ABSTRACT

BLUNDEN, JESSICA. Characterization of Non-Methane Volatile Organic Compounds at Swine Facilities in Eastern North Carolina. (Under the direction of Dr. Viney P. Aneja)

A total of 110 samples of volatile organic compounds (VOCs) were collected and analyzed in a field study to characterize such compounds emitted at six swine facilities in Eastern North Carolina between April 2002 and March 2003 as part of the Project OPEN (Odors, Pathogens, and Emissions of Nitrogen). Two baseline sites employed conventional lagoon and field spray technologies while four sites utilized various alternative "Environmentally Superior Technologies" (ESTs) in an effort to substantially reduce gaseous compound emissions, odor, and pathogens from these swine facilities. More than 200 compounds, including various paraffins, alkynes, aromatics, esters, ethers, monoterpenes, alcohols, aldehydes, ketones, monoterpenes, halogenated hydrocarbons, phenols, and sulfides were identified and quantified by Gas Chromatographic/Flame Ionization Detection (GC/FID) analysis as well as confirmed and/or verified by Gas Chromatographic/Mass Spectrometry (GC/MS). GC/MS analysis of three particularly complex samples collected at one site assisted in providing identification and retention times for more than 20 sulfur type volatile organic compounds (VOCs) including methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and dimethyl trisulfide as well as many other VOCs. Carbonyl sulfide and carbon disulfide were positively identified by GC/MS analysis but were not identified by GC/FID due to their particular compound characteristics. The results of these samples were subsequently used as a source fingerprint to identify and/or verify these compounds in all other samples collected.

Overall, the highest VOC concentration levels measured at each of the sites were in close proximity to the hog barns. The total measured VOCs at the hog barns were typically dominated by ethanol, methanol, acetaldehyde, and acetone. The combined overall contribution of these compounds in relation to total measured VOCs generally ranged from 46-94%. The highest concentration levels of both dimethyl sulfide and dimethyl disulfide, the most commonly detected sulfur type compounds, as well as 4-methylphenol, were also observed near the hog barns.

Hazardous air pollutants measured were acetaldehyde, benzene, *n*-hexane, methanol, methyl ethyl ketone (MEK), styrene, toluene, 4-methylphenol and xylene (m-, p-, & o), which were identified in many of the samples. In many instances, acetaldehyde, styrene (which was determined to co-elute with heptanal), and MEK were all measured at levels higher than their respective U.S. ambient background concentrations. Acetaldehyde was also measured at levels above its reference concentration (10 ppbC) in many of the samples. Statistical analysis performed on 35 samples to test for possible relationships between various VOCs, meteorological parameters, and Scentometer and odor intensity ratings revealed that only hydrogen sulfide had a strong effect on both odor intensity levels and Scentometer ratings. Alcohols and measured organic sulfur compounds had slight to moderate positive relationships with Scentometer ratings.

CHARACTERIZATION OF NON-METHANE VOLATILE ORGANIC COMPOUNDS AT SWINE FACILITIES IN EASTERN NORTH CAROLINA

by

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BIOGRAPHY

Jessica Blunden was born on October 12, 1971 in Chapel Hill, North Carolina to Giles Blunden and Patricia Kasdorf where she grew up and attended Chapel Hill High School. In 1993, she graduated from Appalachian State University in Boone, N.C. where she developed a love and respect for nature and the outdoors. After obtaining a B.S. degree in Business Administration, Jessica moved to New Orleans, L.A. and pursued an interest in the hospitality industry.

After a short length of time she moved back to North Carolina, settling in Asheville. Here, Jessica decided to follow her heart and pursue her long-time interest in both environmental issues and atmospheric science. She attended the University of North Carolina at Asheville part-time for three years to obtain the necessary skills to pursue a graduate degree in this field. Combining her two interests, Jessica entered graduate school at North Carolina State University in August 2001 as a member of the Air Quality Research group. Upon completion of her M.S., she will continue in her studies and pursue a Ph.D. in the same field, also under the direction of Dr. Aneja.

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1.0 Introduction

1.1 Background

Swine production has increased dramatically over the last decade in North Carolina, making the state the second largest producer of hogs in the United States (NCDA, 2003). According to the North Carolina Department of Agriculture and Consumer Services, since 1990 the number of hogs in North Carolina has amplified from an inventory of 2.5 million to ~10 million head (NCDA, 2003), a statistic current as of March 1, 2003. The vast majority of the hog farms are located in Eastern North Carolina (Figure 1.1).

Rapid swine growth in North Carolina has been attributed to the development and extensive use of contract production arrangements by a few large integrators. Contract production has aided the expansion of hog operations by facilitating the accumulation of capital necessary for swine operations to adopt new technologies and achieve major growth (McBride and Key, 2003). Consequently, more hogs are confined to smaller areas, thereby releasing increasing amounts of odorous and potentially harmful compounds due to a higher amount of excretion. Environmental concerns and complaints regarding air and water quality associated with the increased number of animals and management of subsequent wastes accompanying the growth of this industry has been considerable.

In 1997, the Clean Water Responsibility Act was passed in North Carolina and a moratorium was established on any new or expanded corporate hog farms, giving county commissioners zoning authority over hog farms containing over 5000 animals. In 2003, the North Carolina legislature passed House Bill 1113 that extended the moratorium on the construction or expansion of swine farms and on lagoons and animal waste management systems for swine farms until September 2007. In response to the moratorium, the North

Carolina Attorney General determined that the development of potentially "environmentally superior waste technologies" (ESTs) would serve well the public interest of North Carolina. The moratorium allows time for the development of alternative waste technologies for the more than 2500 hog farms that are located within the state with the objective of reducing potentially hazardous emissions from these swine facility sites. Sponsored by an agreement between Smithfield Foods, Inc. and Premium Standard Farms, Inc., two of the leading producers of hogs in the state, and the N.C. Attorney General; and funded by Animal and Poultry Waste Management Center (A&PWMC), Project OPEN (Odors, Pathogens, and Emissions of Nitrogen) was established in an effort to evaluate the various alternative waste treatment technologies.

As a subset of Project OPEN, this research project focuses exclusively on the characterization of C_2-C_{12} volatile organic compounds (VOCs) present in the ambient air at various swine facilities located in the eastern region of North Carolina; and estimating the flux of these compounds from tunnel ventilated animal houses (i.e., barns). No literature to date has been published regarding VOCs identification at swine facilities by means of SUMMA canister collection. This field study may be regarded as a survey to determine various gaseous compounds, particularly those compounds associated with unpleasant odors in this type of rural environment, which are present in the ambient atmosphere at these locales.

VOCs may be defined as any gaseous organic compounds that participate in atmospheric chemical reactions. VOCs in the C_2-C_{12} range (i.e., each compound contains between 2 and 12 carbon atoms in its atomic structure) reside primarily in the gaseous phase in the ambient atmosphere. The compounds detected in this study include various paraffins,

alkynes, aromatics, esters, ethers, monoterpenes, alcohols, aldehydes, ketones, monoterpenes, halogenated hydrocarbons, phenols, and sulfides.

Studies have previously been conducted to attempt identification of odorous compounds in the ambient air at confined (or concentrated) animal feeding operations (CAFOs) (Schiffman *et al.*, 2001; Zahn *et al.*, 1997; O'Neill and Phillips, 1992; Hammond *et al.*, 1989). These studies have all provided qualitative identification, but little quantification.

VOC samples were collected with the intent of providing an assessment of various environmentally superior technologies as well as conventional technologies (i.e., lagoon and spray i.e., land application of lagoon slurry). It should be noted that a collection of samples in this manner has previously not been accomplished. Samples were collected at the housing areas as well as the technologies (i.e., storage lagoons) in an effort to characterize all of the compounds on site along with their origin, be it the hog barns, storage lagoons, or another off site locale.

The main objectives of this field study are to:

1) Characterize C_2-C_{12} VOCs that are present in the ambient atmosphere at swine confined animal feedong operations (CAFOs)
2) Identify the VOCs that may be classified as irritants and/or malodors in the atmosphere
3) Identify any potentially hazardous air pollutants as defined by the United States Environmental Protection Agency (US EPA) (US EPA, 1994)
4) Compare concentrations from conventional lagoon and spray technologies with four potential "Environmentally Superior Technologies" that have been implemented on different farms in this study

5) Address seasonal variations of VOC concentrations

6) Calculate flux of VOCs emitted from hog barns at the various sampling sites

1.2 Characteristics of Volatile Organic Compounds

There are literally hundreds of VOCs that reside in the ambient rural atmosphere. Many originate from anthropogenic (human-made) sources such as fossil fuel burning (i.e., coal fired power plants, automobile exhaust, natural gas, etc.). Other compounds are emitted naturally (biogenically) into the environment from plants and vegetation, soils, biomass burning, oceans, volcanoes, and animal waste. Various compounds (e.g., carbonyls) may be emitted from primary sources or derived through a complex set of photochemical reactions via another compound residing in the atmosphere.

Many species have multiple origin sources. For example, according to Graedel *et al*. (1986), ethanol may be emitted from animal waste, automobile emissions, solvents, volcanoes, vegetation, along with many other sources. To complicate things even more, each specie has a different reaction mechanism once borne into the surrounding environment and many are ubiquitous in the ambient air due to their extended lifetimes. This implies that compounds characterized on site may be carried in by air masses and makes it difficult to ascertain the exact point of origin. Therefore, it is difficult to determine which compounds are emitted from within the hog farms, as well as the exact source (i.e., animal waste, animal feed, etc.).

Over two hundred different VOCs were identified through samples collected at the various swine facilities in this field study. Many of these were "target" VOCs, determined to play an important role as precursors to tropospheric ozone, fine particulate matter (PM_{fine}),

and other atmospheric photochemical oxidation formation such as peroxyacetal nitrate (PAN) (Kang *et al*., 2001). Many compounds identified (e.g., reduced organic sulfur compounds) are related to odor and irritation senses while others are defined to be hazardous air pollutants by the United States Environmental Protection Agency (US EPA, 1994).

1.2.1 Hydrocarbons

Hydrocarbons (HCs), the simplest organic compounds, are classified as those compounds containing elemental carbon and hydrogen. Non-methane hydrocarbons (NMHCs) comprise all hydrocarbons except for methane (CH_4).

Hydrocarbons in the C_2 –C_{12} range are the lightest and most volatile of all the NMHCs. They reside primarily in the gaseous phase upon release into the atmosphere. With a few exceptions, NMHCs generally have lifetimes on the order of days (Finlayson-Pitts and Pitts, 2000). This is due to their rapid photochemical reaction with the hydroxyl radical ($OH\cdot$) in the atmosphere. Alkanes, also known as paraffins, are saturated HCs containing only a single bond, while alkenes, also grouped as either olefins or aromatics depending on atomic structure, and alkynes are unsaturated HCs containing double and triple bonds, respectively (Ebbing, 1996).

Alkenes tend to be more reactive in the atmosphere than alkanes because many reactants add to the double bond structure. They have lifetimes of hours, thus limiting spread from their originating source (Warneck, 2000). Similarly, alkynes are generally more reactive than alkenes due to their triple bond structure (Ebbing, 1996).

Hydrocarbons are normally separated into two broad categories based on their source emissions, i.e. anthropogenic and natural (biogenic). Anthropogenic NMHCs derive mainly

from automobile emissions, gasoline evaporation and spillage, natural gas, emissions from petroleum manufacturing plants and refineries, and commercial solvents, while the sources of natural (biogenic) NMHCs are plants and vegetation, oceans, and biomass burning (Warneck, 2000). Table 1.1 provides a breakdown of global emissions of VOCs. VOC emissions from confined animal feeding operations (CAFOs) have not been included, thus far, in either of these source categories since characterization from CAFOs has never been performed to date.

Anthropogenic Hydrocarbons

Anthropogenic NMHCs are dominant in urban areas, although they may be found in less populated locations as well. Higher alkanes, which are in the C_2-C_5 range, associate mainly with emissions from solvents (Mayrson and Crabtree, 1976 and Nelson *et al*., 1983). To provide some examples, the major source of ethane (C_2H_6) is natural gas. Propane (C_3H_8) also derives from natural gas as well as petrochemical industries. Butane (C_4H_{10}) and pentane (C_5H_{12}) are found in automotive exhaust. Alkenes also derive from automotive exhaust. The major source of acetylene (C_2H_2) is through combustion, although small amounts are produced from burning of agricultural waste and other plants (Nelson *et al*., 1983). Approximately 75% of benzene (C_6H_6) arises from automotive exhaust and the rest from evaporation and spillage of fuel, and solvent emissions from the chemical industry. Toluene ($C_6H_5CH_3$) and ethylbenzene ($C_6H_6C_2H_5$) originate from both automotive exhaust and solvent emissions. Although a sampling area may be far removed from urban sources, due to extended lifetimes, NMHCs may still be transported relatively far from their source (Hagerman, 1997; Kang *et al*, 2001; Das *et al*, 2003).

Biogenic Hydrocarbons

Thousands of biogenic NMHCs and VOCs have been studied and identified (Isidorov *et al.*, 1985; Graedel *et al.*, 1986; Puxbaum, 1997; Fall, 1999). The most recognized are ethene, isoprene, and monoterpenes, which are typically emitted from plants (Finlayson-Pitts and Pitts, 2000). In rural areas, these compounds may be much more abundant in the troposphere as compared to anthropogenically emitted NMHCs. Schiffman *et al.* (2001) identified β-pinene in a study that characterizes various compounds at a swine facility. It has been estimated that global emissions of biogenic NMHCs are on the order of one magnitude greater than anthropogenic NMHCs (Guenther and Wildermuth, 1994). According to Guenther and Wildermuth (1994), annual emissions from vegetation are 1.2 x 10^{15} gC worldwide, an amount comparable to that of methane emissions.

Biogenic NMHCs are unsaturated alkenes containing double bonds, thus allowing for a high reaction rate (Finlayson-Pitts and Pitts, 2000). Once emitted into the atmosphere, biogenic NMHCs take part in a complex sequence of reactions, initiated by the hydroxyl radical ($OH\cdot$), oxidant ozone (O_3), or the nitrate radical ($NO_3\cdot$). It should be noted that the lifetimes of these compounds, due to their high reaction rates, are on the order of hours, whereas most anthropogenic NMHCs have lifetimes on the order of days.

Isoprene (C_5H_8) is the dominant biogenic hydrocarbon in the atmosphere and is emitted from deciduous trees such as oak and spruce (US EPA, 2001). Both temperature and light intensity strongly affect the rate of emission of isoprene (Fuentes *et al.*, 2000). The highest emission rates occur during peak daylight hours and during the warmest times of the year (Claes *et al.*, 1998). This dependence on light and temperature is due to the production

of isoprene in the plant, involving the precursor enzyme isoprene synthetase and dimethylallyl diphosphate (DMAPP) (Silver and Fall, 1995)

Monoterpenes are defined as C_{10} NMHCs that are produced from DMAPP and its isomer isopentenyl pyrophosphate (IPP) (Fuentes, 2000). Coniferous trees such as pine, fir, maple, hickory, and spruce emit high levels of monoterpenes (EPA, 2001). These biogenic emissions appear to be exponentially proportional to temperature (Harrison, 1998) and independent of light, although young needles on conifers can have both light-dependent and temperature-independent emission (Seufert *et al*. 1995).

Monoterpenes react quickly with OH·, O_3, and NO_3. They react with OH· and O_3 during the daylight and, since these compounds are not light dependent, they may also react with NO_3· during the nighttime (Warneck, 2000).

Studies have shown that a large fraction of the monoterpenes α- and β-pinene reacting with O_3 and/or OH· can form aerosol-phase products upon emission into the troposphere, namely pinonaldehyde (Yokouchi, 1994). According to Jensen (2000), during the ozonalysis of α-pinene, pinic acid is the dominant aerosol constituent in the newly formed particles and with increasing aerosol volume, more volatile products (i.e. pinonaldehyde) were found to contribute to the particulate phase.

1.2.2 Oxygenated Hydrocarbons

Volatile oxygenated HCs, also known as carbonyls, are those compounds that contain at least one atom each of carbon, hydrogen, and oxygen. These compounds may be emitted either primarily from a source or formed secondarily through an oxidation process in the atmosphere.

Direct biogenic sources account for many alcohols, aldehydes, esters, and ketones (Finlayson-Pitts and Pitts, 2000). For example, all leaves emit methanol when expanding (Nemecek-Marshall et al., 1995) and many conifers emit acetone from their buds (MacDonald and Fall, 1993). Both methanol and acetone have been found in grass, and clover (Kirstine *et al*., 1998). Emissions of acetaldehyde have been observed from oak and pine trees (Kesselmeier *et al.,* 1997). In addition to vegetative emissions, Graedel (1986), O'Neill and Phillips (1992), and Schiffman *et al*. (2001) have cited all four of these compounds, as well as various other carbonyls, as originating from animal waste.

A second source of these oxygenated HCs is via an oxidation process of NMHCs upon release into the ambient environment. These hydrocarbons are oxidized in the atmosphere through the initial reactions with OH·, O_3, or NO_3·. The oxidation process then proceeds via alkylperoxy and alkoxy radicals to form aldehydes and ketones as products (Warneck, 2000). The oxidation of the higher NMHCs and aromatic compounds may lead to condensable products that attach to aerosol particles (Warneck, 2000). Table 1.2 depicts a list of VOCs present in the ambient air at each of these hog farm sampling sites.

Ethane (C_2H_6), for example, may oxidize in the atmosphere through an initial reaction with OH· to form acetaldehyde (CH_3CHO) summarized in the following steps (Aiken *et al*., 1982)

$$C_2H_6 + OH \rightarrow H_2O + C_2H_5 \quad (1)$$

$$C_2H_5 + O_2 \rightarrow C_2H_5OO \quad (2)$$

$$C_2H_5OO + NO \rightarrow C_2H_5O + NO_2 \quad (3)$$

$$C_2H_5OO + HO_2 \rightarrow C_2H_5OOH + O_2 \quad (4)$$

$$C_2H_5O + O_2 \rightarrow CH_3CHO + HO_2 \quad (5)$$

1.3 Tropospheric Ozone Formation Potential

It has been well established that NMHCs play a key role as precursors in the formation of tropospheric ozone. Since passage of the 1970 Clean Air Act Amendments, regulatory efforts to comply with the earlier 0.12 ppm hourly National Ambient Air Quality Standard for ozone have not been entirely successful (NRC, 1991; Dimitriades, 1989). Following the current 8-hourly standard of 0.08 ppm, ozone nonattainment continues to be a problem for many urban and rural areas, especially in the Southeastern United States. Several studies have reported the abundance of NMHCs in the Southeastern United States (Hagerman *et al*, 1997; Reimer *et al*., 1998; Kang *et al*, 2001; Das *et al*, 2003). Although the sites sampled were rural by all accounts, they were influenced by various episodes of transport of pollution.

Tropospheric O_3 arises mainly from gas-phase photochemical reactions in the atmosphere. The interaction of nitrogen oxides (NO_x = NO + NO_2) with hydrocarbons in sunlit air produces an accumulation of O_3 in the troposphere (Warneck, 2000).

Net reaction for the formation of O_3 is begun as a hydrocarbon (e.g., alkane) is converted to ketones and aldehydes and it oxidizes at least 2 molecules of NO to NO_2. The photodissociation of NO_2 is the source of O_3 in photochemical smog. More than two molecules of O_3 are formed for each molecule of HC being oxidized (Warneck, 2000). Aldehydes are more reactive with $OH\cdot$ than are alkanes, such that aldehydes produced are subject to further oxidation and additional NO is converted to NO_2. Table 1.3 shows the potential for ozone formation via the oxidation process.

A generic example for the formation of O_3 is given below where R and RH denote an organic group (e.g. alkyl group) and a representative hydrocarbon (e.g. alkane), respectively:

$$O_3 + h\nu \text{ -> } O_2 + O(\,^1D) \quad (6)$$

$$O(\,^1D) + H_2O_{gas} \text{ - > } 2OH \quad (7)$$

Here, it is notable that 2 OH radicals are created and the process continues:

$$RH + OH \rightarrow H_2O + R\cdot \quad (8)$$

This is followed by the formation of a peroxy radical ($RO_2\cdot$)

$$R + O_2 + M \rightarrow RO_2\cdot + M \quad (9)$$

Ozone is then consequently produced by

$$RO_2 + NO \rightarrow (\text{Aldehyde or carbonyl}) + NO_2 \quad (10)$$

$$HO_2 + NO \rightarrow OH + NO_2 \text{ and} \quad (11)$$

$$2\{NO_2 + h\nu \rightarrow NO + O\} \quad (12)$$

followed by

$$2\{O + O_2 + M \rightarrow O_3 + M\} \text{ (McElroy, 2002).} \quad (13)$$

Additional NO_2 and O_3 arise from the photooxidation of formaldehyde (HCHO) produced from CH_3CHO and from the photooxidation of the ketones occurring as products of alkane oxidation (Warneck, 2000).

The level at which ozone can be considered to have a negligible effect on human health is unclear. In the absence of human activity, models have shown that tropospheric levels of ozone may lie in the 15-30 ppbV range (McElroy, 2002). Continuous exposure to ozone levels above 50 ppbV is known to cause damage to sensitive plants and levels above 150 ppbV are deemed unhealthy for humans, although sensitive individuals (i.e., those with respiratory problems) and children may be susceptible at levels between 50 and 150 ppbV as well. Standards in the United States are set now at 80 ppbV for eight-hour short term

exposure (US EPA, 1999). Even at very low concentrations, ground-level ozone can aggravate asthma, reduce lung capacity, and increase susceptibility to respiratory illnesses such as pneumonia and bronchitis (US EPA, 2000).

1.4 Organic Sulfur Compounds

There are substantial natural emissions of sulfur compounds into the troposphere. Previously, these have been measured in biological activity in vegetation, soils, and water (including marine) ecosystems. Anthropogenic emissions consist almost entirely of sulfur dioxide (SO_2), whereas natural emissions are mainly in the form of reduced organic sulfur compounds (Finlayson-Pitts and Pitts, 2000). The major reduced sulfur compounds consist of hydrogen sulfide (H_2S), dimethyl sulfide (CH_3SCH_3), dimethyl disulfide (CH_3SSCH_3), carbonyl sulfide (COS), carbon disulfide (CS_2), and methyl mercaptan (CH_3SH). For the types of emissions measured (vegetation, soils, and water ecosystems), H_2S, CH_3SCH_3, COS, and CS_2 were usually present in the greatest concentrations. Generally, CH_3SH and CH_3SSCH_3 comprised smaller concentrations (Aneja, 1975; Finlayson-Pitts and Pitts, 2000). In the continental environment, typical mixing ratios for CH_3SCH_3 are on the order of 20 parts per trillion (ppt) or less in rural areas (Singh, 1995).

Due to its long lifetime, COS is the most abundant sulfide in the atmosphere and is evenly distributed throughout the troposphere (Warneck, 2000) and it is thought to contribute to sulfate aerosol layer in the stratosphere (Aneja *et al*, 1979). Bandy *et al*. (1992) examined a time series of measurements since 1977 and found that neither temporal nor seasonal variations appear to exist for this specie. Carbon disulfide contributes to the tropospheric budget of COS as it photochemically oxidizes to equal amounts of the aforementioned and

SO_2. The oxidation of CH_3SCH_3 by OH radical also produces COS in a side reaction (Barnes *et al*., 1994).

Volatilization from animal wastes is an important source of gaseous reduced sulfur compounds, particularly in Eastern North Carolina., where the swine industry constitutes a major animal agricultural activity. While Table 1.4 accounts for natural sources of reduced organic sulfur compounds in the atmosphere, it should be noted that the information does not provide estimates of these species from animal waste and/or production facilities. This suggests that no similar quantitative measurements of reduced organic sulfur compounds have been made to date in CAFOs. Data collected in this study may assist in such quantifications.

1.5 Gaseous Sulfur Malodors

It has been established that many malodorous and potentially harmful volatile organic compounds are emitted from swine containment facilities (Yasuhara *et al*., 1984; Hammond *et al*., 1989; Zahn *et al*., 1997; Schiffman *et al*., 2001). Odors from lagoons and containment buildings that persist any distance from their source, are borne on particles (Hammond *et al*., 1989). According to a study by Hammond *et al*. (1989), the most important contributors to odor at swine facilities were the sulfur containing compounds CH_3SSCH_3 and dimethyl trisulfide ($CH_3S_3CH_3$).

In previous studies, Schiffman *et al*. (2001) and O'Neill and Phillips (1992) have identified H_2S, COS, CS_2, CH_3SCH_3, and CH_3SSCH_3 as compounds present in swine houses and lagoons. Table 1.5 provides a list of these reduced sulfur compounds along with their

known odor threshold. Other important airborne VOCs that contribute to odor are indole, cresols, phenols, and organic acids.

Odor threshold may be defined as the concentration at which odor is first detected. According to Schiffman *et al.* (2001), irritancy occurs at 3-10 times higher concentration than the odor threshold. Although the individual species may not exceed the concentration known to cause irritation, often the combined load of compounds may exceed the irritation threshold (Korpi *et al.*, 1999). Odor complaints have increased rapidly with the increase in the number of swine production facilities (Schiffman *et al.*, 2001). Odor sources from CAFOs include animal confinement houses, anaerobic storage lagoons, and spray fields adjacent to the properties that utilize solid wastes as a means of fertilization treatment on crops.

Adverse health symptoms can occur at concentrations that are above odor detection thresholds but well below the levels that cause irritation (Schiffman *et al.*, 2001). A review of air-related illnesses in workers at confined hog facilities found that 11% had asthma-like systems, more than half had suffered from upper-airway inflammation, and up to 70% had some form of bronchitis (Donham and Thu, 1995). Hog factory workers can develop acute symptoms from as little as 2 hours/day exposure in a confinement area and asthma and other related respiratory illnesses may arise more after six years of working in confined animal feeding operations (CAFOs). A study in Iowa indicated that neighbors of hog facilities had respiratory illnesses that were similar to the workers (Donham, 1998). Schiffman (1998) conducted a study of North Carolina residents who lived in close proximity to hog operations for an average of five years and found that there were significantly higher levels of tension, depression, anger, and fatigue than residents that were not exposed to hog odor

1.6 Particulate Matter Formation

Gaseous sulfur is one of the main chemical species involved in the gas-to-particle process. The oxidation of sulfides in the atmosphere is initiated mainly by reaction with OH· (Warneck, 2000). All sulfides except for COS react quickly with OH·, thereby having a short lifetime in the atmosphere, on the order of days. As a result, mixing ratios fluctuate significantly and decrease rapidly with distance from the locale of origin (Warneck, 2000). Large diurnal variations have been associated with CH_3SCH_3 and CH_3SH. Observations suggest that these compounds are highly reactive with NO_3·, which becomes active during nighttime and is likely the source of a major loss process (Graedel, 1979). Atkinson and Carter (1984) found that the reactions of reduced sulfur species with O_3 are too slow to be considered significant. Table 1.6 provides an estimate of the lifetimes for the reactions of specified reduced sulfur compounds with OH· and NO_3· (Finlayson-Pitts and Pitts, 2000).

Sulfate is the dominant soluble component of larger aerosol particles in the atmosphere. Gases such as H_2S, CS_2, COS, and CH_3SCH_3 may be oxidized to SO_2, which is then further oxidized to the sulfate SO_4^- (Hobbs, 2000). The dominant gas phase pathways are:

$$SO_2 + OH + M \rightarrow HSO_3 \quad (14)$$

$$HSO_3 + O_2 \rightarrow HO_2 + SO_3 \quad (15)$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \quad (16)$$

Atmospheric gas phase reactions may lead to the formation of condensable products that associate with the atmospheric aerosol. Gaseous H_2SO_4 may then be neutralized by ammonia (NH_3) to form sulfate salts (Warneck, 2000). Limited by the supply of NH_3, the chemical reaction is:

$$2NH_3 + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq) \quad (17)$$

Aneja *et al*. (1998) determined that an estimated 68,540 tons of NH_3 are emitted from swine facilities annually in North Carolina. Figure 1.2 provides a generic example of the various routes in which particulate matter (PM) is incorporated into the atmosphere. The right hand side of the diagram is of particular interest because it depicts the basic route of PM formation for gaseous organic sulfur compounds.

The chemical reactivity of atmospheric ammonium sulfate relies largely on the particle phase. This phase also is important in determining the ability of the particle to serve as an effective cloud condensation nucleus. The vapor pressures of NH_3 and H_2SO_4 in equilibrium are much lower than that of sulfuric acid in the presence of water (Scott and Cattell, 1979). This lowers the critical cluster size and thus enhances the rate of nuclei formation (Warneck, 2000).

Particles produced in gas-to-particle conversion reactions at ambient temperatures tend to be in the Aitken nuclei size range, with diameters ≤ 0.08 μm (Claes, 1998). Particles in this size range efficiently act as nuclei for the condensation of low vapor gaseous species or quickly coagulate, thus forming accumulation mode particles in the range of 0.08-2.0 μm. Accumulation mode particles have longer residence times and can be incorporated into cloud droplets, then are removed by wash-out or rain-out (Claes, 1998).

Particulate matter (PM) in the atmosphere may create a cooling effect by scattering incoming light radiation (Lightstone *et al*., 1998). Visual range may be decreased as the number and size of the airborne particulates is increased. Humidity is a factor that plays a large role. An increase in humidity can cause major changes in visibility by increasing the size of the already present aerosols (Kyle, 1991). Ammonium sulfate in the atmosphere may create a regional cooling effect by scattering incoming light radiation (Lightstone *et al*.,

1999). An environmental hazard in eastern North Carolina associated with the ammonium sulfate aerosol is deposition into coastal river systems where nitrogen loading may lead to enhanced eutrophication and soil acidification which, in turn, may upset plant nutrient balances near sources (Paerl, 1997).

It should be noted that measurement of particulate aerosols (both primary and secondary) originating on the hog farms in this field study is beyond the scope of the project. The information is provided to give insight to possible aerosol formation via the compounds detected at these sites.

1.7 Hazardous Air Pollutants

The United States Environmental Protection Agency (US EPA) developed the "EPA Health Effects Notebook for Hazardous Air Pollutants (HAPs)", EPA-452/D-95-003, December 1994 that includes a list of 188 compounds. HAPs may be defined as those pollutants that are known to cause cancer or other serious health effects, such as damage to the immune system, reproductive, developmental, neurological, and respiratory effects (US EPA, 1994). People exposed to HAPs at sufficient concentrations and extended durations of times are more likely to suffer from these adverse health effects.

Of the 188 pollutants listed in the "EPA Health Effects Notebook for Hazardous Air Pollutants (HAPs)", EPA-452/D-95-003, December 1994, nine HAPs were identified near housing source areas at swine facilities in Eastern North Carolina. This list includes acetaldehyde, benzene, *n*-hexane, methanol, methyl ethyl ketone (MEK), 4-methylphenol (*p*-cresol), styrene, toluene, and xylene (m-p-&o-). Schiffman *et al*. (2001) and O'Neill and Phillips (1992) have reported findings of these compounds as well during previous studies,

with the exception of styrene. Graedel *et al.* (1986) also confirms 4-methylphenol, benzene, toluene, methanol, and acetaldehyde to be compounds emitted from animal waste facilities. Of the compounds observed, acetaldehyde, MEK, and styrene were found generally to have higher concentrations at the housing area than average ambient concentrations reported by the US EPA. Acetaldehyde was also found to have higher concentrations than the reference concentration established by the US EPA, which may be defined as an estimate of a daily inhalation exposure of the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime (California Air Resource Board, 2001).

1.7.1 Acetaldehyde

Acetaldehyde (CH_3CHO) exists in the atmosphere primarily in the gas phase. Traditionally, sources of acetaldehyde may be both anthropogenic and biogenic; and also secondary in nature. Known emissions include combustion processes such as vehicle exhaust from mobile sources and fuel combustion from stationary internal combustion engines. It is also a product of incomplete combustion in fireplaces and woodstoves, burning of tobacco, and waste processing. Naturally, acetaldehyde is found as an intermediate product in the respiration of higher plants. For example, emissions of acetaldehyde have been observed from oak and pine trees (Kesselmeier *et al.*, 1997). As discussed earlier, this specie may also be formed in the atmosphere as a result of photochemical oxidation of organic pollutants (e.g., ethane oxidizes to form this compound).

The dominant atmospheric loss process is via its reaction with $OH\cdot$. Based upon this reaction, the lifetime is estimated to be 22 hours (Atkinson and Carter, 1994). Acetaldehyde

may react further to form formaldehyde (HCHO) and peroxyacetyl nitrate (PAN) (Atkinson, 1995).

The US EPA reported concentrations of acetaldehyde from 14 study areas in 1989. The overall mean concentrations in these studies were 1.39 ppbV (2.78 ppbC) (Kelly *et al.*, 1994), where ppbV refers to the concentration by total volume and ppbC refers to concentration by number of carbon atoms.

According to Howard (1990), human exposure to this specie occurs primarily through inhalation. Acute exposure to acetaldehyde vapor may lead to eye, skin, and respiratory tract irritation and the US EPA has established a Reference Concentration (RfC) of 9.0 $\mu g/m^3$ (10 ppbC) based on degeneration of olfactory epithelium in rats (California Air Resources Board, 2001).

1.7.2 Methyl Ethyl Ketone (MEK)

MEK ($CH_3C_2H_5CO$) has its primary anthropogenic origins in solvents and paint removers as well as cigarette smoke and gasoline exhaust. This compound may also be emitted biogenically by volcanoes, forest fires, and products of biological degradation (Howard, 1990).

In the atmosphere, MEK resides in the gaseous phase. Similar to acetaldehyde, the dominant loss process in the troposphere is through reaction with OH·. The lifetime of this compound is longer, however, on the order of 13 days. MEK products of the photochemical reaction with OH· include acetaldehyde, formaldehyde, and, in the presence of nitrogen dioxide (NO_2), peroxyacetyl nitrate (PAN) (Atkinson and Carter, 1994).

Data compiled by the US EPA from 1972 to 1987 provides an average ambient concentration of 0.47 ppbV (1.88 ppbC); however, there was no specification as to rural or urban measurements (California Air Resources Board, 2001). Exposure to MEK at levels above 340 ppbV may cause eyes, nose, throat, and respiratory tract infection. According to the US EPA it is also a known central nervous system depressant (California Air Resources Board, 2001).

1.7.3 4-methylphenol (p-cresol)

4-methylphenol ($CH_3C_6H_4OH$), an aromatic VOC, has been identified as a major malodorous compound in swine manure (Schaffer, 1977; Williams, 1984). This compound has also been detected in emissions from coal tar and metal refining, chemical and glass fiber manufacturing, and motor vehicle exhaust. It may also be formed from the $OH\cdot$ initiated reaction of toluene and exists in the atmosphere in the gaseous phase. Its primary loss processes are via daytime reaction with $OH\cdot$ and nighttime reaction with $NO_3\cdot$. According to the US EPA, the expected lifetime of 4-methylphenol is 5 to 8 hours due in large part to the aforementioned photochemical reactions (California Air Resources Board, 2001). US EPA has reported average urban concentrations for California (1984) at 1.04 ppb (7.28 ppbC) (California Air Resources Board, 2001). No national data is available at this time for rural background levels. In a study conducted by McGinn (2001), average levels in a feedlot were found to be < 0.1 ppbV, whereas Schiffman *et al.* (2001) reported higher levels of 9 ppbV. The odor threshold for this compound is 1.86 ppbV (13.0 ppbC) (Schiffman *et al.*, 2001).

Acute inhalation exposure of humans to mixed cresols results in respiratory tract irritation with symptoms including dryness, nasal constriction, and throat irritation. While a

reference concentration has not yet been established, the US EPA has classified this compound as Group C, possible human carcinogen (California Air Resources Board, 2001).

1.7.4 Styrene

Styrene (C_8H_8) is known to be emitted from cigarette smoke and from waste incineration stack emissions (Howard, 1990). Steele *et al*. (1994) found styrene to be present in 8 of 12 common agricultural commodities.

Styrene also exists primarily in the gaseous phase in the ambient atmosphere. The major atmospheric loss processes are through reaction with OH·, NO_3·, and O_3 (Atkinson, 1994). In urban environments, lifetime due to the reaction with OH· is 6 hours, and 23 hours for the reaction with O_3. The products produced photochemically due to these reactions are mainly formaldehyde and benzaldehyde (Tuazon *et al.*, 1993). In three studies conducted by the US EPA from 1989-1991, an overall average concentration was determined to be 0.13 ppb (1.04 ppbC) (California Air Resources Board, 2001).

According to the US EPA, styrene can cause irritation of the eyes, nose, throat, and lungs. It is also a central nervous depressant, effects of which may include headache, fatigue, nausea, weakness, and dizziness (California Air Resources Board, 2001).

Table 1.1 Summary of Global Emissions of Hydrocarbons and Other Organic Volatiles from Various Sources (Warneck, 2000)

Type of Source	Emission Rate (Tg $year^{-1}$)	Remarks
Anthropogenic sources		
Petroleum-related sources and chemical industry	36-62	Mainly alkanes, alkenes, and aromatic compounds
Natural gas	2-14	Mainly light alkanes
Organic solvent use	8-20	Higher alkanes and aromatic compounds
Biomass burning	25-80	Mainly light alkanes and alkenes
Total anthropogenic sources	71-175	
Biogenic sources		
Emissions from foliage		
Isoprene	175-503	
Monoterpenes	127-480	
Other organic compounds	510	Higher alkanes, alkenes, alcohols, aldehydes, ketones, esters
Grasslands	< 26	
Soils	< 3	
Ocean waters	2.5-6	Light alkanes and alkenes
	< 26	C_9-C_{28} alkanes
Total biogenic sources	815-1530	

Table 1.2 Hydrocarbons and their VOC derivatives

Hydrocarbon	Oxygenated Derivative(s)
Ethane	Acetaldehyde
Propane	Acetone
n-Butane	Butanal, Methyl Ethyl Ketone
Isobutane	Acetone

Table 1.3 Potential for Ozone Formation in the Oxidation of Several Hydrocarbons Following Reaction with OH Radicals (Warneck, 2000)

		NO to NO_2 conversion factors		
Compound	Intermediate aldehydes and ketones	Initial	From carbonyl compounds	Total
Ethene	2HO	2	2	4
Propene	HCHO, CH_3CHO	2	5	7
1-Butene	CH_3CH_2HO, HCHO	2	8	10
cis/trans-2-Butene	$2CH_3CHO$	2	8	10
Isobutene	CH_3COCH_3, HCHO	2	5	7
Ethane	CH_3CHO	2	4	6
Propane	CH_3COCH_3, HCHO, CH_3CHO	2	6	8
n-Butane	$CH_3CH_2COCH_3$, CH_3CHO	2	6	8
Isobutane	CH_3COCH_3, HCHO	3	6	9

Hydroxyl radical	HO
Formaldehyde	HCHO
Acetaldehyde	CH_3CHO
Ethanol	CH_3H_2CHO
Acetone	CH_3COCH_3
Methyl ethyl ketone(MEK)	$CH_3CH_2COCH_3$

Table 1.4 Natural Sources of Sulfur in the Atmosphere (Gmol year^{-1} of sulfur)

Source	H_2S	CH_3SCH_3	CS_2	COS	SO_2
Oceans	<9	500-1300	2.4-9.5	2.7-7.8	-
Coastal wetlands	0.2-30	0.2-18	0.2-1.2	2.3-8.7	-
Soils and plants	2-56	3-24	0.4	-	-
Volcanoes	16-47	-	0.2-2.4	0.1-1.5	230-300
Biomass burning	-	-	-	0.7-4.3	81
Other	-	-	-	4.5-14.8[a]	-
Sums	**18-133**	**503-1342**	**3.3-14.1**	**10.4-37.1**	**311-381**

[a] Reaction of OH with CS_2 and CH_3SCH_3
(Warneck, 2000)

Table 1.5 Reduced Sulfur Compounds Associated with Animal Production Facilities

Compound	Odor threshold[a] (ppm)	Sensory and Odor Characteristics[b]
H_2S	0.0178	rotten eggs
CS_2	0.0955	rotten eggs
CH_3SCH_3	0.00224	stench, decayed
CH_3SH	0.00105	rotten cabbage
CH_3SSCH_3	0.0123	putrid, garlic

[a] Schiffman *et al.* (2001)
[b] Merck index (1996)

Table 1.6 Lifetimes at Room Temperature for the Reactions of OH and NO_3 Radicals with some Reduced Sulfur Compounds (Warneck, 2000)

Compound	OH· (day)	NO_3· (night)
H_2S	5 days	-
COS	63 yr	-
CS_2	8 days	-
CH_3SCH_3	4 days	1.1 hr
CH_3SH	17 hr	1.1 hr
CH_3SSCH_3	2.8 hr	26 hr

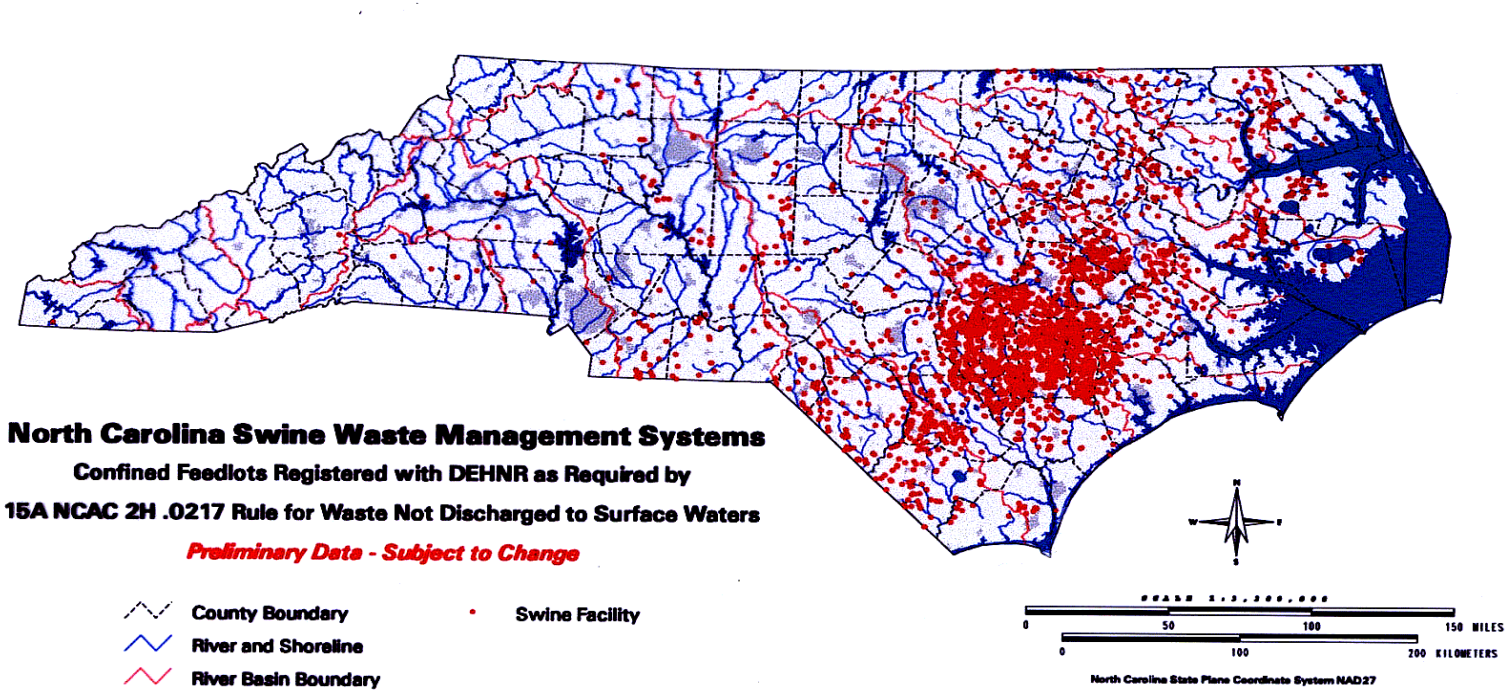


Figure 1.1 North Carolina Swine Facility Site Locations

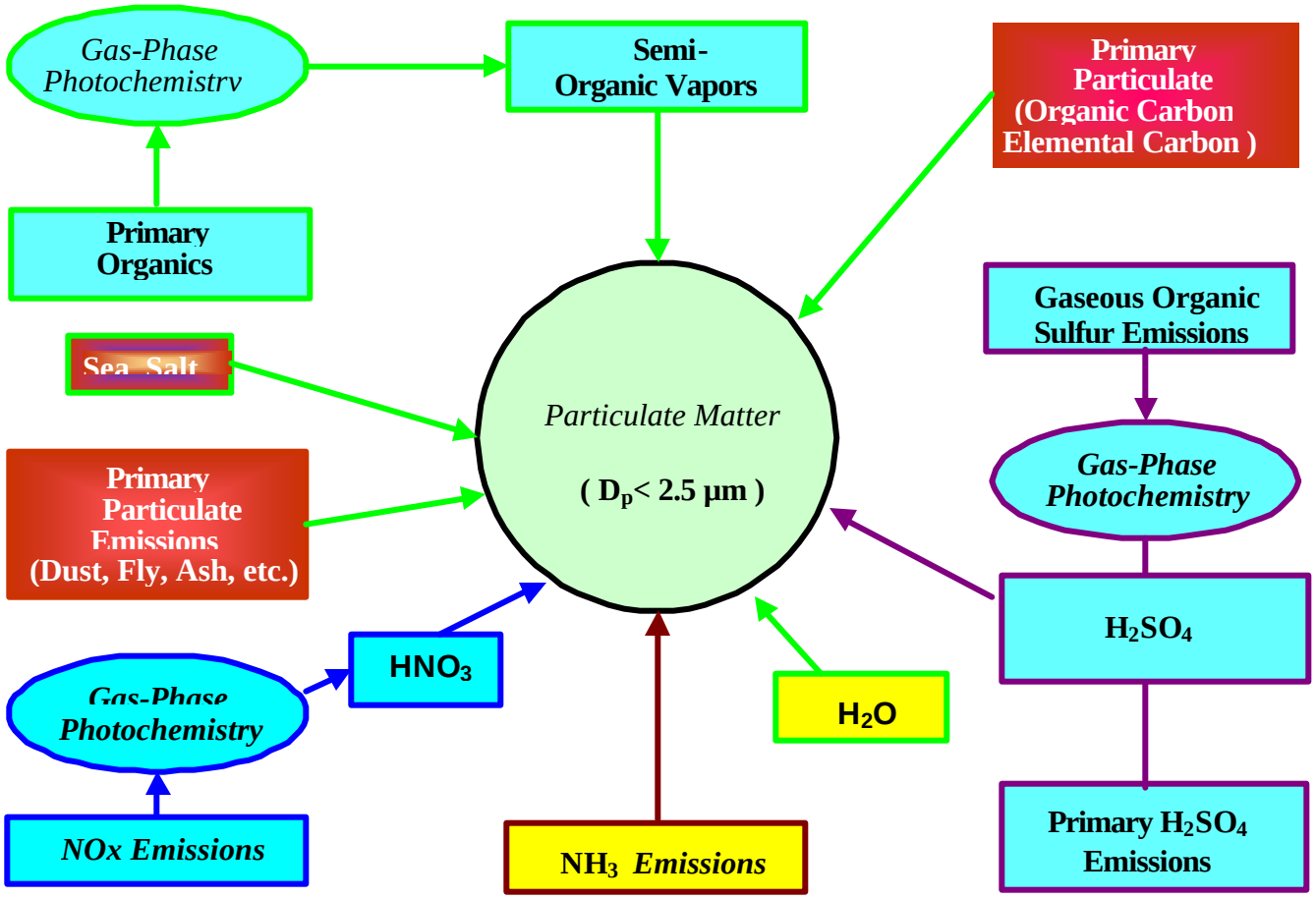


Figure 1.2 Routes of incorporation of chemical species into atmospheric particulate matter (modified from Meng et al., 1997).

2.0 Methods and Materials

2.1 Experimental Research Site Descriptions

Samples were collected at six different farms located in Eastern North Carolina. Four farms utilized an EST to treat animal waste while two farms maintained the conventional technology. Each farm was sampled during two different seasons with the exception of Corbett Farm #2 (RECIP), which was sampled during one season only. Individual site locations are depicted in Figure 2.1 while layouts and/or photos of each farm are shown in Figures 2.2-2.7.

2.1.1 Environmentally Superior Technologies

The first sampling site was Barham Farm, a 4,000 head farrow to wean operation, located near Zebulon, North Carolina (35.70°N, 78.32°W, 130m MSL) (Figure 2.2). There were six hog barns located on the property. Buildings 1, 2, 5, and 6 are gestation houses and buildings 3 and 4 are farrowing houses. Each house contained a fan ventilation system (also sometimes referred to as tunnel ventilated). The numbers of animals in the barns, as well as their average weights (kg), for all of the sites are listed in Table 2.1.

This site utilized a covered in-ground ambient digester as a potential EST. The in-ground ambient digester may be considered as a primary treatment lagoon (4,459 m^2) that had an impermeable polypropylene covering over its surface (Figure 2.2). All the emitted gases including methane and other organic gases were collected under the cover and periodically extracted and delivered to a generator where the gases were converted to electricity through a generator system. Heat from the generator was used to produce hot water that was incoprorated by the farm for production purposes. The effluents from the hog

barns were initially directed to the primary lagoon with the impermeable cover and the effluent then flowed through a single outlet pipe into a secondary storage lagoon (19,398 m^2). Here, the liquid waste was treated via a de-nitrification/biofiltration process. The treated wastewater was then used for two purposes: to flush more waste from the hog barns and as a spray over agricultural crops for nutrient enrichment purposes.

The second sampling site was Grinnells Laboratories, located on the North Carolina State University campus in Raleigh, NC (35.47°N, 78.40°W, 107 m MSL) (Figure 2.3). It should be taken into account that this site was located in a non-rural area. This site utilized a Ganet-Fleming Belt System that consisted of the retrofit installation of a conveyor belt type apparatus in the swine production facility to convey the manure wastes generated therein. The process separated the liquid wastes and the solid wastes as they were deposited inside the production facility. There was no storage lagoon located at this site.

The third farm sampled was Howard Farm, located near Richlands, NC (34.84°N, 77.50°W, 5 m MSL) (Figure 2.4), which utilized a "Solids separation/Constructed Wetlands" system as its potential EST. Effluents from the hog barns were directed initially to a solid separator where the solid waste was separated from the liquid waste. The solids were then removed to an off-site facility and liquid waste was put into two outer lagoon cells (outer cell 19,366 m^2; inner cell 10,256.3 m^2). As the wastewater traveled around the cells, it encountered the constructed wetlands, which treated the wastewater effluent through microbial utilization and the root substrate of the wetland plant species (Project Technical Manager's File, 2002). The treated wastewater was then filtered into a finishing lagoon (7,428 m^2) where it was used in a manner similar to Barham Farm, i.e., the waste was recycled to flush more effluent through the hog barns and as a spray for agricultural crops.

This site was strictly a finishing operation. There were four containment houses located on the property, each utilizing a fan ventilation system.

The fourth and final EST site was RECIP, located near Rose Hill, NC at Corbett Farm #2 (34.84°N, 77.96°W, 30 m MSL) (Figure 2.5), a finishing facility. This technology encompassed two cells, or treatment basins filled with media, that alternately drained and filled on a recurrent basis. The draining and filling cycles created aerobic, anaerobic, and anoxic conditions within the cells, providing both biotic and abiotic treatment processes to provide nitrification, denitrification, and phosphorous removal. This treatment process was prefaced by solids separation. One lagoon (2601.3 m^2) was used for containment of solids and another lagoon (2717.4 m^2) was utilized for treated wastewater. The two hog barns on this site maintained a natural ventilation system rather than fan outlets.

2.1.2 Lagoon and Spray Technology

The last two sites utilized a conventional technology as its primary means of handling effluent. This technology is referred to as a "Lagoon and Spray Technology" and was of the same type that is currently used by most farms in North Carolina. Effluents flowed directly from the hog barns into an on-site storage lagoon. The untreated wastewater was then used to flush effluent from the houses and as spray over agricultural crops.

One site in this study that employed this technology was Stokes Farm, located near Greenville, NC (35.43°N, 77.48°W, 17 m MSL) (Figure 2.6). The storage lagoon was 15,170 m^2 and there were four hog barns located on the property, all containing finishing animals. This farm utilized natural ventilation in their confinement facilities.

The final site sampled was Moore Brothers Farm, located in Jones County near Kinston, NC (35.14°N, 77.47°W, 13 m MSL) (Figure 2.7). The animals at this farm were all finishing hogs. This site was also conventional (i.e., no ESTs were being tested on this property). The storage lagoon was 30,630 m^2 and the farm maintained eight houses on site, each with a fan ventilation system.

2.2 Data Collection and Analyzing Techniques

2.2.1 Meteorological Data Collection

Ambient air temperature, wind speed, and wind direction were measured using a Model 107 temperature probe (Campbell Scientific, Inc., Logan, UT) and 03001 wind sentry unit (03101-5 R.M. Young wind sentry anemometer, 03301-5 R.M. Young wind sentry vane) (Campbell Scientific, Inc., Logan, UT), measured from a 2 meter meteorological tower set up at each sampling site (except Grinnells Laboratories). This data was recorded and averaged every 15 minutes using a CR23X Micrologger (Campbell Scientific, Inc., Logan, UT). Solar radiation and relative humidity (RH) were measured from a separate 10m meteorological tower also set up at each sampling site (except Grinnells Laboratories). RH was measured with a Model HMP45C relative humidity probe (Campbell Scientific, Inc., Logan, UT) which was placed at 2m height facing north while a solar radiation probe Model LI200X Silicon Pyranometer (Campbell Scientific, Inc., Logan, UT) faced south at the same height. Meteorological sensors for RH and solar radiation were also monitored every second and averaged every 15 minutes using Campbell Scientific, Inc CR21X data recorders.

2.2.2 VOC Sample Collection and Sampling Strategies

Ambient air samples were collected in 6-Liter electropolished stainless steel SUMMA canisters, evacuated to a sub-ambient pressure of <0.05 mm Hg. As a sample was collected, the pressure differential allowed for ambient air to be drawn into the canister. For each sample, the valve on the canister was opened slowly over a timeframe of 2-4 minutes and then fully opened on the order of ~1 minute, thus allowing for a ~5 minute sample to be collected.

A total of 110 samples (Appendices 1-11) were collected at six swine facilities in Eastern North Carolina between April 2002 and March 2003. All samples were collected and recorded according to Eastern Standard Time (EST). Samples were collected around solar noon (1200-1300 EST) at various source areas including lagoons, housing fans, and "strong" odorous areas (determined through sense of smell) for each particular site. Simultaneous samples were collected at upwind and downwind locations on the farms in an effort to determine which VOCs originated from the farm rather than being transported from other areas. The location of the samples was dependent on wind direction and the time of sampling was dependent on consistency of 15-minute average wind direction. Simultaneous samples were not collected in instances where the wind direction was variable. Diurnal samples were collected near the edge of the storage lagoons once every six hours for a 24-hour period. These sampling collections took place at 600, 1200, 1800, and 0000 EST. Occasionally, random duplicate and triplicate samples were collected simultaneously at the same location for comparison to ensure there was no contamination and/or leaks inside the canisters.

A total of 40 VOC canister samples were collected at the various facilities alongside a team of odor panelists from Duke University as part of the Project OPEN (Odors, Pathogens, and Emissions of Nitrogen) with the intent of comparing VOC concentrations with various odor and irritation assessments. Occasionally, simultaneous samples were collected as well for quality assurance purposes. These samples were averaged and the mean concentrations were used for analyses. Although the conditions varied from sample to sample and farm to farm (i.e., meteorological parameters, number of animals located on the property), it is possible to use statistical analysis to look for relationships between various VOCs, odor intensity, and scentometer ratings because VOC collections and odor assessments were made simultaneously during each of the sampling episodes.

2.2.3 VOC Sample Analysis

After sampling was accomplished, the canisters were taken to the National Exposure and Research Laboratory (NERL) of the US Environmental Protection Agency (US EPA) located in the Research Triangle Park, NC, where they were stored at air conditioned room temperature until analysis was performed (usually within ~1 to 5 days) using a cryogen Gas Chromatograph (GC) system, Hewlett-Packard Model 5890A Series II, Serial Number 3310A49947, EPA 92716 combined with flame ionization detection (FID). The Cryo GC/FID system consists primarily of 3 components including the GC system, a preconcentration device, and a data integration system to determine VOC identification and concentration.

The GC system uses a 60m x 0.32 mm ID fused silica column. In operation, the column conditions consist of a -50°C initial temperature for two minutes followed by

temperature programming to 200°C at a rate of 8°C/minute. After a 7.75 minute hold period, the column temperature is programmed to 225°C at 25°C/minute rate and held at that temperature for 8 minutes, thus providing separation of the C_2-C_{12} HCs. Liquid nitrogen is used as the cryogen to obtain sub-ambient temperatures and helium is used as the carrier gas.

The samples also were run on a similar GC/FID Hewlett-Packard 5890A Series II (Serial Number 2921A24163, EPA 666784), which is a dual system, for quality assurance purposes to verify peak accuracy and retention time. An identical DB-1 60m x 0.32mm ID fused silica column as described for the former GC/FID system is used as well. This system is also used to obtain better separation of the C_2 compounds, namely ethylene, acetylene, and ethane. The column used is a 30m x 0.53mm ID GS-Q coated porous layer open tubular (PLOT) column (J & W Scientific, Folsom, CA).

A preconcentration system is used which consists of a 6-port gas sample valve configured to use a packed glass bead trap. The glass bead trap consists of a 25cm x 3.2 mm stainless steel trap packed with 60-80 mesh untreated glass beads.

Data files are automatically stored and accessed by the Chrom Perfect-5890 Direct chromatographic software program installed on a Hewlett Packard Vectra Model 486/66XM IBM compatible computer. The chromatographic program acquires the time and voltage digital signal and electronically records the signal for later processing. The GC peaks are quantitatively integrated first automatically through the program and then manually by the user to ensure accuracy of the areas beneath the peaks. The Chrom Perfect software names peaks as VOCs based upon retention time location and converts peaks areas to ppbC concentrations. For a more detailed description of GC/FID operations, one may refer to

Appendix 12 that contains the standard operating procedure for the GC/FID systems written by William Lonneman (US EPA, Research Triangle Park, NC).

2.2.4 GC/FID System Calibration

The GC/FID system is calibrated using a 0.25 ppm propane in air NIST SRM (National Institute of Standards and Technology Standard Reference Material). Propane is used as the response factor to determine the compound concentration of all observed peaks. A 4-compound standard cylinder was used for day-to-day verification of FID response, and random samples were analyzed multiple times to ensure that correct procedure methods had been used.

While propane provides an accurate response for all HCs, the response factor may not be quite so good for substituted HCs such as acetone and ethanol. In other words, compounds containing a molecule in addition to hydrogen and carbon may respond differently within the GC/FID system. Response adjustments must be made for these types of compounds.

Due to the observed stability of the FID, multi-point calibrations are performed on a semi-annual or annual basis. A 4-compound standard cylinder containing 48.7 ppbC ethane, 53.9 ppbC propane, 51.2 ppbC isobutane, and 54.6 ppbC n-butane is used for day-to-day verification of FID response and retention time location.

2.2.5 Analytical Reproducibility

A sample collected at RECIP in March 2003 was used to perform repeat analysis. Table 2.2 shows the results in VOC concentrations, means, and standard deviations from

repeat analysis. It was determined from this data, what information could be used for analysis and comparison and what data was not useful in this regard. Subsequently, some of the data collected was not used in analysis. Some compounds had extraordinarily high concentration levels. The reason for the "outlying" mixing ratios could be due to a number of factors including, but not limited to, canister contamination, system peaks, and/or human error in processing the data. It is noticeable that, while the oxygenated hydrocarbons and sulfides may have a different response to propane calibrations, the results were very consistent, and thus the values are effective for analysis.

2.2.6 SUMMA Canister Cleaning System

The canisters were cleaned by a XonTech Model 960 Canister Cleaning System (XonTech, Inc., Van Nuys, CA). This system follows USEPA TO-14/TO-15 methods on how to clean and certify canisters by measuring the residual level of VOCs remaining after the cleaning process. The system consists of a stainless steel oven that holds four 6-liter canisters. An oven cover allows the spheres of the canisters to be completely heated in the oven. The automated system utilizes repeated cycles of evacuation, fill, and bake at 120°C. The cycles are performed using humidified air. At the end of these cycles, the canisters are free of VOCs (i.e., below detection limit of the analysis) and are dry. The system then automatically switches on a high vacuum pump and evacuates the canisters to < 0.05 mm Hg.

2.2.7 Data Acquisition Instrumentation for Duke University Odor Panel

The following information was obtained from the Quality Assurance Project Plan (QAPP) for Odorous Air Emissions Monitoring of Lagoons and Other Waste Treatment

Facilities**,** compiled by Dr. Susan Schiffman and Brevick Graham for evaluation by Project OPEN.

For accurate assessment, trained odor panelists wore the Half Facepiece mask (3M model 6000 series) fitted with the 3M Multi Gas/Vapor Cartridge with P100 filter before and between field odor assessments. The mask prevents exposure to vapors and eliminates olfactory adaptation.

2.2.7.1 Odor Intensity Assessments

The human panel evaluated ambient air at each of the field sites during midday. All assessments for odor intensity were accomplished by a rating scale as follows: 0=none at all; 1=very weak; 2=weak; 3=moderate weak; 4=moderate; 5=moderate strong; 6=strong; 7=very strong; and 8=maximal.

The odor intensity measurements of samples in the field were calibrated using a butanol scale. The bottles contained a series of dilutions of 1-butanol dissolved in deionized water. Twelve serial dilutions of 1-butanol was used starting at 10-ppm butanol with a geometric progression of two: 10 ppm through 20,480 ppm. The intensities of the ratings of odorous air emissions were matched to the butanol scale. This standard method (E544-75) was established by The American Society for Testing and Materials (ASTM, 1997).

