FINAL REPORT

# COMPARISON OF MITIGATION MEASURES FOR REDUCTION OF EMISSIONS RESULTING FROM GREENWASTE COMPOSTING

PREPARED FOR:
SAN JOAQUIN VALLEYWIDE AIR POLLUTION STUDY AGENCY
09-01-CCOS

PREPARED BY:
FATIH BUYUKSONMEZ
SAN DIEGO STATE UNIVERSITY
CIVIL, CONSTRUCTION, AND ENVIRONMENTAL ENGINEERING
SAN DIEGO, CA

## Table of Contents

## Table of Figures

## Table of Tables

## Executive Summary

This final report is prepared for the San Joaquin Valleywide Air Pollution Study Agency to summarize the results and findings of the Comparison of Mitigation Measures for Reduction of Emissions Resulting from Greenwaste Composting project under Grant#09-01-CCOS. The goal of this project was to evaluate selected mitigation alternatives for their effectiveness in reducing methane, volatile organic compound (VOC) and nitrous oxide emissions.

The mitigation alternatives selected for the investigation were:

- Pseudo-biofilter application
- Surface irrigation
- Interactively managed windrow
- Reduced size

To this end, five windrows including the control windrow were constructed at the Tulare County Compost and Recycling Facility, which was selected among three possible sites after considering advantages and disadvantages of the sites. The windrows were constructed on June 8$^{th}$; sampling started on June 9$^{th}$ and continued until September 14$^{th}$. The initial weights of materials used in constructing windrows were approximately 100 tons (except for the reduced windrow, which was constructed with 67 tons of material). During this period, 14 sampling days were utilized. On each sampling day, the windrows were scanned with a thermal imaging camera to determine the sampling locations that were presumed to be venting and non-venting points on the ridge of the windrows. The emissions from the side of the windrows were not studied since the focus of this work was to compare the emissions resulting from different mitigation alternatives rather than establishing emission factors or determining live-cycle emissions. Therefore, it is important to understand that determination of emission factors and/or life-cycle emissions were not the focus of this investigation. Even though, the term "*emission factor*" is used in comparing different mitigation alternatives, these results should not be used, treated, or cited as emission factors.

The results of this study suggest that the thermography approach can be used effectively in determining sampling locations. The mitigation alternatives investigated in this study resulted in mixed conclusions in terms of reducing emissions for particular VOCs. All mitigation alternatives had resulted in increased methane and nitrous emissions; while reducing VOC emissions. The reduction of non-methane-non-ethane VOCs was most significant for the biofilter application. Even though the focus of this study was to evaluate the mitigation alternatives for various green house contributing gases; there is another factor that should be considered that it is the odor factor. Considering the odorous nature of the NMNEVOCs and associated complaints, application of pseudo-biofilters may be a viable alternative until further studies are reported for speciation and GHG potencies data.

# INTRODUCTION

This final report is prepared for the San Joaquin Valleywide Air Pollution Study Agency to summarize the results and findings of the Comparison of Mitigation Measures for Reduction of Emissions Resulting from Greenwaste Composting project under Grant#09-01-CCOS.

The goal of the project was to evaluate selected mitigation alternatives for their effectiveness in reducing methane, volatile organic compound (VOC) and nitrous oxide emissions. It is important to understand that determination of emission factors and/or life-cycle emissions were not the focus of this investigation. Even though, the term "*emission factor*" is used in comparing different mitigation alternatives, these results should not be used, treated, or cited as emission factors.

Composting is a biological process that offers a low cost and effective management for organic waste streams. The organic waste material is converted to a humus-like stable, value-added end-product that is commonly used as a soil conditioner. Since a large fraction of the municipal solid waste is organic refuse, with the increasing emphasis being placed on composting by the authorities to manage biodegradable organic waste materials to meet their diversion goals, more and more organic waste is being composted. While composting offers a low-cost management alternative, it has been known to emit considerable amount of volatile chemicals (CIWMB, 2008). Even though it has been shown that composting results in reduced emissions compared to the other waste management alternatives (Chou and Buyuksonmez, 2007 and Buyuksonmez and Evans 2008), it has received increasing attention as an emission source amid with deteriorating air quality and increasing stress for GHG emissions reductions. Therefore, mitigation measures that would further reduce emissions are needed as part of an integrated environmental protection program.

The emissions resulting from composting of organic materials are primarily carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and non-methane-non-ethane volatile organic compounds (NMNEVOCs). A discussion for each compound/class, along with the possible control measures are presented below.

**Carbon Dioxide ($CO_2$):** Carbon dioxide is released in large quantities from the composting process as the material undergoes biodegradation. It should be noted that $CO_2$, $H_2O$, and biomass growth, are the major products of the aerobic biological processes. In a composting environment, a small amount of $CO_2$ can be utilized by the nitrifying organisms as the carbon source. It is often the desired to maximize the $CO_2$ emissions as it indicates a healthy biological process. Any measures to reduce $CO_2$ emissions would cause formation of more problematic compounds. Therefore, this study did not investigate the carbon dioxide emissions.

**Methane ($CH_4$):** Methane is a greenhouse gas that is 21 times more potent thatn $CO_2$ (Hao et al., 2001). Methane is generated from the anaerobic breakdown of organic matter by two sequential types of metabolisms: (i) the organic matter is converted to simpler organic acids through hydrolysis and acidogenesis; and (ii) methanogenic microorganisms convert organic acids to methane through methanogenesis. While the first step can be carried out by facultative organisms, it is important to note that methanogenic microorganisms are strict anaerobes, i.e., oxygen is toxic.

Methane generation can only be prevented, in a practical manner, by controlling the aeration. Nevertheless, it should be noted that anaerobic packets are expected for develop within the composting windrow—even with frequent aeration, thus causing emission of methane. Therefore, emission of methane gas from windrow composting is unavoidable.

**Nitrous Oxide ($N_2O$):** Nitrous oxide ($N_2O$), which is 310 times more potent GHG than $CO_2$, forms as an intermediate product in biological systems through several stages involving two separate modes of metabolism—nitrification and denitrification. Nitrification is an autotrophic process, i.e., the microorganisms derive energy for growth from the oxidation of nitrogen compounds, primarily ammonia. In contrast to heterotrophic organism, nitrifiers utilize carbon dioxide as the carbon source. The nitrification is a two-step process involving two genera of microorganism—*Nitrosomonas* and *Nitrobacter*. Ammonia is, first, oxidized to nitrite by Nitrosomonas (R.1); and subsequently, Nitrobacter further oxidizes nitrite to nitrate (R.2). The overall nitrification reaction is presented in R.3; and R.4 presents the cell synthesis during the nitrification. Nitrifying organisms are present in almost all aerobic systems in limited numbers.

$$NH_4^+ + \frac{3}{2}\,O_2 \xrightarrow{Nitrosomonas} NO_2^- + 2H^+ + H_2O \qquad \text{(R.1)}$$

$$NO_2^- + \frac{1}{2}\,O_2 \xrightarrow{Nitrobacter} NO_3^- \qquad \text{(R.2)}$$

$$NH_4^+ + 2O_2 \xrightarrow{Overall\ Nitrification} NO_3^- + 2H^+ + H_2O \qquad \text{(R.3)}$$

$$CO_2 + HCO_3^- + NH_4^+ + H_2O \xrightarrow{Cell\ Synthesis} C_5H_7O_2N + 5O_2 \qquad \text{(R.4)}$$

In denitrification, nitrate is reduced all the way to the nitrogen gas through a series of steps in which nitrate ($NO_3^-$) is reduced to nitrite ($N_2^-$), nitric oxide (NO), nitrous oxide ($N_2O$) and finally to nitrogen gas ($N_2$) in a stepwise manner (R. 5). The overall denitrification reaction is, as presented in R.6, requires presence of an electron donor (i.e., is another organic substrate), which is presented as ethanol in the equation. Therefore, low concentrations of the biodegradable carbon source will hinder the reduction of nitrate. Furthermore, high levels of oxygen are shown to cause repression of the nitrous oxide reductase enzyme, which catalyzes the reduction of nitrous oxide to nitrogen gas as an intermediate product (Rithman and McCarty, 2001). Thus, the high level of oxygen would cause accumulation and release of nitrous oxide.

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2 \qquad \text{(R.5)}$$

$$CH_3COOH + \frac{8}{5}NO_3^- + \frac{4}{5}H_2O \xrightarrow{Denitrification} \frac{4}{5}N_2 + 2H_2CO_3 + \frac{8}{5}OH^- \qquad \text{(R.6)}$$

Based on nitrification and denitrification metabolisms, the following measures can be taken to control emission of $N_2O$:

1- Prevention of Nitrification: Nitrification starts after readily biodegradable organics are consumed, and requires $O_2$. Thus a low oxygen management scheme can be applied towards the end of active composting, where nitrification starts.
2- Control of Nitrate Reduction: Once the nitrification occurs and ammonia is oxidized to nitrate; then, a high oxygen management scheme should be followed. This will help reduce nitrous oxide formation by two ways: (i) by facilitating rapid oxidation of biodegrable carbon; and (ii) by repression of denitrification metabolism.
3- Promotion of Nitrogen Gas Formation: Once denitrification metabolism starts to take place, a low oxygen management would then be implemented to prevent repression of nitrous oxide reductase enzyme, which reduces nitrous oxide to nitrogen gas.

**NMNEVOCs:** A considerable quantity of non-methane-non-ethane volatile organic compounds is emitted as a result of composting of organic wastes. It should be noted NMNEVOCs are not only emitted as a result of decomposition of organic material within the composting windrow, but also directly from the feedstock as a biogenic source. The latter might even be a more prominent source of VOC, especially for fresh material. Whether the waste organic materials are composted or handled otherwise, they continue to emit a variety of VOCs. Chou and Buyuksonmez (2006) and Buyuksonmez and Evans (2007) showed that composting lowers emissions. These VOCs are biogenic origin; thus, they are biodegradable. Since these are of biogenic and biodegradable compounds, any measure that would promote active biological processes will decrease their emissions. The main process controls that can enhance biological process include oxygen content, moisture content, pH, and C:N ratio. Furthermore, since these chemicals are biodegrable, water soluble (to some extent), and has adsorptive potential, there are an array of mitigation alternatives including pseudo-biofilter cap available to control their emissions.

There are number of process related parameters and mitigation measures that can yield reduction of emissions. These parameters oxygen content, moisture content, pH, carbon-to-nitrogen (C:N) ratio. The mitigation methods that can reduce the emissions include addition of activated carbon/ash, activated humic acids, compost blankets and covers. Even though some of these process parameters have a considerable impact on the level of emissions, their control in a composting setup is not practical and/or feasible.

## Process Parameters

**Oxygen Content:** Oxygen is perhaps the most important process control that affects the composting process. Maintaining a healthy oxygen level within the pore space would promote the aerobic biodegradation—which in turn, will increase biological breakdown of the compounds and lower the VOC emissions; inhibit methanogenesis—thus prevent methane generation; and repress denitrification process. However, practice has shown that it is nearly impossible to prevent formation of anaerobic pockets within a windrow. The oxygen gets depleted very quickly within the pore space.

In windrow composting, aeration is typically provided by the turning event that also provides mixing and heat dissipation. While providing mixing, heat dissipation and aeration, turning also exposes the material to the atmosphere causing chemicals trapped within the pore space to volatilize. Therefore, it is important to match the turning schedule to the oxygen demand to minimize fugitive releases of VOCs.

**Moisture Content:** Moisture content is another important process control that has a big impact in the microbial activity by two means. First, all microbial reactions require water. Second, water fills up the void space and might hinder the oxygen transfer. In addition, it can also solubilize various VOCs; thus, prevent them from being emitted. As a rule of thumb, a moisture content that is between 40% and 70% is desired. Below 40%, microbial activity becomes very limited; and above 70% moisture content, it hinders the microbial activity by flooding the pores and preventing air diffusion.

**Temperature:** Temperature in the composting process is an indication of the biological activity. The heat release due to the intense microbial activity in a windrow causes temperatures to increase. In general, mesophilic to thermophilic temperatures are desired in composting since it is an indication of an active biological process. Beyond 65-70°C, microbial activity is hindered. Temperature can affect emissions in variety of ways. Since the higher temperatures indicate high microbial activity; the oxygen level in the pore space would be depleted quickly causing formation of anoxic and anaerobic conditions. This, in turn, would generate malodorous VOCs, methane and promote denitrification. Therefore, composting windrows are turned—aerated more frequently during the early active stage of composting, to dissipate heat.

An important observation that should be mentioned here is that the nitrification activity is hindered at temperatures higher than 45-50°C (Friis, et al., 2000). This might be another explanation for nitrous oxide emissions starting after the active composting phase. Therefore, maintaining higher temperatures without causing oxygen deficiency within the pore space could be an effective way of limiting nitrous oxide, and indirectly methane emissions. Nevertheless, there is no practical way to control temperatures within a composting pile, therefore, the control of temperature was not included within the scope this project.

**pH:** In any biological process, pH is an important factor since it effects the microbial activity. Most organisms require a growth media with a near neutral pH. In terms of its effect on emissions from a composting pile, the higher pH values will cause increase of ammonia volatilization; while the lower pH values will increase formation and emission of volatile organic acids. It can also affect the nitrification/denitrification processes. However, in green waste composting the amount of perusable organic matter that would elevate the formation of organic acids is considerably low. Therefore, a significant change on pH is not of an expected outcome in yard waste composting. Furthermore, the green waste feedstock has quite a high buffering capacity that would make pH changes even harder. Based on our experience, manipulation of pH would require large quantities of additives. Therefore, the effect of pH, or its control is not a part of this investigation.

## Mitigation Methods

**Activated Carbon/Ash/Biochar:** Addition of these materials is very likely to reduce the emissions of NMNEVOCs through adsorption. Many VOCs are very likely to be adsorbed by the ash; and allow them to be biodegraded over time. These materials, on the other hand, would not provide reduction of emission of other GHG (carbon dioxide, methane and nitrous oxide) since these gases don't have a tendency to adsorb. Nevertheless, it should be noted that their addition may still result in reduction of emission of these gases through available organic carbon manipulation, thus, oxygen management. That is, since some of the available carbon will be absorbed by them and become less available for immediate biodegradation, it might reduce the oxygen requirement; thus, prevent formation of anaerobic conditions.

**Activated Humic Acids**: The addition of activated humic acids might result in reduced emissions since they are also adsorbents like the activated carbon/ash derivatives. However, due to availability and relatively high cost compared to the other mitigation alternatives, this mitigation measure was not considered for the study.

**Pseudo-Biofilter Cap:** We have previously shown that application of pseudo-biofilter is highly effective in reducing NMNEOC in both laboratory scale and full-scale composting (CIWMB, 2007). Following the presentation of our results in a US Composting Council Conference, a composter applied pseudo-biofilter as an odor minimization method and stated that it substantially lowered the odor around the site (Smyth, 2007). Visual photographs that were taken with minutes apart are presented in Figure 1 to show that efficacy of the biofilter cap in reducing emissions; and comparisons of emissions to other windrows are presented in Figure 2.

**Figure 1. Visual comparison of emissions from (a) control and (b) pseudo-biofilter windrows.**

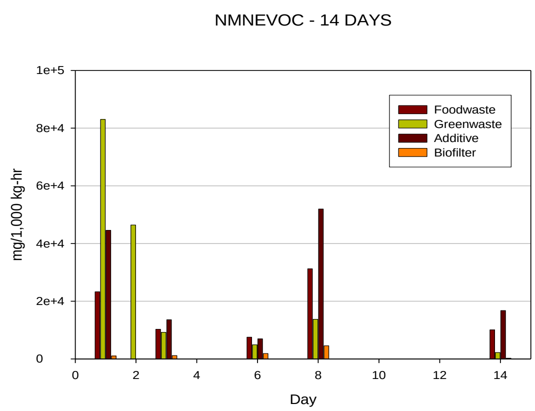



**Figure 2. NMNEOC emissions from various windrows.**

**C:N Ratio:** The carbon-to-nitrogen (C:N) ratio has a direct effect on the biological processes and the emissions. Even though there is a general conception that a feedstock with a lower C:N will result in higher emissions, in reality, it is hard to state the effect of C:N ratio without looking at the composition and availability of the carbon and nitrogen species. For instance, wood chips are very high in carbon content; however, most of it is not readily available for biodegradation. Nevertheless, utilization of C:N ratio as a process variable is quite unfeasible. Most composting facilities are permitted to receive and process certain type(s) of feedstock and they do not have the option to blend various feedstock materials.

**Irrigation:** Most of chemicals that volatilize and escape from the composting windrows are highly soluble in water. Therefore, the application of irrigation, or misting, over the windrows can potentially lower the emissions by trapping and precipitating the chemicals back into the windrow. Irrigation can also lower the emissions by trapping the emissions under a wet (outer) film layer that will form on the surface of the windrow. Another way that this phenomenon can be explained is the fresh feeling of air after a precipitation event as the rain droplets pick up the pollutants from air. If the irrigation of windrows shows reduction in emissions, this practice can be adopted and implemented very easily at a composting facility.

**Reduced Size:** The size of the windrows can affect the biological processes taking place by two means—(i) availability of oxygen and (ii) heat loss. Both parameters can have a considerable affect on the biological processes and thus change the emission of volatile compounds.

**Interactively Managed Windrow:** Certain parameters and formation of intermediary compounds can provide valuable insight as to which direction the biological processes take place; thus certain parameters can be used as process control triggers. For instance, formation of hydrogen sulfide is the indication of formation of anaerobic conditions within the windrow; and can be used as a trigger for an aeration event. Similarly, the detection of nitric oxide can be used as an indicator to delay turning event to limit aeration to promote activity of nitrous oxide reductase enzyme so that the denitrification can progress to completion and yield nitrogen rather than nitrous oxide emissions.

Based on the above discussion, the following four mitigation alternatives were selected for the investigation:

- Pseudo-Biofilter
- Irrigation
- Reduced Size
- Interactively Managed Windrow

## MATERIALS AND METHOD

### Study Site

There were three potential facilities considered as the study site—(i) Highway 59 Composting Facility; (ii) Tulare County Compost and Biomass; and (iii) Community Recycling & Resource Recovery, Inc. After site visits and evaluation of advantages and disadvantages of each site, the Tulare County Compost and Biomass facility located in Tulare, CA was selected for the study.

On June 6$^{th}$, the research team traveled to the study site. Prior to formation of windrows, the terrain was scanned with 3-D scanning camera to determine the base topography to provide us the most accurate determination of windrow dimensions and volumes. On June

8th, five windrows were formed from the freshly ground yard waste to investigate selected mitigation alternatives for emission reduction. However, the beginning of the composting process was considered to be the next day as the construction of windrows had finished late in the day and water was not applied until the next day. These windrows consisted of (i) control; (ii) pseudo-biofilter; (iii) irrigated; (iv) reduced size; and (v) interactively managed windrow. The amount of materials in each windrow is summarized in Table 1.

The summary of sampling days along with the dates of sampling is provided in Table 2. There were total of 14 sampling events covering the first 99 days of operation. The sampling events focused on the initial 30 days of composting due to the fact that most of the emissions occur during the initial weeks of composting decreasing to insignificant levels as it progresses. It should be noted that the Day 2 is considered as the first day of composing in calculations. Furthermore, the feedstock was observed to be very dry when the windrows were formed. Therefore, they were watered several times during the first week of operation.

## Windrow Descriptions

***Control Windrow:*** The control windrow was formed with 98.90 tons of material to provide baseline emission to compare the effectiveness of the mitigation alternatives investigated in this study. This windrow was managed according to the typical operation of windrows at the study facility in terms of turning and watering events.

***Pseudo-Biofilter Windrow:*** The pseudo-biofilter windrow was formed similar to the control windrow with 99.25 tons of material and received finished compost as a blanket layer following on formation and after a turning event during the first month of composting. This windrow was also managed according to the facilities typical operation.

***Reduced Size Windrow:*** A windrow with reduced size was constructed with a lesser amount of material (66.79 tons) to study the effect of windrow size on emissions. This windrow was also managed according to the facilities regular operation.

***Irrigated Windrow:*** This windrow was formed with 101.46 tons of material to investigate the effect of surface irrigation on emissions. This windrow was also managed similar to the other windrows; in addition, the windrow was irrigated for 20 minutes.

***Interactively Managed Windrow:*** This windrow was formed with 97.62 tons of material and managed differently than the other windrows. The moisture content, oxygen, hydrogen sulfide, nitric oxide and methane (as determined by lower explosive limit-LEL) inside the windrow was determined with a portable gas analyzer (Q-RAE Plus) on days when the research team was present on the field. The watering and turning events were decided based on the on-site survey and/or other factors like time passed since the last turning event.

**Table 1.** Amount of freshly ground greenwaste used in windrows

| Row # | Windrow | Tons (Wet) |
|---|---|---|
| 1 | Pseudo-biofilter | 99.25 |
| 2 | Control | 98.90 |
| 3 | Irrigation | 101.46 |
| 4 | Interactively managed | 97.62 |
| 5 | Reduced size | 66.79 |

**Table 2.** Sampling schedule

| Number of sampling | Day of composting | Date |
|---|---|---|
| 1 | Day 1 | June 8 |
| 2 | Day 2 | June 9 |
| 3 | Day 3 | June 10 |
| 4 | Day 5 | June 12 |
| 5 | Day 7 | June 14 |
| 6 | Day 10 | June 17 |
| 7 | Day 15 | June 22 |
| 8 | Day 22 | June 29 |
| 9 | Day 29 | July 6 |
| 10 | Day 36 | July 13 |
| 11 | Day 41 | July 18 |
| 12 | Day 50 | July 27 |
| 13 | Day 80 | August 24 |
| 14 | Day 99 | September 14 |

## Sampling Location and Thermography:

Deciding where to collect samples is, without any doubt, the biggest challenge in emission source sampling from composting windrows. There are number of factors making it challenging: (i) heterogeneity of material, (ii) channel formation within the windrows, and (iii) most importantly the chimney effect, which is caused by the temperature profile within the cross-section of a windrow. In order to overcome these issues, a large number of samples would need to be collected. Unfortunately, due to the associated costs, practicality and time constraints, only a few samples can be collected for a selected windrow.

Earlier emission studies initially collected samples from random locations on the windrow. Later, composite samples—i.e., partial filling of canisters at different locations were employed. Due to the above mentioned reasons, representativeness of the samples with either approach was questionable. In order to address this issue, in a previous study we have employed a strategy to determine the hot (venting) and cold (non-venting) locations on a windrow.  The surface of the windrow was surveyed with a portable gas analyzer. Later, the emission results were multiplied by the venting/non-venting surface area weights. Even though, this approach has thought to result in considerable improvement; there still remains several disadvantages.

First, the portable analyzers are highly affected by the environmental conditions.  A result would be skewed largely by even a very light wind.  Second, it disturbs the windrow since it requires a walk-through on the windrow, which causes compaction and changes of the channeling.  Another significant setback of this approach is inability to survey the entire windrow.  The analyst must rely on a survey results collected from only a small portion of the windrow. In a study we conducted at Modesto, we observed that there was a good correlation between the surface temperatures and the emission fluxes, especially during the early hours of the day before the sunlight heated up the surface and diminished the temperature differences.  Therefore, in this current study, thermography was utilized for determining the sampling locations as the venting and non-venting points on the ridge of the windrow.

On sampling days, the windrows were scanned with a thermal imaging camera (Fluke Ti55FT IR), which was equipped with a wide-angle lens.  In order to scan the windrows, an articulated platform lift was utilized.  First, the windrows were scanned to determine the hot and cold points that were presumed to be venting and non-venting points on the windrows.  Once the sampling locations were determined, the windrows were re-scanned to obtain thermographs.  Even with the wide-angle lens and use of the platform lift (at 45 ft elevation), it was not possible to obtain the thermograph of a windrow with one shot; therefore, there were three shots taken for each windrow as presented in Figure 3.  The images were, then, combined based on the reference points.  This is also the reason for the perspective effect on the thermal images towards the end of the windrows.  However, it should be noted that this effect has only affected the images while the calculations were based on the scaled control surfaces.

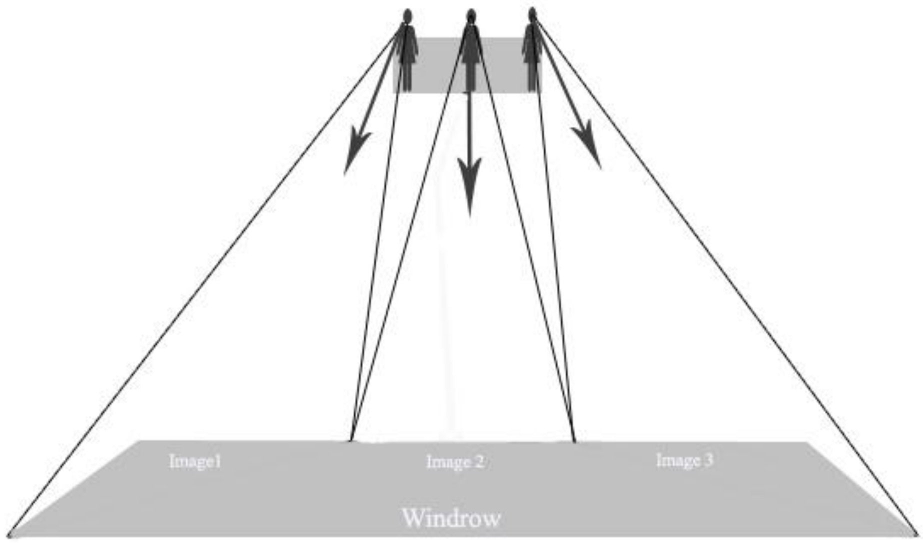



**Figure 3. Thermal scanning of windrows.**

There were at least two emissions samples collected from each of these windrows (except irrigation windrow)—as the cold and hot spots determined by the thermography analysis. On select days, additional samples were collected from the control pile 15 minutes after the turning event to determine spikes in emission.

Once the thermal images were obtained, they were superimposed with the 3-D scans to determine the control area and volume. An example of combined thermograph and control area is presented in Figure 4. The 3-D scans, which were obtained by a Trible GX 3-D laser scanner, were analyzed to determine the windrow dimensions, shapes, surface areas and volumes.

Prior to construction of windrows, the study field was scanned with 3-D laser imaging camera to determine irregularities of the field (scan presented in Figure 5); then, this image was subtracted from the windrow images to improve the accuracy of the volume and area calculations. The actual scan result of all five windrows and an individual windrow scans are presented in Figure 6 and 7.

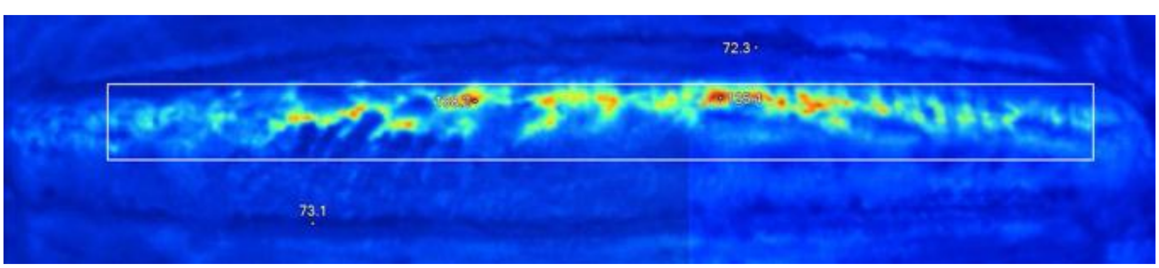



**Figure 4. Example thermograph of a windrow.**

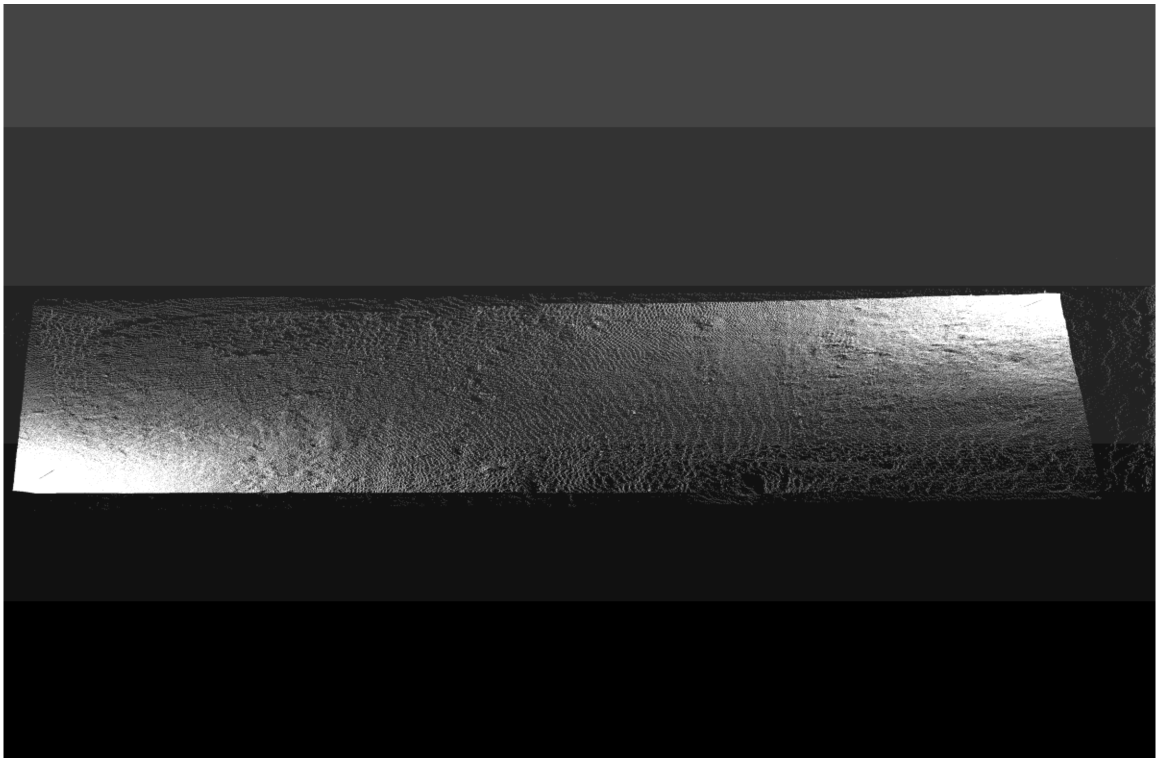


**Figure 5. 3-D scan of the study field prior to the formation of windrows.**

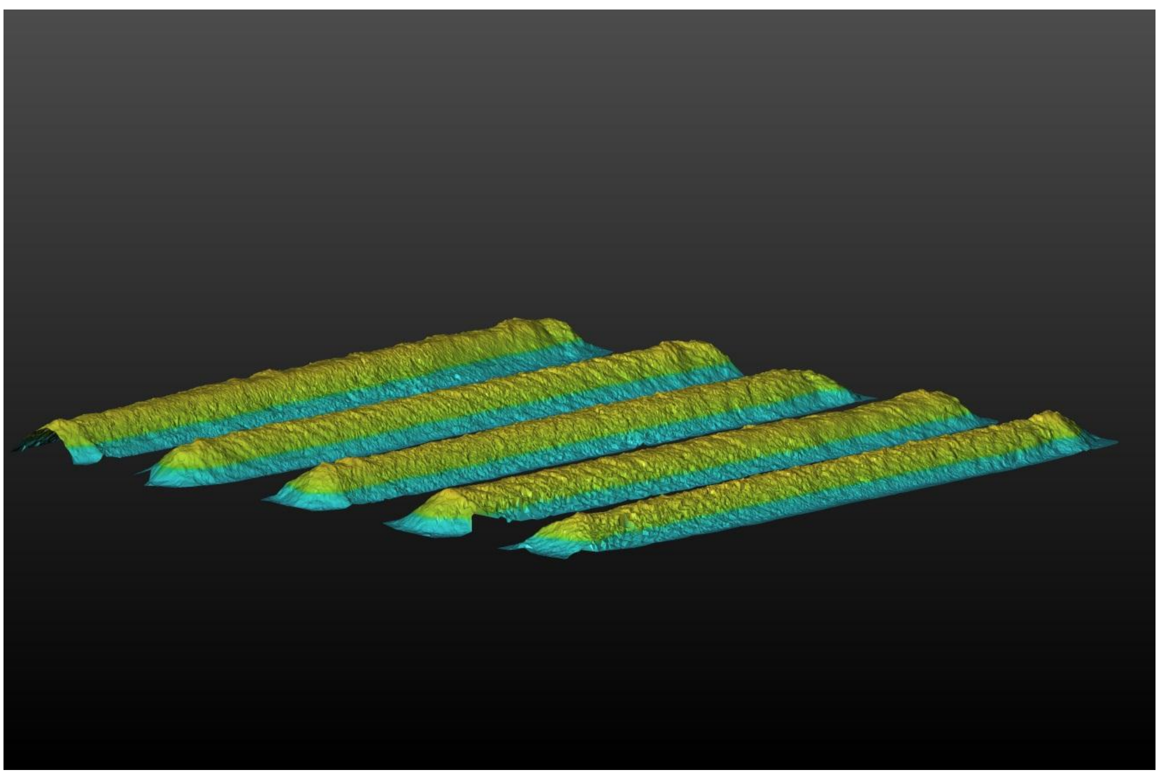


**Figure 6. An example 3-D scan of windrows.**

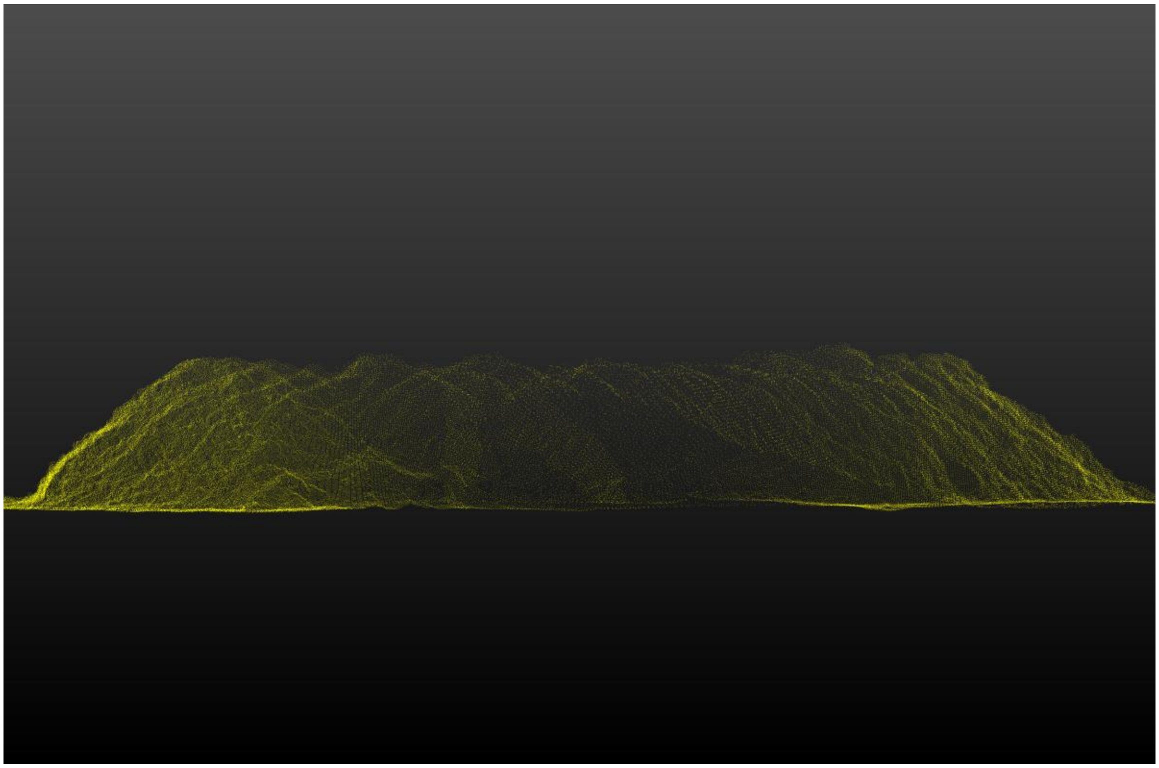


**Figure 7. An example 3-D scan of an individual windrow.**

There were three emission samples collected from irrigation windrow—except for the first day. Three samples were collected from the hottest point only as (i) prior to irrigation (ii) from the same point following on 20 minutes of irrigation and (iii) using a flux-chamber without dome at the same point during the irrigation. There were no samples collected from the cold spots on the irrigation windrow. In order to evaluate the effectiveness of this mitigation alternative, two approaches were followed: (1) the entire windrow surface assumed to be "hot" and compared to average emission factors for other windrows; and (2) using the concentrations of GHG in the samples from "hot" points of other windrows. It should be noted that tracer gas concentrations were "not detect" in most samples collected from open dome isolation flux chambers and the flux of air movement from the windrow was assumed the same as the regular sampling since they were located at the same point.

