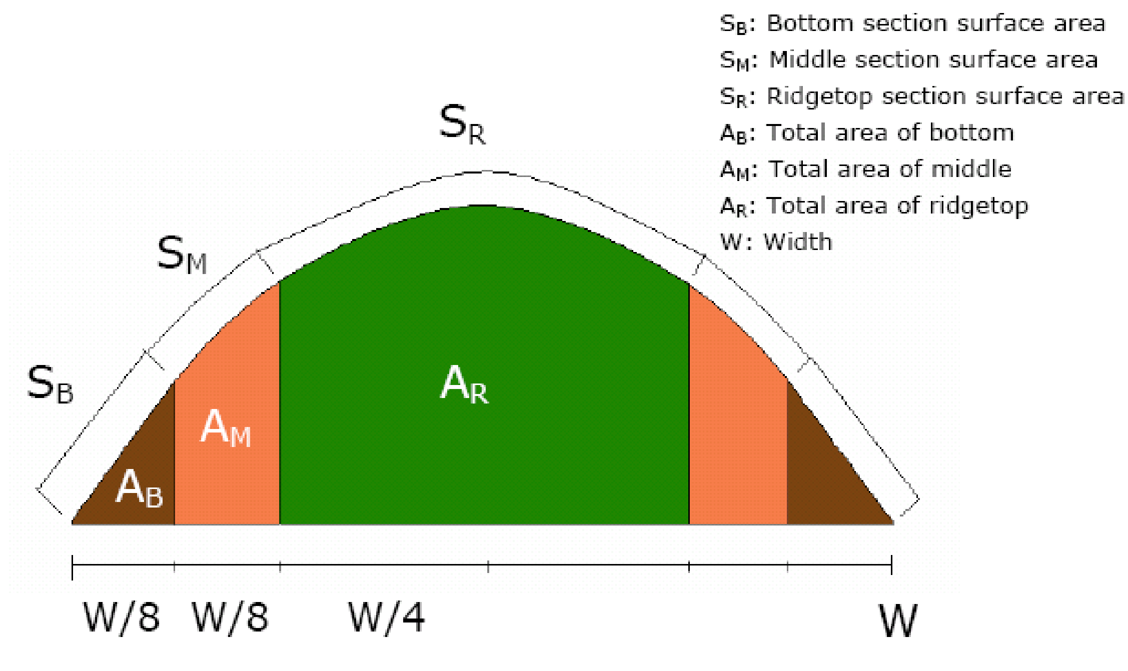


Figure 1. Sampling Segments of Windrows

Table 3. Comparison of Surface Area Allocations.

Source	Top	Middle	Side
This Report	0.5	0.25	0.25
CIWMB Report	0.26	0.37	0.37

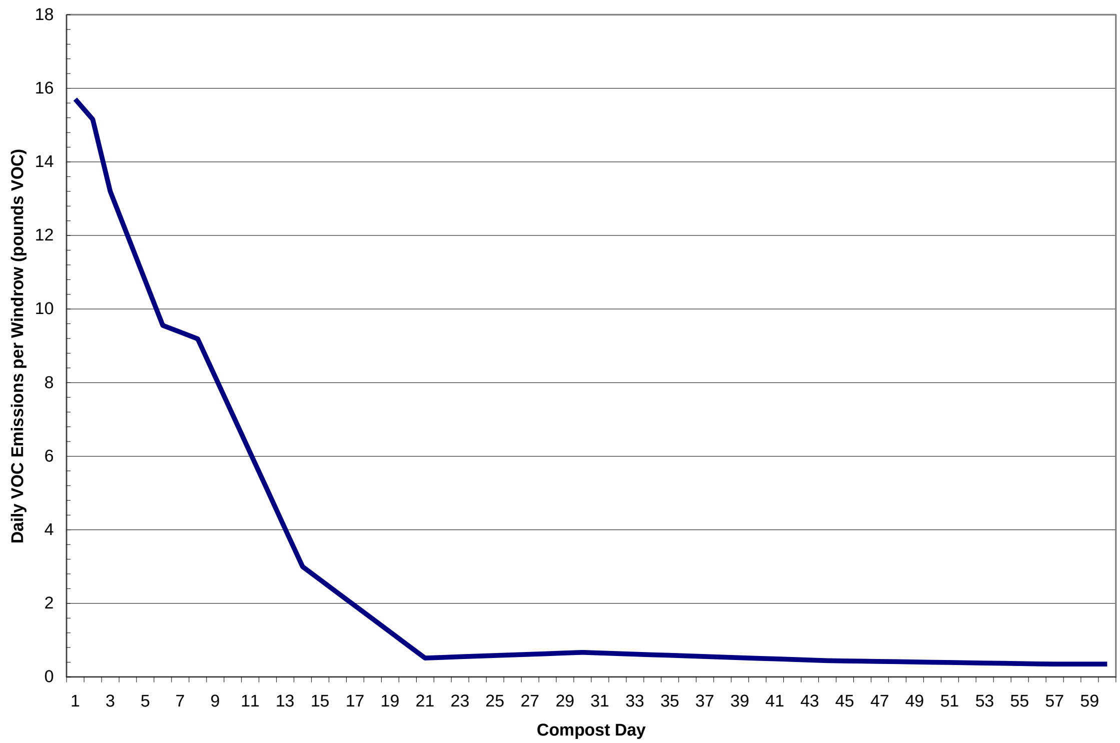
Emission Factor Calculation

Table 4. presents a simulated full 60 day compost cycle emissions based on the CIWMB data. The highlighted values are measured unit emissions, the rest of the data is linearly interpolated from the measured data. Figure 3 shows the daily emissions profile.

Table 4. Simulated VOC Emissions Profile.

Compost	Weighting Factors					Unit Flux (mg/min-m2)					Surface Area	Emissions
Day	RH	RL	Mid	Bot	Total	RH	RL	Mid	Bot	Total	(m2)	VOC (#)
1	0.25	0.25	0.25	0.25	1.00	19.05	34.78	2.71	36.93	23.4	212	15.7
2	0.25	0.25	0.25	0.25	1.00	30.16	38.95	1.96	19.13	22.5	212	15.2
3	0.25	0.25	0.25	0.25	1.00	34.44	41.58	1.21	1.34	19.6	212	13.2
4	0.25	0.25	0.25	0.25	1.00	31.23	38.12	0.94	1.04	17.8	212	12.0
5	0.25	0.25	0.25	0.25	1.00	28.01	34.66	0.68	0.75	16.0	212	10.8
6	0.25	0.25	0.25	0.25	1.00	24.80	31.20	0.41	0.46	14.2	212	9.6
7	0.25	0.25	0.25	0.25	1.00	22.76	27.74	3.49	1.79	13.9	212	9.4
8	0.25	0.25	0.25	0.25	1.00	20.71	24.28	6.57	3.13	13.7	212	9.2
9	0.25	0.25	0.25	0.25	1.00	19.52	20.83	5.54	2.67	12.1	212	8.2
10	0.25	0.25	0.25	0.25	1.00	18.33	17.37	4.51	2.20	10.6	212	7.1
11	0.25	0.25	0.25	0.25	1.00	17.14	13.91	3.48	1.73	9.1	212	6.1
12	0.25	0.25	0.25	0.25	1.00	15.95	10.45	2.45	1.27	7.5	212	5.1
13	0.25	0.25	0.25	0.25	1.00	14.76	6.99	1.42	0.80	6.0	212	4.0
14	0.25	0.25	0.25	0.25	1.00	13.57	3.53	0.39	0.34	4.5	212	3.0
15	0.25	0.25	0.25	0.25	1.00	11.83	3.21	0.35	0.33	3.9	212	2.6
16	0.25	0.25	0.25	0.25	1.00	10.10	2.89	0.30	0.32	3.4	212	2.3
17	0.25	0.25	0.25	0.25	1.00	8.36	2.57	0.26	0.30	2.9	212	1.9
18	0.25	0.25	0.25	0.25	1.00	6.63	2.25	0.22	0.29	2.3	212	1.6
19	0.25	0.25	0.25	0.25	1.00	4.89	1.93	0.18	0.28	1.8	212	1.2
20	0.25	0.25	0.25	0.25	1.00	3.15	1.60	0.14	0.27	1.3	212	0.9
21	0.25	0.25	0.25	0.25	1.00	1.42	1.28	0.10	0.26	0.8	212	0.5
22	0.25	0.25	0.25	0.25	1.00	1.44	1.38	0.09	0.24	0.8	212	0.5
23	0.25	0.25	0.25	0.25	1.00	1.46	1.48	0.09	0.22	0.8	212	0.5
24	0.25	0.25	0.25	0.25	1.00	1.48	1.58	0.09	0.20	0.8	212	0.6
25	0.25	0.25	0.25	0.25	1.00	1.51	1.68	0.09	0.19	0.9	212	0.6
26	0.25	0.25	0.25	0.25	1.00	1.53	1.77	0.09	0.17	0.9	212	0.6
27	0.25	0.25	0.25	0.25	1.00	1.55	1.87	0.09	0.15	0.9	212	0.6
28	0.25	0.25	0.25	0.25	1.00	1.57	1.97	0.09	0.13	0.9	212	0.6
29	0.25	0.25	0.25	0.25	1.00	1.59	2.07	0.09	0.11	1.0	212	0.6
30	0.25	0.25	0.25	0.25	1.00	1.62	2.17	0.09	0.10	1.0	212	0.7
31	0.25	0.25	0.25	0.25	1.00	1.62	2.05	0.10	0.10	1.0	212	0.6
32	0.25	0.25	0.25	0.25	1.00	1.63	1.92	0.11	0.10	0.9	212	0.6
33	0.25	0.25	0.25	0.25	1.00	1.64	1.80	0.13	0.10	0.9	212	0.6
34	0.25	0.25	0.25	0.25	1.00	1.65	1.68	0.14	0.11	0.9	212	0.6
35	0.25	0.25	0.25	0.25	1.00	1.66	1.56	0.15	0.11	0.9	212	0.6
36	0.25	0.25	0.25	0.25	1.00	1.67	1.44	0.17	0.11	0.8	212	0.6
37	0.25	0.25	0.25	0.25	1.00	1.68	1.32	0.18	0.11	0.8	212	0.6
38	0.25	0.25	0.25	0.25	1.00	1.69	1.20	0.20	0.12	0.8	212	0.5
39	0.25	0.25	0.25	0.25	1.00	1.70	1.08	0.21	0.12	0.8	212	0.5
40	0.25	0.25	0.25	0.25	1.00	1.71	0.96	0.22	0.12	0.8	212	0.5
41	0.25	0.25	0.25	0.25	1.00	1.72	0.84	0.24	0.12	0.7	212	0.5
42	0.25	0.25	0.25	0.25	1.00	1.73	0.72	0.25	0.12	0.7	212	0.5
43	0.25	0.25	0.25	0.25	1.00	1.73	0.60	0.26	0.13	0.7	212	0.5
44	0.25	0.25	0.25	0.25	1.00	1.74	0.48	0.28	0.13	0.7	212	0.4
45	0.25	0.25	0.25	0.25	1.00	1.64	0.55	0.27	0.13	0.6	212	0.4
46	0.25	0.25	0.25	0.25	1.00	1.54	0.62	0.26	0.13	0.6	212	0.4
47	0.25	0.25	0.25	0.25	1.00	1.43	0.68	0.25	0.14	0.6	212	0.4
48	0.25	0.25	0.25	0.25	1.00	1.33	0.75	0.24	0.14	0.6	212	0.4
49	0.25	0.25	0.25	0.25	1.00	1.22	0.82	0.23	0.14	0.6	212	0.4
50	0.25	0.25	0.25	0.25	1.00	1.12	0.89	0.22	0.14	0.6	212	0.4
51	0.25	0.25	0.25	0.25	1.00	1.01	0.96	0.21	0.14	0.6	212	0.4
52	0.25	0.25	0.25	0.25	1.00	0.91	1.02	0.20	0.15	0.6	212	0.4
53	0.25	0.25	0.25	0.25	1.00	0.81	1.09	0.19	0.15	0.6	212	0.4
54	0.25	0.25	0.25	0.25	1.00	0.70	1.16	0.18	0.15	0.5	212	0.4
55	0.25	0.25	0.25	0.25	1.00	0.60	1.23	0.18	0.15	0.5	212	0.4
56	0.25	0.25	0.25	0.25	1.00	0.49	1.30	0.17	0.15	0.5	212	0.4
57	0.25	0.25	0.25	0.25	1.00	0.39	1.37	0.16	0.16	0.5	212	0.3
58	0.25	0.25	0.25	0.25	1.00	0.39	1.37	0.16	0.16	0.5	212	0.3
59	0.25	0.25	0.25	0.25	1.00	0.39	1.37	0.16	0.16	0.5	212	0.3
60	0.25	0.25	0.25	0.25	1.00	0.39	1.37	0.16	0.16	0.5	212	0.3
												159
											Emission Factor (#/ton)	1.5

Figure 3. Simulated VOC Emissions Profile.



Summary

An independent analysis of the Modesto flux data as supplied in the CE Schmidt Technical Memorandum was conducted. The emission estimate reported in the CIWMB report could not be duplicated, and the differences in assumptions, especially those that may be more significant have been identified and discussed. All things considered, the independent recalculation of the Modesto site emission factors are surprisingly similar to the CIWMB emission factors. This recalculation, again considering the differences and the similarity of the independently derived emission factors indicates that:

- Assumptions thought to be significant probably have less of an influence on the emission factor development process;

- The similarity in the emission factor estimates clearly establishes the ‘ball park’ for greenwaste emissions as those representing a site complying with a given site operations plan with regular maintenance and inspection. In other words, these data may represent sites that are capable of maintaining lower VOC emissions while producing an acceptable compost product.