2.2.7.2 Scentometer Ratings

The Scentometer (Barnebey and Sutcliffe, Columbus, OH) was used to measure the intensity of ambient odors in threshold units D/T (number of dilutions to threshold). The device is a hand-held plastic box with two nasal ports on one end and six inlets for the

odorous air. The six inlets are different sizes (0.08 cm, 0.16 cm, 0.32 cm, 0.48 cm, 0.64 cm, and 1.27 cm) that correspond to 350, 170, 31, 15, 7, and 2 D/T, respectively. Two additional inlets on the top and bottom allow air to be pulled through an activated carbon cartridge into the mixing chamber. This provides a clean air source that dilutes the odorous air in the mixing chamber. D/T values are measured with all but one of the six odorous inlets closed and the size of the inlet determines the dilution of the odorous air.

2.2.7.3 Hydrogen Sulfide Measurements (Duke University)

The Jerome Hydrogen Sulfide Analyzer (Arizona Instruments, model 631-X) was used to measure the airborne concentrations of hydrogen sulfide present in the air. Samples were taken every minute over a 30-minute timeframe and an average ppbV level of hydrogen sulfide was calculated.

The Jerome meter uses an internal pump to pull ambient air across a thin gold film that attracts hydrogen sulfide. As the hydrogen sulfide builds up the machine registers the change in electrical resistance across the gold film. This change is proportional to the amount of hydrogen sulfide adsorbed. The machine integrates the result over the sampling period and displays the result in ppm of hydrogen sulfide. The unit has a microprocessor that re-zeros the instrument at the beginning of each sample and freezes the display until the next result is registered. Since ammonia can interfere with the Jerome meter's ability to accurately measure hydrogen sulfide levels, an ammonia filter containing silicon orthophosphate, silicon pyrophosphate and quartz dust is attached to the sampling inlet during measurements.

2.3 Limitations of Data Collection

Project OPEN is a large-scale project directed toward the evaluation of a number of potential Environmentally Superior Technologies for odor and odorants, pathogens, and emissions of ammonia and other gases by different scientific groups involved. Measurement campaigns were conducted as the farms became "steady-state" with the individual technologies in place. The farms were available for sampling for about two weeks in each warm or cold season.. Some of the limitations of our sampling strategies are due to limited sampling periods at each site (i.e., very few dates were available for sampling at each farm).

The number of SUMMA canisters available for use was limited. Consequently, only about 10-15 samples were taken per farm (four at RECIP). If a canister was analyzed and found to be contaminated upon analysis (i.e., a leak occurred within the canister), the sample was discarded. As discussed previously, samples were collected at these sites to provide an accurate assessment of the VOCs in the ambient air at the swine facilities. Due to the nature of Project OPEN, many different farms were sampled within a relatively short timeframe. An overview of the C_2-C_{12} VOCs that were present at the different source locales such as farm boundary lines, storage lagoons, hog barns, and general locations that were chosen by the Duke University odor panel as VOC samples were collected simultaneously in coordination with their on-site odor assessments is provided in Appendices 1-11.

Table 2.1 Number of animals and weights at the sampling sites

	House #								
	1	2	3	4	5	6	7	8	Total
Barham*									
April 1-12, 2002									
# hogs	840	840	320	320	840	840			4000
Avg Weight (kg)	238	238	238	238	238	238			238
Nov 11-22, 2002									
# hogs	840	840	320	320	840	840			4000
Avg Weight (kg)	238	238	238	238	238	238			238
Grinnells									
April 15-26, 2002									
# hogs	74								74
Avg Weight (kg)	46								46
Oct 28-Nov1, 2002									
# hogs	74								74
Avg Weight (kg)	51								51
Howard									
June 3-14, 2002									
(Week # 1)									
# hogs	840	1054	863	865					3622
Avg Weight (kg)	70	68	59	50					62
(Week # 2)									
# hogs	840	1049	861	864					3622
Avg Weight (kg)	75	73	64	54					67
Dec 2-13, 2002									
(Week # 2)**									
# hogs	800	1011	1091	973					3875
Avg Weight (kg)	113	104	95	86					99

Table 2.1 (Continued) Number of animals and weights at the sampling sites

	House #								
	1	2	3	4	5	6	7	8	Total
Stokes									
Sept 9-20, 2002									
(Week # 2)**									
# hogs	1071	1059	1096	1129					4363
Avg Weight (kg)	102	105	101	108					104
Jan 6-17, 2003									
(Week # 1)									
# hogs	1056	884	1098	1194					4232
Avg Weight (kg)	86	86	86	86					86
(Week # 2)									
# hogs	1021	532	810	858					3221
Avg Weight (kg)	91	91	91	91					91
Moore									
Sept 1-Oct 11, 2002									
(Week # 1)**									
# hogs	946	930	985	1050	907	1047	1047	1048	7960
Avg Weight (kg)	77	73	73	68	43	39	29	29	54
Jan 27-Feb 7, 2003									
(Week # 2)**									
# hogs	904	881	868	873	920	0	814	829	6089
Avg Weight (kg)	61	57	54	34	29	0	113	113	65
RECIP									
Mar 7-18, 2003									
# hogs	920	920							1840
Avg Weight (kg)	68	68							68

* The numbers and weights of animals remained constant during the sampling episode
** All samples were collected during that week

Table 2.2 Analytical reproducibility of select VOCs from RECIP site in March 2003, canister # AQ-185

Compound	Analysis 1	Analysis 2	Analysis 3	Mean	Std Dev.
Ethane	2.90	2.91	2.90	2.90	0.01
Propane	2.41	2.28	2.41	2.37	0.08
Acetaldehyde	2.75	2.91	2.41	2.69	0.26
Acetone	8.26	8.72	7.97	8.32	0.38
Isoprene	3.38	3.29	3.47	3.38	0.09
Dimethyl sulfide[1]	0.16	0.13	0.19	0.16	0.03
MEK	1.09	1.10	1.27	1.15	0.10
Benzene	0.61	0.63	0.58	0.61	0.03
Toluene	0.44	0.46	0.49	0.46	0.03
Octanal	1.57	1.55	1.72	1.61	0.09

[1] canister AQ-125 (Moore Farm)

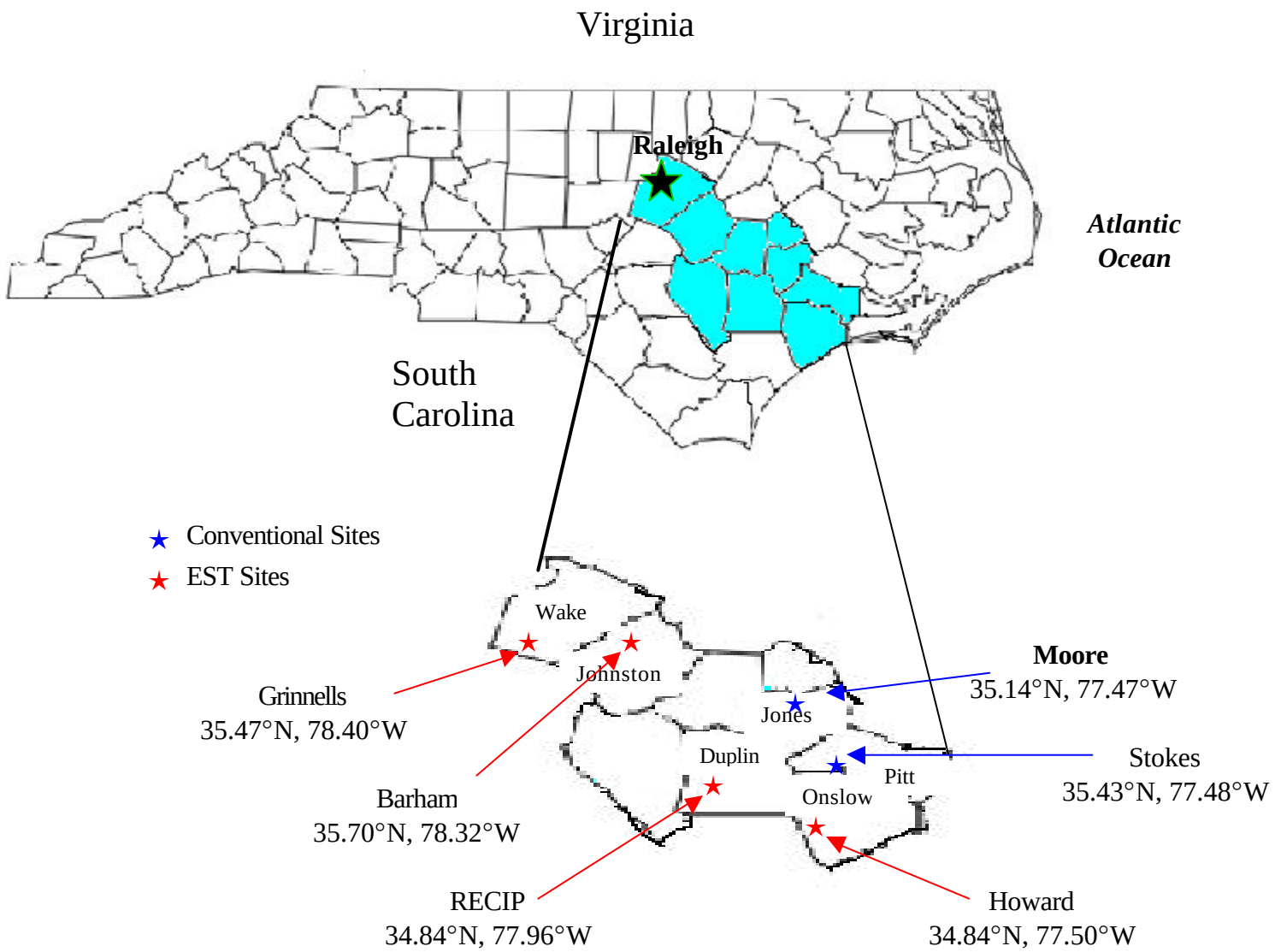


Figure 2.1 North Carolina Swine Facility Site Locations for Field Study Project

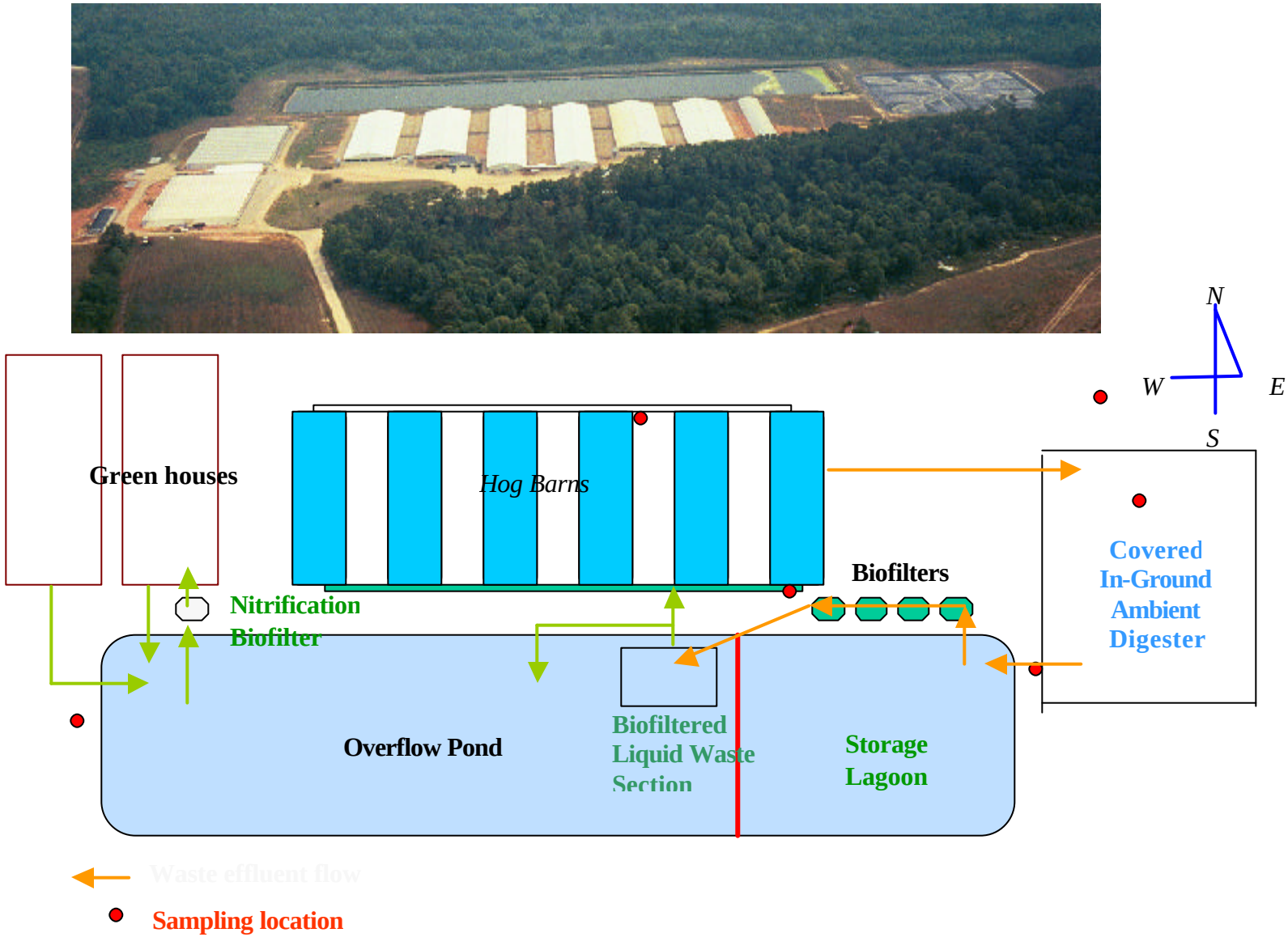


Figure 2.2 Aerial photo and schematic (not drawn to scale) of Barham Farm: In-Ground Ambient Digester Technology

Sample collection at ventilation fan outside of Grinnells Laboratories

Housing area for hogs inside of Grinnells Laboratories

Figure 2.3 Grinnells Laboratories (NCSU campus): Koger/Van Kempen Belt and Gasification Project. Manure and urine are collected underneath the hog pens in the house. The belt system collects manure and a gutter collects the urine.

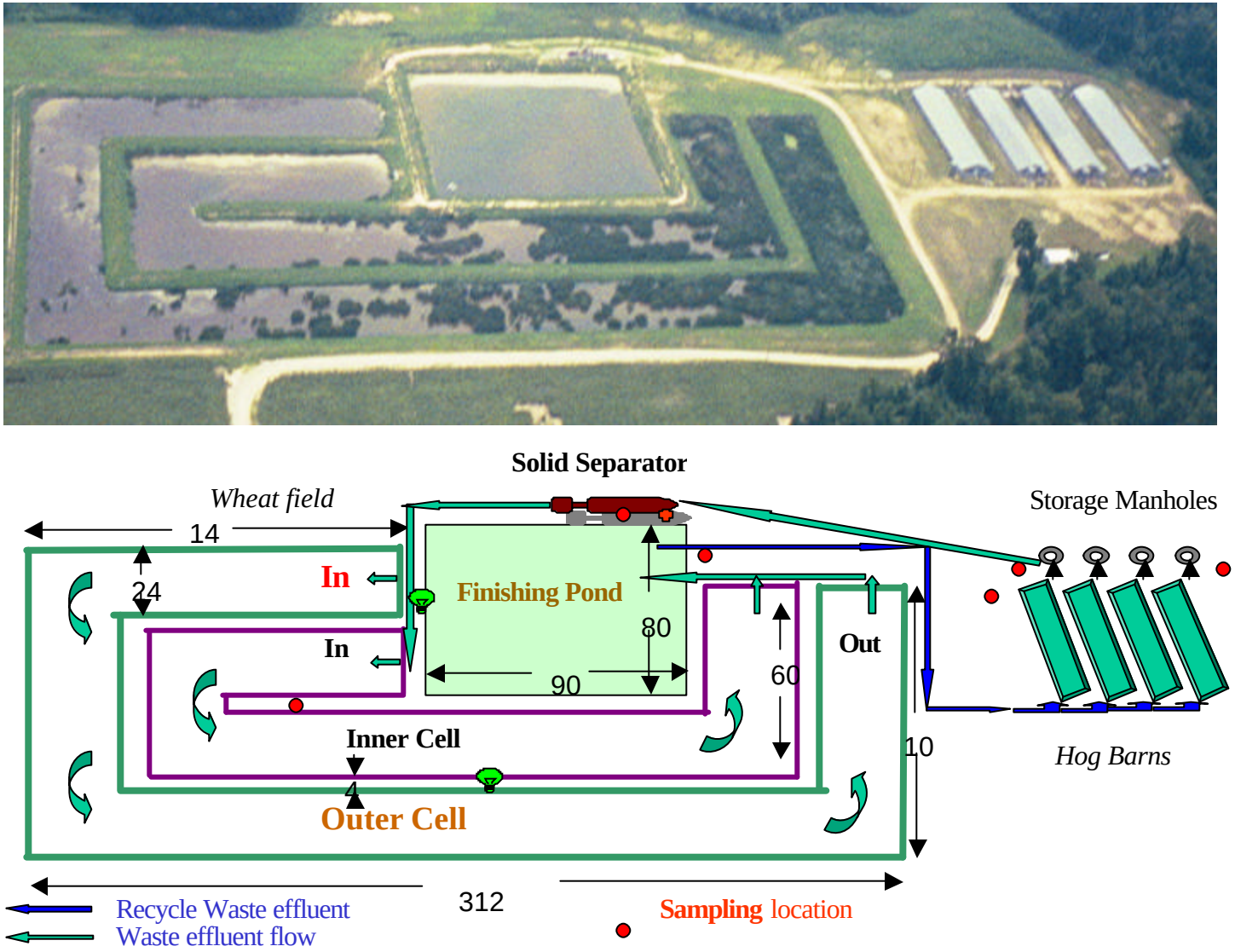
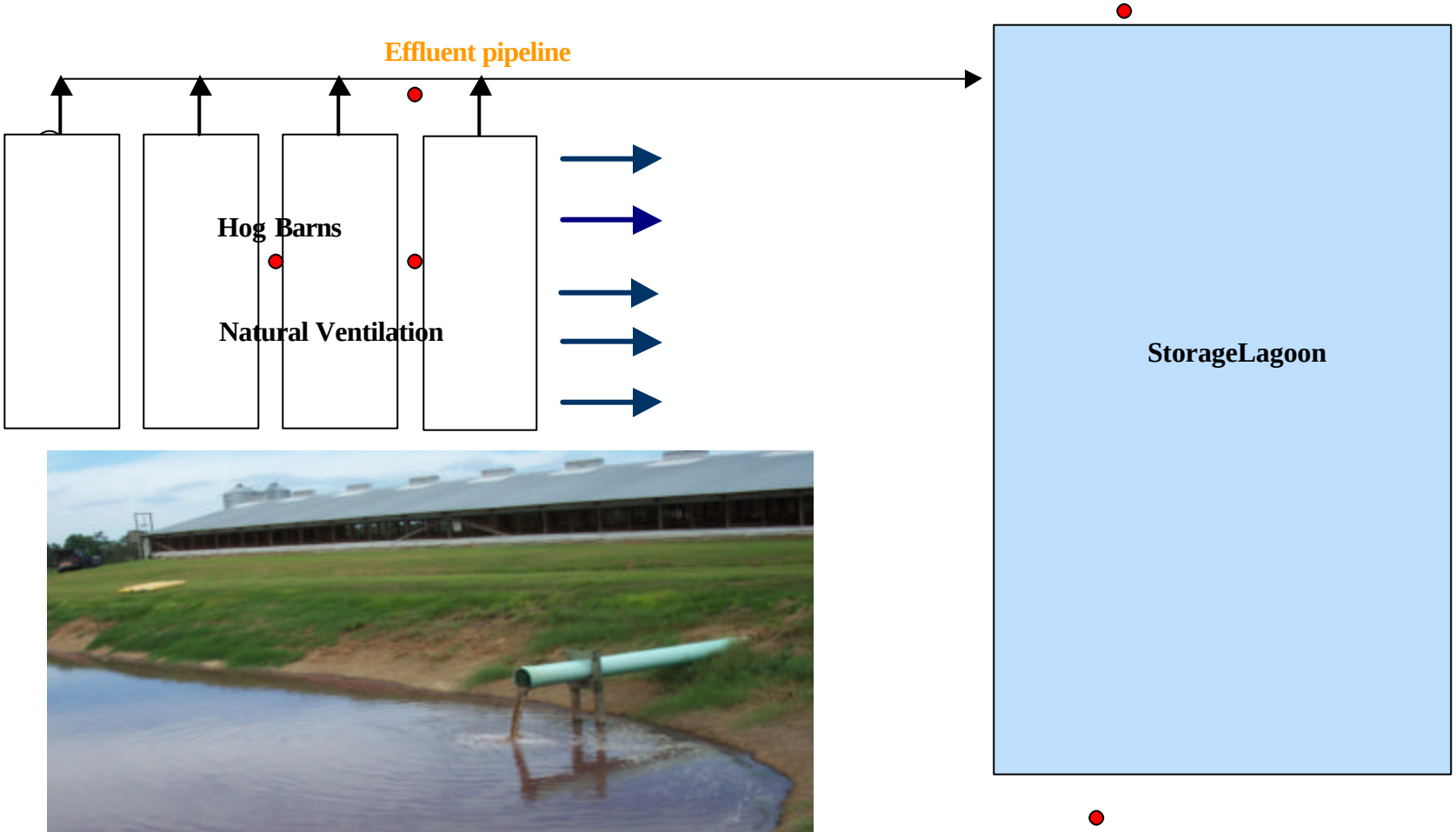


Figure 2.4 Aerial Photo and Schematic of Howard Farm (not drawn to scale): Constructed Wetlands Technology

Aerial view of RECIP site; depicts hog barns, treatment basins, and storage lagoons

Treatment basins filled with media, alternately drained and refilled on a recurrent basis

Figure 2.5 RECIP Site (Corbett Farm # 2) Solid Separation/Reciprocating Water Technology System



Sampling location

Figure 2.6 Schematic of Stokes Farm (not drawn to scale): Lagoon & Spray Technology. Photo depicts effluent pipe emptying into storage lagoon

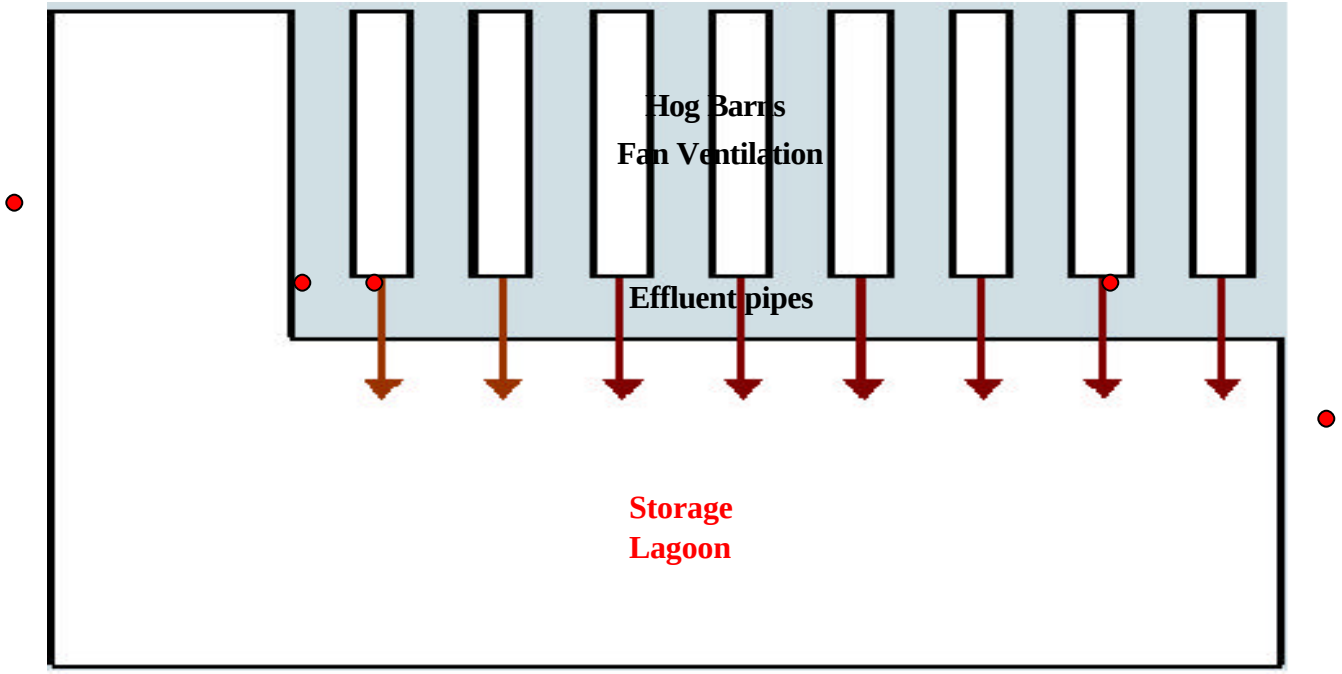


Figure 2.7 Moore Farm: Lagoon & Spray Technology

3.0 Results

3.1 Gas Chromatography-Mass Spectrometric (GC/MS) Analysis

GC/FID analysis for all samples collected during this field study were performed by the author while GC/MS analyses was performed by Bill Lonneman, Research Chemist, (Senior Employment Program, US EPA, Research Triangle Park, NC). Results presented in this section are based on his analysis and obtained by personal communication.

The CALTABLE (see GC/FID SOP in Appendix 2) is used in GC/FID analysis results to identify GC peaks with compound names using GC column retention time location. It should be noted that this CALTABLE has been developed primarily to identify HCs typically observed for urban ambient air studies. The GC/MS analyses aided in the identification of other compounds that appear unique to the farm sites.

Two types of compounds are provided in the CALTABLE including named compounds and unidentified compounds each called "Unknown". All CALTABLE entries have unique retention times and RTINDEX values. Compound peaks not identified by the GC/FID CALTABLE are called "unnamed". In this study, the GC/MS analyses were helpful in identifying some of the "Unknown" and "unnamed" compound peaks and also to provide confirmation to those peaks identified with compound names.

3.1.1 Barham Farm

VOC analyses of the swine facilities were greatly assisted by the collection of a sample (canister 494) at the outlet of a pipe at Barham Farm during the April sampling period, due to the complex VOC mixture observed in this sample by GC/MS and GC/FID analysis. This pipe was used to extract methane as well as other organic gases from a primary

treatment lagoon fitted with an impermeable cover that trapped the gaseous species. The GC/FID analysis results indicated a complex pattern of peaks, several of which could not be determined by retention time identification. Methane was clearly the most abundant VOC observed; however, quantitative determination of this compound could not be made with the GC/FID system. The merged C_2-C_3 compounds could not be identified by retention time location. Quantitative evaluation of this sample was limited to the GC peaks eluting from isobutane to the end of the chromatogram.

The GC/FID analysis results indicated that total concentration exceeded 200 ppm, and was more than two orders of magnitude larger than the concentration in all other canisters collected at the facility.

GC/MS analysis of canister # 494 confirmed most of the identified compounds obtained with the GC/FID analysis. Similarly, it was very helpful in providing tentative identification to several of the "Unknown" and "unnamed" peaks also observed with the GC/FID results. Seventeen sulfur-type VOCs were identified and eventually added to the GC/FID CALTABLE to use for the other canister samples collected at the swine farm sites. No standards were available for 100% positive identification of these compounds; however, compound molecular weight and boiling point were considered to be appropriate for observed GC column retention times.

Some of the sulfur-type VOCs are generally thought to be unstable in SUMMA canisters. To evaluate storage stability this sample was stored in the laboratory and analyzed by both GC/FID and GC/MS on three separate occasions: May 13, 2002, July 11, 2002, and January 31, 2003. A percent composition profile of the C_4-C_{14} VOCs for each analysis is provided in Table 3.1. With few exceptions, the composition of the compounds remained

very much the same upon reanalysis. For quality assurance purposes, the repeat analyses ensured that the compounds all maintained a very strong storage capability and were stable within the canisters. The only noticeable differences in percent composition over time were found in dimethyl disulfide, which increased from 17.7 to 32.0 %, while dimethyl trisulfide decreased by nearly the same amount, 24.3 to 7.3 %. The reason for the dramatic change in these particular compositions is unclear. Canister surface passification by water vapor, also in the canister, is credited for storage stability.

A wide variety of compounds were identified by GC/MS, including alkanes, alkenes, ketones, aldehydes, and sulfides. The sulfides were of particular interest because many produce distinct malodors. The three largest peaks observed from the GC/FID at column retention times later than isobutane were dimethyl sulfide, dimethyl disulfide, and dimethyl trisulfide. Using GC/FID quantitative results, these compounds represented 21.1, 17.7 and 24.4% of the total concentration of all the GC compound peaks eluting from the column between isobutane and the last observed GC compound peak. The last compound peak observed on the GC/FID system typically occurs at approximately 37 minutes, since compound peaks beyond this retention time have vapor pressures < 0.01 mm and are considered to be nonexistent in the vapor phase.

Dimethyl sulfide, dimethyl disulfide, and dimethyl trisulfide have previously been identified (but not quantified) at swine facilities by Hammond *et al*., 1989; O'Neill and Phillips, 1992; and Schiffman *et al*., 2001.

In addition to these compounds, 14 other sulfur VOCs were also observed in this sample, namely thiophene, 2-methylthiophene, 3-methylthiophene, methyethyldisulfide, 2-ethylthiophene, 2,5-dimethylthiophene, 3-ethylthiophene, 2,3-dimethylthiophene,

methylisopropyldisulfide, methylpropyldisulfide, methyl-sec-butyldisulfide, and dimethyl tetrasulfide. It was conjectured that this VOC composition profile could serve as a template to look at other samples collected in these swine facilities. The template is useful because both the compounds and their retention times were determined.

Two other sulfur containing VOCs also observed in the GC/MS results were carbonyl sulfide, which eluted early from the GC column at the retention time between the C_2s and C_3s, and carbon disulfide, which eluted from the GC column at about 14.7 minutes, near 2-methyl-2-butene. Neither compound is expected to respond in the FID and would therefore not be observed in the GC/FID results. Hydrogen sulfide is expected to elute from the GC column prior to the C_2s and cannot be positively identified with this GC/MS system.

Many of the sulfur containing VOCs had very small percent concentrations. These compounds may be below detectable limits among samples collected in the ambient air. It is unlikely that the percent compositions of the detected compounds remained the same after emission into the ambient air. This may be due to dispersion, vertical mixing, and/or photochemical reactions that occur in the atmosphere near ground level.

Five additional samples collected during the April sampling period at Barham Farm were also selected for GC/MS analysis, based on the observation of large concentration levels determined for acetaldehyde, methanol, and acetone from GC/FID analyses. The oxygenated VOCs were confirmed in canister 122 and 652, which were both collected at Barham Farm at side ventilation fans, as well as canisters AQ-185 and AQ-128, which were collected at the storage lagoon and farm boundary line, respectively. The GC/MS results also indicated that both dimethyl sulfide and dimethyl disulfide were observed in canister 122. Carbon disulfide was observed in all of the canister samples.

The compound reported as 2,3,5-trimethylhexane with GC/FID was observed to be hexamethylcyclotrisiloxane by the GC/MS results for all canister samples analyzed. The compound peak identified as styrene by GC/FID consisted of both styrene and heptanal. GC/MS results indicate that octamethylcyclotetrasiloxane co-eluted with 1,2,4-trimethylbenzene; however, based upon the relative magnitude of the observed mass spectra, it is believed that the majority of this peak consisted of 1,2,4-trimethylbenzene. Several compounds have been suggested by GC/MS to have co-eluting peaks. It should be noted that the percent contribution of each compound in this type of peak is extremely difficult, if not impossible, to calculate. Also, it is possible that these percent contributions may vary among samples, depending on the type and strength of background source. For example, higher levels of styrene may be present when automotive exhaust is a probable VOC contributor. However, when samples are collected in a very rural environment with little outside influence, it may be more likely that heptanal dominates the co-eluting peak. This may be true for many of the co-elutions listed in the data collection results (Appendices 1-11).

During the second Barham Farm sampling campaign in November, two canisters (127 and 2009) were selected for GC/MS analysis. The percent compositions of the detected VOCs are listed in Table 3.2. Both samples were collected in a manner similar to canister 494 (April sampling) at the pipe from the covered lagoon, in an effort to determine how much, if any, the VOC profile changed from the first field study. The VOC compositions in canisters 127 and 2009 were significantly different, suggesting that the process that produced these VOCs was variable. The canisters were collected 40 minutes apart at the same locale. Canister 127 contained only 11 of the 17 sulfur containing VOCs that were reported in canister 494. Both dimethyl sulfide and dimethyl disulfide were observed in canister 127 at

much lower percent contribution levels and dimethyl trisulfide was not observed at all. The most abundant compounds in this sample consisted of HCs. Toluene, at 9.6%, is the most abundant VOC observed. Octane, cis-& trans-octene-2, octane-3, octane-4, and 3-methylnonane, comprised ~29% of total VOCs eluting after isobutane. The two most abundant sulfur containing VOCs were dimethyl sulfide and 3-ethylthiophene, 7.3 and 5.5 %, respectively.

Twelve sulfur containing VOCs were observed in canister 2009, but this included only eight of the compounds identified in the first field study. The four new sulfur compounds included ethanethiol, 2-propanethiol, 1-propanethiol, and 2-butanethiol, all mercaptans. These compounds have a hydrogen atom (as opposed to an alkyl group) attached to a sulfur atom. Dimethyl sulfide and dimethyl disulfide comprise only 2.2 and 0.08 %, respectively, to the total contribution of VOCs eluting after isobutane. The most abundant sulfur compound was 2-methylthiophene at 6.0%. Similar to canister 127, the most abundant VOCs consisted of HCs. Again, toluene was the most abundant compound at 8.6%. The contribution of octane, cis-& trans-octene-2, octane-3, octane-4, and 3-methylnonane was ~29%, almost identical to canister 127.

3.1.2 Grinnells Laboratories

Canister AQ-206, collected inside an enclosed housing area during the April sampling campaign at Grinnells, was selected for GC/MS analysis. Methanol, ethanol, n-butanol, acetaldehyde, acetone, dimethyl sulfide, and dimethyl disulfide were all verified by GC/MS analysis.

A large peak (663.1 ppbC) that was initially identified by GC/FID analysis to be propane based on typical retention time was actually determined to be Freon-22 by GC/MS. Freon-22 is a VOC typically used in commercial and residential air conditioning systems. Unknown peaks observed at RTINDEX values 592.36 and 619.80 were identified by GC/MS as tetrahydrofuran and 2-butanol, respectively. The unnamed peak (12.7 ppbC) observed at 14.981 minutes on the GC/FID system is suggested by GC/MS results to be n-propanol and the unnamed peak (1.98 ppbC) observed to elute at 21.663 minutes is suggested to be n-pentanol.

Three samples were selected for GC/MS analysis from the November sampling episode at Grinnells. Canisters AQ-171 and 2017, both collected in front of the ventilation fan, were selected based on observed high concentrations of ethanol, acetaldehyde, methanol, and acetone. GC/MS confirmed all of these compounds as well as n-propanol, 2-butanol, tetrahydrofuran, and benzaldehyde. Freon-22 and Freon-12 were also confirmed by these results. All of these VOCs had been observed in canister AQ-026, collected during the first site campaign. Isopropanol, 4-methylphenol, and decamethylcyclopentasiloxane were also observed in canister AQ-171. Decamethylcyclopentasiloxane is a compound that is typically present in silicone products and is also used in deodorants.

Canister AQ-105, which was collected 10 m downwind of the ventilation fan and also near a busy roadway, was selected for GC/MS analysis because the VOC peak pattern suggested the influence of significant levels of vehicular tailpipe emission. GC/MS verified the correct identification of many of the HCs.

3.1.3 Howard Farm

Two canisters from the June sampling episode at Howard were selected for GC/MS analysis in an effort to confirm sulfur containing VOC compound peaks. GC/MS analysis confirmed methanol, acetaldehyde, acetone, cyclohexanone, benzaldehyde, α-pinene, 1,3,5-trimethylbenzene, octanal, nonanal, and decanal. The co-eluting peak at RTINDEX value 881.42 was observed to consist primarily of heptanal rather than styrene. The unnamed peak eluting at 27.484 minutes is suggested to be 6-methyl-5-heptene-2-one.

Two samples were selected for GC/MS analysis from the December Howard sampling episode. Both samples were selected primarily for verification of dimethyl sulfide and dimethyl disulfide peaks. Confirmation was made for these compounds as well as for acetaldehyde, methanol, ethanol, acetone, and 4-methylphenol.

3.1.4 Stokes Farm

One sample, collected in September at Stokes, was primarily chosen for GC/MS analysis based on the observation of dimethyl sulfide and dimethyl disulfide. In addition to these compounds, methanol, ethanol, acetone, n-pentane, isoprene, and MEK were all verified by GC/MS. The results suggested that the compound identified by GC/FID as 4-methyl-1-pentene was actually n-propanol. The retention time observed for this compound corresponded well to that observed in canister AQ-026 collected at Barham. The unnamed peak (33.12 ppbC) with retention time 29.706 minutes was identified as 4-methylphenol by GC/MS analysis. As with all canister samples in which 4-methylphenol is reported, the observed peak was broad and tailing as expected for this compound. Also, the observed 29.760 minute retention time for 4-methylphenol on the GC/FID column corresponds well with the compound boiling point and molecular weight. Graedel *et al.* (1986), Hammond *et*

al. (1989), O'Neill and Phillips (1992), Zahn *et al*. (1997), and Schiffman *et al*. (2001) have all identified 4-methylphenol at swine waste facilities.

3.1.5 Moore Brothers Farm

Four canister samples were selected from the October sampling campaign at Moore. GC/FID results for canisters AQ-207 and AQ-146 suggest that VOC composition was strongly influenced by sources associated with automotive type emissions. The observed low concentrations measured for acetylene in these samples indicated that the source was vaporized gasoline. It should be pointed out that hydrocarbon composition of vaporized gasoline is different than gasoline headspace vapors and that these are two independent source types associated with automotive emissions. The observed composition appeared to be a combination of these two source types. The observation of 1-methylcyclopentene co-eluting at the front edge of the benzene peak in both samples confirms the influence of these two automotive source types. GC/MS results verify the identification of these compounds. The samples were collected during the late evening (0000 EST) and early morning hours (0600 EST) at the edge of a storage lagoon where a vehicle that had recently been operated. Calm winds and a nocturnal inversion layer in the atmosphere may have an influence, trapping the compounds near the surface, and thereby contributing to the overall VOC composition profile.

The VOC composition in canister AQ-048, collected in the early evening (1800) in the same location as canisters AQ-207 and AQ-146, also contained several HCs, but with the exception of n-butane and isopentane, at lower concentrations. The higher n-butane and isopentane concentration relative to other HCs suggests a greater contribution of gasoline

headspace sources relative to vaporized gasoline. Trace contributions of dimethyl sulfide were observed by the GC/MS results for the compound reported as trans-2-pentene. GC/MS results indicated that carbon disulfide was observed for all canisters. Canister AQ-211 was also analyzed by GC/MS but the results were poor and did not provide any useful peak confirmation.

The final sample selected for analysis was canister 1862, collected in February at Moore farm in front of a ventilation fan. GC/MS confirmation was made for dimethyl sulfide and dimethyl disulfide as well as acetaldehyde, methanol, ethanol, acetone, MEK, butanal, hexanal, benzaldehyde α-pinene, nonanal, and decanal. 4-methylphenol was also observed in this sample.

GC/MS analysis was not performed on any samples collected at Stokes during the second sampling campaign in January or at RECIP in March.

While many of the compounds that have been identified and/or confirmed by GC/MS analyses may be assumed to be associated with the swine farms, it is not certain what the particular origins are. Compounds may be emitted into the atmosphere from varying sources such as animal waste, animal feed, cleansing agents utilized for the hog barns, or possibly from other activities associated with this type of environment.

3.2 Selected Comparisons to Rural Hydrocarbon Measurements

Comparisons were made between selected C_2-C_6 hydrocarbons measured during different seasons at each farm. These compounds are typically anthropogenic in nature. The comparisons were made from samples collected at different sites in the Southeastern US during the Southern Oxidant Study (SOS) in 1992 and 1993. All samples during both studies

were collected during the midday hours when strong vertical mixing in the troposphere tends to occur.

Results listed in Tables 3.3-3.6 show that the concentration levels of the compounds at each farm during each season are similar to the other sites listed, signifying that the compounds on site are likely background levels of the species carried downwind from some anthropogenic source and, thus likely not originating on site. This is not surprising given the fact that none of the farms are located within a close proximity to any major anthropogenic sources (i.e. coal fired power plants or major highways).

3.3 VOCs Observed at Hog Barns

Highest VOC concentrations generally observed at each swine facility site were sampled at the barn ventilation locations. With the exception of Stokes, this location was directly in front of the fan ventilation systems. At the Stokes site, natural barn ventilations are utilized rather than ventilation fans and samples collected next to or between the barns were selected for comparison. Measurements from the RECIP site were not used in this analysis because no background (i.e., upwind) sample was collected.

Ideally, conditions within the hog barns at each of the different site locations should be uniform. As these farms are corporate owned, it is anticipated that they should adhere to the same typical standards. It would be expected that the feed provided to the animals is the same type, as should the cleaning agents used to sanitize the barns each time the animals are removed. With these expectations in mind, comparisons were made to determine the types as well as the concentration levels of detected compounds being emitted from these different houses. It should be noted that the number of animals as well as the animal weights, size,

and type (i.e., farrowing or finish) vary from barn to barn as well as farm to farm and could affect observed VOCs measured.

The dominant compounds observed near the hog barns from each sampling episode were compared with background samples (i.e., upwind of lagoons and houses) collected relatively in the same timeframe. The observed VOC composition at the ventilation outputs consists of those in ambient air combined with the VOC sources within the barn facility. It is assumed that the ambient air VOCs are similar to those observed in the upwind boundary air samples collected within a similar time frame. The differences between the samples in the concentration levels of various compounds, as well as percent contributions to the net total VOCs are provided in Tables 3.7-3.11.

Upon comparison, some similarities in regards to specie characterization among the various barns at the different sites were noticeable while concentration levels tended to vary quite a bit (although all were within the same order of magnitude). Acetaldehyde, methanol, ethanol, and acetone were among the most dominant compounds measured at the farms where samples were compared. Acetaldehyde was measured at high concentration levels at the barns as compared to other samples collected at various locations on the properties (i.e., farm boundary line, store lagoon) for every farm where sampling episodes took place. At Barham, during both sampling periods in April and November, net concentration levels measured above the reference concentration (RfC) were 16.23 ppbC and 40.12 ppbC, respectively. At Grinnells in November the acetaldehyde level was observed at 9.57 ppbC net total concentration, just below the RfC. Ethanol was a dominant compound among all measured VOCs at all farms with the exception of Grinnells in April and Moore in October. Concentration levels at Barham were 47.09 and 155.41 ppbC net concentrations (17.7 and

46.1% of net total measured VOCs originating in the barn), in April and November, respectively, 110.74 ppbC net concentration at Grinnells in November (49.5% of net total measured VOCs originating in the barn), and 43.95 and 82.8 ppbC net concentrations at Howard in June and December, (49.8% and 41.1% of net total measured VOCs originating in the barn), respectively. Ethanol concentrations at the two baseline farms were comparable, e.g., at Stokes in September (36.9 ppbC net concentration and 28.2% of net total measured VOCs originating in the barn), and at Moore in February (22.4 ppbC net concentration and 30.3% of net total measured VOCs originating in the barn). Considering the seasonal variability of these observations, temperature does not appear to be the primary or only determining factor in the concentration levels in these sample locations. The highest levels of methanol were observed at samples collected within ~1 meter of ventilation exhaust fans at Barham, again during both April and November sampling episodes, 42.9 ppbC and 26.1ppbC net concentrations (16.2 and 7.7% of net total measured VOCs originating in the barn), respectively, and at Grinnells in April (23.3 ppbC and 35.7% of net total measured VOCs originating in the barn). Acetone was a dominant compound in the hog barns at all farms with the exceptions of Barham in November and Stokes in January. At the other sites where comparisons were made, acetone contributed ~3-9% of the net difference for total measured VOCs.

These compounds, in addition to other oxygenated VOCs measured at the various sites, generally represented ~46-94% of net total measured VOCs that are likely emitted from the hog barns. Stokes in January and Moore in October had slightly lower contributions, ~38 and ~21%, respectively, of net total measured VOCs.

At Barham in April propane comprised ~43% (114.0 ppbC) of the net difference in concentration of measured VOCs originating in the barn. The reason for this unusually high concentration level is unclear. The level was much lower when sampled in November.

Dimethyl sulfide and dimethyl disulfide, both recognized as malodorous compounds, were found at concentration levels at the barns above the background concentration at every farm sampled with the only exception being Stokes in September. Dimethyl sulfide was measured at levels above its odor threshold (~4.5 ppbC net total concentration) at Barham in November (14.5 ppbC net total concentration) and at Howard in Decmeber (6.6 ppbC net total concentration). 4-methylphenol, another compound associated with swine farms, was also measured at higher levels near the barns than the background atmosphere at Barham and Grinnells in April, Howard and Stokes during both sampling seasons, and at Moore in February. The largest concentrations of 4-methylphenol were measured at Howard in June and December, 14.33 ppbC net concentration (16.2% of net total VOCs originating in the barn) and 43.3 ppbC net concentration (21.5% of net VOCs originating in the barn), respectively, and at Stokes in September (33.1 ppbC net concentration, 25.3 % of net total VOCs originating in the barn).

3.4 Detected Sulfur Compounds

Various reduced organic sulfur compounds were detected at each of the sites. The highest concentrations were measured at the ventilation fans of the hog houses. For houses that utilized natural ventilation, the highest concentrations were generally in the closest proximity to the barns. Figure 3.2 provides a comparison of the concentrations of total reduced organic sulfur compounds emitted from houses with their average concnetrations in

the ambient air around swine facilities. We note that carbonyl sulfide and carbon disulfide were detected through GC/MS analysis but was not detected by the GC/FID.

The most common sulfur compounds overall with the highest concentrations were dimethyl sulfide, dimethyl disulfide, and methyl ethyl disulfide. At the ventilation fans dimethyl sulfide and dimethyl disulfide were always present in the greatest concentrations exception for Grinnells in April, where dimethyl sulfide was not detected, and RECIP where dimethyl disulfide was not detected. At Grinnells, methyl ethyl disulfide was detected in noticeable amounts in April and methyl propyl disulfide was detected in November. At Barham, Howard, Stokes, and Moore Farms the two most dominant compounds were dimethyl sulfide and dimethyl disulfide. Dimethyl trisulfide was also detected at Moore in February, 2,5-dimethylthiophene at Moore in October, and 2-methylthiopropane was detected at Howard in June. At RECIP dimethyl sulfide and methyl ethyl disulfide were the dominant reduced organic sulfur species.

Dimethyl sulfide was detected in the ambient air at each of the sites with the exceptions of Grinnells in April, Howard in June, and Stokes in January. Dimethyl disulfide was detected at Barham during both sampling episodes, Grinnells in November, Howard in December, Stokes in September, and Moore in February. Dimethyl trisulfide was also detected at Moore Farm in February.

Total reduced organic sulfur compounds were measured at the ventilation fans of each farm that utilized this method and normalized by LAW in the barn (ppbC/1000kg). Concentration levels were consistently higher during the colder season than the warmer season at each of the farms (Figure 3.3). It is important to keep in mind that the age and type of animal, in addition to LAW, varied from farm to farm. At Barham, concentration

levels were 0.028 ppbC/1000kg and 0.046 ppbC/1000kg in April and November, respectively. At Grinnells total levels were 0.079 ppbC/1000kg in April and 0.411 ppbC/1000kg in November. At Howard sulfur concentrations were 0.068 ppbC/1000kg in June and 0.141 ppbC/1000kg in December. Finally, at Moore concentrations were 0.021 ppbC/1000kg and 0.016 ppbC/1000kg in October and February, respectively. Grinnells had the overall highest normalized concentration during the November sampling period.

In the ambient air, higher sulfur levels were not always associated with the summer season. Total measured reduced organic sulfur at Howard was the same (1.11 ppbC) in both June and December. However, the dominant compounds varied: methyl ethyl disulfide in June and dimethyl sulfide and dimethyl disulfide in December. At Barham and Grinnells, total measured sulfur was higher in April than November. Dimethyl sulfide and dimethyl disulfide were the dominant compounds at Barham during both seasons and Grinnells in November; however, methyl ethyl disulfide was the dominant compound at Grinnells during the April sampling campaign. Stokes farm had higher levels in September than January, 1.00 ppbC and 0.49 ppbC, respectively. Dimethyl sulfide and dimethyl disulfide were present in September while 2-methylthiophene dominated in January. At Moore, overall average sulfur levels in the ambient air were more consistent, 0.65 ppbC in February and 0.49 ppbC in October, respectively; however, dimethyl sulfide and methylisopropyldisulfide were dominant in October and dimethyl sulfide, dimethyl disulfide, dimethyltrisulfide, and methyl-sec-butylsulfide dominated in February. It should be noted that temperatures at Moore farm during the February sampling were unseasonably warm, ~ 19°C.

RECIP, a site that utilized natural ventilation at the hog barns was sampled only once, during March. Dimethyl sulfide was the dominant measured sulfur compound in the ambient air at this facility.

3.5 Hazardous Air Pollutant Concentrations

Nine hazardous air pollutants were detected at the various swine facility sites. These included acetaldehyde, benzene, *n*-hexane, methanol, MEK, styrene, toluene, xylene (m-, p-, & o-), and 4-methylphenol. Table 3.12 lists the concentrations of these compounds detected at each farm where measurement campaigns took place. Samples collected at ventilation fans were compared to those collected in the ambient air at each of the individual farm sites.

Acetaldehyde, MEK, and methanol, all carbonyls, were measured at higher levels for samples collected within ~1 meter in front of the ventilation fans as compared to those in the ambient air. 4-methylphenol was also measured at higher concentration levels ~1 meter in front of the ventilation fans with the exception of Barham in November and Grinnells in April; however, the differences in concentration levels were < 1 ppbC.

Benzene, *n*-hexane, toluene, and (m-& p-, o-) xylene were consistently measured below US average concentrations in samples collected within ~1 meter in front of the ventilation fans as well as in the ambient atmosphere. Slightly higher ambient levels of toluene, (m-& p-, o-) xylene, and *n*-hexane, 8.68, 7.29, and 4.61 ppbC, respectively, were measured in the ambient air at Grinnells Laboratories in November compared to all other sites. This is not surprising since this is the only site located in an urban area (a busy roadway is located ~ 50 meters from the facility site) and these compounds are typically of anthropogenic origin such as automobile exhaust.

Acetaldehyde, MEK, and styrene were measured at levels at or above U.S. average concentrations in samples collected with ~1 meter in front of the ventilation fans. It should be noted that GC/MS analysis of selected samples revealed that heptanal co-eluted with styrene. The percent contribution of each compound in the peak varied in different samples. This may be due to the possible influence of automotive exhaust or some other anthropogenic source in the atmosphere. In the ambient air, acetaldehyde was measured at above average concentrations except for Grinnells in November, Howard in December, and Stokes in January.

Acetaldehyde was the only compound measured at levels above reference concentration (Figure 3.4). The highest levels were observed in sampled collected directly in front of the ventilation fans at Barham (21.95 and 25.00 ppbC) and Howard (7.45 and 9.14 ppbC) during both sampling seasons, Moore (13.45) in October, and Grinnells (11.77 ppbC) in November. In the ambient air, higher levels were detected at Barham in April and Stokes in September. Only Stokes in January had acetaldehyde levels below U.S. average concentrations.

3.6 Comparison of Odor Assessments and VOC Concentrations

Taking into account various meteorological parameters such as temperature, relative humidity, and average wind speed, there are no significant correlations between the total concentration of VOCs measured by the GC/FID system (SUMMA canister collection) and Scentometer ratings or odor intensity as assessed by the Duke University human odor panel. To inspect possible contributions to correlation to both Scentometer ratings and odor intensity, a detailed analysis of the total load of VOCs was broken down by the following

compound types: alcohols, aldehydes, alkynes, aromatics, esters, ethers, halocarbons, isoprene and monterpenes, ketones, olefins, paraffins, phenols, sulfides, and hydrogen sulfide. Hydrogen sulfide was not grouped with the sulfides because that compound was measured by a different type of instrumentation (Jerome Meter).

Among the meteorological parameters, simple statistical correlation analysis did reveal that the carbonyl (aldehydes and ketones) were strongly related to temperature with r-values of 0.73 and 0.64, respectively, and p-values of <0.0001 for both correlations, as were isoprene and monoterpenes emissions with r-value of 0.42 and p-value of 0.01. Paraffins were also correlated strongly (p-value=0.04); however, this was a negative relationship (r =-0.35). Average wind speed was positively correlated with hydrogen sulfide, with r-value of 0.33 and p-value of 0.05, and negatively correlated with aromatics and olefins, with r-values of –0.34 and –0.32 (p-value=0.05 and 0.06), respectively. There were no correlations of interest for relative humidity and this parameter was therefore not included in any of the statistical analysis.

3.6.1 VOCs vs Scentometer Ratings

Statistical analysis was performed using SAS software (SAS Inc., Cary, NC) to determine if mean Scentometer ratings at each farm depended on other variables that may vary from farm to farm and there was no statistical significance. Pearson's Correlation Coefficients reveal some relationships among some individual parameters (Table 3.13). Isoprene and monoterpenes have a moderate negative correlation with Scentometer ratings while alcohols (primarily ethanol and methanol) and organic sulfides (mainly dimethyl sulfide and dimethyl disulfide) have a moderate positive correlation, and hydrogen sulfide has a strong positive correlation. It is notable that hydrogen sulfide was consistently

measured at higher concentration levels (and above its odor threshold) in the ambient air than other organic sulfur compounds and phenols. Possibly, this compound was providing a greater contribution to odor in the ambient air than other compounds that were measured at much smaller concentrations. This may be the reason for the strong relationship between hydrogen sulfide and the Scentometer ratings and the weaker relationships for all other measured odorous compounds (i.e., other organic sulfur compounds and phenols).

Using Type III multiple regression analysis, taking into account all measured VOCs and Akaike's information criteria (AIC), a best fit model for the determination of Scentometer ratings (R^2 = 0.56, p-value = 0.007) from the measured VOCs at the swine facilities may be given by

$$S = \underset{(90.59)}{313.28} - \underset{(4.39)}{7.7}T + \underset{(11.40)}{11.40}V - \underset{(5.16)}{9.46}ald - \underset{(3.09)}{5.51}ar + \underset{(4.06)}{8.78}k + \underset{(4.37)}{14.16}o - \underset{(1.65)}{3.01}p + \underset{(24.78)}{33.47}s + \underset{(0.47)}{1.08}hs \quad (1)$$

where

	S	Scentometer Rating
	T	temperature (°C)
	V	average wind speed at 2 m (m s^{-1})
	ald	aldehydes
	ar	aromatics
	k	ketones
	o	olefins
	p	paraffins
	s	sulfides (primarily dimethyl sulfide and dimethyl disulfide)
	hs	Hydrogen sulfide

where units of concentration are ppbV (hydrogen sulfide, ppbV). The standard error of each variable is provided in parentheses below the slope and intercept terms for the model.

It is notable that temperature appears to have a negative effect on the Scentometer ratings while wind speed seems to have a positive effect. As expected, both sulfides and hydrogen sulfide appear in the model. Surprisingly, phenols (4-methylphenol) do not have an effect on Scentometer ratings. Again, this may be due to concentration levels of this compound measured below odor threshold while other compounds (i.e., hydrogen sulfide) are above their odor threshold.

Maximum Scentometer ratings (350) were observed seven times, once during each sampling campaign at Barham and Howard, once at Grinnells in November, and twice at Moore in February. At Barham, in both instances, the ratings were assessed at 2 m downwind of a ventilation fan. At Grinnells, the ratings were assessed at 20 m downwind of the exhaust fan. At Howard, sampling in June took place next to the solid separator, located near the finishing lagoon, and sampling in December was 2 m from a housing ventilation fan. At Moore, the highest Scentometer rating occurred near the houses in both instances. Total sulfide levels in relation to the maximum Scentometer ratings were measured at concentrations between 0.32 and 1.70 ppbC. The highest average hydrogen sulfide concentration was recorded next to the solid separator at Howard (910 ppbV), which was exceptionally high compared to concentrations measured at other locales on site; however, the sulfides collected by canister at this location measured only 1.70 ppbC. Hydrogen sulfide concentrations were also high just downwind of the ventilation fans at Barham, 54.0 ppbV in April and 128.9 ppbV in November. Similarly, measured levels were high at Moore, 42.6 and 77 ppbV, near the hog barns. At Grinnells, the concentration of hydrogen sulfide was

much lower (4.7 ppbV) at 20 m downwind and other sulfide concentrations were 0.20 ppbV. At Barham, the alcohol levels were exceptionally high, 32.0 and 93.2 ppbV in April and November, respectively. These samples were collected at about 2 m downwind of ventilation fans. At Moore, levels were also fairly high, 20.7 and 24.6 ppbC about 4 m from the hog barns. The alcohol concentrations were much lower (11.9 ppbV) at the solid separator at Howard and (3.8 ppbV) downwind at Grinnells.

3.6.2 VOCs vs Odor Intensity

Pearson's Correlation Coefficients reveal a moderate relationship between odor intensity measurements and alcohols ($r = 0.32$, p-value = 0.06) and hydrogen sulfide concentrations ($r = 0.35$, p-value = 0.04) but, again, no statistically significant relationship between odor intensity and other measured organic sulfur compounds or phenols (4-methylphenol) was found. It also appears that none of the meteorological parameters (temperature, relative humidity, and average wind speed) had an effect on the odor intensity detected by the human panel at the various swine facilities. Statistical analysis was performed similar to that of Scentometer ratings to search for variations of mean odor intensity among farms and none was found of statistical significance.

At Howard in June, the highest odor intensity level was recorded (7) at the solid separator. This high level of intensity is consistent with the highest concentration (911 ppb) of hydrogen sulfide monitored there. The concentration of all other sulfides measured, however, was only 1.70 ppbC.

The lowest odor intensity observations (= 1.5) occurred at Barham (April), Howard (June), and Grinnells (April and November) in locations where measurements were made

"upwind" of suspected source points (i.e. ventilation fans or storage lagoon). An exception was Grinnells in November where low odor intensity was observed 20 m downwind of the ventilation fan. During this sampling period, however, there tended to be variable winds at 2 m height. Hydrogen sulfide was measured at 4.7 ppbV, and other organic sulfur compounds were measured at 0.32 ppbC. These levels are all below individual odor thresholds for the observed species.

Performing the Type III multiple linear regression analysis similar to that of Scentometer ratings and taking into account all measured VOCs and Akaike's information criteria (AIC), a best fit model for the determination of odor intensity (R^2 = 0.6923, p-value = 0.0003) from the measured VOCs may be given by

$$\begin{matrix} OI = 6.52 - 0.03T - 0.12V - 0.26ald + 2.82e + 0.35h + 0.13k + 0.12o - 0.07p \\ \quad (1.01)\ (0.05)\ \ (0.12)\ \ (0.06)\ \ \ \ (1.76)\ \ (0.14)\ \ (0.05)\ \ (0.04)\ \ (0.02) \end{matrix} \qquad (2)$$

$$\begin{matrix} + 0.70s + 0.02hs \\ \quad (0.27)\ \ (0.01) \end{matrix}$$

where

	OI	Odor Intensity
	T	temperature (°C)
	V	average wind speed at 2 m (m s^{-1})
	ald	aldehydes
	e	esters
	h	halogenated hydrocarbons
	k	ketones
	o	olefins
	p	paraffins
	s	sulfides (primarily dimethyl sulfide and dimethyl disulfide)

hs hydrogen sulfide

where units of concentration are ppbC (hydrogen sulfide, ppbV). The standard error of each variable is provided in parentheses below the slope and intercept terms for the model.

In this model it is notable that both temperature and wind speed have a negative relationship with odor intensity, suggesting that the intensity is affected more by the location of the measurements rather than the ambient meteorological parameters. Also, it is likely that there are other compounds abundant in the ambient air (i.e., carbonyl sulfide, carbon disulfide, and possibly others that were undetected in the air) but not measured by the given instrumentation that may play a role in odor intensity levels (and Scentometer ratings).