## Emission Sampling Method

Source emission samples were collected using the USEPA's Surface Isolation Flux Chamber (USEPA, 1986) and evacuated sample canisters with condensate traps. The emission samples were collected in evacuated canisters after passing the air stream through a cold trap to capture condensable organics as illustrated in Figure 8. The details of the cold-trap and canister setup are presented in Figure 9.

The sampling train was assembled and leak tested prior to the beginning of a sampling event. The leak test was performed by plugging the sample inlet and opening the canister's valve to apply vacuum, then, the valve was closed and the pressure drop over one minute was observed. A pressure drop of less than 10-inches of mercury was considered satisfactory. The sweep air, which is ultra high purity air with helium (He) added as the tracer, was uniformly introduced from the inner perimeter of the flux chamber at a rate of 5.0 liters per minute using a rotameter or digital mass flow controllers. In order to reach steady-state conditions within the isolation flux chamber, the sweep air was introduced for 30 minutes prior to the beginning of sampling.

Upon reaching the steady-state conditions, sample collection was initiated. At the end of 30 minutes of sample collection, deionized water was introduced to the sample inlet to collect any condensable VOC left in the sampling tubing. The condensate traps were removed from the sampling train, capped, and shipped to the laboratory in an ice-chest for analysis. The remaining portion of the sampling assembly was removed, and the sample canister was capped for transportation to the laboratory.

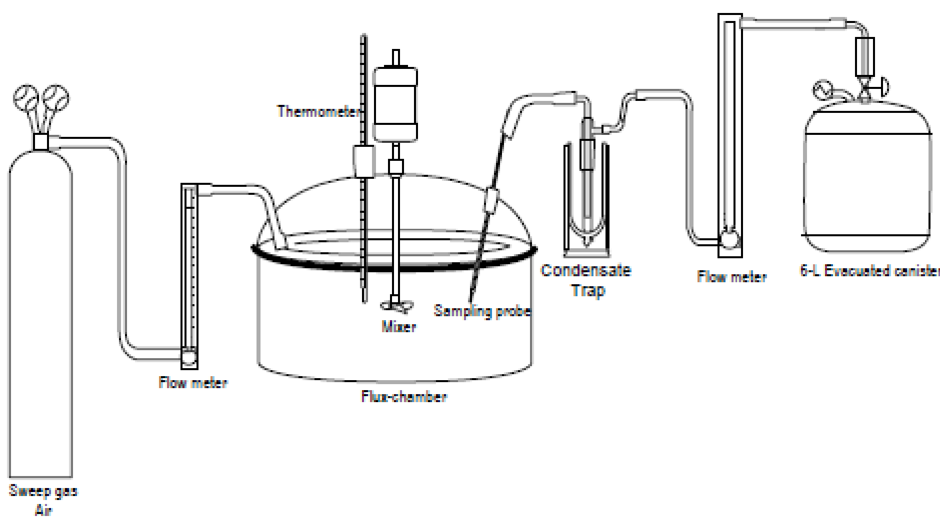



**Figure 8. Sampling train utilizing evacuated canister and condensate trap**

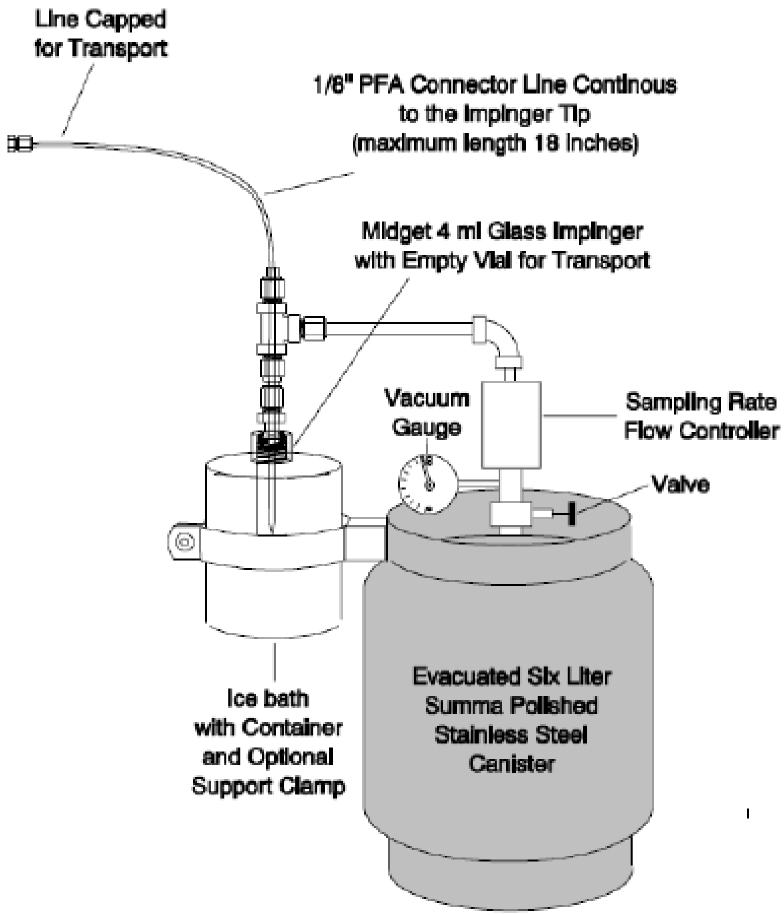



**Figure 9. Evacuated canister and cold-trap**

## Analysis of Samples

When analyzing for VOC emissions by SCAQMD Method 25.3, there are two emission sample fractions of concern, the liquid fraction and the gas fraction. To minimize sample loss and underestimation of the VOC emissions during sampling, condensable gases or the liquid fraction of the VOC emissions were captured in condensate traps, kept on ice in the field, and refrigerated until analyzed. The gas fraction of VOC emissions captured in stainless steel Summa canister.

Samples were shipped overnight to SDSU Environmental Engineering Laboratory for analysis. Upon receipt, our lab processes the gas fractions according to SCAQMD Method 25.3 protocol for sampling handling, analysis, and retention times. In all cases, the samples were analyzed within the acceptable storage and retention time protocols for SCAQMD Method 25.3 as detailed below.

The emission samples collected in evacuated canisters were analyzed for methane and non-methane-non-ethane organic carbon (NMNEOC) content according to the SCAQMD Method 25.3. The Total Combustion Analysis (TCA) system consists of a gas chromatography (GC) modified with a backflush valve and both flame ionization and thermal conductivity detectors. Method 25.3 first oxidizes the contents to carbon dioxide and subsequently reduces them to methane for detection by a flame ionization detector (FID). Figure 10 is a schematic of the gas chromatograph. Isobutane ($C_4H_{10}$) was used as calibration gas to quantify the NMNEOC.

The contents of condensate traps were analyzed with a Shimadzu TOC-5000 analyzer according to the SCAQMD. Total organic carbon is measured by the difference between total carbon (TC) and inorganic carbon (IC). The instrument determines the TOC byself following triplicate analysis.

### Analytical Method for Nitrous Oxide

$N_2O$ was analyzed using an Agilent 6890 gas chromatograph (GC) equipped with a micro-electron capture detector (ECD). The operating temperature of the detector was 250 ºC. All of the analyses were performed isothermally at column temperature of 50 ºC. The column is customer packed stainless steel Chromosorb 106 with mesh size 80/100. The typical column is 1/8”o.d. with the length of 6 feet. The sample size used is 5 ml. The instrument detection limit for $N_2O$ is 0.15 ppmv.

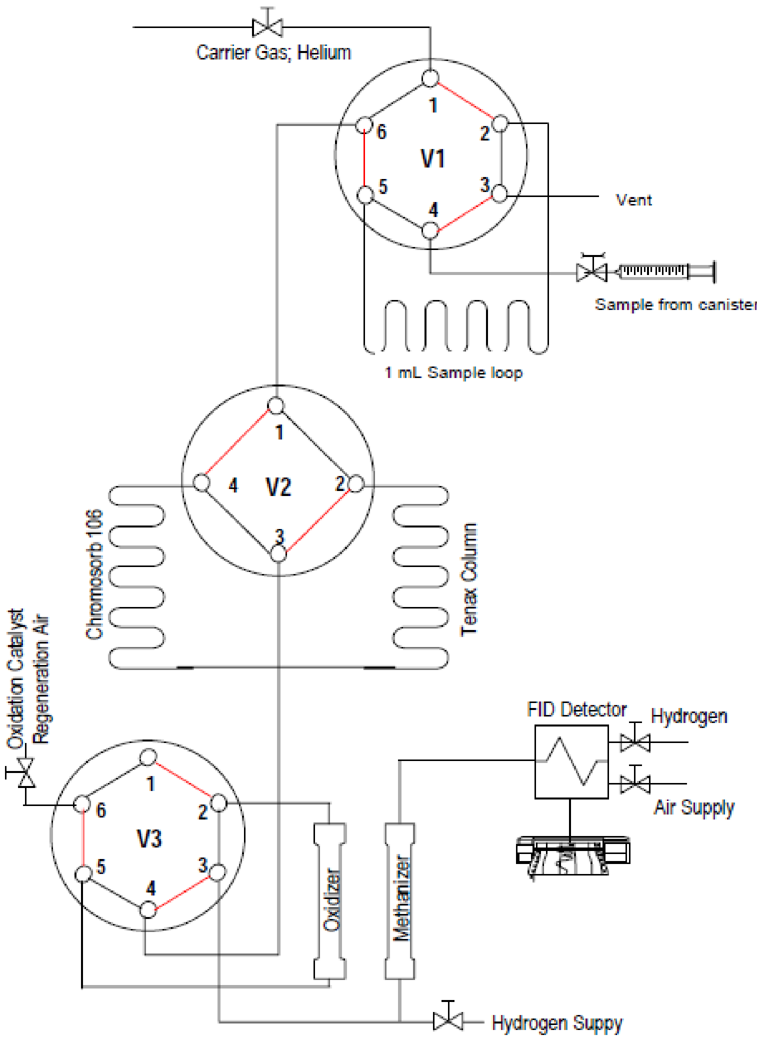



**Figure 10. Schematic of gas chromatograph for SCAQMD method 25.3**

**Calculation of Flux:** In order to determine the flux of air movement from the windrow, sweep air containing helium as the tracer was uniformly introduced into the chamber from the inner perimeter of the flux chamber at a rate of 5.0 liters per minute. The flux rate was, then, determined by the performing the mass balance for helium for the isolation flux chamber as described in Figure 11.

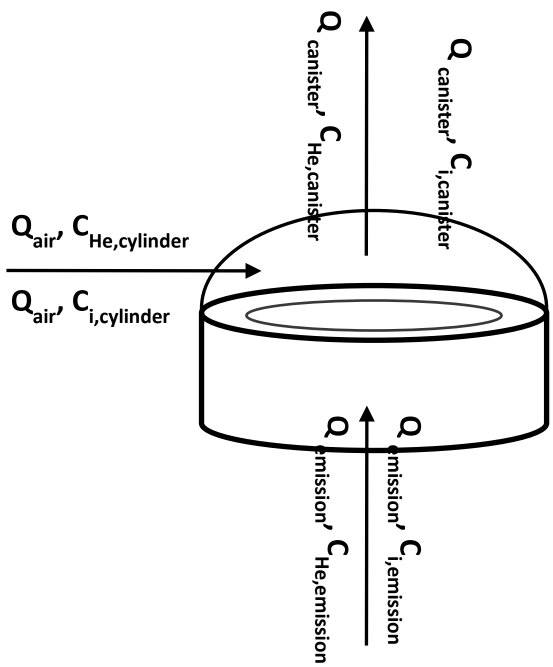



**Figure 11. Flux calculation through mass balance within the isolation chamber**

## Calculations

**1) Calculation of flux: This is the flux of emissions (volume/time) from the windrow determined by the analysis of tracer gas in the sweep air.**

The mass balance within the isolation flux chamber (Figure 11) for helium gives:

$$Q_{Air} \times C_{He,cylinder} + Q_{Emission} \times C_{He,emission} = (Q_{Air} + Q_{Emission}) \times C_{He,\,canister} \qquad (1)$$

Where,

$Q_{Air}$ = sweep air flow rate, L/min
$C_{He,cylinder}$ = % of He in sweep air
$Q_{Emission}$ = compost emission flow from compost, L/min
$C_{He,emission}$ = He concentration in compost emission, %
$C_{He,canister}$ = He concentration in canister, %

Assuming there is no helium emission from the compost (i.e., $C_{He,emission}$ is 0), and by rearranging equation (1) the flux rate is calculated by equation 2:

$$Q_{Emission} = Q_{Air} \times (\frac{C_{He,cylinder}}{C_{He,canister}} - 1) \quad (2)$$

**2) Determination the concentrations of chemical in the aliquots: Concentrations of methane, nitrous oxide and non-condensable VOCs are determined by the gas chromatograph and the condensable organics determined by the total organic carbon analyzer.**

**3) Calculation of condensable organic carbon in the traps:**

$$C_w = \frac{C_i \times V_i \times P_a \times V_{id}}{V_c \times (P_r - P_0) \times A_c} \quad (3)$$

Where,

$A_c$ = atomic weight of carbon (12.01 g/mol)
$C_w$ = gaseous concentration of TOC as ppmv as carbon in condensate trap water
$C_i$ = TOC concentration in μg/ml of condensate trap
(Assume TOC concentration μg/g = μg/ml at 4 °C)
$V_i$ = volume of condensate trap water in ml
$V_{id}$ = volume of ideal gas per mole at 25°C (24.4652 l/mole)
$V_c$ = volume of the Summa canister in liters (6L)
$P_a$ = atmospheric pressure in mm Hg (760 mmHg)
$P_r$ = return pressure in mm Hg
$P_0$ = evacuated canister pressure in mmHg

**4) Calculation of concentrations of chemicals in the canister: Since the sample is diluted during the extraction of samples from the canisters, the concentration readings from the GCs are corrected according to the pressure readings of the canisters.**

The concentrations of components in the canister were calculated by the following equation:

$$C_c = C_m \times \frac{P_f - P_0}{P_r - P_0} \quad (4)$$

Where,

$C_c$ = end of sampling canister concentration, ppmv
$C_m$ = average of duplicate measured concentrations by gas chromatograph, ppmv
$P_f$ = canister pressure after pressurization, mmHg
$P_r$ = return pressure in mm Hg
$P_0$ = evacuated canister pressure in mmHg

**5) Calculation of NMNEVOC: Since the gas chromatograph is calibrated against *iso*-butane, the concentration readings are required to be converted to carbon equivalents to allow summation with the TOC results from the condensate traps.**

$$C_{c-c} = C_c \times \frac{MW(4C)}{MW(C_4H_{10})} \tag{5}$$

Where;

$C_{c-c}$ = end of VOC concentration in canister as ppmv carbon
MW = molecular weight (C: 12 g/mole, $C_4H_{10}$: 58 g/mole)

**Therefore the total volatile organic carbon, $C_t$ (ppmv C) is calculated as:**

$C_t = C_w + C_{c-c}$

**Once $Q_{Emission}$ and the concentrations of chemicals in the samples are determined, then the concentration of a gas *i* ($CH_4$, VOC and $N_2O$) in the emission is calculated as follows:**

$$C_{i,emission} = C_{i,canister} \times \left(\frac{Q_{Air}}{Q_{Emission}} + 1\right) \tag{6}$$

**6) Calculation of concentrations of chemicals in terms of mg/m$^3$. Once the concentrations of chemicals are determined in ppmv, the unit of concentration is converted to the mass/volume according to the *Ideal Gas Law* as follows:**

Convert sample concentration in ppmv to mg/m$^3$ using the following equation:

$$C_{mg/m^3} = C_{ppmv} \frac{RT}{PM} \times 10^{-3} \tag{7}$$

Where;

$C_{mg/m3}$ = end of sample concentration in mg/m$^3$,
$C_{ppmv}$ = end of sample concentration in ppmv
R = universal gas constant, 8.31 Pa-m$^3$/K-mol
P = atmospheric pressure, 101325 pa
T = temperature, 293 K,
M = molecular weight of gas component

**7) Calculation of emissions rate (flux of chemicals) from the windrow: The amount of chemical emissions, in terms of mass/time-area is calculated according to the equation 8.**

The gas *i* flux ($m_i$) in terms of mg/m$^2$-min was calculated:

$$m_i = \frac{C_{i,emission} \times Q_{Emission} \times 10^{-3}}{A_{chamber}} \qquad (8)$$

Where;

$A_{chamber}$ = bottom area of gas chamber, $m^2$

**8) Calculation of average flux rate for chemicals: The flux results for hot and cold spots (high and low) are, then, averaged according to their weights as determined by the thermography. This calculation is further explained at the end of the Appendix E, F and G for methane, VOCs and nitrous oxide, respectively.**

**9) Calculation of total emissions. This is done by integrating the area below the emissions rates versus time as presented in Appendixes H, I and J.**

## Example Calculation

An example emission calculation is described below for methane and NMNEVOCs for sample ID: 61-71-H, which was collected on Day 1 from the hot point on the pseudo-biofilter windrow.

The raw data is as follows:

Tracer gas, He, in cylinder (%): 9.88 (He concentration in the sweep air provided by the vendor; 3rd column on Appendix A)
Tracer gas, He, in canister (%): 1.11 (He concentration in the sample; the 4th column on Appendix A)
Evacuated canister pressure (mmHg) $P_0$: -738.89 (Vacuum in the canister prior to field sampling)
Return pressure (mm Hg) $P_r$: -200.00 (Vacuum in the canister after field sampling)
Canister pressure after pressurization (mmHg) $P_f$: 153.00 (Vacuum in the canister prior to taking aliquots)
Average $CH_4$ concentration in canister (ppmv): 1.57 (Mean concentration as determined by the GC)
Average NMNEO concentration in canister (ppmv): 7.80 (Mean concentration as determined by the GC)
Average TOC concentration in condensate trap (mg/L): 130.44 (Mean concentration as determined by TOC analyzer)
Volume of condensate trap water (ml): 2.18

**Flux rate calculation**

a. Calculate the concentration of He from canister. This accounts for dilution of sample within the sample canister during pressurization prior to taking aliquots.

$$C_c = C_m \times \frac{P_f - P_0}{P_r - P_0}$$

Where;

$C_c$ = end of sampling canister concentration, ppmv
$C_m$ = average of duplicate measured concentrations from GC analysis, ppmv
$P_f$ = canister pressure after pressurization, mmHg
$P_r$ = return pressure in mm Hg
$P_0$ = evacuated canister pressure in mmHg

Therefore, He concentration in canister = $1.11\% \times \frac{153.00 - (-738.89)}{(-200) - (-738.89)}$ = 1.83% (5th column on App. A)

b. Calculation of flux from the windrow using mass balance for He within the isolation flux chamber.

The flux rate, $Q_{Flux} = Q_{Air} \times (\frac{C_{He,cylinder}}{C_{He,canister}} - 1)$

Where;

$Q_{Flux}$= flux flow from compost, L/min
$Q_{Air}$ = sweep air flow rate, L/min (set to 5 L/min per method description)
$C_{He,cylinder}$ = He concentration in sweep air, %
$C_{He,canister}$ = He concentration in canister, %

The emission flow rate = 5 L/min× (9.88/1.84-1) = 21.98 L/min; this is the flux rate of emissions from the windrow and presented in the last column of Appendix A.

**Methane emission calculation:**

a. Calculate the concentration of $CH_4$ from canister analysis:

$C_{CH4}$= 1.57 × (153.00-(-738.89))/((-200)-(-738.89)) = 2.60 ppmv

b. Convert $CH_4$ concentration in ppmv to mg/$m^3$ using Eq. 2:

$$C_{mg/m^3} = C_{ppmv} \frac{PM}{RT} \times 10^{-3}$$

Where,

$C_{mg/m3}$ = end of sample concentration in mg/$m^3$,
$C_{ppmv}$ = end of sample concentration in ppmv
R = universal gas constant, 8.31 Pa-$m^3$/°K-mol
P = atmospheric pressure, 101325 pa

T = temperature, 298°K,
M = molecular weight of gas component ($MW_{methane}$16 g/mol)

$C_{CH4,\ mg/m3}$ = 2.60 × (101325×16)/(8.314×298) ×$10^{-3}$ = 1.70 mg/$m^3$

c. Calculation of $CH_4$ flux in terms of mg/$m^2$-min:

$$m_i = \frac{C_{i,canister} \times (\frac{Q_{Air}}{Q_{Emission}} + 1) \times Q_{Emission} \times 10^{-3}}{A_{chamber}}$$

Where;

$C_{i,canister}$ = gas *i* concentration in canister, mg/$m^3$
$A_{chamber}$ = bottom area of gas chamber, 0.13$m^2$

The $CH_4$ flux in terms of mg/$m^2$-min = (1.70 × (5/21.99+1) × 21.99 × $10^{-3}$)/0.13 = 0.35 mg/$m^2$-min (last column under CH4 in Appendix B)

**NMNEO Emission calculation:**

Calculate the concentration of NMNEO from canister analysis:

$C_{NMNEO}$ = 7.80 × (153.00-(-738.89))/((-200)-(-738.89) = 12.90 ppmv

The VOC from canister is expressed as ppmv of butane ($C_4H_{10}$). Convert the ppmv of butane to ppmv as carbon:

$$C_{voc-c} = C_{voc} \times \frac{MW(4C)}{MW(C_4H_{10})}$$ =12.9×(48/58) = 10.68 ppmv

c. The amount of organic carbon as part per million by volume (ppmv) as gaseous carbon in the condensation trap is calculated by the following equation:

$$C_w = \frac{C_i \times V_i \times P_a \times V_{id}}{V_c \times (P_r - P_0) \times A_c}$$

Where;

$A_c$ = atomic weight of carbon (12.01 g/mol)
$C_w$ = gaseous concentration of TOC as ppmv as carbon in condensate trap water
$C_i$ = TOC concentration in µg/ml of condensate trap
(Assume TOC concentration µg/g = µg/ml at 4 °C)
$V_i$ = volume of condensate trap water in ml
$V_{id}$ = volume of ideal gas per mole at 25°C (24.4652 l/mole)
$V_c$ = volume of the Summa canister in liters (6L)
$P_a$ = atmospheric pressure in mm Hg (760 mmHg)

$P_r$ = return pressure in mm Hg
$P_0$ = evacuated canister pressure in mmHg

The amount of organic carbon as part per million by volume (ppmv) as gaseous carbon in the condensation trap is = (130.44×2.18×760×24.4652)/(6×(-200)-(-738.89)) × 12.01) = 136.28 ppmv

Total NMNEO = 10.68+136.28=146.96 ppmv

Follow the procedure (2) b-c to calculate the NMENO flux = 14.97 $mg/m^2$-min.

Once the fluxes are determined for low and high points, the weighted average flux values and the total emissions are determined as described in Appendixes E through J.

## RESULTS AND DISCUSSION

### Thermography Analysis

In order to determine the sampling locations on compost windrows, thermography approach was applied. In an earlier study sponsored by the Department of Resources Recycling and Recovery (CalRecycle), we utilized temperature and portable gas analyzer data to determine the sampling locations on the windrow. This study had suggested that there could be a correlation between the surface temperatures and the level of emissions. Therefore, in this current investigation, we utilized thermography approach to determine the surface temperatures of the composting windrows. The results of thermography analysis are presented in Appendix K; and constructed temperature histographs are presented in Appendix L.

It should be noted that this was the first time that thermography approach was applied to the field of composting. Therefore, the following issues were encountered during the thermal scanning of the windrows:

- The thermal images needed to be taken prior to the sunrise. As soon as the sun was visible, the east sides of the windrows had showed its effect. This was more apparent on the Pseudo-Biofilter windrow since this pile was located on the far east side (compared to the other windrows) and other windrows were shadowed by this windrow. Therefore, the scans were taken prior to the Sunrise except for the first two days.

- On July 13th, the platform lift that was used in taking thermal images had encountered mechanical issues; therefore, only two of the windrows could be scanned. However, the cold and hot points on the other windrows were determined to allow collection of samples.

- On August 24th, the thermal imaging camera had malfunction and did not record the scanned images. However, the sampling locations were already determined.

Once the thermographs were determined, the histographs were developed within the control boundary for each scan to determine the averaging weights for cold and hot emission results. The corresponding histographs are presented in Appendix L. Summary of low, high and weighted-average temperature values are presented in Table 3. It should be noted that the weighted-averages were also used in proportioning the emission results when combining the emission values from cold and hot spots.

One of the main hypotheses of this investigation was the use of thermal imaging to determine the high and low emission points on a composting windrow. The comparison of the emissions and temperature values did not yield a direct correlation between them; nevertheless, a strong correlation was observed between the temperature hot and cold points and the low and high emission values. In other words, while the temperatures cannot be used to assess emissions quantitatively, it can be used qualitatively to determine low and high emissions commonly referred as non-venting and venting locations. The Figures 12 through 14 present the percentage of the sampling events that the high temperature point on a given windrow resulted in a higher emission of the gas in question for methane (Figure 12), VOC (Figure 13) and nitrous oxide (Figure 14).

More than 90% of the emission samples collected from hot points determined by the thermal imaging had resulted higher methane emissions than the cold points for control, biofilter and interactively managed windrows while the correlation was only 50% for the small windrow. The correlation was more than 70% for VOC emissions and close to 80% for nitrous oxide emissions for control, biofilter and interactively managed windrows. Similar to the methane emissions, the poor correlation was observed for VOC and nitrous oxide. The poor correlation at the small windrow can be attributed to its lower activity. It is very likely that the microbial activity was limited to its size. It should also be noted that the small windrow emitted considerably more GHG than other windrows on a per unit weight of material. The premise of the use of thermography, or the surface temperatures, for the venting and non-venting points lies on the chimney effect caused by the temperature gradient. The emissions carried to the surface by the chimney effect also transfer the heat causing temperature differences on the surface.

In previous emission studies, one of the major criticisms was the selections of the sampling locations and their weights on emission calculations. Based on these results, it can be concluded that the thermography technique to determine the sampling locations can be effectively used to improve the accuracy of the emission sampling studies.

**Table 3.** Summary of cold, hot points and weighted average temperatures on windrows.

| | Date/Windrow | Cold (°C) | Hot (°C) | Weighted Ave (°C) | | Date/Windrow | Cold (°C) | Hot (°C) | Weighted Ave (°C) |
|---|---|---|---|---|---|---|---|---|---|
| ***June 09*** | Control | 13.3 | 24.8 | 16.96 | **July 6** | Control | 13.6 | 43.1 | 20.82 |
| | Pseudo-Biofilter | 13.9 | 41.6 | 17.54 | | Pseudo-Biofilter | 18.4 | 55.1 | 25.21 |
| | Irrigation | 13.3 | 24.8 | 16.96 | | Irrigation | 12.3 | 47.8 | 22.46 |
| | Interactive | 13.8 | 18.8 | 15.58 | | Interactive | 14.1 | 51.1 | 21.65 |
| | Reduced Size | DM* | DM | DM | | Reduced | 14.8 | 41.3 | 19.86 |
| ***June 10*** | Control | 15 | 37.5 | 19.57 | **July 13** | Control | DM | DM | DM |
| | Pseudo-Biofilter | 15.7 | 36.9 | 22.92 | | Pseudo-Biofilter | 17.8 | 54.3 | 24.98 |
| | Irrigation | 15.6 | 32.6 | 20.49 | | Irrigation | 14.8 | 52.3 | 22.20 |
| | Interactive | 15.4 | 39.1 | 20.81 | | Interactive | DM | DM | DM |
| | Reduced Size | 15.3 | 37.8 | 21.08 | | Reduced | DM | DM | DM |
| ***June 12*** | Control | 16.4 | 44.4 | 26.57 | **July 18** | Control | 23.6 | 59.1 | 28.71 |
| | Pseudo-Biofilter | 16.6 | 35.6 | 22.82 | | Pseudo-Biofilter | 23.6 | 59.1 | 30.06 |
| | Irrigation | 16.3 | 46.8 | 26.24 | | Irrigation | 21.1 | 52.9 | 26.78 |
| | Interactive | 15.6 | 43.3 | 24.73 | | Interactive | 22.1 | 50.1 | 28.48 |
| | Reduced Size | 16.3 | 45.5 | 25.19 | | Reduced | 21.4 | 44.6 | 26.32 |
| ***June 14*** | Control | 13.6 | 45.8 | 22.68 | **July 27** | Control | 19.7 | 46.4 | 25.21 |
| | Pseudo-Biofilter | 15.8 | 39.3 | 22.02 | | Pseudo-Biofilter | 19.6 | 52.8 | 26.14 |
| | Irrigation | 13.8 | 50.1 | 25.35 | | Irrigation | 20.5 | 43.5 | 24.85 |
| | Interactive | 13.1 | 45.6 | 22.00 | | Interactive | 20.5 | 43.5 | 25.11 |
| | Reduced Size | 14.3 | 42.5 | 24.53 | | Reduced | 20 | 42.3 | 24.01 |
| ***June 17*** | Control | 15.8 | 47.9 | 28.18 | **August 24** | Control | 13.3 | 37.5 | 18.26 |
| | Pseudo-Biofilter | 17.4 | 39.3 | 25.30 | | Pseudo-Biofilter | 13.4 | 41.1 | 20.83 |
| | Irrigation | 18.4 | 45.4 | 28.13 | | Irrigation | 13.6 | 45.6 | 19.41 |
| | Interactive | 15.4 | 52.4 | 26.90 | | Interactive | 12.1 | 42.4 | 18.47 |
| | Reduced Size | 15.1 | 49.9 | 27.13 | | Reduced | 13.0 | 41.5 | 18.48 |
| ***June 22*** | Control | 11 | 50.5 | 21.74 | **Sept. 14** | Control | 18.9 | 29.1 | 22.71 |
| | Pseudo-Biofilter | 14.4 | 38.4 | 23.45 | | Pseudo-Biofilter | 20.7 | 32.9 | 25.68 |
| | Irrigation | 13.7 | 47.9 | 23.47 | | Irrigation | 17.8 | 35.6 | 22.59 |
| | Interactive | 10.6 | 49.3 | 20.18 | | Interactive | 18.4 | 27.4 | 21.93 |
| | Reduced Size | 11 | 45 | 18.22 | | Reduced | 20.6 | 32.3 | 22.91 |
| ***June 29*** | Control | 20 | 49.8 | 26.42 | | | | | |
| | Pseudo-Biofilter | 20.1 | 52.1 | 25.71 | | | | | |
| | Irrigation | 20.4 | 46.4 | 26.11 | | | | | |
| | Interactive | 19.5 | 51.5 | 27.36 | | | | | |
| | Reduced | 14.7 | 49.9 | 25.48 | | | | | |

*DM: Data was lost due to the issues with the scanner.

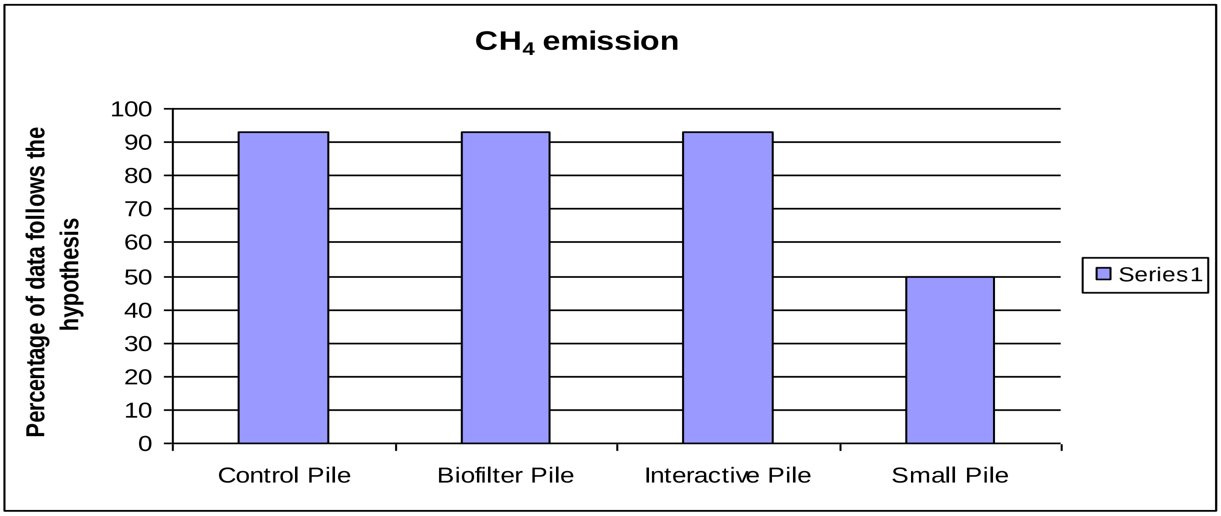



**Figure 12. Hypothesis testing for methane emissions for thermography analysis.**

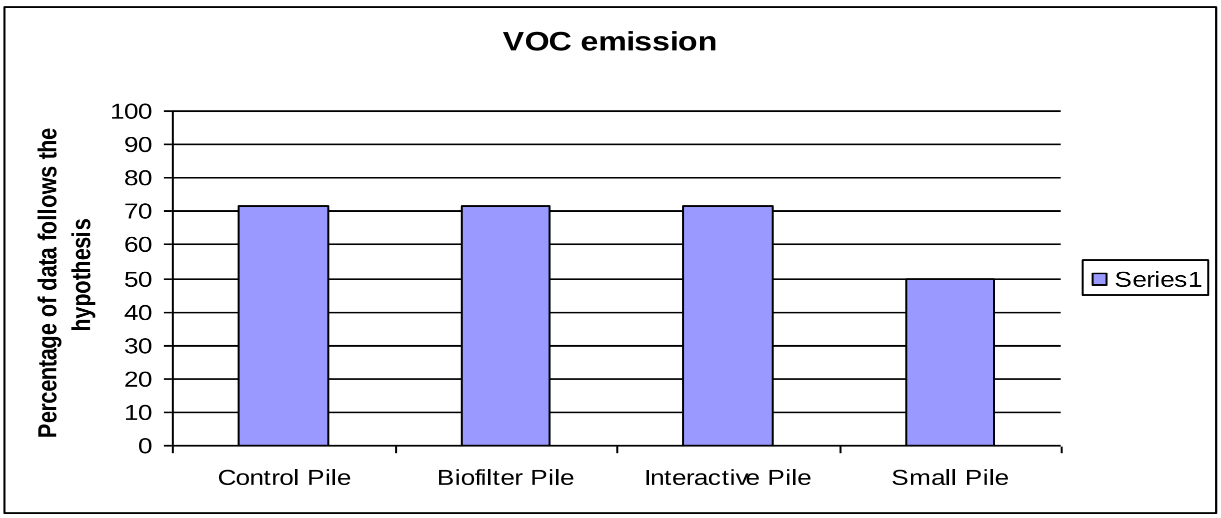



**Figure 13. Hypothesis testing for VOC emissions for thermography analysis.**

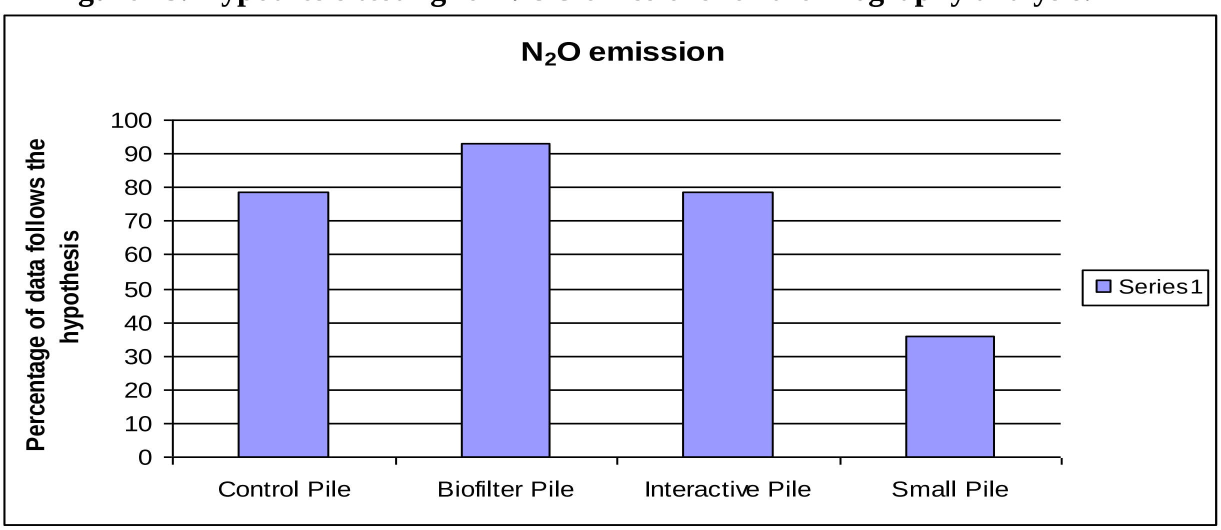



**Figure 14. Hypothesis testing for nitrous emissions for thermography analysis.**

## Comparison of Emission Values

From the onset, it should be stated that the emission results and factors provided herein are only for comparison of mitigation alternatives investigated in this study. **They should not be interpreted, used, referenced, or cited as emission factors from composing process**.