- Given that the accuracy and precision specifications for flux chamber testing with GC analysis is +/- 50%, the data should be viewed as stated below:
    - 0.7 +/- 0.35 Range is 0.35 #/ton to 1.1 #/ton
    - 1.5 +/- 0.75 Range is 0.75 #/ton to 2.3 #/ton

- Note that these ranges overlap indicating no statistical difference in the numbers (0.7 and 1.5)

- Emission factors for the other test piles are not offered at this time.

Appendix C
Technical Memorandum
Site X Emission Report

Technical MEMORANDUM

Environmental Management Consulting
41125 278th Way SE, Enumclaw, WA 98022 USA
Phone: 360-802-5540 Fax: 360-802-5541
E-Mail: trcard@earthlink.net

TO: [redacted]

COPY: Chuck Schmidt

FROM: Tom Card

DATE: April 24, 2008

SUBJECT: Compost Emissions Source Test
Preliminary Results

A preliminary analysis has been made for your site emissions and this memo presents those results. The results are not final yet, but we are not expecting any dramatic changes. However, do not make important decisions regarding these results until they are finalized.

Table 1 summarizes the results for you site and Table 2 provides comparison data (windrow emissions only) from the SCAQMD and a site similar to yours (that must remain confidential). You are about twice the SCAQMD number for VOC and about four times for ammonia. However, you are lower in VOC than a similar tested site. Figure 1 shows the emissions profile for a typical windrow.

One of our concerns regarding the data set is that the flow rate through the flux chambers was about five times higher than we would expect. This is likely due to the wind speed. Unfortunately your site is located in a high wind area and there is not much that can be done to mitigate wind speed.

Table 3 is a list of assumptions made about your operation that have a direct bearing on the emissions estimate. Please review these assumptions and correct them where appropriate.

Table 1. Preliminary Results

	Emissions (pounds per ton received)	
Source	**VOC**	**Ammonia**
Receiving Stockpile	7.76	0.03
Windrows	6.30	2.34
Total	14.06	2.37

Table 2. Comparative Results (Windrow only)

	Emissions (pounds per ton received)	
Source	**VOC**	**Ammonia**
Site X	6.30	2.34
SCAQMD	3.80	0.50
Site Z	[redacted]	

Figure 1. Emissions Profile

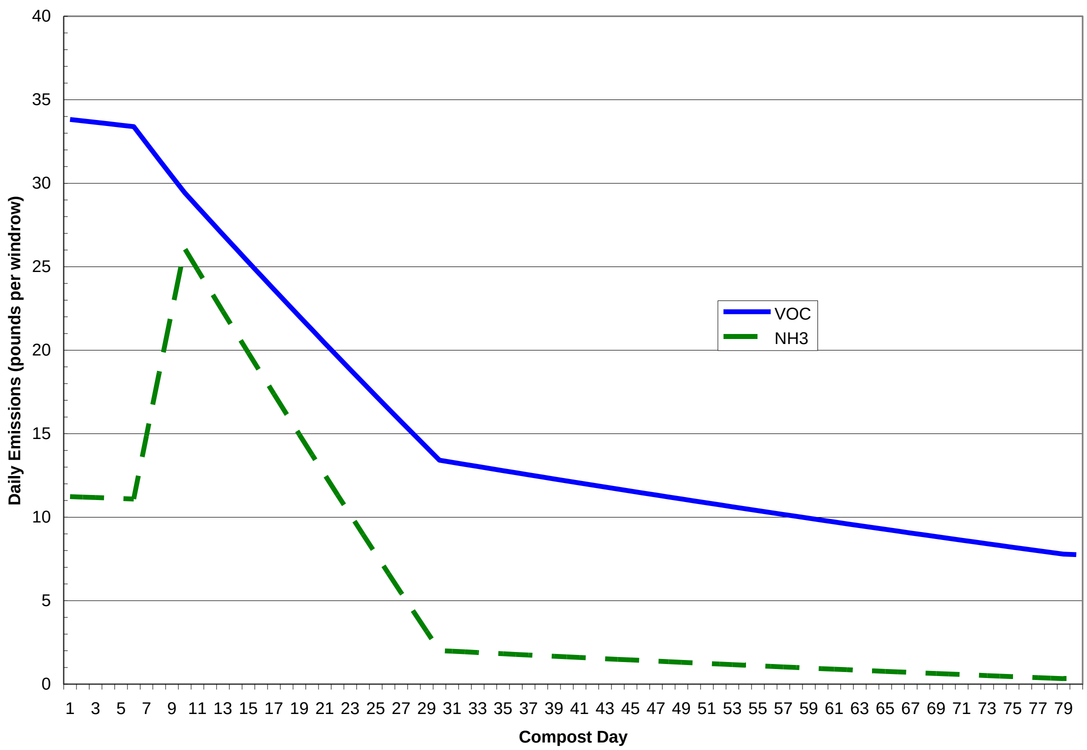


Table 3. Key Assumptions

Item	Value	Units
Average daily throughput	356	Tons
Stockpile density	800	#/yd3
Average stockpile duration	45	days
Mass in windrow	200	tons
Compost cycle duration	80	days

CE Schmidt, Ph.D.
Environmental Consultant

TECHNICAL MEMORANDUM

FLUX CHAMBER SOURCE TESTING OF FUGITIVE AIR EMISSIONS FROM SITE X COMPOST FACILITY

Prepared By:

Mr. Tom Card
Environmental Management Consulting
41125 278th Way SE
Enumclaw, WA 98022

Dr. C.E. Schmidt
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19200 Live Oak Road
Red Bluff, California 96080

May 7, 2008

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Field measurements were conducted at the Site X compost facility located in the California Central Valley. Testing was conducted on the pre-compost windrow and compost windrow area sources on site for the purpose of assessing total volatile organic compound (VOC- expressed as total non-methane non-ethane organic compounds by SCAQMD Method 25.3) emissions and ammonia emissions from the composting of greenwaste on site. Although the scope of work was limited by comparison to a full life-cycle emissions assessment, these data provide a good estimate of process emissions as tested.

The testing was conducted on March 10, 2008; the one-day testing effort was conducted on a day with winds running about 13 mph to 14 mph for the duration of the testing activities. Because most information points toward higher air emissions during windy conditions, it is possible that the measured flux data and thus site emission data were influenced by the higher winds resulting in a higher air emissions estimate.

The data collection approach included using the USEPA-recommended flux chamber modified as per the SCAQMD Rule 1133 as approved by recent method improvements, and standard air sample collection methods for VOCs or reactive organic gases, and ammonia. This approach provided data of high quality (accuracy and precision) representative of air emissions of study compounds from the organic composting process and the greenwaste static pile windrow composting process. The testing was scheduled so that fugitive air emissions could be measured at key times in the composting processes studied. The organic composting system was evaluated by collecting fugitive emission samples from the following area sources:

GREENWASTE COMPOSTING OPERATION

Feedstock as received and aged	Not tested
Compost Day 0	2 Flux tests, (T1, S2)
Compost Day 6	2 Flux tests, (T1, S1)
Compost Day 10	4 Flux tests, (T1, T2, S1, S2)
Compost Day 10, 1-hr post mixed	2 Flux tests, (T1, S1)
Compost Day 10, 3-hr post mixed	2 Flux tests, (T1, S1)
Compost Day 10, 5-hr post mixed	2 Flux tests, (T1, S1)

Compost Day 30	2 Flux tests, (T1, S1)
Compost Day 79	2 Flux tests, (T1, S1)
Blank testing	1 Flux test
Replicate testing	1 Flux test
TOTAL	20 Flux tests

Testing was conducted using the USEPA surface emission isolation flux chamber, real time detection for ammonia (screening-level analysis), SCAQMD Method 25.3 for total VOCs, and SCAQMD Method 207.1 for ammonia. The assessment of the test surfaces included screening using real time detection in the field (colorometric tubes for ammonia), and flow conditions in the flux chamber as a result of advective flow from the area sources tested. Advective flow from the windrow composting (gas production and wind) was quantitatively assessed by using a tracer gas (10% helium) in the flux chamber, gas collection in evacuated stainless steel canisters, and analysis off site by gas chromatography/thermal conductivity detection (GC/TCD). The dilution of helium was used to calculate advective flow, and these data were used in the calculation of compound emissions from the test sources.

Note that the recommended SCAQMD method bias factor correction of 1.086 was not applied to these data. There is no scientific justification for applying a specific bias correction factor generated from one laboratory to another laboratory, since a given analytical method bias is unique to that laboratory and not intrinsic to the method.

The data tables generated and reported in this document describe the fugitive air emission from the sources tested on site. These flux data, combined with engineering data that describes the composting operations, can be used to generate a facility emission factor data base and a facility baseline emission estimate for total VOCs and ammonia. The engineering estimate for VOC and ammonia emissions is reported elsewhere.

I. INTRODUCTION

This technical memorandum describes the field testing that was conducted in order to assess air emissions of ammonia, and VOC air emissions from the Site X greenwaste compost facility. Testing was conducted by Dr. C.E. Schmidt , Mr. Tom Card, and Ms. Katie Schmidt on March 10, 2008. Site preparation included arranging for the test piles and providing access to the facility.

The objective of the study was to provide representative, fugitive air emissions of study compounds from the purpose of generating ammonia and VOC emission estimates from the composting of greenwaste at the facility. This was accomplished by selecting representative test locations, and quantitative analysis of air emissions producing representative average air emissions data.

This memorandum includes a discussion of the testing methodology, quality control procedures, results, discussion of the results, and summary statements.

II. TEST METHODOLOGY

Testing for surface flux was conducted using the USEPA recommended Surface Isolation Flux Chamber (USEPA. Radian Corporation, February 1986). Flux chamber sampling was performed on static windrow piles of greenwaste materials as found on site the day of testing.

The operation of the surface flux chamber is given below:

1) Flux chamber, sweep air, sample collection equipment, and field documents were located on-site.

2) The site information, location information, equipment information, date, and proposed time of testing were documented on the Emissions Measurement Field Data Sheet.

3) The exact test location was selected and placed about 0.25" to 0.5" into compost matrix sealing the chamber for surface testing, or on the agricultural bag positioned to achieve a chamber/interface seal. .

4) The sweep air flow rate (ultra high purity air with a carbon monoxide tracer gas additive) was initiated and the rotometer, which stabilizes the flow rate, was set at 5.0 liters per minute. A constant sweep air flow rate was maintained throughout the measurement for each sampling location.

5) Flux chamber data were recorded every residence interval (6 minutes) for five intervals, or 30 minutes.

6) At steady-state (assumed to be greater than 5 residence intervals), the screening by colorimetric tube and real-time instrument was performed. After screening, sample collection was performed by interfacing the sample container (acid impinger, trap and canister, and tedlar bag (if scheduled) sequentially) to the purged, sample line and filling the container with sample gas or collecting the desired sample following sample collection protocols as per the work plan.

7) After sample collection (impinger solution, trap and evacuated canister, and tedlar bag) all sample media was sealed, labeled, and stored as per protocol, and sample collection information was documented on the data sheet.

8) After sampling, the flux measurement was discontinued by shutting off the sweep air,

removing the chamber, and securing the equipment. The chamber was cleaned by dry wipe with a clean paper towel and the sample lines were purged with UHP air.

9) Sampling locations were recorded on the field data sheet. The equipment was then relocated to the next test location and steps 1) through 8) were repeated.

III. QUALITY CONTROL

Control procedures that were used to assure that data of sufficient quality resulted from the flux chamber study are listed and described below. The application and frequency of these procedures were developed to meet the program data quality objectives as described in SCAQMD Rule 1133a with some modifications.

Field Documentation -- A field notebook containing data forms, including sample chain-of-custody (COC) forms, was maintained for the testing program. Attachment A contains the Emission Measurement Data Sheets.

Chain-of-Custody -- COC forms were not used for field data collection. Field data were recorded on the Chain-of-Custody forms provided in Attachment B.

Ammonia Analysis by SCAQMD Method 207.1

Laboratory Spike Recovery- One laboratory spike sample was performed and the recovery of the spike was 101%. These data indicate acceptable method performance.

Calibration – A five point calibration curve was performed for the ammonia method, and the correlation curve was reported within method specification. These data indicate acceptable method performance.

Trip Blank—One trip blank sample was collected and the level reported was <0.004 mg per sample (MDL 0.004 mg) or below method detection. These data indicate acceptable method performance.

Field Replicate Sample Analysis -- One field sample was collected in replicate and analyzed for the project. The RPD values for sample/replicate pair was 12 (QC criteria 50 RPD). These data indicate acceptable method repeatability and method performance.

Total Non-Methane and Non-Ethane Organic Compound Analysis by SCAQMD Method 25.3

Method Quality Control –Method quality control included method blank determinations, and method response to four-point calibration curves. All method QC testing was with method specifications, and these data indicate acceptable method performance.

Field System Blank – One blank samples was analyzed as blind QC sample. TNMNEO levels in the blank sample were less that <1.0 ppmvC for the condensable, volatile and total hydrocarbon analysis (method detection limit 1 ppmvC). These data establish sensitivity for the method (project QC criteria), and indicate acceptable method performance.

Field Replicate Sample – One field sample was collected and analyzed in replicate. In this data set, study compounds detected showed precision within precision criteria for field samples (RPD 50) for the TNMNEO or total VOC concentration. The RPD for the data set was 9.0 indicating acceptable method precision and performance.

Tracer Helium Analysis by GC/TCD

Laboratory Control Spike and QC Duplicate Analysis- Laboratory control spike sample data are not available at this time.

Laboratory Precision– Laboratory QC sample data are not available at this time.

Tracer Recovery Sample- One media blank sample was collected in the field by filling a canister for analysis in order to determine tracer recovery apart from the flux measurement technology or the advective flow from sources. The tracer was recovered from the media blank samples with a value of 105% (QC criteria $\pm$50%, or 50% to 150% recovery). These data indicate acceptable method performance.