Table 3.1 Identification and Percent C_2 -C_{14} Compounds in Complex Sample

Percent Composition of the C_4 to C_{14} VOCs
Barham Hog Farm Pipe from Covered Treatment Lagoon Collected April 5, 2002 (1235-1240 EST)
Listed 93 VOCs Represent About 98% of Total C_4 to C_{14} VOCs for Analysis Times

Analysis Date			5/13/02	7/11/02	1/31/03
Retention Time (minutes)	RTINDEX	COMPOUND	%	%	%
7.019	361.88	Isobutane	0.032	0.010	0.103
7.301	372.25	Acetaldehyde	0.865	1.038	1.243
8.188	390.92	Isobutylene	0.700	0.375	1.245
8.573	400.00	n-Butane	0.062	0.029	0.010
8.701	408.00	Methanol	1.244	0.738	1.666
9.265	411.64	t-Butene-2	0.057	0.047	0.152
9.848	425.94	c-Butene-2	0.036	0.052	0.090
11.060	457.43	3-Methyl-1-Butene	0.164	0.097	0.181
11.260	461.50	Ethanol	0.428	0.261	0.125
11.774	476.37	Acetone	2.804	*3.625	*3.786
11.843	477.00	Propanal	0.694	n/d	n/d
12.415	489.36	Pentene-1	0.092	0.070	0.122
12.469	490.75	Furan	0.130	0.158	0.121
12.701	496.17	2-Methyl-1-Butene	0.999	0.987	1.028
12.860	500.00	n-Pentane	0.736	0.766	0.809
13.026	504.19	Isoprene + Iodomethane	0.328	0.317	0.219
13.134	507.30	DiMethylsulfide	21.120	21.485	21.976
13.666	521.04	2-Methyl-2-Butene	0.420	0.419	0.409
14.466	542.18	Isobutanal	0.098	0.098	0.103
14.886	552.82	Methacrolein	0.040	0.046	0.061
14.977	555.00	4-Me-2-Pentene	0.157	0.148	0.125
15.533	570.09	2-Methylpentane	0.289	0.288	0.291
15.628	572.72	Butanal	0.231	0.239	0.283
15.795	577.35	MEK	2.127	2.152	2.271
16.042	583.52	3-Methylpentane	0.409	0.423	0.452
16.265	589.36	Hexene-1	0.027	0.028	0.034
16.363	592.36	2-Butanol	0.090	0.058	0.019
16.443	594.02	2-Methylfuran	0.188	0.221	0.256
16.548	595.81	Unknown	0.040	0.036	0.027
16.670	600.00	n-Hexane	2.436	2.471	2.563
16.776	602.80	cis-3-Hexene	0.123	0.120	0.157
16.922	607.37	2-Methyl-2-Pentene	0.032	0.033	0.028

Table 3.1 (Continued) Identification and Percent C_2 -C_{14} Compounds in Complex

17.300	618.54	Methyl Propanate	0.061	0.063	0.031
17.592	627.20	Methylcyclopentane	0.445	0.458	0.505
17.887	635.89	Isopentanal	0.043	0.045	0.048
18.087	641.77	3-Methyl-2-Butanon	0.033	0.034	0.038
18.408	651.21	Benzene	1.979	2.039	2.045
18.548	655.66	Thiophene	0.065	0.047	0.051
18.799	662.64	2-Methylthiopropane	0.079	0.077	0.071
18.955	667.26	2-Pentanone	0.115	0.115	0.126
19.163	673.45	Unknown	0.035	0.027	0.025
19.240	675.78	Pentanal	0.212	0.181	0.199
19.749	690.72	2,2,4-TriMethylpentane + 2-Ethylfuran	0.057	0.056	0.048
19.928	696.02	2,5-DiMethylfuran	0.048	0.047	0.043
20.069	700.00	n-Heptane	0.205	0.195	0.202
20.445	712.30	2,4,4-TriMethyl-1-	0.023	0.019	0.021
20.736	721.82	4-Methyl-2-Pentano	0.035	0.034	0.035
20.983	729.82	DiMethyldisulfide	17.694	23.376	31.961
21.531	747.75	Unknown	0.027	0.026	0.028
21.861	758.58	Toluene	2.647	2.691	2.821
21.934	760.85	2-Methylthiophene	0.806	0.811	0.847
22.156	767.55	2-Methylheptane + 3-Methylthiophene	0.316	0.317	0.346
22.474	778.54	Hexanal	0.113	0.107	0.108
22.629	783.92	t-1,4-Dimethylcycl	0.033	0.024	0.033
22.795	789.04	Octene-1	0.274	0.274	0.283
22.969	794.85	2,2,4-TriMethylhexane + 4-Octene	0.226	0.228	0.225
23.037	796.71	3-Octene	1.377	1.381	1.400
23.134	800.00	n-Octane	2.760	2.791	2.913
23.221	803.11	trans-2-Octene	1.009	1.016	1.039
23.485	812.37	cis-2-Octene	0.843	0.838	0.823
23.634	817.91	Unknown	0.031	0.029	0.029
23.774	822.91	Methylethyldisulfide	0.259	0.300	0.301
24.680	855.40	Ethylbenzene + 4-H	0.187	0.184	0.199
24.729	857.11	2-Ethylthiophene	0.059	0.061	0.060
24.876	862.37	2,5-Dimethylthiophene	0.032	0.033	0.033
24.910	863.65	m-& p-Xylene	0.058	0.059	0.058
25.002	866.98	2-Methyloctane	0.261	0.267	0.226
25.106	870.23	2-Heptanone + 3-Ethylthiophene	0.041	0.036	0.082
25.204	873.73	3-Methyloctane	0.024	0.025	0.036
25.402	881.42	Styrene + 2,3-Dimethylthiophene	0.095	0.087	0.080
25.463	883.39	Methylisopropyldisulfide	0.078	0.097	0.100
25.927	900.00	Nonane	0.118	0.116	0.128
26.143	908.79	Unknown	0.036	0.036	0.039
26.505	922.24	2-Methyl-3-Heptanone+	0.090	0.083	0.055
26.885	937.70	2,6-DiMethyloctane	0.027	0.022	0.031

Table 3.1 (Continued) Identification and Percent C_2 -C_{14} Compounds in Complex Sample

26.971	940.10	Benzaldehyde	0.038	0.034	0.036
27.067	943.64	alpha-Pinene + 3,6	0.027	0.023	0.013
27.424	958.75	2,3-DiMethyloctane	0.051	0.042	0.028
27.570	963.85	Dimethyltrisulfide	24.363	18.250	7.275
27.632	966.32	2-Methylnonane	0.445	0.411	0.433
27.815	973.55	3-Methylnonane	1.085	1.095	1.134
28.088	983.98	Octanal	0.025	0.012	0.021
28.252	990.36	Methyl-sec-butyldisulfide	0.069	0.077	0.067
28.500	1000.00	n-Decane	0.119	0.122	0.119
29.041	1022.93	p-Cymene	0.038	0.035	0.035
29.119	1025.79	Unknown	0.024	0.019	0.013
29.652	1048.17	Acetophenone	0.032	0.031	0.028
30.630	1089.44	Undecene-1	0.063	0.026	0.011
30.719	1092.85	1,3-DiMe-2-Ethylbenzene	0.027	0.014	n/d
30.876	1100.00	n-Undecane	0.094	0.083	0.070
32.026	1152.00	m-DiisoPropylbenzeme	0.025	0.021	0.013
33.518	1220.30	Dimethyltetrasulfide	0.785	0.603	0.158
		Total VOC**	205.96 ppmC		

n/d Below detectable limits

* Combination of Acetone & Propanal

Table 3.2 Identification and percent C_2-C_{14} compounds in two complex samples at Barham Farm in November 2002

Percentage profiles for canisters 127 and 2007 collected at the covered lagoon pipe
(Listed VOCs consist of approximately 90% of all VOCs after Isobutane)

Retention Time (minute)	RTINDEX	Compound	Can#127	Can#2007
			%	%
7.348	361.88	Isobutane	0.1148	0.0262
7.792	372.25	Acetaldehyde	0.3457	0.4130
8.241	389.97	Butene-1	0.3012	0.1541
8.305		(Methanethiol ?)	0.2426	0.5524
8.413	400.00	n-Butane	1.2834	0.0261
8.799	408.00	Methanol	0.1705	3.1626
9.288			0.4426	0.5604
11.171	461.50	Ethanol	0.3564	0.3808
11.893	474.54	Isopentane	1.9991	2.4748
12.515	489.36	Pentene-1 + Ethanethiol	n/d	2.3477
12.765	496.17	2-Methyl-1-Butene	2.6838	0.8787
12.935	500.00	n-Pentane	0.7480	0.7591
13.087	504.19	Isoprene	0.2782	n/d
13.200	507.30	DiMethylsulfide	7.3447	2.2240
13.727	521.04	2-Methyl-2-Butene	1.5888	0.7638
15.593	570.09	2-Methylpentane	0.7527	0.7566
15.708	572.72	Butanal	0.0759	0.1135
15.874	577.35	MEK	0.9077	1.5392
16.101	583.52	3-Methylpentane	1.2637	1.4952
16.533		1-Propanethiol	n/d	1.5456
16.502	594.02	2-Methylfuran	0.6253	n/d
16.727	600.00	n-Hexane	5.0735	5.3940
16.835	602.80	cis-3-Hexene	0.3995	0.3574
16.978	607.37	2-Methyl-2-Pente	0.1377	n/d
17.431	620.74	Unknown	0.1705	0.1169
17.651	627.20	Methylcyclopenta	0.9326	0.9253
18.466	651.21	Benzene	4.4618	4.6603
18.588		2-Butanethiol	n/d	0.9156
19.043	668.68	2-Methylhexane	0.1030	0.1517
19.305	675.78	Pentanal	n/d	0.2505
19.357	677.22	3-Methylhexane + 3	n/d	0.1658
19.807	690.72	2,2,4-TriMethylpentane + 2-Ethylfuran	0.2965	0.2459

Table 3.2 (Continued) Identification and percent C_2-C_{14} compounds in two complex samples at Barham Farm in November 2002

20.000	696.02	2,5-DiMethylfuran	0.1817	0.1507
20.123	700.00	n-Heptane	0.3845	0.5659
21.021	729.82	DiMethyldisulfide	1.7513	0.0802
21.919	758.58	Toluene	9.5574	8.5747
21.990	760.85	2-Methylthiophene	5.5400	6.0373
22.211	767.55	2-Methylheptane + 3-Methylthiophene	1.3274	1.4185
22.538	778.69	4-Methyl-3-Pente	0.0993	0.4913
22.605	780.46	Cyclopentanone	0.1063	0.1201
22.769	785.98	Unknown	0.1232	0.0814
22.850	789.04	Octene-1	0.3906	0.2015
23.025	794.85	2,2,4-TriMethylhexane + 4-Octene	1.0937	1.2086
23.092	796.71	3-Octene	6.5279	6.1894
23.186	800.00	n-Octane	7.2838	7.9738
23.276	803.11	trans-2-Octene	5.4379	5.7357
23.337	805.44	1-Pentanethiol	n/d	0.5495
23.540	812.37	cis-2-Octene	4.4407	2.7268
23.705	817.91	Unknown	0.1054	0.0961
24.280	838.60	2,5-DiMeHeptane	0.1176	0.1722
24.372	841.50	3,3-DiMethylheptan	n/d	0.6185
24.740	855.40	Ethylbenzene +	0.4848	0.5307
24.790	857.11	2-Ethylthiophene	0.2464	0.2639
24.936	862.37	2,5-Dimethylthiophene	0.1513	0.2344
24.971	863.65	m-& p-Xylene	0.2979	0.2565
25.060	866.98	2-Methyloctane	1.3616	1.7530
25.183	870.23	2-Heptanone + 3-Ethylthiophene	0.0796	n/d
25.258	873.73	3-Methyloctane	n/d	0.0629
25.307		3-Ethylthiophene	n/d	0.0313
25.455	880.95	Heptanal	0.1148	0.1645
25.642	887.56	o-Xylene	0.0440	0.0400
25.987	900.00	Nonane	0.3443	0.3608
26.456		4-Octanone	0.1939	0.2504
27.035	940.10	Benzaldehyde	0.0370	0.1173
27.120	943.64	alpha-Pinene	0.0815	0.0384
27.265		Methylpropyldisulfide	0.1578	n/d
27.186	947.14	Unknown	n/d	0.1569
27.479	957.45	m-Ethyltoluene	0.2979	0.3403
27.589	963.85	Dimethyltrisulfide	2.3850	n/d
27.694	966.32	2-Methylnonane	1.6267	1.9381

Table 3.2 (Continued) Identification and percent C_2-C_{14} compounds in two complex samples at Barham Farm in November 2002

27.875	973.55	3-Methylnonane	4.3944	5.4068
28.117		2-Pentylfuran	0.2820	0.2023
28.346	991.48	1,2,4-TriMethylbenzene	0.2511	0.1239
28.560	1000.00	n-Decane	0.5096	0.4413
30.937	1100.00	n-Undecane	0.2314	0.2100
33.146	1200.00	n-Dodecane	0.0234	0.0348

Table 3.3 Average hydrocarbon concentrations (ppbC) at various rural Southeastern U.S. sites during the summer months (June, July, August)

Compound	Centreville[a] AL	Candor[a] NC	Metter[a] GA	Oak Grove[a] MS	Howard Farm[b] Richlands, NC
Alkanes					
Ethane	1.74	0.09	1.71	1.02	2.99
Propane	2.60	2.19	2.24	4.04	1.61
Isobutane	0.77	0.45	0.91	1.25	0.70
n-Butane	1.48	0.98	1.05	1.87	1.77
Isopentane	2.22	3.13	1.89	5.90	3.13
n-Pentane	1.04	1.00	1.84	16.51	1.26
2-Methylpentane	3.34	2.81	1.83	2.16	1.55
3-Methylpentane	0.82	0.39	0.82	0.93	0.42
n-Hexane	0.68	0.28	0.92	0.72	0.37
Olefins					
Ethene	0.61	0.47	0.92	0.57	1.28
Propene	0.36	1.75	1.05	0.61	0.49
cis-3-Hexene	0.70	0.22	0.41	0.48	0.25
Alkynes					
Acetylene	0.36	0.17	0.82	0.45	1.01
Aromatics					
Benzene	0.61	0.90	0.60	0.69	0.86
Toluene	1.20	2.94	2.24	3.63	1.25
Organic Sulfur					***1.11***

Reference
[a]Hagerman *et al.* (1997)
[b]This study (June 2002)

Table 3.4 Average hydrocarbon concentrations (ppbC) at various rural Southeastern U.S. sites during the autumn months (September, October, November)

Compound	Centreville[a] AL	Candor[a] NC	Stokes[b] Kinston NC	Moore[b] Trenton NC	Barham[b] Clayton NC
Alkanes					
Ethane	3.11	2.51	3.40	3.62	3.55
Propane	4.22	3.77	2.53	3.30	4.78
Isobutane	1.03	0.97	1.06	1.09	1.17
n-Butane	2.18	2.83	0.82	2.70	3.19
Isopentane	1.53	2.91	1.14	4.22	1.92
n-Pentane	1.04	1.17	0.67	1.61	0.83
2-Methylpentane	0.64	0.81	0.59	1.50	0.54
3-Methylpentane	0.50	0.57	0.31	0.81	0.62
n-Hexane	0.39	0.73	0.35	0.75	0.41
Olefins					
Ethene	0.88	1.67	0.75	0.64	0.95
Propene	0.66	0.70	0.41	0.64	0.44
cis-3-Hexene	0.07	0.13	0.00	0.00	0.00
Alkynes					
Acetylene	1.06	1.34	0.51	0.42	1.14
Aromatics					
Benzene	0.87	12.77	0.67	1.20	0.95
Toluene	1.08	2.26	0.95	2.08	3.12
Organic Sulfur			***1.00***	***0.49***	***0.63***

Reference
[a]Hagerman *et al.* (1997)
[b]This study
Stokes (September 2002)
Moore (October 2002)
Barham (November 2002)

Table 3.5 Average hydrocarbon concentrations (ppbC) at various rural Southeastern U.S. sites during the winter months (December, January, February)

Compound	Centreville[a] AL	Candor[a] NC	Howard[b] Richlands NC	Stokes[b] Kinston NC	Moore[b] Trenton NC
Alkanes					
Ethane	3.30	2.81	4.95	5.54	3.13
Propane	8.40	5.84	6.62	5.32	5.67
Isobutane	1.95	1.71	1.54	1.27	1.21
n-Butane	4.92	4.97	3.61	2.72	2.32
Isopentane	3.25	2.65	2.35	1.35	1.14
n-Pentane	2.00	1.55	1.33	0.87	0.65
2-Methylpentane	0.80	0.88	1.56	0.38	0.53
3-Methylpentane	0.89	0.86	1.07	0.58	0.58
n-Hexane	0.72	0.73	1.22	0.67	0.34
Olefins					
Ethene	1.98	2.28	1.28	0.81	0.74
Propene	0.78	0.78	0.75	0.24	0.25
cis-3-Hexene	0.01	0.00	0.00	0.00	0.00
Alkynes					
Acetylene	2.21	2.53	2.96	0.37	0.18
Aromatics					
Benzene	1.36	1.59	1.66	0.99	0.97
Toluene	1.86	1.83	4.20	1.07	0.79
Organic Sulfur			***1.11***	***0.49***	***0.65***

Reference
[a]Hagerman *et al.* (1997)
[b]This study
Howard (December 2002)
Stokes (January 2003)
Moore (February 2003)

Table3.6 Average hydrocarbon concentrations (ppbC) at various rural Southeastern U.S. sites during the spring months (March, April, May)

Compound	Centreville[a] AL	Candor[a] NC	Metter[a] GA	RECIP[b] Rose Hill, NC	Barham[b] Clayton NC
Alkanes					
Ethane	1.31	1.67	2.90	2.79	3.85
Propane	4.25	3.44	4.17	2.32	3.84
Isobutane	0.89	0.83	1.50	0.46	0.92
n-Butane	1.96	2.15	3.16	0.92	1.41
Isopentane	2.78	2.08	5.24	0.56	1.08
n-Pentane	0.90	1.04	2.08	0.27	0.51
2-Methylpentane	1.20	1.22	1.29	0.06	1.51
3-Methylpentane	0.67	0.69	0.98	0.18	0.39
n-Hexane	0.34	0.56	0.56	0.45	0.47
Olefins					
Ethene	1.92	1.93	1.55	0.57	1.57
Propene	0.60	0.41	0.61	0.35	0.94
cis-3-Hexene	0.10	0.11	0.32	0.00	0.07
Alkynes					
Acetylene	1.08	1.12	1.37	0.17	1.95
Aromatics					
Benzene	0.79	1.00	1.05	0.51	1.35
Toluene	0.88	1.43	2.88	0.54	1.51
Organic Sulfur				***0.37***	***0.95***

Reference
[a]Hagerman *et al.* (1997)
[b]This study
Barham (April 2002)

Table 3.7 Dominant VOCs (ppbC) observed at hog barns and background ambient air at Barham Farm. Net concentration depicts the difference in concentration levels between the two samples and % of total VOCs depicts the percent contribution of the specie relative to these net measured VOCs.

Barham Farm

April '02					**November '02**				
Compound	hog barn	upwind	net conc	% net	Compound	hog barn	upwind	net conc	% net
Canister #	122	AQ-146		total VOCs	Canister #	1862	119		total VOCs
Date	4/5/02	4/5/02			Date	11/21/02	11/21/02		
Time(EST)	12:58	13:17			Time (EST)	11:29	11:45		
propane	118.17	4.19	113.98	42.9	ethanol	157.09	1.68	155.41	46.1
ethanol	48.19	1	47.09	17.7	isopentane	47.55	2.47	45.08	13.4
methanol	45.61	2.69	42.92	16.2	acetaldehyde	43.47	3.35	40.12	11.9
acetaldehyde	21.95	5.72	16.23	6.1	methanol	27.33	1.26	26.07	7.7
n-propanol	8.75	0	8.75	3.7	MEK	18.95	0.63	18.3	5.4
acetone	20	12.32	7.68	2.9	dimethylsulfide	14.54	0.09	14.45	4.3
ethylene	12.39	4.89	7.5	2.8	2-butanal	11.64	0.12	11.52	3.4
2-methypentane	7.61	1.15	6.46	2.4	acetylene	9.6	0.52	9.08	2.6
1,2,4-trimethylbenzene	6.83	0.74	6.04	2.3	n-propanol	6.66	0	6.66	2.0
hexamethylcyclotrisiloxane	6.13	0.41	5.72	2.2	n-hexene	6.03	0.4	5.63	1.7
dimethylsulfide	1.1	0.17	0.93	0.4	n-pentene	5.24	1.05	4.19	1.2
dimethyldisulfide	0.76	0.11	0.65	0.2	dimethyldisulfide	0.62	0	0.62	0.2
4-methylphenol	1.41	0.2	1.21	0.5					
Total*	298.90	33.59	265.31		Total *	348.72	11.5	337.22	

*Total refers to the dominant VOCs listed above

Table 3.8 Dominant VOCs (ppbC) observed at hog barns and background ambient air at Grinnells Laboratories. Net concentration depicts the difference in concentration levels between the two samples and % of total VOCs depicts the percent contribution of the specie relative to these net measured VOCs.

Grinnells Laboratories

	April '02					**November '02**			
Compound	hog barn	upwind	net conc	% net	Compound	hog barn	upwind	net conc	% net
Canister #	AQ-171	AQ-048		Total VOCs	Canister #	2017	AQ-022		Total VOCs
Date	4/16/02	4/16/02			Date	11/4/02	11/4/02		
Time(EST)	10:05	9:58			Time (EST)	10:45	10:45		
methanol	32.75	9.42	23.31	35.7	ethanol	111.88	1.14	110.74	49.5
ethane	10.87	2.31	8.65	13.2	n-propanol	23.46	0.15	23.31	10.4
propane	8.85	1.94	6.91	10.6	2-methylpentane	16.25	1.17	15.08	6.7
acetone	20.17	13.68	6.49	9.9	acetone	20.28	7.55	12.73	5.7
acetaldehyde	8.68	4.87	3.81	5.8	methanol	13.97	1.84	12.13	5.4
toluene	7.52	3.81	3.71	5.7	3 & 4-methylcyclohexene	12.13	0	12.13	5.4
n-butanol	3.34	0	3.34	5.1	n-butanol	11.27	0.62	10.65	4.8
butanal	5	1.81	3.19	5.9	acetaldehyde	11.11	1.54	9.57	4.1
isobutane	4.17	1.18	2.99	4.6	3-methylpentene	8.95	0.87	8.11	3.6
dichloromethane	2.19	0.08	2.83	4.3	MEK	8.72	0.72	8	3.6
dimethylsulfide	0.23	0	0.23	0.4	dimethylsulfide	0.54	0	0.54	0.2
dimethyldisulfide	0.12	0	0.12	0.2	dimethyldisulfide	0.65	0	0.65	0.3
4-methylphenol	0.58	0	0.58	0.9					
Total*	104.47	39.1	65.37		Total *	239.21	15.6	223.61	

*Total refers to the dominant VOCs listed above

Table 3.9 Dominant VOCs (ppbC) observed at hog barns and background ambient air at Howard Farm. Net concentration depicts the difference in concentration levels between the two samples and % of total VOCs depicts the percent contribution of the specie relative to these net measured VOCs.

Howard Farm

June '02

Compound	hog barn	upwind	net conc	% net
Canister #	127	AQ-171		Total VOCs
Date	6/3/02	6/3/02		
Time (EST)	11:59	12:25		
ethanol	47.46	3.51	43.95	49.8
4-methylphenol	14.33	0	14.33	16.2
ethylene	5.77	1.58	4.19	4.8
n-propanol	4.01	0	4.01	4.5
acetaldehyde	7.45	4.36	3.09	3.5
dimethylsulfide	2.48	0	2.48	2.8
hexanal	4.19	2.21	1.98	2.2
2-methylnonane	1.49	0	1.49	1.7
6-methyl-5-heptene-2-one	1.06	0	1.06	1.3
isobutanal	0.85	0	0.85	1.0
dimethyldisulfide	0.77	0	0.77	0.9
Total*	99.86	11.66	88.2	

December '02

Compound	hog barn	upwind	net	% net
Canister #	JP-1066	AQ-146	conc	Total VOCs
Date	12/11/02	12/11/02		
Time (EST)	12:38	12:58		
ethanol	84.44	1.64	82.75	41.1
4-methylphenol	43.41	0.12	43.29	21.5
acetylene	26.89	0.89	26	12.9
methanol	10.68	1.04	9.64	4.8
acetone	13.93	4.96	6.97	3.5
acetaldehyde	9.14	1.59	7.55	3.8
dimethylsulfide	6.8	0.22	6.58	3.3
n-hexane	6.98	0.57	6.41	3.2
n-pentane	5.11	1.07	4.04	2.0
n-butanol	4.38	0.49	3.89	1.9
dimethyldisulfide	2.05	0	2.05	1.0
Total*	213.81	12.59	201.22	

*Total refers to the dominant VOCs listed above

Table 3.10 Dominant VOCs (ppbC) observed at hog barns and background ambient air at Stokes Farm. Net concentration depicts the difference in concentration levels between the two samples and % of total VOCs depicts the percent contribution of the specie relative to these net measured VOCs.

Stokes Farm

	September '02					**January '03**			
Compound	hog barn	upwind	net conc	% net	Compound	hog barn	upwind	net conc	% net
Canister #	AQ-080	39		Total VOCs	Canister #	122	AQ-128		Total VOCs
Date	9/19/02	9/19/02			Date	1/14/03	1/14/03		
Time(EST)	12:35	12:37			Time (EST)	13:29	12:51		
ethanol	38.09	1.2	36.89	28.2	2,4-dimethylhexane	2.75	0	2.75	35.6
4-methylphenol	33.12	0	33.12	25.3	acetaldehyde	1.98	0.69	1.29	16.7
n-propanol	14.75	0.55	14.2	10.9	ethanol	2.36	1.63	0.73	9.5
acetone	24.4	11.49	12.9	9.9	methanol	1.81	1.2	0.61	7.9
methanol	14.83	4.05	10.75	8.2	2-methylheptane	0.57	0.13	0.44	5.2
2-butanal	10.55	0	10.55	8.1	3-methypentane	0.83	0.44	0.39	5.1
dimethyldisulfide	3.33	0	3.33	2.5	n-hexane	1.13	0.75	0.38	4.9
dimethylsulfide	2.35	0	2.35	1.8	dimethyldisulfide	0.34	0	0.34	4.4
acetaldehyde	7.81	5.46	2.35	1.8	octanal	0.26	0	0.26	3.3
MEK	3.44	1.25	2.19	1.7	1,2-dichloroethane	0.48	0.25	0.23	3.0
n-pentane	0.26	0.26	2.09	1.6	dimethylsulfide	0.21	0	0.21	2.7
					4-methylphenol	0.09	0	0.09	1.2
Total*	155.02	24.26	130.76		Total*	12.81	5.09	7.72	

*Total refers to the dominant VOCs listed above

Table 3.11 Dominant VOCs (ppbC) observed at hog barns and background ambient air at Moore Farm. Net concentration depicts the difference in concentration levels between the two samples and % of total VOCs depicts the percent contribution of the specie relative to these net measured VOCs.

Moore Farm

	October '02					**February '03**			
Compound	hog barn	upwind	net conc	% net	Compound	hog barn	upwind	net conc	% net
Canister #	1870	AQ-211		Total VOCs	Canister #	1862	AQ-171		Total VOCs
Date	10/4/02	10/4/02			Date	2/4/03	2/4/03		
Time (EST)	12:04	11:35			Time (EST)	13:05	12:12		
Freon-142b	10.88	0.09	10.79	21.7	ethanol	26.09	3.68	22.41	30.3
n-pentene	6.75	0.36	6.39	12.8	4-methylphenol	10.50	0	10.50	14.2
m-diisopropylbenzene	5.72	0	5.72	11.5	nonanal	7.22	0.55	6.67	9.0
isoprene	8.72	3.44	5.28	10.6	2-methylpentane	6.41	0.09	6.32	8.6
dodecene-1[1]	4.6	0	4.6	9.2	acetone	9.98	2.77	7.21	9.8
acetaldehyde	13.45	9.44	4.01	8.1	3-methylpentane	5.67	0	5.67	7.7
toluene	3.97	0.62	3.35	6.7	methanol	6.05	0.74	5.31	7.2
3-octanone	3.35	0	3.35	6.7	acetylene	3.67	0.10	3.57	4.8
acetone	24.05	20.97	3.08	6.2	acetaldehyde	3.9	0.95	2.95	4.0
2,5-DiMeHeptane[2]	2.78	0	2.78	5.6	propane	3.89	1.77	2.12	2.9
dimethylsulfide	0.55	0.07	0.48	1.0	dimethylsulfide	0.90	0	0.90	1.2
					dimethyldisulfide	0.34	0	0.34	0.5
Total*	84.77	34.99	49.78		Total*	84.44	10.60	73.84	

*Total refers to the dominant VOCs listed above

[1] co-elutes with napthatene
[2] co-elutes with 5-me-2-hexanone

Table 3.12 Hazardous Air Pollutants levels (ppbC) measured at selected swine facility field study sites

Samples collected at ventilation fans

	US EPA Reference Conc (ppbC)	U.S. Average Ambient Conc (ppbC)*	Barham Apr '02	Barham Nov '02	Grinnells Apr '02	Grinnells Nov '02	Howard Jun '02	Howard Dec '02	Moore Oct '02	Moore Feb '03
Acetaldehyde	10	2.78	**21.95**[2]	**25.00**[2]	**4.39**	**11.77**[2]	**7.45**	**9.14**	**13.45**[2]	**3.90**
Benzene	133.2	21.6	1.90	1.19	1.49	1.88	0.68	2.26	0.92	0.68
n-Hexane	342	21.6	1.21	3.21	1.35	1.19	1.21	6.98	2.43	1.73
Methanol	236.5	17.6	**45.61**	17.50	**19.29**	16.32	10.43	10.68	4.41	6.05
MEK	1057.7	1.88	**4.05**	**11.90**	**2.22**	**14.84**	**2.36**	**3.58**	**3.06**	1.53
Styrene[3]	1312	1.04	**1.61**	0.97	**1.16**	**1.54**	**1.57**	**1.04**	**3.99**	**2.33**
Toluene	742	18.9	2.80	2.24	10.28	3.51	0.69	4.63	3.97	0.86
m-& *p*-Xylene	n/a	26.4	0.56	1.20	1.94	3.24	n/d	2.14	n/d	n/d
o-Xylene	n/a	4.8	0.32	0.82	n/d	1.59	n/d	0.70	0.25	n/d
4-Methylphenol	n/a	7.3	1.41	0.11	0.37	5.61	**14.33**	**43.41**	1.18	**10.5**

Samples collected in ambient air

	US EPA Reference Conc (ppbC)	U.S. Average Ambient Conc (ppbC)	Barham Apr '02	Barham Nov '02	Grinnells Apr '02	Grinnells Nov '02	Howard Jun '02	Howard Dec '02	Moore Oct '02	Moore Feb '03
Acetaldehyde	10	2.78	**8.08**	**3.44**	**4.01**	2.03	**6.03**	2.06	**4.08**	**3.07**
Benzene	133.2	21.6	1.35	1.35	1.57	4.61	0.86	1.66	1.20	0.92
n-Hexane	342	21.6	0.47	0.41	0.58	1.91	0.37	1.22	0.75	0.34
Methanol	236.5	17.6	3.75	0.96	6.78	2.40	6.64	1.99	4.04	2.64
MEK	1057.7	1.88	**2.01**	0.91	1.61	1.16	1.13	0.80	1.11	1.27
Styrene[3]	1312	1.04	**2.19**	0.64	**1.58**	1.03	**1.75**	0.58	**1.04**	0.73
Toluene	742	18.9	1.51	3.12	2.92	8.68	1.25	4.20	2.08	0.79
m-& *p*-Xylene	n/a	26.4	0.60	0.44	1.61	5.15	0.45	2.73	0.84	0.08
o-Xylene	n/a	4.8	0.52	0.33	0.52	2.14	0.29	1.24	0.38	0.09
4-Methylphenol	n/a	7.3	0.60	0.15	1.55	0.73	0.82	6.28	0.87	0.11

Table 3.12 (Continued) Hazardous Air Pollutants levels (ppbC) measured at selected swine facility field study sites

Samples collected in ambient air

	US EPA Reference Conc (ppbC)	U.S. Average Ambient Conc (ppbC)	Stokes Sept '02	Stokes Jan '03	RECIP Mar '03
Acetaldehyde	10	2.78	**10.80**[2]	1.25	**3.02**
Benzene	133.2	21.6	0.67	0.99	2.7
n-Hexane	342	21.6	0.35	0.67	0.70
Methanol	236.5	17.6	**6.03**	1.25	0.45
MEK	1057.7	1.88	1.65	0.31	0.51
Styrene[3]	1312	1.04	**1.26**	0.22	0.54
Toluene	742	18.9	0.95	1.07	0.10
m-& *p*-Xylene	n/a	26.4	0.19	0.24	0.86
o-Xylene	n/a	4.8	0.05	0.22	n/d
4-Methylphenol	n/a	7.3	0.21	0.02	0.17

n/d below detectable limits

[1] average levels are listed as provided by the US EPA and were not necessarily measured in rural areas

[2] measured above reference concentrations

[3] co-elutes with Heptanal

Table 3.13 Pearson's correlation coefficients between Scentometer ratings and some VOCs (N=35)

Scentometer	Alcohols	Isoprene & Monoterpenes	Sulfides	Hydrogen Sulfide
r	0.32489	-0.31537	0.31358	0.49919
Std Error	(16.74)	(4.11)	(0.79)	(42.33)
P-value	0.0569	0.0650	0.0666	0.0023

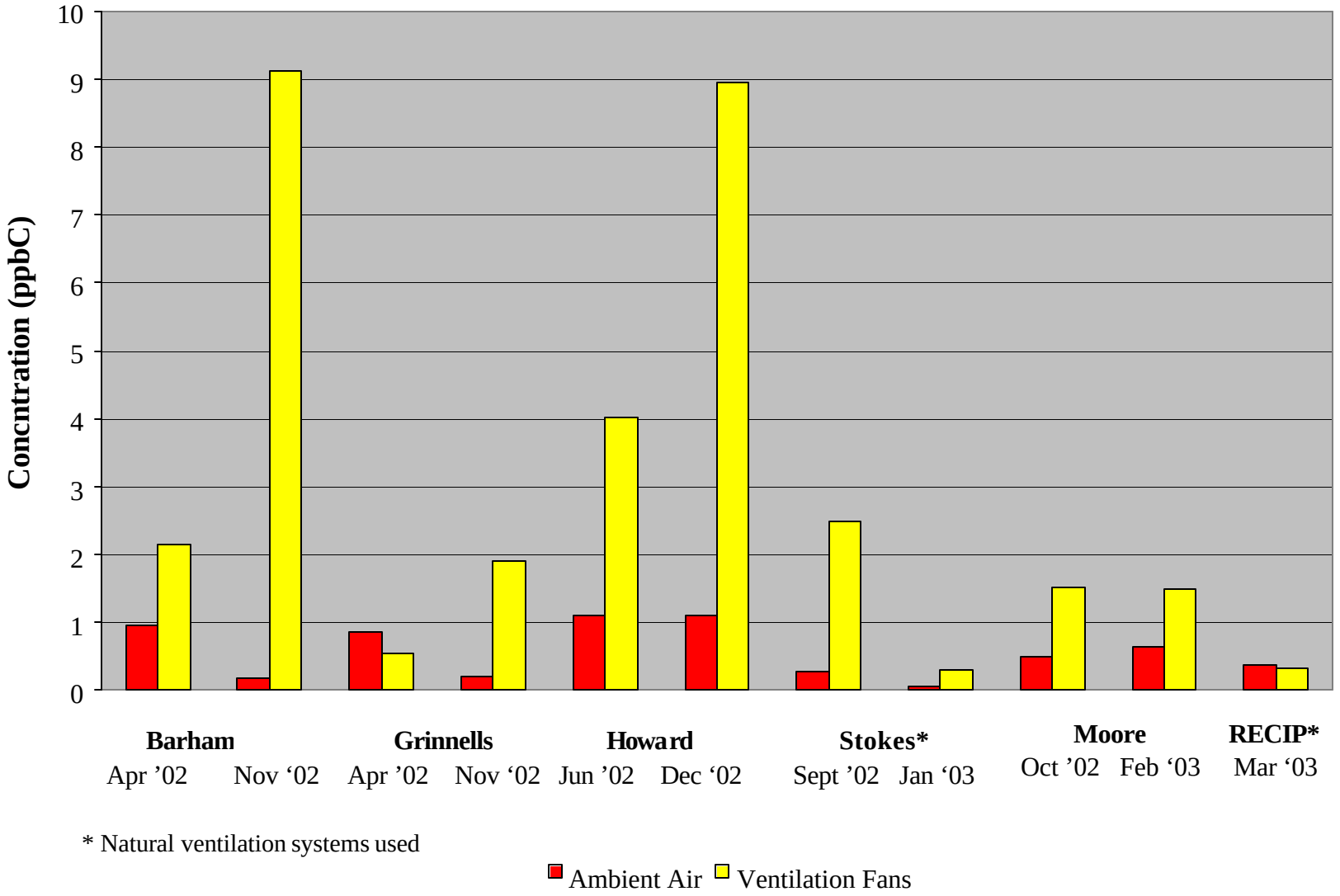


Figure 3.1 Total reduced organic sulfur concentrations (ppbC) at various swine facilities in Eastern North Carolina

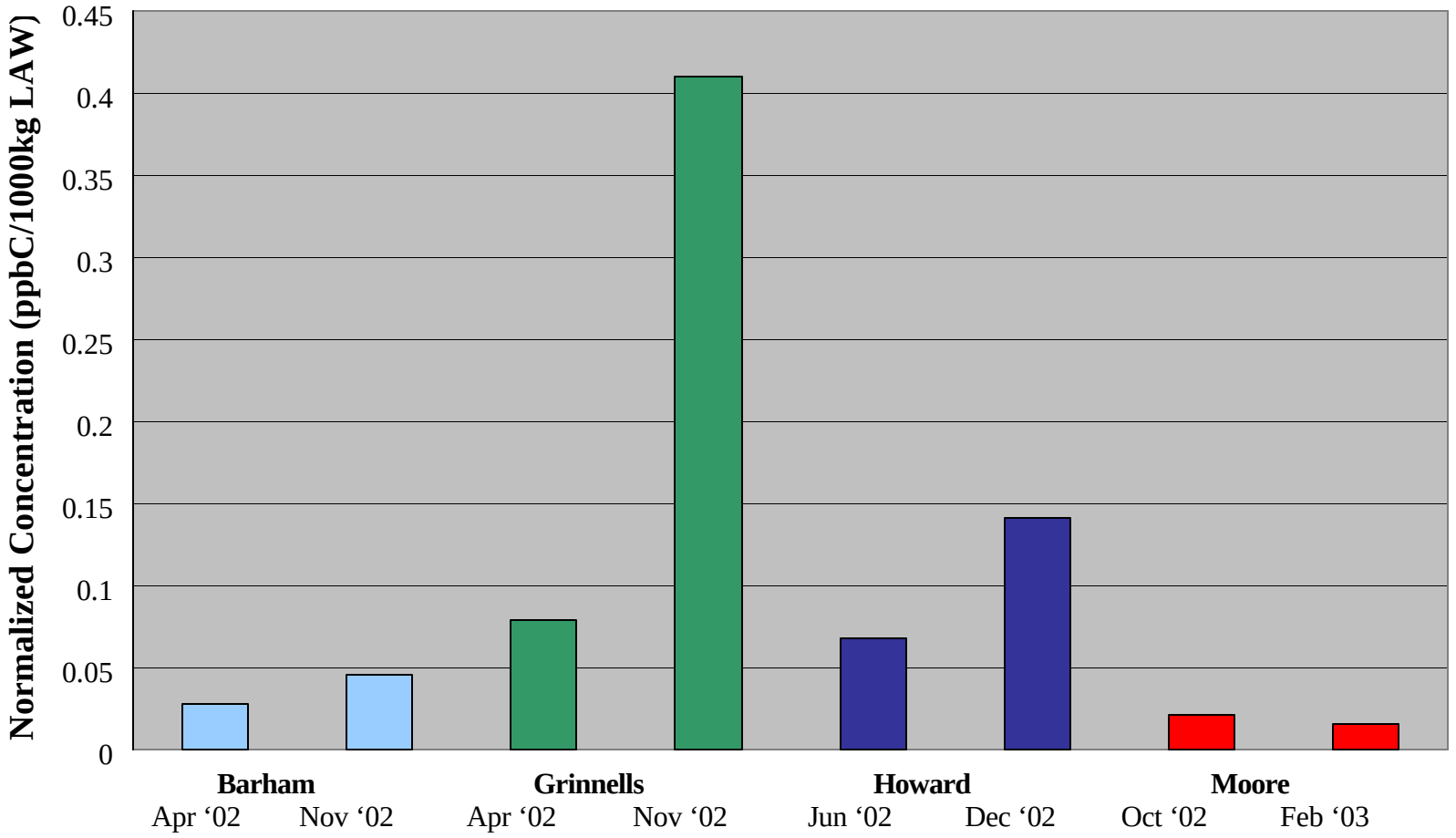


Figure 3.2 Total Reduced Organic Sulfur Concentrations (ppbC) Detected at Ventilation Fans, Normalized by Live Animal Weight (LAW)

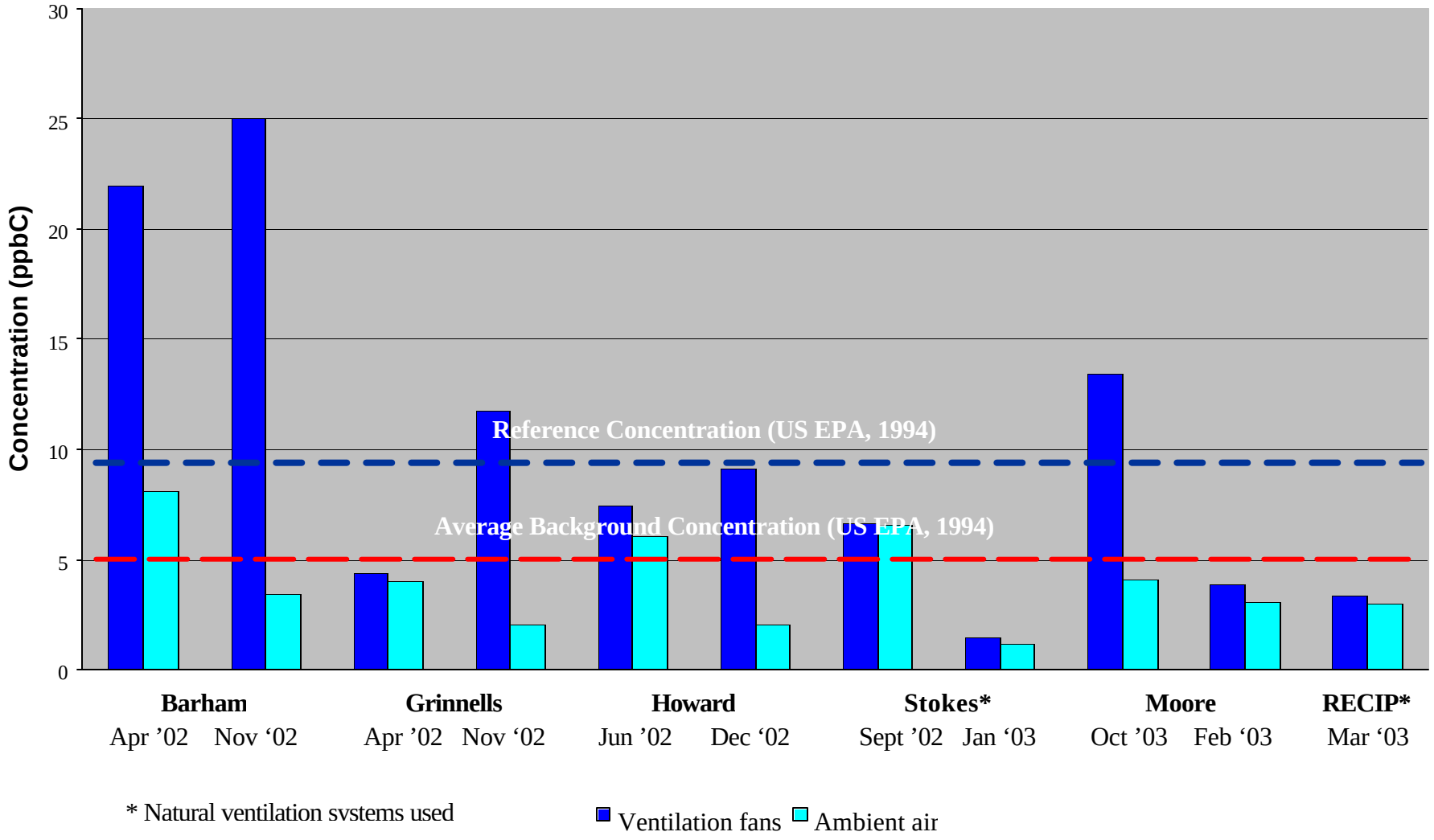


Figure 3.3 Acetaldehyde concentration levels at various swine facility sites in Eastern North Carolina

4.0 Conclusions and Recommendations

A total of 110 samples were collected by means of SUMMA stainless steel canisters in a field study to characterize volatile organic compounds (VOCs) detected at six swine facilities in Eastern North Carolina between April 2002 and March 2003. Two sites, Stokes Farm and Moore Brothers Farm, employed traditional lagoon and field spray technologies while four sites, Barham Farm, Grinnells Laboratories, Howard Farm, and RECIP (Corbett Farm # 2), utilized various potential "Environmentally Superior Technologies" in an effort to reduce ammonia and VOCs emissions, odor and odorants, and pathogens at swine farms. More than 200 compounds, including various paraffins, alkynes, aromatics, esters, ethers, monoterpenes, alcohols, aldehydes, ketones, monoterpenes, halogenated hydrocarbons, phenols, and sulfides were identified and quantified by GC/FID analysis. One sample was retained and evaluated on three separate occasions over a seven-month period. Results ensured storage stability of measurable compounds in the canister.

The results of GC/MS analysis of selected samples have verified and/or confirmed the presence of many compounds. An analysis of three complex samples collected at Barham Farm aided in the identification of more than 20 organic sulfur compounds including dimethyl sulfide, dimethyl disulfide, and dimethyl trisulfide, as well as many other VOCs. Carbonyl sulfide and carbon disulfide were positively identified by GC/MS analysis but were not identified by GC/FID, as expected, due to their particular characteristics. Another compound commonly associated with malodors at swine facilities as well as general air toxicity, 4-methylphenol, was also identified in many of the GC/FID sample results and verified by GC/MS analysis.

Other hazardous air pollutants including acetaldehyde, benzene, *n*-hexane, methanol, MEK, styrene, toluene, and xylene (m-, p-, & o-) were identified in many of the samples. In many instances, acetaldehyde, styrene (which was found to co-elute with heptanal), and MEK were all measured at levels higher than their respective ambient background concentrations. Acetaldehyde was also measured at levels above its reference concentration (10 ppbC) in many of the samples.

Overall, the highest VOC concentration levels measured at each of the sites were in close proximity to the hog barns. The dominant compounds observed near the hog barns from each sampling period were compared with background samples (i.e., upwind of lagoons and houses) collected relatively in the same timeframe. The difference between concentrations near the barn and upwind is called the net concentration. The total measured VOCs at the hog barns were typically dominated by ethanol, methanol, acetaldehyde, and acetone. Acetaldehyde was measured at much higher concentration level at the barns compared to the upwind concentration at every farm sampled. At Barham Farm during both sampling periods in April and November, net concentration levels were well above the reference concentration (RfC), 16.23 ppbC and 40.12 ppbC, respectively. At Grinnells in November, the net acetaldehyde concentration was observed at 9.57 ppbC, just below the RfC. These compounds, in addition to other oxygenated VOCs measured at the various sites, generally represented ~46-94% of net total measured VOCs that were emitted from the hog barns. Stokes Farm in January and Moore Farm in October had slightly lower contributions, ~38 and ~21%, respectively, of net total measured VOCs. Dimethyl sulfide and dimethyl disulfide, both recognized as malodorous compounds, had concentration levels at the barns above the background concentration at every farm sampled with the only exception of Stokes

in September. Dimethyl sulfide was measured at levels above its odor threshold (~4.5 ppbC) at Barham in November (14.5 ppbC net total concentration) and Howard in Decmeber (6.6 ppbC net total concentration). 4-methylphenol, another odorous compound associated with swine waste was also measured at higher levels near the barns than the background levels at Barham and Grinnells in April, Howard and Stokes during both sampling seasons, and at Moore in February. The largest net concentrations of 4-methylphenol were measured at Howard Farm in June and December, at 14.33 ppbC and 43.3 ppbC (16.2 and 21.5% of net total measured VOCs originating in the barn), respectively, and at Stokes Farm in September (33.1 ppbC net concentration, 25.3% of net total measured VOCs originating in the barn).

Statistical analysis performed on 35 samples to test for possible relationships between various VOCs, meteorological parameters, and Scentometer and odor intensity ratings revealed that only hydrogen sulfide had a strong effect on odor intensity levels, suggesting that this compound was likely providing a greater contribution of odor in the ambient air than other odorous compounds that were measured at much smaller concentrations. Alcohols and sulfides (mainly dimethyl sulfide and dimethyl disulfide) had a slight to moderate effect on Scentometer ratings, p-value = 0.06 and 0.07, respectively, while hydrogen sulfide had a strong positive relationship with Scentometer ratings (p-values < 0.0023). 4-methylphenol had no significant statistical effect on either odor intensity or Scentometer ratings. The levels of this compound were generally less than its odor threshold.

Temperature appeared to have a negative correlation with both Scentometer ratings and odor intensity, while wind speed shows a positive correlation with Scentometer ratings and a negative correlation with odor intensity. Simple statistical correlations revealed that the carbonyls (aldehydes and ketones) and isoprene and monoterpenes emissions were positively

correlated with temperature, with p-values <0.0001 and 0.01, respectively. Average wind speed was positively correlated with hydrogen sulfide, p-value = 0.05 and negatively correlated with aromatics, also with p-value = 0.05. There were no significant correlation between both odor assessments and VOCs and relative humidity.

Over 200 compounds were positively identified at the swine facilities in this study; however, some organic sulfur compounds, as well as other malodorous and potentially harmful VOCs that may exist in this type of environment, were not detected by GC/FID analysis. Future research is necessary to characterize and quantify emissions of these compounds. Quantifying these compounds will greatly assist in estimating regional emissions of harmful compounds from swine facilities and may provide a better idea of how these compounds impact the environment, possibly through potential aerosol formation as well as deposition far from the source area.

This study also compared selected anthropogenic HCs (generally accepted as precursors for ozone formation) measured in this study with those measured at other rural Southeastern U.S. sites. Future studies may entail a more detailed monitoring of oxygenated VOCs such as alcohols and carbonyls (i.e. methanol, ethanol, acetaldehyde, and acetone), as well as ozone levels, in these rural areas of concentrated animal farms to study the role these compounds play in rural tropospheric chemistry (both gas phase and heterogeneous), as the importance of these VOCs are increasingly being recognized (MacDonald and Fall, 1993; Kesselmeier *et al.*, 1997; Kirstine *et al.*, 1998; Kang *et al*, 2001; Das *et al*., 2003).

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Appendix 1 VOCs (ppbC) detected at Barham Farm in April 2002

Canister #	**Retention**	**115**	**704**	**39**	**AQ 185**	**652**	**119**	**AQ 146**	**AQ 128**
Date	**Index #**	**4/5/02**	**4/5/02**	**4/5/02**	**4/5/02**	**3/15/02**	**4/5/02**	**4/5/02**	**4/5/02**
Time		**23:58**	**6:02**	**12:15**	**18:25**	**12:00**	**12:20**	**13:17**	**13:31**
Location		**storage lagoon**	**storage lagoon**	**storage lagoon**	**storage lagoon**	**covered lagoon**	**~10 m N of covered lagoon**	**boundary line**	**boundary line**
Temperature (Celcius)		**2.6**	**2**	**12.1**	**12**	**no data**	**11.7**	**12.5**	**12.7**
Wind Speed (m/s)		**0.62**	**0.2**	**2.8**	**0.2**	**no data**	**2.1**	**3**	**1.5**
Alcohols									
Methanol	408.00	2.74	2.82	3.36	28.59	16.57	4.72	2.69	49.92
Ethanol	461.50	1.37	1.06	1.34	121.62	2.23	1.65	1.00	4.01
2 butanol	592.36	0.32	0.28		0.29	0.55		0.20	0.22
n-Butanol + Thiophene	653.00	0.72	4.12	1.10	5.37	1.03	0.42	3.72	3.62
n-Propanol	556.82		0.30	0.45	.68		0.68		0.68
SUM		**5.15**	**8.58**	**6.25**	**156.55**	**22.32**	**6.79**	**7.74**	**58.57**
Aldehydes									
Acetaldehyde	372.25	10.75	6.25	12.62	3.69	36.62	15.25	5.72	5.75
Isobutanal	542.18					1.23			0.83
pentanal			.10		.06			.13	.12
Butanal	572.72	2.73	2.02	2.98	2.07	7.49	0.95	2.99	3.82
Isopentenal	635.89	0.12					0.19		
Hexanal	778.54	0.48	1.43	0.58	1.99	1.27		1.39	1.07
Heptanal + Styrene	881.42		0.88	0.56	1.33	0.99		6.91	0.80
Benzaldehyde	940.10	0.33	1.18	0.46					
Octanal	983.98	0.28	0.66	0.59	0.68	0.68		0.39	1.41
Nonanal	1086.66	0.70	0.91	1.21	0.52	0.52			1.91
Decanal	1189.79	0.62	0.49	1.14	1.45	0.79		0.80	1.59
SUM		**16.01**	**13.92**	**20.14**	**11.79**	**49.59**	**16.39**	**18.33**	**17.30**
Alkynes									
Acetylene	187.39	0.77	1.10	0.81	1.01	0.39	0.64	5.64	2.43
SUM		**1.10**	**1.10**	**0.81**	**1.66**	**0.39**	**0.64**	**6.00**	**2.75**

Aromatics									
Benzene	651.21	1.19	1.33	1.77	1.13	4.70	1.73	3.12	1.44
Toluene	758.58	1.56	1.58	1.65	1.69	1.99	1.51	2.91	5.05
Ethylbenzene + 4-Heptanone	855.40	0.32	0.28	0.29	0.37	0.32	0.32	0.61	0.77
m-& p-Xylene	863.65	0.75	0.52	1.52	0.55	0.61	0.66	1.22	1.74
o-Xylene	887.56	0.46	0.31	0.70	0.60	0.43	0.47	0.47	0.39
Isopropylbenzene	920.34						0.14		
Benzaldehyde	940.10								2.31
n-Propylbenzene	950.95		0.07	0.19		0.35	0.43	0.10	
m-Ethyltoluene	957.45	0.28	0.61	0.46	0.15	0.19		0.24	0.41
p-Ethyltoluene	960.02				0.27	0.15	0.47	0.16	
1,3,5-TriMethylbenzene	964.32	0.29	0.30	0.46					0.69
o-Ethyltoluene	976.97	0.16	0.11	0.21	0.07		0.26	0.26	0.36
1,2,4-TriMethylbenzene	991.48	2.87	1.77	2.48	0.44	1.53	0.64	0.74	0.93
Isobutylbenzene	1008.16					0.07			0.33
1,2,3-TriMethylbenzene	1022.13				0.19		0.43	0.16	0.34
p-Cymene	1022.93	0.45	0.19			0.12			
o-Cymene	1037.53	0.39	0.27	1.51					
1,Me-3-n-Propylbenzene	1049.14								
p-Diethylbenzene	1053.84								2.22
n-Butylbenzene	1054.69		0.63		0.32	1.15		0.24	
1-Me-2-n-Propylbenzene	1067.27				0.10			0.31	
1,2-DiMe-4-Ethylbenzene	1084.27	0.12		0.25	0.09			0.08	
1,3-DiMe-2-Ethylbenzene	1092.85					1.31		0.40	
1,2-DiMe-3-Ethylbenzene	1107.49		0.21						0.06
1,2,4,5-Tetra-Me-Benzene	1119.01	0.48	0.32	0.64	0.17	0.82	0.17	0.25	0.55
1,2,4,5-TetraMe-Benzene	1121.01								
t-1-But-3,5-DiMeBenzene	1174.77								0.43
t-1-But-4-Ethylbenzene	1183.89				0.08	0.43		0.08	0.22
1,3,5-TriEthylbenzene	1216.90				0.24	0.24		0.11	
SUM		**9.32**	**8.50**	**12.13**	**6.46**	**14.41**	**7.23**	**11.46**	**18.24**
Esters									
Propyl Acetate	697.61							0.06	0.13
SUM		**0**	**0**	**0**	**0**	**0**	**0**	**0.06**	**0.13**

Ethers									
Furan	490.750		0.09						
2-Methylfuran	594.02								
3-Methylfuran + cis -3-Hexene	602.8		0.22		0.41	0.24			0.14
Tetrahydrofuran	620.74		0.30		0.82	0.21		0.48	0.54
2-Ethylfuran	690.72			0.81	0.44	0.36		0.35	0.82
SUM		**0**	**0.61**	**0.81**	**1.67**	**0.81**	**0**	**0.83**	**1.5**
Halogenated Hydrocarbons									
Freon-22	304.94	0.12		0.32	0.16	0.13	0.11	0.09	2.66
Freon-12	314.04	0.44	0.50	0.24	0.22	0.33	0.36	0.14	0.34
Methyl Chloride	339.70	1.10	0.81	0.71	0.67	1.32	0.71	0.83	0.78
Freon-114	369.43				0.14				
Ethyl Chloride	433.37		0.21	0.29		0.36	0.45		
Freon-11	480.75								18.44
Dichloromethane	518.77	0.23	0.14		0.49	0.12	0.10	0.09	1.96
Freon-113	531.54	0.22	0.24	0.26	0.46	0.23	0.22		1.23
1,1-Dichloethane	562.00		0.18			0.14			
1,1,1-Trichloethane	635.44		0.08	0.08	0.15			0.15	0.23
c-1,3-Dichlopropene	720.09		0.19						
Perchloroethylene	805.33			0.51	0.11	0.13		0.08	0.51
SUM		**2.11**	**2.35**	**2.41**	**2.40**	**2.76**	**1.95**	**1.38**	**26.15**
Isoprene & Monoterpenes									
Isoprene	504.19	1.80	0.41	1.02	0.40	0.11	0.45	0.64	0.21
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.35			2.22			0.49	0.73
Camphene + 2,6-DiMe-4-Heptanone	959.75	0.39							0.36
beta-Pinene	986.65				0.62				
Limonene	1033.82			0.11	0.24	0.09	0.23	0.13	0.67
SUM		**2.54**	**0.41**	**1.13**	**3.48**	**0.20**	**0.68**	**1.26**	**1.97**
Acetone	476.37	16.12	11.46	19.89	9.38	33.62	15.85	12.32	16.33
Methacrolein	552.82					4.87			
MEK	577.35	2.58	2.00	2.96	1.77	8.21	2.19	1.65	3.05
2-Pentanone	668.68	1.33	1.01		0.71	3.12		0.95	1.33

4-Methyl-2-Pentanone	721.82					0.63			0.39
2-Methyl-3-Pentanone	734.78	0.31			0.32	0.25		0.28	
3-Heptanone	867.95	0.28							
2-Heptanone + 3-Ethylthiophene	870.23	0.59	0.52	0.62	1.27	1.00		1.37	4.31
Cyclohexanone	870.91		0.79		0.60	1.36		0.76	1.39
2-Methyl-3-Heptanone	922.24							0.09	
2-Octanone	971.63		0.23	0.28	0.25	0.54		0.21	0.71
Acetaphenone	1048.17								
2-Nonanone	1073.92		0.37	0.21	0.21	0.47	0.25		0.49
SUM		**21.21**	**16.38**	**23.96**	**14.51**	**54.07**	**18.29**	**17.63**	**28.00**
Olefins									
Ethylene	173.78	3.59	1.21	1.40	0.95	2.43	1.64	4.89	1.75
Propylene	289.65	1.05	1.13	1.14	0.55	1.64	0.86	2.39	1.19
Butene-1	389.97	0.48	0.83	0.81	0.51	1.26	0.73	0.84	0.46
Isobutylene	390.92							0.46	0.42
1,3-Butadiene	394.58			0.09		0.11		0.52	0.11
t-Butene-2	411.64			0.10				0.13	
c-Butene-2	425.94			0.21	0.17	0.12	0.62	0.15	
3-Methyl-1-Butene	457.43	0.10	0.28	0.18		0.19	0.07		0.25
Pentene-1	489.36	0.09	0.11	0.28		0.37	0.42	0.38	
trans-2-Pentene	508.72						0.25		
cis-2-Pentene	516.35	0.14			0.07	0.08		0.07	0.11
2-Methyl-2-Butene	521.04		0.11	0.10	0.35	0.18		0.25	0.19
Hexene-1	589.36	0.21	0.14	0.35	0.19	0.41	0.13	0.44	0.39
cis-3-Hexene	602.80								
cis-2-Hexene	614.50			0.10					0.07
t-1,3-Hexadiene	621.57	0.37		0.20			0.16		
2,4-DiMethyl-1-Pentene	647.79	0.09	0.15					0.14	0.07
Cyclohexene	676.50	1.73	1.91		1.99	3.29		2.58	2.56
Heptene-1	689.22				0.32	0.24		0.42	0.48
2,4,4-TriMethyl-1-Pentene	712.30				2.79			0.94	1.02
Octene-1	789.04		0.12	0.37	0.20	0.23	0.16	0.41	0.40
3-Octene	796.71		0.13			0.19			
trans-2-Octene	803.11	2.93	0.77			0.25			
Nonene-1	889.31							0.33	

Decene-1	989.42				0.14			0.45	0.30
2-Carene	1007.00			0.26		0.06			
Undecene-1	1089.44				0.93			0.51	
SUM		**10.78**	**6.99**	**5.59**	**8.48**	**11.11**	**5.72**	**16.43**	**9.89**
Paraffins									
Ethane	200.00	3.77	5.01	5.25	7.50	3.34	4.80	6.40	8.96
Propane	300.00	7.12	7.67	3.94	6.31	3.22	3.70	4.19	9.27
Cyclopropane	341.42						1.87		
Isobutane	361.88	1.65	0.90	1.31	1.61	0.87	1.46	1.32	3.89
n-Butane	400.00	2.49	2.08	2.17	3.92	2.42	2.10	2.19	5.89
Isopentane	474.54	2.46	1.60	1.96	2.38	1.27	1.79	1.41	2.51
n-Pentane	500.00	1.02	0.87	0.92	1.45	2.02	0.82	0.74	4.11
2,2-Dimethylbutane	535.47	0.35	0.38	0.31	0.39		0.23	0.29	0.31
Cyclopentane	562.82				0.17			0.07	0.18
2,3-Dimethylbutane	565.46	0.19	0.17	0.14	0.22	0.13	0.19	0.16	0.28
2-Methylpentane	570.09	3.99	0.55	2.19	1.14	4.20	0.76	1.15	2.23
3-Methylpentane	583.52		0.52	0.78	0.30	0.48	0.66	0.56	0.84
n-Hexane	600.00	0.53	0.48	0.86	0.64	0.57	0.41	0.32	1.68
Methylcyclopentane	627.20		0.20	0.18	0.28	1.70	0.23		0.75
2,4-Dimethylpentane	631.38		0.08			0.08	0.28	0.25	0.28
2,2,3-TriMethylbutane	637.00					0.62		0.49	0.32
Cyclohexane	660.96		0.30		0.27			0.15	0.52
3-Methylhexane + 3-Pentanone	677.22			1.56			0.68		
3-EthylPentane	687.12					0.09	0.10		0.21
2,2,4-TriMethylpentane	690.72	0.49	0.40				0.56		
n-Heptane	700.00	0.44	0.20	0.31	0.35	0.42	0.45	0.26	0.72
MethylCyclohexane	724.30			0.48			0.37		0.43
2,4-DiMethylhexane	735.91			0.39		0.31	0.22		0.53
hexamethylcyclotrisiloxane	753.56	0.24	0.28	0.33	0.33	0.51	0.15	0.22	0.72
2,3-DiMethylhexane	762.98	0.34	0.31	0.39	0.24	0.91			0.56
2-Methylheptane	767.55	0.16	0.20	0.25	0.22		0.10	0.16	0.35
4-MeHeptane + 2-Hexanone	769.28					1.05			0.70
3-Methylheptane	775.34	0.11	0.09			0.11	0.09	0.08	0.22
1,1-DiMethylCyclohexane	790.50	12.02							
n-Octane	800.00	0.07	0.19	0.15	0.15	0.35	0.15	0.18	0.24
Hexamethylcyclotrisiloxane	819.44	0.66	1.00	0.73	0.45	2.00	0.28	0.41	0.25