The daily emission factors are presented in Appendix H through J for each windrow for methane, VOCs and nitrous oxide. The cumulative emission values are summarized in Tables 4 and 5. The comparison of the mitigation alternatives reveals different scenario for different gasses in question. It should be noted that two distinct data sets are used in comparing the efficacy of the mitigation alternatives. The first set, i.e, the emission factors calculated for the control area using weighted averaging of cold and hot emissions, is to compare the Control, Biofilter, and Interactive and Small windrows (Table 4). The second set utilizes emission data obtain only from the hot points since the irrigation windrow was only sampled from the hot points (Table 5). In this case, i.e., the calculations are based on the hot points, the entire windrow surface was assumed to be emitting at the same rate of the hot point emissions. The results presented on Table 5 are, thus, considerably higher than the values presented on Table 4.

**Table 4.** Total gas emission

| **Windrow** | $CH_4$ (g/kg) | VOC (g/kg) | $N_2O$ (g/kg) |
|---|---|---|---|
| Control | 100.5 | 7.4 | 0.6 |
| Biofilter | 199.1 | 2.9 | 4.3 |
| Interactive | 155.7 | 6.4 | 1.0 |
| Small | 365.3 | 15.7 | 14.4 |

**Table 5.** Total gas emission from different windrows*

| | | $CH_4$ (g/kg) | VOC (g/kg) | $N_2O$ (g/kg) |
|---|---|---|---|---|
| Control | | 206.99 | 16.40 | 2.27 |
| Biofilter | | 642.52 | 5.56 | 5.67 |
| Interactive | | 392.32 | 13.69 | 3.69 |
| Small | | 359.69 | 12.44 | 3.27 |
| Irrigation | Before irrigation | 502.79 | 13.05 | 7.33 |
| | After irrigation | 425.66 | 6.83 | 7.92 |
| | Open chamber | 14.88 | 3.62 | 3.57 |

* based on hot point emissions only.

The comparison shows that control windrow emitted the lowest amount of methane; the methane emissions were almost doubled (increased by 93%) from the biofilter windrow and increased by 50% from the interactive windrow. The small windrow has resulted 2.52 times higher methane emissions compared to the control windrow. The higher methane emissions from the pseudo-biofilter and interactively managed windrows can be explained by the oxygen availability.  The application of finished compost layer, in a way, seals the windrow, thus, limits the diffusion of air into the pile.  The interactively managed windrow was turned-over (aerated) for fewer times that would also increase the development of anaerobic conditions.

On the other hand, the biofilter filter has resulted in 60.8% lower VOC emission while the interactively managed windrow has yielded only 13.5% VOC reduction.  In earlier studies, we had shown the efficacy of pseudo-biofilter idea for VOC reduction on both laboratory and field scale.  This present works affirms to the efficacy of the pseudo-biofilter blanket to reduce VOC emissions resulting from greenwaste composting.

The small windrow, similar to the methane emissions, had twice as much VOC emissions than the control windrow.  The interactively managed windrow showed a considerable nitrous oxide reduction at 44% while the biofilter windrow has resulted in 21% nitrous oxide reduction.  The small windrow emitted more than 5 times nitrous oxide than control windrow.

It is clear that the reduced size windrow has resulted in considerably higher emissions for all three emission types; therefore, no further discussion is made.  When we look at the emission results from pseudo-biofilter and the interactively managed windrows, we see that elevated methane and reduced VOC and nitrous oxide emissions.  Therefore, it is necessary to look at the GHG potency of these emissions.

The potencies of methane and nitrous oxide are reported to be 21 and 310 times the carbon dioxide.  However, when it comes to VOC emissions, their GHG potencies have not been established yet—even though there are several on-going studies.  Since their potencies have not been established, we are going to assume them as potent as methane to allow us make comparison.  It should also be noted that the carbon dioxide emissions and their effect on the GHG emissions are omitted herein.  Since, it is impossible to make a complete comparison based on the GHG potency of the emissions, it is omitted from the discussion.

The interactively managed windrow was monitored for moisture, oxygen, nitric oxide, sulfur dioxide, and LEL on sampling days and compared to the control windrow.  In most cases, oxygen content in both windrows was very low—close to zero.  There was no clear trigger point observed to decide turning events; the results required considerable interpretation of what was possibly happening.  Even though, significant reduction was observed, there is potential to make things worse by misinterpretation of the readings from the instrument.  Thus, the operators are cautioned when applying this mitigation alternative.

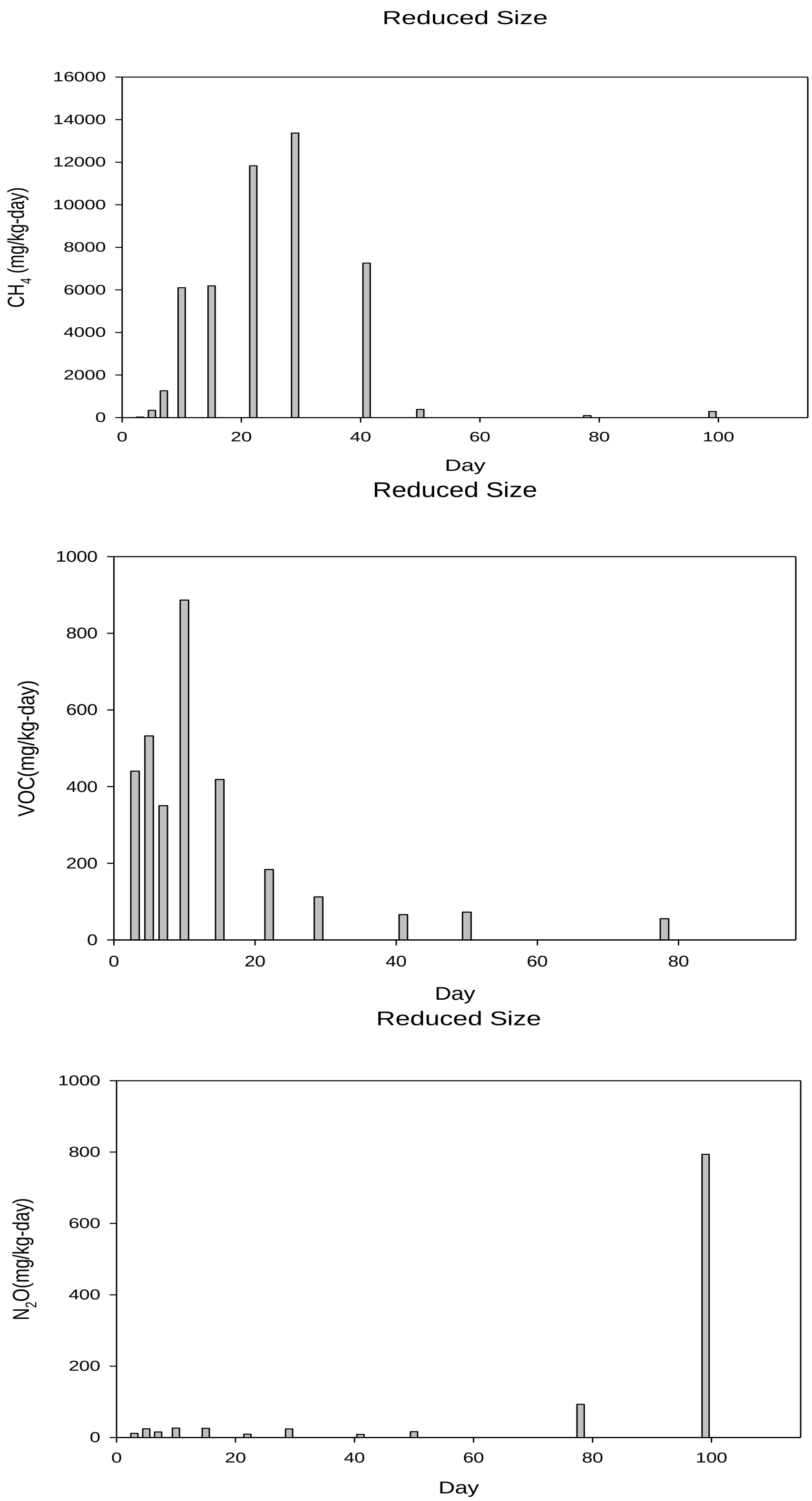



**Figure 15. Daily emission factors for reduced size windrow: a-methane, b-VOC, c-nitrous oxide**

As explained above, Table 5 utilizing data only from the hot points is used to determine the effectiveness of the irrigation for lowering emissions. There were three samples collected at the hot spot on the surface; these were (i) before the start of irrigation, (ii) after 20 minutes of irrigation with a standard isolation flux chamber; and (iii) after the irrigation with an isolation chamber without the dome cover. The use of the isolation flux chamber without the dome cover was to see the effect of irrigation during the irrigation process. The irrigation windrow seemed to emit considerably more methane and VOCs, while the nitrous oxide emissions were similar when there was no irrigation compared to the control windrow. On the other hand, the after the irrigation, the emissions were reduced by 15% and 48% for methane and VOCs, respectively, compared to the emissions prior to the start of irrigation. Nevertheless, it should be noted that methane emission was still twice as much as the control windrow; while the VOC emission was 20% less compared to the control windrow.

The significance of the irrigation as the mitigation alternative was apparent for samples taken during the irrigation event with open isolation flux chambers. In this case, the methane and VOC emissions were both reduced by 93% and 78%, respectively, compared to the emissions from the control windrow. The nitrous oxide emissions were increased by 57%.

In summary, the irrigation of the windrow had increased the emissions when comparing the before and after irrigation events. On the other hand, when the emissions during the irrigation events are compared to the control, there is a substantial reduction of both methane and VOC emissions. The reductions seen for both methane and VOCs emissions can be attributed to the solubility of these compounds in water. Most VOCs, if not all, generated and/or emitted during the composting process are water soluble chemicals. Methane's water solubility is 35 mg/L. Nitrous oxide is also a highly soluble gas in water. It was expected to see such a major reduction in emissions. In order to make the effect of irrigation on emission more comprehendible, an analogy to the "wet scrubbers" can be made. Wet scrubbers are air pollution control devices that are commonly used for removal of water soluble pollutants from air streams. Another way to explain this is the fresh feeling of air after a precipitation event.

On the other hand, the irrigated windrow had substantially higher emissions compared to the control windrow when it was not irrigated. This can be explained by the over watering of the windrow. The application of irrigation was in addition to the regular watering events by the facility. Therefore, any additional water applied by the irrigation events had caused over watering. The overwatering caused by the irrigation was visually apparent on the field. Nevertheless, in order to see its effect, the irrigation scheme was not altered.

It is likely that if the watering is managed by a continuous irrigation system, the emissions can be reduced. It should be noted that a similar system is already used by a commercial composting facility located in Southern California for watering the windrows. According to the facility owner, the use of an irrigation system, in fact, costs less than running a water truck. Therefore, the use of an irrigation system holds a good promise as a best management practice.  However, further research is needed to determine the intensity of irrigation to provide enough watering and reduce emissions.

### Effect of Turning on Windrow Size

In select days, the effect of turning on windrow dimensions (Table 6) were also investigated for select windrows.  The volume change ranged from 1.74 to 12.3% for the control windrow and 2.21 to 5.25% for the interactive windrow—that is attributed to the fluffing effect of turning event.

**Table 6.** The effect of turning on windrow volume

| Date | Control Windrow | | | Interactive Windrow | | |
|---|---|---|---|---|---|---|
| | Volume ($m^3$) | | | Volume ($m^3$) | | |
| | Before | After | Change (%) | Before | After | Change (%) |
| July 6 | 134.16 | 143.95 | 6.80 | 133.31 | 140.33 | 5.00 |
| July 18 | 126.79 | 129.04 | 1.74 | 114.94 | 121.31 | 5.25 |
| July 27 | 115.81 | 121.69 | 4.84 | 111.89 | 114.41 | 2.21 |
| August 24 | 91.09 | 103.87 | 12.30 | 95.95 | 102.12 | 6.04 |

## CONCLUSIONS

Based on the findings of this investigation, we have drawn the following conclusions.

- The thermography technique can be effectively used to determine the sampling locations on windrow to improve the accuracy of the emission sampling.
- The smaller windrow resulted in substantially higher emissions of all three gas emissions investigated in this study.
- Pseudo-biofilter application can be effectively used for control of emissions.
- Windrows can be managed interactively to reduce the emissions; however, this requires experience in interpreting the data.
- Use of an irrigation system continuously for watering can substantially lower the emissions; however, further research is needed to determine the effect of irrigation intensity on moisture content and emissions.

## REFERENCES

Amlinger, F., Peyr, S., and Cuhls,C. 2008. Waste Management and Research. 26:47-60

Büyüksönmez, F. and Evans, J. 2007. Compost Science and Utilization, 15: 191-199

CIWMB. (Buyuksonmez) 2008. #442-07-009

Chou, C.-H. and Büyüksönmez, F. 2006. Compost Science and Utilization, 14:16-22

Friis, B.B., Pell, M., Sonesson, U., Jonsson, H.,and Kirchmann. 2000. Environmental Monitoring and Assessment, 62:317-331

Fukumoto, Y., Osada, T., Hanajima, D., and Haga, K. 2003. 89:109-114

Hao, X., C. Chang, F.J. Larney, and G.R. Travis. 2001. Greenhouse gas emissions during cattle feedlot manure composting. J. Environ. Qual. 30:376–386

He. Y., Inamori, Y., Mizuochi. M., Kong, H., Iwami, N., and Sun,T. 2000. 254:65-74

Hellebrand., H.J., and Schade., G.W. 2008. Journal of Environmental Quality. 37:592-598

Miyoshi, A., Hatakeyama, S., and Washida, N. 1994. J. Geophys. Res. 99:18779-18787

Novelli, P.C., Steele, L.P., Tans, P.P. 1992. J. Geophys. Res. 97:20731-20750

Rittmann, B.E., and McCarty, P.L., 2001. Environmental Biotechnology: Principles and Applications

Schmidt, C.E. 2005. Personal Communication.

Smyth, B. 2007. Personal Communition

Tchobanoglous, G., and Burton, F.L. 1991. Wastewater Engineering.

Varella, R.F., Bustamante, M.M.C., Pinto, A.S., Kisselle, K.W., Santos, R.V., Burke, R.A., Zepp, R.G., and Viana, L.T. 2004. Ecol. Appl.14:111-231.

## Appendix A. Field Emission Data and Flux Calculation

| SOURCE | Sample ID | He(%) | | | Total Flow(lpm) ‡ |
|---|---|---|---|---|---|
| | | $C_{cylinder}$ | $C_{Canister}$ | $C_{canister-converted}$† | |
| **DAY 1** | | | | | |
| Pesudo Biofilter Pile - cold | 15-42-1C | 9.88 | 2.05 | 2.55 | 14.35 |
| Pesudo Biofilter Pile - hot | 61-71-1H | 9.88 | 1.11 | 1.83 | 21.98 |
| Irrigation Pile - cold | 35-49-2C | 9.88 | 0.78 | 1.02 | 43.20 |
| Irrigation Pile - hot | 51-77-2H | 9.88 | 0.63 | 0.99 | 44.82 |
| Control Pile - cold | 68-9-3C | 9.88 | 0.92 | 1.35 | 31.61 |
| Control Pile - hot | 64-39-3H | 9.88 | 1.13 | 1.75 | 23.30 |
| Interactive Pile - cold | 56-5-4C | 9.88 | 0.18 | 0.38 | 126.40 |
| Interactive Pile - hot | 38-63-4H | 9.88 | 0.28 | 0.48 | 98.72 |
| Reduced size Pile - cold | 62-3-5C | 9.88 | 0.15 | 0.23 | 213.58 |
| Reduced size Pile - hot | 36-22-5H | 9.88 | 0.88 | 1.10 | 39.75 |
| **DAY 2** | | | | | |
| Pesudo Biofilter Pile - cold | 60-8-1C | 9.88 | 0.43 | 0.67 | 69.25 |
| Pesudo Biofilter Pile - hot | 22-18-1H | 9.88 | 0.46 | 0.78 | 58.23 |
| Irrigation Pile - hot (open Chamber) | 67-40-2 | -- | -- | -- | 304.33 |
| Irrigation Pile - hot (before irrigation) | 66-61-2H | 9.88 | 0.27 | 0.47 | 99.40 |
| Irrigation Pile - hot (after irrigation) | 21-52-2H | 9.88 | 0.09 | 0.16 | 304.33[&] |
| Control Pile - cold | 27-21-3C | 9.88 | 0.74 | 1.23 | 35.19 |
| Control Pile - hot | 20-29-3H | 9.88 | 0.62 | 1.02 | 43.37 |
| Interactive Pile - cold | 17-68-4C | 9.88 | 0.49 | 0.79 | 57.35 |
| Interactive Pile - hot | 4-38-4H | 9.88 | 0.74 | 1.09 | 40.14 |
| Reduced size Pile - cold | 7-12-5C | 9.88 | 0.64 | 1.04 | 42.40 |
| Reduced size Pile - hot | 70-47-5H | 9.88 | 0.66 | 1.08 | 40.90 |
| **DAY 3** | | | | | |
| Pesudo Biofilter Pile - cold | 73-19-1C | 9.88 | 1.02 | 1.68 | 24.46 |
| Pesudo Biofilter Pile – hot | 71-2-1H | 23.85 | 9.88 | 1.09 | 1.71 |

**Appendix A. Field Emission Data and Flux Calculation (cont.)**

| SOURCE | Sample ID | He(%) | | | Total Flow(lpm) |
|---|---|---|---|---|---|
| | | $C_{cylinder}$ | $C_{Canister}$ | $C_{canister\text{-}converted}$ | |
| Pesudo Biofilter Pile – hot | 71-2-1H | 9.88 | 1.09 | 1.71 | 23.85 |
| Irrigation Pile - hot (open Chamber) | 58-46-2 | -- | -- | -- | 58.59[&] |
| Irrigation Pile - hot (before irrigation) | 75-55-2H | 9.88 | 0.65 | 1.03 | 42.89 |
| Irrigation Pile - hot (after irrigation) | 79-23-2H | 9.88 | 0.48 | 0.78 | 58.59 |
| Control Pile – cold | 74-30-3C | 9.88 | 0.34 | 0.50 | 93.88 |
| Control Pile – hot | 26-76-3H | 9.88 | 0.70 | 1.10 | 39.76 |
| Interactive Pile - cold | 72-33-4C | 9.88 | 1.59 | 2.49 | 14.88 |
| Interactive Pile – hot | 76-27-4H | 9.88 | 0.47 | 0.77 | 59.12 |
| Reduced size Pile – cold | 81-15-5C | 9.88 | 0.30 | 0.42 | 111.52 |
| Reduced size Pile – hot | 78-6-5H | 9.88 | 0.40 | 0.66 | 70.33 |
| **DAY 5** | | | | | |
| Pesudo Biofilter Pile – cold | 25-48-1C | 9.88 | 0.83 | 1.14 | 38.16 |
| Pesudo Biofilter Pile – hot | 57-79-1H | 9.88 | 0.90 | 1.53 | 27.33 |
| Irrigation Pile - hot (open Chamber) | 2-11-2 | -- | -- | -- | 145.36[&] |
| Irrigation Pile - hot (before irrigation) | 30-56-2H | 9.88 | 0.43 | 0.71 | 64.86 |
| Irrigation Pile - hot (after irrigation) | 47-31-2H | 9.88 | 0.22 | 0.33 | 145.36 |
| Control Pile – cold | 43-45-3C | 9.88 | 0.46 | 0.73 | 62.24 |
| Control Pile – hot | 1-1-3H | 9.88 | 0.32 | 0.47 | 99.22 |
| Interactive Pile - cold | 5-72-4C | 9.88 | 0.24 | 0.43 | 109.03 |
| Interactive Pile – hot | 24-44-4H | 9.88 | 0.25 | 0.36 | 131.36 |
| Reduced size Pile – cold | 41-54-5C | 9.88 | 0.05 | 0.09 | 573.93 |
| Reduced size Pile – hot | 37-50-5H | 9.88 | 0.06 | 0.08 | 600.16 |
| **DAY 7** | | | | | |
| Pesudo Biofilter Pile - cold | 32-70-1C | 9.88 | 1.35 | 2.19 | 17.57 |
| Pesudo Biofilter Pile – hot | 65-26-1H | 9.88 | 1.28 | 2.09 | 18.68 |
| Pesudo Biofilter Pile – hot | 71-2-1H | 9.88 | 1.09 | 1.71 | 23.85 |

## Appendix A. Field Emission Data and Flux Calculation (cont.)

| SOURCE | Sample ID | He(%) $C_{cylinder}$ | $C_{Canister}$ | $C_{canister-converted}$ | Total Flow(lpm) |
|---|---|---|---|---|---|
| Irrigation Pile - hot (after irrigation) | 10-74-2H | 9.88 | 0.30 | 0.48 | 98.15 |
| Control Pile – cold | 16-67-3C | 9.88 | 0.38 | 0.61 | 75.68 |
| Control Pile – hot | 55-73-3H | 9.88 | 0.08 | 0.13 | 389.24 |
| Interactive Pile - cold | 18-60-4C | 9.88 | 285.85 | 0.73 | 62.35 |
| Interactive Pile – hot | 59-25-4H | 9.88 | 56.33 | 0.13 | 369.15 |
| Reduced size Pile – cold | 46-62-5C | 9.88 | 0.11 | 0.17 | |
| Reduced size Pile – hot | 50-32-5H | 9.88 | 0.51 | 0.81 | |
| **DAY 10** | | | | | |
| Pesudo Biofilter Pile – cold | 11-75-1C | 9.88 | 1.10 | 1.84 | 21.80 |
| Pesudo Biofilter Pile – hot | 42-4-1H | 9.88 | 0.75 | 1.23 | 35.05 |
| Irrigation Pile - hot (open Chamber) | 39-17-2 | -- | -- | -- | 66.24[&] |
| Irrigation Pile - hot (before irrigation) | 33-20-2H | 9.88 | 0.28 | 0.48 | 98.33 |
| Irrigation Pile - hot (after irrigation) | 23-66-2H | 9.88 | 0.42 | 0.69 | 66.24 |
| Control Pile – cold | 12-36-3C | 9.88 | 0.44 | 0.72 | 63.61 |
| Control Pile – hot | 31-34-3H | 9.88 | 0.49 | 0.79 | 57.32 |
| Control Pile (after turn over) | 70-41-3 | -- | -- | -- | 103.50* |
| Control Pile (2nd sample after turn over) | 38-16-3 | -- | -- | -- | 109.57* |
| Interactive Pile - cold | 8-78-4C | 9.88 | 0.14 | 0.25 | 190.33 |
| Interactive Pile – hot | 82-14-4H | 9.88 | 0.61 | 0.99 | 44.67 |
| Reduced size Pile – cold | 34-37-5C | 9.88 | 0.04 | 0.07 | 753.51 |
| Reduced size Pile – hot | 3-53-5H | 9.88 | 0.06 | 0.11 | 444.45 |
| **DAY 15** | | | | | |
| Pesudo Biofilter Pile – cold | 68-97-1C | 9.88 | 0.10 | 0.16 | 297.49 |
| Pesudo Biofilter Pile – hot | 71-94-1H | 9.88 | 0.39 | 0.63 | 73.01 |
| Irrigation Pile - hot (open Chamber) | 7-85-2 | -- | -- | -- | 201.97* |
| Irrigation Pile - hot (before irrigation) | 20-88-2H | 9.88 | 0.32 | 0.50 | 93.77 |
| Irrigation Pile - hot (after irrigation) | 17-102-2H | 9.88 | 0.52 | 0.76 | 60.02 |

## Appendix A. Field Emission Data and Flux Calculation (cont.)

| SOURCE | Sample ID | He(%) $C_{cylinder}$ | He(%) $C_{Canister}$ | He(%) $C_{canister\text{-}converted}$ | Total Flow(lpm) |
|---|---|---|---|---|---|
| Control Pile - cold | 64-104-3C | 9.88 | 0.34 | 0.55 | 84.36 |
| Control Pile - hot | 76-91-3H | 9.88 | 0.09 | 0.15 | 314.77 |
| Interactive Pile - cold | 61-96-4C | 9.88 | 0.04 | 0.07 | 681.83 |
| Interactive Pile - hot | 79-92-4H | 9.88 | 0.12 | 0.19 | 251.13 |
| Reduced size Pile - cold | 73-100-5C | 9.88 | 0.04 | 0.07 | 739.47 |
| Reduced size Pile - hot | 74-105-5H | 9.88 | 0.06 | 0.09 | 528.34 |
| **DAY 22** | | | | | |
| Pesudo Biofilter Pile - cold | 46-83-1C | 9.88 | 1.32 | 2.20 | 17.48 |
| Pesudo Biofilter Pile - hot | 3-93-1H | 9.88 | 1.01 | 1.80 | 22.39 |
| Irrigation Pile - hot (open Chamber) | 30-89-2 | -- | -- | -- | 114.56[&] |
| Irrigation Pile - hot (before irrigation) | 34-84-2H | 9.88 | 0.15 | 0.24 | 202.46 |
| Irrigation Pile - hot (after irrigation) | 47-109-2H | 9.88 | 0.25 | 0.41 | 114.56 |
| Control Pile - cold | 65-106-3C | 9.88 | 0.15 | 0.26 | 182.20 |
| Control Pile - hot | 54-99-3H | 9.88 | 0.27 | 0.42 | 114.01 |
| Interactive Pile (after turn over, 1st sample) | 35-95-4 | -- | -- | -- | 26.23* |
| Interactive Pile (after turn over, 2nd sample) | 51-87-4 | -- | -- | -- | 31.41* |
| Interactive Pile - cold | 31-101-4C | 9.88 | 0.37 | 0.62 | 74.41 |
| Interactive Pile - hot | 11-82-4H | 9.88 | 0.17 | 0.28 | 168.45 |
| Reduced size Pile - cold | 24-110-5C | 9.88 | 0.14 | 0.23 | 211.77 |
| Reduced size Pile - hot | 8-98-5H | 9.88 | 0.12 | 0.20 | 238.18 |
| **DAY 29 (06 July)** | | | | | |
| Pesudo Biofilter Pile - cold | 21-169-1C | 9.88 | 0.82 | 1.25 | 34.53 |
| Pesudo Biofilter Pile - hot | 72-168-1H | 9.88 | 0.41 | 0.65 | 70.71 |
| Irrigation Pile - hot (open Chamber) | 62-160-2 | -- | -- | -- | 247.61* |
| Irrigation Pile - hot (before irrigation) | 4-165-2H | 9.88 | 0.16 | 0.30 | 162.08 |

**Appendix A. Field Emission Data and Flux Calculation (cont.)**

| SOURCE | Sample ID | He(%) | | | Total Flow(lpm) |
|---|---|---|---|---|---|
| | | $C_{cylinder}$ | $C_{Canister}$ | $C_{canister\text{-}converted}$ | |
| Irrigation Pile - hot (after irrigation) | 56-159-2H | 9.88 | 0.20 | 0.31 | 154.82 |
| Control Pile – cold | 78-166-3C | 9.88 | 0.29 | 0.49 | 95.52 |
| Control Pile – hot | 22-167-3H | 9.88 | 0.09 | 0.15 | 318.51 |
| Control Pile (after turn over) | 63-153-3 | -- | -- | -- | 51.53* |
| Interactive Pile – cold | 15-161-4C | 10.10 | 0.18 | 0.29 | 170.50 |
| Interactive Pile – hot | 26-164-4H | 10.10 | 0.12 | 0.21 | 241.24 |
| Interactive Pile (after turn over) | 27-152 | -- | -- | -- | 72.67* |
| Reduced size Pile – cold | 67-151-5C | 10.10 | 0.04 | 0.06 | 828.47 |
| Reduced size Pile – hot | 58-158-5H | 10.10 | 0.07 | 0.12 | 430.49 |
| **DAY 36 (July 13)** | | | | | |
| Pesudo Biofilter Pile - cold | 28-196-1C | 10.10 | 1.26 | 1.94 | 21.02 |
| Pesudo Biofilter Pile – hot | 53-186-1H | 10.10 | 0.97 | 1.46 | 29.51 |
| Irrigation Pile - hot (open Chamber) | 43-192-2 | -- | -- | -- | 101.38[&] |
| Irrigation Pile - hot (before irrigation) | 48-189-2H | 10.10 | 0.11 | 0.19 | 261.61 |
| Irrigation Pile - hot (after irrigation) | 42-183-2 | 10.10 | 0.28 | 0.47 | 101.38 |
| Control Pile – cold | 14-187-3C | 10.10 | 0.44 | 0.75 | 62.23 |
| Control Pile – hot | 7-195-3H | 10.10 | 0.21 | 0.37 | 133.02 |
| Control Pile (after turn over) | 66-193-3 | -- | -- | -- | 70.72* |
| Interactive Pile (after turn over) | 75-191-4 | -- | -- | -- | 62.63* |
| Interactive Pile – cold | 74-180-4C | 10.10 | 0.07 | 0.12 | 412.45 |
| Interactive Pile – hot | 23-199-4H | 10.10 | 0.26 | 0.43 | 113.04 |
| Reduced size Pile – cold | 19-190-5C | 10.10 | 0.07 | 0.11 | 450.93 |
| Reduced size Pile – hot | 38-188-5H | 10.10 | 0.07 | 0.13 | 394.20 |
| **Day 41 (July 18)** | | | | | |
| Pesudo Biofilter Pile - cold | 15-184-1C | 10.10 | 1.04 | 1.65 | 25.69 |

## Appendix A. Field Emission Data and Flux Calculation (cont.)

| SOURCE | Sample ID | He(%) $C_{cylinder}$ | He(%) $C_{Canister}$ | He(%) $C_{canister\text{-}converted}$ | Total Flow(lpm) |
|---|---|---|---|---|---|
| Pesudo Biofilter Pile – hot | 21-197-1H | 10.10 | 0.30 | 0.53 | 90.12 |
| Irrigation Pile - hot (open Chamber) | 73-214-2 | -- | -- | -- | 82.75[&] |
| Irrigation Pile - hot (before irrigation) | 62-210-2H | 10.10 | 0.11 | 0.18 | 271.55 |
| Irrigation Pile - hot (after irrigation) | 56-219-2H | 10.10 | 0.35 | 0.58 | 82.75 |
| Control Pile – cold | 4-209-3C | 10.10 | 0.80 | 1.32 | 33.12 |
| Control Pile – hot | 22-208-3H | 10.10 | 0.20 | 0.34 | 145.21 |
| Control Pile (after turn over) | 58-203-3 | -- | -- | -- | 55.29* |
| Interactive Pile – cold | 78-216-4C | 10.10 | 0.35 | 0.62 | 76.60 |
| Interactive Pile – hot | 26-207-4H | 10.10 | 0.13 | 0.23 | 216.95 |
| Interactive Pile (after turn over) | 65-202-4 | -- | -- | -- | 54.98* |
| Reduced size Pile – cold | 72-215-5C | 10.10 | 0.07 | 0.12 | 417.11 |
| Reduced size Pile – hot | 67-213-5H | 10.10 | 0.15 | 0.26 | 191.64 |
| **Day 50 (July 27)** | | | | | |
| QC Blank Sample | 37-201-B | 10.10 | 6.42 | 10.08 | 0.01 |
| Pesudo Biofilter Pile - cold | 50-205-1C | 10.10 | 1.00 | 1.47 | 29.37 |
| Pesudo Biofilter Pile – hot | 35-200-1H | 10.10 | 0.33 | 0.56 | 84.77 |
| Irrigation Pile - hot (open Chamber) | 51-236-2 | -- | -- | -- | 357.95 |
| Irrigation Pile - hot (before irrigation) | 11-194-2H | 10.10 | 0.07 | 0.12 | 433.90 |
| Irrigation Pile - hot (after irrigation) | 54-235-2H | 10.10 | 0.08 | 0.14 | 357.95 |
| Control Pile – cold | 3-204-3C | 10.10 | 1.42 | 2.40 | 16.08 |
| Control Pile – hot | 76-198-3H | 10.10 | 0.43 | 0.66 | 71.44 |
| Control Pile (after turn over) | 30-211-3 | 10.10 | 0.15 | 0.27 | 179.78 |
| Interactive Pile – cold | 13-237-4C | 10.10 | 0.25 | 0.45 | 106.74 |
| Interactive Pile – hot | 82-238-4H | 10.10 | 0.20 | 0.35 | 141.02 |
| Interactive Pile (after turn over) | 32-212-4 | 10.10 | 0.12 | 0.21 | 235.35 |
| Reduced size Pile – cold | 8-231-5C | 10.10 | 0.05 | 0.10 | 506.88 |
| Reduced size Pile – hot | 59-230-5H | 10.10 | 0.21 | 0.34 | 141.41 |

## Appendix A. Field Emission Data and Flux Calculation (cont.)

| SOURCE | Sample ID | He(%) $C_{cylinder}$ | $C_{Canister}$ | $C_{canister\text{-}converted}$ | Total Flow(lpm) |
|---|---|---|---|---|---|
| **Day 64 - (August 10)** | | | | | |
| Pesudo Biofilter Pile - cold | 14-314-1C | 10.10 | 0.40 | 0.69 | 67.83 |
| Pesudo Biofilter Pile – hot | 42-315-1H | 10.10 | 0.25 | 0.46 | 104.90 |
| Irrigation Pile - hot (open Chamber) | 55-308-2 | -- | -- | -- | 325.44[&] |
| Irrigation Pile - hot (before irrigation) | 70-302-2H | 10.10 | 0.53 | 0.90 | 51.06 |
| Irrigation Pile - hot (after irrigation) | 17-300-2H | 10.10 | 0.09 | 0.15 | 325.44 |
| Control Pile – cold | 18-316-3C | 10.10 | 1.03 | 1.63 | 26.04 |
| Control Pile – hot | 7-303-3H | 10.10 | 1.19 | 2.12 | 18.78 |
| Interactive Pile – cold | 66-317-4C | 10.10 | 0.96 | 1.56 | 27.43 |
| Interactive Pile – hot | 19-319-4H | 10.10 | 0.39 | 0.69 | 68.54 |
| Reduced size Pile – cold | 43-310-5C | 10.10 | 0.88 | 1.47 | 29.31 |
| Reduced size Pile – hot | 23-301-5H | 10.10 | 0.10 | 0.17 | 286.44 |
| **Day78 (August 24)** | | | | | |
| Pesudo Biofilter Pile - cold | 76-350-1C | 10.10 | 0.19 | 0.30 | 161.62 |
| Pesudo Biofilter Pile – hot | 54-357-1H | 10.10 | 0.34 | 0.60 | 79.83 |
| Irrigation Pile - hot (open Chamber) | 4-354-2OP | -- | -- | -- | 223.46[&] |
| Irrigation Pile - hot (before irrigation) | 16-355-2H | 10.10 | 0.16 | 0.28 | 172.75 |
| Irrigation Pile - hot (after irrigation) | 3-309-2H | 10.10 | 0.13 | 0.22 | 223.46 |
| Control Pile – cold | 15-356-3C | 10.10 | 0.72 | 1.31 | 33.62 |
| Control Pile – hot | 30-351-3H | -- | -- | -- | -- |
| Control Pile (after turn over) | 63-318-3 | 10.10 | 0.31 | 0.55 | 87.60 |
| Interactive Pile - cold | 13-358-4C | 10.10 | 0.26 | 0.48 | 100.90 |
| Interactive Pile - hot | 53-353-4H | 10.10 | 0.10 | 0.18 | 268.27 |
| Interactive Pile (after turn over) | 51-312-4 | 10.10 | 0.21 | 0.38 | 128.69 |
| Reduced size Pile - cold | 35-305-5C | 10.10 | 0.09 | 0.16 | 305.53 |

**Appendix A. Field Emission Data and Flux Calculation (cont.)**

| SOURCE | Sample ID | He(%) $C_{cylinder}$ | $C_{Canister}$ | $C_{canister\text{-}converted}$ | Total Flow(lpm) |
|---|---|---|---|---|---|
| Reduced size Pile – hot | 27-306-5H | 10.10 | 0.07 | 0.11 | 442.69 |
| **Day99- (SEP 14)** | | | | | |
| Pesudo Biofilter Pile - cold | 78-400-1C | 10.10 | 0.82 | 1.42 | 30.63 |
| Pesudo Biofilter Pile – hot | 23-411-1H | 10.10 | 0.74 | 1.38 | 31.63 |
| Irrigation Pile - hot (open Chamber) | 14-403-2 | -- | -- | -- | 312.20[&] |
| Irrigation Pile - hot (before irrigation) | 7-401-2H | 10.10 | 0.16 | 0.28 | 172.91 |
| Irrigation Pile - hot (after irrigation) | 11-414-2H | 10.10 | 0.09 | 0.16 | 312.20 |
| Control Pile – cold | 70-413-3C | 10.10 | 0.07 | 0.10 | 492.84 |
| Control Pile – hot | 28-402-3H | 10.10 | 0.07 | 0.12 | 429.31 |
| Control Pile (after turn over) | 66-407-3T | 10.10 | 0.43 | 0.71 | 66.38 |
| Interactive Pile – cold | 37-415-4C | 10.10 | 0.07 | 0.12 | 418.75 |
| Interactive Pile – hot | 55-405-4H | 10.10 | 0.40 | 0.65 | 72.33 |
| Interactive Pile (after turn over) | 82-417-4T | 10.10 | 0.05 | 0.09 | 566.92 |
| Reduced size Pile – cold | 59-416-5C | 10.10 | 0.06 | 0.11 | 447.65 |
| Reduced size Pile – hot | 10-406-5H | 10.10 | 5.70 | 0.08 | 656.69 |

& Assume the same flux as "after irrigation".