Field Replicate Sample – One field sample was collected in replicate. The precision (relative percent difference) for the field replicate sample pair was 0.0, which is less than the QC criteria of 50 RPD. These data indicate acceptable method performance.

IV. RESULTS AND DISCUSSIONS

A summary of the field sample collection for the field testing is shown in Table 1. All field data for the on site surface flux chamber testing (screening for ammonia, temperature), and sample identification information are presented in Table 1. All laboratory data including quality control data are presented in Table 2. These flux data include measured advective flow rate in the flux calculation. Surface flux data are shown in flux units for hydrocarbon emissions (mg/m2,min-1 as methane, ppmvC) and for ammonia (mg/m2,min-1 as ammonia).

Surface flux data for a surface area source are calculated using measured target compound concentrations and flux chamber operating parameter data (sweep air flow rate of 5.0 liters per minute [or 0.005 m3/min] plus advective flow [m3/min], surface area of 0.13 square meters [m^2]). The site emissions can be calculated by multiplying the flux by the surface area of the source. The flux is calculated from the sweep air flow rate Q (cubic meters per minute [m^3/min]), the species concentration Yi (micrograms per cubic meter [mg/m^3)], and exposure to the chamber surface area A (square meters [m^2]), as follows:

$$Fi = (Q)\ (Yi)\ /\ (A)$$

Emission rate of from a given static windrow test pile can be calculated by multiplying unit or average flux data per compound by surface area and reported as a function of area source.

Note that the recommended SCAQMD method bias factor correction of 1.086 was not applied to these data. There is no scientific justification for applying a specific bias correction factor generated from one laboratory to another laboratory, since a given analytical method bias is unique to that laboratory and not intrinsic to the method.

V. SUMMARY

Emission testing was performed on the Site X static windrow, greenwaste compost operations in order to generate an estimate of the facility baseline emissions for VOCs and ammonia. Testing was conducted at key times (compost at different age and under different conditions) in the compost cycle for the purpose of obtaining representative air emissions of ammonia and VOCs from the test piles. The following is a summary of activities and results associated with this objective:

- Surface flux measurements of study compounds were measured on static windrow piles in the compost cycle, from the pre-compost windrow piles to near the end-of-cycle compost (Day 79). Testing was performed using the USEPA recommended surface flux chamber technology as modified by the SCAQMD for advective flow sources at compost sites. This technology quantitatively measures flux at the test surface of study compounds.

- Field and laboratory quality control data indicate acceptable data quality for SCAQMD Method 207.1 (ammonia) and SCAQMD Method 25.3 (organic gases). System blank levels were acceptable, and precision between a sample and replicate field samples was within the RPD criteria of 50. The recovery of the helium tracer QC showed acceptable method performance, and the use of the helium recovery data per sample demonstrated to be a effective and representative approach to assessing volumetric flow from the sources tested.

- Note that the recommended SCAQMD method bias factor correction of 1.086 was not applied to these data. There is no scientific justification for applying a specific bias correction factor generated from one laboratory to another laboratory, since a given analytical method bias is unique to that laboratory and not intrinsic to the method.

- The wind speeds experienced on the day of testing may have affected the emission estimate. It is believed that higher winds generate higher flux and thus air emissions. The winds on the day of testing ranged from 13 mph to 14 mph. This is a high wind area, however, using these test data to represent an annual emissions estimate may result in a bias in the emissions.

- Two samples were collected on a ‘pre-compost’ windrow, meaning that material prepared composting was tested and the pile was not yet included in the life-cycle process. Data from this ‘front-end’ area source, although small in surface area, was used to represent greenwaste material on site prior to entering the composting operations, including the tipping piles, screening piles, and storing piles.

- The flux data can be used to estimate ammonia, and VOC emissions from the test pile surfaces. Emission rate data is obtained by multiplying surface areas of the test piles by the surface area of the test piles.

REFERENCES

USEPA. 1986. "Measurement of Gaseous Emission Rates From Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide." EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA Contract No. 68-02-3889, Work Assignment No. 18, Radian Corporation, February 1986. NTIS # PB 86-223161.

Table 1. Summary of Test Information.

DATE	TIME	SOURCE	COMPOST	Section	TEST LOCATION	NH3	Helium	TRACER	25.3	207.1	IN SURF	IN AIR	OUT SURF	OUT AIR	WINDS	COMMENT
			DAY	PILE		(ppmv)	(%)	SF6	ID	ID	°F	°F	°F	°F	(mph)	
3/10/2008	941	Windrow Compost	10	D-16	Top- T1	10	10.31	1.046	G-101	A-101	63	83	63	61	13	Mixed and water added 3 days prior, pile 4.5' tall, 10' base
3/10/2008	942	Windrow Compost	10	D-16	Top-T2	12	10.22	1.049	G-102	A-102	89	95	84	61	13	Mixed and water added 3 days prior
3/10/2008	942	Windrow Compost	10	D-16	Side- S1	12	10.20	1.058	G-103	A-103	66	92	66	66	13	Mixed and water added 3 days prior
3/10/2008	943	Windrow Compost	10	D-16	Side- S2	4	10.33	1.042	G-104	A-104	58	75	58	62	13	Mixed and water added 3 days prior
3/10/2008	1136	Windrow Compost	6	D-18	Top- T1	28	10.33	1.042	G-105	A-105	64	100	64	68	13	
3/10/2008	1139	Windrow Compost	6	D-18	Side- S1	2	10.31	1.046	G-106	A-106	62	90	62	68	13	
3/10/2008	1144	Windrow Compost- Post Mix Hr-1	10	D-16	Top- T1	8	10.20	1.058	G-107	A-107	66	92	66	70	13	Mixed at 1107
3/10/2008	1148	Windrow Compost- Post Mix Hr-1	10	D-16	Side- S1	12	10.22	1.049	G-108	A-108	125	95	125	68	13	Mixed at 1107
3/10/2008	1250	Windrow Compost- Post Mix Hr-3	10	D-16	Top- T1	10	10.20	1.058	G-111	A-111	65	84	65	76	14	Mixed at 1107
3/10/2008	1343	Windrow Compost- Post Mix Hr-3	10	D-16	Side- S2	20	10.22	1.049	G-112	A-112	60	90	60	77	14	Mixed at 1107
3/10/2008	1351	Windrow Compost	30	E-7	Top- T1	8	10.33	1.042	G-109	A-109	60	104	60	76	ND	Pile 4' tall, 10' wide base
3/10/2008	1351	Windrow Compost	30	E-7	Side- S1	6	10.31	1.046	G-110	A-110	62	92	62	77	ND	
3/10/2008	1535	Windrow Compost- Post Mix Hr-5	10	D-16	Top- T1	8	10.20	1.058	G-113	A-113	63	80	63	75	ND	Mixed at 1107
3/10/2008	1537	Windrow Compost- Post Mix Hr-5	10	D-16	Side-2	16	10.22	1.049	G-114	A-114	66	86	66	77	ND	Mixed at 1107
3/10/2008	1548	Windrow Compost	79	B-10	Top- T1	4	10.31	1.046	G-115	A-115	64	93	64	75	ND	Pile 3.5' tall and 9 ' wide base
3/10/2008	1549	Windrow Compost	79	B-10	Side- S2	2	10.33	1.042	G-116	A-116	70	81	70	76	ND	
3/10/2008	1707	Windrow Compost- Prep Pile	0	C-12	Top- T1	<0.05	10.20	1.058	G-117	A-117	72	82	72	78	ND	
3/10/2008	1715	Windrow Compost- Prep Pile	0	C-12	Side- S1	1	10.20	1.058	G-118	A-118	74	79	74	78	ND	
3/10/2008	1715	Sample Replicate	0	C-12	Side- S1	1	10.20	1.058	G-119	A-119	74	79	74	78	ND	Sample Replicate
3/10/2008	1715	Media Blank	N/A	N/A	N/A	N/A	10.20	1.058	G-120	A-120	N/A	N/A	N/A	N/A	NA	Reagent Blank

Table 2. Summary of Flux Data (mg/m2,min-1).

SOURCE	COMPOST	TEST LOCATION	25.3	207.1	Methane	Ethane	TNMNEO	NMNEO Trap	NMNEO Tank	NH3	NH3 Vol	NH3	Helium
	DAY		ID	ID	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(mg)	(m3)	(mg/m3)	%
Windrow Compost	10	Top- T1	G-101	A-101	27.4	ND	**12.2**	6.06	6.12	0.365	0.0295	12.4	10.31
Windrow Compost	10	Top-T2	G-102	A-102	16.7	ND	**11.8**	11.2	1.0	0.489	0.0268	18.2	10.22
Windrow Compost	10	Side- S1	G-103	A-103	93	ND	**21.0**	20.1	1.0	0.278	0.0282	9.9	10.20
Windrow Compost	10	Side- S2	G-104	A-104	17.2	ND	**4.25**	3.58	1.0	0.055	0.0248	2.2	10.33
Windrow Compost	6	Top- T1	G-105	A-105	10	ND	**17.7**	17.2	1.0	0.505	0.0311	16.2	10.33
Windrow Compost	6	Side- S1	G-106	A-106	65	ND	**9.94**	9.37	1.0	0.029	0.0303	0.96	10.31
Windrow Compost- Post Mix Hr-1	10	Top- T1	G-107	A-107	14.9	ND	**5.62**	4.89	1.0	0.113	######	3.8	10.20
Windrow Compost- Post Mix Hr-1	10	Side- S1	G-108	A-108	65.7	ND	**10.6**	9.45	1.14	0.239	0.0332	7.2	10.22
Windrow Compost- Post Mix Hr-3	10	Top- T1	G-111	A-111	11.5	ND	**5.77**	5.23	1.0	0.123	0.0271	4.5	10.20
Windrow Compost- Post Mix Hr-3	10	Side- S2	G-112	A-112	48.7	ND	**7.15**	5.65	1.49	0.202	0.0254	8.0	10.22
Windrow Compost	30	Top- T1	G-109	A-109	58.3	ND	**5.97**	5.57	1.0	0.050	0.0130	3.8	10.33
Windrow Compost	30	Side- S1	G-110	A-110	574	ND	**6.65**	5.82	1.0	0.002	0.0103	0.19	10.31
Windrow Compost- Post Mix Hr-5	10	Top- T1	G-113	A-113	19.3	ND	**3.91**	3.34	1.0	0.089	0.0231	3.9	10.20
Windrow Compost- Post Mix Hr-5	10	Side-2	G-114	A-114	42.0	ND	**5.19**	4.14		0.163	0.0219	7.4	10.22
Windrow Compost	79	Top- T1	G-115	A-115	100	ND	**5.41**	2.91		0.011	0.0587	0.19	10.31
Windrow Compost	79	Side- S2	G-116	A-116	79.60	ND	**5.70**	4.27		0.009	0.0588	0.15	10.33
Windrow Compost- Prep Pile	0	Top- T1	G-117	A-117	2.13	ND	**27.6**	27.6	1.0	0.004	0.0509	0.08	10.20
Windrow Compost- Prep Pile	0	Side- S1	G-118	A-118	47.20	ND	**116**	115	1.0	0.013	0.0512	0.25	10.20
Sample Replicate	0	Side- S1	G-119	A-119	46.70	ND	**106**	105	1.0	0.013	0.0605	0.21	10.20
Media Blank	N/A	N/A	G-120	A-120	1.0	ND	**1.0**	1.0	1.0	0.004	0.0540	0.074	10.20

Flux Unit: mg/m2,min-1

Note 1- Methane Flux = (CH4 ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 CH4

Note 2- TNMNEO Flux = (TNMNEO ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 TNMNEO

Note 3- Ammonia Flux = (NH3 mg/m3)(m3/min)/(0.13 m2) = mg/m2,min-1 NH3

Note 4- Total Flow = (Helium %/Helium % recovered)(0.005 m3/min) = m3/min total flow

Note 5- MDL value used for ND or non-detect for calcuation purposes

Table 2. Summary of Flux Data (mg/m2,min-1).