2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98								
4,4-DiMethylheptane	829.05					0.43			0.25
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.35	0.20			0.22		0.09	0.26
3,3-DiMethylheptane	841.50				0.07				0.16
Nonane	900.00	0.20		0.31	0.31	0.47	0.31		0.32
Cyclooctane	928.80					0.35			
IsopropylCyclohexane	929.10		0.18	0.12	0.22			0.17	0.67
2,6-DiMethyloctane	937.70	0.41	0.55	0.36	0.41	1.18	0.15	0.39	1.69
3,3-DiMethyloctane	942.00				0.93	1.51	0.17	1.51	
2-Methylnonane	966.32				1.73	0.39		1.30	
3-Methylnonane	973.55	0.14					0.13		
Pinane	993.97								1.23
n-Decane	1000.00	0.21	0.26	0.18	0.20			0.15	0.60
n-Undecane	1100.00	0.16	0.17	0.30	0.22	0.09		0.09	0.62
n-Dodecane	1200.00	0.19	0.09	0.32	0.20			0.23	0.48
SUM		**39.76**	**24.93**	**26.19**	**32.61**	**31.31**	**23.21**	**24.93**	**53.23**
Phenols									
4-methylphenol		0.56	0.32	1.16	0.24	0.28	0.98	0.2	1.09
SUM		**0.56**	**0.32**	**1.16**	**0.24**	**0.28**	**0.98**	**0.2**	**1.09**
Sulfides									
Dimethylsulfide	507.3	0.4			0.17	0.2		0.17	0.12
Thiophene	655.66								
2-Methylthiopropane	662.64								
Dimethyldisulfide	729.82			0.25		0.4		0.11	0.12
MeEthyldisulfide	822.98					0.28			0.2
Methyl-sec-butyldisulfide	990.36								
SUM		**0.4**	**0**	**0.25**	**0.17**	**0.88**	**0**	**0.28**	**0.44**
Unknowns									
Unknown	266.92		0.07	0.45	0.32		0.14	0.06	0.12
Unknown	326.30	0.31	0.46					0.23	0.21
Unknown	346.30	0.15	0.17	0.25	0.23			0.33	0.35
Unknown	350.47								

Unknown	354.72						0.10	0.53	0.92
Unknown	469.37	1.76		0.88		6.23	1.65		0.33
Unknown	616.59				0.18	0.13			0.63
Unknown	655.66					1.24			
Unknown	684.41	0.07				0.07		0.09	0.08
Unknown	704.63					0.09		0.11	
Unknown	716.76	0.35	0.23			0.48			0.19
Unknown	747.75		0.52		0.24	0.59		0.22	0.26
Unknown	779.81						0.30		
Unknown	783.92		0.99	0.20		0.14			
Unknown	793.28								
Unknown	851.61							0.13	
Unknown	860.26			1.51					0.14
Unknown	894.35				0.12				0.07
Unknown	897.75					3.18		2.10	
Unknown	905.72								
Unknown	908.79								
Unknown	933.29	0.17	0.29			0.29	6.01	0.10	
Unknown	947.14	0.10			0.18	0.18	1.30		0.23
Unknown	1013.63	3.57	2.52	3.96	2.92				
Unknown	1025.79								0.19
Unknown	1027.85		0.34						0.53
Unknown	1040.81				0.27	0.16			0.40
Unknown	1062.68				0.07				0.24
Unknown	1094.62								1.59
Unknown	1137.02	0.08	0.11	0.55	0.17	0.13		0.07	0.24
Unknown	1148.05	0.11		0.20	0.15	0.17			0.14
Unknown	1153.22	4.07	0.76	0.41				0.19	
Unknown	1156.53			1.33	0.71			0.30	2.86
Unknown	1175.95	0.22				0.69			0.84
Unknown	1179.17			1.33					
Unknown	1207.53	0.18	0.18	0.46					0.21
Unknown	1215.69	0.08	0.17	0.64					0.20
Unknown	1220.30				0.26		0.27		
SUM		**11.22**	**6.81**	**12.45**	**5.82**	**14.24**	**9.92**	**4.57**	**11.14**
Total VOCs		**120.16**	**91.12**	**113.38**	**245.78**	**202.35**	**91.80**	**110.84**	**230.16**

Appendix 1 (Continued) VOCs (ppbC) detected at Barham Farm in April 2002

Canister #	**Retention**	**AQ 204***	**AQ 207***	**AQ 125***	**AQ 060***	**AQ 080***	**AQ-040***	**122**
Date	**Index #**	**4/9/02**	**4/9/02**	**4/9/02**	**4/5/02**	**4/9/02**	**4/9/02**	**4/5/02**
Time		**10:20**	**10:25**	**11:55**	**11:50**	**14:21**	**14:26**	**12:58**
Location		**boundary line**	**boundary line**	**driveway near houses**	**driveway near houses**	**downwind of fan**	**downwind of fan**	**at side fan**
Temperature (Celcius)		**22.9**	**22.9**	**24.8**	**24.8**	**26**	**26**	**12.3**
Wind Speed (m/s)		**4.7**	**4.7**	**4.8**	**4.8**	**4.2**	**4.2**	**1.2**
Alcohols								
Methanol	408.00	2.37	2.44	3.95	4.56	3.29	6.81	45.61
Ethanol	461.50	0.73	0.94	2.32	3.18	27.06	19.56	48.09
2 butanol	592.36	0.12	0.28	0.43	0.34	1.25	0.83	
n-Butanol + Thiophene	653.00	2.98	3.46	4.61	4.61	2.59	2.69	4.11
n-Propanol	556.82	.50	0.28	0.79	1.12	1.52	0.73	8.75
SUM		**6.70**	**7.40**	**12.1**	**13.81**	**35.71**	**30.62**	**106.56**
Aldehydes								
Acetaldehyde	372.25	5.73	6.24	4.56	6.38	3.64	3.27	21.95
Isobutanal	542.18							0.70
Butanal	572.72	2.97	2.43	3.39	2.38	1.99	1.37	2.61
Isopentenal	635.89						0.12	
pentanal		2.27	2.43	3.06	1.87		1.66	1.78
Hexanal	778.54	2.24	2.48	3.01	2.17	2.04	1.88	2.89
Heptanal + Styrene	881.42	1.49	2.37	3.45	1.78	1.16	1.12	1.61
Benzaldehyde	940.10			2.72		1.09		0.74
Octanal	983.98	1.41	2.86	3.17	1.53	0.73	1.09	0.98
Nonanal	1086.66	0.69	2.41	2.32	1.04	0.70	0.62	1.57

Decanal	1189.79	1.19	1.70	1.93	1.03	0.62	0.90	1.73
SUM		**15.72**	**20.49**	**24.55**	**16.31**	**11.97**	**10.37**	**34.78**
Acetylene	187.39	0.38	0.25	3.96	4.04	0.19	0.38	2.15
Propyne	328.11	0.17						0.14
SUM		**3.25**	**2.68**	**7.02**	**9.91**	**0.19**	**2.04**	**4.07**
Aromatics								
Benzene	651.21	0.53	0.40	0.60	0.57	0.38	0.46	1.90
Toluene	758.58	0.43	0.32	1.33	3.04	0.36	0.48	2.80
Ethylbenzene + 4-Heptanone	855.40		0.12		0.18		0.14	0.34
m-& p-Xylene	863.65	0.10	0.15	0.20				0.56
o-Xylene	887.56	0.41		0.59			1.95	0.32
Isopropylbenzene	920.34							0.07
Benzaldehyde	940.10	3.25	2.25		1.99		2.45	
n-Propylbenzene	950.95		0.14		0.16			0.15
m-Ethyltoluene	957.45	0.09						0.13
p-Ethyltoluene	960.02				0.24		0.26	0.38
1,3,5-TriMethylbenzene	964.32	2.40	2.53	1.32	1.61	0.76	0.89	
o-Ethyltoluene	976.97	0.23						0.18
1,2,4-TriMethylbenzene	991.48	0.55	0.43	0.37	0.43	0.18		6.83
Isobutylbenzene	1008.16	0.23	0.17	0.30	0.25	0.08	0.21	
1,2,3-TriMethylbenzene	1022.13							0.15
o-Cymene	1037.53		1.62					
1,Me-3-n-Propylbenzene	1049.14							
p-Diethylbenzene	1053.84		1.12				0.50	
n-Butylbenzene	1054.69	0.52		1.61	0.66			
1-Me-2-n-Propylbenzene	1067.27							
1,2-DiMe-4-Ethylbenzene	1084.27				0.10			
1,3-DiMe-2-Ethylbenzene	1092.85				0.50			
1,2-DiMe-3-Ethylbenzene	1107.49							0.22
1,2,4,5-Tetra-Me-Benzene	1119.01		0.43			0.60	0.45	0.42
t-1-But-3,5-DiMeBenzene	1174.77					1.21		

t-1-But-4-Ethylbenzene	1183.89		0.14		0.60		0.67	
1,3,5-TriEthylbenzene	1216.90	0.11	0.28	0.41	0.09			
SUM		**8.85**	**10.10**	**7.24**	**10.94**	**3.57**	**8.46**	**14.45**
Esters								
Propyl Acetate	697.61		0.06		0.12		0.07	0.35
SUM		**0**	**0.06**	**0**	**0.12**	**0**	**0.07**	**0.35**
Ethers								
Furan	490.750							
2-Methylfuran	594.02			0.43				1.88
3-Methylfuran + cis -3-Hexene	602.8	0.21	0.25	0.32	0.33	0.17		0.47
Tetrahydrofuran	620.74	0.34	0.40	0.73	0.46	0.54	0.38	0.47
2-Ethylfuran	690.72				0.23		0.29	
SUM		**0.55**	**0.65**	**1.48**	**1.02**	**0.71**	**0.67**	**2.82**
Halogenated Hydrocarbons								
Freon-22	304.94	0.11	0.24	0.08	0.48		0.39	
Freon-12	314.04	0.27	0.35	0.19	0.31	0.23	0.58	0.38
Methyl Chloride	339.70	0.69	0.66	0.79	0.77	0.65	0.98	1.08
Freon-114	369.43		0.16		0.20			
Ethyl Chloride	433.37	0.14	0.14		0.12	0.16		0.09
Freon-11	480.75							
Dichloromethane	518.77				0.13		0.49	0.20
Freon-113	531.54	0.23	0.21	0.34	0.25	0.22	0.29	0.25
1,1-Dichloethane	562.00							
1,1,1-Trichloethane	635.44			0.13	0.10		0.12	
c-1,3-Dichlopropene	720.09		0.12		0.10			
Perchloroethylene	805.33							
SUM		**1.44**	**1.88**	**1.57**	**2.46**	**1.26**	**2.85**	**2.00**
Isoprene & Monoterpenes								
Isoprene	504.19	0.30		0.49	0.31		0.28	1.80

alpha-Pinene + 3,6-DiMethyloctane	943.64	0.54			0.68	0.75		0.46
Camphene + 2,6-DiMe-4-Heptanone	959.75		0.39					
beta-Pinene	986.65							
Limonene	1033.82	0.33		0.15	0.17	0.12	0.11	0.30
SUM		**1.17**	**0.39**	**0.64**	**1.16**	**0.87**	**0.39**	**2.56**
Ketones								
Acetone	476.37	10.43	8.60	11.48	12.58	8.32	7.53	20.00
Methacrolein	552.82		0.08				0.19	
MEK	577.35	1.72	1.20	2.04	1.75	2.01	1.76	4.05
2-Pentanone	668.68	0.77	0.85	0.85	0.84	0.48	0.83	1.65
4-Methyl-2-Pentanone	721.82		0.23	0.48		0.57		1.08
2-Methyl-3-Pentanone	734.78				0.09			0.24
3-Heptanone	867.95						2.12	
2-Heptanone + 3-Ethylthiophene	870.23	0.85	0.52			0.58	6.20	0.50
Cyclohexanone	870.91	0.98	0.75		1.23			
2-Methyl-3-Heptanone	922.24	0.20		0.08	0.09			
2-Octanone	971.63	0.32	0.41	0.59	0.42	0.23	0.57	
Acetaphenone	1048.17			0.30				
2-Nonanone	1073.92	0.79	0.32	0.64	0.23	0.29	0.30	
SUM		**16.06**	**12.96**	**16.46**	**17.23**	**12.48**	**19.50**	**27.52**
Olefins								
Ethylene	173.78	0.53	0.18	0.35	0.20	1.06	0.60	12.39
Propylene	289.65	0.28	0.51	0.47	0.52	0.35		4.74
Butene-1	389.97	0.33	0.36	0.56	0.63	0.51	0.41	0.73
1,3-Butadiene	394.58							0.14
t-Butene-2	411.64							
3-Methyl-1-Butene	457.43							0.10
Pentene-1	489.36	0.12	0.15	0.22	0.25	0.19	0.12	0.25
cis-2-Pentene	516.35		0.07					
2-Methyl-2-Butene	521.04							0.29

Cyclopentene	551.84	0.20			0.26			
Hexene-1	589.36	0.13	0.19	0.35	0.35	0.28	0.21	0.22
cis-3-Hexene	602.80		0.17			0.23		0.47
2,4-DiMethyl-1-Pentene	647.79	0.27	0.19	0.16	0.16	0.19	0.09	0.26
Heptene-1	689.22	0.35	0.22	0.58	0.73	0.37	0.36	
2,4,4-TriMethyl-1-Pentene	712.30	0.39	0.31	0.48	0.48	0.25	0.53	
Octene-1	789.04	0.27	0.14	0.72	0.41	0.17	0.25	0.32
3-Octene	796.71				0.07	0.08		0.19
trans-2-Octene	803.11							0.29
Nonene-1	889.31				1.02	0.49		0.20
Decene-1	989.42			0.32	0.22			
Undecene-1	1089.44			1.56	0.33			
SUM		**1.87**	**2.49**	**5.77**	**5.63**	**4.17**	**2.57**	**20.52**
Paraffins								
Ethane	200.00	2.52	2.41	1.48	2.00	2.28	2.53	6.89
Propane	300.00	0.99	1.24	7.96	10.31	0.84	1.20	118.17
Isobutane	361.88	0.18	0.30	0.60	1.28	0.25	0.22	3.19
n-Butane	400.00	0.37	0.47	0.45	1.87	0.33	0.49	2.97
Isopentane	474.54	0.47	0.93	0.36	0.45	0.20	0.23	2.00
n-Pentane	500.00	0.17	0.11	0.15	0.26	0.16	0.25	2.32
2,2-Dimethylbutane	535.47							0.42
Cyclopentane	562.82							0.26
2,3-Dimethylbutane	565.46							0.24
2-Methylpentane	570.09	0.70	0.32	0.72	1.26	5.86	1.05	7.61
3-Methylpentane	583.52				0.31			0.62
n-Hexane	600.00		0.16	0.34	0.63		0.61	1.21
Methylcyclopentane	627.20			1.11	0.69			0.52
2,4-Dimethylpentane	631.38				0.20			0.08
2,2,3-TriMethylbutane	637.00	0.49		0.45	0.28			0.80
Cyclohexane	660.96				0.09			0.20
3-Methylhexane + 3-Pentanone	677.22					1.58		
3-EthylPentane	687.12	0.07						

2,2,4-TriMethylpentane	690.72		0.25					0.37
n-Heptane	700.00		0.10	0.18	0.17			0.61
2,4-DiMethylhexane	735.91							0.24
hexamethylcyclotrisiloxane	753.56		0.31			0.35		
2,3-DiMethylhexane	762.98	0.65	0.92	0.77	0.48	0.55	0.47	0.35
2-Methylheptane	767.55		0.16		0.18			
4-MeHeptane + 2-Hexanone	769.28	0.45	0.44	0.53	0.46		0.55	0.38
3-Methylheptane	775.34							0.13
n-Octane	800.00	0.08	0.15		0.14	0.16	0.19	0.57
Hexamethylcyclotrisiloxane	819.44	0.70	0.55	0.89	0.49		0.49	6.13
2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98		1.06					
4,4-DiMethylheptane	829.05	0.38	0.40	0.55	0.33		0.33	0.20
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.19	0.68		0.18		0.35	0.14
3,3-DiMethylheptane	841.50	0.10		0.33		1.57		
Nonane	900.00				0.33			0.38
Cyclooctane	928.80							0.09
IsopropylCyclohexane	929.10	0.37	0.13	0.33	0.33	0.20	0.16	
2,6-DiMethyloctane	937.70	0.55	0.36	1.11	1.07	0.35	0.77	0.50
2-Methylnonane	966.32							1.22
3-Methylnonane	973.55							0.31
n-Decane	1000.00	0.26	0.18		0.15		0.50	0.34
n-Undecane	1100.00	0.20	0.12	0.38	0.16	0.17	0.11	0.31
n-Dodecane	1200.00	0.36	0.21		0.16	0.21	0.20	0.58
SUM		**10.25**	**11.96**	**18.69**	**24.26**	**15.06**	**10.70**	**160.35**
Phenols								
4-methylphenol		0.34	0.3	0.22	0.23	0.7	0.37	1.41
SUM		**0.34**	**0.3**	**0.22**	**0.23**	**0.7**	**0.37**	**1.41**
Sulfides								
Dimethylsulfide	507.3			0.5	0.25	0.4	0.46	1.1

2-Methylthiopropane	662.64	0.16	0.07	0.15		0.16		
Dimethyldisulfide	729.82						0.29	0.76
MeEthyldis ulfide	822.98							0.3
2-Ethylthiophene	857.11			0.11				
2,5-Dimethylthiophene	862.37			0.15		0.36		
Methylisopropyldisulfide	883.39				1.58			
Dimethyltrisulfide	963.85			2.53				
Methyl-sec-butyldisulfide	990.36			0.43			0.51	
SUM		**0.16**	**0.07**	**3.87**	**1.83**	**0.92**	**1.26**	**2.16**
Unknowns								
Unknown	266.92						0.68	
Unknown	326.30							0.11
Unknown	346.30				0.14	0.30	0.15	0.25
Unknown	350.47	0.06						0.19
Unknown	354.72	0.53	0.14		0.68	0.36	0.26	
Unknown	469.37				0.43			1.55
Unknown	594.02							1.88
Unknown	704.63				0.11		0.09	0.09
Unknown	716.76	0.36	0.12	0.21	0.26	0.20	0.21	0.21
Unknown	747.75	0.41	0.20	0.57	0.30	0.38	0.25	0.43
Unknown	783.92				0.07			0.28
Unknown	793.28	0.18	5.60		0.12		0.08	
Unknown	847.21	0.18	0.10		0.21			0.20
Unknown	851.61		0.29	4.95				1.46
Unknown	870.09			4.02				
Unknown	894.35		0.19					7.97
Unknown	905.72	2.17	0.28	0.47	0.29	0.26	0.47	
Unknown	908.79							1.29
Unknown	933.29							0.10
Unknown	947.14				0.13			0.12
Unknown	1013.63	3.37	8.05		6.94	3.70	4.14	
Unknown	1027.85		0.15					

Unknown	1040.81	0.17			0.12			
Unknown	1062.68	0.13		0.12	0.30	0.10	0.27	
Unknown	1094.62	0.28						0.20
Unknown	1137.02	0.12		0.28	0.15		0.14	
Unknown	1148.05	0.12			0.23		0.07	0.20
Unknown	1153.22	0.20			0.22			2.79
Unknown	1156.53	0.60	1.19	1.27	0.63	0.51		
Unknown	1175.95	0.39	0.52	0.59			0.67	
Unknown	1207.53		0.14	0.19				
Unknown	1215.69					0.18	0.18	
Unknown	1220.30						0.82	
SUM		**9.27**	**16.97**	**12.67**	**11.33**	**5.99**	**8.48**	**19.49**
Total VOCs		**76.20**	**88.40**	**112.24**	**112.24**	**93.60**	**98.56**	**399.47**

*** Samples taken in conjunction with Duke University odor panel**
Samples selected for GC/MS analysis

Appendix 2 VOCs detected at Barham Farm in November 2002

Canister #	**Retention**	**AQ-026***	**JP-1066***	**AQ-146**	**AQ-060**	**AQ-207**	**AQ-125**
Date	**Index #**	**11/11/02**	**11/11/02**	**11/15/02**	**11/15/02**	**11/15/02**	**11/15/02**
Time		**1110**	**1148**	**615**	**1400**	**1825**	**2330**
Location		**output fan**	**downwind of fan**	**0600 diurnal lagoon**	**1200 diurnal lagoon**	**1800 diurnal lagoon**	**0000 diurnal lagoon**
Temperature (Celcius)		**20**	**20**	**4.1**	**17.8**	**13.6**	**10.5**
Wind Speed (m/s)		**4.1**	**4.1**	**0.9**	**2.5**	**0**	**0**
Alcohols							
Methanol	408.00	7.67	0.34	1.30	1.11	2.80	1.38
Ethanol	461.50	79.70	5.88	6.68	3.48	10.35	3.20
2-Butanol	592.36	5.18		0.08		0.97	0.07
n-Butanol + Thiophene	655.66	1.18	0.46	0.39	0.36	2.70	0.57
n-Propanol	556.82	0.19	0.17	0.09	0.12	0.13	0.32
SUM		**93.92**	**6.85**	**8.54**	**5.07**	**16.95**	**5.54**
Aldehydes							
Acetaldehyde	372.25	6.53	5.43	1.37	1.67	2.85	3.80
Butanal	572.72	1.74	0.37	0.42	0.79	2.28	1.38
Isopentanal	635.89			0.07			0.11
pentanal		1.09			1.54		
Hexanal	778.54	2.67			0.60	2.03	1.44
Heptanal + Styrene	881.42	1.66	0.95	0.66	0.79	2.05	1.00
Benzaldehyde	940.10						
Octanal	983.98	1.52	1.43				0.67
Nonanal	1086.66	2.45	2.60	0.27		1.19	
SUM		**19.80**	**13.18**	**3.16**	**5.39**	**11.88**	**8.40**

Alkynes							
Propyne	328.11			0.13		0.11	
SUM		**0.00**	**0.00**	**0.13**	**0.00**	**0.11**	**0.00**
Aromatics							
Benzene	651.21	0.37	0.50	1.26	0.98	0.85	0.83
Toluene	758.58	0.96	5.73	1.93	1.13	1.28	0.81
Ethylbenzene + 4-Heptanone	855.40	0.13	0.08	0.29	0.33	0.18	0.10
m-& p-Xylene	863.65	0.27	0.29	0.90		0.42	0.35
o-Xylene	887.56	1.32	0.09	0.46	0.28	0.33	0.22
Isopropylbenzene	920.34	0.31		0.08			0.16
Benzaldehyde	940.10	0.68	0.33				0.46
n-Propylbenzene	950.95	0.12	0.11	0.09	0.10	0.07	
p-Ethyltoluene	960.02	0.34					0.21
1,3,5-TriMethylbenzene	964.32	1.56				0.44	
o-Ethyltoluene	976.97	0.53		1.05	1.69	1.28	
1,2,4-TriMethylbenzene	991.48	0.79	0.48	0.59	0.38	0.43	0.27
Isobutylbenzene	1008.16	0.12				0.24	0.22
sec-Butylbenzene	1010.39		0.13				
p-Diethylbenzene	1053.84	0.58				0.09	
n-Butylbenzene	1054.69		1.34	0.23		0.23	0.24
1-Me-4-isoPropylbenzene	1059.44				0.19	0.21	
1-Me-2-n-Propylbenzene	1067.27			0.15			0.06
1,4-DiMe-2-Ethylbenzene	1075.98	0.38		0.29	0.06		
1,2-DiMe-4-Ethylbenzene	1084.27	0.06	0.09	0.08		0.09	0.07
n-Pentylbenzene	1158.21				0.09		
t-1-But-4-Ethylbenzene	1183.89				0.08	0.19	
1,3,5-TriEthylbenzene	1216.90				0.06		
SUM		**8.52**	**9.17**	**7.40**	**5.37**	**6.49**	**4.00**

Esters							
Methyl Propanate	618.54			0.07			
Methyl Pentanate	806.32			0.07			
SUM		**0**	**0**	**0.14**	**0.00**	**0.00**	**0.00**
Ethers							
Furan	490.75	0.06					
3-Methylfuran	602.80	0.14				0.47	
SUM		**0.20**	**0.00**	**0.00**	**0.00**	**0.47**	**0.00**
Halogenated Hydrocarbons							
Freon-22	304.94	0.18	0.13	0.21	0.11	0.12	
Freon-12	314.04	0.23	0.26	0.15	0.17	0.29	0.12
Methyl Chloride	339.70	0.61	0.85	0.65	0.40	0.51	0.70
Freon-142b	346.30	0.12	0.12		0.10	0.42	0.15
Freon-114	369.43			0.10			
Ethyl Chloride	433.37		0.06				0.06
Dichloromethane	518.77	0.10				0.12	0.08
Freon-113	531.54	0.15	0.16	0.14	0.14	0.24	0.23
1,1-Dichloethane	562.00				0.12	0.13	0.06
1,2-Dichloroethane	626.70		0.10			0.30	
Trichloroethylene	688.10					0.07	
p-Dichlorobenzene	1005.93	0.08					
p-Cymene	1022.93		0.12	0.36	1.11	0.30	0.12
SUM		**1.47**	**1.80**	**1.61**	**2.15**	**2.50**	**1.52**
Isoprene & Monoterpenes							
Isoprene	504.19	0.47	0.36	3.99	1.64	1.79	0.2
Camphene + 2,6-DiMe-4-Heptanone	959.75		0.25	0.60	1.42	1.78	
alpha-Pinene + 3,6-DiMethyloctane	943.64	3.31	3.79	6.76	22.29	41.05	1.76
beta-Pinene	986.65	1.23	1.49	2.61	8.85	18.50	0.63

Limonene	1033.82	0.77	0.78	3.23	8.14	3.93	0.20
SUM		**5.78**	**6.67**	**17.19**	**42.34**	**67.05**	**2.79**
Ketones							
Acetone	476.37	13.26	6.86	7.66	5.43	9.98	6.93
MEK	577.35	4.86	1.38	0.54	0.69	2.05	0.90
2-Pentanone	667.26	0.08					0.10
4-Methyl-2-Pentanone	721.82	0.55				0.33	
3-Heptanone	867.95	0.11	0.07	0.07		0.22	0.09
Cyclohexanone	870.91	0.63	0.31	0.29		0.61	0.41
2-Methyl-3-Heptanone	922.24		0.08		3.24	0.15	
3-Methyl-3-Heptanone	926.44				0.85		
3-Octanone	926.94	0.15					
2-Octanone	971.63	0.35	0.24	0.10		0.40	0.15
Acetophenone	1048.17	0.22	0.36	0.12		0.11	0.07
2-Nonanone	1073.92	0.77	0.15			0.34	
SUM		**20.98**	**9.45**	**8.78**	**10.21**	**14.19**	**8.65**
Olefins							
Ethylene	173.78	0.96	0.65	1.68	0.56	0.78	0.73
Acetylene	187.39	3.42	0.11	0.47	3.77	0.32	0.34
Propylene	289.65	0.53	0.20	0.80	0.63	0.54	0.40
Butene-1	389.97	0.44	0.64	0.38	0.27	0.35	0.20
1,3-Butadiene	394.58	0.09		0.19	0.23		
c-Butene-2	425.94	0.06		0.11	0.09		
3-Methyl-1-Butene	457.43			0.17	0.24		
Pentene-1	489.36	0.08		0.20		0.23	
2-Methyl-1-Butene	496.17	0.22		0.12	0.12	0.15	
cis-2-Pentene	516.35	0.15	0.25		0.21		
2-Methyl-2-Butene	521.04	0.18		0.08		0.12	
Cyclopentene	551.84	0.12		0.12		0.10	

Hexene-1	589.36	0.20	0.08	0.07		0.09	0.17
trans-2-Hexene	604.98		0.23	0.20			0.11
2-Methyl-2-Pentene	607.37	0.12					
cis-2-Hexene	614.50				0.17		
2,4-DiMethyl-1-Pentene	647.79		0.11	0.07	0.09	0.20	
Heptene-1	689.22	0.14			0.11		
2,4,4-TriMethyl-1-Pentene	712.30	0.13			0.06		0.09
3-&4-MethylCyclohexene	738.50		0.31				
Octene-1	789.04	0.17		0.12		0.09	4.56
trans-2-Octene	803.11	0.07					0.13
cis-2-Octene	812.37	0.07	0.14		0.16		0.90
Nonene-1	889.31		0.23				
trans-2-Nonene	902.49	0.44					
2-Carene	1007.00				0.87		
Undecene-1	1089.44			0.16			
n-Tridecene-1	1289.33		0.08		0.10	0.26	
Paraffins							
Ethane	200.00	1.74	1.60	5.20	3.85	4.14	4.37
Propane	300.00	2.02	1.37	9.62	5.94	6.58	4.33
Isobutane	361.88	0.44	0.33	1.59	0.78	0.97	0.82
n-Butane	400.00	1.06	0.78	3.95	2.11	2.36	1.99
Isopentane	474.54	0.74	0.58	2.89	1.59	1.43	1.23
n-Pentane	500.00	1.24	0.23	1.26	0.70	0.69	0.61
2,2-Dimethylbutane	535.47	0.14	0.07	0.31	0.11	0.35	0.14
Cyclopentane	562.82			0.15			
2,3-Dimethylbutane	565.46		0.09	0.19	0.25	0.15	0.12
2-Methylpentane	570.09	14.78	0.19	0.78	0.42		0.31
3-Methylpentane	583.52	0.18		0.82	0.50	0.54	0.44
n-Hexane	600.00	0.40	0.13	0.99	0.24	0.41	0.17
Methylcyclopentane	627.20	0.32		0.38	0.14		0.12

2,4-Dimethylpentane	631.38	0.19		0.17	0.23	0.14	0.23
2,2,3-TriMethylbutane	637.00	0.80			0.14	0.42	
Cyclohexane	660.96		0.09	0.09		0.17	
2-Methylhexane	668.68	1.04		0.31		0.53	
3-Methylhexane + 3-Pentanone	677.22		0.87	0.91	0.60		1.30
3-EthylPentane	687.12	0.18		0.07			
2,2,4-TriMethylpentane	690.72	0.38	0.36	0.74	0.41	0.71	0.54
n-Heptane	700.00	0.12	0.14	0.30	0.25	0.20	0.12
MethylCyclohexane	724.30		0.19	0.29			0.21
2,5-DiMethylhexane	733.56		0.13	0.17			
2,4-DiMethylhexane	735.91		0.10	0.37	0.16		0.23
3,3-DiMethylhexane	743.87						0.19
Hexamethylcyclotrisiloxane	753.56	0.53	0.20		0.20	0.36	0.18
2,3-DiMethylhexane	762.98	0.36		0.07		0.19	
2-Methyl-3-Ethylpentane	765.00		0.17				
2-Methylheptane	767.55		0.07	0.17			0.06
4-MeHeptane + 2-Hexanone	769.28					0.43	
3-Methylheptane	775.34	0.06		0.08	0.11		
n-Octane	800.00	0.22	0.07	0.10	0.18	0.11	0.06
2,3,5-TriMethylhexane	819.44	0.44	0.14	0.09	0.19	0.29	
4,4-DiMethylheptane	829.05	0.22		0.09		0.28	
1,3,5-TriMethylcyclohexane	837.00						0.13
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60			0.08		0.18	
3,3-DiMethylheptane	841.50					0.11	
3,4-DiMethylheptane	862.50				0.54		
3,3-DiEthylpentane	884.00	0.67					
Nonane	900.00	1.02	0.10	0.14	0.13	0.12	0.10
IsopropylCyclohexane	929.10	0.12	0.07	0.06			
2,6-DiMethyloctane	937.70	0.33	0.22	0.18	0.62	0.23	0.13
2,3-Dimethyloctane	958.75	0.26	0.15	0.32		0.27	0.09

2-Methylnonane	966.32		0.58	0.58	0.31	0.70	0.97
t-ButylCyclohexane	998.50				0.31		
n-Decane	1000.00	0.11	0.17	0.15		0.31	0.16
n-Undecane	1100.00		0.25	0.11		0.24	0.11
n-Dodecane	1200.00	0.20	0.22	0.14		0.17	
SUM		**30.31**	**9.73**	**33.91**	**21.01**	**23.78**	**19.46**
Phenols							
4-methylphenol		0.22	0.36	0.12	0.07	0.11	0.07
SUM		**0.22**	**0.36**	**0.12**	**0.07**	**0.11**	**0.07**
Sulfides							
DiMethylsulfide	507.30	2.12		0.28		1.02	
2-Methylthiopropane	662.64				0.09		0.13
Dimethyldisulfide	730.02	0.38					
MeEthyldisulfide	822.98			0.39			
Dimethyltetrasulfide	1220.30						0.12
SUM		**2.50**	**0.00**	**0.67**	**0.09**	**1.02**	**0.25**
Unknowns							
Unknown	266.92		0.31	0.10	0.12	0.30	
Unknown	326.30		0.07	0.08	0.14	0.15	0.06
Unknown	354.72	0.18	0.15	0.08		0.09	
Unknown	437.96			0.09			
Unknown	447.17	0.15					
Unknown	544.47				0.28		
Unknown	548.47						0.07
Unknown	557.98	3.05					
Unknown	595.81		0.23	0.10			0.12
Unknown	610.49		0.07		0.07		

Unknown	617.91					0.07	
Unknown	620.74	0.37				0.27	
Unknown	644.55		0.12	0.12	0.12		0.12
Unknown	684.41			0.06			
Unknown	710.01		0.30			0.13	
Unknown	716.76	0.17				0.20	
Unknown	726.61				0.10		0.11
Unknown	747.75	0.23				0.19	
Unknown	751.44			7.40			
Unknown	779.81		1.05	2.86			
Unknown	783.92	0.36					
Unknown	785.98		1.54			0.06	
Unknown	793.28	0.10		0.10			
Unknown	809.72			0.34			
Unknown	815.37	0.11	0.18		0.06		
Unknown	828.81		0.09				
Unknown	851.61	0.47				0.28	
Unknown	860.26			0.08			
Unknown	905.72					0.23	
Unknown	933.29		0.07	0.23	0.38	0.51	0.07
Unknown	947.14			0.07			
Unknown	1013.63	2.59				1.45	
Unknown	1062.68	0.09					
Unknown	1078.46				0.07		
Unknown	1094.62	0.30					
Unknown	1119.01	0.29	0.20	0.08		0.24	0.19
Unknown	1123.00	0.13	0.10				
Unknown	1137.02	0.13	0.10	0.10		0.09	
Unknown	1144.96			0.10			
Unknown	1148.05	0.18	0.24		0.20	0.28	
Unknown	1153.22	0.42	0.22	0.28		0.16	

Unknown	1156.53	0.79	0.57	0.20	0.13	0.23	0.49
Unknown	1175.95	0.47	0.21	0.16			0.20
Unknown	1192.06			0.56	0.78		
Unknown	1207.53					0.10	
Unknown	1210.71			0.07			
Unknown	1215.69	0.12					
Unknown	1254.24			0.06			
Unknown	1257.73	0.33		0.23			0.24
Unknown	1263.87	0.06	0.18	0.09			0.06
Unknown	1291.80	0.49					
SUM		**16.90**	**18.09**	**13.64**	**29.27**	**35.26**	**1.86**
Total VOCs		**202.94**	**66.15**	**100.32**	**100.38**	**154.35**	**60.17**

Appendix 2 (continued) VOCs detected at Barham Farm in November 2002

Canister #	**Retention**	**1862**	**1870**	**119**	**AQ-128**
Date	**Index #**	**11/21/02**	**11/21/02**	**11/21/02**	**11/21/02**
Time		**1129**	**1129**	**1145**	**1145**
Location		**output fan**	**downwind of fan**	**upwind of lagoon/houses**	**downwind lagoon/houses**
Temperature (Celcius)		**12.1**	**12.1**	**12.4**	**12.4**
Wind Speed (m/s)		**0.2**	**0.2**	**0.2**	**0.2**
Alcohols					
Methanol	408.00	27.33	0.54	1.26	1.57
Ethanol	461.50	157.09	4.32	1.68	1.78
2-Butanol	592.36	11.64	0.29	0.12	0.13
n-Butanol + Thiophene	655.66	1.57	0.47	0.5	0.43
n-Propanol	556.82	6.66	0.21		0.33
SUM		**204.29**	**5.83**	**3.56**	**4.24**
Aldehydes					
Acetaldehyde	372.25	43.47	3.24	3.35	3.52
Isobutanal	542.18	1.98	0.08		
Butanal	572.72	3.70	0.79	0.84	0.82
Isopentanal	635.89		0.11	0.08	0.42
pentanal		2.02			
Hexanal	778.54	2.81	0.82		
Heptanal + Styrene	881.42	0.94	0.61	0.45	0.42
Benzaldehyde	940.10	1.08			
Octanal	983.98	0.62	0.73		
Nonanal	1086.66	0.70	1.47		0.66

Decanal	1189.79		1.33	0.45	0.60
SUM		**57.32**	**9.18**	**5.17**	**6.44**
Alkynes					
Propyne	328.11	0.10	0.11	0.32	0.06
SUM		**0.10**	**0.11**	**0.32**	**0.06**
Aromatics					
Benzene	651.21	2.00	1.34	0.94	0.97
Toluene	758.58	3.52	3.80	1.72	3.23
Ethylbenzene + 4-Heptanone	855.40	0.44	0.37	0.30	0.27
m-& p-Xylene	863.65	2.12	0.67	0.48	0.77
o-Xylene	887.56	0.31	0.44	0.37	0.48
Isopropylbenzene	920.34			0.12	0.13
Benzaldehyde	940.10			0.20	
n-Propylbenzene	950.95	0.15	0.08	0.07	0.17
p-Ethyltoluene	960.02	0.35	0.09		
1,3,5-TriMethylbenzene	964.32			0.19	
o-Ethyltoluene	976.97	0.32	0.20	0.11	0.19
1,2,4-TriMethylbenzene	991.48	0.54	0.43	0.37	0.39
sec-Butylbenzene	1010.39				0.14
1,2,3-TriMethylbenzene	1022.13		0.69		
n-Butylbenzene	1054.69		0.25	0.27	0.22
1-Me-4-isoPropylbenzene	1059.44		0.06	0.19	
1-Me-2-n-Propylbenzene	1067.27		0.15		0.07
1,2-DiMe-4-Ethylbenzene	1084.27			0.07	0.07
1,2-DiMe-3-Ethylbenzene	1107.49	0.17			
m-DiisoPropylbenzene	1152.00	0.20			
n-Pentylbenzene	1158.21			0.18	
t-1-But-4-Ethylbenzene	1183.89	0.22	0.09		
Dodecene-1 + Naphthalene	1189.56	1.37			

1,3,5-TriEthylbenzene	1216.90		0.31	0.11	
1,2,4-TriEthylbenzene	1239.00	0.25			
n-Hexylbenzene	1261.77		0.36	0.17	
SUM		**11.96**	**9.33**	**5.97**	**7.16**
Esters					
Ethyl Propanate	696.02	0.12			
Butyl Formate	708.48	0.66			
Butyl Acetate	796.12		0.13		
Methyl Pentanate	806.32	0.30			
SUM		**1.08**	**0.13**	**0.00**	**0.00**
Ethers					
Tetrahydrofuran	619.80	0.45	0.07		0.12
3-Methylfuran	602.80				
SUM		**0.45**	**0.07**	**0.00**	**0.12**
Halogenated Hydrocarbons					
Freon-22	304.94	0.09	0.19	0.11	0.16
Freon-12	314.04	0.31	0.22	0.15	0.38
Methyl Chloride	339.70	0.72	0.57	1.01	0.75
Freon-142b	346.30	0.10	0.18	0.08	0.32
Freon-114	369.43		0.15	0.06	
Methyl Bromide	415.35		0.68		
Ethyl Chloride	433.37	0.13		0.08	
Dichloromethane	518.77	0.14	0.21	0.07	0.32
Freon-113	531.54	0.16	0.17	0.18	0.51
1,1-Dichloethane	562.00			0.11	0.07
1,2-Dichloroethane	626.70			0.25	0.27
Trichloroethylene	688.10	0.22			
Perchloroethylene	805.33		0.28	0.32	0.07

p-Dichlorobenzene	1005.93			0.10	
p-Cymene	1022.93			0.56	0.42
o-Cymene	1037.53		0.27	0.07	0.21
SUM		**1.87**	**2.92**	**3.15**	**3.48**
Isoprene & Monoterpenes					
Isoprene	504.19	0.47	0.42	0.97	0.28
Camphene + 2,6-DiMe-4-Heptanone	959.75			0.35	0.23
alpha-Pinene + 3,6-DiMethyloctane	943.64	1.28	0.73	2.77	1.66
beta-Pinene	986.65	0.42	0.30	0.74	0.54
Limonene	1033.82	0.30	0.08	1.15	0.35
SUM		**2.47**	**1.53**	**5.98**	**3.06**
Ketones					
Acetone	476.37	37.55	6.25	8.92	5.45
MEK	577.35	18.93	1.35	0.63	0.52
4-Methyl-2-Pentanone	721.82	0.58			
3-Heptanone	867.95			0.23	
Cyclohexanone	870.91	0.45	0.21		
3-Octanone	926.94	0.11			
2-Octanone	971.63	0.42			
Acetophenone	1048.17	0.48	0.07		0.10
2-Nonanone	1073.92		0.11		
SUM		**58.52**	**7.99**	**9.78**	**6.07**
Olefins					
Ethylene	173.78	0.32	1.33	1.03	1.16
Acetylene	187.39	9.6	0.74	0.52	0.58
Propylene	289.65	0.54	0.37	0.42	0.56
Butene-1	389.97	0.52		0.51	0.48
Isobutylene	390.92		0.25		

1,3-Butadiene	394.58	0.14		0.23	
c-Butene-2	425.94			0.33	
3-Methyl-1-Butene	457.43	0.07		0.21	
Pentene-1	489.36	0.65		0.12	
2-Methyl-1-Butene	496.17	0.37	0.09		0.14
2-Methyl-2-Butene	521.04	0.13		0.07	
Cyclopentene	551.84		0.13		
Hexene-1	589.36	0.32			0.29
trans-2-Hexene	604.98		0.08	0.12	
2,4-DiMethyl-1-Pentene	647.79			0.08	0.10
4-Me-1-Hexene	665.23			0.07	
2,4,4-TriMethyl-1-Pentene	712.30		0.48		
3-&4-MethylCyclohexene	738.50				0.10
2-Ethyl-1-Hexene	787.50				0.13
Octene-1	789.04	0.18		0.08	0.29
trans-2-Octene	803.11	0.81			
cis-2-Octene	812.37	0.26	0.07		
trans-3-Nonene	895.32		0.19		
Cyclooctene	903.75				0.08
cis-2-Nonene	912.37		0.16		
Undecene-1	1089.44	0.61			
n-Tridecene-1	1289.33				0.14
SUM		**14.52**	**3.89**	**3.79**	**4.05**
Paraffins					
Ethane	200.00	3.89	4.42	3.88	3.99
Propane	300.00	7.86	5.92	5.07	5.60
Isobutane	361.88	1.48	1.43	1.23	2.06
n-Butane	400.00	4.32	4.15	3.99	4.93
Isopentane	474.54	10.00	2.53	2.47	2.43
n-Pentane	500.00	5.24	1.11	1.05	1.07

2,2-Dimethylbutane	535.47	0.27	0.25	0.35	0.27
Cyclopentane	562.82	0.16			
2,3-Dimethylbutane	565.46	0.25	0.21	0.16	0.24
2-Methylpentane	570.09		0.73	0.64	0.71
3-Methylpentane	583.52	1.73	0.92	0.73	0.93
n-Hexane	600.00	6.03	0.75	0.40	0.51
Methylcyclopentane	627.20	2.41	0.29		
2,4-Dimethylpentane	631.38	0.20	0.26	0.28	0.26
Cyclohexane	660.96	0.28	0.09	0.19	0.11
2-Methylhexane	668.68	1.34	0.19	0.31	0.26
2,3-Dimethylpentane	670.80	0.09		0.42	0.43
3-Methylhexane + 3-Pentanone	677.22		0.95	0.91	0.85
3-EthylPentane	687.12		0.06		0.13
2,2,4-TriMethylpentane	690.72	0.62	0.61	0.58	0.63
n-Heptane	700.00	0.43	0.29	0.37	0.28
MethylCyclohexane	724.30		0.24	0.19	
2,4-DiMethylhexane	735.91	0.25	0.25	0.24	
3,3-DiMethylhexane	743.87	0.10	0.12	0.08	
hexamethylcyclotrisiloxane	753.56	0.61	0.18		0.26
2,3-DiMethylhexane	762.98	0.30			
2-Methyl-3-Ethylpentane	765.00			0.28	0.18
2-Methylheptane	767.55	0.34	0.20	0.21	0.14
4-MeHeptane + 2-Hexanone	769.28	0.50			
3-Methylheptane	775.34		0.10		0.09
2,2,4-TriMethylhexane	794.85			0.07	
n-Octane	800.00	0.28	0.18	0.15	0.20
2,3,5-TriMethylhexane	819.44		0.08		0.36
2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98	0.29			
4,4-DiMethylheptane	829.05	0.22			
1c2-DiMethylcyclohexane	834.70	1.75			
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.08	0.13	0.06	0.10

3-Methyloctane	873.73	0.38			
Nonane	900.00	0.65	0.27	0.23	0.14
2,2-DiMethyloctane	921.05	0.21			
Cyclooctane	928.80	0.61			
IsopropylCyclohexane	929.10		0.12		0.10
2,6-DiMethyloctane	937.70	0.60	0.29	0.16	0.12
2,3-Dimethyloctane	958.75	0.23	0.10	0.37	0.23
2-Methylnonane	966.32		0.14		0.31
3-Methylnonane	973.55		0.10	0.11	0.07
t-ButylCyclohexane	998.50		0.11		
n-Decane	1000.00	0.92	0.49	0.15	0.18
nButCycHexan	1042.20	0.18			
+ n-Undecane	1100.00	0.74	0.13	0.19	0.15
n-Dodecane	1200.00	0.11	0.12	0.11	0.12
SUM		**55.95**	**28.51**	**25.63**	**28.44**
Phenols					
4-methylphenol		1.72	0.07	0.13	0.10
SUM		**1.72**	**0.07**	**0.13**	**0.10**
Sulfides					
DiMethylsulfide	507.30	14.54	0.25	0.09	
2-Methylthiopropane	662.64		0.09	0.15	0.15
Dimethyldisulfide	730.02	0.62			
MeEthyldisulfide	822.98		0.13		
2,5-Dimethylthiophene	862.37	0.19			
Dimethyltrisulfide	963.85	0.37			
SUM		**15.72**	**0.47**	**0.24**	**0.15**
Unknowns					
Unknown	266.92		0.19	0.15	

Unknown	326.30		0.09		
Unknown	354.72	0.08	0.16		0.11
Unknown	437.96				0.10
Unknown	447.17				0.20
Unknown	469.37	0.63			
Unknown	523.25	0.28			
Unknown	595.81		0.29	0.12	0.13
Unknown	610.49				0.07
Unknown	642.02	0.33			
Unknown	644.55		0.24	0.15	
Unknown	655.66		0.47	0.50	0.43
Unknown	673.45	0.41			
Unknown	684.41	0.11	0.12	0.06	
Unknown	695.08		0.07		0.07
Unknown	708.41		0.06		
Unknown	710.01	0.68			0.12
Unknown	716.76	0.11			
Unknown	747.75	0.19			
Unknown	751.44			1.67	
Unknown	779.81			0.46	0.64
Unknown	781.70			0.12	
Unknown	783.92	0.08			
Unknown	785.98	0.06			
Unknown	796.71	0.09			0.06
Unknown	815.37	0.13			
Unknown	817.91	0.15			
Unknown	844.42	0.10	0.11		
Unknown	847.21	0.23			
Unknown	894.35		0.07	0.14	
Unknown	933.29		0.20		0.10
Unknown	995.10	0.08			

Unknown	1013.63	0.69			
Unknown	1025.79	0.17			
Unknown	1040.81	0.10			
Unknown	1062.68	0.07			
Unknown	1119.01	0.86	0.11		0.15
Unknown	1123.00			0.20	
Unknown	1128.86	0.55		0.08	
Unknown	1134.17			0.18	
Unknown	1137.02	0.31		0.07	
Unknown	1144.96			0.14	
Unknown	1148.05	0.19		0.16	0.09
Unknown	1153.22		0.11	0.08	0.27
Unknown	1156.53		0.24		
Unknown	1175.95	1.18	0.08	0.16	0.08
Unknown	1179.17	0.06			
Unknown	1207.53	0.25			
Unknown	1210.71			0.10	
Unknown	1215.69	0.22			
Unknown	1243.93		0.19		
Unknown	1254.24	0.72			
Unknown	1263.87			0.37	0.06
Unknown	1272.12	0.24			
Unknown	1275.66	0.74			
Unknown	1284.89		0.06		
Unknown	1291.80	0.89	0.22		
SUM		**11.05**	**3.22**	**5.05**	**2.68**
Total VOCs		**437.43**	**73.25**	**68.77**	**66.05**

***samples taken in conjunction with Duke University odor panel**
Samples selected for GC/MS analysis

Appendix 3 VOCs (ppbC) detected at Grinnells Laboratories in April 2002

Canister #		**AQ-211***	**AQ-048***	**AQ-022***	**AQ-105**	**AQ-171***	**AQ-026**
Date		**4/23/02**	**4/16/02**	**4/16/02**	**4/23/02**	**4/16/02**	**4/16/02**
Time (EST)		**1105**	**958**	**950**	**943**	**1005**	**1237**
Location		**~12 m in front of bldg**	**~10 m upwind of fan**	**~10 m downwind of fan**	**Directly in front of fan**	**Directly in front of fan**	**Inside laboratory housing area**
Temperature (Celcius)							
Alcohols							
Methanol	408.00	4.06	9.42	6.85	5.84	32.73	32.61
Ethanol	461.50	1.88	1.61	1.61	5.96	7.16	96.98
2-Butanol	592.36	0.13		0.16		0.27	2.55
n-Butanol + Thiophene	653.00	3.57		7.74		3.34	11.46
n-Propanol		.40	0.63			0.83	12.70
n-Pentanol				1.52			1.98
SUM		**10.04**	**11.66**	**17.88**	**11.80**	**44.33**	**158.28**
Aldehydes							
Acetaldehyde	372.25	4.57	4.87	2.59	0.10	8.68	13.45
Isobutanal	542.18					1.72	0.92
Butanal	572.72	2.81	1.81	1.91	0.77	5.00	2.76
Isopentanal	635.89	0.1	0.14	0.13		0.25	1.19
Pentanal	675.78	2.43	1.86	1.97		4.58	3.81
Hexanal	778.54	2.07	1.62	1.95	1.57	1.91	7.19
Heptanal + Styrene	881.42	1.21	1.47	2.06	1.21	1.10	4.20
Octanal	983.98	0.47	1.27	3.45	2.12	0.41	3.99
Nonanal	1086.66		1.28	2.35	4.70	0.30	1.73
Decanal	1189.79	0.91	1.59	3.91	9.16		0.80

SUM		**14.57**	**15.91**	**20.32**	**19.63**	**23.95**	**40.04**
Alkynes							
Propyne	328.11	0.14	0.24	0.11			
SUM		**0.14**	**0.24**	**0.11**	**0.00**	**0.00**	**0.00**
Aromatics							
Benzene	651.21	1.00	2.06	1.65	0.79	2.18	2.55
Toluene	758.58	1.25	3.81	3.69	13.04	7.52	6.66
Ethylbenzene + 4-Heptanone	855.40	0.30	0.66	0.85	0.40	1.15	1.78
m-& p-Xylene + MeEthyl Disulfide	863.65	0.52	1.76	2.54	0.91	2.97	5.93
o-Xylene	887.56	0.26	0.78				3.57
Isopropylbenzene	920.34		0.09	0.31			0.69
n-Propylbenzene	950.95	0.10			0.16	0.15	1.53
m-Ethyltoluene	957.45	0.29	0.61	1.31	0.35	0.65	2.64
p-Ethyltoluene	960.02	0.30	0.37	0.83	0.33	0.56	1.21
1,3,5-TriMethylbenzene	964.32		2.85	3.55	18.16	0.84	5.93
o-Ethyltoluene	976.97	0.18	0.42	0.64	0.26	0.45	0.95
1,2,4-TriMethylbenzene	991.48	0.51	1.14	2.22	0.52	1.24	3.86
Isobutylbenzene	1008.16	0.07		0.61		0.31	0.31
sec-Butylbenzene	1010.39						0.18
m-Cymene	1018.22					0.32	1.00
1,2,3-TriMethylbenzene	1022.13	0.14	0.48	0.87		0.58	1.54
o-Cymene	1037.53	0.39			0.14		0.90
m-Diethylbenzene	1046.57					0.13	0.26
1,Me-3-n-Propylbenzene	1049.14	0.16	0.40				0.76
p-Diethylbenzene	1053.84						
n-Butylbenzene	1054.69		0.64		0.88		
1-Me-4-isoPropylbenzene	1059.44	0.12	0.07	0.36			1.46
1-Me-2-n-Propylbenzene	1067.27	0.08	0.17	0.82		0.38	
1,4-DiMe-2-Ethylbenzene	1075.98	0.11	0.34	0.43	0.35		

1,2-DiMe-4-Ethylbenzene	1084.27	0.09	0.21	0.80	0.08	0.14	0.83
1,2-DiMe-3-Ethylbenzene	1107.49		0.15	0.22	0.12		0.52
1,2,4,5-Tetra-Me-Benzene	1119.01	0.09	0.30	1.03	0.46	0.48	0.70
n-Pentylbenzene	1158.21	0.35					
1,2,4-TriChlorobenzene	1181.85		0.49				
t-1-But-4-Ethylbenzene	1183.89			0.21			
Dodecene-1 + Naphthalene	1189.56					2.54	1.59
1,3,5-TriEthylbenzene	1216.90		0.23				
SUM		**6.31**	**18.03**	**24.30**	**37.11**	**22.59**	**48.22**
Esters							
Ethyl Propanate	696.02						0.08
Methyl Butanate	706.79						0.18
Butyl Acetate	796.12					0.10	
SUM		**0**	**0**	**0**	**0**	**0.10**	**0.26**
Ethers							
Tetrahydrofuran	619.80			1.03			1.43
SUM		**0.00**	**0.00**	**1.03**	**0.00**	**0.00**	**1.43**
Halogenated Hydrocarbons							
Freon-22	304.94	0.32		0.40	0.44	0.92	663.05
Freon-12	314.04	0.21		0.14	0.20		
Methyl Chloride	339.70	0.55		0.69	0.57	0.66	
Freon-142b	346.30	0.11			0.73	0.77	
Freon-114	369.43	0.09	0.38				
Freon-11	480.75					2.58	
Dichloromethane	518.77	0.09	0.08	0.08	0.17	2.91	0.85
Freon-113	531.54	0.22		0.31	0.19	1.94	0.72
Trichloroethylene	688.10	0.12			0.60		
Perchloroethylene	805.33		0.08	0.15	0.21	0.18	0.14

p-Dichlorobenzene	1005.93		0.27				0.28
o-Dichlorobenzene	1031.59				0.07	0.24	
SUM		**1.71**	**0.81**	**1.77**	**3.29**	**10.20**	**665.04**
Isoprene & Monoterpenes							
Isoprene	504.19	1.60	4.64	0.98	3.49	0.67	0.89
alpha-Pinene + 3,6-DiMethyloctane	943.64	1.94	2.13	1.39	0.45	1.00	3.3
beta-Pinene	986.65	0.54	0.65		0.19	0.43	
Limonene	1033.82	0.15	0.16	0.29	0.19	1.73	1.04
SUM		**4.23**	**7.58**	**2.66**	**4.32**	**3.83**	**5.23**
Ketones							
Acetone	476.37	12.23	13.68	12.34	13.31	20.17	23.95
Methacrolein	552.82	0.10					
MEK	577.35	1.81	1.35	1.68	0.64	3.80	7.60
2-Pentanone	667.26		0.13				
3,3-Dimethyl-2-Butanone	692.82			0.11			0.10
4-Methyl-2-Pentanone	721.82						2.01
Cyclopentanone	780.46					0.43	
3-Heptanone	867.95	1.05	0.30	1.44	0.07	3.00	3.33
2-Heptanone	870.23			1.69	0.67		
Cyclohexanone	870.91	0.81	0.67			1.27	1.40
2-Methyl-3-Heptanone	922.24	0.11					
2-Octanone	971.63	0.35		1.62		0.83	
Acetophenone	1048.17			1.35		0.63	
2-Nonanone	1073.92			1.13			
SUM		**16.46**	**16.13**	**21.36**	**14.69**	**30.13**	**38.39**
Olefins							
Ethylene	173.78	1.22	3.16	2.11	0.84	2.04	2.45
Acetylene	187.39	0.96	2.16	1.68	0.91	1.91	2.96

Propylene	289.65	0.64		1.16	0.26	1.69	5.27
Butene-1	389.97	1.09	1.18	0.84	0.23	1.33	1.43
1,3-Butadiene	394.58		0.46	0.22		0.21	0.29
c-Butene-2	425.94	0.32	0.32	0.32		0.33	0.80
3-Methyl-1-Butene	457.43	0.23	0.19	0.17	0.26		0.25
Pentene-1	489.36	0.60	0.32	1.16			
2-Methyl-1-Butene	496.17	0.31	0.36	0.35	0.13	0.23	5.22
trans-2-Pentene	508.72		0.30	0.26	0.12		0.81
cis-2-Pentene	516.35	0.08	0.18	0.15	0.09	0.16	0.45
2-Methyl-2-Butene	521.04		0.45	0.30	0.14	0.30	1.51
Cyclopentene	551.84		0.12	0.10		0.14	0.19
3-Methyl-1-pentene	557.98						
Hexene-1	589.36	0.25	0.25	0.38	0.07	0.26	0.55
cis-3-Hexene + 3-MeFuran	602.80		0.23			0.40	
trans-2-Hexene	604.98		0.10	0.11			0.27
2-Methyl-2-Pentene	607.37	0.09	0.10	0.13	0.07	0.09	0.26
cis-2-Hexene	614.50		0.09	0.09			1.95
t-1,3-Hexadiene	621.57				0.16		
2,4-DiMethyl-1-Pentene	647.79	0.21	0.13	0.14	0.40	0.18	
Heptene-1	689.22	0.23				0.29	
trans-3-Heptene	697.82			0.10			0.14
2,4,4-TriMethyl-1-Pentene	712.30	1.50	0.41	1.11		1.22	1.52
Octene-1	789.04		0.17	0.26	0.12	0.37	0.48
trans-2-Octene	803.11						0.30
cis-2-Octene	812.37						0.17
Nonene-1	889.31	0.24					
trans-2-Nonene	902.49			4.03		2.05	
cis-2-Nonene	912.37	0.11					
Decene-1	989.42	0.16		0.19		0.18	0.27
2-Carene	1007.00				0.32		
Undecene-1	1089.44	0.45		0.50		0.17	1.38

SUM		**8.69**	**10.68**	**16.03**	**4.12**	**13.55**	**28.92**
Paraffins							
Ethane	200.00	4.65	2.31	2.19	3.07	10.87	4.50
Propane	300.00	2.87	1.94	2.09	1.89	8.85	
Cyclopropane	341.42		0.82				
Isobutane	361.88	0.75	1.18	0.99	0.91	4.17	2.97
n-Butane	400.00	1.64	4.37	3.53	1.14	5.61	8.04
Isopentane	474.54	1.96	5.64	4.65	1.96	4.19	8.52
n-Pentane	500.00	0.69	1.69	1.70	0.90	4.47	15.37
2,2-Dimethylbutane	535.47	0.14	0.51	0.55	0.26	0.55	1.28
Cyclopentane	562.82		0.25	0.17	0.11	0.24	0.44
2,3-Dimethylbutane	565.46	0.15	0.54	0.56	0.25	0.59	1.71
2-Methylpentane	570.09	1.75	3.18	3.04	0.81	3.18	15.57
3-Methylpentane	583.52	0.60	1.01	1.08	0.62	1.49	4.14
n-Hexane	600.00	0.29	0.70	0.76	0.71	1.98	7.64
2,2-DiMethylpentane	625.13				0.06		0.08
Methylcyclopentane	627.20		0.49	0.74	0.39	1.26	1.93
2,4-Dimethylpentane	631.38		0.23	0.31	0.16	0.39	0.48
2,2,3-TriMethylbutane	637.00	0.34	0.30	0.21		0.26	
Cyclohexane	660.96	0.12	0.15	0.28	0.17	1.34	0.72
2-Methylhexane	668.68	0.83	1.01	1.35	0.80	1.66	1.83
2,3-Dimethylpentane	670.80		0.38	0.35		0.46	0.59
3-Methylhexane + 3-Pentanone	677.22				0.95		
3-EthylPentane	687.12		0.12	0.23		0.26	0.40
n-Heptane	700.00	0.19	0.40	0.57	0.28	1.38	1.46
MethylCyclohexane	724.30		0.30	0.25	0.40	1.17	1.14
2,5-DiMethylhexane	733.56	0.08	0.10	0.12		0.16	0.38
2,4-DiMethylhexane	735.91		0.30	0.24	0.16	0.74	0.67
3,3-DiMethylhexane	743.87	0.22	0.13	0.09		0.24	0.15
Hexamethylcyclotrisiloxane	753.56	0.32	0.54		0.28	0.70	