* Flux was calculated based on the trace gas $C_2H_6$ concentration.

† Calculate the converted concentration of component in the canister using the following equation:

$$C_c = C_m \times \frac{P_f - P_0}{P_r - P_0}$$

Where $C_c$ = end of sampling canister concentration, ppmv

$C_m$ = average of duplicate measured concentrations from TCA analysis, ppmv

$P_f$ = canister pressure after pressurization, mmHg

$P_r$ = return pressure in mm Hg

$P_0$ = evacuated canister pressure in mmHg

‡ The emission flowrate can be calculated based on the air flow and tracer concentration in the air (mostly Helium and some samples with C2H6):

$$Q_{Emission} = Q_{Air} \times (\frac{C_{He,cylinder}}{C_{He,canister}} - 1)$$

Where $Q_{Air}$ = sweep air flow rate, L/min

$C_{He,cylinder}$ = % of He in sweep air

$Q_{Emission}$ = compost emission flow from compost, L/min

$C_{He,canister}$ = He concentration in canister, %

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$

| SOURCE | Sample ID | Total Flow (lpm)& | $CH_4$ | | | | $N_2O$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{CH4}$ (ppmv) | Flux ($mg/m^2$-min) † | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{N2O}$ (ppmv) | Flux ($mg/m^2$-min) † |
| **DAY 1** | | | | | | | | | | |
| QC Blank Sample | 63-65-B | 0.00 | 1.46 | 1.33 | 1.39 | 0.06 | ND | ND | ND | ND |
| Pesudo Biofilter Pile - cold | 15-42-1C | 14.35 | 1.77 | 1.61 | 1.69 | 0.20 | 0.45 | | 0.45 | 0.15 |
| Pesudo Biofilter Pile - hot | 61-71-1H | 21.98 | 1.48 | 1.67 | 1.57 | 0.35 | 28.37 | 28.45 | 28.41 | 17.56 |
| Irrigation Pile - cold | 35-49-2C | 43.20 | 1.54 | 1.55 | 1.55 | 0.49 | NA | 0.31 | 0.31 | 0.28 |
| Irrigation Pile - hot | 51-77-2H | 44.82 | 1.29 | 1.30 | 1.30 | 0.51 | 0.86 | 0.79 | 0.83 | 0.89 |
| Control Pile - cold | 68-9-3C | 31.61 | 6.33 | 7.10 | 6.71 | 1.82 | 28.99 | 27.94 | 28.46 | 21.24 |
| Control Pile - hot | 64-39-3H | 23.30 | 5.65 | 5.73 | 5.69 | 1.25 | 18.66 | 11.75 | 15.20 | 9.18 |
| Interactive Pile - cold | 56-5-4C | 126.40 | 1.88 | 1.97 | 1.92 | 2.65 | 23.30 | 23.56 | 23.43 | 88.86 |
| Interactive Pile - hot | 38-63-4H | 98.72 | 2.38 | 2.52 | 2.45 | 2.14 | 19.99 | 20.86 | 20.42 | 49.02 |
| Reduced size Pile - cold | 62-3-5C | 213.58 | 3.13 | 2.23 | 2.68 | 4.50 | 7.11 | 5.38 | 6.25 | 28.78 |
| Reduced size Pile - hot | 36-22-5H | 39.75 | 2.19 | 3.06 | 2.62 | 0.74 | 6.76 | 7.81 | 7.29 | 5.64 |
| **DAY 2** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 60-8-1C | 69.25 | 1.53 | 1.66 | 1.60 | 0.92 | 2.00 | 2.73 | 2.37 | 3.73 |
| Pesudo Biofilter Pile - hot | 22-18-1H | 58.23 | 5.25 | 5.16 | 5.21 | 2.84 | 13.96 | 15.46 | 14.71 | 22.10 |
| Irrigation Pile - hot (open Chamber) | 67-40-2 | 304.33 | 1.39 | 1.48 | 1.44 | 3.71 | 0.35 | 0.00 | 0.18 | 1.25 |
| Irrigation Pile - hot (before irrigation) | 66-61-2H | 99.40 | 4.08 | 5.15 | 4.61 | 4.20 | 19.20 | 20.99 | 20.09 | 50.33 |
| Irrigation Pile - hot (after irrigation) | 21-52-2H | 304.33 | 1.98 | 2.03 | 2.01 | 5.25 | 6.04 | 5.00 | 5.52 | 39.76 |
| Control Pile - cold | 27-21-3C | 35.19 | 7.06 | 7.12 | 7.09 | 2.40 | 8.54 | 0.00 | 4.27 | 3.97 |
| Control Pile - hot | 20-29-3H | 43.37 | 6.87 | 6.88 | 6.88 | 2.74 | 4.38 | 4.51 | 4.45 | 4.87 |
| Interactive Pile - cold | 17-68-4C | 57.35 | 1.17 | 1.42 | 1.29 | 0.65 | 0.59 | 1.37 | 0.98 | 1.36 |
| Interactive Pile - hot | 4-38-4H | 40.14 | 2.36 | 2.15 | 2.25 | 0.76 | 5.07 | 9.96 | 7.52 | 6.97 |
| Reduced size Pile - cold | 7-12-5C | 42.40 | 2.08 | 2.08 | 2.08 | 0.81 | 10.80 | 7.68 | 9.24 | 9.94 |
| Reduced size Pile - hot | 70-47-5H | 40.90 | 1.82 | 1.97 | 1.89 | 0.71 | 7.10 | 6.27 | 6.68 | 6.90 |
| **DAY 3** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 73-19-1C | 24.46 | 1.88 | 1.84 | 1.86 | 0.45 | 0.15 | 0.29 | 0.22 | 0.15 |

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$ (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | $CH_4$ C1 (ppmv) | $CH_4$ C2 (ppmv) | $CH_4$ Avg $C_{CH4}$ (ppmv) | $CH_4$ Flux (mg/m²-min) | $N_2O$ C1 (ppmv) | $N_2O$ C2 (ppmv) | $N_2O$ Avg $C_{N2O}$ (ppmv) | $N_2O$ Flux (mg/m²-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Pesudo Biofilter Pile - hot | 71-2-1H | 23.85 | 3.83 | 3.53 | 3.68 | 0.84 | 0.58 | 0.77 | 0.67 | 0.42 |
| Irrigation Pile - hot (open Chamber) | 58-46-2 | 58.59 | 1.59 | 1.82 | 1.70 | 0.88 | 0.36 | 0.00 | 0.18 | 0.26 |
| Irrigation Pile - hot (before irrigation) | 75-55-2H | 42.89 | 21.58 | 19.53 | 20.55 | 7.90 | 11.49 | NA | 11.49 | 12.14 |
| Irrigation Pile - hot (after irrigation) | 79-23-2H | 58.59 | 44.99 | 46.37 | 45.68 | 23.74 | 13.98 | 14.24 | 14.11 | 20.17 |
| Control Pile - cold | 74-30-3C | 93.88 | 1.75 | 1.75 | 1.75 | 1.28 | 0.39 | 0.19 | 0.29 | 0.58 |
| Control Pile - hot | 26-76-3H | 39.76 | 22.46 | 23.14 | 22.80 | 8.15 | NA | 4.28 | 4.28 | 4.21 |
| Interactive Pile - cold | 72-33-4C | 14.88 | 3.82 | 3.64 | 3.73 | 0.58 | 1.66 | 1.87 | 1.77 | 0.76 |
| Interactive Pile - hot | 76-27-4H | 59.12 | 3.85 | 4.17 | 4.01 | 2.12 | 1.89 | 1.41 | 1.65 | 2.39 |
| Reduced size Pile - cold | 81-15-5C | 111.52 | 6.54 | 6.46 | 6.50 | 5.31 | 0.75 | 0.56 | 0.66 | 1.47 |
| Reduced size Pile - hot | 78-6-5H | 70.33 | 3.88 | 3.59 | 3.73 | 2.32 | 1.70 | 3.52 | 2.61 | 4.47 |
| **DAY 5** | | | | | | | | | | |
| QC Blank Sample | 13-24-B | 0.00 | 1.15 | 1.25 | 1.20 | 0.06 | ND | ND | ND | ND |
| Pesudo Biofilter Pile - cold | 25-48-1C | 38.16 | 83.05 | 81.61 | 82.33 | 24.52 | ND | ND | ND | ND |
| Pesudo Biofilter Pile - hot | 57-79-1H | 27.33 | 3223.16 | 3176.08 | 3199.62 | 881.78 | 23.78 | 22.68 | 23.23 | 17.61 |
| Irrigation Pile - hot (open Chamber) | 2-11-2 | 145.36 | 7.97 | 7.82 | 7.89 | 10.17 | 0.59 | 0.40 | 0.50 | 1.75 |
| Irrigation Pile - hot (before irrigation) | 30-56-2H | 64.86 | 119.79 | 119.01 | 119.40 | 68.55 | 7.21 | 9.87 | 8.54 | 13.49 |
| Irrigation Pile - hot (after irrigation) | 47-31-2H | 145.36 | 113.34 | 112.14 | 112.74 | 126.11 | 14.82 | 9.26 | 12.04 | 37.03 |
| Control Pile - cold | 43-45-3C | 62.24 | 3.04 | 2.77 | 2.91 | 1.57 | 0.27 | NA | 0.27 | 0.40 |
| Control Pile - hot | 1-1-3H | 99.22 | 86.68 | 86.37 | 86.52 | 67.34 | 4.22 | 3.77 | 3.99 | 8.54 |
| Interactive Pile - cold | 5-72-4C | 109.03 | 10.57 | 10.53 | 10.55 | 11.06 | 1.01 | 0.96 | 0.98 | 2.83 |
| Interactive Pile - hot | 24-44-4H | 131.36 | 34.42 | 34.54 | 34.48 | 34.58 | 3.17 | 3.02 | 3.09 | 8.53 |
| Reduced size Pile - cold | 41-54-5C | 573.93 | 5.54 | 5.45 | 5.50 | 25.01 | 0.32 | 0.27 | 0.30 | 3.69 |
| Reduced size Pile - hot | 37-50-5H | 600.16 | 47.84 | 47.53 | 47.69 | 207.91 | 0.91 | 0.82 | 0.87 | 10.40 |
| **DAY 7** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 32-70-1C | 17.57 | 85.40 | 83.91 | 84.66 | 15.64 | 0.39 | NA | 0.39 | 0.20 |
| Pesudo Biofilter Pile - hot | 65-26-1H | 18.68 | 2904.95 | 2898.83 | 2901.89 | 561.73 | 44.41 | 39.39 | 41.90 | 22.30 |
| Irrigation Pile - hot (open Chamber) | 54-57-2 | 98.15 | 3.80 | 3.85 | 3.82 | 3.13 | 0.22 | 0.14 | 0.18 | 0.40 |

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$ (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | $CH_4$ C1 (ppmv) | $CH_4$ C2 (ppmv) | $CH_4$ Avg $C_{CH4}$ (ppmv) | $CH_4$ Flux (mg/m$^2$-min) | $N_2O$ C1 (ppmv) | $N_2O$ C2 (ppmv) | $N_2O$ Avg $C_{N2O}$ (ppmv) | $N_2O$ Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation Pile - hot (before irrigation) | 6-51-2H | 130.82 | 268.62 | 263.13 | 265.88 | 317.43 | 14.57 | 11.04 | 12.80 | 42.04 |
| Irrigation Pile - hot (after irrigation) | 10-74-2H | 98.15 | 257.64 | 253.29 | 255.46 | 209.08 | 19.28 | 13.98 | 16.63 | 37.44 |
| Control Pile - cold | 16-67-3C | 75.68 | 16.27 | 14.97 | 15.62 | 10.16 | 0.85 | 0.53 | 0.69 | 1.23 |
| Control Pile - hot | 55-73-3H | 389.24 | 13.24 | 11.88 | 12.56 | 37.18 | 2.06 | 1.43 | 1.75 | 14.21 |
| Interactive Pile - cold | 18-60-4C | 62.35 | 97.29 | 101.20 | 99.25 | 51.78 | 0.77 | 0.96 | 0.87 | 1.24 |
| Interactive Pile - hot | 59-25-4H | 369.15 | 45.28 | 45.37 | 45.33 | 142.97 | 0.59 | 0.65 | 0.62 | 5.41 |
| Reduced size Pile - cold | 46-62-5C | 285.85 | 114.63 | 112.31 | 113.47 | 266.32 | 0.75 | 0.51 | 0.63 | 4.05 |
| Reduced size Pile - hot | 50-32-5H | 56.33 | 487.87 | 479.83 | 483.85 | 237.02 | 0.94 | 1.47 | 1.21 | 1.62 |
| **DAY 10** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 11-75-1C | 21.80 | 162.21 | 161.28 | 161.74 | 36.54 | ND | ND | ND | ND |
| Pesudo Biofilter Pile - hot | 42-4-1H | 35.05 | 5614.22 | 5543.42 | 5578.82 | 1840.00 | 8.60 | 7.33 | 7.97 | 7.23 |
| Irrigation Pile - hot (open Chamber) | 39-17-2 | 66.24 | 12.40 | 12.20 | 12.30 | 8.19 | 0.25 | 0.41 | 0.33 | 0.61 |
| Irrigation Pile - hot (before irrigation) | 33-20-2H | 98.33 | 393.29 | 386.28 | 389.79 | 340.85 | 1.76 | 1.32 | 1.54 | 3.71 |
| Irrigation Pile - hot (after irrigation) | 23-66-2H | 66.24 | 1037.30 | 1014.27 | 1025.79 | 607.62 | 5.24 | 4.38 | 4.81 | 7.83 |
| Control Pile - cold | 12-36-3C | 63.61 | 26.85 | 26.49 | 26.67 | 15.24 | 0.38 | 0.48 | 0.43 | 0.68 |
| Control Pile - hot | 31-34-3H | 57.32 | 625.14 | 620.26 | 622.70 | 314.90 | 6.93 | NA | 6.93 | 9.63 |
| Control Pile (after turn over) | 70-41-3 | 103.50 | 426.87 | 421.32 | 424.10 | 367.01 | 6.80 | 6.23 | 6.51 | 15.50 |
| Control Pile (2nd sample after turn over) | 38-16-3 | 109.57 | 272.64 | 267.80 | 270.22 | 250.55 | 9.26 | 11.61 | 10.44 | 26.61 |
| Interactive Pile - cold | 8-78-4C | 190.33 | 236.28 | 236.63 | 236.46 | 410.71 | 0.64 | 0.41 | 0.53 | 2.53 |
| Interactive Pile - hot | 82-14-4H | 44.67 | 412.30 | 418.11 | 415.21 | 169.78 | 1.90 | NA | 1.90 | 2.13 |
| Reduced size Pile - cold | 34-37-5C | 753.51 | 173.68 | 169.34 | 171.51 | 1081.92 | 0.27 | NA | 0.27 | 4.75 |
| Reduced size Pile - hot | 3-53-5H | 444.45 | 363.05 | 353.67 | 358.36 | 1414.26 | 0.57 | 0.52 | 0.55 | 5.93 |
| **DAY 15** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 68-97-1C | 297.49 | 30.51 | 30.18 | 30.35 | 76.50 | 0.22 | 0.22 | 0.22 | 1.51 |
| Pesudo Biofilter Pile - hot | 71-94-1H | 73.01 | 537.96 | 539.52 | 538.74 | 342.38 | 1.13 | 1.20 | 1.16 | 2.03 |
| Irrigation Pile - hot (open Chamber) | 7-85-2 | 201.97 | 10.87 | 10.53 | 10.70 | 18.66 | 0.27 | 0.21 | 0.24 | 1.15 |

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$ (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | $CH_4$ C1 (ppmv) | $CH_4$ C2 (ppmv) | Avg $C_{CH4}$ (ppmv) | $CH_4$ Flux (mg/m$^2$-min) | $N_2O$ C1 (ppmv) | $N_2O$ C2 (ppmv) | Avg $C_{N2O}$ (ppmv) | $N_2O$ Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation Pile - hot (before irrigation) | 20-88-2H | 93.77 | 1002.83 | 986.43 | 994.63 | 769.16 | 2.78 | 1.55 | 2.17 | 4.61 |
| Irrigation Pile - hot (after irrigation) | 17-102-2H | 60.02 | 1532.27 | 1490.77 | 1511.52 | 724.09 | 4.58 | 3.99 | 4.29 | 5.65 |
| Control Pile - cold | 64-104-3C | 84.36 | 361.95 | 359.52 | 360.74 | 265.47 | 1.76 | 1.67 | 1.72 | 3.48 |
| Control Pile - hot | 76-91-3H | 314.77 | 434.35 | 433.93 | 434.14 | 1185.91 | 2.98 | 2.71 | 2.85 | 21.38 |
| Interactive Pile - cold | 61-96-4C | 681.83 | 17.80 | 17.71 | 17.76 | 99.80 | 0.23 | 0.29 | 0.26 | 4.07 |
| Interactive Pile - hot | 79-92-4H | 251.13 | 428.48 | 429.56 | 429.02 | 899.79 | 0.58 | 0.58 | 0.58 | 3.35 |
| Reduced size Pile - cold | 73-100-5C | 739.47 | 14.25 | 14.52 | 14.39 | 85.58 | 0.32 | NA | 0.32 | 5.24 |
| Reduced size Pile - hot | 74-105-5H | 528.34 | 1275.38 | 1246.68 | 1261.03 | 5420.90 | | 0.38 | 0.38 | 4.54 |
| **DAY 22** | | | | | | | | | | |
| QC Blank Sample | 32-105-B | 0.00 | 1.56 | 1.55 | 1.55 | 0.06 | 0.32 | 0.31 | 0.31 | 0.03 |
| Pesudo Biofilter Pile - cold | 46-83-1C | 17.48 | 340.36 | 330.40 | 335.38 | 63.19 | 0.16 | NA | 0.16 | 0.08 |
| Pesudo Biofilter Pile - hot | 3-93-1H | 22.39 | 6150.19 | 6049.74 | 6099.97 | 1498.00 | 3.43 | 3.65 | 3.54 | 2.39 |
| Irrigation Pile - hot (open Chamber) | 30-89-2 | 114.56 | 95.84 | 94.03 | 94.93 | 103.08 | 0.25 | 0.20 | 0.22 | 0.67 |
| Irrigation Pile - hot (before irrigation) | 34-84-2H | 202.46 | 1907.64 | 1877.95 | 1892.80 | 3159.56 | 0.66 | NA | 0.66 | 3.05 |
| Irrigation Pile - hot (after irrigation) | 47-109-2H | 114.56 | 63.07 | 61.22 | 62.14 | 61.23 | 0.24 | 0.20 | 0.22 | 0.60 |
| Control Pile - cold | 65-106-3C | 182.20 | 57.46 | 56.58 | 57.02 | 95.24 | 0.16 | NA | 0.16 | 0.75 |
| Control Pile - hot | 54-99-3H | 114.01 | 948.43 | 931.56 | 939.99 | 877.42 | 1.28 | 1.10 | 1.19 | 3.05 |
| Interactive Pile (after turn over, 1st sample) | 35-95-4 | 26.23 | 545.40 | 534.95 | 540.18 | 148.04 | 42.17 | 39.52 | 40.84 | 30.78 |
| Interactive Pile (after turn over, 2nd sample) | 51-87-4 | 31.41 | 520.75 | 506.93 | 513.84 | 166.58 | 52.33 | 36.88 | 44.60 | 39.77 |
| Interactive Pile - cold | 31-101-4C | 74.41 | 823.26 | 812.41 | 817.83 | 543.50 | 0.89 | 0.66 | 0.78 | 1.42 |
| Interactive Pile - hot | 11-82-4H | 168.45 | 707.69 | 691.44 | 699.56 | 1022.60 | 0.66 | 0.68 | 0.67 | 2.69 |
| Reduced size Pile - cold | 24-110-5C | 211.77 | 1600.85 | 1570.54 | 1585.70 | 2910.85 | 0.35 | 0.39 | 0.37 | 1.87 |
| Reduced size Pile - hot | 8-98-5H | 238.18 | 464.20 | 458.12 | 461.16 | 980.34 | 0.45 | 0.40 | 0.42 | 2.48 |
| **DAY 29 (06 July)** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 21-169-1C | 34.53 | 331.13 | 323.26 | 327.19 | 99.12 | 0.39 | 0.43 | 0.41 | 0.34 |

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$ (cont.)

| SOURCE | Sample ID | Total Flow[&] (lpm) | $CH_4$ | | | | $N_2O$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{CH4}$ (ppmv) | Flux (mg/m$^2$-min) | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{N2O}$ (ppmv) | Flux (mg/m$^2$-min) |
| Pesudo Biofilter Pile - hot | 72-168-1H | 70.71 | 6457.08 | 6367.28 | 6412.18 | 3848.36 | 4.19 | 4.36 | 4.28 | 7.06 |
| Irrigation Pile - hot (open Chamber) | 62-160-2 | 247.61 | 83.44 | 82.85 | 83.14 | 160.96 | 0.26 | 0.15 | 0.21 | 1.10 |
| Irrigation Pile - hot (before irrigation) | 4-165-2H | 162.08 | 1047.40 | 1038.14 | 1042.77 | 1612.93 | NA | NA | NA | NA |
| Irrigation Pile - hot (after irrigation) | 56-159-2H | 154.82 | 2272.20 | 2077.02 | 2174.61 | 2730.47 | 2.34 | 1.45 | 1.90 | 6.55 |
| Control Pile - cold | 78-166-3C | 95.52 | 4.68 | 4.34 | 4.51 | 3.85 | 0.18 | 0.27 | 0.22 | 0.52 |
| Control Pile - hot | 22-167-3H | 318.51 | 266.07 | 259.02 | 262.55 | 732.18 | 0.75 | 0.79 | 0.77 | 5.93 |
| Control Pile (after turn over) | 63-153-3 | 51.53 | 204.98 | 201.84 | 203.41 | 98.14 | 17.65 | 2.09 | 9.87 | 13.10 |
| Interactive Pile - cold | 15-161-4C | 170.50 | 491.92 | 501.68 | 496.80 | 689.48 | 0.87 | NA | 0.87 | 3.34 |
| Interactive Pile - hot | 26-164-4H | 241.24 | 1585.83 | 1554.94 | 1570.39 | 3219.26 | 1.14 | 1.03 | 1.08 | 6.11 |
| Interactive Pile (after turn over) | 27-152 | 72.67 | 1035.38 | 1023.82 | 1029.60 | 662.34 | 28.46 | 21.77 | 25.11 | 44.43 |
| Reduced size Pile - cold | 67-151-5C | 828.47 | 485.05 | 473.73 | 479.39 | 3295.82 | 0.27 | 0.37 | 0.32 | 6.07 |
| Reduced size Pile - hot | 58-158-5H | 430.49 | 626.72 | 616.30 | 621.51 | 2238.20 | 0.34 | 0.35 | 0.35 | 3.42 |
| **DAY 36 (July 13)** | | | | | | | | | | |
| QC Blank Sample | 60-185-B | 0.00 | 1.90 | 1.88 | 1.89 | 0.08 | ND | ND | ND | ND |
| Pesudo Biofilter Pile - cold | 28-196-1C | 21.02 | 540.66 | 521.74 | 531.20 | 107.42 | 3.10 | 2.05 | 2.58 | 1.43 |
| Pesudo Biofilter Pile - hot | 53-186-1H | 29.51 | 14615.20 | 14439.80 | 14527.50 | 3808.99 | 6.28 | NA | 6.28 | 4.53 |
| Irrigation Pile - hot (open Chamber) | 43-192-2 | 101.38 | 22.37 | 21.51 | 21.94 | 19.27 | 0.17 | 0.00 | 0.08 | 0.20 |
| Irrigation Pile - hot (before irrigation) | 48-189-2H | 261.61 | 4962.53 | 4996.83 | 4979.68 | 11349.33 | 1.07 | 1.63 | 1.35 | 8.45 |
| Irrigation Pile - hot (after irrigation) | 42-183-2 | 101.38 | 6619.27 | 6422.52 | 6520.89 | 5825.40 | 1.39 | 1.24 | 1.31 | 3.23 |
| Control Pile - cold | 14-187-3C | 62.23 | 1058.89 | 1040.34 | 1049.61 | 604.34 | 0.67 | NA | 0.67 | 1.05 |
| Control Pile - hot | 7-195-3H | 133.02 | 1275.53 | 1242.66 | 1259.09 | 1489.29 | 0.92 | 0.99 | 0.95 | 3.10 |
| Control Pile (after turn over) | 66-193-3 | 70.72 | 303.13 | 299.38 | 301.25 | 198.87 | 8.17 | 7.78 | 7.97 | 14.48 |
| Interactive Pile (after turn over) | 75-191-4 | 62.63 | 300.47 | 255.61 | 278.04 | 168.20 | 8.57 | 6.63 | 7.60 | 12.64 |
| Interactive Pile - cold | 74-180-4C | 412.45 | 370.08 | 362.87 | 366.47 | 1284.71 | 0.50 | 0.43 | 0.46 | 4.47 |
| Interactive Pile - hot | 23-199-4H | 113.04 | 1944.70 | 1904.19 | 1924.45 | 1891.88 | 0.75 | 0.77 | 0.76 | 2.06 |
| Reduced size Pile - cold | 19-190-5C | 450.93 | 470.47 | | 470.47 | 1780.61 | 0.51 | 0.50 | 0.51 | 5.27 |

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$ (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | $CH_4$ | | | | $N_2O$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{CH4}$ (ppmv) | Flux (mg/m$^2$-min) | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{N2O}$ (ppmv) | Flux (mg/m$^2$-min) |
| Reduced size Pile - hot | 38-188-5H | 394.20 | 553.74 | 542.82 | 548.28 | 1915.60 | 0.48 | 0.52 | 0.50 | 4.78 |
| **Day 41 (July 18)** | | | | | | | | | | |
| QC Blank Sample | 27-206-B | 0.01 | 6.95 | 8.25 | 7.60 | 0.27 | 0.17 | 0.14 | 0.15 | 0.01 |
| Pesudo Biofilter Pile - cold | 15-184-1C | 25.69 | 1628.74 | 1599.57 | 1614.16 | 393.29 | 1.97 | 1.89 | 1.93 | 1.29 |
| Pesudo Biofilter Pile - hot | 21-197-1H | 90.12 | 10356.00 | 9950.95 | 10153.48 | 8504.32 | 3.70 | 3.24 | 3.47 | 7.98 |
| Irrigation Pile - hot (open Chamber) | 73-214-2 | 82.75 | 168.32 | 168.69 | 168.51 | 121.81 | 0.10 | 0.00 | 0.05 | 0.10 |
| Irrigation Pile - hot (before irrigation) | 62-210-2H | 271.55 | 1374.35 | 1353.46 | 1363.91 | 3158.71 | 0.94 | 0.00 | 0.47 | 3.00 |
| Irrigation Pile - hot (after irrigation) | 56-219-2H | 82.75 | 4626.93 | 4580.93 | 4603.93 | 3314.81 | 1.90 | 1.48 | 1.69 | 3.35 |
| Control Pile - cold | 4-209-3C | 33.12 | 776.59 | 755.96 | 766.28 | 243.95 | NA | NA | NA | NA |
| Control Pile - hot | 22-208-3H | 145.21 | 2066.35 | 2027.49 | 2046.92 | 2650.68 | 1.08 | 0.97 | 1.03 | 3.66 |
| Control Pile (after turn over) | 58-203-3 | 55.29 | 580.84 | 578.35 | 579.60 | 294.44 | 10.76 | 15.38 | 13.07 | 18.26 |
| Interactive Pile - cold | 78-216-4C | 76.60 | 2378.48 | 2375.68 | 2377.08 | 1706.46 | 0.85 | 0.70 | 0.77 | 1.52 |
| Interactive Pile - hot | 26-207-4H | 216.95 | 2112.31 | 2062.42 | 2087.37 | 3980.84 | 0.74 | 0.73 | 0.74 | 3.86 |
| Interactive Pile (after turn over) | 65-202-4 | 54.98 | 298.84 | 287.10 | 292.97 | 149.37 | 8.55 | 7.40 | 7.98 | 11.18 |
| Reduced size Pile - cold | 72-215-5C | 417.11 | 534.49 | 535.16 | 534.83 | 2046.51 | 0.21 | NA | 0.21 | 2.20 |
| Reduced size Pile - hot | 67-213-5H | 191.64 | 860.83 | 840.33 | 850.58 | 1423.70 | 0.59 | NA | 0.59 | 2.71 |
| **Day 50 (July 27)** | | | | | | | | | | |
| QC Blank Sample | 37-201-B | 0.01 | 4.30 | 4.06 | 4.18 | 0.17 | 0.33 | 0.21 | 0.27 | 0.03 |
| Pesudo Biofilter Pile - cold | 50-205-1C | 29.37 | 70.80 | 70.80 | 70.80 | 18.07 | 0.59 | 0.81 | 0.70 | 0.49 |
| Pesudo Biofilter Pile - hot | 35-200-1H | 84.77 | 5212.42 | 5214.60 | 5213.51 | 3963.65 | 2.88 | 2.98 | 2.93 | 6.13 |
| Irrigation Pile - hot (open Chamber) | 51-236-2 | 357.95 | 10.95 | 10.29 | 10.62 | 29.01 | 0.37 | 0.35 | 0.36 | 2.72 |
| Irrigation Pile - hot (before irrigation) | 11-194-2H | 433.90 | 389.22 | 390.21 | 389.72 | 1488.51 | 0.33 | 0.28 | 0.31 | 3.22 |
| Irrigation Pile - hot (after irrigation) | 54-235-2H | 357.95 | 649.78 | 648.96 | 649.37 | 2027.01 | 0.39 | 0.38 | 0.38 | 3.29 |
| Control Pile - cold | 3-204-3C | 16.08 | 188.71 | 187.64 | 188.18 | 33.73 | 0.55 | 0.33 | 0.44 | 0.22 |
| Control Pile - hot | 76-198-3H | 71.44 | 1924.82 | 1922.65 | 1923.74 | 1138.75 | 0.66 | 0.96 | 0.81 | 1.32 |
| Control Pile (after turn over) | 30-211-3 | 179.78 | 67.16 | 66.65 | 66.91 | 111.90 | 3.11 | 2.18 | 2.64 | 12.17 |

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$ (cont.)

| SOURCE | Sample ID | Total Flow[&] (lpm) | $CH_4$ | | | | $N_2O$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{CH4}$ (ppmv) | Flux (mg/m$^2$-min) | $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{N2O}$ (ppmv) | Flux (mg/m$^2$-min) |
| Interactive Pile - cold | 13-237-4C | 106.74 | 6.16 | 6.20 | 6.18 | 6.18 | 0.28 | NA | 0.28 | 0.76 |
| Interactive Pile - hot | 82-238-4H | 141.02 | 1735.54 | 1736.26 | 1735.90 | 2170.87 | 1.03 | 0.11 | 0.57 | 1.96 |
| Interactive Pile (after turn over) | 32-212-4 | 235.35 | 150.35 | 152.01 | 151.18 | 316.63 | 6.61 | 4.14 | 5.37 | 30.94 |
| Reduced size Pile - cold | 8-231-5C | 506.88 | 13.87 | 13.96 | 13.91 | 66.83 | 0.45 | | 0.45 | 5.89 |
| Reduced size Pile - hot | 59-230-5H | 141.41 | 300.02 | 300.25 | 300.13 | 357.91 | 0.54 | 0.39 | 0.46 | 1.52 |
| **Day 64 - (August 10)** | | | | | | | | | | |
| QC Blank Sample | 48-313-B | 0.02 | 2.72 | 2.10 | 2.41 | 0.11 | ND | ND | ND | ND |
| Pesudo Biofilter Pile - cold | 14-314-1C | 67.83 | 62.89 | 63.05 | 62.97 | 40.35 | 20.73 | 21.15 | 20.94 | 36.90 |
| Pesudo Biofilter Pile - hot | 42-315-1H | 104.90 | 711.20 | 711.25 | 711.23 | 715.60 | 13.00 | NA | 13.00 | 35.97 |
| Irrigation Pile - hot (open Chamber) | 55-308-2 | 325.44 | 7.01 | 8.97 | 7.99 | 22.11 | 0.24 | NA | 0.24 | 1.81 |
| Irrigation Pile - hot (before irrigation) | 70-302-2H | 51.06 | 397.93 | 396.58 | 397.26 | 189.14 | NA | NA | NA | NA |
| Irrigation Pile - hot (after irrigation) | 17-300-2H | 325.44 | 237.40 | 235.60 | 236.50 | 638.35 | 1.77 | 1.74 | 1.75 | 13.02 |
| Control Pile - cold | 18-316-3C | 26.04 | 104.57 | 106.21 | 105.39 | 25.89 | 0.60 | 0.35 | 0.48 | 0.32 |
| Control Pile - hot | 7-303-3H | 18.78 | 2236.17 | 2235.20 | 2235.69 | 475.80 | 1.09 | 0.81 | 0.95 | 0.56 |
| Interactive Pile - cold | 66-317-4C | 27.43 | 48.54 | 46.98 | 47.76 | 12.59 | 0.22 | NA | 0.22 | 0.16 |
| Interactive Pile - hot | 19-319-4H | 68.54 | 1430.01 | 1432.01 | 1431.01 | 940.16 | 1.58 | 0.99 | 1.28 | 2.32 |
| Reduced size Pile - cold | 43-310-5C | 29.31 | 502.90 | 501.25 | 502.08 | 145.47 | 1.08 | 1.16 | 1.12 | 0.89 |
| Reduced size Pile - hot | 23-301-5H | 286.44 | 112.57 | 111.36 | 111.97 | 278.70 | 9.80 | 9.14 | 9.47 | 64.81 |
| **Day78 (August 24)** | | | | | | | | | | |
| QC Blank Sample | 50-352-B | 0.00 | 4.10 | 3.96 | 4.03 | 0.17 | 0.16 | NA | 0.16 | 0.02 |
| Pesudo Biofilter Pile - cold | 76-350-1C | 161.62 | 366.18 | 367.16 | 366.67 | 495.17 | 8.25 | 6.61 | 7.43 | 27.60 |
| Pesudo Biofilter Pile - hot | 54-357-1H | 79.83 | 780.00 | 781.25 | 780.63 | 578.52 | 8.73 | 13.79 | 11.26 | 22.95 |
| Irrigation Pile - hot (open Chamber) | 4-354-2OP | 223.46 | 10.31 | 10.21 | 10.26 | 18.03 | 10.51 | 0.00 | 5.25 | 16.94 |
| Irrigation Pile - hot (before irrigation) | 16-355-2H | 172.75 | 170.33 | 171.35 | 170.84 | 265.74 | 4.09 | 3.83 | 3.96 | 0.53 |
| Irrigation Pile - hot (after irrigation) | 3-309-2H | 223.46 | 186.73 | 184.56 | 185.65 | 359.12 | 6.44 | 6.96 | 6.70 | 35.65 |
| Control Pile - cold | 15-356-3C | 33.62 | 861.11 | 859.65 | 860.38 | 301.87 | 0.63 | 0.47 | 0.55 | 5.38 |

## Appendix B. Field Emission Data for $CH_4$ and $N_2O$ (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | $CH_4$ C1 (ppmv) | $CH_4$ C2 (ppmv) | $CH_4$ Avg $C_{CH4}$ (ppmv) | $CH_4$ Flux (mg/m$^2$-min) | $N_2O$ C1 (ppmv) | $N_2O$ C2 (ppmv) | $N_2O$ Avg $C_{N2O}$ (ppmv) | $N_2O$ Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Control Pile - hot | 30-351-3H | -- * | 1124.48 | 1123.65 | 1124.06 | --* | 1.43 | 1.29 | 1.36 | --* |
| Control Pile (after turn over) | 63-318-3 | 87.60 | 49.46 | 48.62 | 49.04 | 40.14 | 8.02 | NA | 8.02 | 18.05 |
| Interactive Pile - cold | 13-358-4C | 100.90 | 6.33 | 6.20 | 6.27 | 6.09 | 0.76 | 0.61 | 0.68 | 1.83 |
| Interactive Pile - hot | 53-353-4H | 268.27 | 70.90 | 70.96 | 70.93 | 173.23 | 5.23 | 2.83 | 4.03 | 27.09 |
| Interactive Pile (after turn over) | 51-312-4 | 128.69 | 39.21 | 38.65 | 38.93 | 46.38 | 30.75 | 38.71 | 34.73 | 113.79 |
| Reduced size Pile - cold | 35-305-5C | 305.53 | 3.99 | 4.01 | 4.00 | 11.39 | 2.04 | NA | 2.04 | 16.00 |
| Reduced size Pile - hot | 27-306-5H | 442.69 | 27.19 | 28.56 | 27.88 | 105.40 | 6.82 | 9.24 | 8.03 | 83.48 |
| **Day99- (SEP 14)** | | | | | | | | | | |
| QC Blank Sample | 2-412-CTRL | 0.01 | 6.78 | 6.68 | 6.73 | 0.30 | 0.28 | NA | 0.28 | 0.03 |
| Pesudo Biofilter Pile - cold | 78-400-1C | 30.63 | 36.46 | 36.07 | 36.27 | 11.25 | 1.49 | 1.29 | 1.39 | 1.19 |
| Pesudo Biofilter Pile - hot | 23-411-1H | 31.63 | 84.98 | 83.49 | 84.23 | 28.82 | 61.59 | 55.74 | 58.67 | 55.20 |
| Irrigation Pile - hot (open Chamber) | 14-403-2 | 312.20 | 20.96 | 20.04 | 20.50 | 52.47 | 1.11 | NA | 1.11 | 7.82 |
| Irrigation Pile - hot (before irrigation) | 7-401-2H | 172.91 | 309.47 | 303.21 | 306.34 | 498.90 | 16.50 | 15.92 | 16.21 | 72.59 |
| Irrigation Pile - hot (after irrigation) | 11-414-2H | 312.20 | 298.47 | 287.46 | 292.97 | 818.66 | 17.78 | 12.76 | 15.27 | 117.36 |
| Control Pile - cold | 70-413-3C | 492.84 | 93.47 | 92.00 | 92.74 | 362.36 | 0.28 | NA | 0.28 | 2.99 |
| Control Pile - hot | 28-402-3H | 429.31 | 115.34 | 120.43 | 117.88 | 435.85 | 0.30 | NA | 0.30 | 3.02 |
| Control Pile (after turn over) | 66-407-3T | 66.38 | 64.92 | 64.74 | 64.83 | 38.63 | 5.62 | 3.34 | 4.48 | 7.35 |
| Interactive Pile - cold | 37-415-4C | 418.75 | 50.38 | 50.04 | 50.21 | 189.84 | 0.29 | 0.34 | 0.32 | 3.28 |
| Interactive Pile - hot | 55-405-4H | 72.33 | 501.99 | 494.07 | 498.03 | 316.44 | 0.76 | NA | 0.76 | 1.33 |
| Interactive Pile (after turn over) | 82-417-4T | 566.92 | 29.20 | 28.81 | 29.01 | 139.34 | 82.17 | 102.35 | 92.26 | 1218.80 |
| Reduced size Pile - cold | 59-416-5C | 447.65 | 15.71 | 15.52 | 15.62 | 62.05 | 20.74 | 23.06 | 21.90 | 239.27 |
| Reduced size Pile - hot | 10-406-5H | 656.69 | 36.72 | 36.45 | 36.58 | 202.08 | 23.06 | 13.73 | 18.40 | 279.45 |

* Trace gas helium was not detected in the sample and therefore the flux cannot be calculated.