Trace	Total Flow	SF6 UHP	SF6 Detect	Methane	TNMNEO	NH3	SOURCE	TEST LOCATION	COMPOST	COMMENT
%	(m3/min)	(ppbv)	(ppbv)	Flux	Flux	Flux			DAY	
0.20	0.2578	N/A	N/A	35.47	**16**	**25**	Windrow Compost	Top- T1	10	
0.27	0.1893	N/A	N/A	15.88	**11**	**27**	Windrow Compost	Top-T2	10	
0.23	0.2217	N/A	N/A	103.58	**23**	**17**	Windrow Compost	Side- S1	10	
0.19	0.2718	N/A	N/A	23.49	**5.8**	**4.6**	Windrow Compost	Side- S2	10	
0.27	0.1913	N/A	N/A	9.49	**17**	**24**	Windrow Compost	Top- T1	6	
0.16	0.3222	N/A	N/A	105.52	**16**	**2.4**	Windrow Compost	Side- S1	6	
0.15	0.3400	N/A	N/A	25.45	**9.6**	**10**	Windrow Compost- Post Mix Hr-1	Top- T1	10	
0.19	0.2689	N/A	N/A	88.76	**14**	**15**	Windrow Compost- Post Mix Hr-1	Side- S1	10	
0.12	0.4250	N/A	N/A	24.55	**12**	**15**	Windrow Compost- Post Mix Hr-3	Top- T1	10	
0.16	0.3194	N/A	N/A	78.13	**11**	**20**	Windrow Compost- Post Mix Hr-3	Side- S2	10	
0.28	0.1845	N/A	N/A	54.02	**5.5**	**5.5**	Windrow Compost	Top- T1	30	
0.24	0.2148	N/A	N/A	619.30	**7.2**	**0.32**	Windrow Compost	Side- S1	30	
0.12	0.4250	N/A	N/A	41.20	**8.3**	**13**	Windrow Compost- Post Mix Hr-5	Top- T1	10	
0.18	0.2839	N/A	N/A	59.89	**7.4**	**16**	Windrow Compost- Post Mix Hr-5	Side-2	10	
0.47	0.1097	N/A	N/A	55.09	**3.0**	**0.16**	Windrow Compost	Top- T1	79	
0.30	0.1722	N/A	N/A	68.84	**4.9**	**0.20**	Windrow Compost	Side- S2	79	
0.19	0.2684	N/A	N/A	2.87	**37**	**0.16**	Windrow Compost- Prep Pile	Top- T1	0	Representative of Tipping Pile/Pre Pile
0.16	0.3188	N/A	N/A	75.57	**186**	**0.62**	Windrow Compost- Prep Pile	Side- S1	0	
0.16	0.3188	N/A	N/A	74.77	**170**	**0.53**	Sample Replicate	Side- S1	0	
10.7	0.005	N/A	N/A	0.025	**0.025**	**0.0028**	Media Blank	N/A	N/A	105 Percent Recovery of He Tracer

MDL Value Used

Note 1- Methane Flux = (CH4 ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 CH4
Note 2- TNMNEO Flux = (TNMNEO ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 TNMNEO
Note 3- Ammonia Flux = (NH3 mg/m3)(m3/min)/(0.13 m2) = mg/m2,min-1 NH3
Note 4- Total Flow = (Helium %/Helium % recovered)(0.005 m3/min) = m3/min total flow
Note 5- MDL value used for ND or non-detect for calcuation purposes

ATTACHMENT A

EMISSION MEASUREMENT DATA SHEETS

ATTACHMENT B

CHAIN OF CUSTODY

CE Schmidt, Ph.D.
Environmental Consultant

ATTACHMENT C

LABORATORY REPORTS

Appendix B

Comments and Responses to the "Organic Material Composting and Drying focusing on Greenwaste Compost Air Emissions Data Review"

Responses to Comments on the document entitled "Organic Material Composting and Drying focusing on Greenwaste Compost Air Emissions Data Review", by Thomas R. Card and Charles E. Schmidt, June 2008. This report will be referred to as the "green waste report" hereafter within this document.

Summary of comments from Center on Race, Poverty and the Environment (CRPE) / Committee for a Better Arvin:

CRPE 1: The CIWMB Modesto Study should be excluded from consideration because it did not include emissions from the stockpiles.

Response: The green waste report included separate VOC emission factors for the windrows and the stockpiles. The report averaged the measurement results for each of these two processes separately. The CIWMB Modesto Study measurement was used only in developing the windrow VOC emission factor. The lack of a stockpile emission factor from this study does not affect the VOC emission factor for the windrows.

CRPE 2: The CIWMB Modesto Study should be excluded from consideration because the results are not replicable.

Response: This comment is based on Schmidt's recalculation of the results, and his conclusion that the published results of the Modesto Study are incorrect. The District has reviewed Dr. Schmidt's recalculation, and has determined that there is not enough justification within the analysis to support the recalculation of previously published study results. Therefore, the District will use the originally published emission factor of 0.8 to 0.9 lb-VOC/ton.

CRPE 3: The CIWMB Modesto Study should be excluded from consideration because it did not account for the effect of wind on emissions.

Response: The studies that were chosen for inclusion in the green waste report were the studies that were found to be the most complete and valid for the purpose of generating VOC emission factors for composting operations. Conditions during emission measurements at each of the study sites were representative of conditions during actual operations. It is not possible to determine if wind is expected to have a significant effect on the VOC emission rates or adjust measured emission rates without full speciation of the compounds measured. The studies that were determined to be the most valid, including the CIWMB Modesto Study, used total VOC methods without speciation because total VOC methods have been found to capture a higher proportion of the total VOC emissions when compared to other methods. Additionally, there are currently no validated procedures to adjust the measured rates for differing wind velocities. In conclusion, the District is using the most complete scientific data available to update the composting emission factor. As with other emission factors, the proposed composting VOC emission factor will be periodically updated to incorporate if new scientific information indicates that revisions may be necessary.

CRPE 4: None of the three studies relied upon were conducted during the hotter months in the Central Valley. The Modesto report was conducted between October and December, some of the coldest months of the year in the Central Valley. The studies may underestimate emissions because they did not account for the high summer temperatures common in the Central Valley.

Response: As stated above, the studies that were chosen were the studies that were found to be the most complete and valid for the purpose of generating emission factors.

In regards to the comment that the testing for the Modesto report was conducted in the coldest part of the year, records indicate that the coldest months in the Central Valley are December-February and that the average temperature for October is actually higher than both March and April. It must also be noted that the NorCal study was conducted during August in Vacaville, CA, and records indicate that the average summer temperatures in Vacaville are very similar to summer temperatures found in the Central Valley.

The annual compost VOC emission factor developed from the studies are intended to be representative of average annual emissions rather than peak daily emissions. The studies that were determined to be suitable for developing VOC emission factors are actually very representative of seasonal variation throughout the year with testing performed in the spring (Site X testing in March), autumn to early winter (CIWMB, Modesto testing in October - December), and summer (NorCal testing in August).

Summary of Comments from ERM on behalf of Norcal Waste Systems, Inc. Note that this letter includes comments on both the emission factor report and the rulemaking process. Only those comments on the emission factor report are presented here:

ERM 1: The data is limited.

Response: The District agrees that the data is limited, but the purpose of this report was to find all studies that were robust enough to be considered useful in determining an emission factor. The resulting emission factor is based on the best science available at the time.

ERM 2: Limited duration of testing. Site X only one day of testing. Also, Modesto study was recalculated, and did not include stockpiles.

Response: Regarding the one day of testing at Site X: While all sampling was conducted on one day, piles of different ages were sampled in order to obtain flux measurements throughout the life of a pile. Regarding the recalculation of the Modesto Study and lack of stockpile emissions – see responses to CPRE comments 2 and 1, above.

ERM 3: The emissions data are extremely variable. There appeared to be no attempt to account for temporal variations throughout the composting cycle in deriving "average" emission factors. There is insufficient documentation provided to allow for independent analysis of temporal or spatial factors as they relate to the reported flux rates.

Response: The District agrees that there were limited data available that were complete and valid for developing emission factors given the variability of the source. However, the resulting emission factor is based on the best science available at the time. Each individual study used in the report accounted for the variation throughout the composting process. The individual emission factors from each study referenced in the report were developed from emission measurements for different stages throughout complete composting cycle at each site. Additional information on the time and location of emission measurements is available in the original study reports referenced.

ERM 4: The data from the green waste report should not be averaged for the purpose of developing emission factors for regulatory purposes.

Response: The average emission factors are based on the best science available at the time for calculating VOC emissions from composting.

ERM 5: The data from the green waste report should not be averaged for the purpose of calculating annual emissions. There is insufficient documentation provided in the report to allow for an independent analysis of the data relative to the type of composting operation, throughput, size of piles, and length of composting cycle.

Response: See response to ERM comment 4, above. Additional information on each composting operation is available in the original study reports referenced.

ERM 6: The impact of compost process temperature on emissions should be considered. It is ERM's professional judgment that temperature variations relate more to the time in the composting cycle than seasonal variation in ambient temperature. No information was given in the green waste report as to the location of temperature measurements.

Response: The individual emission factors from each study referenced in the report were developed from emission measurements at different stages throughout the composting cycle at each site, which accounts for temperature variation of the piles during the composting process. Additional information on temperature measurements may be available in the original study reports referenced.

ERM 7: The emissions released during turning of windrows were not addressed in the green waste report.

Response: The District is not aware of any studies that measured emissions released during turning of windrows. If additional information becomes available on emissions released during turning of composting windrows, the District will review this information and incorporate it if appropriate. Based on discussions with Dr. Schmidt, elevated emissions have been measured from windrows immediately after turning but only for a few hours, at most, and would not be significant over the life cycle of well-managed composting operations.

ERM 8: Data presented for Site X as well as the South Coast Air Quality Management District (SCAQMD) data yielded higher emissions from stockpiles than from the windrows, which ERM considers unlikely.

Response: The District surveyed the green waste composting facilities in the San Joaquin Valley. The result of the survey indicates an average stockpile time of 3.85 days, and ranged from 0-21 days. The Site X stockpile EF was based on sampling at day 45, and is not representative of stockpiling in the San Joaquin Valley. The Site X stockpile test will not be included in the stockpile EF since it is not representative of SJV stockpiling. The SCAQMD stockpile data is considered as some of the most relevant green waste composting data available according to the green waste report. The SCAQMD samples were taken on a very representative day 2 stockpile. These emission measurements were conducted under conditions that were representative of conditions found during actual operations and are considered representative of emissions from these operations.

ERM 9: The green waste report states that the Norcal data exhibits a VOC "spike" in emissions during the first few days of composting. It is ERM's experience from green waste compost testing that this is very representative of the typical windrow composting emissions cycle. Source test documentation should be made available and analyzed systematically to ensure proper review of the test data and a statistical analysis of all test data should be performed.

Response: The District agrees that the measured emissions spike may be characteristic of some types of composting operations. Additional source test documentation may be available in the original study reports and from agencies that performed the studies.

ERM 10: The green waste report's conclusions are based on highly variable and extremely limited data. The green waste report only considered data that were measured using SCAQMD Method 25.3. Data collected by other methods may provide useful relative contributions from the different unit processes and temporal variability. A peer review of the NorCal report prior to issuance may have provided the opportunity to address some of the comments in this letter.

Response: The District agrees that there were limited data available for developing emission factors given the variability of the source. However, the resulting emission factor is based on the best science available at the time. SCAQMD Method 25.3 has been found to capture a higher proportion of the total VOC emissions than the other methods mentioned; therefore, this method was the most appropriate for development of VOC emissions factors. The District acknowledges that data collected by other methods may still be valuable for uses other than development of emission factors. The District agrees that peer review of reports can be valuable and is generally desirable when time and resource constraints allow. However, the NorCal report was created for another District, the Yolo-Solano APCD, and District source tests are typically not peer reviewed.

Summary of Comments from California Integrated Waste Management Board (CIWMB), now know as Department of Resources Recycling and Recovery (CalRecycle):

CIWMB 1: The green waste report states that the emission factors from each study are averaged for reference only with no implication that the average is representative of green waste compost emissions in the San Joaquin Valley. If the average is not representative of green waste compost emissions, it should not be displayed.

Response: The report does not state that the average emission factors are not representative of green waste compost emissions, but is based on a limited data set from studies suitable for developing emission factors. The average emission factors are presented for reference purposes, per District request, and are based on the best science available at the time to calculate annual emissions from green waste composting. The District will base the final EF on the average of valid, representative test data. As more relevant data becomes available, the EF should be adjusted accordingly.

CIWMB 2: The weighted average of the three studies based on number of samples presents a better starting point for negotiations of the green waste composting emissions factors.

Response: Each study at the different composting sites was found to have sufficient measurements for the purpose of generating valid emission factors; therefore, each study is weighted equally to capture the variability of composting operations. The District used the best scientific information available to develop the green waste composting emission factor and is willing to evaluate and discuss any additional scientific information presented related to the emission factor.

CIWMB 3: The report states "The data are even more diverse than this table may indicate." A reasonable interpretation of this comment and the one above is that there is too little data to formulate an emissions factor applicable to composting facilities in the San Joaquin Valley.

Response: The District understands this comment to refer to the variation in daily emissions throughout the composting cycle, which is not clearly evident when presenting the single overall emission factors for each site. This interpretation is supported by the fact that immediately after this comment the report refers to a figure showing daily compost windrow emissions. Also see responses to ERM comment 1, above.

<u>CIWMB 4:</u> The spike in VOC emissions at the NorCal site may be an outlier since it is based on one flux sample. The District and Dr. Schmidt should review the Day 3 NorCal sampling event to determine whether there are other confounding circumstances.

<u>Response:</u> Other composting studies have also shown an initial increase in emissions during the composting cycle (see referenced report on Tierra Verde Industries composting operation and ERM comment 7, above). There is no indication in the report that the measured emission point was an outlier and comparatively high emissions were also measured on day 6 of the composting operation.

<u>CIWMB 5:</u> Is Figure 2.1 based on actual measured data or is it figurative?

<u>Response:</u> Figure 2.1 of the report is based on actual data from the NorCal composting site.

<u>CIWMB 6:</u> Figure 2.2 appears to be identical to Figure ES 2 on page 4.

<u>Response:</u> The District agrees.

<u>CIWMB 7:</u> We question whether there is enough data to support the contention that smaller windrows increase emissions. It seems more reasonable that emissions will correlate with the amount of materials in the windrow and operational factors and this is the rationale for having an emissions factor. Assuming that similar materials have similar potential emissions, a smaller windrow might have higher emissions earlier in the process but these emissions should trail off more rapidly.

<u>Response:</u> The report states that "For the same unit surface flux rate, the smaller row will have twice the emissions on a per ton input basis." This is true. As long as the surface flux rates remain the same, smaller windrows will have greater emissions on a per ton basis. However, the District agrees that the flux rate for the smaller windrow would likely decline more rapidly resulting in similar emissions on a per ton basis.

<u>CIWMB 8:</u> We believe we can identify Site X and believe the site receives overflow green waste from San Francisco and the East Bay and may include some food waste. Therefore, it is possible that the Site X data is more representative of food waste composting than green waste composting.

<u>Response:</u> The technical memorandum for the study performed at Site X did not indicate that the composting piles that were tested at the site included food waste. The District's understanding is that the piles at Site X that were tested did not include food waste. The District but will evaluate any evidence that conclusively demonstrates that this was not the case at the time of testing.

<u>CIWMB 9:</u> The report states that the CIWMB Modesto study consisted of 36 measurements. The CIWMB Modesto data set consists of 100 flux chamber samples and 9 quality control samples.