2,3-DiMethylhexane	762.98	0.28	0.39	0.63	0.62	1.62	0.59
2-Methylheptane	767.55	0.21	0.21	0.25	0.23	0.58	0.78
4-MeHeptane + 2-Hexanone	769.28		0.40	0.73		0.83	0.65
3,4-DiMethylhexane	772.50						0.08
3-Methylheptane	775.34	0.07	0.22	0.17		0.30	0.65
3-Ethylhexane	777.10				0.09		
2,2,4-TriMethylhexane	794.85						0.09
n-Octane	800.00	0.40	0.25	0.27	0.22	0.47	1.49
2,3,5-TriMethylhexane	819.44		1.50	0.89	0.21	0.30	1.16
2,4-DiMethylheptane	825.88					0.09	0.23
4,4-DiMethylheptane	829.05	0.31	0.35	0.40		0.32	0.28
2,6-DiMethylheptane	831.77						0.32
1c2-DiMethylcyclohexane	834.70						0.15
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60		0.11	0.20	0.29	0.35	0.82
2-Methyloctane	866.98						
3-Methyloctane	873.73		0.14	0.15		0.31	1.03
Nonane	900.00	0.14	0.21	0.31	0.26	0.69	3.84
2,2-DiMethyloctane	921.05				0.94		
Cyclooctane	928.80		0.10	0.46			
IsopropylCyclohexane	929.10	0.20			0.16	0.29	8.49
2,6-DiMethyloctane	937.70	0.63				1.18	2.18
3,3-DiMethyloctane	942.00	1.85					
2-Methylnonane	966.32	1.39					
3-Methylnonane	973.55				0.75		1.28
Indane	1036.98		0.21	0.77		0.18	
nButCycHexan	1042.20					0.23	1.22
n-Undecane	1100.00	0.21	0.32	0.62	0.33	0.83	5.02
n-Dodecane	1200.00	0.24	0.20	0.34	0.19	0.79	2.53
SUM		**24.11**	**34.85**	**34.23**	**21.36**	**67.49**	**121.25**

Phenols

4-methylphenol		0.4	0	3.91	0.15	0.58	1.9
SUM		**0.4**	**0**	**3.91**	**0.15**	**0.58**	**1.9**
Sulfides							
Dimethyl Sulfide	507.36			0.26		0.23	0.30
2-Methylthiopropane	662.64	0.18					
Dimethyldisulfide	730.02	0.57		0.17		0.12	1.57
MeEthyldisulfide	822.98					0.19	
Dimethyl Tetrasulfide	1220.30						
SUM		**0.75**	**0**	**0.43**	**0**	**0.54**	**1.87**
Unknowns							
Unknown	266.92	0.21	0.09		0.25	0.56	
Unknown	323.07						
Unknown	326.30	0.07		0.07		0.16	
Unknown	350.47	0.06			0.08		
Unknown	354.72	0.39	0.34			0.31	0.12
Unknown	441.29		0.58				
Unknown	469.37	0.75	0.79			2.46	0.61
Unknown	532.24		0.39				
Unknown	602.24			0.30			0.67
Unknown	610.49		0.11	0.10			0.12
Unknown	616.59	0.10				0.96	
Unknown	617.91		0.13		0.16		
Unknown	620.74	0.66	0.57			0.88	
Unknown	642.02						0.46
Unknown	644.55				0.12		
Unknown	673.45						0.36
Unknown	684.41		0.20	0.14	0.10	0.14	0.22
Unknown	704.63	0.11	0.06				0.10
Unknown	716.76	0.37	0.20	0.22		0.16	0.35

Unknown	729.03	0.57	0.08	0.17		0.12	1.57
Unknown	747.75	0.51	0.25	0.28		0.27	0.19
Unknown	781.70						0.62
Unknown	783.92			0.24	0.09	0.06	0.33
Unknown	785.98		0.08			0.11	0.16
Unknown	796.71						0.10
Unknown	815.37						0.10
Unknown	844.42						0.32
Unknown	847.21	0.08	0.13	0.06	0.19	0.15	0.25
Unknown	851.61			0.91			1.00
Unknown	860.26					0.20	0.55
Unknown	894.35	0.07				0.18	0.46
Unknown	905.72				2.80	0.23	
Unknown	910.70				0.99		
Unknown	923.10				0.18		
Unknown	933.29	0.06					
Unknown	936.33			1.60	0.46		
Unknown	971.22						0.61
Unknown	995.10						0.29
Unknown	1013.63		3.56	6.17	0.83		10.91
Unknown	1025.79			0.27	0.11	0.22	1.26
Unknown	1027.85			0.30			
Unknown	1040.81		0.08	0.29	0.09		
Unknown	1062.68	0.10	0.10	0.33		0.25	1.49
Unknown	1073.24				2.58		1.82
Unknown	1078.46		0.10	0.39			0.47
Unknown	1094.62		0.53				
Unknown	1123.00		0.17	0.29			0.38
Unknown	1125.95						0.18
Unknown	1128.86			0.07			
Unknown	1137.02		0.12	0.54	0.18	0.13	0.30

Unknown	1144.96			0.16			
Unknown	1148.05		0.24	0.44	0.11	0.16	0.60
Unknown	1153.22	0.10	0.24			0.34	1.38
Unknown	1156.53		0.70			0.57	1.49
Unknown	1161.98		0.07	0.18	0.09		0.56
Unknown	1164.70			0.15			
Unknown	1168.51			0.24			0.31
Unknown	1172.96			0.71			0.37
Unknown	1175.95		0.51	1.03	0.35		0.53
Unknown	1179.17			0.36			
Unknown	1204.30		1.44				
Unknown	1207.53			0.31			
Unknown	1210.71						0.08
Unknown	1215.69			0.39	0.14		0.28
Unknown	1232.94						
Unknown	1249.88						0.20
Unknown	1257.73	0.17					
SUM		**4.83**	**18.09**	**18.34**	**25.04**	**10.92**	**34.43**
TOTAL VOCs		**81.32**	**116.16**	**148.22**	**116.10**	**206.65**	**1104.66**

***samples taken in conjunction with Duke University odor panel**
Samples selected for GC/MS analysis

Appendix 4 VOCs (ppbC) detected at Grinnells Laboratories in November 2002

Canister #	**Retention**	**AQ-022***	**2017**	**AQ-040**	**AQ-204***
Date	**Index #**	**11/4/02**	**11/4/02**	**11/4/02**	**11/4/02**
Time		**1045**	**1045**	**1140**	**1140**
Location		**Upwind SW corner of bldg**	**Directly in front of fan**	**Downwind SW corner of house variable wind**	**Upwind ~5 yd from fan**
Temperature (Celcius)					
Alcohols					
Methanol	408.00	1.84	13.97	2.16	1.49
Ethanol	461.50	1.14	111.88	2.07	2.55
2-Butanol			3.51	0.06	
n-Butanol + Styrene	653.00	0.62	11.27	0.48	0.72
n-Propanol	555.00	0.15	23.46	0.13	0.14
SUM		**3.75**	**164.09**	**4.90**	**4.90**
Aldehydes					
Acetaldehyde	372.25	1.54	11.11	2.31	2.08
Isobutanal	542.18				
Butanal	572.72	0.80	0.93	0.46	0.79
Isopentanal	635.89				
pentaal		1.64			
Heptanal + Styrene	881.42	1.03	1.50		0.68
Octanal	983.98	1.50	1.01		0.40
Nonanal	1086.66	2.33	1.60		0.25
Decanal	1189.79	2.62	0.61		
SUM		**10.46**	**16.76**	**2.77**	**4.20**

Alkynes					
Acetylene	187.39	1.06	3.16	0.58	0.64
Propyne	328.11	0.12	0.19	0.21	0.15
SUM		**1.18**	**3.35**	**0.79**	**0.79**
Aromatics					
Benzene	651.21	1.78	1.84	2.07	1.70
Toluene	758.58	2.85	3.04	3.37	2.99
Ethylbenzene + 4-Heptanone	855.40	0.55	0.99	0.63	1.48
m-& p-Xylene	863.65	1.28	3.07	1.81	
o-Xylene	887.56	0.76	1.47	0.80	0.75
Isopropylbenzene	920.34		0.10		0.20
n-Propylbenzene	950.95	0.47	0.19	0.34	0.16
m-Ethyltoluene	957.45	0.60	5.41	0.59	0.51
p-Ethyltoluene	960.02	0.43		0.39	0.31
1,3,5-TriMethylbenzene	964.32	1.44	0.99	1.77	1.16
o-Ethyltoluene	976.97	0.39	0.78	0.35	0.32
1,2,4-TriMethylbenzene	991.48	0.90	1.43	1.14	0.87
Isobutylbenzene	1008.16		0.10		
m-Cymene	1018.22		0.43		
1,2,3-TriMethylbenzene	1022.13	0.25	0.49	0.27	0.38
o-Dichlorobenzene	1031.59			0.09	0.11
o-Cymene	1037.53	0.49	0.31		
p-Diethylbenzene	1053.84	1.22			
n-Butylbenzene	1054.69			1.44	1.17
1-Me-2-n-Propylbenzene	1067.27	0.47	0.70	0.40	
1,4-DiMe-2-Ethylbenzene	1075.98			0.12	0.14
1,2-DiMe-4-Ethylbenzene	1084.27	0.51	0.23	0.14	0.10
1,2-DiMe-3-Ethylbenzene	1107.49		0.14		
1,2,4-TriChlorobenzene	1181.85		0.09		

t-1-But-4-Ethylbenzene	1183.89			0.10	
SUM		**14.39**	**21.80**	**15.82**	**12.35**
Esters					
Methyl Propanate	618.54			0.12	0.07
Ethyl Propanate	696.02		0.07		
Methyl Butanate	706.79		0.18		
Propyl Propanate	791.77		2.39		0.11
Methyl Pentanate	806.32		0.23		
SUM		**0**	**2.87**	**0.12**	**0.18**
Halogenated Hydrocarbons					
Freon-22	304.94	0.14	65.64	0.34	0.50
Methyl Chloride	339.70	0.72	0.75	0.57	0.53
Freon-142b	346.30	0.10	0.23	0.13	0.06
Dichloromethane	518.77		0.08		0.07
Freon-113	531.54	0.29	0.26		0.23
1,1-Dichloethane	562.00	0.19	0.29		0.13
1,2-Dichloroethane	626.70				0.37
1,1,1-Trichloethane	635.44	0.11		0.28	0.11
Perchloroethylene	805.33			0.15	0.19
SUM		**1.55**	**67.25**	**1.46**	**2.19**
Isoprene & Monoterpenes					
Isoprene	504.19	1.19	0.66	1.94	1.00
alpha-Pinene + 3,6-DiMethyloctane	943.64	1.27	1.50	1.52	1.26
beta-Pinene	986.65	0.65	0.53	0.58	0.41
Limonene	1033.82	0.36	0.22	0.24	0.36
SUM		**3.47**	**2.91**	**4.28**	**3.03**
Ketones					

Acetone	476.37	7.55	20.28	8.56	7.41
MEK	577.35	0.72	8.72	0.69	0.74
4-Methyl-2-Pentanone	721.82		2.01		
2,4-Dimethyl-3-Pentanone	762.30			0.08	
3-Heptanone	867.95			0.16	
2-Heptanone	870.23	1.24			
Cyclohexanone	870.91		0.43	0.21	
2-Octanone	971.63	0.77			
2-Nonanone	1073.92	1.00			
SUM		**11.28**	**31.44**	**9.70**	**8.15**
Olefins					
Ethylene	173.78	1.72	0.54	1.86	1.93
Propylene	289.65	0.96	1.07	1.28	1.27
Butene-1	389.97	0.71	0.95	0.85	0.90
1,3-Butadiene	394.58	0.36	0.28	0.28	0.28
c-Butene-2	425.94	0.17	0.12	0.14	0.09
3-Methyl-1-Butene	457.43	0.34	0.08	0.18	0.19
Pentene-1	489.36	0.08	0.14	0.13	0.09
2-Methyl-1-Butene	496.17	0.22	0.42	0.26	0.22
trans-2-Pentene	508.72	0.15	0.19	0.27	0.26
cis-2-Pentene	516.35	0.15	0.13	0.14	0.15
2-Methyl-2-Butene	521.04	0.28	0.28	0.26	0.28
Cyclopentene	551.84	0.15	0.14	0.12	0.07
Hexene-1	589.36	0.21		0.22	
trans-2-Hexene	604.98	0.10		0.17	0.16
2-Methyl-2-Pentene	607.37	0.09	0.12	0.15	
cis-2-Hexene	614.50	0.06		0.09	0.10
2,4-DiMethyl-1-Pentene	647.79	0.07			0.07
2,4,4-TriMethyl-1-Pentene	712.30	0.07		0.15	0.10

3-&4-MethylCyclohexene	738.50				
4-Methyl-3-Penten-2-one	778.69	0.88	5.86		
Octene-1	789.04		0.40	0.15	0.10
trans-2-Octene	803.11		0.29		
cis-2-Octene	812.37	0.09	0.38		
2-Carene	1007.00			0.09	
n-Tridecene-1	1289.33				0.07
SUM		**6.86**	**11.39**	**6.79**	**6.33**
Paraffins					
Ethane	200.00	4.62	4.29	4.75	5.10
Propane	300.00	7.55	7.52	10.04	9.60
Isobutane	361.88	1.27	1.94	1.60	1.34
n-Butane	400.00	4.46	4.41	5.22	4.65
Isopentane	474.54	3.89	3.36	4.42	3.95
n-Pentane	500.00	1.54	4.45	1.74	1.49
2,2-Dimethylbutane	535.47	0.30	0.86	0.27	0.33
Cyclopentane	562.82			0.21	
2,3-Dimethylbutane	565.46	0.38	1.79	0.41	0.32
2-Methylpentane	570.09	1.17	16.25	1.53	1.27
3-Methylpentane	583.52	0.87	8.98	1.02	0.82
n-Hexane	600.00	0.65	0.89	0.74	0.74
Methylcyclopentane	627.20	0.36	0.47	0.44	
2,4-Dimethylpentane	631.38	0.27	0.30	0.22	0.29
2,2,3-TriMethylbutane	637.00		1.20		
Cyclohexane	660.96	0.19	0.40	0.21	0.19
2-Methylhexane	668.68	0.63	1.14	0.44	0.44
2,3-Dimethylpentane	670.80	0.18	0.36	0.51	0.42
3-Methylhexane + 3-Pentanone	677.22	1.23		1.10	1.12
3-EthylPentane	687.12	0.17	0.10	0.12	0.09
2,2,4-TriMethylpentane	690.72	1.18	0.92	1.32	1.35

n-Heptane	700.00	0.48		0.34	0.38
MethylCyclohexane	724.30	0.53		0.33	0.35
2,5-DiMethylhexane	733.56	0.15	0.10	0.14	0.09
2,4-DiMethylhexane	735.91	0.33	0.19	0.29	0.40
3,3-DiMethylhexane	743.87	0.11			0.13
Hexamethylcyclotrisiloxe	753.56	0.69	2.69	0.52	0.53
2,3-DiMethylhexane	762.98	0.33	0.18		0.18
2-Methyl-3-Ethylpentane	765.00			0.08	0.24
2-Methylheptane	767.55	0.21	0.14	0.18	0.20
4-MeHeptane + 2-Hexanone	769.28	0.39			
3-Methylheptane	775.34	0.10	0.17	0.18	0.15
n-Octane	800.00	0.22	0.30	0.21	0.16
2,3,5-TriMethylhexane	819.44		0.15	0.22	0.36
2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98		0.27		
2,4-DiMethylheptane	825.88			0.09	
4,4-DiMethylheptane	829.05	0.29			
1c2-DiMethylcyclohexane	834.70	0.11	0.07		
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.15	0.11	0.12	
3-Methyloctane	873.73	0.09	0.11	0.12	0.10
Nonane	900.00	0.33	0.35	0.69	0.15
4,4-DiMethyloctane	925.00				0.08
3,5-DiMethyloctane	927.97	7.21			
Cyclooctane	928.80				0.08
IsopropylCyclohexane	929.10		0.22	0.06	
2,6-DiMethyloctane	937.70		0.46	0.19	0.15
3,3-DiMethyloctane	942.00	0.17	1.01	0.21	0.30
3-Methylnonane	973.55		0.13	0.08	
n-Decane	1000.00	0.23	0.79	0.17	0.22
nButCycHexan	1042.20		0.31		0.08
+ n-Undecane	1100.00	0.27	0.87	0.20	0.16
n-Dodecane	1200.00	0.47	0.40	0.29	0.23

SUM		**43.77**	**68.65**	**41.02**	**38.23**
Phenols					
4-Methylphenol	1049.14	0.23	1.98	0.16	0.76
SUM		**0.23**	**1.98**	**0.16**	**0.76**
Sulfides					
DiMethylsulfide	507.30		0.54		
DiMethyldisulfide	729.82		0.65		
MeEthyldisulfide	822.98	0.32			
Mepropyldisulfide	916.10			1.88	
SUM		**0.32**	**1.19**	**1.88**	**0**
Unknowns					
Unknown	266.92		0.17	0.29	
Unknown	323.07				0.07
Unknown	326.30	0.10	0.13	0.19	0.09
Unknown	354.72	0.06	0.07		0.22
Unknown	441.29		0.13		
Unknown	513.67			0.08	0.08
Unknown	532.24			0.42	
Unknown	602.24		0.56		
Unknown	610.49			0.08	
Unknown	620.74	0.24	1.07		
Unknown	644.55			0.23	0.09
Unknown	684.41	0.12	0.10	0.11	0.10
Unknown	704.63			0.14	
Unknown	716.76	0.21	0.31	0.07	
Unknown	747.75	0.13	0.14		
Unknown	779.81			0.66	0.71
Unknown	783.92		0.73	0.06	

Unknown	785.98	0.14		0.12	0.12
Unknown	793.28			0.11	
Unknown	796.71		0.39		
Unknown	844.42	0.20	0.06		
Unknown	860.26	0.07	0.19		
Unknown	894.35		0.20		
Unknown	933.29	0.35	0.10	0.08	0.07
Unknown	936.33	1.64			
Unknown	947.14	0.07	0.13	0.34	
Unknown	988.06	0.44			
Unknown	1013.63	0.79	0.88		
Unknown	1025.79		0.20		
Unknown	1036.98			0.24	
Unknown	1040.81	0.35			
Unknown	1062.68		0.20		
Unknown	1073.24		1.35		
Unknown	1078.46		0.12	0.11	0.09
Unknown	1119.01	1.26	0.41	0.13	0.07
Unknown	1123.00	0.11	0.24	0.15	
Unknown	1128.86	0.27			
Unknown	1134.17			0.19	
Unknown	1137.02	0.94	0.22		
Unknown	1144.96		0.11	0.13	
Unknown	1148.05	0.54	0.25	0.27	0.13
Unknown	1153.22	0.75	0.55		0.09
Unknown	1156.53			1.23	
Unknown	1164.70	0.43			
Unknown	1168.51	0.22			
Unknown	1172.96	0.52	0.17		
Unknown	1175.95	1.52	0.32	0.33	0.13
Unknown	1179.17	0.55			

Unknown	1192.06		0.41	1.11	0.96
Unknown	1207.53	0.28	0.06		
Unknown	1215.69	0.66	0.21		
Unknown	1254.24	0.51	0.38		
Unknown	1257.73	0.74	0.17		0.21
Unknown	1291.80	1.76	0.56		
SUM		**16.36**	**11.84**	**6.96**	**3.54**
TOTAL VOCs		**113.62**	**405.16**	**96.64**	**84.65**

Appendix 4 (Continued) VOCs (ppbC) detected at Grinnells Laboratories in November 2002

Canister #	**Retention**	**AQ-080***	**39**	**AQ-171**	**AQ-105***	**JP1503**
Date	**Index #**	**11/5/02**	**11/5/02**	**11/5/02**	**11/5/02**	**11/5/02**
Time		**1023**	**1102**	**1023**	**1102**	**1121**
Location		**~3 m in front of fan**	**~3 m in front of fan**	**directly in front of fan**	**10 m downwind of fan**	**upwind ~26 m SSW of fan**
Temerature (Celcius)						
Alcohols						
Methanol	408.00	3.58	3.56	18.67	2.51	1.64
Ethanol	461.50	18.49	14.21	225.28	2.46	2.08
2-Butanol			0.52	5.88	0.22	0.06
n-Butanol + Styrene	653.00	1.12	1.40	13.56	1.18	0.54
n-Propanol	555.00	0.06	0.09	28.90	0.25	0.10
SUM		**23.25**	**19.78**	**292.29**	**6.62**	**4.42**
Aldehydes						
Acetaldehyde	372.25	1.31	3.00	12.42	3.53	0.46
Isobutanal	542.18			0.70		
Butanal	572.72	0.66	0.72	1.68	0.80	0.40
Isopentanal	635.89		0.08	1.12		
pentanal			2.20			
Heptanal + Styrene	881.42	0.51	1.11	1.57	3.03	0.88
Benzaldehyde	940.10			1.32		
Octanal	983.98		0.67	1.01	0.84	0.31
Nonanal	1086.66	0.32	0.90	0.92	0.58	
Decanal	1189.79		1.18	0.52	0.99	
SUM		**2.80**	**9.86**	**21.26**	**9.77**	**2.05**

Alkynes						
Acetylene	187.39	0.64	4.20	0.38	5.58	6.28
Propyne	328.11	0.33	0.27	0.17	2.26	0.31
SUM		**0.97**	**4.47**	**0.55**	**7.84**	**6.59**
Aromatics						
Benzene	651.21	1.51	3.29	1.91	16.79	5.15
Toluene	758.58	3.39	5.64	3.97	31.34	11.21
Ethylbenzene + 4-Heptanone	855.40	0.55	1.00	0.99	6.40	1.99
m-& p-Xylene	863.65	1.53	3.48	3.40	21.05	6.88
o-Xylene	887.56	0.70	1.25	1.70	7.80	2.91
Isopropylbenzene	920.34	0.09	0.29	0.32	0.66	0.25
n-Propylbenzene	950.95	0.16	0.31	0.19	1.54	0.86
m-Ethyltoluene	957.45	0.54	1.10	1.76	6.88	2.74
p-Ethyltoluene	960.02	0.39	0.77		2.99	
1,3,5-TriMethylbenzene	964.32	0.50	0.90	1.05	3.59	1.71
o-Ethyltoluene	976.97	0.32	0.50	0.77	2.48	1.16
1,2,4-TriMethylbenzene	991.48	0.96	1.66	1.34	10.32	4.48
Isobutylbenzene	1008.16		0.12	0.13	0.27	0.13
sec-Butylbenzene	1010.39				0.12	0.08
m-Cymene	1018.22	0.08		0.35	0.24	
1,2,3-TriMethylbenzene	1022.13	0.30	0.45	0.61	2.14	1.19
o-Dichlorobenzene	1031.59			0.13	0.23	0.12
m-Diethylbenzene	1046.57				0.67	0.16
n-Butylbenzene	1054.69	0.43		0.81	3.40	1.28
1-Me-4-isoPropylbenzene	1059.44		1.28		0.15	
1-Me-2-n-Propylbenzene	1067.27	0.13	0.35		0.72	0.37
1,4-DiMe-2-Ethylbenzene	1075.98	0.16	0.31		1.06	0.47
1,2-DiMe-4-Ethylbenzene	1084.27	0.09	0.31	0.27	2.08	0.86
1,3-DiMe-2-Ethylbenzene	1092.85				0.17	0.07

1,2-DiMe-3-Ethylbenzene	1107.49	0.12	0.08	0.32	0.48	0.23
t-1-But-2-MeBenzene	1139.52				0.21	0.11
t-1-But-3,5-DiMeBenzene	1174.77		0.15			
t-1-But-4-Ethylbenzene	1183.89				0.17	
1,3,5-TriEthylbenzene	1216.90				0.12	0.13
1,2,4-TriEthylbenzene	1239.00				0.09	0.06
n-Hexylbenzene	1261.77				0.37	
SUM		**11.95**	**24.97**	**20.02**	**124.53**	**44.60**
Esters						
Methyl Propanate	618.54					0.09
Ethyl Propanate	696.02			0.09		
Propyl Acetate	697.61				0.36	
Methyl Butanate	706.79		0.06	0.11	0.06	0.06
Propyl Propanate	791.77			1.76		
Butyl Acetate	796.12		0.42	0.58	0.41	0.56
SUM		**0.00**	**0.48**	**2.54**	**0.83**	**0.71**
Halogenated Hydrocarbons						
Freon-12	314.04	0.22	0.19	0.28		0.21
Methyl Chloride	339.70	0.53	0.45	0.59	0.57	0.61
Freon-142b	346.30	0.11	0.13	0.14	0.17	0.07
Freon-22	304.94	5.67	7.22	64.42	0.41	0.19
Ethyl Chloride	433.37		0.23			
Dichloromethane	518.77	0.12	0.06	0.12	0.08	
Freon-113	531.54	0.22		0.21		
Chloroform	601.86			0.60		
1,1,1-Trichloethane	635.44	0.07			0.67	0.54
1,2-Dichloropropane	679.55	0.15				
c-1,3-Dichlopropene	720.09				0.08	

Perchloroethylene	805.33	0.20	0.10	0.45		
SUM		**6.87**	**8.38**	**66.81**	**2.08**	**1.62**
Isoprene & Monoterpenes						
Isoprene	504.19	1.54	0.70	0.64	4.52	2.96
alpha-Pinene + 3,6-DiMethyloctane	943.64	1.27	1.15	1.77	1.31	1.48
Camphene + 2,6-DiMe-4-Heptanone	959.75			0.99		2.58
beta-Pinene	986.65	0.49	0.52	0.65		0.57
Limonene	1033.82	0.35	0.28	0.60	0.29	0.30
SUM		**3.65**	**2.65**	**4.65**	**6.12**	**7.89**
Ketones						
Acetone	476.37	18.49	6.59	23.04	7.61	7.04
MEK	577.35	1.82	2.11	20.98	1.10	0.94
4-Methyl-2-Pentanone	721.82	0.14		2.92		
Cyclohexanone	870.91	0.27	0.40	0.61	0.23	0.28
2-Octanone	971.63		0.50			
2-Nonanone	1073.92		0.33			
SUM		**20.72**	**9.93**	**47.55**	**8.94**	**8.26**
Olefins						
Ethylene	173.78	1.70	3.56	2.78	18.54	3.92
Propylene	289.65	0.94	3.09	1.25	19.91	3.28
Butene-1	389.97	0.84	1.89	0.84	11.62	2.19
1,3-Butadiene	394.58	0.22	0.71	0.19	5.70	0.78
c-Butene-2	425.94	0.16	0.34	0.18	1.58	0.35
3-Methyl-1-Butene	457.43	0.27	0.20	0.22	0.95	0.32
Pentene-1	489.36	0.17	0.54		1.57	0.48
2-Methyl-1-Butene	496.17	0.22	0.45	7.98	2.49	0.70
trans-2-Pentene	508.72	0.41	0.77	0.35	2.79	0.79

cis-2-Pentene	516.35	0.14	0.39	0.20	1.57	0.42
2-Methyl-2-Butene	521.04	0.20	1.07	0.48	5.01	1.00
Cyclopentene	551.84		0.21	0.08	0.82	0.20
2-Methyl-1-Pentene	588.52				0.62	0.36
Hexene-1	589.36	0.23	0.24	0.11	0.73	
trans-2-Hexene	604.98		0.27	0.07	0.90	0.22
2-Methyl-2-Pentene	607.37	0.10	0.25	0.09	1.29	0.29
cis-2-Hexene	614.50		0.15		0.46	0.24
2,4-DiMethyl-1-Pentene	647.79	0.09	0.09		0.30	0.09
4-Me-1-Hexene	665.23				0.17	
2,4,4-TriMethyl-1-Pentene	712.30		0.15		0.62	
3-&4-MethylCyclohexene	738.50			4.09	6.20	
4-Methyl-3-Penten-2-one	778.69		0.89	5.39	0.62	0.41
Octene-1	789.04	0.19	0.11	0.23	0.08	
trans-2-Octene	803.11			0.33		
cis-2-Octene	812.37			0.29	0.09	0.09
trans-2-Nonene	902.49				0.14	0.07
Undecene-1	1089.44		0.57		0.99	
n-Tridecene-1	1289.33				0.28	
SUM		**5.88**	**15.94**	**25.15**	**86.04**	**16.28**
Paraffins						
Ethane	200.00	9.77	9.20	9.12	11.22	8.72
Propane	300.00	12.12	11.32	12.33	11.41	10.70
Isobutane	361.88	2.40	2.79	3.41	4.58	2.75
n-Butane	400.00	6.27	9.21	6.96	24.26	11.12
Isopentane	474.54	3.94	8.80	3.78	28.81	10.98
n-Pentane	500.00	2.06	4.07	5.26	12.11	4.25
2,2-Dimethylbutane	535.47	0.32	0.75	0.74	2.69	1.11
Cyclopentane	562.82	0.21	0.55	0.31	1.20	0.40
2,3-Dimethylbutane	565.46	0.41	1.11	1.66	3.53	1.52

2-Methylpentane	570.09	3.34	6.56	29.19	12.50	6.66
3-Methylpentane	583.52	1.27	2.76	6.74	7.25	3.82
n-Hexane	600.00	1.13	1.96	1.49	6.26	1.90
2,2-DiMethylpentane	625.13	0.06	0.07	0.07	0.23	0.10
Methylcyclopentane	627.20	0.54	1.18	0.78	3.94	1.21
2,4-Dimethylpentane	631.38	0.20	0.46	0.31	2.04	1.07
2,2,3-TriMethylbutane	637.00		0.23			
Cyclohexane	660.96	0.36	0.47	0.40	1.02	0.51
2-Methylhexane	668.68	0.49	1.35	1.40	4.82	1.52
2,3-Dimethylpentane	670.80		0.66	0.34	2.19	1.20
3-Methylhexane + 3-Pentanone	677.22	0.73	1.80		5.44	1.96
3-EthylPentane	687.12	0.15	0.46	0.34	1.55	0.36
2,2,4-TriMethylpentane	690.72	1.02	2.47	1.30	10.75	5.38
n-Heptane	700.00	0.47	0.86		3.21	1.13
MethylCyclohexane	724.30	0.48	1.11		2.37	0.92
2,5-DiMethylhexane	733.56	0.22	0.29	0.17	1.32	0.68
2,4-DiMethylhexane	735.91	0.35	0.73	0.32	2.28	1.23
3,3-DiMethylhexane	743.87		0.14		0.60	0.26
Hexamethylcyclotrisiloxane	753.56	0.63	1.13	2.51	4.22	2.24
2,3-DiMethylhexane	762.98		0.46	0.20	1.44	0.85
2-Methylheptane	767.55	0.20	0.38	0.22	1.90	0.54
4-MeHeptane + 2-Hexanone	769.28		0.35		3.77	0.26
3,4-DiMethylhexane	772.50		0.10		0.39	0.14
3-Methylheptane	775.34	0.17	0.32	0.30	1.90	0.66
2,2,4-TriMethylhexane	794.85				0.19	
n-Octane	800.00		0.34	0.44	1.41	0.54
2,3,5-TriMethylhexane	819.44	0.41	0.14	0.13	0.44	0.19
2,4-DiMethylheptane	825.88	0.13	0.10	0.08	0.42	0.10
4,4-DiMethylheptane	829.05		0.22	0.29		
2,6-DiMethylheptane	831.77	0.20			0.51	0.23
1c2-DiMethylcyclohexane	834.70	0.09	0.15	0.07	0.37	0.07

2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.10	0.25	0.13	1.05	0.36
3-Methyloctane	873.73	0.16		0.22	0.98	0.32
Nonane	900.00	0.24	2.79	0.48	0.93	0.32
3,5-DiMethyloctane	927.97				0.15	
IsopropylCyclohexane	929.10		0.26	0.20	0.17	0.12
2,6-DiMethyloctane	937.70	0.23		0.47	0.55	0.44
3,3-DiMethyloctane	942.00	0.15	0.46		0.81	0.16
3,4,5-TriMethylheptane	955.00			0.79		
3-Methylnonane	973.55	0.09		0.33	0.49	0.24
n-Decane	1000.00	0.35	0.41	0.85	0.81	0.44
nButCycHexan	1042.20	0.09		0.21		
+ n-Undecane	1100.00	0.28	0.49	0.87	0.82	0.40
n-Dodecane	1200.00	0.23	0.31	0.46	0.71	0.33
SUM		**52.06**	**80.02**	**95.67**	**192.01**	**90.41**
Phenols						
4-Methylphenol	1049.14	1.19	1.73	11.22	1.90	0.52
SUM		**1.19**	**1.73**	**11.22**	**1.90**	**0.52**
Sulfides						
DiMethylsulfide	507.30			0.83		
DiMethyldisulfide	729.82		0.09	1.08		
Mepropyldisulfide	916.10				0.15	0.09
SUM		**0**	**0.09**	**1.91**	**0.15**	**0.09**
Unknowns						
Unknown	239.83			0.08		
Unknown	266.92		0.14		0.21	0.19
Unknown	326.30	0.11	0.24	0.17	1.53	0.22
Unknown	354.72			0.08	0.09	0.09
Unknown	410.23				0.95	

Unknown	419.66				0.18	
Unknown	441.29			0.06	0.22	0.16
Unknown	523.25		0.28			0.13
Unknown	532.24		0.46		3.03	0.54
Unknown	544.47			0.08		
Unknown	557.98		2.03		0.60	
Unknown	595.81	0.44			0.22	0.06
Unknown	602.24		0.06		0.61	0.10
Unknown	610.49		0.19	0.06	0.61	0.17
Unknown	612.17				0.22	0.08
Unknown	616.59				0.17	
Unknown	617.91	0.26	0.31			
Unknown	620.74		0.50		1.33	0.37
Unknown	638.63				0.47	
Unknown	642.02			0.22		
Unknown	644.55		0.08			0.18
Unknown	680.55				0.16	
Unknown	684.41	0.10	0.28	0.14	1.05	0.31
Unknown	695.08				0.18	
Unknown	701.86				1.12	
Unknown	704.63				0.22	0.10
Unknown	710.01		0.10		0.30	0.11
Unknown	716.76		0.20	0.41		
Unknown	726.61		0.19		0.14	
Unknown	747.75		0.13	0.14		
Unknown	779.81	1.00				
Unknown	781.70		0.12		0.49	0.15
Unknown	783.92		0.14	0.70	0.11	
Unknown	785.98	0.25	0.26		0.93	0.59
Unknown	791.10		0.09		0.36	0.15
Unknown	793.28		0.07		0.16	0.09

Unknown	796.71	0.93		0.38		
Unknown	805.65				0.12	0.09
Unknown	815.37	0.09	0.07	0.11		0.07
Unknown	844.42		0.11	0.21	0.17	
Unknown	847.21		0.10		0.17	
Unknown	860.26	0.10		0.09	0.28	0.14
Unknown	894.35	0.08		0.19	0.23	0.09
Unknown	910.70				0.15	0.09
Unknown	933.29	0.17		0.08		0.09
Unknown	936.33		0.57			
Unknown	947.14	0.06	0.11	0.15	0.10	3.38
Unknown	988.06				1.81	
Unknown	1013.63		1.11	1.57	0.70	
Unknown	1025.79	0.09		0.35	0.14	
Unknown	1036.98	0.18	0.26	0.39	1.34	0.53
Unknown	1040.81		0.41			
Unknown	1043.84				1.42	0.22
Unknown	1062.68				0.18	
Unknown	1073.24			2.27	0.27	0.08
Unknown	1078.46	0.13	0.19	0.09	1.05	0.38
Unknown	1119.01	0.14	0.49	0.24	0.93	0.52
Unknown	1123.00	0.09	0.20	0.20	1.34	0.62
Unknown	1125.95			0.07	0.10	
Unknown	1128.86		0.25			
Unknown	1137.02	0.09	0.28	0.08	0.21	0.16
Unknown	1144.96	0.12			1.08	0.41
Unknown	1148.05	0.07	0.24	0.23		0.10
Unknown	1153.22	0.53	0.20	7.59	0.86	0.39
Unknown	1156.53				2.04	0.69
Unknown	1161.98	0.12		0.14	0.49	0.13
Unknown	1164.70			0.08		

Unknown	1168.51		0.08		0.59	0.20
Unknown	1172.96			0.08	0.08	
Unknown	1175.95	0.06	0.52	0.09	0.20	0.19
Unknown	1179.17					
Unknown	1192.06	0.59	0.71	0.44	2.98	2.50
Unknown	1204.30		0.08		0.24	0.11
Unknown	1207.53		0.18			
Unknown	1210.71	0.11			0.20	0.07
Unknown	1215.69		0.34	0.12		
Unknown	1224.38					0.16
Unknown	1249.88				0.23	
Unknown	1254.24		0.59	0.06		
Unknown	1257.73				0.38	0.34
Unknown	1263.87	0.09	0.13	0.09		
Unknown	1272.12		0.29			
Unknown	1275.66	0.35		0.28		
Unknown	1291.80	0.10	1.03	0.26	0.31	
SUM		**6.45**	**14.41**	**18.07**	**36.05**	**15.54**
TOTAL VOCs		**136.21**	**189.13**	**609.95**	**483.00**	**199.14**

***samples taken in conjunction with Duke University odor panel**

Samples selected for GC/MS analysis

Appendix 5 VOCs (ppbC) detected at Howard Farm in June 2002

Canister #	**Retention**	**AQ-171**	**AQ-022***	**39**	**AQ-207**	**115**	**127**	**AQ-125**
Date	**Index #**	**6/3/02**	**6/4/02**	**6/3/02**	**6/3/02**	**6/11/02**	**6/3/02**	**6/11/02**
Time (EST)		**1225**	**1258**	**1211**	**1239**	**1110**	**1159**	**1242**
Location		**upwind of lagoon/houses**	**N end of finishing pond**	**B/n inner cell & finishing pond**	**Downwind of ponds**	**Downwind of ponds**	**in front of housing fan**	**~5 m downwind of housing fan**
Temperature (Celcius)		**29**	**28.6**	**29.1**	**29.3**	**27.3**	**28.7**	**27.8**
Wind Speed (m/s)		**2.2**	**3**	**1**	**2.6**	**1.8**	**2**	**2.7**
Alcohols								
Methanol	408.00	12.75	4.57	5.23	6.34	3.86	10.43	6.99
Ethanol	461.50	3.51	0.41	0.76	1.34	0.63	47.46	22.26
2-butanol			0.24	0.11	0.28		0.39	0.26
n-propanol		0.38	.65	0.85	.90	0.53	4.01	0.52
n-Butanol + Thiophene	653.00	1.68	1.01	1.01	1.01	1.01	1.01	1.01
SUM		**17.94**	**6.88**	**7.96**	**9.87**	**6.03**	**63.30**	**31.04**
Aldehydes								
Acetaldehyde	372.25	4.36	4.43	4.14	5.02	1.69	7.45	5.70
Isobutanal	542.18						0.85	0.52
Butanal	572.72	1.79	1.18		1.38	1.21	0.86	1.38
Isopentanal	635.89			0.11		0.12	0.08	
pentanal		1.64						
Hexanal	778.54	2.21	1.24	1.42	2.45	0.74	4.19	3.67
Heptanal + Styrene	881.42	1.89	1.04	0.96	1.72	0.83	1.57	1.90
Benzaldehyde	940.10	0.90		0.30	0.65	0.3	0.31	2.49
Nonanal	1086.66	2.07	1.53	1.67	1.99	2.34		3.80
Decanal	1189.79	1.88	1.42	1.28	1.33	1.92		
SUM		**16.74**	**10.84**	**9.88**	**14.54**	**9.15**	**15.31**	**19.46**

Alkynes								
Acetylene	187.39	0.62	0.61	0.47	0.51	0.46	0.24	0.24
Propyne	328.11	0.80	0.29			0.41		
SUM		**1.42**	**0.90**	**0.47**	**0.51**	**0.87**	**0.24**	**0.24**
Aromatics								
Benzene	651.21	1.36	0.63	0.47	0.44	0.45	0.68	0.53
Toluene	758.58	3.38	0.72	0.62	0.53	0.83	0.69	0.83
Ethylbenzene + 4-Heptanone	855.40	0.48	0.18			0.14	0.10	0.12
m-& p-Xylene	863.65	1.49	0.36			0.26		
o-Xylene	887.56	0.85	0.18			0.16		
Isopropylbenzene	920.34					0.08		
n-Propylbenzene	950.95	0.15				0.21		
p-Ethyltoluene	960.02	0.32						
o-Ethyltoluene	976.97	1.36	2.26	0.40		0.22	0.23	0.55
1,2,4-TriMethylbenzene	991.48	0.91	0.39	0.46	0.29	0.49	0.50	0.39
p-Dichlorobenzene	1005.93							0.06
Isobutylbenzene	1008.16	0.12			0.22	0.28		0.21
p-Cymene	1022.93					0.45	0.06	0.15
m-Diethylbenzene	1046.57				0.11			0.06
p-Diethylbenzene	1053.84	1.86		0.57				
n-Butylbenzene	1054.69				0.40			
1-Me-4-isoPropylbenzene	1059.44	0.21	0.07					
1-Me-2-n-Propylbenzene	1067.27	0.25				0.27		
1,2-DiMe-4-Ethylbenzene	1084.27	0.17				0.09		
1,2-DiMe-3-Ethylbenzene	1107.49	0.35	0.18		0.17	0.27	0.21	
1,2,4,5-Tetra-Me-Benzene	1119.01	1.14	0.19	0.30	0.18		0.21	0.54
m-DiisoPropylbenzene	1152.00						0.65	
t-1-But-4-Ethylbenzene	1183.89	0.09			0.13			
1,3,5-TriEthylbenzene	1216.90	0.39		0.30				
1,2,4-TriEthylbenzene	1239.00			0.30				
SUM		**14.88**	**5.16**	**3.42**	**2.47**	**4.20**	**3.33**	**3.44**

Esters								
Methyl Propanate	618.54			0.13				
Propyl Acetate	697.61				0.07			
Methyl Butanate	706.79	0.07	0.12					
Butyl Propanante	888.77		0.20	0.39		0.20	0.14	0.23
SUM		**0.07**	**0.32**	**0.52**	**0.07**	**0.2**	**0.14**	**0.23**
Ethers								
Furan	490.31					0.1	0.06	
SUM		**0**	**0**	**0**	**0**	**0.1**	**0.06**	**0.42**
Halogenated Hydrocarbons								
Freon-22	304.94	0.19	0.20	0.19	0.14	0.16	0.19	0.17
Freon-12	314.04		0.21	0.32	0.26	0.32	0.23	0.28
Methyl Chloride	339.70	0.81	0.64	0.60	0.56	0.60	0.63	0.68
Freon-114	369.43				0.17			
Dichloromethane	518.77	0.22		0.17		0.06		
3-Chloropropene	522.88						0.13	
Freon-113	531.54	0.25	0.25	0.21	0.63	0.15	0.22	
1,1,1-Trichloethane	635.44	0.12	0.11		0.11	0.12		0.16
Perchloroethylene	805.33		0.23		0.53			
SUM		**1.59**	**1.644**	**1.49**	**2.40**	**1.41**	**1.40**	**1.29**
Isoprene & Monoterpenes								
Isoprene	504.19	9.39	15.00	6.95	6.43	2.23	5.42	4.32
alpha-Pinene + 3,6-DiMethyloctane	943.64	1.16	2.09	0.48	0.57	0.24	1.09	1.54
Camphene + 2,6-DiMe-4-Heptanone	959.75				0.33			
beta-Pinene	986.65	0.71	0.57				0.33	
Limonene	1033.82	0.71	1.19	0.25	0.21	0.42	0.21	1.10
SUM		**11.97**	**18.85**	**7.68**	**7.54**	**2.89**	**7.05**	**6.96**

Ketones								
Acetone	476.37	26.45	8.73	9.60	12.60	9.12	17.82	14.96
Methacrolein	552.82							0.55
MEK	577.35	1.82	1.01		1.90	0.56	2.36	1.82
2-Pentanone	667.26	0.12	0.07		0.10			0.09
4-Methyl-2-Pentanone	721.82	1.95	0.17			0.13	0.45	0.32
2-Methyl-3-Pentanone	734.78	0.25					0.33	
2,4-Dimethyl-3-Pentanone	762.30		1.55					
3-Heptanone	867.95	0.27	0.08	0.11	0.19		0.12	0.14
2-Heptanone + 3-Ethylthiophene	870.23	1.44	0.6	1.03	0.67	0.37	0.33	0.49
2-Methyl-3-Heptanone	922.24					0.10		
6-methyl-5-heptene-2-one							1.06	
2-Octanone	971.63	0.79	0.42	0.37	0.28	0.20		0.29
Acetophenone	1047.96	0.42	0.41			0.07		
2-Nonanone	1073.92	0.63	0.31		0.33	0.15		0.91
SUM		**34.14**	**13.35**	**11.11**	**16.07**	**10.70**	**22.47**	**19.57**
Olefins								
Ethylene	173.78	1.58	1.04	0.63	0.40	0.25	5.77	3.23
Propylene	289.65	1.16	0.52	0.30	0.29	0.24	0.17	0.26
Butene-1	389.97	0.86	0.38			0.21	0.22	0.34
1,3-Butadiene	394.58	0.25	0.10					0.12
c-Butene-2	425.94	0.32						
1,2-Butadiene	447.17		0.19					
3-Methyl-1-Butene	457.43	0.35	0.34					
Pentene-1	489.36	1.17						
2-Methyl-1-Butene	496.17	0.34	0.06	0.24			0.18	
trans-2-Pentene	508.72	0.35						
cis-2-Pentene	516.35	0.24						
2-Methyl-2-Butene	521.04	0.63		0.15				
Cyclopentene	551.84	0.15						
Hexene-1	589.36	0.26	0.16		0.18		0.10	0.15

cis-3-Hexene	602.80	0.40	0.21		0.25	0.25	0.56	0.13
2-Methyl-2-Pentene	607.37	0.20						
cis-2-Hexene	614.50	0.07						
t-1,3-Hexadiene	621.57		0.28	0.16			0.31	
2,4-DiMethyl-1-Pentene	647.79	0.14	0.11	0.10	0.15	0.21	0.29	0.33
Heptene-1	689.22				0.53			0.21
2,4,4-TriMethyl-1-Pentene	712.30	0.14	0.17					0.11
3-&4-MethylCyclohexene	738.50	0.08						
Octene-1	789.04	0.19	0.11	0.10	0.16		0.08	0.16
3-Octene	796.71						0.10	
cis-2-Octene	812.37			0.1			0.09	0.09
Nonene-1	889.31				0.13			
cis-3-Nonene	898.03					0.47	0.06	
Cyclooctene	903.75							
Decene-1	989.42	0.19						0.11
2-Carene	1007.00						0.47	
Undecene-1	1089.44		0.57					
n-Tridecene-1	1289.33				0.28			
SUM		**9.07**	**4.24**	**1.78**	**2.37**	**1.63**	**8.40**	**5.24**
Paraffins								
Ethane	200.00	3.76	2.90	3.25	3.42	2.69	3.26	2.78
Propane	300.00	3.22	1.19	1.54	1.39	2.33	1.44	1.18
Isobutane	361.88	1.24	0.30	0.43	0.45	0.44	0.16	
n-Butane	400.00	2.74	0.55	0.68	0.46	0.87	0.41	0.59
Isopentane	474.54	4.66	1.37	1.46	1.15	2.10	0.40	1.52
n-Pentane	500.00	2.94	0.32	0.37	0.30	0.57		0.91
2,2-Dimethylbutane	535.47	0.51				0.29		
Cyclopentane	562.82	0.14						
2,3-Dimethylbutane	565.46	0.35	0.14			0.14		
2-Methylpentane	570.09	3.55	0.90		1.04	0.21	2.79	2.77
3-Methylpentane	583.52	0.55	0.16			0.35	0.35	0.27
n-Hexane	600.00	0.70	0.12	0.13	0.20	0.16	1.21	0.45

Methylcyclopentane	627.20	0.53	0.08			0.14	0.34	0.25
2,4-Dimethylpentane	631.38	0.21		0.23				
2,2,3-TriMethylbutane	637.00	0.33					0.62	0.86
Cyclohexane	660.96	0.29				0.10		
2-Methylhexane	668.68	0.89						0.65
2,3-Dimethylpentane	670.80	0.25						
3-Methylhexane + 3-Pentanone	677.22		0.93	0.69	1.59	0.58	0.85	1.31
3-EthylPentane	687.12	0.11						
2,2,4-TriMethylpentane	690.72	0.65	0.35	0.20	0.29	0.15	0.11	0.16
n-Heptane	700.00	0.37	0.10		0.20	0.12		0.17
3,3-DiMethylhexane	743.87		0.17		0.08			
hexmethylcyclotrisiloxane	753.56		0.22	0.19	0.23	0.18	0.33	0.31
2,3-DiMethylhexane	762.98	1.54		0.93	0.94	0.60		0.61
2-Methylheptane	767.55	0.24						
4-MeHeptane + 2-Hexanone	769.28	0.60	0.29					0.34
3-Methylheptane	775.34	0.09				0.10		
n-Octane	800.00	0.20	0.14	0.15		0.08	0.46	0.29
1t2-DiMethylcyclohexane	802.07							
2,3,5-TriMethylhexane	819.44		0.25	0.16	0.22		0.46	0.37
2,4-DiMethylheptane	825.88	0.13						
4,4-DiMethylheptane	829.05	0.20	0.20		0.25	0.22		0.41
2,5-DiMeHeptane + 5-Me-2	838.60	0.18				0.25		
3,3-DiMethylheptane	841.50	0.13						
Nonane	900.00	0.72	0.36	0.13	0.20		0.18	0.17
4,4-DiMethyloctane	925.00						0.08	
3,5-DiMethyloctane	927.97							5.05
Cyclooctane	928.80	0.14					0.10	
IsopropylCyclohexane	929.10					0.11		
2,6-DiMethyloctane[a]	936.33	1.2	0.64	0.51	0.51	0.93	0.32	0.21
2,3-DiMethyloctane	958.75	0.39	0.12	0.16		0.33		
2-Methylnonane	966.32						1.49	
IsoButylcyclohexane	997.00	0.10						
t-ButylCyclohexane	998.50					0.06	0.08	0.08

n-Decane	1000.00	0.22	0.07	0.17	0.12	0.16		
Indane	1036.98	0.37		0.19				
n-Undecane	1100.00	0.28	0.13	0.16	0.09	0.22		
n-Dodecane	1200.00	0.22		0.13		0.19		
SUM		**34.94**	**12.00**	**11.86**	**13.13**	**14.67**	**15.44**	**21.71**
Phenols								
4-methylphenol			0.66	0.61	0.20	0.32	14.33	3.56
SUM			**0.66**	**0.61**	**0.20**	**0.32**	**14.33**	**3.56**
Sulfides								
Dimethylsulfide	507.3						2.48	2.08
Dimethyldisulfide	729.82						0.77	0.11
Thiophene	655.66			0.37				
2-Methylthiopropane	662.64		0.16				0.77	0.1
MeEthyldisulfide	822.98		0.27	0.16	0.48	0.19		0.15
2-Ethylthiophene	857.11			0.36				
SUM		**0**	**0.43**	**0.89**	**0.48**	**0.19**	**4.02**	**2.44**
Unknowns								
Unknown	266.92	0.36						
Unknown	323.07					0.21		
Unknown	326.30							0.22
Unknown	346.30						0.09	
Unknown	354.72				0.56	0.09		
Unknown	373.09		0.26					
Unknown	452.36	0.22						
Unknown	469.37	1.41	0.41			0.63		
Unknown	548.47	0.16						
Unknown	594.02	0.43						
Unknown	595.81			0.11				
Unknown	610.49				0.19			
Unknown	612.17						0.07	

Unknown	617.91				0.09			
Unknown	620.74	0.58			0.28			0.89
Unknown	644.55		0.20	0.14			0.25	0.21
Unknown	684.41	0.09				0.09		
Unknown	708.41				0.17			
Unknown	716.76	0.24	0.13		0.27	0.17		0.19
Unknown	729.03						0.77	0.11
Unknown	747.75	0.18	0.29		0.18	0.20	0.13	
Unknown	785.98	0.09						
Unknown	793.28		0.15					
Unknown	796.71						0.10	
Unknown	805.65	0.25						
Unknown	844.42		1.21					
Unknown	847.21	0.11						
Unknown	851.61	0.55	0.10	2.30				0.23
Unknown	905.72				0.32			
Unknown	908.79		0.20			0.36		
Unknown	910.70						0.58	
Unknown	916.10			0.17				
Unknown	933.29			0.16			0.14	
Unknown	1013.63	1.30	1.02	0.65				
Unknown	1027.85	0.42	0.24	0.16	0.13			0.06
Unknown	1040.81	0.43	0.26		0.09	0.10	0.08	0.22
Unknown	1062.68	0.46						
Unknown	1078.46	0.27						
Unknown	1125.95	0.14						
Unknown	1128.86							
Unknown	1137.02	0.37	0.11	0.10		0.16		
Unknown	1148.05	0.17	0.20	0.13		0.10		
Unknown	1156.53		0.68		0.58			
Unknown	1168.51	0.09						
Unknown	1172.96	0.28						
Unknown	1175.95	0.45	0.43	0.59				

Unknown	1179.17	0.09						
Unknown	1207.53	0.19						
Unknown	1215.69		0.25			0.14		
Unknown	1243.93	0.98					0.31	
Unknown	1263.87					0.09		
Unknown	1291.80	0.73	0.47	0.56	0.38		0.22	
SUM		**11.04**	**6.61**	**5.07**	**3.24**	**2.34**	**3.00**	**2.34**
TOTAL VOCs		**154.18**	**81.88**	**62.74**	**72.89**	**54.70**	**158.30**	**122.82**

Appendix 5 (Continued) VOCs (ppbC) detected at Howard Farm in June 2002

Canister #	**Retention**	**704 (MTC-65)***	**119***	**AQ-105***	**AQ-128**	**AQ-060**	**AQ-080**	**AQ-146**
Date	**Index #**	**6/4/02**	**6/4/02**	**6/4/02**	**6/4/02**	**6/4/02**	**6/5/02**	**6/5/02**
Time (EST)		**1142**	**1201**	**1229**	**1759**	**2318**	**620**	**1200**
Location		**~10 m upwind of houses**	**~10 downwind of houses**	**solid sepatator**	**finishing lagoon**	**Finishing lagoon**	**finishing lagoon**	**finishing lagoon**
Temperature (Celcius)		**28.3**	**28.5**	**28.4**	**25.9**	**22**	**19.7**	**28.7**
Wind Speed (m/s)		**2.7**	**2.6**	**3**	**3.4**	**0**	**0**	**2.56**
Alcohols								
Methanol	408.00	7.88	5.61	7.92	4.46	2.23	4.03	5.24
Ethanol	461.50	1.20	3.50	1.94	0.62	0.80	1.01	0.31
2-butanol			0.42	0.43	0.13	0.09	0.11	
n-propanol		0.52	0.60	0.59	0.22		0.45	
n-Butanol + Thiophene	653.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01
SUM		**10.61**	**11.14**	**11.89**	**6.44**	**4.13**	**6.61**	**6.56**
Aldehydes								
Acetaldehyde	372.25	9.46	7.97	9.90	4.17	3.84	3.36	7.63
Butanal	572.72	1.90	1.25	2.13	1.66	0.93	1.59	1.43
Isopentanal	635.89	0.18	0.08		0.16			0.09
Pentanal	675.78			2.51			0.12	
Hexanal	778.54	1.88	2.24	4.83	2.05	1.45	0.92	1.60
Heptanal + Styrene	881.42	1.38	1.21	5.02	1.11	0.98	0.97	1.55
Benzaldehyde	940.10	2.06	1.26	2.19	0.71	0.41	0.49	1.17
Nonanal	1086.66	3.63	3.46	6.22	2.03	2.05	1.09	3.83
Decanal	1189.79		1.88	3.57	1.67	1.21	0.87	3.39
SUM		**20.49**	**19.35**	**36.37**	**13.56**	**10.87**	**9.41**	**20.69**
Alkynes								

Acetylene	187.39	5.39	0.89	0.55	0.31	0.24	0.33	0.36
Propyne	328.11	0.26		0.09		0.14		
SUM		**5.65**	**0.89**	**0.64**	**0.31**	**0.38**	**0.33**	**0.36**
Aromatics								
Benzene	651.21	2.46	0.78	1.05	0.34	0.52	0.53	0.41
Toluene	758.58	3.15	0.87	1.02	0.36	0.78	1.23	0.51
Ethylbenzene + 4-Heptanone	855.40	0.59		0.34	0.16		0.22	0.15
m-& p-Xylene	863.65	1.82	0.34			0.37	0.31	0.19
o-Xylene	887.56	1.12		0.57			0.20	
Isopropylbenzene	920.34	0.13						
n-Propylbenzene	950.95	0.28			0.13			
p-Ethyltoluene	960.02	0.50						0.37
o-Ethyltoluene	976.97		0.24		0.60	0.29	0.72	1.58
1,2,4-TriMethylbenzene	991.48	2.00	0.37	0.56	0.38	0.40	0.48	0.33
p-Dichlorobenzene	1005.93							0.15
Isobutylbenzene	1008.16		0.18	0.20	0.14	0.30	0.57	
1,2,3-TriMethylbenzene	1022.13	0.60						
p-Cymene	1022.93		0.21	0.49		0.18	0.38	
o-Cymene	1037.53			0.72	0.16			
p-Diethylbenzene	1053.84		0.13					
n-Butylbenzene	1054.69	2.56	0.89	2.68				
1-Me-4-isoPropylbenzene	1059.44						0.11	0.15
1-Me-2-n-Propylbenzene	1067.27			0.30	0.20			0.35
1,2-DiMe-3-Ethylbenzene	1107.49				0.30	0.15	0.21	0.33
1,2,4,5-Tetra-Me-Benzene	1119.01	0.97	0.26	1.35	0.78		0.21	
m-DiisoPropylbenzene	1152.00			0.41	0.29	0.14	0.37	0.17
t-1-But-3,5-DiMeBenzene	1174.77			0.12				
t-1-But-4-Ethylbenzene	1183.89				0.13			
1,3,5-TriEthylbenzene	1216.90					0.18	0.24	
SUM		**16.18**	**4.27**	**9.81**	**3.97**	**3.31**	**5.78**	**4.69**
Esters								

Propyl Acetate	697.61		0.15				0.11	
Methyl Butanate	706.79			0.18				
Propyl Propanate	791.77			0.29				
Butyl Propanante	888.77				0.31			0.22
SUM		**0**	**0.15**	**0.47**	**0.31**	**0**	**0.11**	**0.22**
Ethers								
Furan	490.31					0.13		0.11
2,5-Dimethylfuran	696.02			0.53				
SUM		**0**	**0**	**0.96**	**0**	**0.22**	**0**	**0.11**
Halogenated Hydrocarbons								
Freon-22	304.94	0.11		0.22	0.15	0.21	0.14	0.26
Freon-12	314.04	0.27	0.78	0.22	0.17	0.29	0.19	0.42
Methyl Chloride	339.70	0.69	0.54	0.83	0.75	0.59	0.54	0.55
Freon-114	369.43		0.09					
Freon-11	480.75					6.77		
Dichloromethane	518.77	0.08	0.09			0.90		0.06
Freon-113	531.54		0.22	0.24	0.20		0.21	0.26
Carbon Tetrachloride	656.36			0.42				
Trichloroethylene	688.10			1.21				
1,2-Dibromoethane	785.00			0.18				
Perchloroethylene	805.33						0.32	
SUM		**1.15**	**1.72**	**3.32**	**1.27**	**8.76**	**1.40**	**1.55**
Isoprene & Monoterpenes								
Isoprene	504.19	11.60	9.38	9.13	4.27	3.95	4.14	11.29
alpha-Pinene + 3,6-DiMethyloctane	943.64		0.91	0.98	0.55	2.14	7.14	1.04
Camphene + 2,6-DiMe-4-Heptanone	959.75				0.13	0.54	0.60	
beta-Pinene	986.65					0.96	2.71	0.56
Limonene	1033.82	2.43	0.69	1.69	0.21	0.48	1.79	0.69
SUM		**14.03**	**10.98**	**11.80**	**5.16**	**8.07**	**16.38**	**13.58**

Ketones								
Acetone	476.37	19.15	14.75	17.86	9.65	5.28	11.35	15.92
MEK	577.35	1.41	1.25		0.90	1.03	0.90	1.52
2-Pentanone	667.26				0.07			0.12
3,3-Dimethyl-2-Butanone	692.82			0.07				
4-Methyl-2-Pentanone	721.82			0.93				
2-Methyl-3-Pentanone	734.78			0.13				0.08
2,4-Dimethyl-3-Pentanone	762.30			1.37				
3-Heptanone	867.95	0.19	0.21	0.57	0.37	0.29	0.11	0.17
2-Heptanone + 3-Ethylthiophene	870.23	0.82	0.3		1.44	0.91	0.95	0.91
2-Methyl-3-Heptanone	922.24		0.22	0.24				
3-Methyl-3-Heptanone	926.44	0.10						
6-methyl-5-heptene-2-one				4.43				
2-Octanone	971.63		0.25	2.29	0.56	0.28	0.31	0.43
Acetophenone	1047.96				0.41	0.33	0.53	0.44
5-Nonanone	1057.29			0.48				
2-Nonanone	1073.92		0.15	0.58	0.52	0.30	0.35	0.45
SUM		**21.67**	**17.13**	**28.95**	**13.92**	**8.42**	**14.50**	**20.04**
Olefins								
Ethylene	173.78	3.06	1.43	0.82	0.49	0.16	1.30	0.39
Propylene	289.65	1.37	0.49	0.29	0.27	0.39	0.39	
Butene-1	389.97	1.18	0.38	0.53	0.17	0.32	0.42	0.27
1,3-Butadiene	394.58		0.14			0.15	0.22	0.26
c-Butene-2	425.94	0.71	0.12					
3-Methyl-1-Butene	457.43	0.35			0.40	0.18	0.23	
Pentene-1	489.36	0.92		0.26			0.13	
2-Methyl-1-Butene	496.17	1.10	0.20	0.10	0.14	0.22	0.13	0.16
trans-2-Pentene	508.72	1.49		0.14				
cis-2-Pentene	516.35	0.73	0.07					
2-Methyl-2-Butene	521.04	2.06	0.12	0.21			0.22	
Cyclopentene	551.84	0.38		0.09				