& Copied from Appendix A

NA – Run out of sample for analysis

ND – Not detected (the concentration is too low to be detected)

† The gas emission ($CH_4$, $CO_2$ and $N_2O$) flux mi in terms of mg/$m^2$-min can be calculated according to the following equation:

$$m_i = \frac{C_{i,emission} \times Q_{Emission} \times 10^{-3}}{A_{chamber}}$$

where $C_{i,emission}$ = the gas i concentration in emission, mg/$m^3$

$Q_{Emission}$ = compost emission flow from compost, L/min

$A_{chamber}$ = bottom area of gas chamber, 0.13$m^2$

$C_{i,emission}$, can be calculated based on:

$$C_{i,emission} = C_{i,canister} \times (\frac{Q_{Air}}{Q_{Emission}} + 1)$$

where $C_{i,\,canister}$ = the gas i concentration in canister, mg/$m^3$

Convert sample concentration in ppmv to mg/$m^3$ using the following equation:

$$C_{mg/m^3} = C_{ppmv} \frac{PM}{RT} \times 10^{-3}$$

where

$C_{mg/m3}$ = end of sample concentration in mg/$m^3$,

$C_{ppmv}$ = end of sample concentration in ppmv

R = universal gas constant, 8.31 Pa-$m^3$/K-mol

P = atmospheric pressure, 101325 pa

T = temperature, 298 K,

M = molecular weight of gas component

## Appendix C. Field Emission Data for NMNEOC

| SOURCE | Sample ID | Total Flow (lpm)[&] | NMNEO Canister $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{NMNEO}$ (ppmv) | $C_{converted}$ as C [‡] | NMNEO Trap TOC (mg/l) | Gaseous VOC (ppmv) [†] | TNMNEO $C_{total}$ (ppmC) | Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| **DAY 1** | | | | | | | | | | |
| QC Blank Sample | 63-65-B | 0.00 | 1.60 | 2.75 | 2.17 | 2.95 | 55.21 | 41.12 | 44.07 | 0.83 |
| Pesudo Biofilter Pile - cold | 15-42-1C | 14.35 | 3.89 | 7.01 | 5.45 | 5.63 | 148.17 | 104.65 | 110.28 | 8.05 |
| Pesudo Biofilter Pile - hot | 61-71-1H | 21.98 | 7.46 | 8.14 | 7.80 | 10.68 | 130.44 | 136.28 | 146.96 | 14.97 |
| Irrigation Pile - cold | 35-49-2C | 43.20 | 4.02 | 4.98 | 4.50 | 4.91 | 173.30 | 152.03 | 156.95 | 28.56 |
| Irrigation Pile - hot | 51-77-2H | 44.82 | 5.64 | 8.41 | 7.02 | 9.09 | 230.59 | 142.67 | 151.75 | 28.54 |
| Control Pile - cold | 68-9-3C | 31.61 | 34.68 | 34.72 | 34.70 | 42.28 | 376.88 | 347.10 | 389.38 | 53.82 |
| Control Pile - hot | 64-39-3H | 23.30 | 38.83 | 35.34 | 37.09 | 47.32 | 516.60 | 502.20 | 549.52 | 58.72 |
| Interactive Pile - cold | 56-5-4C | 126.40 | 8.56 | 10.30 | 9.43 | 16.27 | 169.06 | 180.12 | 196.39 | 97.42 |
| Interactive Pile - hot | 38-63-4H | 98.72 | 33.28 | 24.17 | 28.72 | 39.74 | 544.63 | 529.86 | 569.60 | 223.04 |
| Reduced size Pile - cold | 62-3-5C | 213.58 | 20.94 | 23.19 | 22.06 | 27.81 | 324.68 | 295.13 | 322.94 | 266.48 |
| Reduced size Pile - hot | 36-22-5H | 39.75 | 23.54 | 28.74 | 26.14 | 27.04 | 501.21 | 346.97 | 374.01 | 63.18 |
| **DAY 2** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 60-8-1C | 69.25 | 4.00 | 4.00 | 4.00 | 5.09 | 21.48 | 19.29 | 24.38 | 6.83 |
| Pesudo Biofilter Pile - hot | 22-18-1H | 58.23 | 8.69 | 11.78 | 10.23 | 14.54 | 65.92 | 73.37 | 87.91 | 20.98 |
| Irrigation Pile - hot (open Chamber) | 67-40-2 | 304.33 | 1.75 | 2.33 | 2.04 | 2.79 | 14.95 | 13.84 | 16.63 | 19.42 |
| Irrigation Pile - hot (before irrigation) | 66-61-2H | 99.40 | 34.27 | 42.76 | 38.52 | 55.25 | 618.20 | 597.38 | 652.63 | 257.21 |
| Irrigation Pile - hot (after irrigation) | 21-52-2H | 304.33 | 13.77 | 18.14 | 15.95 | 22.21 | 181.61 | 178.36 | 200.57 | 234.21 |
| Control Pile - cold | 27-21-3C | 35.19 | 41.50 | 46.12 | 43.81 | 60.63 | 343.28 | 290.61 | 351.23 | 53.29 |
| Control Pile - hot | 20-29-3H | 43.37 | 16.19 | 22.45 | 19.32 | 26.13 | 222.40 | 217.16 | 243.29 | 44.43 |
| Interactive Pile - cold | 17-68-4C | 57.35 | 4.00 | 4.60 | 4.30 | 5.71 | 143.12 | 140.07 | 145.77 | 34.31 |
| Interactive Pile - hot | 4-38-4H | 40.14 | 23.91 | 27.09 | 25.50 | 31.33 | 447.25 | 406.11 | 437.44 | 74.55 |
| Reduced size Pile - cold | 7-12-5C | 42.40 | 4.12 | 5.72 | 4.92 | 6.67 | 103.40 | 98.61 | 105.28 | 18.84 |
| Reduced size Pile - hot | 70-47-5H | 40.90 | 4.99 | 6.91 | 5.95 | 8.00 | 113.77 | 107.55 | 115.55 | 20.02 |
| **DAY 3** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 73-19-1C | 24.46 | 5.24 | 3.87 | 4.56 | 6.17 | 9.61 | 8.89 | 15.06 | 1.68 |

## Appendix C. Field Emission Data for NMNEOC (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | NMNEO Canister $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{NMNEO}$ (ppmv) | $C_{converted}$ as C | NMNEO Trap TOC (mg/l) | Gaseous VOC (ppmv) | TNMNEO $C_{total}$ (ppmC) | Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Pesudo Biofilter Pile - hot | 71-2-1H | 23.85 | 2.68 | 2.68 | 2.68 | 3.48 | 11.34 | 10.56 | 14.05 | 1.53 |
| Irrigation Pile - hot (open Chamber) | 58-46-2 | 58.59 | 1.75 | 2.24 | 2.00 | 2.67 | 16.50 | 16.93 | 19.59 | 4.70 |
| Irrigation Pile - hot (before irrigation) | 75-55-2H | 42.89 | 27.40 | 29.50 | 28.45 | 37.53 | 271.52 | 268.07 | 305.60 | 55.25 |
| Irrigation Pile - hot (after irrigation) | 79-23-2H | 58.59 | 58.23 | 59.55 | 58.89 | 79.12 | 417.24 | 411.71 | 490.83 | 117.83 |
| Control Pile - cold | 74-30-3C | 93.88 | 3.15 | 3.88 | 3.51 | 4.27 | 111.48 | 93.73 | 98.01 | 36.58 |
| Control Pile - hot | 26-76-3H | 39.76 | 16.18 | 16.18 | 16.18 | 21.24 | 139.18 | 146.85 | 168.08 | 28.40 |
| Interactive Pile - cold | 72-33-4C | 14.88 | 12.55 | 12.90 | 12.72 | 16.43 | 226.30 | 200.51 | 216.94 | 16.28 |
| Interactive Pile - hot | 76-27-4H | 59.12 | 2.60 | 3.99 | 3.29 | 4.46 | 69.40 | 71.91 | 76.37 | 18.49 |
| Reduced size Pile - cold | 81-15-5C | 111.52 | 3.73 | 5.82 | 4.77 | 5.50 | 260.32 | 195.67 | 201.17 | 88.49 |
| Reduced size Pile - hot | 78-6-5H | 70.33 | 10.09 | 12.68 | 11.39 | 15.46 | 239.40 | 253.41 | 268.87 | 76.47 |
| **DAY 5** | | | | | | | | | | |
| QC Blank Sample | 13-24-B | 0.00 | ND | ND | ND | ND | 22.94 | 21.31 | 21.31 | 0.40 |
| Pesudo Biofilter Pile - cold | 25-48-1C | 38.16 | 1.51 | 1.51 | 1.51 | 1.71 | 12.41 | 9.64 | 11.35 | 1.85 |
| Pesudo Biofilter Pile - hot | 57-79-1H | 27.33 | 18.09 | 19.94 | 19.02 | 26.65 | 94.65 | 98.97 | 125.62 | 15.33 |
| Irrigation Pile - hot (open Chamber) | 2-11-2 | 145.36 | 1.61 | 1.61 | 1.61 | 2.27 | 15.69 | 16.30 | 18.57 | 10.54 |
| Irrigation Pile - hot (before irrigation) | 30-56-2H | 64.86 | 12.61 | 14.37 | 13.49 | 18.23 | 344.70 | 414.02 | 432.25 | 113.99 |
| Irrigation Pile - hot (after irrigation) | 47-31-2H | 145.36 | 7.11 | 8.78 | 7.94 | 9.72 | 154.00 | 153.83 | 163.54 | 92.83 |
| Control Pile - cold | 43-45-3C | 62.24 | 1.46 | 2.21 | 1.83 | 2.42 | 17.23 | 16.46 | 18.89 | 4.79 |
| Control Pile - hot | 1-1-3H | 99.22 | 12.12 | 14.89 | 13.50 | 16.58 | 220.90 | 198.39 | 214.97 | 84.57 |
| Interactive Pile - cold | 5-72-4C | 109.03 | 1.88 | 3.33 | 2.61 | 3.94 | 49.91 | 53.48 | 57.42 | 24.72 |
| Interactive Pile - hot | 24-44-4H | 131.36 | 5.34 | 6.55 | 5.95 | 7.19 | 22.94 | 23.53 | 30.73 | 15.82 |
| Reduced size Pile - cold | 41-54-5C | 573.93 | 3.00 | 3.67 | 3.33 | 4.30 | 45.50 | 41.31 | 45.61 | 99.69 |
| Reduced size Pile - hot | 37-50-5H | 600.16 | 4.65 | 5.93 | 5.29 | 6.26 | 82.90 | 74.63 | 80.90 | 184.81 |
| **DAY 7** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 32-70-1C | 17.57 | 2.07 | 2.07 | 2.07 | 2.79 | 7.73 | 6.86 | 9.65 | 0.82 |
| Pesudo Biofilter Pile - hot | 65-26-1H | 18.68 | 20.08 | 19.64 | 19.86 | 26.69 | 157.10 | 167.96 | 194.66 | 17.40 |

## Appendix C. Field Emission Data for NMNEOC (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | NMNEO Canister C1 (ppmv) | NMNEO Canister C2 (ppmv) | NMNEO Canister Avg $C_{NMNEO}$ (ppmv) | $C_{converted}$ as C | NMNEO Trap TOC (mg/l) | NMNEO Trap Gaseous VOC (ppmv) | TNMNEO $C_{total}$ (ppmC) | TNMNEO Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation Pile - hot (open Chamber) | 54-57-2 | 98.15 | ND | ND | ND | ND | 11.55 | 9.67 | 9.67 | 3.76 |
| Irrigation Pile - hot (before irrigation) | 6-51-2H | 130.82 | 7.23 | 8.81 | 8.02 | 11.59 | 223.40 | 276.01 | 287.60 | 147.46 |
| Irrigation Pile - hot (after irrigation) | 10-74-2H | 98.15 | 7.13 | 8.73 | 7.93 | 10.35 | 35.70 | 36.86 | 47.21 | 18.38 |
| Control Pile – cold | 16-67-3C | 75.68 | 3.51 | 4.75 | 4.13 | 5.48 | 221.30 | 220.60 | 226.08 | 68.86 |
| Control Pile – hot | 55-73-3H | 389.24 | 3.36 | 4.58 | 3.97 | 4.90 | 189.60 | 193.21 | 198.12 | 294.86 |
| Interactive Pile - cold | 18-60-4C | 62.35 | 1.75 | 2.31 | 2.03 | 2.59 | 16.37 | 13.01 | 15.59 | 3.96 |
| Interactive Pile – hot | 59-25-4H | 369.15 | 1.58 | 2.04 | 1.81 | 2.51 | 56.10 | 56.60 | 59.11 | 83.49 |
| Reduced size Pile – cold | 46-62-5C | 285.85 | 1.73 | 2.59 | 2.16 | 2.86 | 78.10 | 76.13 | 79.00 | 86.74 |
| Reduced size Pile – hot | 50-32-5H | 56.33 | 4.74 | 5.37 | 5.05 | 6.63 | 165.00 | 180.66 | 187.29 | 43.36 |
| **DAY 10** | | | | | | | | | | |
| Pesudo Biofilter Pile – cold | 11-75-1C | 21.80 | 1.62 | 1.70 | 1.66 | 2.30 | 4.74 | 4.64 | 6.94 | 0.70 |
| Pesudo Biofilter Pile – hot | 42-4-1H | 35.05 | 13.48 | 21.39 | 17.44 | 23.61 | 331.50 | 405.23 | 428.84 | 64.84 |
| Irrigation Pile - hot (open Chamber) | 39-17-2 | 66.24 | 1.78 | 1.67 | 1.73 | 2.65 | 8.78 | 9.39 | 12.04 | 3.24 |
| Irrigation Pile - hot (before irrigation) | 33-20-2H | 98.33 | 4.72 | 7.34 | 6.03 | 8.39 | 243.10 | 272.41 | 280.80 | 109.54 |
| Irrigation Pile - hot (after irrigation) | 23-66-2H | 66.24 | 9.01 | 12.88 | 10.94 | 14.96 | 158.33 | 171.74 | 186.71 | 50.21 |
| Control Pile – cold | 12-36-3C | 63.61 | 1.94 | 2.14 | 2.04 | 2.79 | 25.66 | 26.87 | 29.66 | 7.68 |
| Control Pile – hot | 31-34-3H | 57.32 | 9.77 | 13.06 | 11.42 | 15.23 | 313.90 | 397.15 | 412.38 | 97.01 |
| Control Pile (after turn over) | 70-41-3 | 103.50 | 58.15 | 62.70 | 60.42 | 79.24 | 1254.74 | 1412.80 | 1492.04 | 611.16 |
| Control Pile (2nd sample after turn over) | 38-16-3 | 109.57 | 33.56 | 29.55 | 31.55 | 41.98 | 868.50 | 937.62 | 979.60 | 423.71 |
| Interactive Pile - cold | 8-78-4C | 190.33 | 2.26 | 2.22 | 2.24 | 3.27 | 35.52 | 38.18 | 41.46 | 30.57 |
| Interactive Pile - hot | 82-14-4H | 44.67 | 5.51 | 6.75 | 6.13 | 8.30 | 84.70 | 93.79 | 102.08 | 19.14 |
| Reduced size Pile - cold | 34-37-5C | 753.51 | 1.68 | 2.36 | 2.02 | 2.76 | 55.50 | 57.95 | 60.71 | 173.84 |
| Reduced size Pile - hot | 3-53-5H | 444.45 | 4.04 | 4.85 | 4.45 | 6.42 | 86.00 | 96.03 | 102.45 | 173.83 |
| **DAY 15** | | | | | | | | | | |
| Pesudo Biofilter Pile - cold | 68-97-1C | 297.49 | | | | 0.00 | 7.58 | 7.82 | 7.82 | 8.93 |
| Pesudo Biofilter Pile - hot | 71-94-1H | 73.01 | 1.57 | 1.55 | 1.56 | 2.09 | 9.39 | 9.33 | 11.42 | 3.36 |

## Appendix C. Field Emission Data for NMNEOC (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | NMNEO Canister: $C_1$ (ppmv) | NMNEO Canister: $C_2$ (ppmv) | NMNEO Canister: Avg $C_{NMNEO}$ (ppmv) | $C_{converted}$ as C | NMNEO Trap: TOC (mg/l) | NMNEO Trap: Gaseous VOC (ppmv) | TNMNEO: $C_{total}$ (ppmC) | TNMNEO: Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation Pile - hot (open Chamber) | 7-85-2 | 201.97 | ND | ND | ND | ND | 10.30 | 11.14 | 11.14 | 8.71 |
| Irrigation Pile - hot (before irrigation) | 20-88-2H | 93.77 | 2.37 | 3.66 | 3.01 | 3.88 | 72.40 | 88.60 | 92.47 | 34.48 |
| Irrigation Pile - hot (after irrigation) | 17-102-2H | 60.02 | 4.68 | 5.40 | 5.04 | 6.11 | 30.86 | 33.03 | 39.14 | 9.61 |
| Control Pile - cold | 64-104-3C | 84.36 | 1.69 | 1.97 | 1.83 | 2.48 | 67.09 | 68.98 | 71.46 | 24.11 |
| Control Pile - hot | 76-91-3H | 314.77 | 3.46 | 5.18 | 4.32 | 6.06 | 159.10 | 221.14 | 227.21 | 274.27 |
| Interactive Pile - cold | 61-96-4C | 681.83 | ND | ND | ND | ND | 8.87 | 9.34 | 9.34 | 24.21 |
| Interactive Pile - hot | 79-92-4H | 251.13 | 4.65 | 4.69 | 4.67 | 6.29 | 73.62 | 93.64 | 99.93 | 96.62 |
| Reduced size Pile - cold | 73-100-5C | 739.47 | 14.25 | 14.52 | 14.39 | 18.90 | 12.21 | 12.79 | 31.69 | 89.08 |
| Reduced size Pile - hot | 74-105-5H | 528.34 | 1.57 | 1.88 | 1.72 | 2.28 | 23.00 | 26.36 | 28.64 | 57.66 |
| **DAY 22** | | | | | | | | | | |
| QC Blank Sample | 32-105-B | 0.00 | ND | ND | ND | ND | 3.46 | 3.33 | 3.33 | 0.06 |
| Pesudo Biofilter Pile - cold | 46-83-1C | 17.48 | 1.73 | 1.73 | 1.73 | 2.39 | 5.78 | 6.21 | 8.60 | 0.73 |
| Pesudo Biofilter Pile - hot | 3-93-1H | 22.39 | 4.60 | 5.65 | 5.13 | 7.56 | 82.67 | 102.82 | 110.38 | 11.41 |
| Irrigation Pile - hot (open Chamber) | 30-89-2 | 114.56 | ND | ND | ND | ND | 4.55 | 5.09 | 5.09 | 2.30 |
| Irrigation Pile - hot (before irrigation) | 34-84-2H | 202.46 | 1.87 | 2.42 | 2.14 | 2.84 | 70.63 | 82.13 | 84.96 | 66.54 |
| Irrigation Pile - hot (after irrigation) | 47-109-2H | 114.56 | 1.43 | 0.90 | 1.16 | 1.58 | 20.46 | 21.99 | 23.57 | 10.64 |
| Control Pile - cold | 65-106-3C | 182.20 | 1.35 | 1.23 | 1.29 | 1.89 | 19.10 | 21.44 | 23.33 | 16.49 |
| Control Pile - hot | 54-99-3H | 114.01 | 3.67 | 4.75 | 4.21 | 5.42 | 102.81 | 117.65 | 123.08 | 55.29 |
| Interactive Pile (after turn over, 1st sample) | 35-95-4 | 26.23 | 31.32 | 28.56 | 29.94 | 43.20 | 842.21 | 1183.77 | 1226.97 | 144.64 |
| Interactive Pile (after turn over, 2nd sample) | 51-87-4 | 31.41 | 18.85 | 19.63 | 19.24 | 28.17 | 751.62 | 1016.22 | 1044.39 | 143.53 |
| Interactive Pile - cold | 31-101-4C | 74.41 | 4.21 | 4.69 | 4.45 | 6.12 | 100.08 | 128.28 | 134.40 | 40.29 |
| Interactive Pile - hot | 11-82-4H | 168.45 | 9.52 | 10.15 | 9.83 | 13.62 | 192.89 | 229.80 | 243.42 | 159.39 |
| Reduced size Pile - cold | 24-110-5C | 211.77 | 1.19 | 1.19 | 1.19 | 1.66 | 47.60 | 53.97 | 55.63 | 45.53 |
| Reduced size Pile - hot | 8-98-5H | 238.18 | 1.21 | 0.68 | 0.95 | 1.36 | 13.29 | 13.64 | 15.00 | 13.77 |

**Appendix C. Field Emission Data for NMNEOC (cont.)**

| SOURCE | Sample ID | Total Flow (lpm)[&] | NMNEO Canister C1 (ppmv) | C2 (ppmv) | Avg $C_{NMNEO}$ (ppmv) | $C_{converted}$ as C | NMNEO Trap TOC (mg/l) | Gaseous VOC (ppmv) | TNMNEO $C_{total}$ (ppmC) | Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| **DAY 29 (06 July)** | | | | | | | | | | |
| Pesudo Biofilter Pile - hot | 72-168-1H | 70.71 | 7.54 | 8.11 | 7.82 | 10.19 | 115.70 | 166.65 | 176.84 | 50.55 |
| Irrigation Pile - hot (open Chamber) | 62-160-2 | 247.61 | 3.08 | 3.08 | 3.08 | 3.88 | 7.04 | 6.58 | 10.46 | 9.97 |
| Irrigation Pile - hot (before irrigation) | 4-165-2H | 162.08 | 1.57 | 1.57 | 1.57 | 2.39 | 27.42 | 31.76 | 34.15 | 21.54 |
| Irrigation Pile - hot (after irrigation) | 56-159-2H | 154.82 | 2.08 | 2.08 | 2.08 | 2.68 | 7.82 | 8.25 | 10.93 | 6.60 |
| Control Pile - cold | 78-166-3C | 95.52 | 1.57 | 1.57 | 1.57 | 2.19 | 5.39 | 5.81 | 8.00 | 3.04 |
| Control Pile - hot | 22-167-3H | 318.51 | 2.40 | 2.40 | 2.40 | 3.40 | 25.70 | 29.96 | 33.36 | 40.74 |
| Control Pile (after turn over) | 63-153-3 | 51.53 | 8.90 | 9.83 | 9.37 | 13.14 | 253.40 | 329.91 | 343.06 | 73.21 |
| Interactive Pile - cold | 15-161-4C | 170.50 | 1.52 | 2.07 | 1.79 | 2.33 | 35.65 | 37.17 | 39.50 | 26.17 |
| Interactive Pile - hot | 26-164-4H | 241.24 | 3.21 | 2.93 | 3.07 | 4.20 | 60.55 | 73.26 | 77.47 | 72.01 |
| Interactive Pile (after turn over) | 27-152 | 72.67 | 8.06 | 9.29 | 8.68 | 11.82 | 187.10 | 243.08 | 254.89 | 74.74 |
| Reduced size Pile - cold | 67-151-5C | 828.47 | 1.66 | 1.66 | 1.66 | 2.25 | 5.82 | 5.90 | 8.15 | 25.65 |
| Reduced size Pile - hot | 58-158-5H | 430.49 | 3.65 | 3.62 | 3.64 | 4.94 | 10.64 | 11.71 | 16.66 | 27.39 |
| **DAY 36 (July 13)** | | | | | | | | | | |
| QC Blank Sample | 60-185-B | 0.00 | 8.15 | 2.50 | 5.32 | 7.58 | 3.43 | 3.54 | 11.12 | 0.21 |
| Pesudo Biofilter Pile - cold | 28-196-1C | 21.02 | 1.98 | 1.98 | 1.98 | 2.52 | 4.33 | 4.02 | 6.54 | 0.64 |
| Pesudo Biofilter Pile - hot | 53-186-1H | 29.51 | 6.17 | 6.00 | 6.09 | 7.60 | 82.90 | 89.11 | 96.71 | 12.60 |
| Irrigation Pile - hot (open Chamber) | 43-192-2 | 101.38 | ND | ND | ND | ND | 3.32 | 3.41 | 3.41 | 1.37 |
| Irrigation Pile - hot (before irrigation) | 48-189-2H | 261.61 | 3.26 | 2.68 | 2.97 | 4.18 | 61.80 | 79.93 | 84.11 | 84.65 |
| Irrigation Pile - hot (after irrigation) | 42-183-2 | 101.38 | 6.34 | 4.86 | 5.60 | 7.73 | 50.30 | 61.20 | 68.93 | 27.68 |
| Control Pile - cold | 14-187-3C | 62.23 | 2.85 | 2.68 | 2.76 | 3.89 | 45.75 | 50.99 | 54.89 | 13.93 |
| Control Pile - hot | 7-195-3H | 133.02 | 3.98 | 5.00 | 4.49 | 6.33 | 97.43 | 117.74 | 124.06 | 64.64 |
| Control Pile (after turn over) | 66-193-3 | 70.72 | 4.97 | 4.56 | 4.76 | 6.83 | 127.50 | 160.25 | 167.08 | 47.76 |
| Interactive Pile (after turn over) | 75-191-4 | 62.63 | 4.45 | 5.36 | 4.90 | 7.21 | 151.80 | 218.73 | 225.94 | 57.69 |
| Interactive Pile - cold | 74-180-4C | 412.45 | ND | ND | ND | ND | 55.45 | 62.75 | 62.75 | 98.89 |
| Interactive Pile - hot | 23-199-4H | 113.04 | 3.46 | 3.68 | 3.57 | 4.89 | 67.19 | 80.51 | 85.40 | 38.05 |

## Appendix C. Field Emission Data for NMNEOC (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | NMNEO Canister $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{NMNEO}$ (ppmv) | $C_{converted}$ as C | NMNEO Trap TOC (mg/l) | Gaseous VOC (ppmv) | TNMNEO $C_{total}$ (ppmC) | Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Reduced size Pile - cold | 19-190-5C | 450.93 | 1.69 | 1.69 | 1.69 | 2.30 | 20.72 | 21.14 | 23.44 | 40.35 |
| Reduced size Pile - hot | 38-188-5H | 394.20 | 1.87 | 1.87 | 1.87 | 2.69 | 28.56 | 33.68 | 36.37 | 54.82 |
| **Day 41 (July 18)** | | | | | | | | | | |
| QC Blank Sample | 27-206-B | 0.01 | ND | ND | ND | ND | 15.58 | 13.09 | 13.09 | 0.25 |
| Pesudo Biofilter Pile - cold | 15-184-1C | 25.69 | 1.14 | 1.14 | 1.14 | 1.48 | 28.60 | 28.82 | 30.30 | 3.51 |
| Pesudo Biofilter Pile - hot | 21-197-1H | 90.12 | 5.46 | 7.18 | 6.32 | 9.15 | 11.10 | 13.08 | 22.23 | 7.98 |
| Irrigation Pile - hot (open Chamber) | 73-214-2 | 82.75 | ND | ND | ND | ND | 21.88 | 23.01 | 23.01 | 7.62 |
| Irrigation Pile - hot (before irrigation) | 62-210-2H | 271.55 | ND | ND | ND | ND | 40.90 | 42.60 | 42.60 | 44.48 |
| Irrigation Pile - hot (after irrigation) | 56-219-2H | 82.75 | 1.30 | 1.73 | 1.52 | 2.04 | 30.12 | 35.81 | 37.86 | 12.54 |
| Control Pile - cold | 4-209-3C | 33.12 | ND | ND | ND | ND | 15.97 | 18.16 | 18.16 | 2.61 |
| Control Pile - hot | 22-208-3H | 145.21 | 2.07 | 2.07 | 2.07 | 2.93 | 77.70 | 97.53 | 100.46 | 56.97 |
| Control Pile (after turn over) | 58-203-3 | 55.29 | 5.96 | 5.96 | 5.96 | 8.26 | 175.20 | 240.15 | 248.41 | 56.54 |
| Interactive Pile - cold | 78-216-4C | 76.60 | 1.19 | 1.19 | 1.19 | 1.73 | 60.33 | 74.41 | 76.14 | 23.45 |
| Interactive Pile - hot | 26-207-4H | 216.95 | 1.33 | 1.32 | 1.32 | 1.87 | 34.30 | 41.67 | 43.54 | 36.48 |
| Interactive Pile (after turn over) | 65-202-4 | 54.98 | 1.96 | 3.30 | 2.63 | 3.68 | 75.80 | 100.45 | 104.12 | 23.58 |
| Reduced size Pile - cold | 72-215-5C | 417.11 | ND | ND | ND | ND | 8.80 | 10.82 | 10.82 | 17.24 |
| Reduced size Pile - hot | 67-213-5H | 191.64 | ND | ND | ND | ND | 20.90 | 24.26 | 24.26 | 18.01 |
| **Day 50 (July 27)** | | | | | | | | | | |
| QC Blank Sample | 37-201-B | 0.01 | ND | ND | ND | ND | 8.91 | 8.50 | 8.50 | 0.16 |
| Pesudo Biofilter Pile - cold | 50-205-1C | 29.37 | ND | ND | ND | ND | 18.32 | 16.97 | 16.97 | 2.20 |
| Pesudo Biofilter Pile - hot | 35-200-1H | 84.77 | 3.16 | 3.14 | 3.15 | 4.38 | 69.30 | 99.98 | 104.36 | 35.37 |
| Irrigation Pile - hot (open Chamber) | 51-236-2 | 357.95 | ND | ND | ND | ND | 25.56 | 24.15 | 24.15 | 33.09 |
| Irrigation Pile - hot (before irrigation) | 11-194-2H | 433.90 | ND | ND | ND | ND | 11.10 | 13.28 | 13.28 | 22.01 |
| Irrigation Pile - hot (after irrigation) | 54-235-2H | 357.95 | ND | ND | ND | ND | 74.38 | 90.80 | 90.80 | 124.41 |
| Control Pile - cold | 3-204-3C | 16.08 | ND | ND | ND | ND | 29.51 | 31.79 | 31.79 | 2.53 |
| Control Pile - hot | 76-198-3H | 71.44 | 1.85 | 2.32 | 2.09 | 2.66 | 10.10 | 10.33 | 12.98 | 3.75 |

## Appendix C. Field Emission Data for NMNEOC (cont.)

| | | | NMNEO Canister | | | | NMNEO Trap | | TNMNEO | |
|---|---|---|---|---|---|---|---|---|---|---|
| **SOURCE** | **Sample ID** | **Total Flow (lpm)$^{\&}$** | **$C_1$ (ppmv)** | **$C_2$ (ppmv)** | **Avg $C_{NMNEO}$ (ppmv)** | **$C_{converted}$ as C** | **TOC (mg/l)** | **Gaseous VOC (ppmv)** | **$C_{total}$ (ppmC)** | **Flux (mg/m$^2$-min)** |
| Control Pile (after turn over) | 30-211-3 | 179.78 | 2.30 | 2.76 | 2.53 | 3.77 | 93.90 | 125.64 | 129.41 | 90.27 |
| Interactive Pile - cold | 13-237-4C | 106.74 | ND | ND | ND | ND | 18.44 | 21.84 | 21.84 | 9.21 |
| Interactive Pile – hot | 82-238-4H | 141.02 | ND | ND | ND | ND | 20.07 | 25.65 | 25.65 | 14.14 |
| Interactive Pile (after turn over) | 32-212-4 | 235.35 | 2.56 | 2.50 | 2.53 | 3.62 | 77.00 | 104.91 | 108.53 | 98.48 |
| Reduced size Pile – cold | 8-231-5C | 506.88 | ND | ND | ND | ND | 9.51 | 11.74 | 11.74 | 22.68 |
| Reduced size Pile – hot | 59-230-5H | 141.41 | ND | ND | ND | ND | 34.70 | 39.46 | 39.46 | 21.81 |
| **Day 64 - (August 10)** | | | | | | | | | | |
| QC Blank Sample | 48-313-B | 0.02 | ND | ND | ND | ND | 8.07 | 8.04 | 8.04 | 0.15 |
| Pesudo Biofilter Pile - cold | 14-314-1C | 67.83 | ND | ND | ND | ND | 19.40 | 21.22 | 21.22 | 5.84 |
| Pesudo Biofilter Pile – hot | 42-315-1H | 104.90 | 1.31 | 1.31 | 1.31 | 1.97 | 11.79 | 14.82 | 16.79 | 6.97 |
| Irrigation Pile - hot (open Chamber) | 55-308-2 | 325.44 | ND | ND | ND | | 13.02 | 13.11 | 13.11 | 16.35 |
| Irrigation Pile - hot (before irrigation) | 70-302-2H | 51.06 | 1.28 | 1.28 | 1.28 | 1.79 | 31.30 | 36.88 | 38.67 | 8.19 |
| Irrigation Pile - hot (after irrigation) | 17-300-2H | 325.44 | 1.22 | 1.22 | 1.22 | 1.63 | NA | NA | NA | NA |
| Control Pile – cold | 18-316-3C | 26.04 | ND | ND | ND | | 17.83 | 22.53 | 22.53 | 2.64 |
| Control Pile – hot | 7-303-3H | 18.78 | 2.09 | 2.09 | 2.09 | 3.08 | 12.10 | 13.87 | 16.95 | 1.52 |
| Interactive Pile – cold | 66-317-4C | 27.43 | 1.17 | 1.17 | 1.17 | 1.56 | 17.22 | 17.97 | 19.52 | 2.39 |
| Interactive Pile – hot | 19-319-4H | 68.54 | 1.41 | 1.41 | 1.41 | 2.07 | 35.50 | 46.20 | 48.27 | 13.40 |
| Reduced size Pile – cold | 43-310-5C | 29.31 | ND | ND | ND | ND | 16.97 | 18.60 | 18.60 | 2.41 |
| Reduced size Pile – hot | 23-301-5H | 286.44 | ND | ND | ND | ND | 27.00 | 32.96 | 32.96 | 36.26 |
| **Day78 (August 24)** | | | | | | | | | | |
| QC Blank Sample | 50-352-B | 0.00 | ND | ND | ND | ND | 6.71 | 6.85 | 6.85 | 0.13 |
| Pesudo Biofilter Pile - cold | 76-350-1C | 161.62 | ND | ND | ND | ND | 25.60 | 27.96 | 27.96 | 17.59 |
| Pesudo Biofilter Pile – hot | 54-357-1H | 79.83 | ND | ND | ND | ND | 26.90 | 32.89 | 32.89 | 10.53 |
| Irrigation Pile - hot (open Chamber) | 4-354-2OP | 223.46 | ND | ND | ND | ND | 6.87 | 6.50 | 6.50 | 5.61 |
| Irrigation Pile - hot (before irrigation) | 16-355-2H | 172.75 | ND | ND | ND | ND | 16.00 | 19.36 | 19.36 | 12.99 |
| Irrigation Pile - hot (after irrigation) | 3-309-2H | 223.46 | 1.18 | | 1.18 | 1.64 | 11.45 | 13.70 | 15.34 | 13.23 |