Response: The District agrees that the complete CIWMB Modesto data set consists of 100 flux chamber samples, including emission measurements from green waste composting, food waste composting, composting with a pseudo-biofilter cover, and composting with chemical additives. Only the 36 emission measurements from uncontrolled green waste composting were considered in this section of the report since the purpose was to evaluate emissions studies for use in developing an emission factor for uncontrolled green waste composting.

CIWMB 10: The report states that there is no baseline data for food waste composting. The CIWMB Modesto study includes an emissions profile for an uncontrolled windrow of 85% green waste and 15% food waste.

Response: The District agrees that the CIWMB Modesto study may provide useful information on VOC emissions from composting operations that include some food waste.

CIWMB 11: We question the assumptions and procedures used to recalculate the emissions reported in the CIWMB Modesto study report.

Response: See response to CPRE comment 2, above.

CIWMB 12: Have the results of the emissions study test at Site X been finalized?

Response: These results have been finalized.

CIWMB 13: What is Site Z and why is that data blacked out?

Response: Site Z is a composting operation in California. The Green waste report only included data that was provided to the District. Site Z was not evaluated in the report because this information was not included in the composting emission studies provided to the District from the responsible government agency. Additionally, the report authors indicated that the emissions information was from an older study and this operation was not considered to be representative of current composting practices.

CIWMB 14: What is the basis for the daily throughput number for Site X? This number appears to be less than we expect.

Response: The basis of this number is information reported from the facility.

CIWMB 15: Table 3 in the report for Site X indicates that the average age of the feedstock piles is 45 days. We believe that this feedstock pile is anaerobic. If anaerobic materials are used to create windrows, initial emissions may be expected to be higher.

Response: While this may be the case, the resulting windrow VOC EF at Site X, 6.30 lb/ton, is very close to the NorCal windrow VOC EF of 5.65 lb/ton, and less than the

Zamora windrow VOC EF of 10.03 lb/ton. As such, the emission measurements at Site X are considered representative of emissions from green waste windrows.

<u>CIWMB 16:</u> We believe the emissions factors developed from the studies at Site X and NorCal are skewed high because of high wind speed, low sample count, inclusion of food waste, and small windrow piles.

<u>Response:</u> See responses to CIWMB comments 7, 8, and 15 and ERM comments 1 and 2, above.

Appendix C

"Northern Recycling Zamora Compost Facility Air Emissions Source Test", by Thomas R. Card and Charles E. Schmidt, May 2009

Northern Recycling
Zamora Compost Facility

Baseline Air Emissions Assessment

Air Emissions Source Test

Evaluation of Complete Compost Cycle VOC and Ammonia Emissions

Report

Revision 2

May 2009

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Executive Summary

This report documents the completed project of assessing baseline air emissions for the new Northern Recycling greenwaste composting facility located near Zamora, California. This report contains the results of two sampling events. The first event was completed in October 2008 and included winery waste in the compost mix. The second event was completed in April 2009 with no winery waste present. USEPA flux chamber samples were taken from actual compost operations to provide unit emissions data that were used to complete the calculation of full scale annual emissions for VOC and ammonia. All sampling and analysis were completed in compliance with the source test protocol document previously submitted to Yolo-Solano APCD.

Emissions were calculated based on a simulation of a full 80 day compost cycle by sampling key process days and interpolating the emissions between those days. Three mixing cycle events were sampled during the first event and mixing was found to be a significant contributor to emissions.

Table ES-1a and ES-1b summarizes the results of this baseline emissions assessment. The measured compost emission factor for compost with winery waste of 16.55 # VOC per ton of composting material is substantially higher than the most comparable previously measured values (5.65 # and 6.3 # VOC per ton compost mix) reported by the San Joaquin Valley APCD (see Table ES-2). The factor without winery waste was 10.03 # VOC per ton of compost mix.

Total site emissions for VOC were 3,030 tons per year with about two thirds of that attributed to the emissions from the feedstock stockpile for compost with winery waste. Total site emissions for VOC were 1,070 tons per year with about one half of that attributed to the emissions from the feedstock stockpile for compost without winery waste. The annual emissions calculations were based on 100,000 tons per year of throughput. No attempt was made in this report to prorate actual annual emissions based on the presence or absence of winery waste.

A concern about this data set are the extremely low ammonia emissions from Event 1 when winery waste was present. The emissions on this site are over an order of magnitude lower than comparable facilities. Most of the ammonia samples were below the method detection limit. The method detection limit for ammonia for this project was typically between 0.2 and 0.4 mg/m3. These are very low detection limits, about a factor of three lower than most SCAQMD Method 207.1 method detection limits. No other comments or explanations are offered for this with the exception that the ammonia sampling and analysis was in full compliance with the QA/QC program and the laboratory samples agreed with the field screening samples. The ammonia emissions without winery waste, however, were essentially the same as other greenwaste compost facilities.

Table ES-1a. – Calculated VOC and NH3 emissions from the feedstock storage, compost cycle, and finished product storage (with winery waste).

Source	Mass on Site (tons)	VOC Emission Factor (pounds/ton)	VOC Total Emissions (Tons/year)	Ammonia Emission Factor (pounds/ton)	Ammonia Total Emissions (Tons/year)
Feedstock Storage	27,000	44.03	2,201	0.017	0.94
Composting	20,000	16.55	828	0.011	0.573
Product Storage	3,000	0.02	1.2	0.0004	0.014
Total	50,000		3,030		1.52
Overall Emission Factor (#/ton)		60.61		0.030	

Table ES-1b. – Calculated VOC and NH3 emissions from the feedstock storage, compost cycle, and finished product storage (without winery waste).

Source	Mass on Site (tons)	VOC Emission Factor (pounds/ton)	VOC Total Emissions (Tons/year)	Ammonia Emission Factor (pounds/ton)	Ammonia Total Emissions (Tons/year)
Feedstock Storage	27,000	11.34	567	1.643	89.93
Composting	20,000	10.03	502	0.445	22.236
Product Storage	3,000	0.02	1.2	0.0004	0.014
Total	50,000		1,070		112.18
Overall Emission Factor (#/ton)		21.40		2.244	

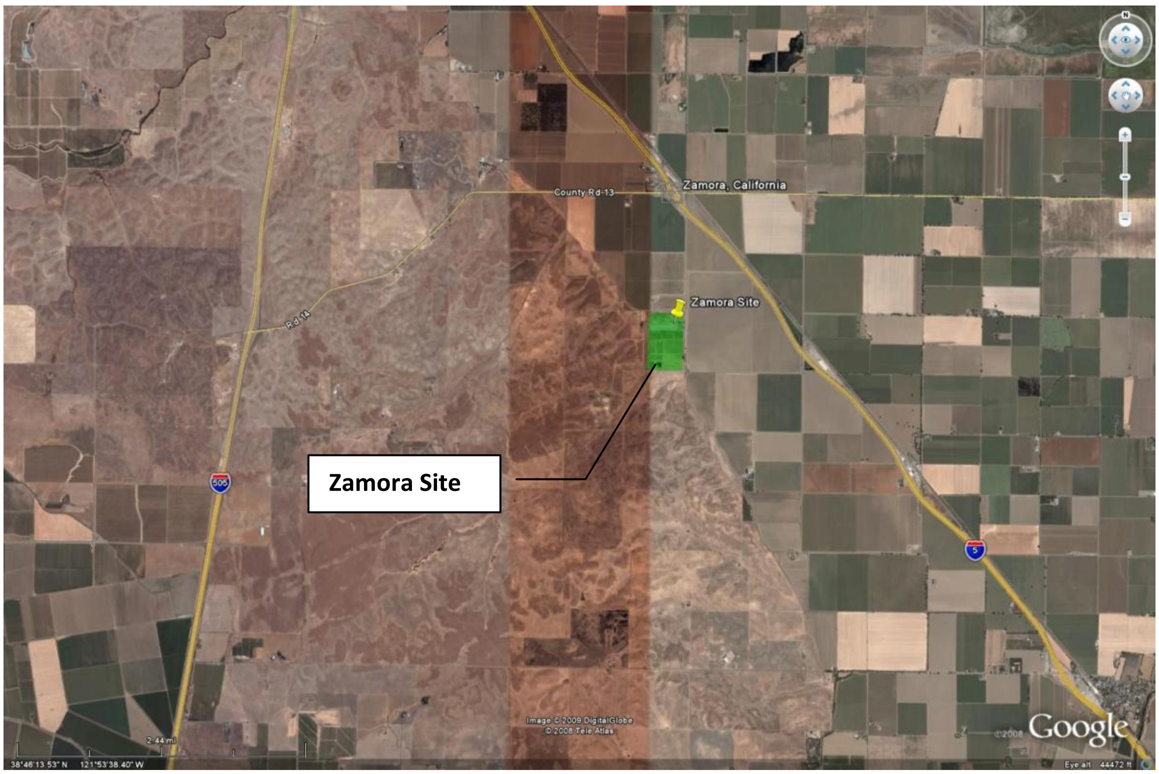
Table ES-2. – Comparative greenwaste compost emissions (from SJVAPCD).

			VOC							NH3						
			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)			EF	Unit Flux (mg/min-m2)			Unit Flux (#/hr-1,000ft2)		
Location	**Material**	**Activity**	**(#/ton)**	**Peak**	**Avg**	**Min**	**Peak**	**Avg**	**Min**	**(#/ton)**	**Peak**	**Avg**	**Min**	**Peak**	**Avg**	**Min**
Site X	Landscape	Stockpiles	7.76	186	111	37	2.30	1.38	0.46	0.03	0.62	0.39	0.16	0.01	0.00	0.002
	Waste	Windrows	6.30	23	11	3	0.29	0.13	0.04	2.34	26.56	12.07	0.20	0.33	0.15	0.003
		Total	14.06							2.37						
CIWMB Modesto		Windrows	1.54	42	9	0.1	0.51	0.11	0.001							
NorCal		Stockpiles	2.95	110	54	4	1.36	0.66	0.046	0.08	2.1	1.21	0.61	0.03	0.01	0.008
		Windrows	5.65	376	73	1	4.65	0.90	0.010	0.54	7.29	1.68	0.22	0.09	0.02	0.003
		Total	8.60							0.62						
CIWMB TV		Mix HCN		124	42	2	1.53	0.52	0.02							
		Mix LCN		443	110	1	5.48	1.36	0.02							
		UnMix HCN		23	6	1	0.28	0.07	0.01							
		UnMix LCN		38	10	1	0.47	0.13	0.01							
SCAQMD Inland Summer		Stockpiles	4.75		24			0.30		0.01		6.55			0.081	
		Windrows	0.3		6			0.08		1.31		0.32			0.004	
		Total	5.05							1.32						
SCAQMD Inland Winter		Stockpiles	1.96		20			0.25		0.29		2.67			0.033	
		Windrows	0.5		6			0.08		0.03		0.32			0.004	
		Total	2.47							0.32						

1.0 Introduction

This project directly measured the VOC and ammonia air emissions from greenwaste composting to develop a baseline air emissions value for a full compost/cure cycle plus feedstock and product storage. All compost operations were located at the Northern Recycling Compost Facility in Zamora, CA as shown in Figure 1.1.

Figure 1.1 Site Vicinity Map



2.0 Process Description and Sampling

This is a new compost facility that composts greenwaste material into a high value landscaping material. Compost is received in a stockpile. The stockpiled material is then ground and placed into windrows. The windrows are mechanically mixed approximately 20 times during an 80 day composting cycle. The windrows are then broken down and screened into the final product. The site is permitted to have a total of 50,000 tons of material on site. Table 2.1 shows the amount of material assumed to be on site for the baseline emissions assessment.

Table 2.1 Amount of Material Assumed to be on Site for Baseline Emissions Estimate

Material	Total Tons on Site
Feedstock Storage	27,000
Composting	20,000
Product Storage	3,000
Total Tons	50,000

The sampling and analysis was conducted in compliance with the document entitled PROTOCOL FOR FLUX CHAMBER SOURCE TESTING OF FUGITIVE AIR EMISSIONS FROM THE NORTHERN RECYCLING COMPOST (NRC) ZAMORA FACILITY, plus a supplemental protocol for the second event, that was previously submitted to the Yolo-Solano APCD.

All sampling took place between October 28 and 30, 2008 for the first event (compost with winery waste) and on April 12, 2009 (compost without winery waste). All surface samples were taken using USEPA Surface Isolation Emission Flux Chamber technology per the source test protocol. Total VOC was analyzed per SCAQMD Method 25.3 and ammonia was measured per SCAQMD Method 207.1. The technical memorandum in Appendix C presents a summary of data validation, project documentation, and laboratory methods used for this project.

The following compost operations were sampled:

Event 1

1. Incoming feedstock (12 samples)
2. Compost Day 1 (4 samples)
3. Compost Day 3 (4 samples)
4. Compost Day 3 Mixing Event (4 samples)
5. Compost Day 7 (4 samples)
6. Compost Day 15 (4 samples)
7. Compost Day 15 Mixing Event (4 samples)
8. Compost Day 29 (4 samples)
9. Compost Day 29 Mixing Event (4 samples)
10. Compost Day 63 (4 samples)
11. Finished product (4 samples)

Event 2

1. Incoming feedstock (4 samples)
2. Compost Day 1 (2 samples)
3. Compost Day 5 (4 samples)
4. Compost Day 8 (2 samples)
5. Compost Day 16 (2 samples)
6. Compost Day 31 (2 samples)

3.0 Sampling Results

Figure 3.1a presents of a summary of sampling results for Event 1. The appendix contains complete sampling data. Note that the vast majority of the ammonia data points had no ammonia detected. The typical ammonia detection limit for this project was between 0.2 and 0.4 mg/m^3.