3-Methyl-1-pentene	557.98							
2-Methyl-1-Pentene	588.52	0.40						
Hexene-1	589.36		0.19	0.25	0.14	0.20	0.15	0.08
cis-3-Hexene	602.80	0.43	0.28	0.20	0.29			0.30
trans-2-Hexene	604.98	0.33				0.47		
2-Methyl-2-Pentene	607.37	0.46		0.25				
cis-2-Hexene	614.50	0.15			0.10			0.11
t-1,3-Hexadiene	621.57		0.28		0.27	0.19		0.21
2,4-DiMethyl-1-Pentene	647.79	0.19	0.22	0.16	0.12	0.16	0.12	0.10
Heptene-1	689.22							
trans-3-Heptene	697.82	0.14						
2,4,4-TriMethyl-1-Pentene	712.30	0.17		0.11				0.12
Octene-1	789.04	0.36	0.14	0.22	0.17	0.13	0.16	0.15
cis-2-Octene	812.37						0.16	
Nonene-1	889.31		0.52	0.37		0.25		
Decene-1	989.42			0.31				
Undecene-1	1089.44				0.73			
n-Tridecene-1	1289.33			1.14				
SUM		**15.98**	**4.58**	**5.45**	**3.29**	**2.82**	**3.63**	**2.15**
Paraffins								
Ethane	200.00	2.54	2.89	3.32	2.45	1.66	2.74	2.30
Propane	300.00	1.45	1.25	1.44	0.74	1.05	2.44	1.08
Cyclopropane	341.42		1.92					
Isobutane	361.88	2.43	0.33	0.55	0.40	0.20	0.45	0.80
n-Butane	400.00	9.86	0.79	0.78	0.22	0.36	0.81	0.38
Isopentane	474.54	15.43	1.96	0.97	1.04	0.42	1.86	0.72
n-Pentane	500.00	5.31	0.51	1.08	0.25	0.40	0.66	0.29
2,2-Dimethylbutane	535.47	1.27	0.21	0.25	0.25	0.13	0.27	0.29
Cyclopentane	562.82	0.44						
2,3-Dimethylbutane	565.46	0.97	0.13	0.12			0.11	
2-Methylpentane	570.09	5.38	0.82	0.85			0.29	
3-Methylpentane	583.52	2.06	0.40	0.22		0.08	0.33	0.23

n-Hexane	600.00	1.27	0.29	0.23	0.11	0.14	0.36	0.13
2,2-DiMethylpentane	625.13	0.07						
Methylcyclopentane	627.20	0.78	0.15	0.32			0.16	0.1
2,4-Dimethylpentane	631.38	0.72					0.30	
2,2,3-TriMethylbutane	637.00			0.38				
Cyclohexane	660.96	0.15				0.14		
2-Methylhexane	668.68	1.32		2.83				1.13
3-Methylhexane + 3-Pentanone	677.22	1.57	0.79		0.91	0.70	0.77	0.98
3-EthylPentane	687.12	0.18		0.24				0.08
2,2,4-TriMethylpentane	690.72	0.92	0.42	0.25		0.19	0.36	0.44
n-Heptane	700.00	0.55	0.27	0.17	0.31	0.18	0.26	0.10
MethylCyclohexane	724.30			0.13				
2,5-DiMethylhexane	733.56	0.11						
2,4-DiMethylhexane	735.91	0.41		0.21				
3,3-DiMethylhexane	743.87	0.13		0.12		0.13	0.07	
Hexamethylcyclotrisiloxane	753.56	0.36	0.27			0.31	0.21	
2,3-DiMethylhexane	762.98	0.50			0.41			0.47
2-Methylheptane	767.55	0.25						
4-MeHeptane + 2-Hexanone	769.28			2.41	0.55			0.66
3-Methylheptane	775.34	0.23						
n-Octane	800.00	0.13	6.87	0.18	0.20		0.18	0.07
2,3,5-TriMethylhexane	819.44	0.77			0.20	0.44	0.29	0.35
4,4-DiMethylheptane	829.05	0.28	0.53	0.94	0.58			0.31
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.26		0.76	0.11	0.14		0.15
3,3-DiMethylheptane	841.50			0.29			0.10	0.15
3,3-DiEthylpentane	884.00			0.38				
Nonane	900.00	0.29	0.35	0.20		0.16	0.20	
2,2-DiMethyloctane	921.05				0.07	0.41	0.17	
Cyclooctane	928.80				0.13			0.09
IsopropylCyclohexane	929.10		0.06	0.22		0.08		
2,6-DiMethyloctane[a]	936.33	0.65	0.62		0.98	0.46	0.72	0.65
2,3-DiMethyloctane	958.75	0.59		0.54			0.25	

2-Methylnonane	966.32				2.21			
3-Methylnonane	973.55			1.42	0.19		0.19	
t-ButylCyclohexane	998.50			0.22				
n-Decane	1000.00		0.16	0.29		0.11	0.11	0.12
n-Undecane	1100.00		0.16	0.52	0.18	0.23	0.13	0.10
n-Dodecane	1200.00		0.11	0.50	0.17	0.16	0.11	0.11
SUM		**59.63**	**22.26**	**23.33**	**12.66**	**8.28**	**14.90**	**12.28**
Phenols								
4-methylphenol			2.50	0.75	1.33	0.73	0.69	0.57
SUM			**2.50**	**0.75**	**1.33**	**0.73**	**0.69**	**0.57**
Sulfides								
Dimethylsulfide	507.3		0.43			0.28	0.59	0.31
Thiophene	655.66					0.38		
2-Methylthiopropane	662.64	0.18						0.17
MeEthyldisulfide	822.98	0.17	1.64	1.47	0.25	2.12	0.4	0.2
2-Ethylthiophene	857.11						0.14	
2,5-Dimethylthiophene	862.37			0.11				
Dimethyltetrasulfide	1220.3			0.12				0.87
SUM		**0.35**	**2.07**	**1.7**	**0.25**	**2.40**	**0.83**	**1.55**
Unknowns								
Unknown	266.92		0.38					
Unknown	323.07					0.23		
Unknown	346.30	0.12	0.18		0.08		0.13	
Unknown	354.72	0.07		0.70	0.39		0.33	
Unknown	437.96						0.15	
Unknown	532.24	0.51				0.25		
Unknown	594.02			0.43		0.09		
Unknown	595.81	0.26					0.19	
Unknown	610.49	0.24						
Unknown	620.74	0.38		0.39				

Unknown	644.55	0.15	0.13			0.15	0.16	0.17
Unknown	673.45			0.29				
Unknown	684.41	0.21						
Unknown	708.41							0.08
Unknown	710.01	0.21	0.19		0.21			
Unknown	716.76	0.15	0.16		0.19		0.18	0.12
Unknown	726.61							0.08
Unknown	729.03							
Unknown	747.75	0.26		0.81	0.30	0.3	0.24	0.22
Unknown	751.44			1.35				
Unknown	783.92			0.16			0.19	0.09
Unknown	793.28				0.14	0.08		
Unknown	796.71					0.43		
Unknown	815.37							0.12
Unknown	817.91			0.49				
Unknown	844.42		0.57			0.56		
Unknown	847.21	0.20		0.28				0.08
Unknown	851.61			1.15	0.56		1.94	0.23
Unknown	860.26					0.26		
Unknown	908.79							0.75
Unknown	933.29						0.21	
Unknown	995.10			0.29			0.08	
Unknown	1013.63		1.40		1.09	0.87	0.84	1.86
Unknown	1027.85				0.25		0.46	0.49
Unknown	1040.81			0.29	0.27		0.19	0.31
Unknown	1062.68			0.06			0.06	
Unknown	1094.62			2.34	0.09		0.08	
Unknown	1128.86				0.19			
Unknown	1137.02			0.37	0.42	0.09	0.13	
Unknown	1148.05				0.17	0.10	0.24	0.27
Unknown	1156.53	1.37		0.69		0.62		
Unknown	1168.51			0.19	0.13			
Unknown	1172.96				0.40			

Unknown	1175.95		0.21		0.67	0.33	0.51	0.27
Unknown	1207.53				0.11	0.09		
Unknown	1215.69				0.35			
Unknown	1239.67			0.42				0.74
Unknown	1243.93				0.36	0.16		
Unknown	1249.88			0.39				
Unknown	1254.24				1.00			
Unknown	1257.73			0.24				
Unknown	1263.87			0.15	0.12	0.19		0.15
Unknown	1272.12				0.27			
Unknown	1275.66				0.71			
Unknown	1291.80		0.33		0.69	0.42	0.34	0.78
SUM		**4.29**	**3.55**	**20.87**	**22.58**	**5.43**	**6.90**	**6.81**
TOTAL VOCs		**170.03**	**100.59**	**147.02**	**72.3**	**63.99**	**82.61**	**90.62**

***samples taken in conjunction with Duke University odor panel**

Samples selected for GC/MS analysis

Appendix 6 VOCs (ppbC) detected at Howard Farm in December 2002

Canister #	**Retention**	**AQ-185***	**AQ-048***	**704***	**JP-1066**	**JP-1503**	**AQ-146**
Date	**Index #**	**12/9/02**	**12/9/02**	**12/9/02**	**12/11/02**	**12/11/02**	**12/11/02**
Time		**1238**	**1420**	**1350**	**1238**	**1238**	**1258**
Location		**~2 m from fan**	**Downwind of spray field**	**Downwind of NE outer cell**	**Directly in front of fan**	**8 m downwind of fan**	**upwind of lagoon 145 m yd from downwind sample**
Temperature (Celcius)		**7**	**7.2**	**7.2**	**5.6**	**5.6**	**6.1**
Wind Speed (m/s)		**3.1**	**2.8**	**3.1**	**1.7**	**1.7**	**3.5**
Alcohols							
Methanol	408.00	3.13	1.09	1.07	10.68	5.36	1.04
n-propanol			0.06		0.09		0.10
2-butanol		0.38	0.20	0.09	1.39		0.07
Ethanol	461.50	18.14	1.07	0.53	84.44	37.97	1.69
n-Butanol + Thiophene	653.00	1.33	0.65	0.30	4.38	2.48	0.49
SUM		**22.98**	**3.07**	**1.99**	**100.98**	**45.81**	**3.39**
Aldehydes							
Acetaldehyde	372.25	2.80	1.19	1.41	9.14	5.23	1.59
Butanal	572.72	0.81	0.71	0.39	1.27	0.55	0.68
Isopentanal	635.89	0.09	0.09	0.16		0.08	0.12
Hexanal	778.54	0.97	0.67	0.37	1.49	1.04	
Heptanal + Styrene	881.42	1.49	0.74	0.35	1.04	0.86	
Nonanal	1086.66	0.28	0.45		0.63	1.30	0.43
Decanal	1189.79		0.48			0.91	1.11
SUM		**6.44**	**4.33**	**2.68**	**13.57**	**9.97**	**3.93**

Alkynes							
Acetylene	187.39	4.89	0.28	0.26	26.89	13.44	0.89
Propyne	328.11	0.10		0.11	0.22	0.26	0.11
SUM		**4.99**	**0.28**	**0.37**	**27.11**	**13.70**	**1.00**
Aromatics							
Benzene	651.21	1.87	2.19	1.37	2.26	1.90	1.41
Toluene	758.58	7.78	10.34	3.11	4.63	3.30	1.59
Ethylbenzene + 4-Heptanone	855.40	1.59	2.88	0.93	0.61	0.88	0.28
m-& p-Xylene	863.65		10.72	3.81	2.14	1.93	0.75
o-Xylene	887.56	1.32	3.56	1.51	0.70	0.67	0.33
Isopropylbenzene	920.34	0.20			0.28	0.25	0.70
Benzaldehyde	940.10	0.26	0.61	0.15	0.36	0.24	
n-Propylbenzene	950.95	0.45	0.74	0.41	0.12	0.13	0.10
p-Ethyltoluene	960.02	0.70	1.07	0.64	0.33		0.49
1,3,5-TriMethylbenzene	964.32		1.26	0.75	0.65	0.39	
o-Ethyltoluene	976.97	0.62	0.79	0.48	0.32	1.59	
1,2,4-TriMethylbenzene	991.48	2.55	2.96	2.35	1.27	1.02	0.61
Isobutylbenzene	1008.16			0.06			0.09
sec-Butylbenzene	1010.39			0.06			
m-Cymene	1018.22	0.62	0.08				
1,2,3-TriMethylbenzene	1022.13		0.58	0.56	0.49		0.27
p-Cymene	1022.93					0.28	
m-Diethylbenzene	1046.57		0.18				0.11
n-Butylbenzene	1054.69	0.71		0.67			0.29
1-Me-4-isoPropylbenzene	1059.44	0.09		0.13			
o-Diethylbenzene	1061.38		0.43				
1-Me-2-n-Propylbenzene	1067.27	0.27	0.19	0.20			
1,4-DiMe-2-Ethylbenzene	1075.98	0.28	0.46	0.30			
1,2-DiMe-4-Ethylbenzene	1084.27	0.54	0.57	0.48	0.17	0.08	
	1107.49	0.20	0.16	0.16	0.17		

1,2-DiMe-3-Ethylbenzene							
t-1-But-2-MeBenzene	1139.52	0.13		0.13	0.11		
m-DiisoPropylbenzene	1152.00	0.19	0.21	0.12			
Dodecene-1 + Naphthalene	1189.56	0.83					
SUM		**21.20**	**39.98**	**18.38**	**14.61**	**12.66**	**7.02**
Esters							
Propyl Formate	608.87		0.07				
Ethyl Propanate	696.02				0.09		
Methyl Butanate	706.79		0.09				
SUM		0	**0.16**	**0.00**	**0.09**	**0.00**	**0.00**
Ethers							
Furan	490.75				0.11	0.06	
2-Methylfuran	594.02					0.89	
2,5-Dimethylfuran	696.02		0.12				
SUM		**0**	**0.12**	**0**	**0.11**	**0.95**	**0**
Halogenated Hydrocarbons							
Freon-22	304.94	0.12	0.15	0.10	0.19	0.14	0.23
Freon-12	314.04	0.20	0.24	0.22	0.25	0.19	0.14
Methyl Chloride	339.70	0.83	0.64	0.62	0.77	0.70	0.68
Freon-142b	346.30		0.09	0.09	0.06		0.13
Dichloromethane	518.77	0.06			0.06	0.09	0.29
3-Chloropropene	522.88					0.20	
Freon-113	531.54	0.26	0.21	0.22		0.38	0.37
1,1-Dichloethane	562.00			0.22			0.20
c-1,2-Dichloroethene	591.31					0.06	
1,2-Dichloropropane	679.55					0.25	
Perchloroethylene	805.33						0.10
o-Dichlorobenzene	1031.59		0.22				

SUM		**1.47**	**1.55**	**1.47**	**1.33**	**2.01**	**2.14**
Isoprene & Monoterpenes							
Isoprene	504.19	0.66	0.12	0.09	0.47	0.66	1.19
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.97	1.13	0.59	2.18	2.32	2.70
beta-Pinene	986.65	0.23	0.28		0.94	0.66	1.07
Limonene	1033.82	0.10	0.11		0.29	0.32	0.41
SUM		**1.96**	**1.64**	**0.68**	**3.88**	**3.96**	**5.37**
Ketones							
Acetone	476.37	7.91	2.21	3.42	13.93	9.15	4.96
MEK	577.35	1.30	0.66	0.40	3.58	2.29	0.58
2-Pentanone	667.26		0.08				
4-Methyl-2-Pentanone	721.82	0.4			1.16	0.64	
2,4-Dimethyl-3-Pentanone	762.30		4.10				
Cyclohexanone	870.91	0.16	0.36		0.17	0.21	0.29
2-Methyl-3-heptanone + Methylpropyldisulfide	922.24		0.87				
3-Octanone	926.94				0.20		
2- & 3-Methylcyclohexanone	930.96			0.49			
2-Octanone	971.63						0.13
Acetophenone	1048.17	0.34	0.37	0.34		34.19	
2-Nonanone	1073.92				0.73		
SUM		**10.11**	**8.65**	**4.65**	**19.77**	**46.48**	**5.96**
Olefins							
Ethylene	173.78	0.65	0.92	0.77	3.03	2.08	1.49
Propylene	289.65	0.42	0.41	0.23	1.82	1.42	0.98
Butene-1	389.97	0.31	0.13	0.34	0.95	0.70	0.55
Isobutylene	390.92		0.17				
1,3-Butadiene	394.58	0.15		0.09	0.49	0.35	0.20

c-Butene-2	425.94		0.07		0.16	0.14	
3-Methyl-1-Butene	457.43		0.11	0.22	0.13	0.36	
Pentene-1	489.36	0.26	0.24		0.23	0.10	
2-Methyl-1-Butene	496.17	0.16	0.23	0.14	0.69	0.48	0.12
cis-2-Pentene	516.35	0.09	0.21	0.17	0.15		
2-Methyl-2-Butene	521.04	0.13	0.52	0.25	0.43	0.21	
Cyclopentene	551.84		0.21	0.10	0.12		
4-Methyl-1-pentene	556.82			0.10			
2-Methyl-1-Pentene	588.52	0.28	0.21	0.17			
Hexene-1	589.36		0.19		0.30	0.13	0.12
trans-2-Hexene	604.98	0.12	0.25	0.12	0.11		
2-Methyl-2-Pentene	607.37	0.20	0.32	0.16	0.11		
cis-2-Hexene	614.50	0.08	0.24	0.12		0.08	
2,4-DiMethyl-1-Pentene	647.79	0.16				0.22	0.10
trans-3-Heptene	697.82	0.15	0.14				
2,4,4-TriMethyl-1-Pentene	712.30	0.31	0.09				
cis-2-Heptene	713.54				0.09		
Octene-1	789.04	0.08			0.09		0.11
trans-2-Octene	803.11		0.09		0.10	0.20	
cis-2-Octene	812.37	0.15	0.13		0.09	0.06	
2-Carene	1007.00					0.07	
Undecene-1	1089.44	0.51	0.25				
n-Tridecene-1	1289.33	0.34					
SUM		**4.55**	**5.13**	**2.98**	**9.09**	**6.60**	**3.67**
Paraffins							
Ethane	200.00	5.37	5.35	5.07	4.04	4.51	5.07
Propane	300.00	5.15	4.97	4.66	7.85	7.86	7.86
Isobutane	361.88	1.30	1.44	1.19	1.83	1.76	1.64
n-Butane	400.00	2.70	4.46	3.32	4.69	4.32	3.46
Isopentane	474.54	1.41	3.49	2.20	2.90	2.63	2.17

n-Pentane	500.00	1.01	2.10	1.38	5.11	1.64	1.07
2,2-Dimethylbutane	535.47	0.18	0.43	0.19	0.45	0.26	0.22
Cyclopentane	562.82	0.19	0.25		0.13	0.08	
2,3-Dimethylbutane	565.46	0.28	0.73	0.41	0.28	0.19	0.29
2-Methylpentane	570.09	2.92	2.85	1.18		1.13	0.97
3-Methylpentane	583.52	1.62	1.71	1.13	2.09	1.11	0.68
n-Hexane	600.00	1.49	1.60	1.09	6.98	2.72	0.57
2,2-DiMethylpentane	625.13	0.06	0.07	0.09			
Methylcyclopentane	627.20	0.89	1.20	0.71	1.77	0.80	
2,4-Dimethylpentane	631.38	0.38	0.50	0.22	0.17	0.16	0.19
2,2,3-TriMethylbutane	637.00	0.46	0.14		1.18	0.66	
Cyclohexane	660.96	0.28	0.38	0.29	0.14	0.34	0.15
2-Methylhexane	668.68	1.45	1.79	0.95	0.72	0.76	
2,3-Dimethylpentane	670.80	0.59	0.73	0.42	0.28		
3-Methylhexane + 3-Pentanone	677.22	2.20	2.67	1.22	1.31	0.63	0.89
3-EthylPentane	687.12	0.40	0.73	0.25	0.23		0.06
2,2,4-TriMethylpentane	690.72	2.87	3.85	1.71	0.95	0.60	0.47
n-Heptane	700.00	1.23	1.45	0.76	0.45	0.41	0.37
MethylCyclohexane	724.30	0.84	1.26	0.57	0.33	0.28	0.43
2,5-DiMethylhexane	733.56	0.40	0.55	0.19	0.16	0.17	
2,4-DiMethylhexane	735.91	0.82	1.40	0.41	0.24	0.22	0.38
3,3-DiMethylhexane	743.87	0.19	0.39	0.15	0.06	0.10	0.16
2,3,4-TriMethylpentane	753.56	1.57	2.19	0.65	0.89	0.57	0.27
2,3-DiMethylhexane	762.98	0.44		1.46	0.87	1.33	
2-Methylheptane	767.55	0.71	1.24	0.30	0.33	0.40	0.17
4-MeHeptane + 2-Hexanone	769.28	0.42	0.63	0.17	0.32	0.18	
3,4-DiMethylhexane	772.50	0.10	0.17	0.06			
3-Methylheptane	775.34	0.73	1.32	0.35	0.17	0.18	0.12
2,2,4-TriMethylhexane	794.85	0.17	0.19	0.07			
n-Octane	800.00	0.70	1.29	0.32	0.42	0.41	0.14
2,3,5-TriMethylhexane	819.44	0.18	0.24	0.12	0.13	1.50	0.10

2,4-DiMethylheptane	825.88	0.16	0.34	0.11		0.20	
4,4-DiMethylheptane	829.05				0.15	0.35	
2,6-DiMethylheptane	831.77	0.20	0.32	0.16			
1c2-DiMethylcyclohexane	834.70	0.06	0.22	0.09			
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.28	0.68	0.22	0.16	0.10	0.15
3,3-DiMethylheptane	841.50					0.22	
3-Methyloctane	873.73	0.30	0.78	0.25	0.19		
3,3-DiEthylpentane	884.00	1.00					
Nonane	900.00	0.29	0.71	16.88	0.15	0.15	
4,4-DiMethyloctane	925.00				0.32		
IsopropylCyclohexane	929.10	0.10	0.09		0.07	0.10	0.12
2,6-DiMethyloctane	937.70	0.22	0.66	0.69	0.14	0.14	0.28
2,3-Dimethyloctane	958.75	1.45	2.25	1.27	0.56	5.94	
2-Methylnonane	966.32	2.00					0.68
3-Methylnonane	973.55	0.23	0.40	0.13	0.09	0.50	
IsoButylcyclohexane	997.00		0.07		0.06		
n-Decane	1000.00	0.18	0.24	0.37	0.15	0.20	0.15
n-Undecane	1100.00	0.18	0.25	0.25	0.13	0.15	0.11
n-Dodecane	1200.00	0.35	0.28	0.14	0.14	0.13	
SUM		**48.74**	**60.98**	**53.81**	**49.78**	**46.09**	**29.39**
Phenols							
4-methylphenol		0.16	0.80	0.15	43.41	34.19	0.12
SUM		**0.16**	**0.80**	**0.15**	**43.41**	**34.19**	**0.12**
Sulfides							
DiMethylsulfide	507.30	0.83	0.53	0.16	6.80	3.96	0.22
2-Methylthiopropane	662.64						0.15
DiMethyldisulfide	729.82	0.21			2.05	1.30	
Methylethyldisulfide	822.98				0.09		

SUM		**1.04**	**0.53**	**0.16**	**8.94**	**5.26**	**0.37**
Unknowns							
Unknown	266.92					0.06	0.32
Unknown	323.07		0.07			0.07	0.16
Unknown	326.30	0.07			0.13	0.20	
Unknown	354.72					0.09	
Unknown	441.29				0.17		0.16
Unknown	447.17			0.35			0.10
Unknown	452.36		0.15				
Unknown	523.25		0.06				
Unknown	532.24				0.35		
Unknown	548.47				0.15		
Unknown	557.98	1.84				5.46	
Unknown	595.81			0.09			0.07
Unknown	602.24		0.11		0.31		
Unknown	610.49	0.13	0.27	0.12	0.07		
Unknown	617.91						0.08
Unknown	620.74	0.55	0.51	0.18	1.06		
Unknown	644.55	0.12		0.10		0.07	
Unknown	684.41	0.34	0.49	0.22	0.12	0.13	0.09
Unknown	695.08	0.07		0.08			
Unknown	701.86	0.43	0.51				
Unknown	704.63	0.08	0.17	0.06			0.07
Unknown	710.01	0.10	0.13	0.08	0.06		
Unknown	716.76				0.18		
Unknown	726.61	0.13	0.10			0.26	
Unknown	747.75		0.08	0.08			
Unknown	751.44	0.08	0.13				
Unknown	779.81						0.66
Unknown	781.70	0.20	0.43				

Unknown	783.92		0.13		0.10	0.06	
Unknown	785.98	0.32	0.62	0.16	0.08	0.07	
Unknown	791.10	0.15	0.23				
Unknown	793.28	0.09	0.12				
Unknown	796.71		0.13		0.12	7.90	
Unknown	805.65		0.06		0.07		
Unknown	815.37	0.11	0.13		0.45	0.22	
Unknown	844.42	0.10	0.18		0.12		
Unknown	847.21	0.08	0.15				
Unknown	860.26	0.11	0.22	0.09			
Unknown	894.35		0.12			0.06	
Unknown	897.75	0.16					
Unknown	908.79				1.85		
Unknown	933.29		0.23			0.07	0.08
Unknown	936.33		0.19				
Unknown	947.14	0.06					
Unknown	1025.79						0.13
Unknown	1036.98	0.46	0.57	0.36	0.19	0.27	
Unknown	1043.84				0.18	0.09	
Unknown	1073.24			0.06		0.35	
Unknown	1078.46	0.30	0.33	0.22			
Unknown	1119.01	0.35	0.33	0.29	0.14	0.13	0.28
Unknown	1123.00	0.52	0.30	0.37	0.13	0.08	
Unknown	1137.02	0.10	0.20				0.09
Unknown	1144.96	0.30	0.38	0.35	0.10		
Unknown	1148.05				0.15		0.10
Unknown	1153.22				0.16	0.17	0.08
Unknown	1156.53	0.71	0.70	0.51	0.19	0.38	
Unknown	1161.98	0.10	0.21	0.08			
Unknown	1168.51	0.13	0.16	0.14			
Unknown	1172.96	0.11	0.09			0.06	

Unknown	1175.95	0.25	0.39	0.13		0.08	
Unknown	1192.06	1.34	0.74	0.83	0.80		
Unknown	1204.30	0.16	0.10				
Unknown	1210.71		0.08	0.10			
Unknown	1215.69	0.09	0.14				
Unknown	1249.88	0.19	0.20		0.09		
Unknown	1257.73	0.33	0.88	0.15	0.16		0.36
Unknown	1291.80					0.64	
SUM		**10.76**	**11.83**	**5.20**	**7.68**	**17.18**	**2.83**
Total VOCs		**134.40**	**139.05**	**92.52**	**300.31**	**244.86**	**65.19**

Appendix 6 (Continued) VOCs (ppbC) detected at Howard Farm in December 2002

Canister #	**Retention**	**AQ-040**	**AQ-204**	**122**	**AQ-211**	**39**
Date	**Index #**	**12/11/02**	**12/11/02**	**12/12/02**	**12/13/02**	**12/12/02**
Time		**1258**	**1816**	**0:10**	**643**	**1318**
Location		**12:00 diurnal downwind of lagoon**	**1800 diurnal downwind of lagoon**	**00:00 diurnal downwind of lagoon**	**6:00 diurnal downwind of lagoon**	**next to solid separator running**
Temperature (Celcius)		**6.1**	**6.8**	**5.8**	**5.6**	**11.6**
Wind Speed (m/s)		**3.5**	**4**	**4**	**0**	**1.8**
Alcohols						
Methanol	408.00	1.28	0.95	1.45	1.97	0.98
n-propanol				0.13	0.15	
2-butanol					0.07	0.07
Ethanol	461.50		0.82	0.74	1.64	0.63
n-Butanol + Styrene	653.00	0.37	0.59	0.64	0.53	0.60
SUM		**1.65**	**2.36**	**2.96**	**4.36**	**2.28**
Aldehydes						
Acetaldehyde	372.25	0.95	1.18	3.08	1.85	1.28
Isobutanal	542.18	0.09				
Butanal	572.72		0.67	0.89	0.99	0.55
Isopentanal	635.89	0.15			0.14	
Hexanal	778.54		0.56		0.85	
Heptanal + Styrene	881.42	0.59	0.52	0.56	0.65	
Nonanal	1086.66	0.87		0.82		0.73
Decanal	1189.79	1.02				
SUM		**3.67**	**2.93**	**5.35**	**4.48**	**2.56**

Alkynes						
Acetylene	187.39	0.49	0.91	2.40	0.44	0.49
Propyne	328.11	0.33	0.20	0.32	0.17	0.30
SUM		**0.82**	**1.11**	**2.72**	**0.61**	**0.79**
Aromatics						
Benzene	651.21	1.36	1.71	3.53	1.26	1.53
Toluene	758.58	1.57	2.48	8.60	1.82	1.68
Ethylbenzene + 4-Heptanone	855.40	0.64	0.50	2.19	0.30	0.24
m-& p-Xylene	863.65	1.07	1.25	7.92	0.63	0.85
o-Xylene	887.56	0.42	0.42	3.29	0.24	0.90
Isopropylbenzene	920.34	0.17		0.27		0.21
Benzaldehyde	940.10			0.30	0.25	
n-Propylbenzene	950.95	0.06	0.30	0.65		0.17
p-Ethyltoluene	960.02		0.50	1.13		
1,3,5-TriMethylbenzene	964.32	0.30	0.69	1.21		
o-Ethyltoluene	976.97	0.24	0.53	0.91	0.56	0.14
1,2,4-TriMethylbenzene	991.48	0.40	1.75	3.41	0.67	0.44
Isobutylbenzene	1008.16			0.09		
sec-Butylbenzene	1010.39		0.25	0.08		
m-Cymene	1018.22			0.09		
1,2,3-TriMethylbenzene	1022.13	0.22	0.62	0.93	0.41	0.29
n-Butylbenzene	1054.69		0.84	0.87	0.20	0.70
1-Me-4-isoPropylbenzene	1059.44			0.17		
1-Me-2-n-Propylbenzene	1067.27		0.17	0.20	0.18	
1,4-DiMe-2-Ethylbenzene	1075.98		0.32	0.27	0.26	
1,2-DiMe-4-Ethylbenzene	1084.27	0.09	0.55	0.45	0.21	0.08
1,3-DiMe-2-Ethylbenzene	1092.85		0.07			
1,2-DiMe-3-Ethylbenzene	1107.49		0.15	0.09	0.12	
m-DiisoPropylbenzene	1152.00		0.16			
Dodecene-1 + Naphthalene	1189.56					0.93

1,3,5-TriEthylbenzene	1216.90	0.08	0.12			
1,2,4-TriEthylbenzene	1239.00		0.06			
SUM		**6.62**	**13.44**	**36.65**	**7.11**	**8.16**
Esters						
Methyl Butanate	706.79				0.09	
SUM		**0.00**	**0.00**	**0.00**	**0.09**	**0.00**
Halogenated Hydrocarbons						
Freon-22	304.94	0.15	0.22	0.13	0.16	0.19
Freon-12	314.04	0.31	0.35	0.31	0.32	0.25
Methyl Chloride	339.70	0.67	0.70	0.64	0.71	0.58
Freon-142b	346.30			0.18		0.19
Ethyl Chloride	433.37	0.13				
Freon-11	480.75	0.31				
Freon-113	531.54	0.36	0.17	0.29	0.26	0.36
1,1-Dichloethane	562.00				0.19	0.14
1,2-Dichloroethane	626.70	0.24			0.26	
Perchloroethylene	805.33		0.33		0.35	
Chlorobenzene	836.81			0.18		
o-Dichlorobenzene	1031.59		0.08			
SUM		**2.17**	**1.85**	**1.73**	**2.25**	**1.71**
Isoprene & Monoterpenes						
Isoprene	504.19	0.06	0.29	0.30	4.15	0.25
alpha-Pinene + 3,6-DiMethyloctane	943.64	2.54	1.92	0.86	1.97	3.24
Camphene	959.75					0.72
beta-Pinene	986.65	0.82	1.14	0.42	0.76	
Limonene	1033.82	0.59	0.19	0.18	0.74	0.15
SUM		**4.01**	**3.54**	**1.76**	**7.62**	**4.36**

Ketones						
Acetone	476.37	3.41	5.05	5.93	9.59	4.64
MEK	577.35		0.72	0.74	0.61	0.34
3-Heptanone	867.95	0.14	0.08	0.22		
Cyclohexanone	870.91	0.21	0.56		0.27	0.32
Acetophenone	1048.17	8.56	0.36	0.34	0.15	
SUM		**12.32**	**6.77**	**7.23**	**10.62**	**5.30**
Olefins						
Ethylene	173.78	1.44	1.99	3.13	1.20	1.58
Propylene	289.65	0.95	1.04	1.42	0.44	0.83
Butene-1	389.97	0.55	0.60	0.65	0.32	0.42
1,3-Butadiene	394.58	0.31	0.12	0.37	0.13	0.24
c-Butene-2	425.94			0.38		
3-Methyl-1-Butene	457.43	0.09	0.18	0.46	0.34	0.27
Pentene-1	489.36			0.23		
2-Methyl-1-Butene	496.17		0.16	0.37		
cis-2-Pentene	516.35	0.07		0.20		
2-Methyl-2-Butene	521.04		0.10	0.64	0.11	
Cyclopentene	551.84			0.14		
4-Methyl-1-pentene	556.82					0.11
2-Methyl-1-Pentene	588.52			0.26		
Hexene-1	589.36	0.15	0.13		0.14	
trans-2-Hexene	604.98		0.10	0.16	0.08	
2-Methyl-2-Pentene	607.37			0.20		
cis-2-Hexene	614.50			0.12		
2,4-DiMethyl-1-Pentene	647.79				0.07	
trans-3-Heptene	697.82			0.07		
2,4,4-TriMethyl-1-Pentene	712.30	0.12		0.06	0.23	
cis-2-Heptene	713.54			0.10		
Octene-1	789.04	0.11	0.10		0.16	

trans-2-Octene	803.11			1.42		
2-Carene	1007.00				0.09	
SUM		**3.79**	**4.52**	**10.38**	**3.31**	**3.45**
Paraffins						
Ethane	200.00	4.49	5.15	5.55	5.25	4.78
Propane	300.00	7.86	7.56	7.07	6.30	8.00
Isobutane	361.88	1.67	1.63	1.90	1.23	1.76
n-Butane	400.00	3.53	4.62	7.41	3.50	3.50
Isopentane	474.54	2.35	2.90	5.71	2.10	2.19
n-Pentane	500.00	1.01	1.39	2.77	1.04	1.11
2,2-Dimethylbutane	535.47	0.21	0.21	0.50	0.30	0.16
Cyclopentane	562.82	0.08	0.28	0.27		
2,3-Dimethylbutane	565.46	0.19	0.27	0.62	0.16	
2-Methylpentane	570.09	0.94	1.25	2.32	0.58	0.95
3-Methylpentane	583.52	0.61	0.84	1.65	0.61	0.65
n-Hexane	600.00	0.55	0.68	1.32	0.37	0.51
2,2-DiMethylpentane	625.13			0.06		
Methylcyclopentane	627.20		0.33	0.85		0.37
2,4-Dimethylpentane	631.38	0.21	0.37	0.39	0.21	0.27
Cyclohexane	660.96	0.12	0.21	0.39	0.11	0.27
2-Methylhexane	668.68	0.23		1.28		0.21
2,3-Dimethylpentane	670.80	0.31		0.66		0.33
3-Methylhexane + 3-Pentanone	677.22	0.75	0.79	1.85	1.07	0.65
3-EthylPentane	687.12	0.06		0.33		
2,2,4-TriMethylpentane	690.72	0.56	0.67	1.96	0.48	0.45
n-Heptane	700.00	0.44	0.35	1.35	0.25	0.38
MethylCyclohexane	724.30	0.29	0.30	0.83	0.38	0.30
2,5-DiMethylhexane	733.56	0.07	0.16	0.34		
2,4-DiMethylhexane	735.91		0.28	0.70	0.13	0.24
3,3-DiMethylhexane	743.87			0.23	0.17	

2,3,4-TriMethylpentane	753.56	0.22	0.39	1.08	0.27	0.16
2,3-DiMethylhexane	762.98	0.72	0.19	0.50	0.20	
2-Methylheptane	767.55	0.12	0.13	0.66	0.16	0.13
3-Methylheptane	775.34	0.16	0.11	0.69	0.10	0.11
n-Octane	800.00		0.23	0.50	0.18	0.36
2,3,5-TriMethylhexane	819.44	2.43	0.12	0.15	0.10	0.10
2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98			0.08		
2,4-DiMethylheptane	825.88	0.08		0.29		
2,6-DiMethylheptane	831.77	0.12		0.22		0.14
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60		0.17	0.54	0.15	
3-Methyloctane	873.73			0.38		
Nonane	900.00	0.20	0.14	0.35	0.28	0.14
2,2-DiMethyloctane	921.05		0.43			
3,5-DiMethyloctane	927.97		0.55			
IsopropylCyclohexane	929.10	0.06		0.22	0.08	
2,6-DiMethyloctane	937.70	0.12	0.40	0.37	0.18	0.16
3,4,5-TriMethylheptane	955.00	0.65				
2,3-Dimethyloctane	958.75	1.44	0.76	2.28	0.63	
2-Methylnonane	966.32				0.91	0.24
3-Methylnonane	973.55		0.17	0.26	0.14	
n-Decane	1000.00	0.18	0.22	0.27	0.14	0.16
nButCycHexan	1042.20				0.08	
n-Undecane	1100.00	0.13	0.25	0.23	0.14	0.15
n-Dodecane	1200.00		0.27	0.14	0.17	0.16
SUM		**33.16**	**34.77**	**57.46**	**28.15**	**29.09**
Phenols						
4-methylphenol		8.56	0.15	0.15	0.12	
SUM		**8.56**	**0.15**	**0.15**	**0.12**	
Sulfides						

DiMethylsulfide	507.30	0.22	0.12	0.48		0.12
2-Methylthiopropane	662.64	0.07				
DiMethyldisulfide	729.82				0.06	
SUM		**0.29**	**0.12**	**0.48**	**0.06**	**0.12**
Unknowns						
Unknown	266.92		0.26			0.25
Unknown	323.07			0.13	0.21	
Unknown	326.30		0.14	0.19		0.20
Unknown	350.47			0.10		
Unknown	354.72		0.12		0.25	0.22
Unknown	441.29	0.06			0.06	
Unknown	447.17	0.10				
Unknown	452.36		0.17			
Unknown	513.67	0.06				
Unknown	544.47		0.31			
Unknown	595.81				0.07	
Unknown	610.49			0.19		
Unknown	616.59				0.08	
Unknown	620.74			0.28	0.08	0.06
Unknown	644.55		0.18	0.11	0.17	
Unknown	684.41		0.10	0.26	0.08	
Unknown	704.63			0.09		
Unknown	710.01			0.23		
Unknown	716.76			0.06		
Unknown	726.61			0.12		
Unknown	779.81	0.68		0.31		0.79
Unknown	781.70			0.36		
Unknown	783.92				0.11	
Unknown	785.98	0.07	0.10	0.27		
Unknown	791.10			0.13		

Unknown	793.28	0.44				
Unknown	796.71	8.22				
Unknown	815.37			0.07		
Unknown	844.42		0.09	0.13		
Unknown	847.21			0.16		
Unknown	851.61				0.09	
Unknown	860.26			0.15		1.22
Unknown	894.35			0.11		
Unknown	908.79	0.09				
Unknown	916.10				0.58	
Unknown	933.29	0.08			0.13	0.12
Unknown	1036.98		0.27	0.42	0.26	
Unknown	1043.84			0.15		
Unknown	1073.24		0.18			
Unknown	1078.46		0.30	0.20		
Unknown	1119.01		0.40	0.20	0.24	0.29
Unknown	1123.00		0.54	0.15		
Unknown	1144.96	0.17	0.32	0.29	0.13	
Unknown	1148.05	0.10				0.11
Unknown	1153.22			0.14		
Unknown	1156.53	0.22	0.84	0.47	0.45	0.29
Unknown	1161.98		0.15	0.12		
Unknown	1168.51		0.18			
Unknown	1175.95	0.11		0.19		0.23
Unknown	1192.06		1.25	0.89	0.92	
Unknown	1204.30		0.12			
Unknown	1215.69				0.18	
Unknown	1257.73		0.20			
Unknown	1291.80			0.22		
SUM		**10.40**	**6.22**	**6.89**	**4.14**	**3.97**

Total VOCs	**87.46**	**77.78**	**133.76**	**72.87**	**61.60**	

***samples taken in conjunction with Duke University odor panel**
Samples selected for GC/MS analysis

Appendix 7 VOCs (ppbC) detected at RECIP (Corbett Farm # 2) in March 2003

Canister #		**39***	**AQ-204***	**AQ-185***	**115***
Date		**3/17/03**	**3/17/03**	**3/17/03**	**3/17/03**
Time		**12:40**	**13:05**	**13:42**	**13:42**
Location		**Site "A" Between House #1 & #2 variable wind**	**Site "B" 3 yds South of lagoon downwind**	**Site "C" Downwind of houses & recip**	**Site "C" Downwind of houses & recip**
Temperature (Celcius)		**23.9**	**23.9**	**25.6**	**25.6**
Wind Speed (m/s)			**0-2.5**	**0-2**	**0-2**
Alcohols					
Methanol	408.00	2.97	2.68	2.72	2.53
Ethanol	461.50	2.45	0.99	1.52	1.51
n-propanol		0.13	0.17		0.12
2-butanol					
n-Butanol + Thiophene	653.00	0.67	0.77	1.08	0.72
SUM		**6.22**	**4.61**	**5.32**	**4.88**
Aldehydes					
Acetaldehyde	372.25	3.34	2.75	2.75	3.94
Butanal	572.72	0.28	0.71	0.40	0.30
Isopentanal	635.89		0.14		
Hexanal	778.54	0.87	0.81	1.52	1.22
Heptanal + Styrene	881.42	0.80	0.95	1.64	0.95
Octanal	983.98	1.69	0.67	1.57	1.53
Nonanal	1086.66	1.49	0.51	0.74	1.94
Decanal	1189.79	1.19	0.63	2.24	1.25

SUM		**9.66**	**7.17**	**10.86**	**11.13**
Alkynes					
Acetylene	187.39	0.23	0.11	0.13	0.18
Propyne	328.11	0.18	0.32	0.46	0.28
SUM		**0.41**	**0.43**	**0.59**	**0.46**
Aromatics					
Benzene	651.21	0.54	0.47	0.61	0.41
Toluene	758.58	0.84	0.36	0.44	0.42
m-& p-Xylene	863.65	0.11	1		0.36
Isopropylbenzene	920.34				0.22
Benzaldehyde	940.10	0.54	0.26	0.33	0.21
m-Ethyltoluene	957.45		0.12	0.32	
1,3,5-TriMethylbenzene	964.32	1.47	1.50	2.07	2.19
1,2,4-TriMethylbenzene	991.48	0.21	0.18	0.18	
Isobutylbenzene	1008.16		0.12		
1,2,3-TriMethylbenzene	1022.13			0.14	
o-Cymene	1037.53			0.18	
1,Me-3-n-Propylbenzene	1049.14				
p-Diethylbenzene	1053.84	0.52		0.17	0.23
n-Butylbenzene	1054.69		0.28		
m-DiisoPropylbenzene	1152.00				0.76
t-1-But-4-Ethylbenzene	1183.89			0.09	
SUM		**4.23**	**4.29**	**4.53**	**4.80**
Esters					
Ethyl Formate	508.29			0.11	
Propyl Formate	608.87		0.26		
Butyl Propanante	888.77			0.17	0.20

SUM		**0.00**	**0.26**	**0.28**	**0.20**
Halogenated Hydrocarbons					
Freon-22	304.94		0.21	0.15	
Freon-12	314.04	0.23	0.19	0.33	0.28
Methyl Chloride	339.70	0.72	0.72	0.68	0.81
Freon-142b	346.30		0.27	0.15	
Freon-114	369.43				0.18
Ethyl Chloride	433.37	0.17			
Dichloromethane	518.77	0.14			
Freon-113	531.54	0.21	0.18		0.16
1,2-Dichloroethane	626.70	0.26			
Perchloroethylene	805.33	0.19		0.08	
SUM		**1.92**	**1.57**	**1.39**	**1.43**
Isoprene & Monoterpenes					
Isoprene	504.19		0.38	3.38	1.50
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.72	0.11	0.23	
Limonene	1033.82			0.12	
SUM		**0.72**	**0.49**	**3.73**	**1.5**
Ketones					
Acetone	476.37	6.39	8.37	8.26	9.39
Methacrolein	552.82			0.14	
MEK	577.35	0.42	0.85	1.09	0.58
3-Heptanone	867.95	0.21	0.12	0.13	0.16
Cyclohexanone	870.91	0.38	0.40	0.40	0.26
2-Methyl-3-Heptanone	922.24			0.07	
2-Octanone	971.63	0.45	0.12	0.30	
2-Nonanone	1073.92	0.29	0.27	0.39	0.14
SUM		**8.14**	**10.13**	**10.78**	**10.53**

Olefins					
Ethylene	173.78	0.64	0.56	0.51	0.50
Propylene	289.65	0.18	0.51	0.46	0.28
Butene-1	389.97	0.23	0.35	0.36	
1,3-Butadiene	394.58			0.18	
Pentene-1	489.36			0.24	
cis-2-Pentene	516.35				0.14
2-Methyl-2-Butene	521.04		0.35	0.12	0.12
Hexene-1	589.36			0.13	
trans-2-Hexene	604.98			0.28	
2,4-DiMethyl-1-Pentene	647.79	0.11	0.12	0.07	0.12
Heptene-1	689.22			1.09	
trans-3-Heptene	701.44		0.10		
2,4,4-TriMethyl-1-Pentene	712.30	0.29	0.18	0.16	
Octene-1	789.04	1.23	0.12	0.21	
Nonene-1	889.31		0.14		
2-Carene	1007.00	0.10			
Undecene-1	1089.44			0.17	
n-Tridecene-1	1289.33			0.85	
SUM		**2.78**	**2.43**	**4.83**	**1.16**
Paraffins					
Ethane	200.00	2.84	2.71	2.90	2.75
Propane	300.00	2.44	2.21	2.41	2.21
Isobutane	361.88	0.44	0.46	0.39	0.57
n-Butane	400.00	0.83	0.94	0.99	0.96
Isopentane	474.54	0.50	0.59	0.65	0.53
n-Pentane	500.00	0.23	0.30	0.32	0.22
2,2-Dimethylbutane	535.47	0.09		0.20	
2-Methylpentane	570.09	0.14			0.09

3-Methylpentane	583.52	0.53			
n-Hexane	600.00	0.99	0.08	0.24	0.29
Methylcyclopentane	627.20		0.07		
2,3-Dimethylpentane	670.80	0.27			
3-Methylhexane + 3-Pentanone	677.22	0.58	0.90	1.46	0.71
2,2,4-TriMethylpentane	690.72	0.14	0.32		0.09
n-Heptane	700.00			0.25	0.19
3,3-DiMethylhexane	743.87		0.26	0.07	
hexamethylcyclotrisiloxane	753.56		0.25	0.22	0.16
2,3-DiMethylhexane	762.98		0.15	0.10	
2-Methylheptane	767.55			0.06	
4-MeHeptane + 2-Hexanone	769.28	0.18			
n-Octane	800.00		0.14	0.08	
2,3,5-TriMethylhexane	819.44	0.11	0.41		0.25
4,4-DiMethylheptane	829.05	0.35	0.21		
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60		0.13		
3,3-DiMethylheptane	841.50	0.06			0.08
Nonane	900.00	0.38	0.18	0.20	0.18
2,2-DiMethyloctane	921.05		0.18		
Cyclooctane	928.80	0.07		0.11	0.06
2,3-DiMethyloctane	958.75	0.27			0.20
n-Decane	1000.00				0.11
+ n-Undecane	1100.00	0.10	0.11	0.12	
n-Dodecane	1200.00	0.26		0.34	
SUM		**10.28**	**9.24**	**10.54**	**8.77**
Phenols					
4-methylphenol		0.14		0.41	
SUM		**0.14**		**0.41**	
Sulfides					

DiMethylsulfide	507.30	0.26			
2-Methylthiopropane	662.64		0.13	0.12	
Dimethyldisulfide	729.82		0.08		
Methylethyldisulfide	822.91	0.10			
Methyl-sec-butyldisulfide	990.36			0.07	0.68
SUM		**0.36**	**0.21**	**0.19**	**0.68**
Unknowns					
Unknown	326.30			0.36	
Unknown	354.72	0.10	0.33		
Unknown	437.96			0.23	
Unknown	447.17		0.09		
Unknown	532.24			0.29	
Unknown	544.47			0.25	
Unknown	595.81	0.21	0.17		
Unknown	612.17				0.18
Unknown	638.63				0.35
Unknown	644.55	0.18	0.15	0.17	0.10
Unknown	747.75				0.22
Unknown	785.98			0.06	
Unknown	851.61	0.12		0.32	
Unknown	916.10	0.11			
Unknown	933.29		0.16	0.10	
Unknown	1013.63	2.25	1.29	1.70	1.54
Unknown	1027.85				0.18
Unknown	1040.81				0.21
Unknown	1119.01	0.31	0.35	0.24	0.25
Unknown	1137.02	0.12			
Unknown	1153.22	0.15	0.07	1.51	
Unknown	1156.53	0.28	0.15		
Unknown	1175.95	0.21		0.32	

Unknown	1215.69				0.17
Unknown	1257.73				0.11
Unknown	1263.87	0.13			
Unknown	1291.80				1.06
SUM		**4.17**	**2.76**	**5.55**	**4.37**
TOTAL VOCS		**49.03**	**43.59**	**59.00**	**49.91**

***samples taken in conjunction with Duke University odor panel**
Samples selected for GC/MS analysis

Appendix 8 VOCs (ppbC) detected at Stokes Farm in September 2002

Canister #	**Retention**	**2017**	**2009**	**115**	**AQ-026**	**AQ-105***	**AQ-204***
Date	**Index #**	**9/17/02**	**9/17/02**	**9/17/02**	**9/17/02**	**9/18/02**	**9/18/02**
Time		**655**	**1252**	**1848**	**0:16**	**1225**	**1220**
Location		**Diurnal NE lagoon 14 m W of pipe**	**Diurnal NE lagoon 14 m W of pipe**	**Diurnal NE lagoon 14 m W of pipe**	**Diurnal NE lagoon 14 m W of pipe**	**east end of lagoon**	**NW lagoon**
Temperature (Celcius)		**21.2**	**28.8**	**23.4**	**21.9**	**27.6**	**27.6**
Wind Speed (m/s)		**0.8**	**2.7**	**0**	**0**	**1.9**	**1.4**
Alcohols							
Methanol	408.00	5.09	6.03	4.92	8.52	8.14	5.67
Ethanol	461.50	3.14	4.31	2.11	2.34	4.30	1.78
n-Butanol + Thiophene	655.66	0.93	0.82	0.39	2.34	1.49	0.63
n-propanol	556.82		0.57	0.81		0.63	0.67
2-butanal		0.34	0.22	0.11	0.39	0.19	0.15
SUM		**9.50**	**11.95**	**8.34**	**13.59**	**14.75**	**8.90**
Aldehydes							
Acetaldehyde	372.25	21.55	10.80	5.29	5.72	7.74	5.73
Isobutanal	542.18	1.01					0.26
Butanal	572.72	2.03	1.89	0.73	3.05	1.51	1.04
Isopentanal	635.89	0.07	0.09	0.07	0.11	0.09	0.16
Hexanal	778.54	0.77		0.78	1.64	2.44	1.34
Heptanal + Styrene	881.42	1.08	0.51	1.38		2.09	1.21
Benzaldehyde	940.10	0.49	0.61	0.41	0.64	0.58	0.54
Octanal	983.98	0.38	0.49		1.12	3.16	2.05
Nonanal	1086.66	0.73	0.35	1.59	1.60	4.26	2.25
Decanal	1189.79	0.46		1.12	1.26	3.20	1.51
SUM		**28.57**	**14.74**	**11.37**	**15.14**	**25.07**	**16.09**

Alkynes							
Acetylene	187.39	12.51	0.23	0.23	0.45	0.43	0.26
Propyne	328.11	0.13	0.19	0.25	0.09	0.13	0.06
SUM		**12.64**	**0.42**	**0.48**	**0.54**	**0.56**	**0.32**
Aromatics							
Benzene	651.21	1.41	0.89	0.58	1.45	0.91	0.65
Toluene	758.58	2.18	1.83	0.84	2.51	1.78	0.52
Ethylbenzene + 4-Heptanone	855.40	0.33	0.33	0.19	0.51	0.26	0.20
m-& p-Xylene	863.65		0.55	0.47		0.58	
o-Xylene	887.56	0.65	0.42	0.16	0.63		
Isopropylbenzene	920.34		0.41		0.20	0.27	
n-Propylbenzene	950.95	0.14	0.12	0.11	0.11	0.13	
p-Ethyltoluene	960.02		0.26				
1,3,5-TriMethylbenzene	964.32	0.24	0.21	0.80	1.00	9.90	9.88
o-Ethyltoluene	976.97	0.29	0.20		0.40	0.30	
1,2,4-TriMethylbenzene	991.48	0.43	0.45	0.86	0.96	0.55	0.25
p-Dichlorobenzene	1005.93		0.17				
Isobutylbenzene	1008.16				0.28		
p-Cymene	1022.93	0.43	0.17	0.58	0.54	0.14	
m-Diethylbenzene	1046.57	0.16	0.10		0.07		
p-Diethylbenzene	1053.84	0.29	0.32	0.39		0.68	
n-Butylbenzene	1054.69				0.53		0.56
1-Me-4-isoPropylbenzene	1059.44				0.10		
1-Me-2-n-Propylbenzene	1067.27	0.13				0.13	
1,4-DiMe-2-Ethylbenzene	1075.98		0.10				
1,2-DiMe-4-Ethylbenzene	1084.27	0.07	0.09		0.15		
1,2-DiMe-3-Ethylbenzene	1107.49			0.12		0.24	
1,2,4,5-TetraMe-Benzene	1121.01	0.36	0.20				0.23
m-DiisoPropylbenzene	1152.00	0.06	0.79				
t-1-But-3,5-DiMeBenzene	1174.77					0.64	
1,2,4-TriChlorobenzene	1181.85		0.14				
SUM		**7.17**	**7.75**	**5.10**	**9.44**	**16.51**	**12.29**

Esters							
Ethyl Propanate	696.02				0.36		
Butyl Formate	708.48	0.30		0.17			
Butyl Propanante	888.77				0.60	0.42	
SUM		**0.3**	**0**	**0.17**	**0.96**	**0.42**	**0**
Ethers							
Furan	490.75			0.15	0.12		
SUM		**0**	**0**	**0.15**	**0.12**	**0.00**	**0.00**
Halogenated Hydrocarbons							
Freon-22	304.94	0.16	0.16	0.22	0.34	0.18	0.45
Freon-12	314.04	0.41	0.26	0.77	0.49	0.19	0.26
Methyl Chloride	339.70	0.87	0.64	0.90	0.67	0.71	0.65
Freon-142b	346.30	0.11	0.29	0.19	0.64	0.35	0.12
Freon-114	369.43						0.18
Dichloromethane	518.77	0.33	0.24	0.06	0.17	0.94	0.17
Freon-113	531.54	0.22	0.20	0.22	0.24	0.52	0.15
c-1,2-Dichloroethene	591.31			0.06			
1,2-Dichloroethane	626.70			0.15			0.07
1,2-Dichloropropane	679.55		0.24				
t-1,3-Dichlopropene	740.31				0.07		
1,1,2-Trichloroethane	747.16				0.08		
Perchloroethylene	805.33		2.56		0.26	0.18	0.07
SUM		**2.10**	**4.59**	**2.57**	**2.96**	**3.07**	**2.02**
Isoprene & Monoterpenes							
Isoprene	504.19	0.97	1.38	16.34	4.14	4.84	2.76
alpha-Pinene + 3,6-DiMethyloctane	943.64	3.93		2.66	8.70	0.89	0.37
Camphene + 2,6-DiMe-4-Heptanone	959.75	0.62		0.53	0.87	0.38	
beta-Pinene	986.65	1.04		1.19	2.95		
Limonene	1033.82	0.45		1.15	1.20	0.33	0.14
SUM		**7.01**	**1.38**	**21.87**	**17.86**	**6.44**	**3.27**

Ketones							
Acetone	476.37	21.08	19.82	12.04	21.70	19.71	21.15
MEK	577.35	2.59	2.26	1.16	3.04	1.31	1.51
2-Pentanone	667.26	0.1			0.14		
2-Methyl-3-Pentanone	734.78			10.31			
3-Heptanone	867.95	0.25	0.42		0.69		0.15
2-Heptanone	870.23	0.66	0.33	0.38	1.14		0.56
2-Methyl-3-Heptanone + MePropyldisulfide	922.24			0.16			
2-Octanone	971.63	0.21	0.17	0.12	0.42	0.34	0.13
Acetophenone	1048.17		0.06	0.14	0.32	0.24	0.20
2-Nonanone	1073.92	0.23		0.07	0.43	0.39	0.68
SUM		**25.12**	**23.06**	**24.38**	**27.88**	**21.99**	**24.38**
Olefins							
Ethylene	173.78	2.21	0.74	0.76	1.61	1.21	0.59
Propylene	289.65	1.28	0.24	0.47	1.19	0.56	0.39
Butene-1	389.97	0.51	0.57	0.27	0.95	0.48	0.11
1,3-Butadiene	394.58				0.29	0.15	0.15
c-Butene-2	425.94				0.11		
3-Methyl-1-Butene	457.43		0.31	0.18	0.36		
Pentene-1	489.36				0.75		
2-Methyl-1-Butene	496.17	0.26	0.18		0.27	0.11	
trans-2-Pentene	508.72		0.09		0.40		
cis-2-Pentene	516.35		0.26		0.11		
2-Methyl-2-Butene	521.04	0.41	0.39	0.06	0.19		
Cyclopentene	551.84			0.24		0.11	
Hexene-1	589.36				0.50	0.17	
2-Methyl-2-Pentene	607.37				0.07	0.17	
2,4-DiMethyl-1-Pentene	647.79	0.16	0.25	0.13	0.10	0.22	0.15
Cyclohexene	676.50				2.50		
Heptene-1	689.22			0.09	0.45		
trans-3-Heptene	697.82			0.36			

2,4,4-TriMethyl-1-Pentene	712.30				0.36	0.08	
Octene-1	789.04	0.11	0.29	0.06	0.42	0.19	0.18
3-Octene	796.71		0.13				
trans-2-Octene	803.11	0.45		1.72			
cis-2-Octene	812.37	0.17		0.09			
trans-3-Nonene	895.32		0.07				
cis-3-Nonene	898.03				0.40		
trans-2-Nonene	902.49					1.13	
Cyclooctene	903.75				0.43		
cis-2-Nonene	912.37					0.20	
Decene-1	989.42				0.41		
2-Carene	1007.00	0.23		0.40			
Undecene-1	1089.44		0.09				
n-Tridecene-1	1289.33				0.27	0.17	
SUM		**5.79**	**3.61**	**4.83**	**12.14**	**4.95**	**1.57**
Paraffins							
Ethane	200.00	2.82	4.05	5.64	5.17	3.95	4.16
Propane	300.00	11.54	3.05	3.80	7.04	3.08	2.87
Isobutane	361.88	0.88	0.70	0.69	1.39	0.59	0.39
n-Butane	400.00	1.67	1.34	1.17	2.24	1.18	0.70
Isopentane	474.54	2.81	1.80	2.25	4.05	1.34	0.67
n-Pentane	500.00	1.29	0.88	0.55	1.63	0.63	0.41
2,2-Dimethylbutane	535.47	0.66	0.55	0.29	0.42	0.21	
Cyclopentane	562.82				0.19		
2,3-Dimethylbutane	565.46	0.34	0.36	0.13	0.40	0.21	
2-Methylpentane	570.09	2.26	2.04	1.02	3.11	1.82	
3-Methylpentane	583.52	0.69	1.20	0.37	0.91	0.71	
n-Hexane	600.00	0.55	0.45	0.28	0.58	0.95	0.16
2,2-DiMethylpentane	625.13			0.07			
Methylcyclopentane	627.20	0.27	0.16		0.37	0.24	
2,4-Dimethylpentane	631.38		0.07		0.17	0.20	
2,2,3-TriMethylbutane	637.00				0.20		

Cyclohexane	660.96		0.09		0.19		
2-Methylhexane	668.68	1.58			1.70		
3-Methylhexane + 3-Pentanone	677.22	1.53	0.79	0.96		1.52	1.05
3-EthylPentane	687.12	0.25	0.07		0.13		
2,2,4-TriMethylpentane	690.72	0.70	0.47	0.24	0.81	0.71	0.39
n-Heptane	700.00	0.22	0.25		0.42	0.21	
MethylCyclohexane	724.30		0.22				
2,5-DiMethylhexane	733.56	0.18	0.06	2.17	0.09		
2,4-DiMethylhexane	735.91	0.54			0.49	0.08	
3,3-DiMethylhexane	743.87	0.08	0.19		0.11		
hexamethylcyclotrisiloxane	753.56	0.38	0.34	0.19	0.87	0.35	
2,3-DiMethylhexane	762.98						0.21
2-Methylheptane + 3-Methylthiophene	767.55	0.16	0.29		0.16	0.06	
3-Methylheptane	775.34		0.06		0.13		
Cycloheptane	798.00			0.18			
n-Octane	800.00	0.16	0.12		0.21	0.21	0.08
2,3,5-TriMethylhexane	819.44	0.27	0.15	0.75	0.36	0.31	0.59
2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98	0.13					
4,4-DiMethylheptane	829.05			0.57		0.33	0.26
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	11.50		0.11	0.25	0.07	
3,3-DiMethylheptane	841.50				0.17		
Nonane	900.00	0.18	0.12	0.28	0.28	0.10	0.71
4,4-DiMethyloctane	925.00						0.44
IsopropylCyclohexane	929.10	0.12			0.09		
2,6-DiMethyloctane	937.70	0.65	0.23	0.25	0.39		
2,3-DiMethyloctane	958.75	0.28	0.21		0.39	0.24	0.16
IsoButylcyclohexane	997.00					0.06	
n-Decane	1000.00	0.15	0.17	0.13	0.33	0.28	0.11
+ n-Undecane	1100.00	0.10	0.27	0.06	0.33	0.18	0.13
n-Dodecane	1200.00	0.07	0.25	0.14	0.18	0.15	0.14
SUM		**45.01**	**21.00**	**22.29**	**35.95**	**19.97**	**13.63**