## Appendix C. Field Emission Data for NMNEOC (cont.)

| SOURCE | Sample ID | Total Flow (lpm)[&] | NMNEO Canister $C_1$ (ppmv) | $C_2$ (ppmv) | Avg $C_{NMNEO}$ (ppmv) | $C_{converted}$ as C | NMNEO Trap TOC (mg/l) | Gaseous VOC (ppmv) | TNMNEO $C_{total}$ (ppmC) | Flux (mg/m$^2$-min) |
|---|---|---|---|---|---|---|---|---|---|---|
| Control Pile – cold | 15-356-3C | 33.62 | ND | ND | ND | ND | 9.69 | 10.88 | 10.88 | 1.59 |
| Control Pile – hot | 30-351-3H | -- * | ND | ND | ND | ND | 42.00 | 53.30 | 53.30 | --* |
| Control Pile (after turn over) | 63-318-3 | 87.60 | 1.65 | 1.65 | 1.65 | 2.40 | 61.90 | 77.93 | 80.33 | 28.08 |
| Interactive Pile – cold | 13-358-4C | 100.90 | ND | ND | ND | ND | 7.50 | 8.98 | 8.98 | 3.59 |
| Interactive Pile – hot | 53-353-4H | 268.27 | ND | ND | ND | ND | 24.14 | 29.53 | 29.53 | 30.46 |
| Interactive Pile (after turn over) | 51-312-4 | 128.69 | ND | ND | ND | ND | 24.50 | 29.70 | 29.70 | 14.99 |
| Reduced size Pile – cold | 35-305-5C | 305.53 | 1.29 | 1.29 | 1.29 | 1.94 | 9.92 | 11.90 | 13.84 | 16.22 |
| Reduced size Pile – hot | 27-306-5H | 442.69 | 1.34 | 1.34 | 1.34 | 1.86 | 9.81 | 10.70 | 12.56 | 21.22 |
| **Day99- (SEP 14)** | | | | | | | | | | |
| QC Blank Sample | 2-412-B | 0.01 | ND | ND | ND | ND | 7.50 | 8.63 | 8.63 | 0.16 |
| Pesudo Biofilter Pile - cold | 78-400-1C | 30.63 | ND | ND | ND | ND | 12.34 | 13.50 | 13.50 | 1.82 |
| Pesudo Biofilter Pile – hot | 23-411-1H | 31.63 | 1.22 | 1.00 | 1.11 | 1.70 | 8.23 | 9.83 | 11.53 | 1.59 |
| Irrigation Pile - hot (open Chamber) | 14-403-2 | 312.20 | ND | ND | ND | ND | 7.11 | 7.08 | 7.08 | 8.47 |
| Irrigation Pile - hot (before irrigation) | 7-401-2H | 172.91 | 1.26 | 1.19 | 1.22 | 1.84 | 31.41 | 38.59 | 40.43 | 27.16 |
| Irrigation Pile - hot (after irrigation) | 11-414-2H | 312.20 | ND | ND | ND | ND | 9.24 | 10.91 | 10.91 | 13.06 |
| Control Pile – cold | 70-413-3C | 492.84 | ND | ND | ND | ND | 8.14 | 8.23 | 8.23 | 15.46 |
| Control Pile – hot | 28-402-3H | 429.31 | 1.32 | 1.15 | 1.24 | 1.73 | 17.70 | 20.66 | 22.39 | 36.71 |
| Control Pile (after turn over) | 66-407-3T | 66.38 | 1.53 | 1.31 | 1.42 | 1.95 | 21.90 | 24.90 | 26.85 | 7.23 |
| Interactive Pile – cold | 37-415-4C | 418.75 | ND | ND | ND | ND | 9.56 | 11.49 | 11.49 | 18.37 |
| Interactive Pile – hot | 55-405-4H | 72.33 | 1.07 | 1.40 | 1.24 | 1.67 | 9.35 | 10.04 | 11.71 | 3.42 |
| Interactive Pile (after turn over) | 82-417-4T | 566.92 | 1.74 | 1.36 | 1.55 | 2.14 | 28.70 | 33.10 | 35.24 | 76.10 |
| Reduced size Pile – cold | 59-416-5C | 447.65 | ND | ND | ND | ND | 9.45 | 10.85 | 10.85 | 18.55 |
| Reduced size Pile – hot | 10-406-5H | 656.69 | 1.24 | 1.24 | 1.24 | 1.70 | 25.00 | 26.58 | 28.28 | 70.64 |

*Trace gas helium was not detected in the sample and therefore the flux cannot be calculated

& Copied from Appendix A

NA – Run out of sample for analysis

ND – Not detected

† THe total VOC as equavalent to gaseous carbon is the sum of VOC from condensation trap water and VOC from canister. The amount of organic carbon as part per million by volume (ppmv) as gaseous carbon in the condensation trap is calculated using the following equation:

$$C_w = \frac{C_i \times V_i \times P_a \times V_{id}}{V_c \times (P_r - P_0) \times A_c}$$

where

$A_c$ = atomic weight of carbon (12.01 g/mol)

$C_w$ = gaseous concentration of TOC as ppmv as carbon in condensate trap water

$C_i$ = TOC concentration in μg/ml of condensate trap

(Assume TOC concentration μg/g = μg/ml at 4 °C)

$V_i$ = volume of condensate trap water in ml

$V_{id}$ = volume of ideal gas per mole at 25°C (24.4652 l/mole)

$V_c$ = volume of the Summa canister in liters (6L)

$P_a$ = atmospheric pressure in mm Hg (760 mmHg)

$P_r$ = return pressure in mm Hg

$P_0$ = evacuated canister pressure in mmHg

‡ The total VOC as equivalent to gaseous carbon is the summary of VOC from condensation trap water and VOC from canister. It should be noted that the VOC from canister (Equation 2) is expresses as ppmv of butane ($C_4H_{10}$), and therefore it needs to be converted to ppmv as carbon before the summation based on the following equations:

$$C_{c-c} = C_c \times \frac{MW(4C)}{MW(C_4H_{10})}$$

where

Cc-c = end of VOC concentration in canister as ppmv carbon

MW = molecular weight (C: 12 g/mole, $C_4H_{10}$: 58 g/mole)

**Appendix C-a. Pressure readings of canisters—before, after sampling and prior to analysis; and condensate trap volumes after each sampling.**

| SOURCE | Sample ID | P (mmHg) | | | NMNEO Trap |
|---|---|---|---|---|---|
| | | $P_0$ | $P_r$ | $P_f$ | V (ml) |
| **DAY 1 (June 08)** | | | | | |
| Control | 63-65-control | -738.89 | -190.00 | 162.00 | 1.58 |
| 1-Cold | 15-42-1C | -740.66 | -17.00 | 162.00 | 1.98 |
| 1-High | 61-71-1H | -738.89 | -200.00 | 153.00 | 2.18 |
| 2-Cold | 35-49-2C | -741.43 | -61.00 | 157.00 | 2.31 |
| 2-High | 51-77-2H | -739.65 | -174.00 | 145.00 | 1.36 |
| 3-Cold | 68-9-3C | -738.12 | -141.00 | 141.00 | 2.13 |
| 3-High | 64-39-3H | -740.66 | -161.00 | 153.00 | 2.18 |
| 4-Cold | 56-5-4C | -738.89 | -314.00 | 147.00 | 1.75 |
| 4-High | 38-63-4H | -738.89 | -209.00 | 147.00 | 2.00 |
| 5-Cold | 62-3-5C | -738.12 | -157.00 | 147.00 | 2.05 |
| 5-High | 36-22-5H | -740.66 | -28.00 | 150.00 | 1.91 |
| **DAY 2 (June 09)** | | | | | |
| 1-Cold (with biofilter) | 60-8-1C | -738.89 | -157.00 | 155.00 | 2.03 |
| 1-High(with biofilter) | 22-18-1H | -737.11 | -214.00 | 161.00 | 2.26 |
| 2-Open Chamber, after 10 min irrigation | 67-40-2 | -738.12 | -197.00 | 159.00 | 1.94 |
| 2-High (before irrigation) | 66-61-2H | -738.12 | -224.00 | 153.00 | 1.93 |
| 2-High (after 10 min irrigation) | 21-52-2H | -740.66 | -210.00 | 152.00 | 2.02 |
| 3-Cold | 27-21-3C | -737.11 | -206.00 | 151.00 | 1.74 |
| 3-High | 20-29-3H | -738.12 | -188.00 | 161.00 | 2.08 |
| 4-Cold | 17-68-4C | -737.11 | -179.00 | 158.00 | 2.12 |
| 4-High | 4-38-4H | -739.65 | -135.00 | 158.00 | 2.13 |
| 5-Cold | 7-12-5C | -737.11 | -196.00 | 150.00 | 2.00 |
| 5-High | 70-47-5H | -738.89 | -193.00 | 148.00 | 2.00 |
| **DAY 3 (June 10)** | | | | | |
| 1-Cold (with biofilter) | 73-19-1C | -738.89 | -189.00 | 161.00 | 1.97 |
| 1-High(with biofilter) | 71-2-1H | -738.12 | -169.00 | 156.00 | 2.05 |
| 2-open (after 20 min irrigation) | 58-46-2 | -742.19 | -184.00 | 158.00 | 2.22 |
| 2-High(before irrigation) | 75-55-2H | -738.12 | -181.00 | 150.00 | 2.13 |
| 2-High(after irrigation) | 79-23-2H | -738.89 | -192.00 | 149.00 | 2.09 |
| 3-Cold | 74-30-3C | -738.12 | -129.00 | 157.00 | 1.98 |
| 3-High | 26-76-3H | -737.11 | -174.00 | 156.00 | 2.30 |
| 4-Cold | 72-33-4C | -741.43 | -169.00 | 152.00 | 1.97 |
| 4-High | 76-27-4H | -738.12 | -195.00 | 150.00 | 2.18 |
| 5-Cold | 81-15-5C | -738.12 | -47.00 | 224.00 | 2.01 |
| 5-High | 78-6-5H | -738.12 | -196.00 | 151.00 | 2.22 |
| **DAY 5 (June 12)** | | | | | |
| Control | 13-24-Control | -739.65 | -255.00 | 151.00 | 1.75 |
| 1-Cold (with biofilter) | 25-48-1C | -738.12 | -91.00 | 149.00 | 1.95 |
| 1-High(with biofilter) | 57-79-1H | -738.89 | -214.00 | 150.00 | 2.13 |
| 2-open (after 20 min irrigation, Low P) | 2-11-2 | -737.11 | -212.00 | 157.00 | 2.11 |
| 2-High (before irrigation) | 30-56-2H | -740.66 | -194.00 | 152.00 | 2.54 |
| 2-High (after 20min irrigation, P low) | 47-31-2H | -739.65 | -135.00 | 154.00 | 2.34 |
| 3-Cold | 43-45-3C | -743.97 | -184.00 | 151.00 | 2.07 |
| 3-High | 1-1-3H | -739.65 | -140.00 | 150.00 | 2.09 |
| 4-Cold | 5-72-4C | -737.11 | -247.00 | 158.00 | 2.04 |

**Appendix C-a. Pressure readings of canisters—before, after sampling and prior to analysis; and condensate trap volumes after each sampling. (cont.)**

| SOURCE | Sample ID | P (mmHg) | | | NMNEO Trap |
|---|---|---|---|---|---|
| **DAY 5 (June 12) (cont.)** | | $P_0$ | $P_r$ | $P_f$ | V (ml) |
| 4-High | 24-44-4H | -737.11 | -130.00 | 150.00 | 2.41 |
| 5-Cold | 41-54-5C | -738.89 | -164.00 | 159.00 | 2.02 |
| 5-High | 37-50-5H | -738.89 | -113.00 | 157.00 | 2.18 |
| **DAY 7 (June 14)** | | | | | |
| 1-Cold (with biofilter) | 32-70-1C | -739.65 | -190.00 | 154.00 | 1.89 |
| 1-High(with biofilter) | 65-26-1H | -738.89 | -191.00 | 151.00 | 2.27 |
| 2-open (after 20 min irrigation) | 54-57-2 | -743.20 | -169.00 | 161.00 | 1.86 |
| 2-High (after 20min irrigation, P good) | 10-74-2H | -738.12 | -169.00 | 159.00 | 2.28 |
| 2-High (before irrigation) | 6-51-2H | -737.11 | -228.00 | 152.00 | 2.44 |
| 3-Cold | 16-67-3C | -740.66 | -180.00 | 158.00 | 2.17 |
| 3-High | 55-73-3H | -739.65 | -135.00 | 162.00 | 2.39 |
| 4-Cold | 18-60-4C | -740.66 | -162.00 | 150.00 | 1.78 |
| 4-High | 59-25-4H | -738.89 | -198.00 | 167.00 | 2.12 |
| 5-Cold | 46-62-5C | -743.97 | -187.00 | 149.00 | 2.10 |
| 5-High | 50-32-5H | -740.66 | -175.00 | 157.00 | 2.40 |
| **DAY 10 (June 17)** | | | | | |
| 1-Cold (with biofilter) | 11-75-1C | -740.66 | -207.00 | 153.00 | 2.02 |
| 1-High(with biofilter) | 42-4-1H | -745.74 | -194.00 | 157.00 | 2.61 |
| 2-open (after 20 min irrigation, P high) | 39-17-2 | -738.00 | -253.00 | 162.00 | 2.01 |
| 2-High (before irrigation) | 33-20-2H | -738.89 | -209.00 | 152.00 | 2.30 |
| 2-High (after irrigation) | 23-66-2H | -741.43 | -200.00 | 153.00 | 2.28 |
| 3 (after turn over) | 70-41-3 | -738.12 | -177.00 | 151.00 | 2.45 |
| 3(2nd sample after turn over) | 38-16-3 | -738.12 | -182.00 | 156.00 | 2.33 |
| 3-Cold | 12-36-3C | -739.65 | -200.00 | 153.00 | 2.19 |
| 3-High | 31-34-3H | -738.12 | -186.00 | 152.00 | 2.71 |
| 4-Cold | 8-78-4C | -737.11 | -231.00 | 157.00 | 2.11 |
| 4-High | 82-14-4H | -738.12 | -192.00 | 155.00 | 2.34 |
| 5-Cold | 34-37-5C | -740.66 | -201.00 | 151.00 | 2.18 |
| 5-High | 3-53-5H | -738.12 | -225.00 | 157.00 | 2.22 |
| **DAY 15 (June 22)** | | | | | |
| 1-Cold (with biofilter) | 68-97-1C | -730.76 | -197.00 | 153.00 | 2.14 |
| 1-High(with biofilter) | 71-94-1H | -737.62 | -175.00 | 173.00 | 2.17 |
| 2-open (after 20 min irrigation) | 7-85-2 | -738.38 | -208.00 | 149.00 | 2.22 |
| 2-High (before irrigation) | 20-88-2H | -738.12 | -162.00 | 158.00 | 2.73 |
| 2-High(after 20 min irrigation, P medium) | 17-102-2H | -739.65 | -138.00 | 141.00 | 2.50 |
| 3-Cold | 64-104-3C | -738.00 | -194.00 | 152.00 | 2.17 |
| 3-High | 76-91-3H | -728.98 | -204.00 | 162.00 | 2.83 |
| 4-Cold | 61-96-4C | -738.89 | -189.00 | 155.00 | 2.24 |
| 4-High | 79-92-4H | -737.62 | -192.00 | 150.00 | 2.69 |
| 5-Cold | 73-100-5C | -740.92 | -169.00 | 167.00 | 2.32 |
| 5-High | 74-105-5H | -738.12 | -181.00 | 154.00 | 2.47 |
| **DAY 22 (June 29)** | | | | | |
| Control | 32-105-cont | -738.38 | -174.00 | 154.00 | 2.11 |
| 1-Cold (with biofilter) | 46-83-1C | -738.38 | -205.00 | 150.00 | 2.22 |
| 1-High(with biofilter) | 3-93-1H | -740.16 | -214.00 | 197.00 | 2.54 |
| 2-open (after 20 min irrigation) | 30-89-2 | -739.39 | -242.00 | 158.00 | 2.16 |

**Appendix C-a. Pressure readings of canisters—before, after sampling and prior to analysis; and condensate trap volumes after each sampling. (cont.)**

| SOURCE | Sample ID | P (mmHg) | | | NMNEO Trap |
|---|---|---|---|---|---|
| **DAY 22 (June 29) (cont.)** | | $P_0$ | $P_r$ | $P_f$ | V (ml) |
| 2-High (before irrigation) | 34-84-2H | -734.06 | -176.00 | 158.00 | 2.51 |
| 2-High(after 20 min irrigation, P good) | 47-109-2H | -738.38 | -197.00 | 148.00 | 2.26 |
| 3-Cold | 65-106-3C | -740.16 | -238.00 | 150.00 | 2.19 |
| 3-High | 54-99-3H | -739.39 | -168.00 | 151.00 | 2.53 |
| 4 (after turn over, 1st sample) | 35-95-4 | -737.62 | -228.00 | 151.00 | 2.78 |
| 4 (after turn over, 2nd sample) | 51-87-4 | -738.12 | -235.00 | 152.00 | 2.64 |
| 4-Cold | 31-101-4C | -740.16 | -206.00 | 148.00 | 2.65 |
| 4-High | 11-82-4H | -739.39 | -207.00 | 152.00 | 2.46 |
| 5-Cold | 24-110-5C | -734.06 | -208.00 | 151.00 | 2.31 |
| 5-High | 8-98-5H | -740.16 | -204.00 | 191.00 | 2.13 |
| | | | | | |
| **DAY 29 (06 July)** | | | | | |
| 1-Cold (with biofilter) | 21-169-1C | -738.12 | -162.00 | 139.00 | 2.19 |
| 1-High(with biofilter) | 72-168-1H | -738.89 | -170.00 | 157.00 | 3.18 |
| 2-open (after 20 min irrigation) | 62-160-2 | -738.89 | -161.00 | 141.00 | 2.09 |
| 2-High (before irrigation) | 4-165-2H | -741.93 | -195.00 | 264.00 | 2.46 |
| 2-High(after 20 min irrigation, P good) | 56-159-2H | -737.62 | -176.00 | 139.00 | 2.30 |
| 3 (after turn over 15 min) | 63-153-3 | -737.11 | -211.00 | 155.00 | 2.65 |
| 3-Cold | 78-166-3C | -737.11 | -217.00 | 141.00 | 2.17 |
| 3-High | 22-167-3H | -737.62 | -217.00 | 154.00 | 2.35 |
| 4(after turn over 15min) | 27-152 | -738.12 | -202.00 | 144.00 | 2.70 |
| 4-Cold | 15-161-4C | -738.89 | -175.00 | 147.00 | 2.28 |
| 4-High | 26-164-4H | -738.12 | -206.00 | 142.00 | 2.50 |
| 5-Cold | 67-151-5C | -738.89 | -180.00 | 177.00 | 2.20 |
| 5-High | 58-158-5H | -739.65 | -203.00 | 142.00 | 2.29 |
| | | | | | |
| **DAY 36 (July 13)** | | | | | |
| 1-Cold (with biofilter) | 28-196-1C | -749.30 | -170.00 | 145.00 | 2.09 |
| 1-High(with biofilter) | 53-186-1H | -723.90 | -147.00 | 147.00 | 2.40 |
| 2-High (before irrigation) | 48-189-2H | -731.52 | -206.00 | 161.00 | 2.63 |
| 2-High(after 20 min irrigation, P good) | 42-183-2 | -736.60 | -204.00 | 152.00 | 2.51 |
| 2-open (after 20 min irrigation) | 43-192-2 | -711.20 | -185.00 | 152.00 | 2.10 |
| 3 (after turn over 15 min) | 66-193-3 | -736.60 | -227.00 | 146.00 | 2.48 |
| 3-Cold | 14-187-3C | -711.20 | -208.00 | 145.00 | 2.17 |
| 3-High | 7-195-3H | -716.28 | -211.00 | 144.00 | 2.37 |
| 4(after turn over 15min) | 75-191-4 | -741.68 | -214.00 | 196.00 | 2.95 |
| 4-Cold | 74-180-4C | -711.20 | -201.00 | 140.00 | 2.24 |
| 4-High | 23-199-4H | -731.52 | -203.00 | 143.00 | 2.45 |
| 5-Cold | 19-190-5C | -756.92 | -207.00 | 150.00 | 2.17 |
| 5-High | 38-188-5H | -749.30 | -239.00 | 138.00 | 2.33 |
| Control | 60-185-contrl | -731.52 | -217.00 | 154.00 | 2.06 |
| **Day 41 (July 18)** | | | | | |
| 1-Cold (with biofilter) | 15-184-1C | -740.16 | -186.00 | 134.00 | 2.16 |
| 1-High(with biofilter) | 21-197-1H | -742.70 | -241.00 | 135.00 | 2.29 |
| 2-High (before irrigation) | 62-210-2H | -739.39 | -197.00 | 163.00 | 2.19 |
| 2-High(after 20 min irrigation, P good) | 56-219-2H | -739.39 | -203.00 | 135.00 | 2.47 |
| 2-open (after 20 min irrigation) | 73-214-2 | -742.70 | -204.00 | 139.00 | 2.20 |

**Appendix C-a. Pressure readings of canisters—before, after sampling and prior to analysis; and condensate trap volumes after each sampling. (cont.)**

| SOURCE | Sample ID | P (mmHg) | | | NMNEO Trap |
|---|---|---|---|---|---|
| **DAY 41 (July 18) (cont.)** | | $P_0$ | $P_r$ | $P_f$ | V (ml) |
| 3 (after turn over 15 min) | 58-203-3 | -742.70 | -216.00 | 139.00 | 2.80 |
| 3-Cold | 4-209-3C | -739.39 | -213.00 | 134.00 | 2.32 |
| 3-High | 22-208-3H | -742.70 | -232.00 | 132.00 | 2.48 |
| 4(after turn over 15min) | 65-202-4 | -738.38 | -220.00 | 137.00 | 2.66 |
| 4-Cold | 78-216-4C | -739.39 | -238.00 | 137.00 | 2.40 |
| 4-High | 26-207-4H | -739.39 | -226.00 | 137.00 | 2.42 |
| 5-Cold | 72-215-5C | -740.16 | -247.00 | 148.00 | 2.35 |
| 5-High | 67-213-5H | -739.14 | -224.00 | 132.00 | 2.32 |
| Control | 27-206-ctrl | -745.49 | -118.00 | 136.00 | 2.04 |
| | | | | | |
| **Day 50 (July 27)** | | | | | |
| 1-Cold (with biofilter) | 50-205-1C | -736.60 | -149.00 | 130.00 | 2.11 |
| 1-High(with biofilter) | 35-200-1H | -706.12 | -208.00 | 132.00 | 2.79 |
| 2-High (before irrigation) | 11-194-2H | -723.90 | -230.00 | 130.00 | 2.29 |
| 2-High(after 20 min irrigation, P good) | 54-235-2H | -736.60 | -230.00 | 129.00 | 2.40 |
| 2-open (after 20 min irrigation) | 51-236-2 | -723.90 | -150.00 | 134.00 | 2.10 |
| 3 (after turn over 15 min) | 30-211-3 | -736.60 | -253.00 | 133.00 | 2.51 |
| 3-Cold | 3-204-3C | -706.12 | -207.00 | 137.00 | 2.08 |
| 3-High | 76-198-3H | -731.52 | -167.00 | 137.00 | 2.24 |
| 4(after turn over 15min) | 32-212-4 | -762.00 | -245.00 | 133.00 | 2.73 |
| 4-Cold | 13-237-4C | -731.52 | -247.00 | 130.00 | 2.22 |
| 4-High | 82-238-4H | -731.52 | -224.00 | 132.00 | 2.51 |
| 5-Cold | 8-231-5C | -731.52 | -264.00 | 140.00 | 2.24 |
| 5-High | 59-230-5H | -741.68 | -203.00 | 130.00 | 2.37 |
| Control | 37-201-Ctrl | -723.90 | -179.00 | 132.00 | 2.01 |
| | | | | | |
| **Day 64 - (August 10)** | | | | | |
| 1-Cold (with biofilter) | 14-314-1C | -749.30 | -248.00 | 127.00 | 2.13 |
| 1-High(with biofilter) | 42-315-1H | -698.50 | -243.00 | 130.00 | 2.22 |
| 2-High (Before irrigation) | 70-302-2H | -736.60 | -220.00 | 135.00 | 2.36 |
| 2-High(after 20 min irrigation, P good) | 17-300-2H | -726.44 | -203.00 | 123.00 | |
| 2-open (after 20 min irrigation) | 55-308-2 | -749.30 | -214.00 | 141.00 | 2.09 |
| 3-Cold | 18-316-3C | -726.44 | -185.00 | 125.00 | 2.65 |
| 3-High | 7-303-3H | -711.20 | -238.00 | 130.00 | 2.10 |
| 4-Cold | 66-317-4C | -736.60 | -200.00 | 130.00 | 2.17 |
| 4-High | 19-319-4H | -731.52 | -245.00 | 132.00 | 2.45 |
| 5-Cold | 43-310-5C | -756.92 | -230.00 | 127.00 | 2.24 |
| 5-High | 23-301-5H | -756.92 | -236.00 | 127.00 | 2.46 |
| Control | 48-313-Ctrl | -749.30 | -233.00 | 143.00 | 2.00 |
| | | | | | |
| **Day78 (August 24)** | | | | | |
| 1-Cold (with biofilter) | 76-350-1C | -749.30 | -202.00 | 132.00 | 2.32 |
| 1-High(with biofilter) | 54-357-1H | -731.52 | -234.00 | 132.00 | 2.36 |
| 2-High (Before irrigation) | 16-355-2H | -731.52 | -236.00 | 130.00 | 2.32 |
| 2-High(after 20 min irrigation, P good) | 3-309-2H | -731.52 | -217.00 | 134.00 | 2.39 |
| 2-open (after 20 min irrigation) | 4-354-2OP | -749.30 | -175.00 | 128.00 | 2.11 |
| 3-Cold | 15-356-3C | -711.20 | -244.00 | 132.00 | 2.03 |

**Appendix C-a. Pressure readings of canisters—before, after sampling and prior to analysis; and condensate trap volumes after each sampling. (cont.)**

| SOURCE | Sample ID | P (mmHg) | | | NMNEO Trap |
|---|---|---|---|---|---|
| **DAY 78 (August 24) (cont.)** | | **$P_0$** | **$P_r$** | **$P_f$** | **V (ml)** |
| 3-High | 30-351-3H | -711.20 | -234.00 | 135.00 | 2.35 |
| 3 (after turn over 15 min) | 63-318-3 | -731.52 | -241.00 | 130.00 | 2.39 |
| 4-Cold | 13-358-4C | -726.44 | -250.00 | 143.00 | 2.21 |
| 4-High | 53-353-4H | -723.90 | -243.00 | 130.00 | 2.28 |
| 4(after turn over 15min) | 51-312-4 | -756.92 | -256.00 | 130.00 | 2.35 |
| 5-Cold | 35-305-5C | -723.90 | -258.00 | 125.00 | 2.17 |
| 5-High | 27-306-5H | -741.68 | -224.00 | 127.00 | 2.19 |
| Control | 50-352-CTRL | -749.30 | -208.00 | 155.00 | 2.14 |
| | | | | | |
| **Day99- (SEP 14)** | | | | | |
| 1-Cold (with biofilter) | 78-400-1C | -736.60 | -231.00 | 138.00 | 2.14 |
| 1-High(with biofilter) | 23-411-1H | -711.20 | -252.00 | 141.00 | 2.13 |
| 2-High (Before irrigation) | 7-401-2H | -711.20 | -247.00 | 133.00 | 2.21 |
| 2-High(after 20 min irrigation, P good) | 11-414-2H | -711.20 | -226.00 | 138.00 | 2.22 |
| 2-open (after 20 min irrigation) | 14-403-2 | -736.60 | -191.00 | 138.00 | 2.10 |
| 3-Cold | 70-413-3C | -723.90 | -175.00 | 132.00 | 2.15 |
| 3-High | 28-402-3H | -711.20 | -215.00 | 128.00 | 2.24 |
| 3 (after turn over 15 min) | 66-407-3T | -736.60 | -208.00 | 140.00 | 2.33 |
| 4-Cold | 37-415-4C | -716.28 | -240.00 | 128.00 | 2.22 |
| 4-High | 55-405-4H | -731.52 | -205.00 | 128.00 | 2.19 |
| 4(after turn over 15min) | 82-417-4T | -723.90 | -208.00 | 137.00 | 2.31 |
| 5-Cold | 59-416-5C | -736.60 | -235.00 | 138.00 | 2.23 |
| 5-High | 10-406-5H | -716.28 | -203.00 | 135.00 | 2.11 |
| Control | 2-412-CTRL | -723.90 | -234.00 | 142.00 | 2.19 |

$P_f$ = canister pressure after pressurization, mmHg

$P_r$ = return pressure in mm Hg

$P_0$ = evacuated canister pressure in mmHg

V = volume of condensate trap water in ml

## Appendix D. Surface Area and Weight of Feedstock in Windrows

| Day | Irrigation | | Control | | Biofilter | | Interactive | | Reduced size | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A ($m^2$) | $W_{compost}$† (kg) | A ($m^2$) | $W_{compost}$† (kg) | A ($m^2$) | $W_{compost}$† (kg) | A ($m^2$) | $W_{compost}$† (kg) | A ($m^2$) | $C_{ompost}$† (kg) |
| 2 | 39.65 | 15527.75 | 27.9 | 11525.1 | 31.4 | 10716.0 | 44.8 | 17770.3 | 38.3 | 11147.4 |
| 3 | 42.65 | 18033.43 | 42.2 | 18683.0 | 43.9 | 17313.5 | 32.2 | 13683.7 | 37.6 | 10501.2 |
| 4 | 48.89 | 16666.1 | 40.6 | 17319.5 | 43.9 | 17895.6 | 36.3 | 18079.0 | 40.7 | 12554.5 |
| 5 | 42.05 | 17210.23 | 64.6 | 32037.7 | 60.2 | 19796.7 | 33.5 | 19069.2 | 36.0 | 12228.6 |
| 7 | 55.73 | 17097.24 | 49.0 | 16889.4 | 55.6 | 17563.2 | 38.7 | 18492.9 | 45.9 | 13385.0 |
| 10 | 49.37 | 20418.16 | 45.8 | 19180.1 | 56.3 | 19967.9 | 43.3 | 19677.4 | 44.6 | 12581.9 |
| 15 | 43.78 | 17250.06 | 37.4 | 16845.1 | 52.3 | 18408.6 | 30.0 | 15084.0 | 40.3 | 11428.2 |
| 22 | 28.93 | 12482.44 | 36.3 | 16074.0 | 40.9 | 15245.0 | 39.1 | 18756.3 | 25.1 | 7765.3 |
| 29 | 38.45 | 16633.85 | 31.9 | 17641.6 | 56.9 | 22567.5 | 28.3 | 15886.5 | 33.2 | 11054.3 |
| 36 | 33.79 | 16800.72 | 30.3 | 17864.1 | 57.9 | 19723.9 | 34.9 | 16875.9 | 32.5 | 11147.4 |
| 41 | 36.63 | 17535.35 | 43.9 | 19878.6 | 40.0 | 16618.0 | 29.3 | 13933.9 | 28.1 | 10655.2 |
| 50 | 35.03 | 14694.66 | 34.8 | 16986.7 | 30.9 | 14038.6 | 31.8 | 16300.3 | 19.9 | 8929.4 |
| 64 | 37.54 | 16525.33 | 37.3 | 17864.1 | 39.7 | 17423.5 | 36.9 | 16875.9 | 31.4 | 11147.4 |
| 78 | 30.73 | 14479.25 | 22.1 | 11308.2 | 36.2 | 16651.2 | 34.3 | 15777.4 | 32.8 | 11538.1 |
| 99 | 37.17 | 17911.48 | 18.9 | 10177.6 | 38.2 | 18325.4 | 30.4 | 14495.4 | 29.5 | 10591.5 |

† Effective compost weight corresponding to the surface area for emission investigation was used in the calculation.