Figure 3.1b presents a summary of sampling results for Event 2. This data was typical or previous greenwaste compost sampling events at other facilities.

Table 3.1a Summary of Event 1 sampling results (compost with winery waste).

SOURCE	TEST CONDITION	VOC Flux	NH3 Flux	COMMENT
Windrow- Day 1	T1	282	0.0131	**Windrow- Day 1**
Windrow- Day 1	T2	79.2	0.0130	
Windrow- Day 1	S1	136	0.0157	
Windrow- Day 1	Replicate	33.5	0.0174	Replicate
Windrow- Day 1	S2	11.2	0.0104	
Windrow- Day 3	T1	453	0.0219	**Windrow- Day 3**
Windrow- Day 3	T2	36.9	0.0227	
Windrow- Day 3	S1	16.1	0.0179	
Windrow- Day 3	S2	35.8	0.0232	
Windrow- Day 3	Post Mix, T1- Hour 0	1631	0.0232	Post Mix, T1- Hour 0
Windrow- Day 3	Post Mix, S1- Hour 0	742	0.0171	Post Mix, S1- Hour 0
Windrow- Day 3	Post Mix, T1- Hour 4	724	0.0187	Post Mix, T1- Hour 4
Windrow- Day 3	Post Mix, S1- Hour 4	254	0.0231	Post Mix, S1- Hour 4
Windrow- Day 7	T1	148	0.108	**Windrow- Day 7**
Windrow- Day 7	T2	764	0.0233	
Windrow- Day 7	S1	4.52	0.0418	
Windrow- Day 7	S2	1.81	0.0245	
Windrow- Day 15	T1	5.72	0.0332	**Windrow- Day 15**
Windrow- Day 15	T2	26.5	0.0401	
Windrow- Day 15	S1	2.36	0.0266	
Windrow- Day 15	S2	2.65	0.0236	
Windrow- Day 15	Replicate	1.30	0.0257	Replicate
Windrow- Day 15	Post Mix, T2- Hour 0	56.0	0.0244	Post Mix, T2- Hour 0
Windrow- Day 15	Post Mix, S2- Hour 0	6.82	0.0250	Post Mix, S2- Hour 0
Windrow- Day 15	Replicate	9.46	0.0246	Replicate
Windrow- Day 15	Post Mix, T2- Hour 4	40.1	0.0252	Post Mix, T2- Hour 4
Windrow- Day 15	Post Mix, S2- Hour 4	6.29	0.0222	Post Mix, S2- Hour 4
Windrow- Day 29	T1	0.454	0.0155	**Windrow- Day 29**
Windrow- Day 29	T2	1.10	0.0192	
Windrow- Day 29	S1	0.645	0.0151	
Windrow- Day 29	S2	0.381	0.00782	
Windrow- Day 29	Post Mix, T2- Hour 0	27.4	0.0301	Post Mix, T2- Hour 0
Windrow- Day 29	Post Mix, S1- Hour 0	4.39	0.0216	Post Mix, S1- Hour 0
Windrow- Day 29	Post Mix, T2- Hour 4	15.4	0.0369	Post Mix, T2- Hour 4
Windrow- Day 29	Post Mix, S1- Hour 4	3.95	0.0245	Post Mix, S1- Hour 4
Windrow- Day 63	T1	0.955	0.0141	**Windrow- Day 63**
Windrow- Day 63	T2	0.671	0.00994	
Windrow- Day 63	S1	0.223	0.0108	
Windrow- Day 63	S2	0.507	0.0137	
Tipping- Old	T1	6.91	0.0290	**Tipping- Old**
Tipping- Old	T2	1.33	0.0229	
Tipping- Old	T3	7.10	0.0241	
Tipping- Old	T4	7.54	0.0204	
Tipping- Middle Age	T1	3.82	0.0387	**Tipping- Middle Age**
Tipping- Middle Age	T2	6.97	0.529	
Tipping- Middle Age	T3	3.13	0.0702	
Tipping- Middle Age	Replicate	2.61	0.0718	Replicate
Tipping- Middle Age	T4	2.40	0.272	**Tipping- New**
Tipping- New	T1	308	0.0399	
Tipping- New	T2	153	0.0452	
Tipping- New	T3	882	0.0202	
Tipping- New	Replicate	848	0.0302	Replicate
Tipping- New	T4	743	0.0293	
Fresh Product- Day 1	T1	1.13	0.0123	**Fresh Product- Day 1**
Fresh Product- Day 1	T2	1.48	0.00687	
Aged Product- Day 60	S1	0.220	0.00876	**Aged Product- Day 60**
Aged Product- Day 60	S2	2.83	0.0400	
QC	Blank	0.139	0.00342	**QC- Blank**
QC	Blank	0.137	0.00342	
QC	Blank	0.112	0.00440	
QC	Blank	0.0929	0.00440	
QC	Blank	0.0736	0.00440	

Flux Unit: mg/m2,min-1

Note 1- Methane Flux = (CH4 ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 CH4

Note 2- TNMNEO Flux = (TNMNEO ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 TNMNEO

Note 3- Ammonia Flux = (NH3 mg/m3)(m3/min)/(0.13 m2) = mg/m2,min-1 NH3

Note 4- Total Flow = (Helium %/Helium % recovered)(0.005 m3/min) = m3/min total flow

Note 5- MDL value used for ND or non-detect for calculation purposes

Table 3.1b Summary of Event 2 sampling results (compost without winery waste).

SOURCE	TEST CONDITION	VOC Flux	NH3 Flux	COMMENT
Tipping	Day 1, T1	**166**	**16**	Tipping Pile, Day 1
Tipping	Day 1, S1	**14**	**6.7**	Tipping Pile, Day 1
Tipping	Day 7, T1	**17**	**5.7**	Tipping Pile, Day 7
Tipping	Day 7, S1	**7.8**	**4.3**	Tipping Pile, Day 7
Tipping	Replicate	**7.7**	**4.1**	Replicate Sample
Compost	Day 1, S1	**83**	**1.6**	Day 1
Compost	Day 1, T1	**27**	**0.26**	Day 1
Compost	Day 5, S1	**15**	**1.9**	Day 5
Compost	Day 5, T1	**242**	**13**	Day 5
Compost	Day 8, S1	**2.4**	**0.078**	Day 8
Compost	Day 8, T1	**157**	**2.5**	Day 8
Compost	Day 8, S2	**1.5**	**0.26**	Day 8
Compost	Day 8, T2	**131**	**5.0**	Day 8
Compost	Day 16, S1	**1.3**	**0.15**	Day 16
Compost	Day 16, T1	**9.4**	**2.56**	Day 16
Compost	Day 31, S1	**3.0**	**0.17**	Day 31
Compost	Day 31, T1	**1.0**	**0.17**	Day 31
QC	Blank	**0.025**	**0.0031**	99.4% Recovery of helium tracer

Flux Unit: mg/m2,min-1

Note 1- Methane Flux = (CH4 ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 CH4

Note 2- TNMNEO Flux = (TNMNEO ppmv)(0.653)(m3/min)/0.13 = mg/m2,min-1 TNMNEO

Note 3- Ammonia Flux = (NH3 mg/m3)(m3/min)/(0.13 m2) = mg/m2,min-1 NH3

Note 4- Total Flow = (Helium %/Helium % recovered)(0.005 m3/min) = m3/min total flow

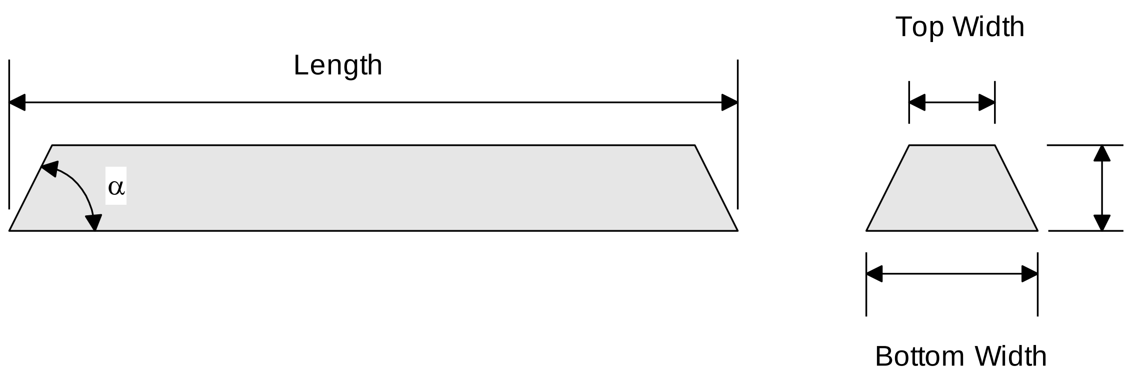
Note 5- MDL value used for ND or non-detect for calculation purposes

4.0 Emissions Calculations

4.1 Compost Pile Configuration

The windrow compost operation consisted of placing ground greenwaste feedstock in a windrow for 80 days. Figure 4.1 shows the typical windrow cross-section for windrow composting as well as the formulas used to compute volume and exposed surface area. Each windrow initially contained about 320 tons of material. Table 4.1 provides the windrow dimensions and calculations.

Figure 4.1. – Compost Windrow Configuration.



Mensuration formulas

$$S = \frac{p_1 + p_2}{2} s + A_2$$

$$V = \frac{h(A_1 + A_2 + \sqrt{A_1 A_2})}{3}$$

$$s = \sqrt{h^2 + ((W_B - W_T)/2)^2}$$

where S = total surface area, p_1 = bottom perimeter, p_2 = top perimeter, s = slant height, V=volume, h=vertical height, A_1 = bottom area, A_2 = top area, α = bottom angle

Table 4.1. – Compost Windrow Dimensions and Calculations.

Property	Units	Value
Length	ft	455
Height	ft	4.5
Bottom Width	ft	14
Top Width	ft	7.0
Top Length	ft	448
alpha	R	0.91
	o	52
Top Perimeter	ft	910
Top Area	ft2	3,136
Bottom Perimeter	ft	938
Bottom Area	ft2	6,370
Slant height	ft	5.7
Surface Area	ft2	8,404
	m2	785
Volume	ft3	20,963
	yd3	776
Conversion Factors	ft2/m2	10.7
	ft3/yd3	27
Top Area Ratio		0.373173
Density	#/yd3	823
	#/ft3	30.5
Mass	#	638,990
	ton	319

4.2 Full Compost Cycle Simulation

The unit emission data was extended to estimate emissions from the full compost cycle using linear interpolation and averaging, as noted in Section 2, above.

Full cycle emissions for each day of the compost process, are then added and the sum of the individual daily emissions are totalized. Consistent with the approved protocol, the emission factor consists of the full total (in pounds) cycle emissions divided by the incoming feedstock weight (in tons). The full site emissions are then calculated be multiplying the annual throughput of material by this calculated emission factor. The simulation data tables are provided in the Appendix.

4.4 Simulated Emissions Profile

Figure 4.2 and 4.3 presents the full cycle emissions profile developed for VOC and ammonia. These emissions profiles were developed using a combination of data averaging and linear interpolation between the data points. The spikes on the graphs are due to mixing events. Three mixing events were measured and mixing was found to be a significant contributor to emissions.

Figure 4.2 Simulated VOC Emissions Profile (per windrow).