Phenols

4-Methylphenol	1049.14	0.16	0.06	0.14	0.32	0.24	0.2
SUM		0.16	**0.06**	**0.14**	**0.32**	**0.24**	**0.2**
Sulfides							
DiMethylsulfide	507.30	0.70		0.06	0.20	0.17	0.24
2-Methylthiopropane	662.64				0.19		0.17
DiMethyldisulfide	729.82				0.08		
MeEthyldisulfide	822.98	0.26			0.12		
2-Ethylthiophene	857.11	3.45					
2,5-Dimethylthiophene	862.37	2.3					
MePropyldisulfide	916.10					0.31	
SUM		**6.71**	**0.00**	**0.06**	**0.59**	**0.48**	**0.41**
Unknowns							
Unknown	266.92	0.10	0.33		1.15		0.12
Unknown	316.37		0.29				
Unknown	323.07				0.12	0.06	0.15
Unknown	326.30	0.09					
Unknown	350.47			0.10			
Unknown	354.72	0.06			0.19	0.21	
Unknown	437.96						
Unknown	447.17				0.08	0.22	
Unknown	452.36				0.09		
Unknown	469.37				1.30		
Unknown	513.67	0.13					
Unknown	595.81		0.22	0.24			0.15
Unknown	610.49	0.14			0.08		
Unknown	616.59	0.11	0.08		0.38		
Unknown	617.91					0.14	
Unknown	620.74				1.19		
Unknown	644.55		0.29	0.18		0.27	0.16
Unknown	684.41				0.10	0.09	
Unknown	695.08					0.07	

Unknown	708.41				0.08		0.27
Unknown	710.01		0.24				
Unknown	716.76	0.10				0.09	
Unknown	726.61	0.06	0.11				
Unknown	747.75			0.30		0.14	
Unknown	783.92				0.07		
Unknown	785.98	0.08			0.10		
Unknown	793.28	0.06			0.11		0.16
Unknown	815.37	0.09				0.17	
Unknown	844.42						0.09
Unknown	847.21				0.24		
Unknown	851.61		0.06			0.13	
Unknown	894.35			0.45			
Unknown	905.72		0.10				1.10
Unknown	908.79	0.10			0.19		
Unknown	910.70		0.12			0.31	
Unknown	916.10			0.06			
Unknown	933.29	0.40	0.09		0.24		
Unknown	936.33					0.22	0.21
Unknown	947.14		0.08				
Unknown	988.06					0.24	0.13
Unknown	995.10		0.08				
Unknown	1013.63		0.59	1.32		1.29	
Unknown	1025.79				0.11		
Unknown	1027.85			0.27			
Unknown	1036.98		0.31			0.16	
Unknown	1040.81	0.10		0.12			
Unknown	1043.84					0.06	
Unknown	1078.46	0.08					
Unknown	1119.01				0.20	0.11	
Unknown	1123.00				0.08	0.17	
Unknown	1125.95		0.20				
Unknown	1128.86	0.16					

Unknown	1137.02	0.15			0.09		0.09
Unknown	1148.05	0.08		0.37	0.35	0.17	0.28
Unknown	1153.22			0.80	0.47		
Unknown	1156.53	0.33			0.36		
Unknown	1161.98				0.08		
Unknown	1164.70						0.25
Unknown	1168.51		0.19				
Unknown	1175.95			0.08	0.33		0.60
Unknown	1192.06		0.51				
Unknown	1207.53			0.13	0.06		
Unknown	1215.69	0.24			0.08		0.25
Unknown	1224.38		0.38				
Unknown	1254.24				0.13	0.07	
Unknown	1263.87			0.15			0.34
Unknown	1272.12	0.13		0.20			
Unknown	1291.80	0.16	0.80	0.39		0.44	
SUM		**3.07**	**5.07**	**5.29**	**8.13**	**4.78**	**4.35**
Total VOCs		**153.15**	**93.63**	**107.04**	**145.62**	**119.28**	**87.53**

Appendix 8 (Continued) VOCs (ppbC) detected at Stokes Farm in September 2002

Canister # **Date** **Time** **Location**	**Retention Index #**	**AQ-022*** **9/18/02** **1250** **by house spraying occurring**	**AQ-080** **9/19/02** **1235** **by house no fan mesh fencing**	**39** **9/19/02** **1237** **upwind of lagoon/ houses**	**AQ-040** **9/19/02** **1243** **downwind of lagoon/ houses**	**AQ-171** **9/19/02** **1230** **downwind boundary spraying occurring**
Temperature (Celcius)		**27.5**	**28.5**	**28.2**	**28.2**	**28.7**
Wind Speed (m/s)		**1.3**	**1.2**	**1.1**	**1.5**	**0.6**
Alcohols						
Methanol	408.00	5.66	14.83	4.05	2.99	2.25
Ethanol	461.50	10.05	38.09	1.20	0.52	0.54
n-Butanol + Thiophene	655.66	0.87		0.64	0.67	0.67
n-propanol	556.82	0.65	14.75	0.55	0.70	0.54
2-butanal		0.25	10.55			
SUM		**17.48**	**78.22**	**6.44**	**4.88**	**4.00**
Aldehydes						
Acetaldehyde	372.25	5.50	7.81	5.46	4.43	5.43
Isobutanal	542.18		0.72			
Butanal	572.72	1.19		0.96	1.17	1.59
Isopentanal	635.89					0.07
Pentanal	675.78			0.08		
Hexanal	778.54	1.58	2.29	1.02	1.12	1.45
Heptanal + Styrene	881.42	1.57	1.55	0.89	0.84	1.42
Benzaldehyde	940.10			0.36		
Octanal	983.98	2.35	1.63	1.48	0.89	1.08
Nonanal	1086.66	3.01	2.00	2.36	0.94	0.88

Decanal	1189.79	1.42	0.69		0.90	0.93
SUM		**16.62**	**16.69**	**12.61**	**10.29**	**12.85**
Alkynes						
Acetylene	187.39	0.43	2.1	0.17	0.12	0.34
SUM		**0.43**	**2.10**	**0.17**	**0.12**	**0.34**
Aromatics						
Benzene	651.21	0.67	0.67	0.43	0.57	0.57
Toluene	758.58	1.50	0.88	0.32	0.29	0.49
Ethylbenzene + 4-Heptanone	855.40	0.21	0.20	0.16	0.13	0.10
m-& p-Xylene	863.65	0.16	0.12	0.08		
1,3,5-TriMethylbenzene	964.32	9.96	2.53	0.49	0.91	1.04
o-Ethyltoluene	976.97	0.10		0.23	0.15	
1,2,4-TriMethylbenzene	991.48	0.24	0.32	0.42	0.22	0.36
m-Dichlorobenzene	1001.00		0.14	0.32		
p-Dichlorobenzene	1005.93			0.19		
Isobutylbenzene	1008.16		0.11			0.13
p-Cymene	1022.93		0.1	0.2	0.26	0.07
m-Diethylbenzene	1046.57					0.08
p-Diethylbenzene	1053.84			0.72		0.30
1-Me-2-n-Propylbenzene	1067.27	0.11				
1,2-DiMe-3-Ethylbenzene	1107.49	0.12		0.25	0.13	
1,2,4,5-TetraMe-Benzene	1121.01					
m-DiisoPropylbenzene	1152.00		0.25		0.64	
Dodecene-1 + Naphthalene	1189.56			2.77		
SUM		**13.07**	**5.32**	**6.58**	**3.30**	**3.14**
Esters						
Methyl Propanate	618.54				0.46	
Propyl Acetate	697.61					0.10
Butyl Formate	708.48		0.15			
	806.32					0.30

Methyl Pentanate						
Butyl Propanante	888.77				0.23	
SUM		**0**	**0.15**	**0**	**0.69**	**0.4**
Ethers						
3-Methylfuran	602.80					0.13
SUM		**0**	**0.00**	**0.00**	**0.00**	**0.13**
Halogenated Hydrocarbons						
Freon-22	304.94	0.15	0.11	0.09	0.10	0.14
Freon-12	314.04	0.21	0.28	0.25	0.48	0.47
Methyl Chloride	339.70	1.01	0.61	0.60	0.55	0.72
Freon-142b	346.30	0.26	0.45	0.19	0.19	0.16
Ethyl Chloride	433.37		0.19			
Dichloromethane	518.77				0.09	
Freon-113	531.54	0.19	0.25	0.25	0.41	0.19
1,2-Dichloroethane	626.70		0.37			
1,2-Dichloropropane	679.55		0.63			
c-1,3-Dichlopropene	720.09		0.09			0.08
Perchloroethylene	805.33	0.16				
SUM		**1.98**	**2.98**	**1.38**	**1.82**	**1.76**
Isoprene & Monoterpenes						
Isoprene	504.19	2.35	6.20	4.36	1.11	2.56
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.32	0.40		1.65	2.71
Camphene + 2,6-DiMe-4-Heptanone	959.75				0.29	0.24
beta-Pinene	986.65				0.29	0.67
Limonene	1033.82	0.15	0.23	0.32	0.15	0.21
SUM		**2.82**	**6.83**	**4.68**	**3.49**	**6.39**
Ketones						
Acetone	476.37	18.83	24.40	11.49	11.79	10.83
Methacrolein	552.82		0.44			

MEK	577.35	1.22	3.44	1.25	0.98	1.20
4-Methyl-2-Pentanone	721.82	5.02	0.62			
3-Heptanone	867.95	0.09	0.09	0.19	0.16	0.09
2-Heptanone	870.23	0.39	0.45	0.48	0.37	0.75
2-Methyl-3-Heptanone + MePropyldisulfide	922.24	0.15	0.11		0.07	
2-Octanone	971.63	0.15	0.31		0.22	0.28
Acetophenone	1048.17	1.61		0.12	0.41	
2-Nonanone	1073.92	0.20			0.29	0.17
SUM		**27.66**	**29.86**	**13.53**	**14.29**	**13.32**
Olefins						
Ethylene	173.78	0.62	0.36	0.72	0.91	0.85
Propylene	289.65	0.25	0.54	0.30	0.66	0.35
Butene-1	389.97		0.51	0.29	0.35	
Isobutylene	390.92					0.34
1,3-Butadiene	394.58		0.18			
3-Methyl-1-Butene	457.43		0.06			
Pentene-1	489.36				0.12	0.07
2-Methyl-1-Butene	496.17		0.18			0.14
cis-2-Pentene	516.35		0.15		0.06	0.15
2-Methyl-2-Butene	521.04		0.16	0.13		
Cyclopentene	551.84	0.11				0.08
2-Methyl-1-Pentene	588.52		0.45			
Hexene-1	589.36				0.50	0.15
trans-2-Hexene	604.98	0.26			0.22	
cis-2-Hexene	614.50		0.14	0.16		
2,4-DiMethyl-1-Pentene	647.79	0.23		0.19		0.12
Cyclohexene	676.50		0.85			
Heptene-1	689.22		0.09			0.37
trans-3-Heptene	697.82		0.13	0.48		
2,4,4-TriMethyl-1-Pentene	712.30		0.24		0.30	0.10
3-&4-MethylCyclohexene	738.50			0.20		
Octene-1	789.04	0.30	0.19	0.32	0.15	0.18

3-Octene	796.71		1.05			0.07
trans-2-Octene	803.11		0.09			
cis-2-Octene	812.37		0.12			
Nonene-1	889.31	0.44	0.11			0.22
Decene-1	989.42				0.07	0.12
2-Carene	1007.00	0.09				0.08
n-Tridecene-1	1289.33		0.06			
SUM		**2.30**	**5.66**	**2.79**	**3.34**	**3.39**
Paraffins						
Ethane	200.00	4.18	4.10	2.29	2.10	2.37
Propane	300.00	2.71	2.94	1.62	1.58	2.41
Isobutane	361.88	0.41	0.42	1.46	0.38	4.11
n-Butane	400.00	0.82	0.95	0.50	0.45	0.62
Isopentane	474.54	0.62	0.66	0.61	1.56	1.87
n-Pentane	500.00	0.39	2.35	0.26	0.23	0.20
2,2-Dimethylbutane	535.47	0.23	0.24			
2,3-Dimethylbutane	565.46					0.16
2-Methylpentane	570.09					0.87
3-Methylpentane	583.52	0.40	0.18			
n-Hexane	600.00	0.26	0.38	0.36	0.08	0.18
2,2-DiMethylpentane	625.13		0.07			
Methylcyclopentane	627.20	0.09				
2,4-Dimethylpentane	631.38			0.18		
2,2,3-TriMethylbutane	637.00		1.16			
Cyclohexane	660.96					0.36
2-Methylhexane	668.68		0.64			
3-Methylhexane + 3-Pentanone	677.22	0.86		0.76	0.92	1.25
3-EthylPentane	687.12					
2,2,4-TriMethylpentane	690.72	0.28	0.16	0.33	0.50	
n-Heptane	700.00	0.11	0.32		0.17	0.14
hexamethylcyclotrisiloxane	753.56	0.11	0.61	0.23	0.14	0.13
2-Methylheptane + 3-Methylthiophene	767.55	0.16		0.06		

3-Methylheptane	775.34	0.07				
n-Octane	800.00	0.07	0.25		0.15	
2,3,5-TriMethylhexane	819.44	0.28		0.47		
2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98		0.09			
4,4-DiMethylheptane	829.05	0.33	0.22	0.27		
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.27	0.32			
3,3-DiMethylheptane	841.50					0.76
Nonane	900.00	0.13		5.58	0.11	
IsopropylCyclohexane	929.10	0.07				0.13
2,6-DiMethyloctane	937.70	0.13			0.16	
3,3-DiMethyloctane	942.00	0.53	1.08		0.52	0.51
2,3-DiMethyloctane	958.75	0.13				
n-Decane	1000.00	0.14			0.18	0.12
n-Undecane	1100.00	0.11	0.20		0.13	0.07
n-Dodecane	1200.00		0.14		0.10	
SUM		**13.89**	**17.48**	**14.98**	**9.46**	**16.26**
Phenols						
4-Methylphenol	1049.14	1.61	33.12		0.51	0.22
SUM		**1.61**	**33.12**			**0.22**
Sulfides						
DiMethylsulfide	507.30	0.00	2.35		0.08	
2-Methylthiopropane	662.64					
DiMethyldisulfide	729.82	0.1	3.33			0.09
MeEthyldisulfide	822.98				0.15	
2-Ethylthiophene	857.11					0.43
2,5-Dimethylthiophene	862.37	0.06	0.06			
SUM		**0.16**	**5.74**	**0.00**	**0.23**	**0.52**
Unknowns						
Unknown	266.92	0.15		0.32		
Unknown	323.07		0.21			

Unknown	326.30				0.45	
Unknown	350.47		0.08			
Unknown	354.72	0.13	0.08	0.24	0.32	0.32
Unknown	437.96		0.08	0.19		
Unknown	447.17			0.09		
Unknown	523.25				0.19	
Unknown	595.81	0.25				
Unknown	610.49		0.07			0.31
Unknown	616.59	0.26				
Unknown	617.91					0.13
Unknown	620.74		0.42			
Unknown	638.63			0.38	0.18	
Unknown	644.55	0.16				0.11
Unknown	704.63		0.14			
Unknown	708.41	0.16				
Unknown	726.61		0.14			
Unknown	747.75	0.10				
Unknown	785.98	0.31				
Unknown	793.28	0.14	0.11		0.86	0.09
Unknown	815.37	0.06	0.26			
Unknown	851.61				0.11	
Unknown	860.26					0.57
Unknown	894.35	0.08			0.08	
Unknown	908.79	0.21				
Unknown	916.10			1.37	0.09	
Unknown	923.10			0.55		
Unknown	933.29		0.11		0.09	
Unknown	936.33		0.20	0.23		0.37
Unknown	995.10	0.06				
Unknown	1013.63	0.64		1.86	0.71	0.57
Unknown	1027.85			0.23		0.11
Unknown	1036.98	0.06			0.14	0.17
Unknown	1073.24		1.17	0.44		

Unknown	1094.62	0.07				
Unknown	1119.01	0.16		0.33	0.12	
Unknown	1128.86	0.12				
Unknown	1137.02	0.09	0.11			
Unknown	1148.05	0.15		0.11	0.12	0.09
Unknown	1153.22					0.49
Unknown	1156.53		0.24		0.30	
Unknown	1175.95	0.47	0.30	0.22		0.39
Unknown	1207.53					0.09
Unknown	1215.69				0.50	
Unknown	1220.30			0.21		
Unknown	1232.94		0.12			
Unknown	1249.88				0.14	0.06
Unknown	1254.24	0.06		0.80		
Unknown	1275.66			0.25		
Unknown	1291.80	0.16	0.18	0.35	0.57	0.26
SUM		**4.05**	**4.02**	**8.17**	**4.97**	**4.13**
Total VOCs		**102.07**	**208.17**	**71.33**	**56.88**	**66.85**

***samples taken in conjunction with Duke University odor panel**
Samples detected for GC/MS analysis

Appendix 9 VOCs (ppbC) detected at Stokes Farm in January 2003

Canister #	**Retention**	**AQ-125**	**1870**	**AQ-128***	**122***	**AQ-026***
Date	**Index #**	**1/7/03**	**1/7/03**	**1/14/03**	**1/14/03**	**1/14/03**
Time		**1205**	**1205**	**1251**	**1329**	**1357**
Location		**15 m downwind of barns**	**Between barns South edge**	**Upwind some odor**	**Between barns**	**Between barn and lagoon**
Temperature (Celcius)		**4**	**4**	**7.1**	**7.4**	**7.4**
Wind Speed (m/s)			**5**	**1.5**	**1.7**	**0.9**
Alcohols						
Methanol	408.00	1.51	1.17	1.20	1.81	2.45
Ethanol	461.50	1.71	1.84	1.63	2.36	0.83
n-Propanol	556.82			0.11	0.11	
2-butanol		0.06				
n-Butanol + Thiophene	653.00	0.48		0.24	0.34	0.31
SUM		**3.76**	**3.01**	**3.18**	**4.62**	**3.59**
Aldehydes						
Acetaldehyde	372.25	1.29	1.02	0.69	1.98	1.31
Butanal	572.72	0.94	0.15	0.32	0.25	0.32
Isopentanal	635.89	0.07	0.09	0.34	0.19	0.08
Pentanal	675.78		0.07			
Hexanal	778.54	0.81				
Heptanal + Styrene	881.42	2.03	0.36	0.37		0.33
Heptanal	880.95	2.03				
Octanal	983.98	0.72	0.41		0.26	
Nonanal	1086.66	0.85	0.46	0.36	0.35	
Decanal	1189.79		0.55	0.54	0.43	
SUM		**8.74**	**3.11**	**2.62**	**3.46**	**2.04**

Alkynes						
Acetylene	187.39	0.31	0.36	0.42	0.32	0.52
Propyne	328.11				0.10	0.19
SUM		**0.31**	**0.36**	**0.42**	**0.42**	**0.71**
Aromatics						
Benzene	651.21	0.87	0.92	1.23	1.14	1.15
Toluene	758.58	0.82	0.96	1.41	1.17	1.78
Ethylbenzene + 4-Heptanone	855.40		0.16	0.28	0.18	0.27
m-& p-Xylene	863.65		0.31	0.42	0.33	0.35
o-Xylene	887.56	0.19	0.17	0.31	0.21	0.34
Isopropylbenzene	920.34			0.11		
n-Propylbenzene	950.95		0.07		0.06	0.13
p-Ethyltoluene	960.02	0.07	0.12			
o-Ethyltoluene	976.97		0.13			
1,2,4-TriMethylbenzene	991.48	0.55	0.71	0.26	0.24	0.35
p-Dichlorobenzene	1005.93		0.17			
Isobutylbenzene	1008.16	0.12				
1,2,3-TriMethylbenzene	1022.13		0.21	0.21		0.11
p-Cymene	1022.93				0.11	
m-Diethylbenzene	1046.57		0.12			
p-Diethylbenzene	1053.84			0.26		
n-Butylbenzene	1054.69		0.73		0.11	0.31
1-Me-4-isoPropylbenzene	1059.44	0.30				
1-Me-2-n-Propylbenzene	1067.27	0.06	0.15	0.44		
1,4-DiMe-2-Ethylbenzene	1075.98		0.43			
1,2-DiMe-4-Ethylbenzene	1084.27		0.36			0.07
1,3-DiMe-2-Ethylbenzene	1092.85	0.54				
1,2-DiMe-3-Ethylbenzene	1107.49	0.31	0.07			0.19
1,2,4,5-TetraMe-Benzene	1121.01					
m-DiisoPropylbenzene	1152.00		0.12			
1,2,4-TriChlorobenzene	1181.85	0.26				
t-1-But-4-Ethylbenzene	1183.89					

1,3,5-TriEthylbenzene	1216.90		0.19			
1,2,4-TriEthylbenzene	1239.00					
SUM		**4.09**	**6.10**	**4.93**	**3.55**	**5.05**
Esters						
Butyl Acetate	796.12	0.06				
SUM		**0.06**	**0**	**0**	**0**	**0**
Halogenated Hydrocarbons						
Freon-22	304.94	0.16	0.15	0.26	0.17	0.13
Freon-12	314.04	0.38	0.21	0.24	0.28	0.25
Methyl Chloride	339.70	0.66	0.81	0.70	0.75	0.71
Freon-142b	346.30	0.09	0.17		0.10	0.15
Dichloromethane	518.77	0.12	0.07		0.08	
Freon-113	531.54	0.25	0.23	0.28	0.21	0.23
1,1-Dichloethane	562.00	0.18		0.21	0.15	0.23
1,2-Dichloroethane	626.70	0.22	0.23	0.25	0.48	0.31
SUM		**2.06**	**1.87**	**1.92**	**2.22**	**2.01**
Isoprene & Monoterpenes						
Isoprene	504.19	0.23	0.39	0.25		0.19
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.25		0.68	0.21	0.49
beta-Pinene	986.65			0.47		0.38
Limonene	1033.82	0.09				0.23
SUM		**0.57**	**0.39**	**1.40**	**0.21**	**1.29**
Ketones						
Acetone	476.37	0.37	3.94	2.93	3.14	3.42
MEK	577.35	0.59	0.33	0.24	0.30	0.31
4-Methyl-2-Pentanone	721.82	0.07				
Cyclohexanone	870.91	0.60	0.41	0.37		0.25
2-Methyl-3-Heptanone + Methylpropyldisulfide	922.24		0.23			
Benzaldehyde	940.10	0.21			0.06	

2-Octanone	971.63	0.21	0.31	0.13	0.09	
2-Nonanone	1073.92					0.41
Acetophenone	1048.17		0.13		0.09	
SUM		**2.05**	**5.35**	**3.67**	**3.68**	**4.39**
Olefins						
Ethylene	173.78	0.60	0.61	1.06	0.95	1.25
Propylene	289.65	0.28	0.23	0.30	0.16	0.35
Butene-1	389.97					0.27
Isobutylene	390.92			0.16		
1,3-Butadiene	394.58					0.16
3-Methyl-1-Butene	457.43			0.26	0.11	
2-Methyl-1-Butene	496.17				0.10	
2-Methyl-2-Butene	521.04				0.16	0.09
Cyclopentene	551.84					0.15
Hexene-1	589.36	0.08				
trans-2-Hexene	604.98					0.19
2,4-DiMethyl-1-Pentene	647.79	0.09			0.09	
cis-2-Heptene	713.54	0.10				
2-Ethyl-1-Hexene	787.50					0.59
Octene-1	789.04	0.07				
cis-2-Octene	812.37		0.08			
Cyclooctene	903.75	0.19				
Undecene-1	1089.44		0.48			
Dodecene-1 + Naphthalene	1189.56	1.50				
SUM		**1.50**	**1.40**	**1.78**	**1.57**	**3.05**
Paraffins						
Ethane	200.00	4.20	4.16	7.57	7.03	7.11
Propane	300.00	3.74	3.85	7.47	7.16	7.39
Isobutane	361.88	1.06	1.01	1.52	1.51	1.72
n-Butane	400.00	2.09	2.05	3.59	3.68	3.68
Isopentane	474.54	1.10	0.99	1.85	1.69	1.72

n-Pentane	500.00	0.69	0.66	1.09	1.13	1.08
2,2-Dimethylbutane	535.47	0.10	0.22	0.38	0.13	0.21
2,3-Dimethylbutane	565.46	0.11	0.21	0.15	0.18	0.12
2-Methylpentane	570.09	0.30	0.30	0.52	0.52	0.37
3-Methylpentane	583.52	0.58	0.53	0.44	0.83	0.52
n-Hexane	600.00	0.60	0.64	0.75	1.13	0.52
2,4-Dimethylpentane	631.38	0.09	0.10	0.17	0.14	
Cyclohexane	660.96	0.12		0.14	0.14	0.24
2-Methylhexane	668.68		0.12	0.21	0.18	0.18
2,3-Dimethylpentane	670.80		0.35	0.28	0.25	0.30
3-Methylhexane + 3-Pentanone	677.22	0.94		0.74	0.27	0.52
3-EthylPentane	687.12			0.07		0.08
2,2,4-TriMethylpentane	690.72	0.14	0.20	0.52	0.33	0.33
n-Heptane	700.00	0.21	0.25	0.32	0.31	0.32
MethylCyclohexane	724.30	0.24	0.33		0.21	0.47
2,4-DiMethylhexane	735.91		0.14		2.75	0.36
3,3-DiMethylhexane	743.87	0.12			0.14	
2,3,4-TriMethylpentane	753.56	0.41	1.50	0.10	0.14	
2,3-DiMethylhexane	762.98				0.10	
2-Methylheptane	767.55	0.09	0.10	0.13	0.57	
3-Methylheptane	775.34		0.06		0.16	
n-Octane	800.00	0.08	0.09	0.15	0.09	0.16
2,3,5-TriMethylhexane	819.44	0.11		0.46	0.08	0.20
2,2-DiMeHeptane + 3-Me-3-Hexanone	821.98	0.24				
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.08	0.30			
Nonane	900.00		0.20	0.08	0.17	0.23
2,2-DiMethyloctane	921.05				0.09	
Cyclooctane	928.80	0.17				
IsopropylCyclohexane	929.10		0.08			
2,6-DiMethyloctane	937.70	0.9	0.24	0.19	0.12	0.17
2,3-Dimethyloctane + m-Ethyltoluene	958.75	0.06	0.11	0.40	0.07	0.31
2-Methylnonane	966.32	0.59	0.28	0.35	0.21	
3-Methylnonane	973.55	1.18				0.20

n-Decane	1000.00	0.08	0.12	0.25	0.14	0.20
+ n-Undecane	1100.00	0.35	0.20			0.13
n-Dodecane	1200.00	0.13	0.22			
SUM		**20.90**	**19.61**	**29.89**	**31.65**	**28.84**
Phenols						
4-methylphenol		1.56	0.13		0.09	
SUM		**1.56**	**0.13**		**0.09**	
Sulfides						
Dimethylsulfide	537.3				0.21	
2-Methylthiopropane	662.64				0.07	
DiMethyldisulfide	729.82				0.34	
2-Methylthiophene	760.85					
Methylethyldisulfide	822.98	0.13				
Dimethyltetrasulfide	1220.30					0.12
SUM		**0.13**	**0**	**0**	**0.62**	**0.12**
Unknowns						
Unknown	266.92		0.12			
Unknown	326.30		0.07	0.08		
Unknown	350.47					
Unknown	354.72	0.36	0.06	0.24		0.45
Unknown	452.36		0.56			
Unknown	462.92			0.30		
Unknown	544.47		0.27	0.44	0.11	0.29
Unknown	595.81	0.10				
Unknown	612.17	0.13				
Unknown	638.63		0.21		0.17	
Unknown	644.55	0.11				
Unknown	655.66		0.30			
Unknown	684.41				0.07	
Unknown	716.76	0.10				

Unknown	779.81		0.34	0.37	0.46	0.52
Unknown	783.92	0.12	0.82			
Unknown	785.98			0.09		
Unknown	796.71					0.12
Unknown	809.72		0.10			
Unknown	851.61	0.43				
Unknown	894.35	0.23				
Unknown	897.75		0.08			
Unknown	908.79		0.25			
Unknown	933.29	0.15		0.10	0.09	
Unknown	1013.63	0.92		0.28		
Unknown	1027.85	0.06				
Unknown	1036.98		0.25	0.11		
Unknown	1073.24	0.21				
Unknown	1078.46		0.16			
Unknown	1113.29		0.13			
Unknown	1119.01	0.94	0.23	0.08		
Unknown	1123.00		0.16			0.24
Unknown	1128.86	0.23	0.15			
Unknown	1137.02		0.25	0.24		
Unknown	1144.96		0.33			0.16
Unknown	1148.05	0.62	0.12			
Unknown	1153.22			0.33		
Unknown	1156.53		0.55			0.30
Unknown	1161.98		0.26		0.19	
Unknown	1168.51	0.11				
Unknown	1175.95	1.32	0.31	0.14	0.15	
Unknown	1192.06		0.29			
Unknown	1204.30		0.10			
Unknown	1207.53	0.20				
Unknown	1210.71		0.10			
Unknown	1215.69	0.29				
Unknown	1220.30	0.26				

Unknown	1224.38		0.11			
Unknown	1243.93				0.19	
Unknown	1257.73					0.10
Unknown	1263.87				0.14	
Unknown	1272.12	0.63				
Unknown	1275.66	0.58				
Unknown	1291.80	0.69	0.26	0.19	0.18	
SUM		**8.79**	**6.95**	**2.99**	**1.75**	**2.18**
Total VOCs		**54.52**	**48.27**	**52.82**	**53.84**	**55.71**

Appendix 9 (continued) VOCs (ppbC) detected at Stokes Farm in January 2003

Canister #	**Retention**	**AQ-207**	**119**	**AQ-022**	**AQ-080**	**AQ-060**
Date	**Index #**	**1/7/03**	**1/7/03**	**1/7/03**	**1/8/03**	**1/8/03**
Time		**1141**	**1141**	**1815**	**0:03**	**6:03**
Location		**Upwind of lagoon**	**Downwind of lagoon 1200 diurnal**	**Downwind of lagoon 1800 diurnal**	**Downwind of lagoon 0000 diurnal**	**Downwind of lagoon 0600 diurnal**
Temperature (Celcius)		**4**	**4**	**No data**	**No data**	**No data**
Wind Speed (m/s)		**5**	**5**			
Alcohols						
Methanol	408.00	0.07	0.57	2.58	1.55	1.49
Ethanol	461.50	0.45	0.96	1.87	1.20	0.34
n-Propanol	556.82			0.31	0.20	0.09
2-butanol		0.06			0.11	
n-Butanol + Thiophene	653.00	0.24	0.21	0.45	0.36	0.22
SUM		**0.82**	**1.74**	**5.21**	**3.42**	**2.14**
Aldehydes						
Acetaldehyde	372.25	1.26	1.21		1.06	1.15
Butanal	572.72	0.71	0.40	0.82	0.69	0.44
Isopentanal	635.89	0.15		0.12	0.15	0.08
Hexanal	778.54	2.45			5.19	
Heptanal + Styrene	881.42	0.33	0.18	0.47	0.27	
Octanal	983.98	0.21		0.23	0.25	0.39
Nonanal	1086.66	0.20	0.47	0.38		
Decanal	1189.79	0.43	0.52	0.42		0.58
SUM		**5.74**	**2.78**	**2.44**	**7.61**	**2.64**

Alkynes						
Acetylene	187.39	0.38	0.30	0.44	0.57	0.59
Propyne	328.11	0.18		0.28		0.44
SUM		**0.56**	**0.30**	**0.72**	**0.57**	**1.03**
Aromatics						
Benzene	651.21	0.80	0.85	1.56	1.09	1.12
Toluene	758.58	0.66	0.68	3.11	1.06	1.42
Ethylbenzene + 4-Heptanone	855.40	0.15	0.31	0.41	0.18	0.31
m-& p-Xylene	863.65		0.26	0.96	0.49	0.51
o-Xylene	887.56	0.08	0.24	0.50	0.22	0.36
Isopropylbenzene	920.34			0.06		
n-Propylbenzene	950.95			0.14	0.08	0.09
p-Ethyltoluene	960.02			0.41		0.19
o-Ethyltoluene	976.97	0.06		0.19		
1,2,4-TriMethylbenzene	991.48	0.47	0.27	0.79	0.38	0.40
1,2,3-TriMethylbenzene	1022.13	0.17		0.26	0.24	0.17
m-Diethylbenzene	1046.57			0.10		0.23
n-Butylbenzene	1054.69	0.45	0.34	0.38	0.26	0.26
1-Me-4-isoPropylbenzene	1059.44			0.09		
1-Me-2-n-Propylbenzene	1067.27	0.08		0.31		
1,4-DiMe-2-Ethylbenzene	1075.98	0.09		0.13		
1,2-DiMe-4-Ethylbenzene	1084.27	0.22		0.23		0.09
1,2-DiMe-3-Ethylbenzene	1107.49	0.07		0.23		
1,2,4,5-TetraMe-Benzene	1121.01				0.33	
m-DiisoPropylbenzene	1152.00	0.12				
t-1-But-4-Ethylbenzene	1183.89	0.09		0.08		
1,3,5-TriEthylbenzene	1216.90				0.12	0.23
1,2,4-TriEthylbenzene	1239.00	0.06	0.24			
SUM		**3.57**	**3.19**	**9.94**	**4.45**	**5.38**
Esters						
Methyl Propanate	618.54				0.12	

Butyl Propanante	888.77	0.12				
SUM		**0.12**	**0**	**0**	**0.12**	**0**
Halogenated Hydrocarbons						
Freon-22	304.94	0.18	0.11	0.12	0.19	0.10
Freon-12	314.04	0.42	0.30	0.35	0.63	0.41
Methyl Chloride	339.70	0.75	0.73	0.57	1.77	0.63
Freon-142b	346.30	0.11	0.09			0.22
Freon-114	369.43				0.19	
Ethyl Chloride	433.37				0.07	
Dichloromethane	518.77		0.26			
Freon-113	531.54	0.19	0.29	0.24	0.37	0.31
1,1-Dichloethane	562.00	0.12	0.43	0.20	0.19	
1,2-Dichloroethane	626.70	0.12	0.25	0.28	0.17	0.23
SUM		**1.89**	**2.46**	**1.76**	**3.58**	**1.90**
Isoprene & Monoterpenes						
Isoprene	504.19	0.21	0.37	0.86	0.48	0.56
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.39	0.25	0.35		
beta-Pinene	986.65	0.17		0.21		
Limonene	1033.82			0.09	0.29	
SUM		**0.77**	**0.62**	**1.51**	**0.77**	**0.56**
Ketones						
Acetone	476.37	3.37	3.04	5.95	4.08	3.07
MEK	577.35	0.37		0.60	0.56	0.31
3-Heptanone	867.95		0.13	0.12	0.15	
Cyclohexanone	870.91	0.35		0.37	0.63	0.32
3-Methyl-3-Heptanone	926.44		0.12			
4-Methylcyclohexanone	938.65		0.38			
Benzaldehyde	940.10			0.15	0.28	0.20
2-Octanone	971.63	0.10		0.13		
2-Nonanone	1073.92	0.13				

Acetophenone	1048.17	0.11		0.13		
SUM		**4.43**	**3.67**	**7.45**	**5.70**	**3.90**
Olefins						
Ethylene	173.78	0.57	0.60	2.39	1.25	1.12
Propylene	289.65	0.18	0.20	1.45	0.53	0.45
Butene-1	389.97	0.25		0.77	0.34	0.38
1,3-Butadiene	394.58	0.12		0.35		0.26
3-Methyl-1-Butene	457.43			0.17		
Pentene-1	489.36			0.12		
2-Methyl-1-Butene	496.17			0.26		
2-Methyl-2-Butene	521.04	0.06		0.17	0.10	
Hexene-1	589.36	0.09		0.20	0.09	
trans-2-Hexene	604.98					0.14
2,4,4-TriMethyl-1-Pentene	712.30	0.06		0.22	0.06	
2-Ethyl-1-Hexene	787.50			0.15		
Octene-1	789.04	0.18		0.17		
cis-2-Nonene	912.37			0.09		
Decene-1	989.42			0.10		
2-Carene	1007.00			0.13	0.18	
Undecene-1	1089.44	0.33		0.37		
SUM		**1.84**	**0.80**	**7.11**	**2.55**	**2.35**
Paraffins						
Ethane	200.00	4.43	4.25	4.58	4.32	4.05
Propane	300.00	3.88	3.72	5.89	5.30	4.87
Isobutane	361.88	1.07	1.00	1.32	1.09	1.08
n-Butane	400.00	1.96	1.98	3.47	2.49	2.67
Isopentane	474.54	1.08	1.00	2.16	1.23	1.59
n-Pentane	500.00	0.64	0.78	1.16	0.84	0.77
2,2-Dimethylbutane	535.47	0.09	0.25	0.39	0.08	0.22
2,3-Dimethylbutane	565.46	0.09	0.16	0.29	0.16	0.12
2-Methylpentane	570.09	0.29	0.33	0.67	0.46	0.40

3-Methylpentane	583.52	0.44	0.75	0.71	0.65	0.53
n-Hexane	600.00	0.38	0.70	0.92	0.52	0.60
2,4-Dimethylpentane	631.38	0.16		0.20	0.21	0.10
Cyclohexane	660.96	0.16	0.09	0.12		0.44
2-Methylhexane	668.68	0.08	0.12	0.18	0.14	0.15
2,3-Dimethylpentane	670.80	0.44	0.30		0.41	0.38
3-Methylhexane + 3-Pentanone	677.22	0.87	0.49	0.90	0.55	0.58
3-EthylPentane	687.12			0.08	0.10	0.09
2,2,4-TriMethylpentane	690.72	0.37	0.34	0.56	0.37	0.37
n-Heptane	700.00	0.19	0.23	0.33	0.25	0.21
MethylCyclohexane	724.30	0.22	0.49	6.83	0.20	0.31
2,4-DiMethylhexane	735.91			0.15		
3,3-DiMethylhexane	743.87					0.09
hexamethylcyclotrisiloxane	753.56	0.18	0.15	0.25	0.16	0.18
2-Methyl-3-Ethylpentane	765.00			0.49		0.08
2-Methylheptane	767.55	0.08	0.13			0.13
3,4-DiMethylhexane	772.50	2.24				
3-Methylheptane	775.34			0.11		0.09
Cycloheptane	798.00	0.30				
n-Octane	800.00		0.14	0.12		0.07
1t2-DiMethylcyclohexane	802.07				1.22	
2,3,5-TriMethylhexane	819.44			0.08	0.31	
4,4-DiMethylheptane	829.05			0.12		
1,3,5-TriMethylcyclohexane	837.00		0.67			0.09
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.13		0.11		0.25
3,4-DiMethylheptane	862.50	0.17				
Nonane	900.00			0.17	0.19	0.16
2,6-DiMethyloctane	937.70	0.24		0.27	0.40	0.30
3,4,5-TriMethylheptane	955.00		0.20			
2,3-Dimethyloctane + m-Ethyltoluene	958.75	0.08		0.55	0.28	0.28
2-Methylnonane	966.32	0.37	0.11	0.48	0.21	0.18
3-Methylnonane	973.55					0.22
n-Decane	1000.00	0.13		0.17	0.21	0.10

+ n-Undecane	1100.00	0.25		0.17	0.24	0.13
n-Dodecane	1200.00	0.37		0.14	0.19	0.19
SUM		**21.38**	**18.38**	**34.14**	**22.78**	**22.07**
Phenols						
4-methylphenol		0.11		0.13		0.23
SUM		**0.11**		**0.13**		**0.23**
Sulfides						
2-Methylthiopropane	662.64	0.11				
SUM		**0.11**	**0**	**0**	**0**	**0**
Unknowns						
Unknown	326.30		0.22	0.18		
Unknown	350.47	0.06				
Unknown	354.72			0.19	0.25	0.17
Unknown	437.96	0.20	0.07			
Unknown	441.29					0.14
Unknown	544.47	0.25	0.39			0.28
Unknown	595.81	0.17			0.11	0.13
Unknown	617.91	0.07				
Unknown	638.63	0.24	0.17		0.18	
Unknown	644.55	0.11		0.20	0.12	0.11
Unknown	655.66		0.21			
Unknown	684.41		0.14	0.08		0.07
Unknown	779.81		0.28	0.66		0.32
Unknown	805.65			0.56		
Unknown	815.37		1.70			0.67
Unknown	851.61	0.10				
Unknown	933.29	0.06		0.09	0.17	
Unknown	1013.63	0.28		0.43		
Unknown	1025.79	0.06				
Unknown	1036.98	0.17		0.25		

Unknown	1043.84			0.07		
Unknown	1078.46	0.08	0.12	0.09		
Unknown	1119.01	0.20		0.21		0.34
Unknown	1123.00	0.21		0.25		
Unknown	1125.95	0.10				
Unknown	1134.17		0.32			
Unknown	1137.02	0.21		0.20	0.10	0.11
Unknown	1144.96	0.24		0.12	0.07	
Unknown	1153.22			0.08	0.09	0.07
Unknown	1156.53	0.64	0.43	0.29	0.17	0.23
Unknown	1161.98	0.27		0.09		
Unknown	1168.51	0.10				
Unknown	1172.96	0.07				
Unknown	1175.95	0.24	0.22	0.19	0.17	0.27
Unknown	1192.06	0.55		0.43		
Unknown	1204.30	0.14				
Unknown	1210.71	0.10				
Unknown	1215.69	0.12	0.09	0.13		
Unknown	1249.88	0.06				
Unknown	1257.73	0.29	0.32	0.16	0.16	0.39
Unknown	1263.87	0.09				
Unknown	1272.12	0.22		0.10		
Unknown	1275.66			0.21		
Unknown	1284.89	0.07				
Unknown	1291.80	0.13	0.21	0.46		0.23
SUM		**5.90**	**4.89**	**4.92**	**1.59**	**3.65**
Total VOCs		**47.24**	**38.83**	**76.13**	**53.14**	**43.41**

***samples taken in conjunction with Duke University odor panel**

Appendix 10 VOCs (ppbC) detected at Moore Brothers Farm in October 2002

Canister #	**Retention**	**1870**	**AQ-060**	**AQ-048**	**AQ-207**	**AQ-146**
Date	**Index #**	**10/4/02**	**10/3/02**	**10/3/02**	**10/4/02**	**10/4/02**
Time		**1204**	**1200**	**1825**	**0:15**	**610**
Location		**Directly in front of housing fan**	**Diurnal East side of lagoon**	**Diurnal East side of lagoon**	**Diurnal East side of lagoon**	**Diurnal East side of lagoon**
Temperature (Celcius)		**29.7**	**n/a**	**24.6**	**20.4**	**19.9**
Wind Speed (m/s)		**2.2**		**0.5**	**0**	**0**
Alcohols						
Methanol	408.00	4.41	5.48	4.27	2.04	1.53
Ethanol	461.50	1.83	1.86	3.45	1.50	1.28
n-propanol		2.77	0.14	0.92	0.80	0.60
2-butanol		0.37	0.07		0.36	
n-Butanol + Thiophene	655.66	1.02	0.53	1.12	1.23	0.59
SUM		**10.40**	**8.08**	**9.76**	**5.93**	**4.00**
Aldehydes						
Acetaldehyde	372.25	13.45	2.96	2.96	3.86	1.45
Butanal	572.72	2.20	1.12	1.09	1.41	0.54
Isopentanal	635.89		0.10	0.09		0.22
Pentanal	675.78	1.44				
Hexanal	778.54	3.13	1.02		0.88	
Heptanal + Styrene	881.42	3.99	0.92	1.25	1.71	1.39
Octanal	983.98	0.97	1.19	1.37	1.69	0.57
Nonanal	1086.66	4.29	1.88	2.25	0.93	0.53
Decanal	1189.79		1.47	2.38	1.53	
SUM		**29.47**	**10.66**	**11.39**	**12.01**	**4.70**

Alkynes						
Acetylene	187.39	0.95	0.21	0.17	0.43	0.52
Propyne	328.11	0.10		0.20		0.09
SUM		**1.05**	**0.21**	**0.37**	**0.43**	**0.61**
Aromatics						
Benzene	651.21	0.92	0.97	3.33	6.73	2.95
Toluene	758.58	3.97	1.54	6.50	19.39	9.25
Ethylbenzene + 4-Heptanone	855.40	0.44	0.27	0.77	4.50	2.41
m-& p-Xylene	863.65		0.67	2.52	18.06	7.50
o-Xylene	887.56	0.25	0.23	1.17	7.27	3.20
Isopropylbenzene	920.34	0.20		0.18	0.81	0.42
Benzaldehyde	940.10	1.22	0.27	0.44	0.45	11.31
n-Propylbenzene	950.95			0.22	2.41	0.97
m-Ethyltoluene	957.45		0.15	0.84	7.52	5.13
p-Ethyltoluene	960.02				4.61	
1,3,5-TriMethylbenzene	964.32		1.46	4.77	5.70	1.50
o-Ethyltoluene	976.97		0.18	1.04	4.48	2.05
1,2,4-TriMethylbenzene	991.48	0.60	0.43	1.69	12.66	5.12
Isobutylbenzene	1008.16			0.25	0.63	0.41
sec-Butylbenzene	1010.39	2.02			0.47	0.15
m-Cymene	1018.22	0.31		0.10	1.00	0.29
1,2,3-TriMethylbenzene	1022.13		0.19	0.40	4.14	1.33
p-Cymene	1022.93	0.29				
o-Cymene	1037.53	0.23				
m-Diethylbenzene	1046.57				0.69	0.26
p-Diethylbenzene	1053.84					
n-Butylbenzene	1054.69		0.76		3.90	1.41
1-Me-4-isoPropylbenzene	1059.44	0.11			0.95	0.18
1-Me-2-n-Propylbenzene	1067.27	2.18		0.12		0.49
1,4-DiMe-2-Ethylbenzene	1075.98			0.15	1.96	0.96
1,2-DiMe-4-Ethylbenzene	1084.27			0.21	2.73	0.99
1,2-DiMe-3-Ethylbenzene	1107.49			0.15	1.00	0.48

t-1-But-2-MeBenzene	1139.52					0.13
m-DiisoPropylbenzene	1152.00	5.72			1.39	
t-1-But-3,5-DiMeBenzene	1174.77	0.56		0.54		
Dodecene-1 + Naphthalene	1189.56	4.60				
1,3,5-TriEthylbenzene	1216.90		0.22			
SUM		**23.62**	**7.34**	**25.39**	**113.45**	**58.89**
Esters						
Propyl Formate	608.87			0.48	0.44	
Methyl Butanate	706.79			0.13	0.08	
SUM		**0**	**0**	**0.61**	**0.52**	**0.00**
Ethers						
Furan	490.75	0.06	0.06			
SUM		**0.06**	**0.06**	**0.00**	**0.00**	**0.00**
Halogenated Hydrocarbons						
Freon-22	304.94	0.21	0.10	0.19	0.17	0.21
Freon-12	314.04	0.26	0.33	0.44	0.17	0.19
Methyl Chloride	339.70	0.72	0.69	0.82	0.86	0.83
Freon-142b	346.30	10.88	0.19	0.14	0.13	0.15
Freon-114	369.43		0.17	0.19	0.15	
Ethyl Chloride	433.37				0.10	0.46
Vinylidene Chloride	509.85	0.47				
Dichloromethane	518.77	0.29			0.06	
3-Chloropropene	522.88	0.78				
Freon-113	531.54	0.17	0.22	0.29	0.32	0.33
1,1-Dichloethane	562.00		0.31			
c-1,3-Dichlopropene	720.09				0.13	0.12
Perchloroethylene	805.33		0.08			0.12
SUM		**13.90**	**2.09**	**2.07**	**2.09**	**2.41**
Isoprene & Monoterpenes						

Isoprene	504.19	8.72	1.24	12.50	3.37	2.52
alpha-Pinene + 3,6-DiMethyloctane	943.64	3.67	0.47	3.65	9.70	4.69
Camphene + 2,6-DiMe-4-Heptanone	959.75			0.79		1.92
beta-Pinene	986.65	0.56		2.12	3.46	1.91
Limonene	1033.82	0.32		0.80	2.38	0.74
SUM		**13.27**	**1.71**	**19.86**	**18.91**	**11.78**
Ketones						
Acetone	476.37	24.05	11.42	15.15	10.32	5.74
MEK	577.35	3.06	1.19	1.30	1.17	0.41
3-Heptanone	867.95			0.10		
Cyclohexanone	870.91	0.81	0.39	0.43	0.63	0.28
2-Methyl-3-Heptanone + Methylpropyldisulfide	922.24	0.21				
3-Octanone	926.94	3.35				
2-Octanone	971.63		0.14	0.25		1.19
Acetophenone	1048.17	1.35	1.75	0.66	2.42	0.66
2-Nonanone	1073.92					
SUM		**32.83**	**14.89**	**17.89**	**14.54**	**8.28**
Olefins						
Ethylene	173.78	3.23	0.96	1.94	4.78	1.95
Propylene	289.65	0.53	0.22	0.71	0.78	1.10
Butene-1	389.97	0.69	0.33	0.74	0.97	0.66
1,3-Butadiene	394.58	0.12			0.21	0.21
c-Butene-2	425.94		0.30	0.70	0.95	0.53
3-Methyl-1-Butene	457.43			0.68	0.52	0.37
Pentene-1	489.36	0.11	0.35	1.60	1.80	0.80
2-Methyl-1-Butene	496.17	0.09	0.44	2.63	2.56	1.12
Trans-2-pentene				3.71	5.09	1.68
cis-2-Pentene	516.35		0.42	1.95	2.33	0.82
2-Methyl-2-Butene	521.04	0.17	0.93	5.28	5.94	2.19
Cyclopentene	551.84		0.19	0.78	1.07	0.51
3-Methyl-1-pentene	557.98					

2-Methyl-1-Pentene	588.52		0.34	1.95	1.04	0.68
Hexene-1	589.36	0.18			0.65	
trans-2-Hexene	604.98		0.34	1.63	1.62	0.33
2-Methyl-2-Pentene	607.37		0.31	1.55	1.66	0.55
cis-2-Hexene	614.50		0.09	0.92	0.73	0.43
2,4-DiMethyl-1-Pentene	647.79		0.08	0.18	0.14	
4-Me-1-Hexene	665.23				0.12	
trans-3-Heptene	697.82		0.10	0.27	0.40	0.13
trans-3-Heptene	701.44				1.18	
2,4,4-TriMethyl-1-Pentene	712.30		0.09	0.48	0.73	0.24
3-&4-MethylCyclohexene	738.50	0.36				
Octene-1	789.04	0.37	0.10	0.09	0.12	0.07
3-Octene	796.71	0.21		1.75	0.28	0.08
trans-2-Octene	803.11				0.19	
cis-2-Octene	812.37	0.77		0.08	0.30	
Nonene-1	889.31		0.28			
cis-2-Nonene	912.37					0.06
2-Carene	1007.00	0.14				
Undecene-1	1089.44				1.07	0.39
n-Tridecene-1	1289.33	0.14			0.14	
SUM		**7.11**	**5.88**	**25.91**	**32.28**	**13.22**
Paraffins						
Ethane	200.00	2.83	2.90	2.89	2.73	2.28
Propane	300.00	3.94	2.54	2.83	12.99	9.15
Cyclopropane	341.42	0.19				
Isobutane	361.88	0.98	0.83	2.08	5.22	1.59
n-Butane	400.00	1.46	2.23	8.46	8.94	4.86
Isopentane	474.54	3.41	7.07	36.03	25.67	14.49
n-Pentane	500.00	6.75	2.56	12.67	13.63	6.44
2,2-Dimethylbutane	535.47	0.29	1.03	4.56	2.39	1.27
Cyclopentane	562.82	0.53		1.42	1.28	0.78

2,3-Dimethylbutane	565.46	0.16	0.93	5.46	3.01	1.81
2-Methylpentane	570.09		2.90	18.06	13.15	5.97
3-Methylpentane	583.52	1.00	2.14	9.39	6.58	3.97
n-Hexane	600.00	2.43	1.28	5.93	6.29	4.47
2,2-DiMethylpentane	625.13		0.07	0.39	0.15	0.07
Methylcyclopentane	627.20	1.59	0.83	4.52	4.02	2.46
2,4-Dimethylpentane	631.38		0.41	2.05	1.51	0.82
2,2,3-TriMethylbutane	637.00	0.99		0.28	0.33	
Cyclohexane	660.96		0.28	0.74	0.56	0.51
2-Methylhexane	668.68	1.32	0.61	3.67	3.76	1.84
2,3-Dimethylpentane	670.80		0.81	2.13	1.36	0.87
3-Methylhexane + 3-Pentanone	677.22		1.24	4.03	3.91	2.07
3-EthylPentane	687.12	0.08	0.24	1.07	1.08	0.61
2,2,4-TriMethylpentane + 2-Ethylfuran	690.72	0.25	1.33	6.57	4.83	2.94
n-Heptane	700.00	0.16	0.58	1.45	2.28	1.10
MethylCyclohexane	724.30		0.33	0.96	0.99	0.97
2,5-DiMethylhexane	733.56		0.07	0.45	3.53	0.31
2,4-DiMethylhexane	735.91		0.24	1.20	1.89	0.67
3,3-DiMethylhexane	743.87		0.16	0.23	0.22	0.16
hexamethylcyclotrisiloxane	753.56	0.24	0.44	1.89	2.17	1.08
2,3-DiMethylhexane	762.98	0.10		0.73	0.89	0.51
2-Methyl-3-Ethylpentane	765.00				0.53	
2-Methylheptane	767.55	0.22	0.31	0.64	1.18	0.47
4-MeHeptane + 2-Hexanone	769.28	0.40			0.89	0.49
3,4-DiMethylhexane	772.50	0.09		5.47	0.11	
3-Methylheptane	775.34	0.16	0.22	0.71	0.99	0.62
2,2,4-TriMethylhexane	794.85				0.20	0.17
n-Octane	800.00	1.10	0.30	0.45	1.10	0.52
2,3,5-TriMethylhexane	819.44	0.30	2.57	0.29	0.51	0.24
2,4-DiMethylheptane	825.88				0.31	
4,4-DiMethylheptane	829.05			0.77	0.17	0.24
2,6-DiMethylheptane	831.77	0.24			0.31	
1c2-DiMethylcyclohexane	834.70	0.29				

2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	2.78		0.29	0.64	0.34
4-Methyloctane	865.00	2.20				
3-Methyloctane	873.73	0.50		0.13	0.93	0.30
Nonane	900.00	0.66		0.36	2.73	0.28
Cyclooctane	928.80					0.24
IsopropylCyclohexane	929.10			0.08	0.78	
2,6-DiMethyloctane	937.70	0.86		0.28	1.77	0.27
3,4,5-TriMethylheptane	955.00	0.51				
2,3-DiMethyloctane	958.75	0.25				
5-Methylnonane	962.00	0.34				
2-Methylnonane	966.32					3.59
3-Methylnonane	973.55	2.42			1.33	
t-ButylCyclohexane	998.50					
n-Decane	1000.00	0.39	0.20	0.39	6.21	0.48
nButCycHexan	1042.20				1.29	
+ n-Undecane	1100.00	0.66	0.08	0.36	7.03	0.64
n-Dodecane	1200.00	0.65	0.21	0.27	4.32	0.50
SUM		**43.72**	**37.94**	**152.63**	**168.69**	**83.46**
Phenols						
4-methylphenol		1.18	1.75	0.66	2.42	0.66
SUM		**1.18**	**1.75**	**0.66**	**2.42**	**0.66**
Sulfides						
DiMethylsulfide	507.30	0.55	0.64			
DiMethyldis ulfide	729.82	0.18		0.23	0.85	0.06
MeEthyldisulfide	822.98	0.10		0.13		
2,5-Dimethylthiophene	862.37		0.23			
MePropyldisulfide	916.10					0.06
Dimethyltrisulfide	963.85	0.68				
SUM		**1.51**	**0.87**	**0.36**	**0.85**	**0.12**
Unknowns						

Unknown	266.92		0.26		0.22	0.23
Unknown	316.37	0.11				
Unknown	326.30				0.14	
Unknown	350.47	0.11				0.16
Unknown	354.72			0.10		
Unknown	441.29	0.12				
Unknown	452.36			0.14		
Unknown	469.37	0.11				
Unknown	513.67			0.11		
Unknown	523.25				0.21	
Unknown	595.81	0.47		0.31		0.06
Unknown	602.24		0.07	0.56	0.86	
Unknown	610.49		0.24	1.07	1.06	0.22
Unknown	612.17			0.26		
Unknown	616.59	1.33				
Unknown	620.74		0.26	1.52	1.67	0.62
Unknown	644.55		0.15	0.25		0.12
Unknown	680.55	0.38		0.15	0.13	
Unknown	684.41		0.15	0.80	0.81	0.39
Unknown	695.08			0.18	0.18	
Unknown	701.86			0.76		0.47
Unknown	704.63			0.13	0.34	0.18
Unknown	710.01	4.99	0.14	0.21	0.29	0.08
Unknown	716.76	0.18		0.10		
Unknown	726.61		0.06	0.11	0.10	0.10
Unknown	747.75	0.39			0.08	
Unknown	779.81			0.96		0.54
Unknown	781.70	0.49		0.25	0.34	0.25
Unknown	783.92	0.19			0.09	
Unknown	785.98		0.09	0.32	0.35	0.29
Unknown	791.10			0.15	0.17	0.16
Unknown	793.28	0.09	0.16		0.16	
Unknown	809.72					0.26

Unknown	815.37	1.05	0.08	0.08	0.22	0.12
Unknown	844.42	0.37			0.21	
Unknown	847.21				0.25	
Unknown	860.26	1.22			0.36	0.11
Unknown	894.35	0.16			0.34	0.10
Unknown	908.79	0.06	0.22			
Unknown	916.10	0.31				
Unknown	933.29		0.19	0.22		0.26
Unknown	936.33		0.16			
Unknown	947.14			0.08	0.52	
Unknown	971.22				0.73	
Unknown	995.10	0.13			0.19	
Unknown	1013.63	1.09	0.95	0.97	0.99	
Unknown	1025.79				1.56	0.07
Unknown	1027.85			0.29		
Unknown	1036.98			0.35	1.65	1.14
Unknown	1040.81	0.10				
Unknown	1043.84					0.17
Unknown	1062.68				0.91	0.15
Unknown	1073.24		0.40		1.35	
Unknown	1078.46	0.20		0.12	1.31	0.54
Unknown	1094.62	0.17			0.47	0.06
Unknown	1119.01	1.13	0.43	0.26	1.84	0.57
Unknown	1123.00			0.23	1.71	0.65
Unknown	1125.95				0.50	
Unknown	1128.86	0.10	0.14			
Unknown	1134.17				0.53	
Unknown	1137.02			0.11	0.71	0.15
Unknown	1144.96	0.25			1.66	0.50
Unknown	1148.05	0.15	0.19	0.43	1.36	0.32
Unknown	1153.22					0.40
Unknown	1156.53		0.86		3.57	1.05
Unknown	1161.98			0.18	1.15	0.36

Unknown	1168.51			0.11		0.30
Unknown	1172.96				0.71	
Unknown	1175.95		0.57		0.63	0.44
Unknown	1179.17	0.11			0.18	
Unknown	1192.06				2.62	1.91
Unknown	1196.05				0.68	
Unknown	1204.30				0.95	
Unknown	1210.71				0.28	0.09
Unknown	1215.69			0.23	1.02	0.17
Unknown	1239.67				0.58	
Unknown	1243.93	0.15				
Unknown	1249.88			0.07	0.55	0.14
Unknown	1257.73					0.30
Unknown	1263.87	0.31		0.29	0.26	0.06
Unknown	1272.12				0.39	
Unknown	1275.66	0.38			1.14	
Unknown	1291.80	1.05	0.40	0.27	0.61	
SUM		**17.61**	**6.17**	**121.73**	**41.96**	**14.26**
Total VOCs		**195.39**	**98.12**	**285.10**	**419.17**	**204.07**

Appendix 10 (Continued) VOCs (ppbC) detected at Moore Brothers Farm in October 2002

Canister #	**Retention**	**AQ-125**	**AQ-211**	**115***	**652***
Date	**Index #**	**10/4/02**	**10/4/02**	**10/9/02**	**10/9/02**
Time		**1135**	**1135**	**1215**	**1150**
Location		**Downwind of houses/ lagoon**	**Upwind of houses/ lagoons**	**NE edge of lagoon**	**N of barn edge of lagoon**
Temperature (Celcius)		**29.8**	**29.8**	**23.2**	**22.9**
Wind Speed (m/s)		**2.1**	**2.1**	**2.6**	**2.9**
Alcohols					
Methanol	408.00	3.54	2.92	2.09	6.17
Ethanol	461.50	2.91	0.32	1.26	2.09
n-propanol		0.26		0.32	
n-Butanol + Thiophene	655.66	0.81		0.36	0.62
SUM		**7.52**	**3.24**	**4.03**	**8.88**
Aldehydes					
Acetaldehyde	372.25	4.30	9.44	3.70	
Isobutanal	542.18		1.08		
Butanal	572.72	1.34	1.66	0.53	0.45
Isopentanal	635.89	0.11			0.35
Pentanal	675.78		1.56		
Hexanal	778.54	1.04	2.07		0.83
Heptanal + Styrene	881.42	1.05	2.09	0.52	0.62
Octanal	983.98	2.68	3.09	1.36	0.61
Nonanal	1086.66	1.54	5.47	2.61	1.01
Decanal	1189.79	1.42	3.69	1.62	1.34
SUM		**13.48**	**30.15**	**10.34**	**5.21**