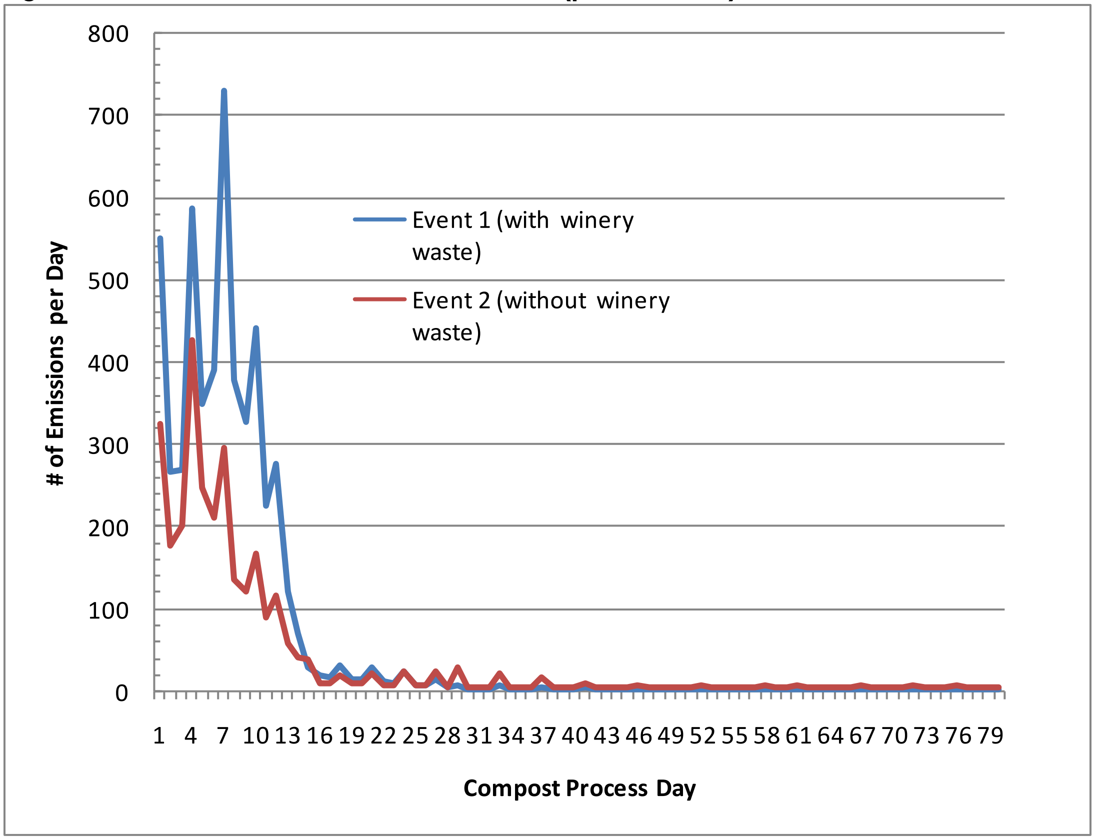
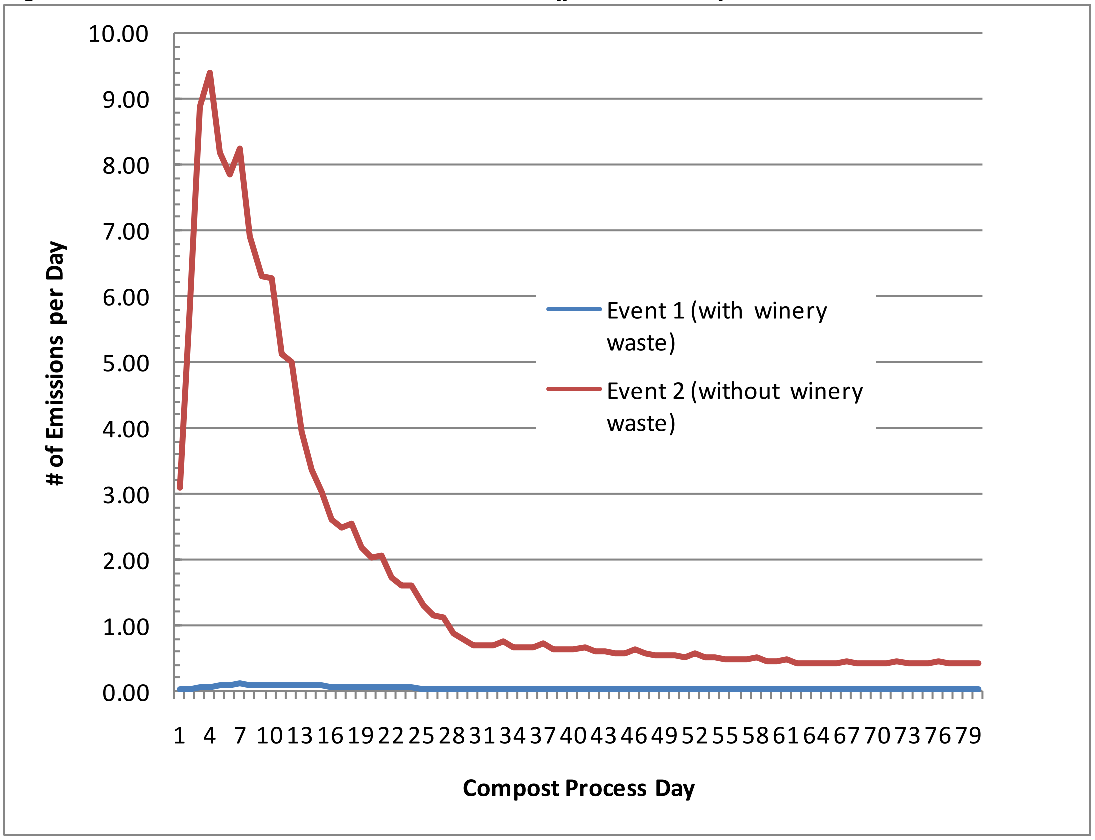


Figure 4.3 Simulated NH_3 Emissions Profile (per windrow).



4.5 Emissions from Feedstock and Product Storage

Table 4.2a, 4.2b, and 4.3 present the VOC and ammonia emission calculations while feedstock is being stored prior to windrowing and from finished compost product storage. The product emissions were assumed to be the same for the winery waste and non-winery waste compost product.

Table 4.2a. – Event 1 Feedstock emission calculations (with winery waste).

Mass	300	tons/day
Density	443	#/yd3
	16.4	#/ft3
Storage Duration	90	day
Total Tons Stored	27,000	tons
Pile Volume	121,896	yd3
	3,291,196	ft3
Pile shape	Frustrum	
Pile Height	20	feet
Pile Length	577	
Pile Width	300	
Pile Area	173,208	feet
Slant Height	28	
Pile Area	204,560	ft2
	19,118	m2

	VOC	**NH3**	
Unit Emissions	198.74	0.084	mg/min-m2
Total Emissions	5,471,153	2,326	gms/day
	12,063	5.1	pounds/day
	2,201	0.9	tons/year
Emission Factor	44.03	0.01709	pounds/ton

Table 4.2b. – Event 2 Feedstock emission calculations (without winery waste).

Mass	300	tons/day
Density	443	#/yd3
	16.4	#/ft3
Storage Duration	90	day
Total Tons Stored	27,000	tons
Pile Volume	121,896	yd3
	3,291,196	ft3
Pile shape	Frustrum	
Pile Height	20	feet
Pile Length	577	
Pile Width	300	
Pile Area	173,208	feet
Slant Height	28	
Pile Area	204,560	ft2
	19,118	m2

	VOC	**NH3**	
Unit Emissions	51.19	8.118	mg/min-m2
Total Emissions	1,409,351	223,497	gms/day
	3,107	492.8	pounds/day
	567	89.9	tons/year
Emission Factor	11.34	1.64254	pounds/ton

Table 4.3. – Finished product storage emission calculations (used for both winery and non-winery waste containing compost).

Mass	200	tons/day
Density	1123	#/yd3
	41.6	#/ft3
Storage Duration	15	day
Total Tons Stored	3000	tons
Pile Volume	5,343	yd3
	144,256	ft3
Pile shape	Frustrum	
Pile Height	20	feet
Pile Length	90	
Pile Width	100	
Pile Area	8,977	feet
Slant Height	28	
Pile Area	15,186	ft2
	1,419	m2

	VOC	**NH3**	
Unit Emissions	1.42	0.017	mg/min-m2
Total Emissions	2,894	35	gms/day
	6	0.08	pounds/day
	1	0.014	tons/year
Emission Factor	0.02	0.00038	pounds/ton

Appendix A

Full Cycle Simulation Table

Table A1a VOC Cycle Simulation Calculations for Event 1

Compost Day	Unit Flux (mg/min-m2) Top	Side	Total	Mix	UF (mg/m-m2)	Area (m2)	Daily Emissions (mg)	(#)
1	181	60	105	2.1	221	785	249,958,006	551
2	213	43	107	1	107	785	120,450,583	266
3	245	26	108	1	108	785	121,873,545	269
4	298	20	124	1.9	235	785	266,173,572	587
5	351	15	140	1	140	785	158,309,162	349
6	403	9	156	1	156	785	176,526,971	389
7	456	3	172	1.7	293	785	331,066,126	730
8	401	3	152	1	152	785	171,472,778	378
9	346	3	131	1	131	785	148,200,776	327
10	291	3	110	1.6	177	785	199,886,039	441
11	236	3	90	1	90	785	101,656,773	224
12	181	3	69	1.6	111	785	125,415,633	277
13	126	3	49	1	49	785	55,112,769	122
14	71	3	28	1	28	785	31,840,767	70
15	16	3	8	1.5	11	785	12,853,148	28
16	15	2	7	1	7	785	8,006,131	18
17	14	2	7	1	7	785	7,443,497	16
18	13	2	6	2	12	785	13,761,725	30
19	12	2	6	1	6	785	6,318,228	14
20	11	2	5	1	5	785	5,755,594	13
21	10	2	5	2.5	11	785	12,982,399	29
22	8	2	4	1	4.1	785	4,630,326	10
23	7	1	4	1	3.6	785	4,067,691	9
24	6	1	3	3	9.3	785	10,515,171	23
25	5	1	3	1	2.6	785	2,942,423	6
26	4	1	2	1	2.1	785	2,379,789	5
27	3	1	2	3.5	5.6	785	6,360,040	14
28	2	1	1	1	1.1	785	1,254,520	2.8
29	0.8	0.5	1	4.7	2.9	785	3,251,863	7.2
30	0.78	0.51	0.61	1	0.6	785	689,246	1.5
31	0.78	0.50	0.61	1	0.6	785	686,606	1.5
32	0.78	0.50	0.60	1	0.6	785	683,967	1.5
33	0.78	0.50	0.60	4	2.4	785	2,725,308	6.0
34	0.78	0.49	0.60	1	0.6	785	678,687	1.5
35	0.78	0.49	0.60	1	0.6	785	676,048	1.5
36	0.78	0.48	0.60	1	0.6	785	673,408	1.5
37	0.79	0.48	0.59	3	1.8	785	2,012,305	4.4
38	0.79	0.47	0.59	1	0.6	785	668,129	1.5
39	0.79	0.47	0.59	1	0.6	785	665,489	1.5
40	0.79	0.47	0.59	1	0.6	785	662,849	1.5
41	0.79	0.46	0.58	2	1.2	785	1,320,419	2.9
42	0.79	0.46	0.58	1	0.6	785	657,570	1.4
43	0.79	0.45	0.58	1	0.6	785	654,930	1.4
44	0.79	0.45	0.58	1	0.6	785	652,290	1.4
45	0.79	0.44	0.57	1	0.6	785	649,651	1.4
46	0.80	0.44	0.57	1.5	0.9	785	970,517	2.1
47	0.80	0.43	0.57	1	0.6	785	644,371	1.4
48	0.80	0.43	0.57	1	0.6	785	641,732	1.4
49	0.80	0.43	0.57	1	0.6	785	639,092	1.4
50	0.80	0.42	0.56	1	0.6	785	636,452	1.4
51	0.80	0.42	0.56	1	0.6	785	633,813	1.4
52	0.80	0.41	0.56	1.5	0.8	785	946,759	2.1
53	0.80	0.41	0.56	1	0.6	785	628,533	1.4
54	0.80	0.40	0.55	1	0.6	785	625,894	1.4
55	0.80	0.40	0.55	1	0.6	785	623,254	1.4
56	0.81	0.40	0.55	1	0.5	785	620,614	1.4
57	0.81	0.39	0.55	1	0.5	785	617,974	1.4
58	0.81	0.39	0.54	1.5	0.8	785	923,002	2.0
59	0.81	0.38	0.54	1	0.5	785	612,695	1.4
60	0.81	0.38	0.54	1	0.5	785	610,055	1.3
61	0.81	0.37	0.54	1.5	0.8	785	911,124	2.0
62	0.81	0.37	0.53	1	0.5	785	604,776	1.3
63	0.8	0.4	0.53	1	0.5	785	602,136	1.3
64	0.81	0.37	0.53	1	0.5	785	602,136	1.3
65	0.81	0.37	0.53	1	0.5	785	602,136	1.3
66	0.81	0.37	0.53	1	0.5	785	602,136	1.3
67	0.81	0.37	0.53	1.5	0.8	785	903,205	2.0
68	0.81	0.37	0.53	1	0.5	785	602,136	1.3
69	0.81	0.37	0.53	1	0.5	785	602,136	1.3
70	0.81	0.37	0.53	1	0.5	785	602,136	1.3
71	0.81	0.37	0.53	1	0.5	785	602,136	1.3
72	0.81	0.37	0.53	1.5	0.8	785	903,205	2.0
73	0.81	0.37	0.53	1	0.5	785	602,136	1.3
74	0.81	0.37	0.53	1	0.5	785	602,136	1.3
75	0.81	0.37	0.53	1	0.5	785	602,136	1.3
76	0.81	0.37	0.53	1.5	0.8	785	903,205	2.0
77	0.81	0.37	0.53	1	0.5	785	602,136	1.3
78	0.81	0.37	0.53	1	0.5	785	602,136	1.3
79	0.81	0.37	0.53	1	0.5	785	602,136	1.3
80	0.81	0.37	0.53	1	0.5	785	602,136	1.3
							Total Emissions	5,289
								16.55 #/Ton

Table A1a NH3 Cycle Simulation Calculations for Event 1

Compost Day	Unit Flux (mg/min-m2) Top	Side	Total	Mix	UF (mg/m-m2)	Area (m2)	Daily Emissions (mg)	(#)
1	0.01	0.01	0.01	1.1	0.02	785	17,391	0.04
2	0.02	0.02	0.02	1	0.02	785	19,897	0.04
3	0.02	0.02	0.02	1	0.02	785	23,985	0.05
4	0.03	0.02	0.03	1.1	0.03	785	33,880	0.07
5	0.04	0.03	0.03	1	0.03	785	37,615	0.08
6	0.05	0.03	0.04	1	0.04	785	44,431	0.10
7	0.07	0.03	0.05	1.1	0.05	785	56,370	0.12
8	0.06	0.03	0.04	1	0.04	785	48,999	0.11
9	0.06	0.03	0.04	1	0.04	785	46,752	0.10
10	0.05	0.03	0.04	1.1	0.04	785	48,956	0.11
11	0.05	0.03	0.04	1	0.04	785	42,258	0.09
12	0.05	0.03	0.04	1.1	0.04	785	44,013	0.10
13	0.04	0.03	0.03	1	0.03	785	37,765	0.08
14	0.04	0.03	0.03	1	0.03	785	35,518	0.08
15	0.04	0.03	0.03	1.1	0.03	785	36,598	0.08
16	0.04	0.02	0.03	1	0.03	785	31,996	0.07
17	0.03	0.02	0.03	1	0.03	785	30,720	0.07
18	0.03	0.02	0.03	1.1	0.03	785	32,390	0.07
19	0.03	0.02	0.02	1	0.02	785	28,170	0.06
20	0.03	0.02	0.02	1	0.02	785	26,894	0.06
21	0.03	0.02	0.02	1.1	0.02	785	28,181	0.06
22	0.03	0.02	0.02	1	0.02	785	24,344	0.05
23	0.03	0.02	0.02	1	0.02	785	23,069	0.05
24	0.02	0.02	0.02	1.1	0.02	785	23,973	0.05
25	0.02	0.02	0.02	1	0.02	785	20,518	0.05
26	0.02	0.01	0.02	1	0.02	785	19,243	0.04
27	0.02	0.01	0.02	1.1	0.02	785	19,764	0.04
28	0.02	0.01	0.01	1	0.01	785	16,692	0.04
29	0.02	0.01	0.01	1.1	0.01	785	16,958	0.04
30	0.02	0.01	0.01	1	0.01	785	15,367	0.03
31	0.02	0.01	0.01	1	0.01	785	15,318	0.03
32	0.02	0.01	0.01	1	0.01	785	15,269	0.03
33	0.02	0.01	0.01	1.1	0.01	785	16,742	0.04
34	0.02	0.01	0.01	1	0.01	785	15,171	0.03
35	0.02	0.01	0.01	1	0.01	785	15,122	0.03
36	0.02	0.01	0.01	1	0.01	785	15,072	0.03
37	0.02	0.01	0.01	1.1	0.01	785	16,525	0.04
38	0.02	0.01	0.01	1	0.01	785	14,974	0.03
39	0.02	0.01	0.01	1	0.01	785	14,925	0.03
40	0.02	0.01	0.01	1	0.01	785	14,876	0.03
41	0.02	0.01	0.01	1.1	0.01	785	16,309	0.04
42	0.02	0.01	0.01	1	0.01	785	14,777	0.03
43	0.02	0.01	0.01	1	0.01	785	14,728	0.03
44	0.01	0.01	0.01	1	0.01	785	14,679	0.03
45	0.01	0.01	0.01	1	0.01	785	14,630	0.03
46	0.01	0.01	0.01	1.1	0.01	785	16,038	0.04
47	0.01	0.01	0.01	1	0.01	785	14,531	0.03
48	0.01	0.01	0.01	1	0.01	785	14,482	0.03
49	0.01	0.01	0.01	1	0.01	785	14,433	0.03
50	0.01	0.01	0.01	1	0.01	785	14,384	0.03
51	0.01	0.01	0.01	1	0.01	785	14,334	0.03
52	0.01	0.01	0.01	1.1	0.01	785	15,714	0.03
53	0.01	0.01	0.01	1	0.01	785	14,236	0.03
54	0.01	0.01	0.01	1	0.01	785	14,187	0.03
55	0.01	0.01	0.01	1	0.01	785	14,138	0.03
56	0.01	0.01	0.01	1	0.01	785	14,089	0.03
57	0.01	0.01	0.01	1	0.01	785	14,039	0.03
58	0.01	0.01	0.01	1.1	0.01	785	15,389	0.03
59	0.01	0.01	0.01	1	0.01	785	13,941	0.03
60	0.01	0.01	0.01	1	0.01	785	13,892	0.03
61	0.01	0.01	0.01	1.1	0.01	785	15,227	0.03
62	0.01	0.01	0.01	1	0.01	785	13,793	0.03
63	0.0	0.0	0.01	1	0.01	785	13,744	0.03
64	0.01	0.01	0.01	1	0.01	785	13,744	0.03
65	0.01	0.01	0.01	1	0.01	785	13,744	0.03
66	0.01	0.01	0.01	1	0.01	785	13,744	0.03
67	0.01	0.01	0.01	1.1	0.01	785	15,119	0.03
68	0.01	0.01	0.01	1	0.01	785	13,744	0.03
69	0.01	0.01	0.01	1	0.01	785	13,744	0.03
70	0.01	0.01	0.01	1	0.01	785	13,744	0.03
71	0.01	0.01	0.01	1	0.01	785	13,744	0.03
72	0.01	0.01	0.01	1.1	0.01	785	15,119	0.03
73	0.01	0.01	0.01	1	0.01	785	13,744	0.03
74	0.01	0.01	0.01	1	0.01	785	13,744	0.03
75	0.01	0.01	0.01	1	0.01	785	13,744	0.03
76	0.01	0.01	0.01	1.1	0.01	785	15,119	0.03
77	0.01	0.01	0.01	1	0.01	785	13,744	0.03
78	0.01	0.01	0.01	1	0.01	785	13,744	0.03
79	0.01	0.01	0.01	1	0.01	785	13,744	0.03
80	0.01	0.01	0.01	1	0.01	785	13,744	0.03
							Total Emissions	4
								0.011 #/Ton

Table A1b VOC Cycle Simulation Calculations for Event 2

Compost Day	Unit Flux (mg/min-m2) Top	Side	Total	Mix	UF (mg/m-m2)	Area (m2)	Daily Emissions (mg)	(#)
1	27	83	62	2.1	131	785	147,843,960	326
2	81	66	72	1	72	785	80,987,316	179
3	135	49	81	1	81	785	91,572,747	202
4	188	32	90	1.9	172	785	194,100,537	428
5	242	15	100	1	100	785	112,743,608	249
6	210	11	85	1	85	785	95,912,037	211
7	177	6	70	1.7	119	785	134,436,791	296
8	144	2	55	1	55	785	62,248,894	137
9	127	2	49	1	49	785	55,076,966	121
10	111	2	42	1.6	68	785	76,648,060	169
11	94	2	36	1	36	785	40,733,109	90
12	77	2	30	1.6	47	785	53,697,889	118
13	60	2	23	1	23	785	26,389,252	58
14	43	1	17	1	17	785	19,217,324	42
15	26	1	11	1.5	16	785	18,068,093	40
16	9	1	4	1	4	785	4,873,467	11
17	9	1	4	1	4	785	4,717,702	10
18	8	2	4	2	8	785	9,123,874	20
19	8	2	4	1	4	785	4,406,173	10
20	7	2	4	1	4	785	4,250,408	9
21	7	2	4	2.5	9	785	10,236,608	23
22	6	2	3	1	3.5	785	3,938,879	9
23	5	2	3	1	3.3	785	3,783,114	8
24	5	2	3	3	9.6	785	10,882,048	24
25	4	2	3	1	3.1	785	3,471,585	8
26	4	2	3	1	2.9	785	3,315,820	7
27	3	3	3	3.5	9.8	785	11,060,193	24
28	3	3	3	1	2.7	785	3,004,291	6.6
29	2	3	3	4.7	11.8	785	13,388,072	29.5
30	2	3	2	1	2.4	785	2,692,761	5.9
31	1.04	2.96	2	1	2.2	785	2,536,997	5.6
32	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
33	1.04	2.96	2.24	4	9.0	785	10,147,986	22.4
34	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
35	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
36	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
37	1.04	2.96	2.24	3	6.7	785	7,610,990	16.8
38	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
39	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
40	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
41	1.04	2.96	2.24	2	4.5	785	5,073,993	11.2
42	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
43	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
44	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
45	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
46	1.04	2.96	2.24	1.5	3.4	785	3,805,495	8.4
47	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
48	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
49	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
50	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
51	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
52	1.04	2.96	2.24	1.5	3.4	785	3,805,495	8.4
53	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
54	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
55	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
56	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
57	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
58	1.04	2.96	2.24	1.5	3.4	785	3,805,495	8.4
59	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
60	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
61	1.04	2.96	2.24	1.5	3.4	785	3,805,495	8.4
62	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
63	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
64	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
65	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
66	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
67	1.04	2.96	2.24	1.5	3.4	785	3,805,495	8.4
68	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
69	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
70	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
71	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
72	1.04	2.96	2.24	1.5	3.4	785	3,805,495	8.4
73	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
74	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
75	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
76	1.04	2.96	2.24	1.5	3.4	785	3,805,495	8.4
77	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
78	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
79	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
80	1.04	2.96	2.24	1	2.2	785	2,536,997	5.6
							Total Emissions	3,205
								10.03 #/Ton

Table A1b NH3 Cycle Simulation Calculations for Event 2

Compost Day	Unit Flux (mg/min-m2) Top	Side	Total	Mix	UF (mg/m-m2)	Area (m2)	Daily Emissions (mg)	(#)
1	0	2	1.13	1.1	1.24	785	1,406,757	3.10
2	3	2	2.35	1	2.35	785	2,657,139	5.86
3	7	2	3.57	1	3.57	785	4,035,408	8.90
4	10	2	3.43	1.1	3.77	785	4,263,343	9.40
5	13	2	3.29	1	3.29	785	3,716,125	8.19
6	10	1	3.14	1	3.14	785	3,556,483	7.84
7	7	1	3.00	1.1	3.30	785	3,736,525	8.24
8	4	0	2.77	1	2.77	785	3,128,743	6.90
9	4	0	2.53	1	2.53	785	2,860,644	6.31
10	3	0	2.29	1.1	2.52	785	2,851,800	6.29
11	3	0	2.06	1	2.06	785	2,324,447	5.12
12	3	0	1.82	1.1	2.00	785	2,261,983	4.99
13	3	0	1.58	1	1.58	785	1,788,249	3.94
14	3	0	1.34	1	1.34	785	1,520,151	3.35
15	3	0	1.11	1.1	1.22	785	1,377,257	3.04
16	3	0	1.05	1	1.05	785	1,185,635	2.61
17	2	0	0.99	1	0.99	785	1,119,218	2.47
18	2	0	0.93	1.1	1.02	785	1,158,081	2.55
19	2	0	0.87	1	0.87	785	986,384	2.17
20	2	0	0.81	1	0.81	785	919,967	2.03
21	2	0	0.75	1.1	0.83	785	938,905	2.07
22	2	0	0.70	1	0.70	785	787,133	1.74
23	1	0	0.64	1	0.64	785	720,715	1.59
24	1	0	0.58	1.1	0.64	785	719,728	1.59
25	1	0	0.52	1	0.52	785	587,881	1.30
26	1	0	0.46	1	0.46	785	521,464	1.15
27	1	0	0.40	1.1	0.44	785	500,552	1.10
28	1	0	0.34	1	0.34	785	388,630	0.86
29	0	0	0.28	1.1	0.31	785	354,434	0.78
30	0	0	0.28	1	0.28	785	318,295	0.70
31	0.17	0.17	0.28	1	0.28	785	314,376	0.69
32	0.17	0.17	0.27	1	0.27	785	310,458	0.68
33	0.17	0.17	0.27	1.1	0.30	785	337,194	0.74
34	0.17	0.17	0.27	1	0.27	785	302,621	0.67
35	0.17	0.17	0.26	1	0.26	785	298,703	0.66
36	0.17	0.17	0.26	1	0.26	785	294,785	0.65
37	0.17	0.17	0.26	1.1	0.28	785	319,953	0.71
38	0.17	0.17	0.25	1	0.25	785	286,948	0.63
39	0.17	0.17	0.25	1	0.25	785	283,030	0.62
40	0.17	0.17	0.25	1	0.25	785	279,111	0.62
41	0.17	0.17	0.24	1.1	0.27	785	302,712	0.67
42	0.17	0.17	0.24	1	0.24	785	271,275	0.60
43	0.17	0.17	0.24	1	0.24	785	267,356	0.59
44	0.17	0.17	0.23	1	0.23	785	263,438	0.58
45	0.17	0.17	0.23	1	0.23	785	259,520	0.57
46	0.17	0.17	0.23	1.1	0.25	785	281,162	0.62
47	0.17	0.17	0.22	1	0.22	785	251,683	0.55
48	0.17	0.17	0.22	1	0.22	785	247,765	0.55
49	0.17	0.17	0.22	1	0.22	785	243,847	0.54
50	0.17	0.17	0.21	1	0.21	785	239,928	0.53
51	0.17	0.17	0.21	1	0.21	785	236,010	0.52
52	0.17	0.17	0.21	1.1	0.23	785	255,301	0.56
53	0.17	0.17	0.20	1	0.20	785	228,173	0.50
54	0.17	0.17	0.20	1	0.20	785	224,255	0.49
55	0.17	0.17	0.19	1	0.19	785	220,337	0.49
56	0.17	0.17	0.19	1	0.19	785	216,418	0.48
57	0.17	0.17	0.19	1	0.19	785	212,500	0.47
58	0.17	0.17	0.18	1.1	0.20	785	229,440	0.51
59	0.17	0.17	0.18	1	0.18	785	204,663	0.45
60	0.17	0.17	0.18	1	0.18	785	200,745	0.44
61	0.17	0.17	0.17	1.1	0.19	785	216,509	0.48
62	0.17	0.17	0.17	1	0.17	785	192,908	0.43
63	0.17	0.17	0.17	1	0.17	785	188,990	0.42
64	0.17	0.17	0.17	1	0.17	785	188,990	0.42
65	0.17	0.17	0.17	1	0.17	785	188,990	0.42
66	0.17	0.17	0.17	1	0.17	785	188,990	0.42
67	0.17	0.17	0.17	1.1	0.18	785	207,889	0.46
68	0.17	0.17	0.17	1	0.17	785	188,990	0.42
69	0.17	0.17	0.17	1	0.17	785	188,990	0.42
70	0.17	0.17	0.17	1	0.17	785	188,990	0.42
71	0.17	0.17	0.17	1	0.17	785	188,990	0.42
72	0.17	0.17	0.17	1.1	0.18	785	207,889	0.46
73	0.17	0.17	0.17	1	0.17	785	188,990	0.42
74	0.17	0.17	0.17	1	0.17	785	188,990	0.42
75	0.17	0.17	0.17	1	0.17	785	188,990	0.42
76	0.17	0.17	0.17	1.1	0.18	785	207,889	0.46
77	0.17	0.17	0.17	1	0.17	785	188,990	0.42
78	0.17	0.17	0.17	1	0.17	785	188,990	0.42
79	0.17	0.17	0.17	1	0.17	785	188,990	0.42
80	0.17	0.17	0.17	1	0.17	785	188,990	0.42
							Total Emissions	142
								0.445 #/Ton

Appendix B
Photographs

Appendix C
Data Validation Technical Memorandum