Alkynes					
Acetylene	187.39	0.14	0.61	0.18	0.94
Propyne	328.11				0.18
SUM		**0.14**	**0.61**	**0.18**	**1.12**
Aromatics					
Benzene	651.21	0.47	0.72	0.81	3.04
Toluene	758.58	0.49	0.62	0.86	6.91
Ethylbenzene + 4-Heptanone	855.40	0.10	0.51	0.14	0.95
m-& p-Xylene	863.65	0.18		0.17	3.16
o-Xylene	887.56		0.47		1.18
Benzaldehyde	940.10	0.66	1.04	0.34	0.14
n-Propylbenzene	950.95	0.20	0.31		0.26
m-Ethyltoluene	957.45		0.64		0.93
p-Ethyltoluene	960.02				0.77
1,3,5-TriMethylbenzene	964.32		5.76	3.31	0.70
o-Ethyltoluene	976.97		0.58		0.61
1,2,4-TriMethylbenzene	991.48	0.65	7.60	0.34	1.66
Isobutylbenzene	1008.16		3.81		0.20
m-Cymene	1018.22	0.28			
1,2,3-TriMethylbenzene	1022.13	0.21			0.71
m-Diethylbenzene	1046.57				0.15
n-Butylbenzene	1054.69	0.15			0.76
1-Me-4-isoPropylbenzene	1059.44		0.12		0.22
o-Diethylbenzene	1061.38	0.19			
1-Me-2-n-Propylbenzene	1067.27	0.07			0.15
1,4-DiMe-2-Ethylbenzene	1075.98	0.47			
1,2-DiMe-4-Ethylbenzene	1084.27		0.21		0.36
1,2-DiMe-3-Ethylbenzene	1107.49		0.69		
t-1-But-4-Ethylbenzene	1183.89		0.22		
1,2,4-TriEthylbenzene	1239.00	0.10			
SUM		**4.22**	**23.30**	**5.97**	**22.86**
Esters					

Methyl Pentanate	806.32		0.18		
Butyl Propanante	888.77	0.21			
SUM		**0.21**	**0.18**	**0.00**	**0.00**
Ethers					
Furan	490.75		0.13	0.13	
ETBE	619.80		0.21		
SUM		**0.00**	**0.34**	**0.13**	**0.00**
Halogenated Hydrocarbons					
Freon-22	304.94	0.14	0.15	0.26	0.25
Freon-12	314.04	0.22	0.33	0.17	0.54
Methyl Chloride	339.70	0.72	0.75	0.68	1.24
Freon-142b	346.30	0.11	0.09	0.14	1.73
Freon-114	369.43				0.27
Methyl Bromide	415.35		0.18		
Dichloromethane	518.77		0.06	0.08	0.18
Freon-113	531.54	0.24	0.14	0.30	0.43
1,1-Dichloethane	562.00		0.39		
1,2-Dichloroethane	626.70			0.14	
Carbon Tetrachloride	656.36		0.13		
Perchloroethylene	805.33	0.10			0.15
m-Dichlorobenzene	1001.00	0.17			
SUM		**1.70**	**2.22**	**1.77**	**4.79**
Isoprene & Monoterpenes					
Isoprene	504.19	1.86	3.44	1.95	2.27
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.60	2.02	0.47	2.75
Camphene + 2,6-DiMe-4-Heptanone	959.75		0.58		
beta-Pinene	986.65		0.98		1.29
Limonene	1033.82	0.18	3.74	0.23	0.57
SUM		**2.64**	**10.76**	**2.65**	**6.88**

Ketones					
Acetone	476.37	14.20	20.97	9.03	6.80
MEK	577.35	1.69	1.41	0.50	0.75
2-Pentanone	667.26		0.11		
4-Methyl-2-Pentanone	721.82	0.14		14.05	
3-Heptanone	867.95	0.06	0.13	0.08	
Cyclohexanone	870.91	0.42	0.92		0.99
2-Octanone	971.63		0.63	0.12	0.22
Acetophenone	1048.17	0.23	0.79	0.11	0.29
2-Nonanone	1073.92		0.60		0.53
SUM		**16.74**	**25.56**	**23.89**	**9.58**
Olefins					
Ethylene	173.78	0.78	0.84	0.59	0.04
Propylene	289.65	0.47	0.62	0.30	1.58
Butene-1	389.97	0.55	0.36	0.23	1.16
1,3-Butadiene	394.58	0.17	0.20		0.28
c-Butene-2	425.94				0.19
3-Methyl-1-Butene	457.43			0.21	0.37
Pentene-1	489.36				0.41
2-Methyl-1-Butene	496.17	0.06	0.10	0.29	0.56
trans-2-Pentene	508.72				0.60
cis-2-Pentene	516.35				0.40
2-Methyl-2-Butene	521.04	0.07	0.08	0.12	0.86
Cyclopentene	551.84				0.23
2-Methyl-1-Pentene	588.52				0.54
Hexene-1	589.36	0.21	0.35		
trans-2-Hexene	604.98	0.27		0.33	0.45
2-Methyl-2-Pentene	607.37				0.48
2,4-DiMethyl-1-Pentene	647.79	0.08	0.48	0.11	
Heptene-1	689.22	0.20	0.17		
2,4,4-TriMethyl-1-Pentene	712.30	0.12	0.35		
cis-2-Heptene	713.54			0.14	

Octene-1	789.04	0.11	0.19	0.13	
trans-2-Octene	803.11		0.11		
Nonene-1	889.31		0.30	0.32	
cis-2-Nonene	912.37			0.42	
2-Carene	1007.00			0.23	0.06
Undecene-1	1089.44				0.69
n-Tridecene-1	1289.33	0.06			
SUM		**3.15**	**4.15**	**3.42**	**8.90**
Paraffins					
Ethane	200.00	2.25	2.25	2.85	7.83
Propane	300.00	1.56	1.48	2.34	8.56
Isobutane	361.88	0.20	0.45	0.48	3.51
n-Butane	400.00	0.63	1.01	1.00	8.64
Isopentane	474.54	0.50	0.96	0.83	11.74
n-Pentane	500.00	0.27	0.36	0.41	4.47
2,2-Dimethylbutane	535.47	0.15		0.18	0.71
Cyclopentane	562.82				0.33
2,3-Dimethylbutane	565.46	0.13			0.87
2-Methylpentane	570.09		0.66	0.14	3.80
3-Methylpentane	583.52				1.91
n-Hexane	600.00		0.13	0.11	2.21
2,2-DiMethylpentane	625.13		0.08		
Methylcyclopentane	627.20				1.16
2,4-Dimethylpentane	631.38				0.54
Cyclohexane	660.96				0.27
2-Methylhexane	668.68		1.27		1.13
2,3-Dimethylpentane	670.80				0.85
3-Methylhexane + 3-Pentanone	677.22	1.03		0.63	1.53
3-EthylPentane	687.12				0.17
2,2,4-TriMethylpentane + 2-Ethylfuran	690.72		0.12	0.22	2.53
n-Heptane	700.00	0.22	0.12		1.14
MethylCyclohexane	724.30				0.81

2,5-DiMethylhexane	733.56				0.33
2,4-DiMethylhexane	735.91				0.79
3,3-DiMethylhexane	743.87		0.07		0.16
hexamethylcyclotrisiloxane	753.56	0.17	2.39		1.09
2,3-DiMethylhexane	762.98	0.19	0.07		0.52
2-Methyl-3-Ethylpentane	765.00		0.18		
2-Methylheptane	767.55	0.07			0.29
4-MeHeptane + 2-Hexanone	769.28		0.54		0.24
3,4-DiMethylhexane	772.50		0.09		0.11
3-Methylheptane	775.34				0.33
3-Ethylhexane	777.10		0.49		
Cycloheptane	798.00		0.13		
n-Octane	800.00	0.07			0.32
2,3,5-TriMethylhexane	819.44	0.20	1.46	0.38	0.45
2,4-DiMethylheptane	825.88				
4,4-DiMethylheptane	829.05		0.41	0.18	0.23
1c2-DiMethylcyclohexane	834.70		0.07		
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60				0.11
3,3-DiMethylheptane	841.50		0.13		
3,4-DiMethylheptane	862.50		1.39		
4-Methyloctane	865.00				3.25
3-Methyloctane	873.73				0.31
Nonane	900.00		0.21		0.42
2,2-DiMethyloctane	921.05		0.26		0.43
4,4-DiMethyloctane	925.00	0.06			
Cyclooctane	928.80	0.14			0.32
IsopropylCyclohexane	929.10		0.21	0.25	
2,6-DiMethyloctane	937.70		0.55		0.27
2,3-DiMethyloctane	958.75			0.39	
2-Methylnonane	966.32	5.00			
t-ButylCyclohexane	998.50		10.71		
n-Decane	1000.00				0.44
+ n-Undecane	1100.00	0.18	0.46	0.18	0.38

n-Dodecane	1200.00	0.13	0.36	0.10	0.24
SUM		**13.15**	**29.07**	**10.67**	**75.74**
Phenols					
4-methylphenol		0.23	1.82	0.27	0.29
SUM		**0.23**	**1.82**	**0.27**	**0.29**
Sulfides					
DiMethylsulfide	507.30		0.07		
2-Methylthiopropane	662.64	0.12			0.06
DiMethyldisulfide	729.82	0.07	0.2		
MeEthyldisulfide	822.98		0.15		
2,5-Dimethylthiophene	862.37	0.06			
Methylisopropyldisulfide	883.39				0.83
SUM		**0.25**	**0.42**	**0.00**	**0.89**
Unknowns					
Unknown	266.92		0.17		0.20
Unknown	316.37			0.11	
Unknown	326.30		0.13	0.18	0.16
Unknown	350.47			0.11	
Unknown	354.72	0.08		0.11	
Unknown	441.29			0.27	
Unknown	452.36				0.14
Unknown	513.67		0.10		
Unknown	523.25		0.16		
Unknown	595.81	0.19		0.18	0.28
Unknown	610.49	0.16			
Unknown	616.59		0.22		
Unknown	617.91				0.51
Unknown	620.74				0.34
Unknown	638.63	0.09		0.51	
Unknown	644.55	0.11		0.13	0.09

Unknown	680.55		0.11		
Unknown	684.41				0.20
Unknown	704.63		0.20		
Unknown	708.41				0.10
Unknown	710.01			0.13	0.07
Unknown	747.75		0.22		
Unknown	779.81			1.40	
Unknown	781.70				0.22
Unknown	783.92		0.18	1.19	0.07
Unknown	785.98				0.24
Unknown	851.61	0.19		0.22	
Unknown	860.26				0.19
Unknown	894.35		0.11	1.03	0.14
Unknown	905.72		0.06		
Unknown	908.79	0.22			
Unknown	933.29	0.11			0.24
Unknown	936.33	0.25		0.41	
Unknown	947.14		0.07		
Unknown	1013.63			1.57	0.59
Unknown	1025.79				0.07
Unknown	1027.85		0.42	0.35	
Unknown	1036.98				0.44
Unknown	1043.84				0.06
Unknown	1062.68				0.11
Unknown	1078.46		0.25		0.11
Unknown	1094.62				0.09
Unknown	1119.01	0.20	0.73		0.31
Unknown	1123.00		0.23		0.13
Unknown	1128.86		0.17		0.06
Unknown	1137.02		0.34		0.16
Unknown	1148.05	0.15	0.29	0.22	0.30
Unknown	1153.22	0.30	3.59		1.21
Unknown	1156.53	0.48			

Unknown	1161.98			0.60	0.07
Unknown	1164.70		0.15		0.11
Unknown	1168.51		0.11		
Unknown	1172.96				0.16
Unknown	1175.95			0.33	0.28
Unknown	1207.53		0.22		
Unknown	1210.71	0.35			
Unknown	1215.69		0.25		0.19
Unknown	1239.67				0.24
Unknown	1243.93				0.10
Unknown	1254.24		0.19		0.57
Unknown	1263.87		0.18	0.15	
Unknown	1272.12		0.11		0.58
Unknown	1291.80		1.18	0.25	0.53
SUM		**3.03**	**10.22**	**9.45**	**9.66**
Total VOCs		**66.72**	**142.04**	**73.09**	**154.80**

***samples taken in conjunction with Duke University odor panel**

Samples selected for GC/MS analysis

Appendix 11 VOCs (ppbC) detected at Moore Brothers Farm in February 2003

Canister #		**AQ-040**	**AQ-211**	**704**	**AQ-105**	**AQ-171**	**1870***
Date		**2/3/03**	**2/4/03**	**2/4/03**	**2/4/03**	**2/4/03**	**2/4/03**
Time		**1745**	**0:00**	**459**	**1212**	**1212**	**1245**
Location		**Between houses & lagoon 1800 diurnal**	**Between houses & lagoon 0000 diurnal**	**Between houses & lagoon 0600 diurnal**	**Between houses & lagoon 1200 diurnal**	**Upwind of houses & lagoon**	**Downwind of houses & lagoon**
Temperature (Celcius)		**16.2**	**12.9**	**16.1**	**15.6**	**15.6**	**17.2**
Wind Speed (m/s)		**3 to 4**	**3.8**	**9**	**4 to 5**	**4 to 5**	**4 to 5**
Alcohols							
Methanol	408.00	3.10	1.84	1.50	1.44	1.53	1.26
Ethanol	461.50	1.97	1.10	6.13	1.10	7.36	0.89
n-propanol		0.12	0.00	0.22	0.00	0.36	0.00
2-butanol		0.16		0.00	0.05	0.00	0.10
n-Butanol + Thiophene	655.66	0.74	0.39	0.43	0.50	0.31	0.49
SUM		**6.08**	**3.32**	**8.28**	**3.08**	**9.55**	**2.72**
Aldehydes							
Acetaldehyde	372.25	1.00	0.30	2.11	1.56	1.91	0.97
Methacrolein	552.82		0.14				0.06
Butanal	572.72	0.66	0.47	0.44	0.84	0.35	0.65
Isopentanal	635.89	0.09	0.11	0.07	0.05	0.09	0.12
Pentanal	675.78					0.04	
Hexanal	778.54	0.89		1.03	0.83		0.68
Heptanal + Styrene	881.42	1.06		0.52	0.84	0.64	0.56
Octanal	983.98	1.48	0.54	0.64	0.82	0.72	0.57
Nonanal	1086.66	1.48	1.00		1.19	1.10	1.15
Decanal	1189.79	1.98	0.89	0.89	1.43	0.81	0.85

SUM		**8.62**	**3.44**	**5.69**	**7.54**	**5.64**	**5.58**
Alkynes							
Acetylene	187.39	0.44	0.23	0.23	0.22	0.19	0.16
Propyne	328.11	0.19					
SUM		**0.63**	**0.23**	**0.23**	**0.22**	**0.19**	**0.16**
Aromatics							
Benzene	651.21	1.27	1.08	0.97	0.85	0.87	0.82
Toluene	758.58	1.59	1.16	0.70	0.57	0.94	0.62
Ethylbenzene + 4-Heptanone	855.40	0.37	0.15	0.10	0.14	0.08	0.12
m-& p-Xylene	863.65	0.51		0.05	0.24	0.29	
o-Xylene	887.56	0.23	0.38	0.07	0.12	0.22	0.22
Isopropylbenzene	920.34	0.19	0.07	0.04			
Benzaldehyde	940.10	0.34					
n-Propylbenzene	950.95		0.07	0.10	0.05	0.04	
p-Ethyltoluene	960.02		0.06		0.11		
1,3,5-TriMethylbenzene	964.32	0.65			0.12	0.12	
o-Ethyltoluene	976.97	0.12		0.16			0.11
sec-Butylbenzene	1010.39	0.15					
1,2,3-TriMethylbenzene	1022.13		0.16	0.18	0.09		
m-Diethylbenzene	1046.57		0.13				
p-Diethylbenzene	1053.84	1.98					0.69
n-Butylbenzene	1054.69		0.16	0.30	0.49	0.95	
o-Diethylbenzene	1061.38	0.16					
1-Me-2-n-Propylbenzene	1067.27	0.06					
1,2-DiMe-4-Ethylbenzene	1084.27		0.09		0.08	0.14	
1,2-DiMe-3-Ethylbenzene	1107.49	0.27			0.06	0.08	
1,2,4,5-TetraMe-Benzene	1121.01			0.06			
m-DiisoPropylbenzene	1152.00	0.21			0.04		0.145
t-1-But-3,5-DiMeBenzene	1174.77	0.89				0.03	
1,2,4-TriChlorobenzene	1181.85		0.07			0.06	

1,3,5-TriEthylbenzene	1216.90		0.08	0.14			0.23
SUM		**8.99**	**3.63**	**2.89**	**2.98**	**3.85**	**3.04**
Esters							
Methyl Propanate	618.54		0.07				
Ethyl Propanate	696.02		0	0.06			
Butyl Propanante	888.77				0.16		
SUM		**0.00**	**0.095**	**0.06**	**0.185**	**0**	**0**
Ethers							
ETBE	619.80			0.15			
SUM		**0.00**	**0**	**0.15**	**0.00**	**0.00**	**0.00**
Halogenated Hydrocarbons							
Freon-22	304.94	0.15	0.30	0.17	0.15	0.19	0.17
Freon-12	314.04	0.26	0.29	0.34	0.14	0.22	0.31
Methyl Chloride	339.70	0.64	0.80	0.51	0.76	0.63	0.60
Freon-142b	346.30	0.16	0.27	0.05		0.16	0.10
Freon-114	369.43					0.23	
Vinyl Chloride	375.57				0.09		
Dichloromethane	518.77	0.09					0.16
3-Chloropropene	522.88						0.05
Freon-113	531.54	0.21	0.19	0.23	0.16	0.33	0.29
c-1,2-Dichloroethene	591.31			0			
1,2-Dichloropropane	679.55			0.11			
Perchloroethylene	805.33	0.19			0.05	0.04	
SUM		**1.69**	**1.85**	**1.40**	**1.35**	**1.79**	**1.67**
Isoprene & Monoterpenes							
Isoprene	504.19	0.32	0.14	0.28	0.16	0.62	0.06
alpha-Pinene + 3,6-DiMethyloctane	943.64	1.13			0.88	0.88	0.79
Camphene + 2,6-DiMe-4-Heptanone	959.75	0.21				0.06	0.10

beta-Pinene	986.65	0.65					0.51
SUM		**2.30**	**0.14**	**0.28**	**1.04**	**1.56**	**1.46**
Ketones							
Acetone	476.37	3.80	3.68	5.13	3.79	5.54	5.31
MEK	577.35	1.37		1.10	0.62	0.57	0.99
4-Methyl-2-Pentanone	721.82	0.23	0.20	0.08	0.08		
2-Heptanone + 3-Ethylthiophene	870.23	1.28					
Cyclohexanone	870.91		0.30	0.36	0.41	0.28	0.26
2-Methyl-3-Heptanone	922.24					0.07	
2-Octanone	971.63	0.54		0.17	0.08	0.10	0.16
2-Nonanone	1073.92			0.23		0.10	
SUM		**7.22**	**4.18**	**7.06**	**4.98**	**6.65**	**6.72**
Olefins							
Ethylene	173.78	0.59	0.54	0.44	0.45	0.28	0.41
Propylene	289.65	0.57	0.29	0.15	0.11	0.18	0.22
Butene-1	389.97	0.31		0.21	0.61	0.27	0.19
c-Butene-2	425.94	0.06					
2-Methyl-1-Butene	496.17	0.09	0.10	0.06			0.04
cis-2-Pentene	516.35	0.05	0.13			0.07	0.04
2-Methyl-2-Butene	521.04	0.08	0.13			0.22	
Hexene-1	589.36	0.12					0.05
trans-2-Hexene	604.98		0.09	0.13			0.52
2-Methyl-2-Pentene	607.37	0.10					
2,4-DiMethyl-1-Pentene	647.79	0.10		0.08	0.10	0.07	0.06
Heptene-1	689.22				0.84		
trans-3-Heptene	697.82						0.06
2,4,4-TriMethyl-1-Pentene	712.30	0.15	0.14				
cis-2-Heptene	713.54					0.19	
Octene-1	789.04	0.08	0.11		0.08		
3-Octene	796.71	0.08	0.11	0.075			

cis-2-Octene	812.37		0.06				
trans-3-Nonene	895.32		0.13	0.06	0.06		
Cyclooctene	903.75		0.45				
cis-2-Nonene	912.37					0.11	
SUM		**2.72**	**2.26**	**1.23**	**2.24**	**1.38**	**1.56**
Paraffins							
Ethane	200.00	3.59	3.10	2.44	2.49	2.22	2.09
Propane	300.00	7.45	4.97	4.14	3.85	3.53	3.78
Isobutane	361.88	1.66	1.06	0.78	0.82	0.83	0.85
n-Butane	400.00	3.55	2.50	1.86	1.74	1.51	1.69
Isopentane	474.54	2.28	1.21	0.86	1.15	0.76	1.02
n-Pentane	500.00	0.99	0.72	0.42	0.60	0.40	0.48
2,2-Dimethylbutane	535.47	0.26	0.08	0.34	0.08	0.13	0.18
Cyclopentane	562.82	0.14					
2,3-Dimethylbutane	565.46	0.20	0.12	0.17	0.19	0.06	0.13
2-Methylpentane	570.09	1.11	0.42	0.17	0.24	0.17	0.18
3-Methylpentane	583.52	1.19	0.59		0.36		
n-Hexane	600.00	0.44	0.33	0.12	0.51	0.16	0.27
Methylcyclopentane	627.20	0.21	0.14	0.105	0.115	0.12	0.15
2,4-Dimethylpentane	631.38		0.12				
Cyclohexane	660.96	0.15	0.08				
2-Methylhexane	668.68	0.60		0.06			
2,3-Dimethylpentane	670.80					0.39	0.27
3-Methylhexane + 3-Pentanone	677.22	0.84	0.38	0.26	0.74	0.47	0.51
3-EthylPentane	687.12	0.05	0.06				0.04
2,2,4-TriMethylpentane	690.72	0.42	0.20	0.18		0.24	0.21
n-Heptane	700.00	0.32	0.27	0.12	0.21	0.08	0.29
MethylCyclohexane	724.30			0.11		0.45	0.31
2,4-DiMethylhexane	735.91	0.12				0.08	0.13
hexamethylcyclotrisiloxane	753.56		0.20	0.26	0.16	0.09	0.13
2,3-DiMethylhexane	762.98	0.71					

2-Methyl-3-Ethylpentane	765.00				0.14		
2-Methylheptane + 3-Methylthiophene	767.55		0.06				
4-MeHeptane + 2-Hexanone	769.28	0.38					
3-Methylheptane	775.34		0.05				0.11
3-Ethylhexane	777.10			0.30			
n-Octane	800.00	0.15	0.12	0.10			
2,3,5-TriMethylhexane	819.44		0.12	0.27	0.23	0.15	
2,4-DiMethylheptane	825.88		0.05			0.03	
4,4-DiMethylheptane	829.05	0.26		0.12	0.18		
2,5-DiMeHeptane + 5-Me-2-Hexanone	838.60	0.11	0.08		0.06		
3,3-DiMethylheptane	841.50		0.05				
3,4-DiMethylheptane	862.50						0.29
3,3-DiEthylpentane	884.00	0.11					
Nonane	900.00	0.22		0.15	0.27	0.08	0.10
2,2-DiMethyloctane	921.05						0.10
3,5-DiMethyloctane	927.97		0.03		0.09		
Cyclooctane	928.80	0.23					
IsopropylCyclohexane	929.10			0.07			
2,6-Dimethyloctane	937.70	1.03	0.135	0.31	0.21	0.16	0.21
3,3-DiMethyloctane	942.00		0.26	0.54	0.20	0.20	
2,3-DiMethyloctane	958.75	0.22	0.12	0.24	0.12	0.06	0.07
5-Methylnonane	962.00	0.20	0.07		0.04		
2-Methylnonane	966.32		0.44	0.67			0.15
3-Methylnonane	973.55		0.18				
n-Decane	1000.00	0.16	0.14	0.15	0.14	0.15	0.07
+ n-Undecane	1100.00		0.10	0.07	0.13	0.07	0.10
n-Dodecane	1200.00	0.11	0.15	0.10	0.13	0.05	
SUM		**29.38**	**18.61**	**15.39**	**15.13**	**12.59**	**13.84**
Phenols							
4-methylphenol		0.28	0.11	0.00	0.06	0.00	0.09

SUM		**0.28**	**0.11**	**0.00**	**0.06**	**0.00**	**0.09**
Sulfides							
DiMethylsulfide	507.30	0.32	0.20				0.07
2-Methylthiopropane	662.64	0.14	0.21	0.12	0.05		0.12
DiMethyldisulfide	729.82	0.43	0.24	0.09	0.115		0.085
Methylethyldisulfide	822.91	0.14	0.09	0.06			
Methyl-sec-butyldisulfide	990.36	0.34	0.59	0.29	0.27	0.25	0.36
Dimethyltetrasulfide	1220.30	0.29					
SUM		**1.63**	**1.32**	**0.55**	**0.45**	**0.25**	**0.64**
Unknowns							
Unknown	266.92				0.17		0.16
Unknown	326.30	0.24		0.03		0.15	
Unknown	350.47		0.20				
Unknown	354.72	0.15	0.08	0.03	0.21		0.25
Unknown	452.36				0.09	0.30	
Unknown	523.25			0.25			
Unknown	544.47	0.21	0.38		0.35	0.08	0.16
Unknown	592.36				0.05		
Unknown	595.81		0.16		0.20	0.12	0.11
Unknown	610.49		0.09				
Unknown	620.74	0.14	0.10				
Unknown	638.63		0.09			0.13	0.12
Unknown	642.02	0.06					
Unknown	644.55	0.16	0.09	0.11	0.10		0.10
Unknown	684.41	0.05					
Unknown	710.01		0.06				0.15
Unknown	716.76	0.21					
Unknown	726.61		0.06		0.06		0.08
Unknown	747.75	0.24		0.12	0.16		
Unknown	779.81		0.62			0.66	

Unknown	785.98	0.08					
Unknown	791.10	0.05					
Unknown	793.28		0.12				
Unknown	809.72	0.15					
Unknown	815.37				0.06		
Unknown	844.42	0.12		0.09		0.06	
Unknown	847.21				0.04	0.12	
Unknown	908.79			0.19			
Unknown	910.70	0.08					
Unknown	916.10		0.14	0.08		0.03	
Unknown	933.29	0.30	0.09	0.11	0.09		
Unknown	1013.63	1.24			0.67	0.84	
Unknown	1027.85	0.27	0.16			0.21	
Unknown	1036.98	0.62			0.05		
Unknown	1040.81	0.22	0.09				
Unknown	1062.68				0.07		
Unknown	1073.24	0.35					
Unknown	1113.29		0.08		0.04		0.05
Unknown	1119.01	0.86	0.29		0.06	0.10	
Unknown	1123.00			0.10	0.05		0.12
Unknown	1128.86	0.26					
Unknown	1137.02		0.05	0.11			
Unknown	1144.96			0.06	0.06	0.09	0.08
Unknown	1148.05		0.07	0.07		0.08	0.09
Unknown	1153.22		0.10	0.12		0.12	
Unknown	1156.53		0.52	0.35		0.18	
Unknown	1161.98			0.16	0.06		0.12
Unknown	1164.70	0.09					
Unknown	1168.51	0.04	0.16				
Unknown	1175.95		0.19	0.16	0.21	0.12	0.31
Unknown	1207.53	0.19					
Unknown	1210.71			0.05			

Unknown	1215.69	0.43					
Unknown	1232.94		0.24	0.08			
Unknown	1243.93	0.37					0.42
Unknown	1257.73			0.21	0.22	0.29	
Unknown	1263.87	0.09		0.12	0.21		
Unknown	1272.12	0.25	0.05			0.10	
Unknown	1275.66	0.56					
Unknown	1291.80	1.00	0.33				0.23
SUM		**9.04**	**4.57**	**2.53**	**3.26**	**3.78**	**2.54**
Total VOCs		**78.54**	**43.72**	**45.69**	**42.49**	**47.29**	**49.98**

Appendix 11 (Continued) VOCs (ppbC) detected at Moore Brothers Farm in February 2003

Canister #		**AQ-125***	**1862**	**AQ-146***	**2009***	**AQ-048***
Date		**2/4/03**	**2/4/03**	**2/3/03**	**2/3/03**	**2/3/03**
Time		**1305**	**1305**	**1251**	**1315**	**1344**
Location		**Between last house & lagoon**	**At fan outlet 12 m from AQ-125**	**Downwind of houses & lagoon**	**Between last house & lagoon**	**Between last 2 houses near lagoon**
Temperature (Celcius)		**18.7**	**18.7**	**21.2**	**20.2**	**21.1**
Wind Speed (m/s)		**4 to 5**	**4 to 5**	**6 to 7**	**6 to 7**	**6 to 7**
Alcohols						
Methanol	408.00	2.71	6.05	1.78	5.38	4.38
Ethanol	461.50	3.14	26.09	1.02	3.88	7.14
n-propanol				0.06	0.37	0.13
2-butanol		0.10	0.39	0.12	0.06	0.19
n-Butanol + Thiophene	655.66	0.53	0.81	0.45	0.65	0.46
SUM		**6.47**	**33.33**	**3.42**	**10.33**	**12.29**
					0	
Aldehydes					0	
Acetaldehyde	372.25	1.41	3.90	1.95	10.29	3.38
Methacrolein	552.82	0.13	0.05	0.10	0.15	
Butanal	572.72	0.88	0.93	0.62	1.85	0.88
Isopentanal	635.89	0.10	0.07		0.11	
Pentanal	675.78	0.08				0.05
Hexanal	778.54	1.12		0.80		1.54
Heptanal + Styrene	881.42	0.71	2.33	0.68	0.54	1.16
Octanal	983.98	0.53	1.30		0.47	0.51
Nonanal	1086.66	0.68	7.22		0.80	

Decanal	1189.79	0.84	1.47		0.71	
SUM		**6.47**	**17.26**	**4.12**	**14.91**	**7.52**
Alkynes						
Acetylene	187.39	0.06	3.67	0.38	0.11	0.14
Propyne	328.11				0.21	0.19
SUM		**0.06**	**3.67**	**0.38**	**0.31**	**0.33**
Aromatics						
Benzene	651.21	0.64	0.68	1.22	1.33	1.06
Toluene	758.58	0.40	0.88	0.94	0.99	1.09
Ethylbenzene + 4-Heptanone	855.40	0.13	0.13		0.21	
o-Xylene	887.56			0.10		
Isopropylbenzene	920.34		0.10			0.08
Benzaldehyde	940.10		0.32	0.20		
n-Propylbenzene	950.95			0.31	0.05	0.03
1,3,5-TriMethylbenzene	964.32	0.28	0.61		0.18	
o-Ethyltoluene	976.97			0.06	0.04	
m-Dichlorobenzene	1001.00					0.155
p-Dichlorobenzene	1005.93	0.09				0.055
Isobutylbenzene	1008.16			0.07		
sec-Butylbenzene	1010.39					0.075
1,2,3-TriMethylbenzene	1022.13	0.17				
p-Cymene	1022.93				0.12	0.105
o-Cymene	1037.53		0.15	0.13		
m-Diethylbenzene	1046.57	0.07				0.09
n-Butylbenzene	1054.69	0.14				
o-Diethylbenzene	1061.38					
1,2-DiMe-3-Ethylbenzene	1107.49			0.07		0.105
1,2,4,5-TetraMe-Benzene	1121.01					0.09
m-DiisoPropylbenzene	1152.00			0.13		
t-1-But-3,5-DiMeBenzene	1174.77	0.13		0.20		

1,2,4-TriChlorobenzene	1181.85					0.03
SUM		**2.04**	**2.85**	**3.40**	**2.90**	**3.01**
Esters						
Butyl Propanante	888.77		0.27			
SUM		**0**	**0.265**	**0**		**0**
Ethers						
Furan	490.75		0.03		0.18	
ETBE	619.80	0.07			0.04	
SUM		**0.07**	**0.03**	**0.00**	**0.22**	**0.00**
Halogenated Hydrocarbons						
Freon-22	304.94	0.24	0.64	0.14	0.27	0.12
Freon-12	314.04	0.27	0.22	0.24	0.30	0.27
Methyl Chloride	339.70	0.76	0.65	0.78	0.87	0.97
Freon-142b	346.30		0.32	0.22		0.16
Freon-114	369.43				0.13	0.16
Dichloromethane	518.77		0.06	0.12	0.28	0.11
Freon-113	531.54	0.39	0.16	0.13	0.17	0.24
c-1,2-Dichloroethene	591.31	0.04				
Trichloroethylene	688.10	0.04	0.07	0.09	0.08	
c-1,3-Dichlopropene	720.09	0.11				
Perchloroethylene	805.33	0.07	0.03		0.10	
SUM		**1.91**	**2.14**	**1.71**	**1.19**	**2.11**
Isoprene & Monoterpenes						
Isoprene	504.19	0.33	0.60		0.47	0.32
alpha-Pinene + 3,6-DiMethyloctane	943.64	0.46	0.98			0.69
beta-Pinene	986.65					0.26
Limonene	1033.82					0.045
SUM		**0.79**	**1.57**	**0.00**	**0.47**	**1.31**

Ketones						
Acetone	476.37	5.55	8.99	7.11	16.87	6.61
MEK	577.35	0.55	1.53	1.31	3.45	1.41
2-Pentanone	667.26				0.03	
4-Methyl-2-Pentanone	721.82	0.35	0.76			0.24
2-Heptanone + 3-Ethylthiophene	870.23			0.54		
Cyclohexanone	870.91	0.30	0.26		0.40	
2- & 3-Methylcyclohexanone	930.96			0.22		
2-Octanone	971.63	0.15	0.07		0.08	
5-Nonanone	1057.29			0.16		
2-Nonanone	1073.92		0.13		0.39	
SUM		**6.89**	**11.73**	**9.34**	**21.21**	**8.25**
Olefins						
Ethylene	173.78	0.58	0.18	1.97	0.77	0.73
Propylene	289.65	0.28	0.42	0.21	0.34	0.40
Butene-1	389.97	0.21	0.34		0.26	
3-Methyl-1-Butene	457.43				0.13	
2-Methyl-1-Butene	496.17	0.08	0.29		0.10	0.08
2-Methyl-2-Butene	521.04					0.085
Hexene-1	589.36	0.04	0.14			0.13
trans-2-Hexene	604.98	0.14			0.16	
cis-2-Hexene	614.50				0.05	
2,4-DiMethyl-1-Pentene	647.79	0.08	0.26		0.16	0.07
4-Me-1-Hexene	665.23	0.17				
Heptene-1	689.22					0.115
2,4,4-TriMethyl-1-Pentene	712.30					0.16
cis-2-Heptene	713.54	0.19	0.07	0.15		
Octene-1	789.04	0.09		0.07		0.26
3-Octene	796.71	0.06	0.12	0.04	0.15	0.11
trans-2-Octene	803.11	0.06	0.08	0.04		0.05

cis-2-Octene	812.37		1.12	0.08		0.11
Nonene-1	889.31	0.10				0.18
cis-3-Nonene	898.03					0.125
SUM		**2.05**	**3.00**	**2.55**	**2.12**	**2.59**
Paraffins						
Ethane	200.00	2.04	1.78	4.64	4.38	4.03
Propane	300.00	3.55	3.94	8.24	8.53	7.51
Isobutane	361.88	0.75	1.04	1.81	1.95	1.45
n-Butane	400.00	1.59	1.45	3.32	3.43	2.93
Isopentane	474.54	0.73	0.61	1.60	1.60	1.14
n-Pentane	500.00	0.52	0.58	0.91	0.86	0.79
2,2-Dimethylbutane	535.47	0.13	0.44	0.15	0.27	0.17
2,3-Dimethylbutane	565.46	0.08	0.62	0.18	0.26	0.16
2-Methylpentane	570.09	0.54	6.41	0.36	1.18	1.06
3-Methylpentane	583.52	0.76	5.67	0.45	1.11	1.40
n-Hexane	600.00	0.29	1.73	0.32	0.44	0.40
Methylcyclopentane	627.20	0.32	0.55	0.19	0.24	0.20
2,4-Dimethylpentane	631.38		0.04			0.11
Cyclohexane	660.96		0.12	0.22	0.28	0.22
2-Methylhexane	668.68	0.05				0.045
3-Methylhexane + 3-Pentanone	677.22	0.86	0.75	0.50	1.23	0.56
2,2,4-TriMethylpentane	690.72			0.21	0.27	0.37
n-Heptane	700.00	0.17	0.15	0.31	0.21	0.31
2,4-DiMethylhexane	735.91	0.12	0.09	0.05		
3,3-DiMethylhexane	743.87				0.19	0.14
hexamethylcyclotrisiloxane	753.56		0.29	0.24	0.25	0.24
2,3-DiMethylhexane	762.98	0.09	0.20			0.23
2-Methylheptane + 3-Methylthiophene	767.55			0.15	1.72	0.165
3-Methylheptane	775.34	0.08	0.04	0.04		0.11
2,2,4-TriMethylhexane	794.85	0.05			0.10	
n-Octane	800.00	0.12	0.32	0.10	0.12	0.08

2,3,5-TriMethylhexane	819.44	0.17	0.18		0.12	0.10
2,4-DiMethylheptane	825.88	0.10				
Nonane	900.00				0.19	
3,5-DiMethyloctane	927.97			0.14		
2,6-Dimethyloctane	937.70	0.13	0.22		0.16	0.13
3,3-DiMethyloctane	942.00	0.40			0.10	0.235
2,3-DiMethyloctane	958.75	0.09	0.13		0.06	0.23
5-Methylnonane	962.00		0.08			
2-Methylnonane	966.32					0.925
3-Methylnonane	973.55					0.18
IsoButylcyclohexane	997.00	0.04				
n-Decane	1000.00	0.10	0.08		0.14	
+ n-Undecane	1100.00	0.14			0.13	0.12
SUM		**13.94**	**27.44**	**24.09**	**29.46**	**25.71**
Phenols						
4-methylphenol		0.07	10.50	0.20	0.32	5.90
SUM		**0.07**	**10.50**	**0.20**	**0.32**	**5.90**
Sulfides						
DiMethylsulfide	507.30	0.27	0.90			0.49
2-Methylthiopropane	662.64				0.21	
DiMethyldisulfide	729.82	0.07	0.34	0.23	0.17	
Methylethyldisulfide	822.91		0.04			
2,5-Dimethylthiophene	862.37		0.18			
Dimethyltrisulfide	963.85			0.695		
Methyl-sec-butyldisulfide	990.36	0.27	0.04	0.195	0.27	0.19
Dimethyltetrasulfide	1220.30			0.05		
SUM		**0.61**	**1.49**	**1.17**	**0.64**	**0.68**
Unknowns						
Unknown	266.92			0.30		

Unknown	326.30			0.07		
Unknown	350.47					0.175
Unknown	354.72	0.09				0.035
Unknown	452.36			0.12		
Unknown	544.47	0.25		0.14		
Unknown	595.81	0.10		0.12	0.14	0.185
Unknown	610.49		0.11			
Unknown	617.91				0.08	
Unknown	620.74		0.23			
Unknown	644.55		0.08	0.11	0.18	0.15
Unknown	710.01					0.12
Unknown	726.61	0.11		0.05		0.085
Unknown	747.75		0.12			
Unknown	779.81				1.50	
Unknown	783.92				0.11	
Unknown	785.98					0.07
Unknown	809.72			0.04		
Unknown	815.37		0.25			
Unknown	844.42	0.05	0.13			
Unknown	847.21			0.07		
Unknown	851.61		0.22	0.23		
Unknown	860.26	0.06		0.32		
Unknown	910.70			0.12		
Unknown	916.10			0.04		0.035
Unknown	933.29				0.21	
Unknown	971.22			0.22		
Unknown	995.10		0.05	0.20		
Unknown	1013.63	0.58	0.55	0.66	0.31	
Unknown	1027.85		0.08			0.04
Unknown	1032.10			0.15		
Unknown	1040.81	0.14				
Unknown	1043.84			0.31		

Unknown	1062.68	0.04				
Unknown	1119.01		0.11		0.49	0.09
Unknown	1123.00	0.18				
Unknown	1134.17		0.03	0.09		
Unknown	1144.96	0.04				0.05
Unknown	1153.22	0.06		0.25	0.06	
Unknown	1156.53					0.1
Unknown	1164.70	0.04		0.05		
Unknown	1172.96			0.21		
Unknown	1175.95					0.07
Unknown	1179.17		0.18			
Unknown	1210.71		0.07		0.09	
Unknown	1232.94		0.30			
Unknown	1243.93			0.15		
Unknown	1257.73		0.19			
Unknown	1275.66	0.15		0.35		0.17
Unknown	1291.80				0.18	
SUM		**1.92**	**2.65**	**4.29**	**3.32**	**1.37**
Total VOCs		**43.26**	**117.98**	**54.65**	**88.36**	**70.96**

*Samples collected in conjunction with Duke University odor panel
Samples selected for GC/MS analysis

Standard Operating Procedure for the Cryogen Gas Chromatographic-Flame Ionization Detection (CryoGC-FID) Systems

by

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Cryo GC/FID SOP

The Cryo GC/FID system consists primarily of 3 components including the GC system, a preconcentration device, and a data integration system to determine VOC identification and concentration. Each component part will be individually described.

GC/FID System#1

The gas chomatograph is Hewlett-Packard Model 5890A Series II, Serial Number 3310A49947, EPA 927168 combined with flame ionization detection (FID). The GC system manufacturer provide operation and instruction manuals that describe in extensive detail proper system operation, limitations, and expected performance under various environmental conditions. Manufacture guidelines also includes information concerning the gases and cryogens required for proper operation. Utilization of the GC systems for ambient air analysis in our laboratory environment are well within the manufacturer's guidelines for proper and quantitative operation.

The GC column used in this system is a 60m x 0.32mm ID fused silica column containing a one micron DB-1coating (J&W Scientific, Folsom, CA). In operation the column conditions consist of a -50^{o}C initial temperature for 2 minutes followed by temperature programming to 200^{o}C at a rate of 8^{o}C/min. After a 7.75 minute hold period column temperature is programmed to 225^{o}C at a 25^{o}C/min rate and held at that temperature for 8 minutes. These temperature conditions provide separation of the C_2-C_{12} hydrocarbons, a major component of the gas phase VOCs. Liquid Nitrogen is used as the cryogen to obtain the sub-ambient temperatures required in this programming

sequence. An electronic pressure control (EPC) device is used to maintain column head pressure of the helium carrier gas at a constant value of 150 kPa throughout the analysis period. For the column used in this system, the 150 kPa pressure provides a column flowrate of 2.65 cc/min at 75°C.

The FID requires the use of hydrogen and air for operation. To maximize response, a nitrogen makeup gas is recommended and utilized. For FID operation in this system the flowrates for hydrogen, air, and nitrogen are adjusted to and are maintained at 48, 325, and 30cc/min respectively. The detector is heated to and maintained at 275°C.

GC/FID System#2

A second GC column is used when needed to obtain better separation of the C_2 hydrocarbons, ethylene, acetylene, and ethane. The column is a 30m x 0.53mm ID GS-Q coated porous layer open tubular (PLOT) column (J&W Scientific, Folsom, CA). In operation the column can be installed in the same GC oven as the DB-1 column if a dual FID GC system is available. Currently the column is installed in Hewlett-Packard 5890 Series II, Serial Number 2921A24163, EPA 666784 which is a dual FID system. Also installed in this GC system is an identical DB-1 60m x 0.32mm ID fused silica column as that described for EPA 927168 and is used as a backup to GC System#1. In operation the column temperature conditions are identical to those described earlier. After a -50°C initial temperature held for 2 minutes, the column oven is temperature programmed to 200°C at a rate of 8°C/min.. After a 7.75 minute hold period the column oven temperature is programmed to 225°C at a 25°C/min rate and held at that temperature for 8 minutes. EPC devices are used to maintain column head pressure for both GC columns. For the

GS-Q PLOT column head pressure is maintained at 12 kPa which provides a column flowrate of 2.08 cc/min at 60°C. For the DB-1 column the head pressure is maintained at 143 kPa which provides a column flowrate of 2.65 cc/min at 60°C.

The FIDs require the use of hydrocarbon and air for operation along with nitrogen as a makeup gas. For optimum response the pressure-flowrate control settings for the FID used with the GS-Q PLOT column are set at 20, 40, and 45 psig for hydrogen, air and nitrogen respectively. For optimum response the pressure-flowrate control settings for the FID used with the DB-1 column are set at 152 and 255 kPa for hydrogen and air respectively; and 45 psig for the nitrogen makeup. The FIDs are heated to and maintained at 275°C.

Preconcentration System

The preconcentration systems for all GC analyses were identical in construction and operation with the exception of the sample valve. The preconcentration system consists of a 6-port gas sample valve configured to use a packed glass bead trap in place of a sample loop. For the DB-1 column used with Hewlett-Packard EPA 927168 the sample valve is a low dead volume diaphragm valve selected for low maintenance and reliable operation (Valco Model VIII, Houston, TX). For both the GS-Q and the DB-1 columns used with Hewlett-Packard EPA 666784 the sample valves are rotor-type (Valco Conical, Houston, TX). The valves and sample inlet lines are maintained at approximately 65°C during operation. The glass bead trap consists of a 25cm x 3.2 mm stainless steel trap packed with 60-80 mesh untreated glass beads. Other components of the preconcentration system include a ballast tank (approximate 1.8 liter volume), a

diaphragm pump (Thomas Model 2107VA20A, Sheboygan, WI), and a vacuum gauge (Wallace & Tiernan Model 61D-1D-0200, Belleville, NJ).

The preconcentration components were arranged to isolate the ballast tank from the sample valve, and to selectively flow sample air or helium through the glass bead trap. Figures 1a and 1b provide diagrams of the preconcentration system operation in the trap and injection modes respectively. A helium flow of 70 cc/min is routed through the trap in a backflush mode compared to that of air sample flow during time periods other than air sample trapping. Preconcentration operation steps are performed in the following sequence. The ballast tank is isolated form the sample valve and is evacuate to a pressure of 40 mm Hg. At the same time the the trap is immersed with a Dewar of liquid Argon (-187^{o}C). When the trap reaches liquid Argon temperature equilibrium, the sample valve is switched to its inject position, helium trap flow is stopped, and sample air is drawn into the trap by the vacuum differential in the ballast tank. When the gauge pressure reaches 60 mm Hg the sample valve is pneumatically switched to it fill position routing sample air through the glass bead trap. Sample air flow through the trap is maintained at about 120 cc/mm. When the gauge pressure reaches 180 mm Hg, air flow through the trap is stopped. Next a series of operations are sequentially performed in the following order and includes switching the valve to its inject position, removing the Dewar containing liquid Argon, then replacing it with a Dewar containing hot water (100^{o}C). For the DB-1 columns of GC System#1 and GC System#2 the trapped VOCs are injected onto the GC column maintained at -50^{o}C and the column temperature programming sequence is started. After a 2.25 minute injection time the valve is switched back to its fill position and the trap is flushed with helium to prepare for the next preconcentration sequence.

Trap temperature during the 2.25 minute injection period generally decreases from 99 to 92°C. Tests with both ambient air samples and known standard mixtures have shown that the 2.25 minute trap injection period is at least 0.5 minutes longer than the required time to quantitatively inject the C_2-C_{12} hydrocarbons onto the GC column at the 99°C trap temperature. For the GS-Q column of GC System#2 the trapped VOCs are injected onto the column 9 minutes after start of the temperature programming sequence to maximize chromatographic resolution of ethylene, acetylene, and ethane.

Data Integration System

Digital data provided by the Hewlett-Packard A/D board is accessed by the ChromPerfect - 5890 Direct chromatographic software program (Justice Inovations, Mountain View, CA) installed on the Hewlett Packard Vectra Model 486/66XM (Serial No. 3330S00523, EPA927144) IBM compatible computer. The chromatographic program acquired the time and voltage digital signal and electronically recorded the signal as RAW data files for later processing. An example of a RAW data file is shown as the chromatogram in Figure 2. The RAW data files are later accessed by chromatographic software and, using selectable threshold, peak width and time event settings, GC peak areas are quantitatively integrated and stored along with retention times in AREA files. The ChromPerfect software uses the AREA files and a user prepared CALTABLE to name the GC peaks as VOCs based upon retention time location and convert peak areas to ppbC concentrations. The CALTABLE preparation and development is performed by the user from known standard mixtures and measured

retention times. User guides that describe how to properly operate the ChromPerfect software are provided by the manufacturer.

The current laboratory procedure does not use the ChromPerfect software beyond the preparation of the AREA files. Rather the AREA files are processed by another software program, HCID, to name the GC peaks and convert peak areas to ppbC. The HCID program (Graham Solutions, Conyers, GA) provides more flexibility in changing the CALTABLE information, compound response factors, and correctly selecting and changing reference peaks; the latter feature is most important for accurate GC peak identification using retention time location. The HCID software program is designed to follow the following sequence of operation. The first step in the process of naming sample compound peaks involves the manual selection of reference peaks and comparison of observed retention times with CALTABLE entries for these compounds. Adjustment factors are determined by the ratio of the observed retention time to its CALTABLE value. The determined ratios are used to adjust all the other GC peaks in the sample. The adjusted retention times are compared to compound peaks in the CALTABLE. If a retention time is found in the CALTABLE within a selectable (+/-) tolerance range, the respective compound is named. The CALTABLE contains lists of compound retention time, RTINDEX value, and name. Peaks selected as reference peaks are indicated with a (+) sign at the left of the compound name. The output of the HCID program is a report file, in ASCII format and provides identification information for the GC peaks in the analyzed sample.

GC System Calibration

Calibration of the GC/FID system is performed using a 0.25 ppm propane in air NIST SRM. The current standard tank is Cylinder No. CLM-09748). The Certification Certificate provided with this cylinder states that the accuracy of the propane concentration is 0.25 ppm +/- 1.2%. Both direct and diluted mixtures of the standard are used to prepare a multi-component calibration curve. The dilution apparatus used to prepare the various diluted standard mixtures is a dual mass flow controller (MFC) system containing a 0-100 cc/min and a 0-10 L/min MCFs (Unit UCS-200, Serial Number 00179, Yorba Linda, CA). Prior to calibration activities, various flowrates of the Unit UCS-200 system are verified with a bubble flow meter calibrator (Hastings Model HBM-1A, Serial No. 564, Hampton, VA). The lowest concentration obtained from this calibration system is 2.54 ppbC and is measured on both GC Systems at approximate +/- 2.5% precision. The slope of the multi-point curve is given in terms of ppbC-area^{-1}, based on propane, and is used as the response factor to determine the compound concentration of all observed peaks. The basis for using a single response factor for all compounds is the assumption of uniform carbon response for the flame ionization detectors (Sternberg et. al., 1962, Dietz, 1967, and Blades, 1976). All compound peaks are reported as ppbC based on propane. Observed hydrocarbon compounds can be converted to parts-per-billion (ppb) concentration by dividing the measured ppbC concentration by the compound carbon number; e.g., butane contains 4 carbons. The per carbon response of VOCs that contain atoms other than carbon and hydrogen are effected by the presence of other atoms; e.g., acetone has an oxygen atom attached to one of it 3 carbon atoms. Consequently the FID response of the carbon atom containing the oxygen atom is significantly lower than the other 2 carbon atoms. If accurate concentrations of

substituted VOCs, like acetone, is required, an independent calibration for these specfic compounds is required. A second option is available by using published values of effective carbon number (ECN) adjustments to obtain reasonable concentrations for these compounds in terms of ppb (Jorgeson et.al. 1990, Scanlon and Willis, 1985, Sternberg et.al., 1962).

Because of the observed stability of the FID, multi-point calibrations are typically performed on a semi-annual or annual basis. For day to day verification of FID response, a 4 compound standard cylinder (CAL-5029) containing 48.7 ppbC Ethane, 53.9 ppbC Propane, 51.2 ppbC Isobutane, and, 54.6 ppbC n-Butane is used.

Confirmation Procedure for the VOCs Reported by the GC/FID Systems

As reported above the GC peaks obtained by the GC/FID systems are named by retention time location using a CALTABLE that contains nearly 400 compound peaks whose retention times have been determined from a combination of complex ambient air samples and several known VOC mixtures. This peak naming procedure is reasonably accurate and routinely used with GC/FID systems. For Quality Assurance purposes it is desirable to verify compound peak identification using a gas chomatograph equipped with a mass spectra detection system (GC/MS). For this laboratory activity a Hewlett-Packard Gas Chromatograph Model 6890 , Serial Number US00004942 (EPA 974511) combined with a Hewlett Packard Model 5972 Mass Selective Detector, Serial Number 3609A03618 (EPA 974512) is used. The GC column used is identical to that used for the GC/FID systems consisting of a 60m x 0.32mm ID fused column containing a one micron DB-1 coating (J&W Scientific, Folsom, CA). Column operation is similar to that

used with the GC/FID systems and consists of a -50°C initial temperature for 2 minutes followed by temperature programming to 200°C at a rate of 8°C/min. After a 7.75 minute hold period column temperature is programmed to 225°C at a 25°C/min rate and held at that temperature for 8 minutes. These temperature conditions provide separation of the C_2-C_{12} hydrocarbons, a major component of the gas phase VOCs. Liquid Nitrogen is used as the cryogen to obtain the sub-ambient temperatures required in this programming sequence. Unlike the GC/FID systems, the electronic pressure control (EPC) device is used to maintain a constant helium carrier gas flowrate of 1.4 cc/min throughout the analysis period. In this mode the column pressure changes with column temperature and is 67 kPa when the column is at 75°C. Compounds peaks eluting from the GC column are routed through a MS interface line maintained at 275°C into an vacuum controlled electron impact (EI) ion source at -70 eV. The compound peaks collide with the high energy electrons and are fragmented into ion patterns which are unique to the compound structure. These ions are routed to a quadrupole system that focuses each individual ion for detection by an ion detector system. The detected results are processed and stored by the data system. The data system also compares the fragmented compound ion results to reference libraries that contain the fragmented ion spectra for more than a 1000 compounds. For this system the NBS75K reference library is used for this comparison. In addition to verification of compounds reported by the GC/FID systems, the GC/MS system also serves as an important tool to identify unknown and unidentified compound peaks. Proper operation routine maintenance of the GC and MS systems are obtained by following operational manuals provided by the manufacturer.

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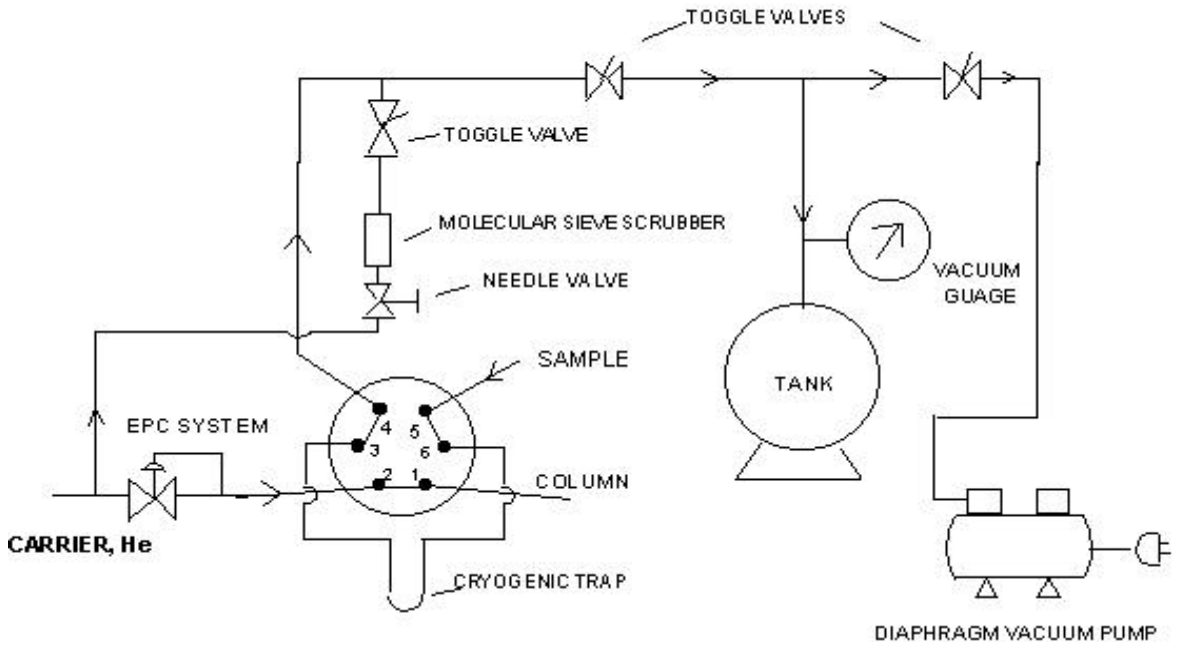

Figure 1a Cryogenic preconcentration system sample trap mode

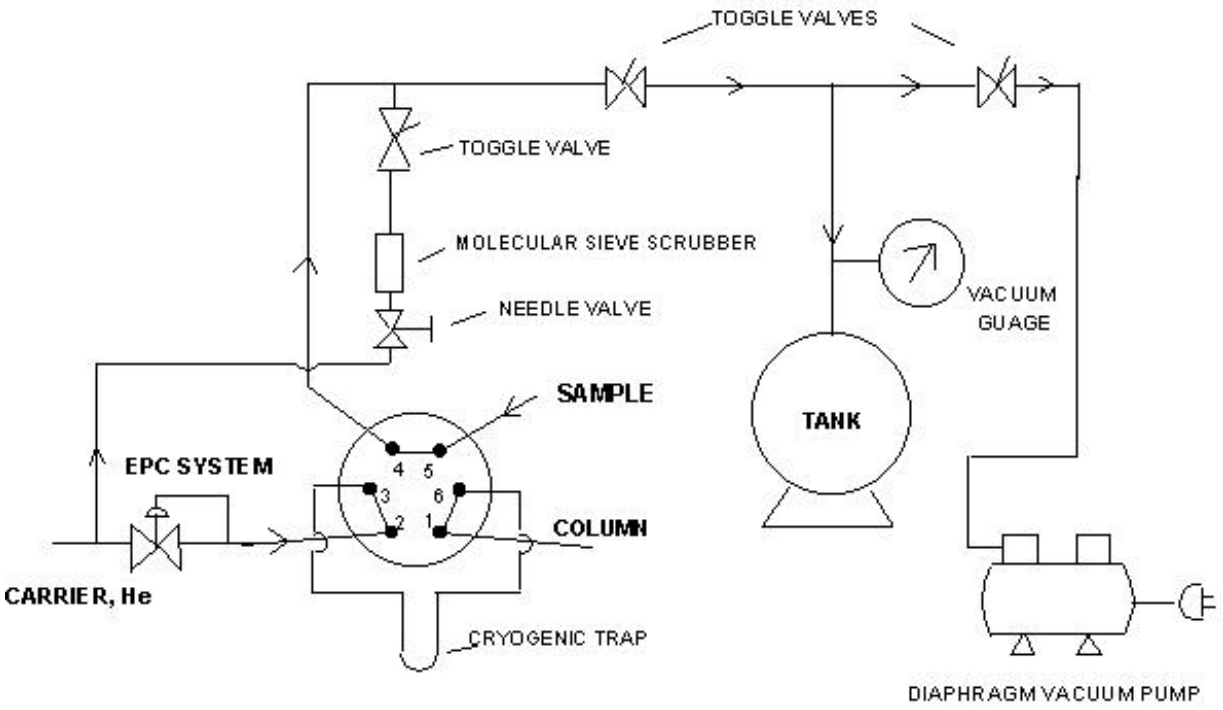

Figure 1b Cryogenic preconcentration system sample inject mode

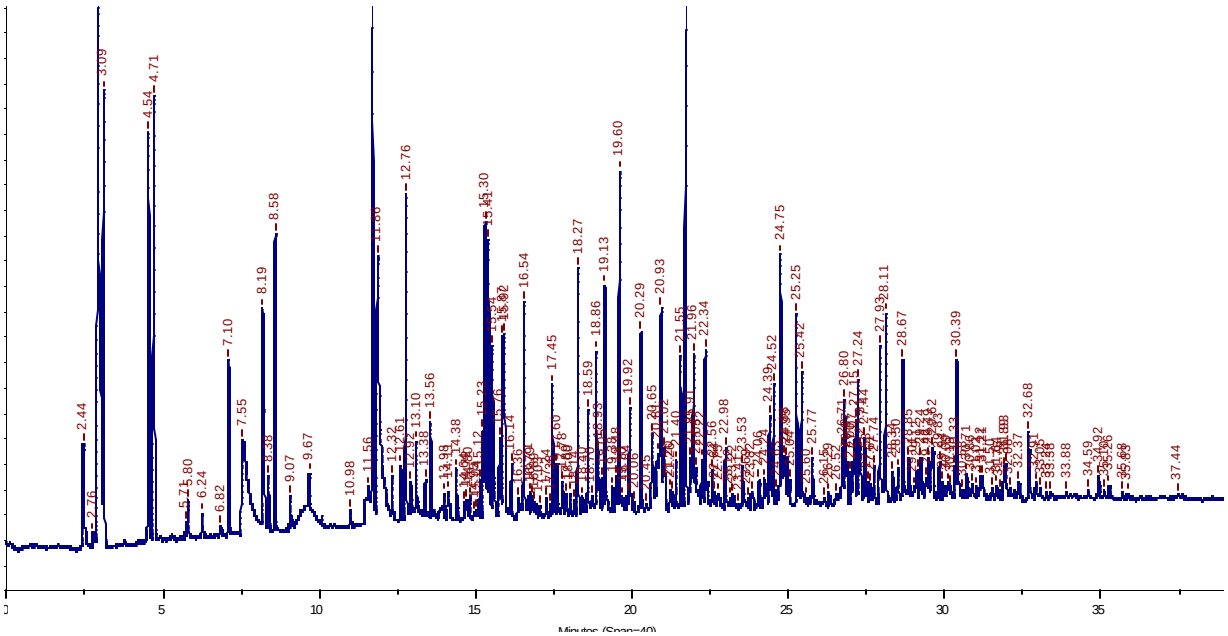

Figure 2 RAW chromatogram data file