## Appendix E. Weighted Average Calculation for Methane Emissions

| Date/Windrow | $T_L$ (°C) | $T_H$ (°C) | $T_{avg}$ (°C) | $F_L$ [&] (mg/m$^2$-min) | $F_H$ [&] (mg/m$^2$-min) | $F_{Avg}$ [†] (mg/m$^2$-min) | m[‡] (mg/kg-day) |
|---|---|---|---|---|---|---|---|
| **DAY 2** | | | | | | | |
| Control | 13.3 | 24.8 | 17.0 | 2.4 | 2.7 | 2.5 | 8.7 |
| Pseudo-Biofilter | 13.9 | 41.6 | 17.5 | 0.9 | 2.8 | 1.5 | 6.2 |
| Interactive | 13.8 | 18.8 | 15.6 | 0.7 | 0.8 | 0.7 | 2.5 |
| Reduced Size | MD | MD | MD | 0.8 | 0.7 | 0.8 | 3.8[#] |
| **DAY 3** | | | | | | | |
| Control | 15 | 37.5 | 19.6 | 1.3 | 8.2 | 2.7 | 8.7 |
| Pseudo-Biofilter | 15.7 | 36.9 | 22.9 | 0.5 | 0.8 | 0.6 | 2.1 |
| Interactive | 15.4 | 39.1 | 20.8 | 0.6 | 2.1 | 0.9 | 3.2 |
| Reduced Size | 15.3 | 37.8 | 21.1 | 5.3 | 2.3 | 4.5 | 23.4 |
| **DAY 5** | | | | | | | |
| Control | 16.4 | 44.4 | 26.6 | 1.6 | 67.3 | 25.5 | 73.9 |
| Pseudo-Biofilter | 16.6 | 35.6 | 22.8 | 24.5 | 881.8 | 305.3 | 1336.6 |
| Interactive | 15.6 | 43.3 | 24.7 | 11.1 | 34.6 | 18.8 | 47.7 |
| Reduced Size | 16.3 | 45.5 | 25.2 | 25.0 | 207.9 | 80.7 | 341.9 |
| **Day 7** | | | | | | | |
| Control | 13.6 | 45.8 | 22.7 | 10.2 | 37.2 | 17.8 | 74.3 |
| Pseudo-Biofilter | 15.8 | 39.3 | 22.0 | 15.6 | 561.7 | 160.1 | 729.2 |
| Interactive | 13.1 | 45.6 | 22.0 | 51.8 | 143.0 | 76.8 | 231.4 |
| Reduced Size | 14.3 | 42.5 | 24.5 | 266.3 | 237.0 | 255.7 | 1261.3 |
| **Day 10** | | | | | | | |
| Control | 15.8 | 47.9 | 28.2 | 15.2 | 314.9 | 121.2 | 416.6 |
| Pseudo-Biofilter | 17.4 | 39.3 | 25.3 | 36.5 | 1840.0 | 503.4 | 2042.4 |
| Interactive | 15.4 | 52.4 | 26.9 | 410.7 | 169.8 | 335.8 | 1065.0 |
| Reduced Size | 15.1 | 49.9 | 27.1 | 1081.9 | 1414.3 | 1196.8 | 6102.8 |
| **Day 15** | | | | | | | |
| Control | 11 | 50.5 | 21.7 | 265.5 | 1185.9 | 515.8 | 1647.3 |
| Pseudo-Biofilter | 14.4 | 38.4 | 23.5 | 76.5 | 342.4 | 176.8 | 722.9 |
| Interactive | 10.6 | 49.1 | 20.2 | 99.8 | 899.8 | 298.8 | 855.5 |
| Reduced Size | 11 | 45 | 18.2 | 85.6 | 5420.9 | 1218.3 | 6186.4 |
| **Day 22** | | | | | | | |
| Control | 20 | 49.8 | 26.4 | 95.2 | 877.4 | 263.9 | 858.1 |
| Pseudo-Biofilter | 20.1 | 52.1 | 25.7 | 63.2 | 1498.0 | 314.7 | 1214.4 |
| Interactive | 19.5 | 51.5 | 27.4 | 543.5 | 1022.6 | 661.9 | 1988.2 |
| Reduced | 14.7 | 49.9 | 25.5 | 2910.9 | 980.3 | 2541.5 | 11834.6 |
| **Day 29** | | | | | | | |
| Control | 13.6 | 43.1 | 20.8 | 3.9 | 732.2 | 182.0 | 474.1 |
| Pseudo-Biofilter | 18.4 | 55.1 | 25.2 | 99.1 | 3848.4 | 794.9 | 2885.2 |
| Interactive | 14.1 | 51.1 | 21.7 | 689.5 | 3219.3 | 1205.6 | 3089.7 |
| Reduced | 14.8 | 41.3 | 19.9 | 3295.8 | 2238.2 | 3094.0 | 13371.4 |
| **Day 36** | | | | | | | |
| Control | MD | MD | MD | 604.3 | 1489.3 | 1046.8[#] | 2553.4[#] |
| Pseudo-Biofilter | 17.8 | 54.3 | 25.0 | 107.4 | 3809.0 | 835.5 | 3528.5 |
| Interactive | MD | MD | MD | 1284.7 | 1891.9 | 1558.3[#] | 4731.1[#] |
| Reduced | MD | MD | MD | 1780.6 | 1915.6 | 1848.1[#] | 7767.2[#] |
| **Day 41** | | | | | | | |
| Control | 23.6 | 59.1 | 28.7 | 244.0 | 2650.7 | 900.8 | 2866.9 |
| Pseudo-Biofilter | 23.6 | 59.1 | 30.1 | 393.3 | 8504.3 | 1869.7 | 6478.1 |
| Interactive | 22.1 | 50.1 | 28.5 | 1706.5 | 3980.8 | 2225.0 | 6747.2 |
| Reduced | 21.4 | 44.6 | 26.3 | 2046.5 | 1423.7 | 1914.5 | 7258.7 |
| **Day 50** | | | | | | | |
| Control | 19.7 | 46.4 | 25.2 | 33.7 | 1138.8 | 261.9 | 773.5 |
| Pseudo-Biofilter | 19.6 | 52.8 | 26.1 | 18.1 | 3963.7 | 795.6 | 2518.3 |
| Interactive | 20.5 | 43.5 | 25.1 | 6.2 | 2170.9 | 400.9 | 1126.3 |
| Reduced | 20 | 42.3 | | | | | |

## Appendix E. Weighted Average Calculation for Methane Emissions (cont.)

| Date/Windrow | $T_L$ (°C) | $T_H$ (°C) | $T_{avg}$ (°C) | $F_L$ [&] (mg/m$^2$-min) | $F_H$ [&] (mg/m$^2$-min) | $F_{Avg}$ [†] (mg/m$^2$-min) | m[‡] (mg/kg-day) |
|---|---|---|---|---|---|---|---|
| **Day 64** | | | | | | | |
| Control | MD | MD | MD | 25.9 | 475.8 | 250.8[#] | 754.5[#] |
| Pseudo-Biofilter | MD | MD | MD | 40.4 | 715.6 | 378.0[#] | 1239.2 |
| Interactive | MD | MD | MD | 12.6 | 940.2 | 476.4[#] | 1498.6[#] |
| Reduced | MD | MD | MD | 145.5 | 278.7 | 212.1[#] | 860.9[#] |
| **Day 78** | | | | | | | |
| Control | 13.3 | 37.5 | 18.3 | 301.9 | NA | NA | NA |
| Pseudo-Biofilter | 13.4 | 41.1 | 20.8 | 495.2 | 578.5 | 517.5 | 1619.3 |
| Interactive | 12.1 | 42.4 | 18.5 | 6.1 | 173.2 | 41.2 | 128.9 |
| Reduced | 13.0 | 41.5 | 18.5 | 11.4 | 105.4 | 29.5 | 94.7 |
| **Day 99** | | | | | | | |
| Control | 18.9 | 29.1 | 22.7 | 362.4 | 435.9 | 389.8 | 1041.8 |
| Pseudo-Biofilter | 20.7 | 32.9 | 25.7 | 11.3 | 28.3 | 18.4 | 58.3 |
| Interactive | 18.4 | 27.4 | 21.9 | 189.8 | 316.4 | 238.5 | 720.4 |
| Reduced | 20.6 | 32.3 | 22.9 | 62.1 | 202.1 | 89.0 | 286.0 |

MD: Data was lost due to the issues with the scanner

#: Arithmetic average of $F_L$ and $F_H$

NA: Trace gas helium was not detected in the sample and therefore the flux cannot be calculated.

&: Copied from Appendix B

†: Weight average flux was calculated based on the following:

$$F_{avg} = X_L F_L + X_H F_H$$

where $X_L$ = Fraction of cold point, $X_L = \frac{T_H - T_{avg}}{T_H - T_L}$

$X_H$ = Fraction of high point, $X_H = \frac{T_{avg} - T_L}{T_H - T_L}$

$F_{avg}$ = weight average flux, mg/m$^2$-min

$F_L$ = gas emission at cold point, mg/m$^2$-min

$F_H$ = gas emission at high point, mg/m$^2$-min

‡: Mass emission per total compost per day was calculated based on:

$$m = \frac{F_{avg} \cdot A}{W} \cdot 24 \cdot 60$$

where m = mass emission, mg/kg-day

$F_{avg}$ = weight average flux, mg/m$^2$-min

A = surface area, m$^2$ (from Appendix D)

W = Effective weight of compost, kg (from Appendix D)

## Appendix F. Weighted Average Calculation for VOC Emissions

| Date/Windrow | $T_L$ (°C) | $T_H$ (°C) | $T_{avg}$ (°C) | $F_L$ [&] (mg/m$^2$-min) | $F_H$ [&] (mg/m$^2$-min) | $F_{Avg}$ [†] (mg/m$^2$-min) | m[‡] (mg/kg-day) |
|---|---|---|---|---|---|---|---|
| **DAY 2** | | | | | | | |
| Control | 13.3 | 24.8 | 17.0 | 53.3 | 44.4 | 50.5 | 175.6 |
| Pseudo-Biofilter | 13.9 | 41.6 | 17.5 | 6.8 | 21.0 | 10.9 | 45.8 |
| Interactive | 13.8 | 18.8 | 15.6 | 34.3 | 74.6 | 49.7 | 180.2 |
| Reduced Size | MD | MD | MD | 18.8 | 20.0 | 19.4 | 96.1[#] |
| **DAY 3** | | | | | | | |
| Control | 15 | 37.5 | 19.6 | 36.6 | 28.4 | 34.9 | 113.6 |
| Pseudo-Biofilter | 15.7 | 36.9 | 22.9 | 1.7 | 1.5 | 1.6 | 5.7 |
| Interactive | 15.4 | 39.1 | 20.8 | 16.3 | 18.5 | 16.8 | 56.8 |
| Reduced Size | 15.3 | 37.8 | 21.1 | 88.5 | 76.5 | 85.4 | 440.1 |
| **DAY 5** | | | | | | | |
| Control | 16.4 | 44.4 | 26.6 | 4.8 | 84.6 | 33.8 | 98.0 |
| Pseudo-Biofilter | 16.6 | 35.6 | 22.8 | 1.9 | 15.3 | 6.3 | 27.4 |
| Interactive | 15.6 | 43.3 | 24.7 | 24.7 | 15.8 | 21.8 | 55.2 |
| Reduced Size | 16.3 | 45.5 | 25.2 | 99.7 | 184.8 | 125.6 | 532.1 |
| **Day 7** | | | | | | | |
| Control | 13.6 | 45.8 | 22.7 | 68.9 | 294.9 | 132.6 | 554.1 |
| Pseudo-Biofilter | 15.8 | 39.3 | 22.0 | 0.8 | 17.4 | 5.2 | 23.7 |
| Interactive | 13.1 | 45.6 | 22.0 | 4.0 | 83.5 | 25.7 | 77.6 |
| Reduced Size | 14.3 | 42.5 | 24.5 | 86.7 | 43.4 | 71.0 | 350.2 |
| **Day 10** | | | | | | | |
| Control | 15.8 | 47.9 | 28.2 | 7.7 | 97.0 | 39.3 | 135.0 |
| Pseudo-Biofilter | 17.4 | 39.3 | 25.3 | 0.7 | 64.8 | 17.3 | 70.2 |
| Interactive | 15.4 | 52.4 | 26.9 | 30.6 | 19.1 | 27.0 | 85.7 |
| Reduced Size | 15.1 | 49.9 | 27.1 | 173.8 | 173.8 | 173.8 | 886.4 |
| **Day 15** | | | | | | | |
| Control | 11 | 50.5 | 21.7 | 24.1 | 274.3 | 92.1 | 294.3 |
| Pseudo-Biofilter | 14.4 | 38.4 | 23.5 | 8.9 | 3.4 | 6.8 | 27.9 |
| Interactive | 10.6 | 49.1 | 20.2 | 24.1 | 274.3 | 42.2 | 120.9 |
| Reduced Size | 11 | 45 | 18.2 | 89.1 | 57.7 | 82.4 | 418.5 |
| **Day 22** | | | | | | | |
| Control | 20 | 49.8 | 26.4 | 16.5 | 55.3 | 24.9 | 80.8 |
| Pseudo-Biofilter | 20.1 | 52.1 | 25.7 | 0.7 | 11.4 | 2.6 | 10.0 |
| Interactive | 19.5 | 51.5 | 27.4 | 40.3 | 159.4 | 69.7 | 209.4 |
| Reduced | 14.7 | 49.9 | 25.5 | 45.5 | 13.8 | 39.5 | 183.7 |
| **Day 29** | | | | | | | |
| Control | 13.6 | 43.1 | 20.8 | 3.0 | 40.7 | 12.3 | 31.9 |
| Pseudo-Biofilter | 18.4 | 55.1 | 25.2 | 1.1 | 50.6 | 10.3 | 37.3 |
| Interactive | 14.1 | 51.1 | 21.7 | 26.2 | 72.0 | 35.5 | 91.0 |
| Reduced | 14.8 | 41.3 | 19.9 | 25.7 | 27.4 | 26.0 | 112.3 |
| **Day 36** | | | | | | | |
| Control | MD | MD | MD | 13.9 | 64.6 | 39.3[#] | 95.8[#] |
| Pseudo-Biofilter | 17.8 | 54.3 | 25.0 | 0.6 | 12.6 | 3.0 | 12.7 |
| Interactive | MD | MD | MD | 98.9 | 38.1 | 68.5[#] | 204.0[#] |
| Reduced | MD | MD | MD | 40.4 | 54.8 | 3.3[#] | 9.7[#] |
| **Day 41** | | | | | | | |
| Control | 23.6 | 59.1 | 28.7 | 2.6 | 57.0 | 17.5 | 55.5 |
| Pseudo-Biofilter | 23.6 | 59.1 | 30.1 | 3.5 | 8.0 | 4.3 | 15.0 |
| Interactive | 22.1 | 50.1 | 28.5 | 23.5 | 36.5 | 26.4 | 80.1 |
| Reduced | 21.4 | 44.6 | 26.3 | 17.2 | 18.0 | 17.4 | 66.0 |
| **Day 50** | | | | | | | |
| Control | 19.7 | 46.4 | 25.2 | 2.5 | 3.8 | 2.8 | 8.2 |
| Pseudo-Biofilter | 19.6 | 52.8 | 26.1 | 2.2 | 35.4 | 8.7 | 27.7 |
| Interactive | 20.5 | 43.5 | 25.1 | 9.2 | 14.1 | 10.1 | 28.4 |
| Reduced | 20 | 42.3 | 24.0 | 22.7 | 21.8 | 22.5 | 72.4 |

## Appendix F. Weighted Average Calculation for VOC Emissions (cont.)

| Date/Windrow | $T_L$ (°C) | $T_H$ (°C) | $T_{avg}$ (°C) | $F_L$ & (mg/m$^2$-min) | $F_H$ & (mg/m$^2$-min) | $F_{Avg}$ † (mg/m$^2$-min) | m‡ (mg/kg-day) |
|---|---|---|---|---|---|---|---|
| **Day 64** | | | | | | | |
| Control | MD | MD | MD | 2.6 | 1.5 | 2.1# | 6.3# |
| Pseudo-Biofilter | MD | MD | MD | 5.8 | 7.0 | 6.4# | 21.0# |
| Interactive | MD | MD | MD | 2.4 | 13.4 | 7.9# | 24.8# |
| Reduced | MD | MD | MD | 2.4 | 36.3 | 19.3# | 78.5# |
| **Day 78** | | | | | | | |
| Control | 13.3 | 37.5 | 18.3 | 1.6 | NA | NA | NA |
| Pseudo-Biofilter | 13.4 | 41.1 | 20.8 | 17.6 | 10.5 | 15.7 | 49.1 |
| Interactive | 12.1 | 42.4 | 18.5 | 3.6 | 30.5 | 9.2 | 28.9 |
| Reduced | 13.0 | 41.5 | 18.5 | 16.2 | 21.2 | 17.2 | 70.4 |
| **Day 99** | | | | | | | |
| Control | 18.9 | 29.1 | 22.7 | 15.5 | 36.7 | 23.4 | 62.6 |
| Pseudo-Biofilter | 20.7 | 32.9 | 25.7 | 1.8 | 1.6 | 1.7 | 5.5 |
| Interactive | 18.4 | 27.4 | 21.9 | 18.4 | 3.4 | 12.6 | 38.1 |
| Reduced | 20.6 | 32.3 | 22.9 | 18.6 | 70.6 | 28.6 | 114.6 |

&: Copied from Appendix B

#: Arithmetic average of $F_L$ and $F_H$

MD: Data was lost due to the issues with the scanner

NA: Trace gas helium was not detected in the sample and therefore the flux cannot be calculated

†: Weight average flux was calculated based on the following:

$F_{avg} = X_L F_L + X_H F_H$

where $X_L$ = Fraction of cold point, $X_L = \frac{T_H - T_{avg}}{T_H - T_L}$

$X_H$ = Fraction of high point, $X_H = \frac{T_{avg} - T_L}{T_H - T_L}$

$F_{avg}$ = weight average flux, mg/m$^2$-min

$F_L$ = gas emission at cold point, mg/m$^2$-min

$F_H$ = gas emission at high point, mg/m$^2$-min

‡: Mass emission per total compost per day was calculated based on:

$$m = \frac{F_{avg} \cdot A}{W} \cdot 24 \cdot 60$$

where m = mass emission, mg/kg-day

$F_{avg}$ = weight average flux, mg/m$^2$-min

A = surface area, m$^2$ (from Appendix D)

W = Effective weight of compost, kg (from Appendix D)

## Appendix G. Weighted Average Calculation for Nitrous Oxide Emissions

| Date/Windrow | $T_L$ (°C) | $T_H$ (°C) | $T_{avg}$ (°C) | $F_L$ [&] (mg/m$^2$-min) | $F_H$ [&] (mg/m$^2$-min) | $F_{Avg}$ [†] (mg/m$^2$-min) | m[‡] (mg/kg-day) |
|---|---|---|---|---|---|---|---|
| **DAY 2** | | | | | | | |
| Control | 13.3 | 24.8 | 17.0 | 5.9 | 4.5 | 5.4 | 19.0 |
| Pseudo-Biofilter | 13.9 | 41.6 | 17.5 | 3.7 | 19.0 | 8.1 | 34.1 |
| Interactive | 13.8 | 18.8 | 15.6 | 2.3 | 7.1 | 4.1 | 15.0 |
| Reduced Size | MD | MD | MD | 6.9 | 9.9 | 8.4[#] | 41.6[#] |
| **DAY 3** | | | | | | | |
| Control | 15 | 37.5 | 19.6 | 3.6 | 6.6 | 4.2 | 13.8 |
| Pseudo-Biofilter | 15.7 | 36.9 | 22.9 | 0.4 | 0.8 | 0.5 | 1.8 |
| Interactive | 15.4 | 39.1 | 20.8 | 1.1 | 5.0 | 2.0 | 6.7 |
| Reduced Size | 15.3 | 37.8 | 21.1 | 8.0 | 8.3 | 8.1 | 41.7 |
| **DAY 5** | | | | | | | |
| Control | 16.4 | 44.4 | 26.6 | 0.7 | 10.9 | 4.4 | 12.9 |
| Pseudo-Biofilter | 16.6 | 35.6 | 22.8 | 0.7 | 14.7 | 5.3 | 23.0 |
| Interactive | 15.6 | 43.3 | 24.7 | 5.5 | 12.8 | 7.9 | 20.0 |
| Reduced Size | 16.3 | 45.5 | 25.2 | 9.5 | 31.3 | 16.1 | 68.2 |
| **Day 7** | | | | | | | |
| Control | 13.6 | 45.8 | 22.7 | 2.4 | 23.0 | 8.2 | 34.2 |
| Pseudo-Biofilter | 15.8 | 39.3 | 22.0 | 0.9 | 16.0 | 4.9 | 22.4 |
| Interactive | 13.1 | 45.6 | 22.0 | 2.3 | 9.7 | 4.3 | 13.0 |
| Reduced Size | 14.3 | 42.5 | 24.5 | 9.8 | 6.1 | 8.5 | 41.7 |
| **Day 10** | | | | | | | |
| Control | 15.8 | 47.9 | 28.2 | 1.2 | 11.6 | 4.9 | 16.7 |
| Pseudo-Biofilter | 17.4 | 39.3 | 25.3 | 0.5 | 9.6 | 2.8 | 11.5 |
| Interactive | 15.4 | 52.4 | 26.9 | 6.6 | 6.3 | 6.5 | 20.7 |
| Reduced Size | 15.1 | 49.9 | 27.1 | 17.8 | 15.3 | 16.9 | 86.2 |
| **Day 15** | | | | | | | |
| Control | 11 | 50.5 | 21.7 | 7.2 | 29.2 | 13.2 | 42.1 |
| Pseudo-Biofilter | 14.4 | 38.4 | 23.5 | 2.1 | 3.7 | 2.7 | 11.1 |
| Interactive | 10.6 | 49.1 | 20.2 | 6.8 | 12.7 | 8.3 | 23.7 |
| Reduced Size | 11 | 45 | 18.2 | 9.3 | 12.9 | 10.1 | 51.1 |
| **Day 22** | | | | | | | |
| Control | 20 | 49.8 | 26.4 | 1.7 | 5.8 | 2.6 | 8.5 |
| Pseudo-Biofilter | 20.1 | 52.1 | 25.7 | 0.3 | 3.5 | 0.8 | 3.3 |
| Interactive | 19.5 | 51.5 | 27.4 | 3.7 | 6.8 | 4.5 | 13.4 |
| Reduced | 14.7 | 49.9 | 25.5 | 6.1 | 4.6 | 5.8 | 27.0 |
| **Day 29** | | | | | | | |
| Control | 13.6 | 43.1 | 20.8 | 1.6 | 11.2 | 3.9 | 10.2 |
| Pseudo-Biofilter | 18.4 | 55.1 | 25.2 | 1.1 | 10.9 | 2.9 | 10.5 |
| Interactive | 14.1 | 51.1 | 21.7 | 6.3 | 14.3 | 8.0 | 20.4 |
| Reduced | 14.8 | 41.3 | 19.9 | 14.9 | 7.7 | 13.6 | 58.6 |
| **Day 36** | | | | | | | |
| Control | MD | MD | MD | 1.1 | 3.1 | 2.1[#] | 5.1[#] |
| Pseudo-Biofilter | 17.8 | 54.3 | 25.0 | 1.5 | 6.1 | 2.4 | 10.0 |
| Interactive | MD | MD | MD | 4.5 | 2.1 | 3.3[#] | 9.7[#] |
| Reduced | MD | MD | MD | 5.3 | 4.8 | 5.0[#] | 21.1[#] |
| **Day 41** | | | | | | | |
| Control | 23.6 | 59.1 | 28.7 | N/A | 13.4 | N/A | N/A |
| Pseudo-Biofilter | 23.6 | 59.1 | 30.1 | 2.1 | 12.2 | 3.9 | 13.6 |
| Interactive | 22.1 | 50.1 | 28.5 | 5.0 | 11.2 | 6.5 | 19.6 |
| Reduced | 21.4 | 44.6 | 26.3 | 7.4 | 12.0 | 8.4 | 31.7 |
| **Day 50** | | | | | | | |
| Control | 19.7 | 46.4 | 25.2 | 0.6 | 5.2 | 1.6 | 4.6 |
| Pseudo-Biofilter | 19.6 | 52.8 | 26.1 | 1.2 | 11.1 | 3.1 | 9.9 |
| Interactive | 20.5 | 43.5 | 25.1 | 0.5 | 14.3 | 3.0 | 8.5 |
| Reduced | 20 | 42.3 | 24.0 | 13.1 | 5.4 | 11.7 | 37.6 |

## Appendix G. Weighted Average Calculation for Nitrous Oxide Emissions (cont.)

| Date/Windrow | $T_L$ (°C) | $T_H$ (°C) | $T_{avg}$ (°C) | $F_L$ [&] (mg/m$^2$-min) | $F_H$ [&] (mg/m$^2$-min) | $F_{Avg}$ [†] (mg/m$^2$-min) | m[‡] (mg/kg-day) |
|---|---|---|---|---|---|---|---|
| **Day 64** | | | | | | | |
| Control | MD | MD | MD | 0.3 | 0.6 | 0.4[#] | 1.3[#] |
| Pseudo-Biofilter | MD | MD | MD | 36.9 | 36.0 | 36.4[#] | 119.4[#] |
| Interactive | MD | MD | MD | 0.2 | 2.3 | 1.2[#] | 3.9[#] |
| Reduced | MD | MD | MD | 0.9 | 64.8 | 32.8[#] | 133.4[#] |
| **Day 78** | | | | | | | |
| Control | 13.3 | 37.5 | 18.3 | 1.5 | NA | NA | NA |
| Pseudo-Biofilter | 13.4 | 41.1 | 20.8 | 25.2 | 17.6 | 23.1 | 82.4 |
| Interactive | 12.1 | 42.4 | 18.5 | 1.8 | 19.0 | 5.4 | 22.3 |
| Reduced | 13.0 | 41.5 | 18.5 | 12.7 | 61.8 | 22.2 | 118.6 |
| **Day 99** | | | | | | | |
| Control | 18.9 | 29.1 | 22.7 | 12.6 | 12.1 | 12.4 | 8.0 |
| Pseudo-Biofilter | 20.7 | 32.9 | 25.7 | 2.0 | 31.6 | 14.1 | 69.4 |
| Interactive | 18.4 | 27.4 | 21.9 | 11.7 | 7.1 | 9.9 | 7.7 |
| Reduced | 20.6 | 32.3 | 22.9 | 139.1 | 134.9 | 138.3 | 990.4 |

MD: Data was lost due to the issues with the scanner

NA: Trace gas helium was not detected in the sample and therefore the flux cannot be calculated

N/A: Run out of sample for analysis

#: Arithmetic average of $F_L$ and $F_H$

&: Copied from Appendix B

†: Weight average flux wass calculated based on the following:

$F_{avg} = X_L F_L + X_H F_H$

where $X_L$ = Fraction of cold point, $X_L = \dfrac{T_H - T_{avg}}{T_H - T_L}$

$X_H$ = Fraction of high point, $X_H = \dfrac{T_{avg} - T_L}{T_H - T_L}$

$F_{avg}$ = weight average flux, mg/m$^2$-min

$F_L$ = gas emission at cold point, mg/m$^2$-min

$F_H$ = gas emission at high point, mg/m$^2$-min

‡: Mass emission per total compost per day was calculated based on:

$$m = \frac{F_{avg} \cdot A}{W} \cdot 24 \cdot 60$$

where m = mass emission, mg/kg-day

$F_{avg}$ = weight average flux, mg/m$^2$-min

A = surface area, m$^2$ (from Appendix D)

W = Effective weight of compost, kg (from Appendix D)

## Appendix H. Integration for Total $CH_4$ Emission in g/kg

| Control | | | | Biofilter | | | | Interactive | | | | Reduced size | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| t (day) | m* (mg/kg-day) | Δt | $m_{avg}$ | t (day) | m* (mg/kg-day) | Δt | $m_{avg}$ | t (day) | m* (mg/kg-day) | Δt | $m_{avg}$ | t (day) | m* (mg/kg-day) | Δt | $m_{avg}$ |
| 2 | 8.7 | 1 | 8.7 | 2 | 6.2 | 1 | 4.1 | 2 | 2.5 | 1 | 2.8 | | | | |
| 3 | 8.7 | 2 | 41.3 | 3 | 2.1 | 2 | 669.3 | 3 | 3.2 | 2 | 25.4 | 3 | 23.4 | 2 | 182.6 |
| 5 | 73.9 | 2 | 74.1 | 5 | 1336.6 | 2 | 1032.9 | 5 | 47.7 | 2 | 139.5 | 5 | 341.9 | 2 | 801.6 |
| 7 | 74.3 | 3 | 245.5 | 7 | 729.2 | 3 | 1385.8 | 7 | 231.4 | 3 | 648.2 | 7 | 1261.3 | 3 | 3682.0 |
| 10 | 416.6 | 5 | 1032.0 | 10 | 2042.4 | 5 | 1382.6 | 10 | 1065.0 | 5 | 960.3 | 10 | 6102.8 | 5 | 6144.6 |
| 15 | 1647.3 | 7 | 1252.7 | 15 | 722.8 | 7 | 968.6 | 15 | 855.5 | 7 | 1421.8 | 15 | 6186.4 | 7 | 9010.4 |
| 22 | 858.1 | 7 | 666.1 | 22 | 1214.4 | 7 | 2049.8 | 22 | 1988.2 | 7 | 2538.9 | 22 | 11834.5 | 7 | 12602.9 |
| 29 | 474.1 | 7 | 1513.7 | 29 | 2885.2 | 7 | 3206.9 | 29 | 3089.7 | 12 | 4918.5 | 29 | 13371.4 | 12 | 10315.0 |
| | | | | 36 | 3528.5 | 5 | 5003.3 | | | | | | | | |
| 41 | 2866.9 | 9 | 1820.2 | 41 | 6478.1 | 9 | 4498.2 | 41 | 6747.2 | 9 | 3936.8 | 41 | 7258.6 | 9 | 3820.9 |
| 50 | 773.5 | 14 | 764.0 | 50 | 2518.3 | 28 | 2068.8 | 50 | 1126.3 | 28 | 627.6 | 50 | 383.1 | 28 | 251.8 |
| | | | | | | | | | | | | | | | |
| 99 | 1041.8 | | | 78 | 1619.2 | 21 | 838.8 | 78 | 128.9 | 21 | 424.6 | 78 | 120.6 | 21 | 238.8 |
| | | | | 99 | 58.3 | | | 99 | 720.4 | | | 99 | 356.9 | | |
| **Total Emission† (Integration)** | | 100.5 g/kg | | **Total Emission† (Integration)** | | 199.1 g/kg | | **Total Emission† (Integration)** | | 155.7 g/kg | | **Total Emission† (Integration)** | | 365.3 g/kg | |

* Copied from Appendix E.

† The total emission amount $\overline{M}$ (g/kg) was calculated by integration the mass emission per day over the days investigated:

$$\overline{M} = \int_{2}^{t} m\, dt$$

where m = Mass emission per total compost per day, mg/kg-day

$\overline{M}$ = total emission amount, g/kg

Trapezoidal rule was used for the integration by using function Sumproduct (Δt, $m_{avg}$) in excel, where $\Delta t = t_i - t_{i-1}$, $m_{avg} = (m_i + m_{i+1})/2$

## Appendix I. Integration for Total VOC Emission in g/kg

| Control | | | | Biofilter | | | | Interactive | | | | Reduced size | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| t (day) | m[&] (mg/kg-day) | Δt | $m_{avg}$ | t (day) | m[&] (mg/kg-day) | Δt | $m_{avg}$ | t (day) | m[&] (mg/kg-day) | Δt | $m_{avg}$ | t (day) | m[&] (mg/kg-day) | Δt | $m_{avg}$ |
| 2 | 175.6 | 1 | 144.6 | 2 | 45.8 | 1 | 25.8 | 2 | 180.2 | 1 | 118.5 | | | | |
| 3 | 113.6 | 2 | 105.8 | 3 | 5.7 | 2 | 16.6 | 3 | 56.8 | 2 | 56.0 | 3 | 440.1 | 2 | 486.1 |
| 5 | 98.0 | 2 | 326.0 | 5 | 27.4 | 2 | 25.6 | 5 | 55.2 | 2 | 66.4 | 5 | 532.1 | 2 | 441.2 |
| 7 | 554.1 | 3 | 344.6 | 7 | 23.7 | 3 | 47.0 | 7 | 77.6 | 3 | 81.6 | 7 | 350.2 | 3 | 618.3 |
| 10 | 135.0 | 5 | 214.6 | 10 | 70.2 | 5 | 49.1 | 10 | 85.7 | 5 | 103.3 | 10 | 886.4 | 5 | 652.4 |
| 15 | 294.3 | 7 | 187.5 | 15 | 27.9 | 7 | 19.0 | 15 | 120.9 | 7 | 165.2 | 15 | 418.5 | 7 | 301.1 |
| 22 | 80.8 | 7 | 56.4 | 22 | 10.0 | 7 | 23.7 | 22 | 209.4 | 7 | 150.2 | 22 | 183.7 | 7 | 148.0 |
| 29 | 31.9 | 12 | 43.7 | 29 | 37.3 | 7 | 25.0 | 29 | 91.0 | 12 | 85.6 | 29 | 112.3 | 12 | 89.1 |
| | | | | 36 | 12.6 | 5 | 13.8 | | | | | | | | |
| 41 | 55.5 | 9 | 31.9 | 41 | 15.0 | 9 | 21.3 | 41 | 80.1 | 9 | 54.3 | 41 | 66.0 | 9 | 69.2 |
| 50 | 8.2 | 49 | 35.4 | 50 | 27.7 | 28 | 38.4 | 50 | 28.4 | 28 | 28.6 | 50 | 72.4 | 28 | 71.4 |
| 64 | 6.3 | 35 | 34.4 | | | | | | | | | | | | |
| 99 | 62.6 | | | 78 | 49.1 | 21 | 27.3 | 78 | 28.9 | 21 | 33.5 | 78 | 70.4 | 21 | 92.5 |
| | | | | 99 | 5.5 | | | 99 | 38.1 | | | 99 | 114.6 | | |
| **Total Emission† (Integration)** | | 7.4g/kg | | **Total Emission† (Integration)** | | 2.9 g/kg | | **Total Emission† (Integration)** | | 6.4 g/kg | | **Total Emission† (Integration)** | | 15.7 g/kg | |

& Copied from Appendix F

† The total emission amount $\overline{M}$ (g/kg) was calculated by integration the mass emission per day over the days investigated:

$$\overline{M} = \int_{2}^{t} m\, dt$$

where m = Mass emission per total compost per day, mg/kg-day

$\overline{M}$ = total emission amount, g/kg

Trapezoidal rule was used for the integration by using function Sumproduct (Δt, $m_{avg}$) in excel, where $\Delta t = t_i - t_{i-1}$, $m_{avg} = (m_i + m_{i+1})/2$

## Appendix J. Integration for Total $N_2O$ Emission in g/kg

| Control | | | | Biofilter | | | | Interactive | | | | Reduced size | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| t (day) | m** (mg/kg-day) | Δt | mavg | t (day) | m** (mg/kg-day) | Δt | mavg | t (day) | m** (mg/kg-day) | Δt | mavg | t (day) | m** (mg/kg-day) | Δt | mavg |
| 2 | 14.8 | 1 | 9.6 | 2 | 37.8 | 1 | 19.3 | 2 | 12.7 | 1 | 8.3 | | | | |
| 3 | 4.3 | 2 | 7.0 | 3 | 0.8 | 2 | 13.0 | 3 | 3.8 | 2 | 7.9 | 3 | 11.5 | 2 | 17.9 |
| 5 | 9.7 | 2 | 15.1 | 5 | 25.2 | 2 | 26.4 | 5 | 11.9 | 2 | 9.6 | 5 | 24.3 | 2 | 20.0 |
| 7 | 20.4 | 3 | 16.8 | 7 | 27.5 | 3 | 17.6 | 7 | 7.2 | 3 | 7.4 | 7 | 15.6 | 3 | 21.0 |
| 10 | 13.2 | 5 | 19.9 | 10 | 7.6 | 5 | 7.3 | 10 | 7.6 | 5 | 9.4 | 10 | 26.3 | 5 | 26.1 |
| 15 | 26.7 | 7 | 15.3 | 15 | 7.0 | 7 | 4.4 | 15 | 11.1 | 7 | 8.2 | 15 | 25.9 | 7 | 17.6 |
| 22 | 4.0 | 7 | 4.4 | 22 | 1.9 | 7 | 3.8 | 22 | 5.2 | 7 | 7.6 | 22 | 9.3 | 7 | 16.6 |
| 29 | 4.8 | 21 | 3.1 | 29 | 5.8 | 7 | 7.2 | 29 | 10.0 | 12 | 8.1 | 29 | 24.0 | 12 | 16.4 |
| | | | | 36 | 8.6 | 5 | 8.7 | | | | | | | | |
| 50 | 1.3 | 49 | 4.7 | 41 | 8.7 | 9 | 6.9 | 41 | 6.2 | 9 | 4.5 | 41 | 8.7 | 9 | 12.6 |
| | | | | 50 | 5.1 | 28 | 43.8 | 50 | 2.8 | 28 | 12.5 | 50 | 16.4 | 28 | 67.5 |
| 99 | 8.0 | | | | | | | | | | | | | | |
| | | | | 78 | 82.4 | 21 | 76.0 | 78 | 22.3 | 21 | 15.0 | 78 | 118.6 | 21 | 554.5 |
| | | | | 99 | 69.6 | | | 99 | 7.7 | | | 99 | 990.4 | | |
| **Total Emission†** | | 0.6 g/kg | | **Total Emission†** | | 4.3 g/kg | | **Total Emission†** | | 1.0 g/kg | | **Total Emission†** | | 14.4 g/kg | |

** Copied from Appendix G.

† The total emission amount $\overline{M}$ (g/kg) was calculated by integration the mass emission per day over the days investigated:

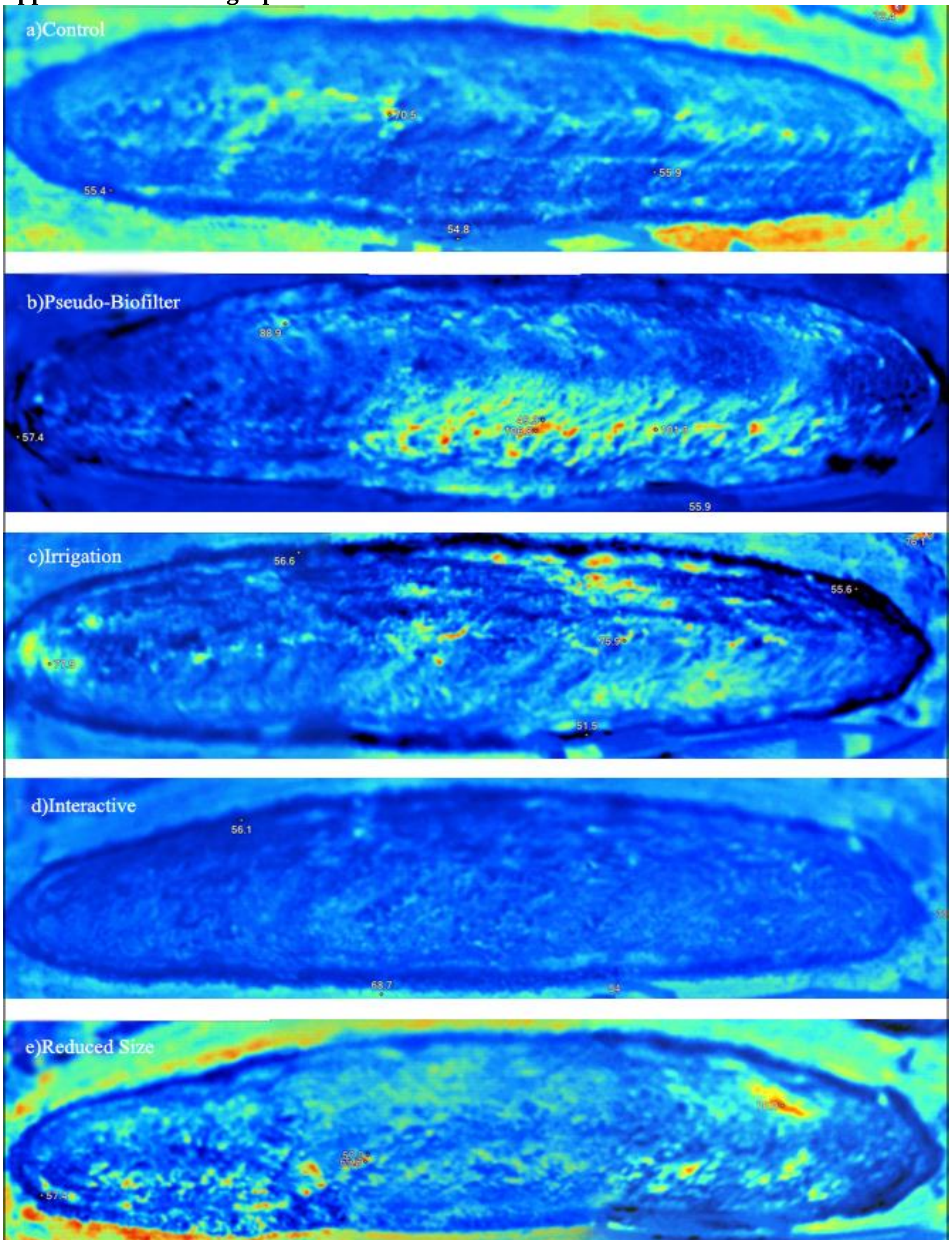
$$\overline{M} = \int_{2}^{t} m\, dt$$

where m = Mass emission per total compost per day, mg/kg-day

$\overline{M}$ = total emission amount, g/kg

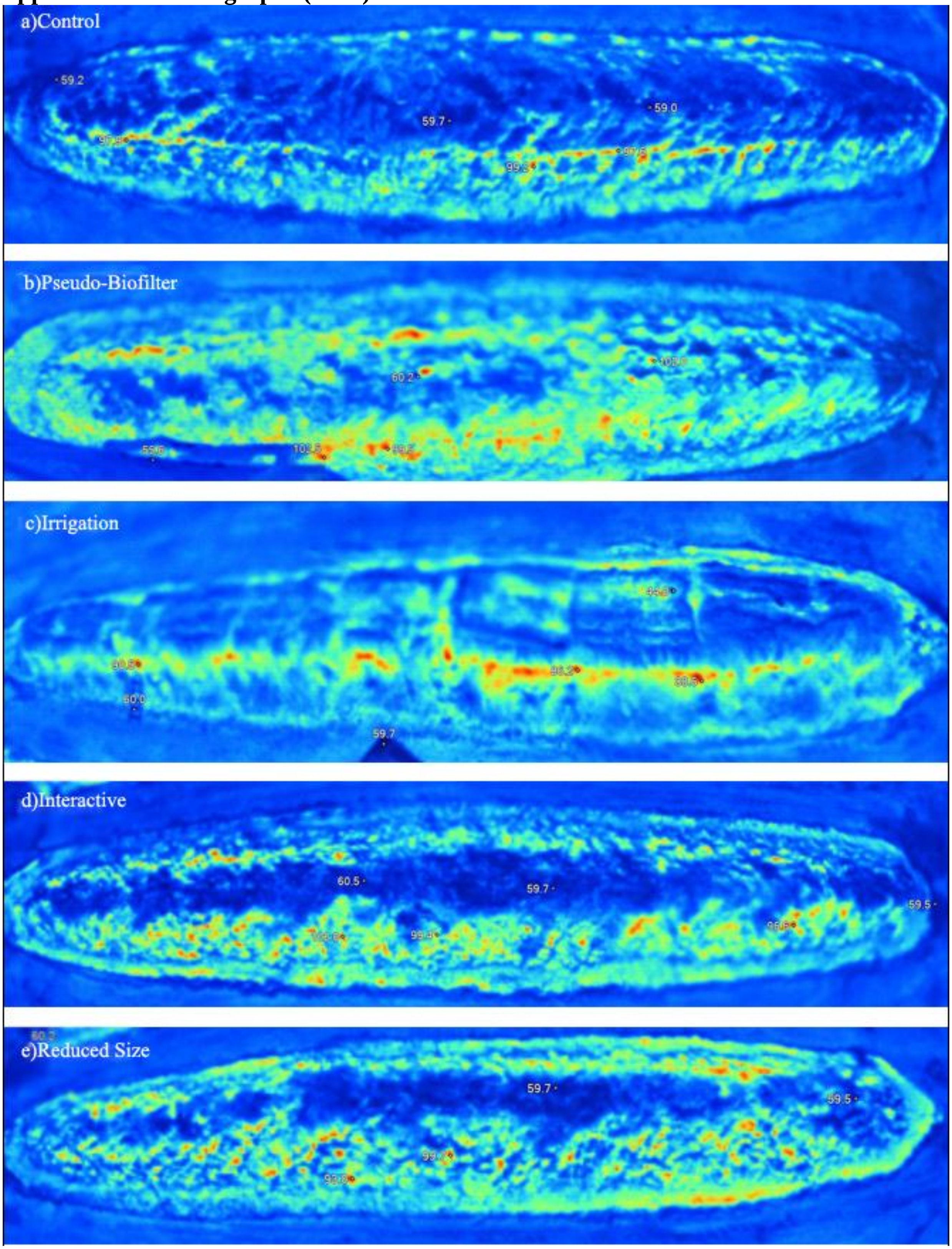
Trapezoidal rule was used for the integration by using function Sumproduct ($\Delta t$, $m_{avg}$) in excel, where $\Delta t = t_i - t_{i-1}$, $m_{avg} = (m_i + m_{i+1})/2$

## Appendix K. Thermographs

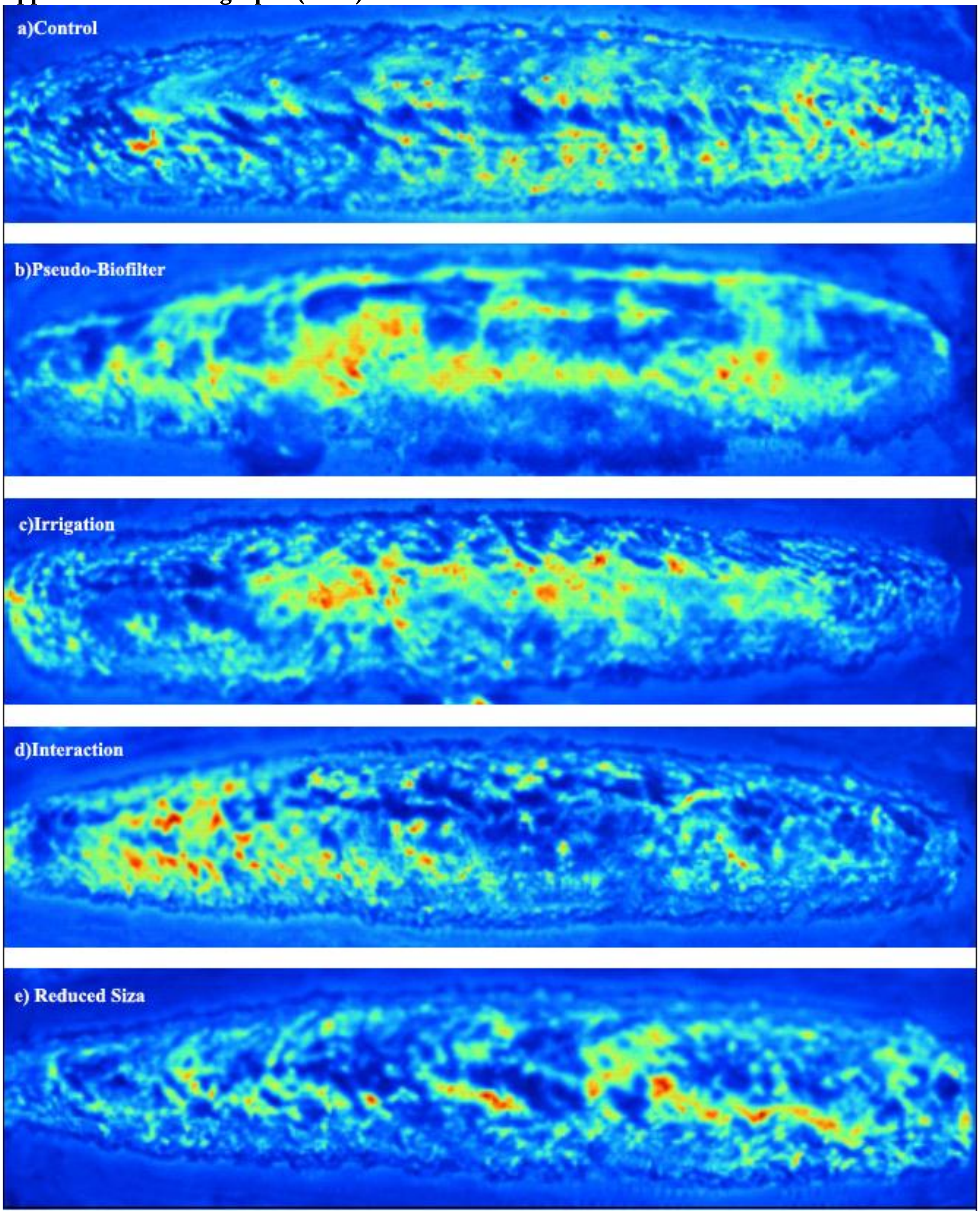



**Thermography analysis for June 9th**

**Appendix K. Thermographs (cont.)**

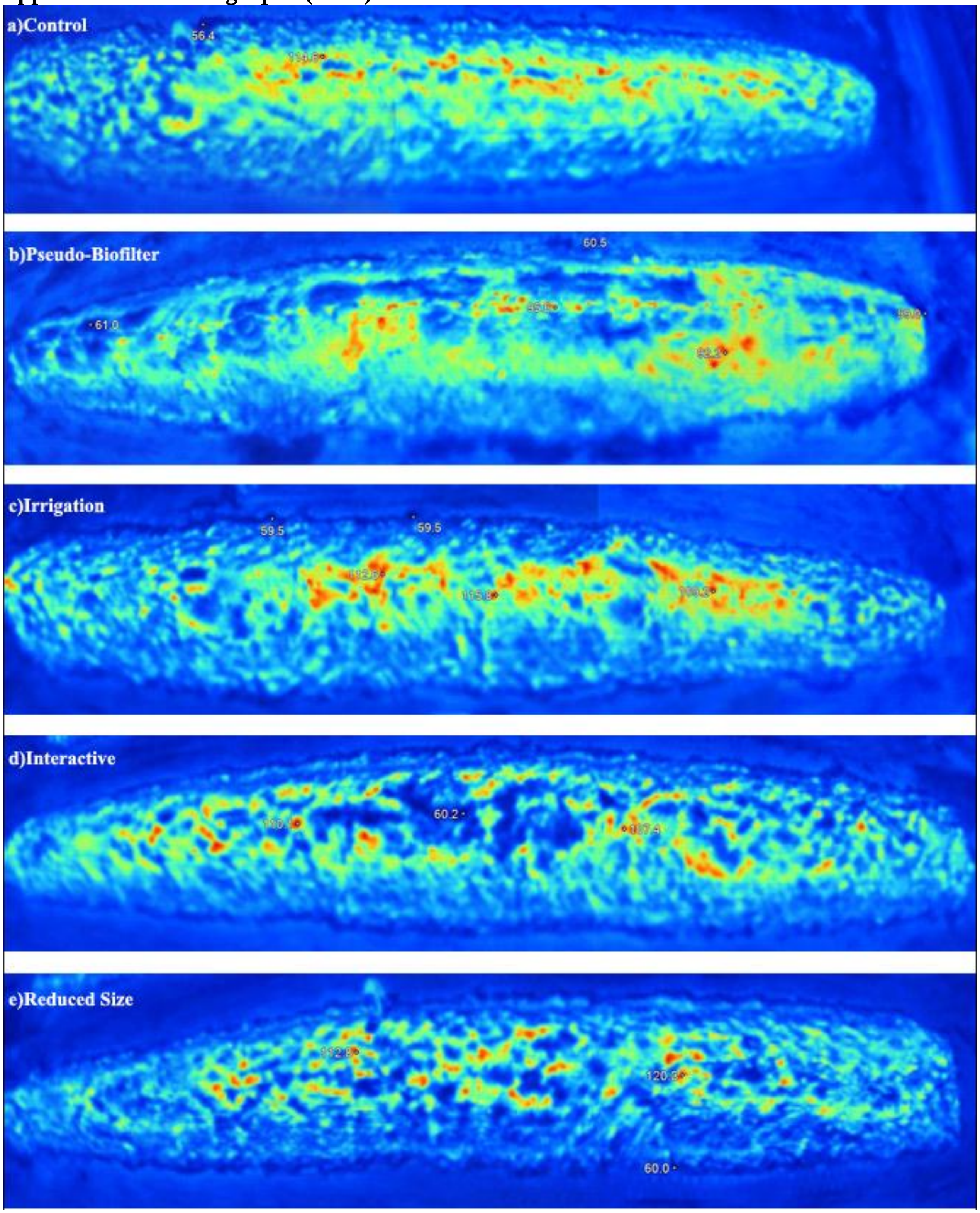



**Thermograph of windrows on June 10th.**



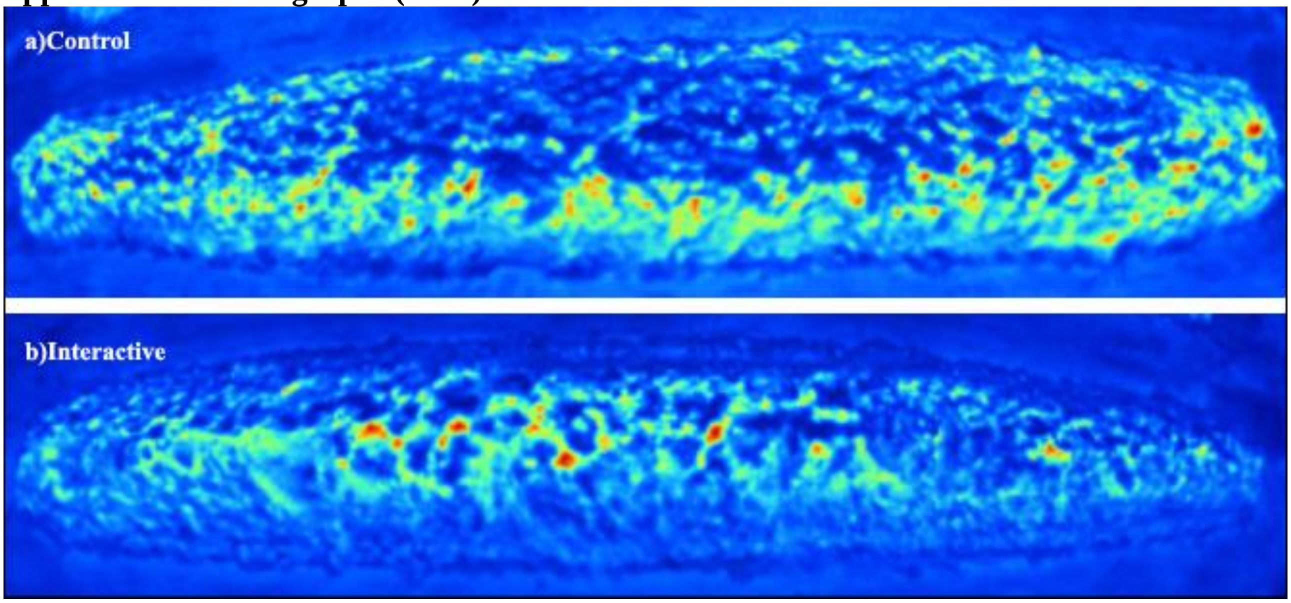

**Thermograph of windrows on June 11th.**

## Appendix K. Thermographs (cont.)



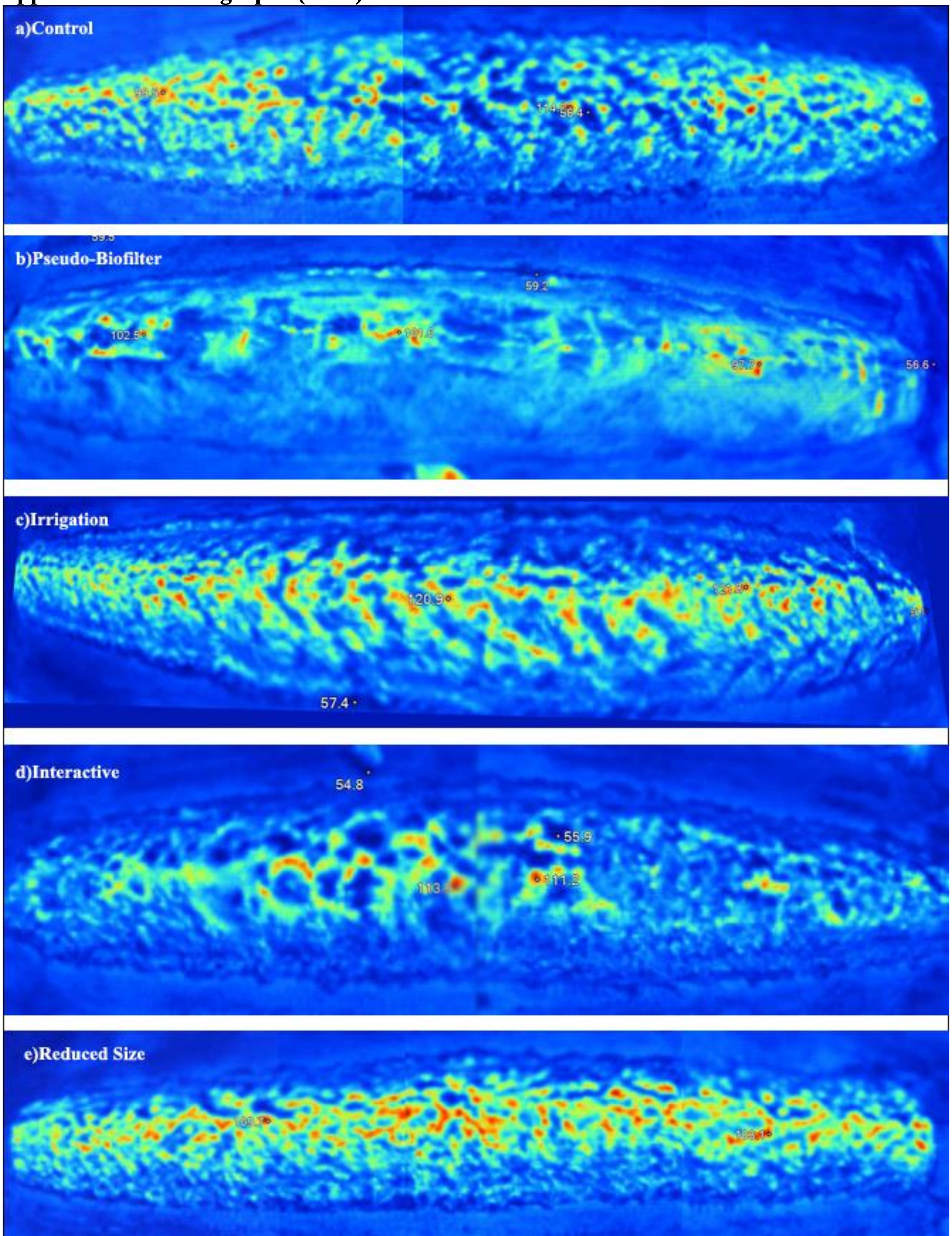

**Thermograph of windrows on June 12th.**

**Appendix K. Thermographs (cont.)**



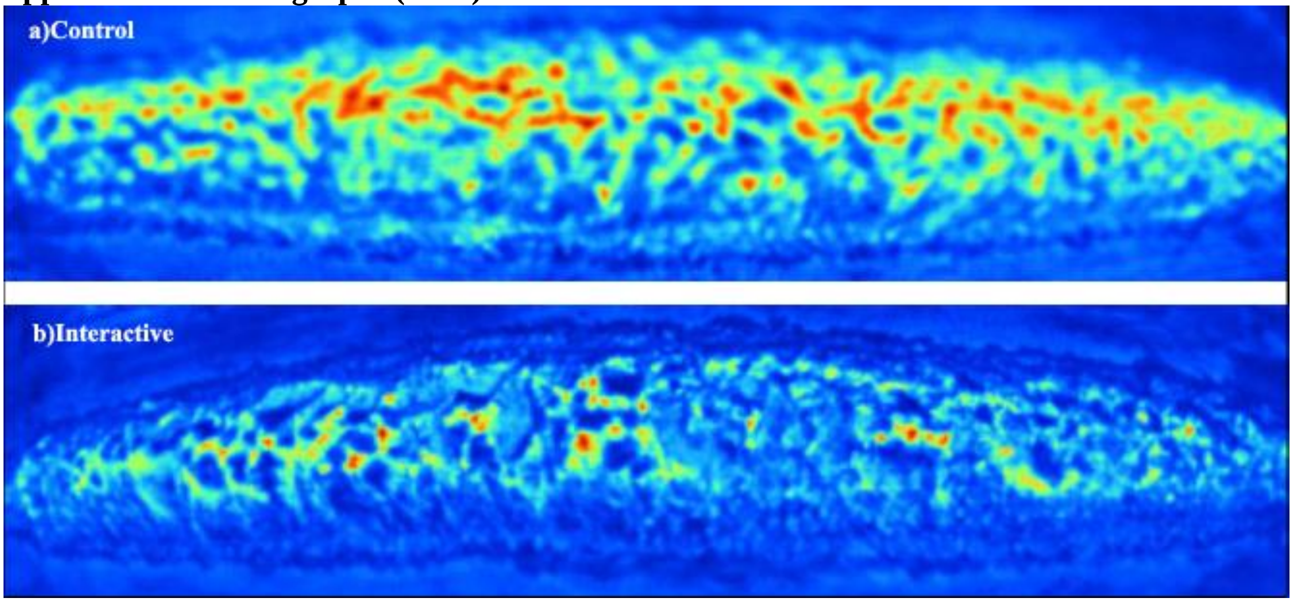

**Thermograph of windrows on June 13th.**

**Appendix K. Thermographs (cont.)**

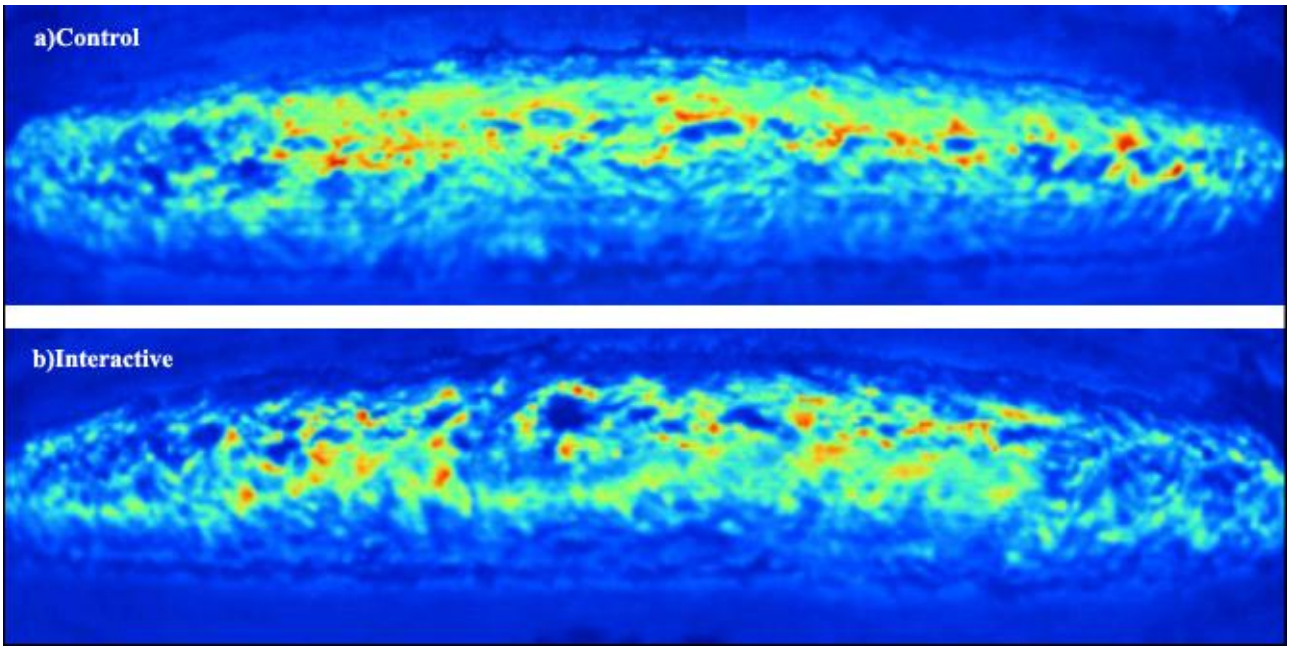



**Thermograph of windrows on June 14$^{th}$.**

**Appendix K. Thermographs (cont.)**

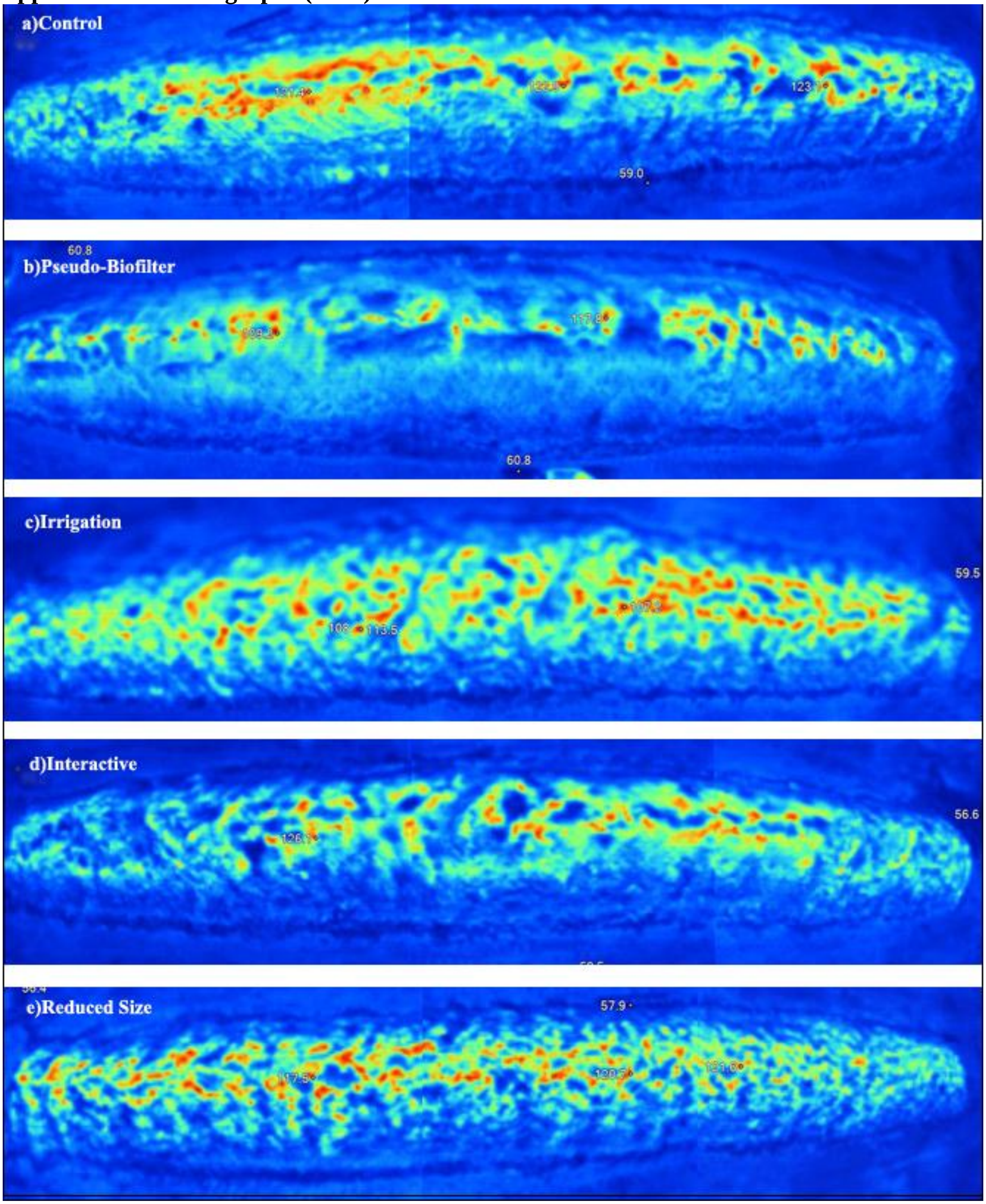



**Thermograph of windrows on June 15th (on this day only the control and interactive windrow was scanned).**



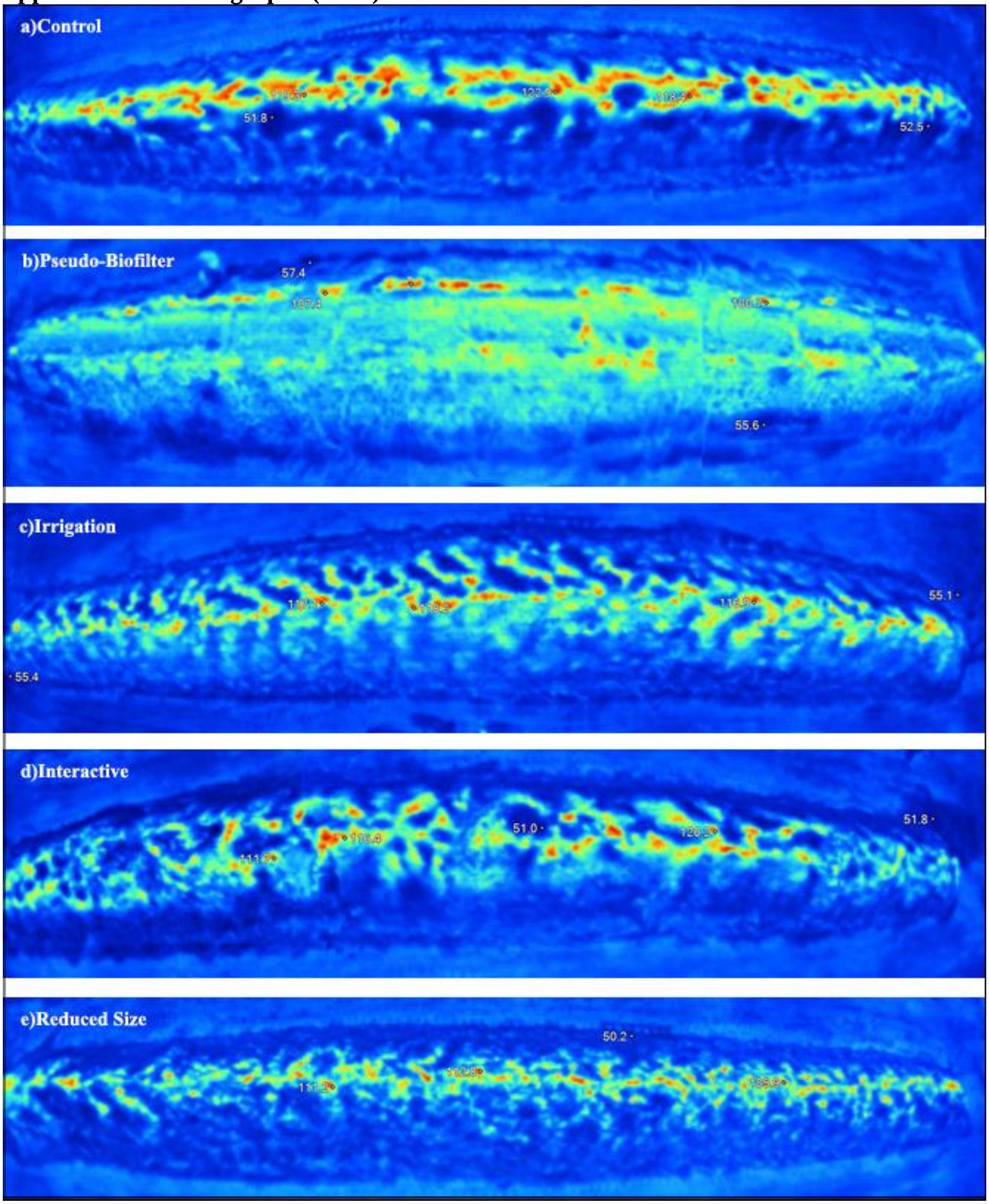

**Thermograph of windrows on June 16th (on this day only the control and interactive windrow was scanned).**

## Appendix K. Thermographs (cont.)



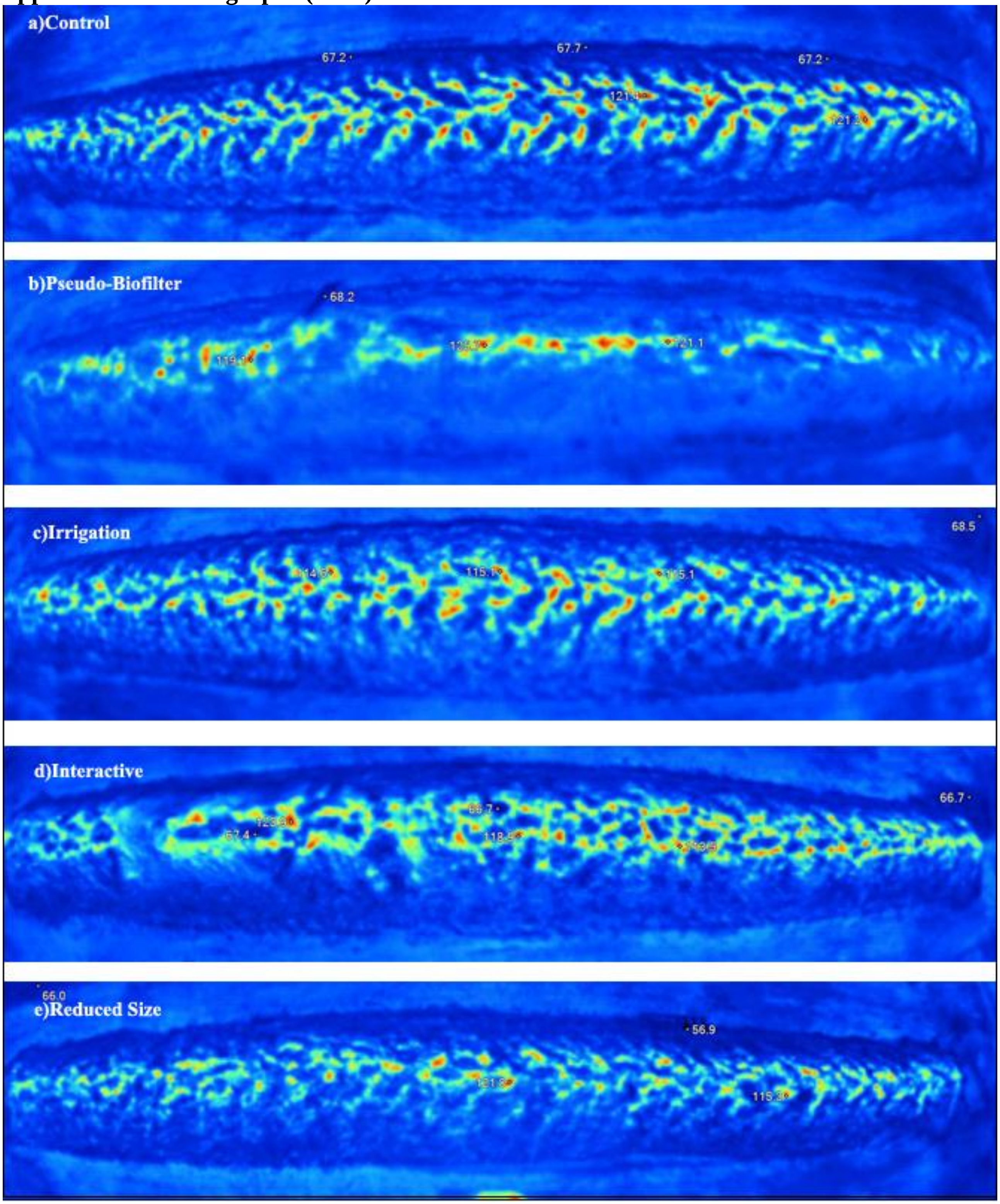

**Thermograph of windrows on June 17th**

## Appendix K. Thermographs (cont.)



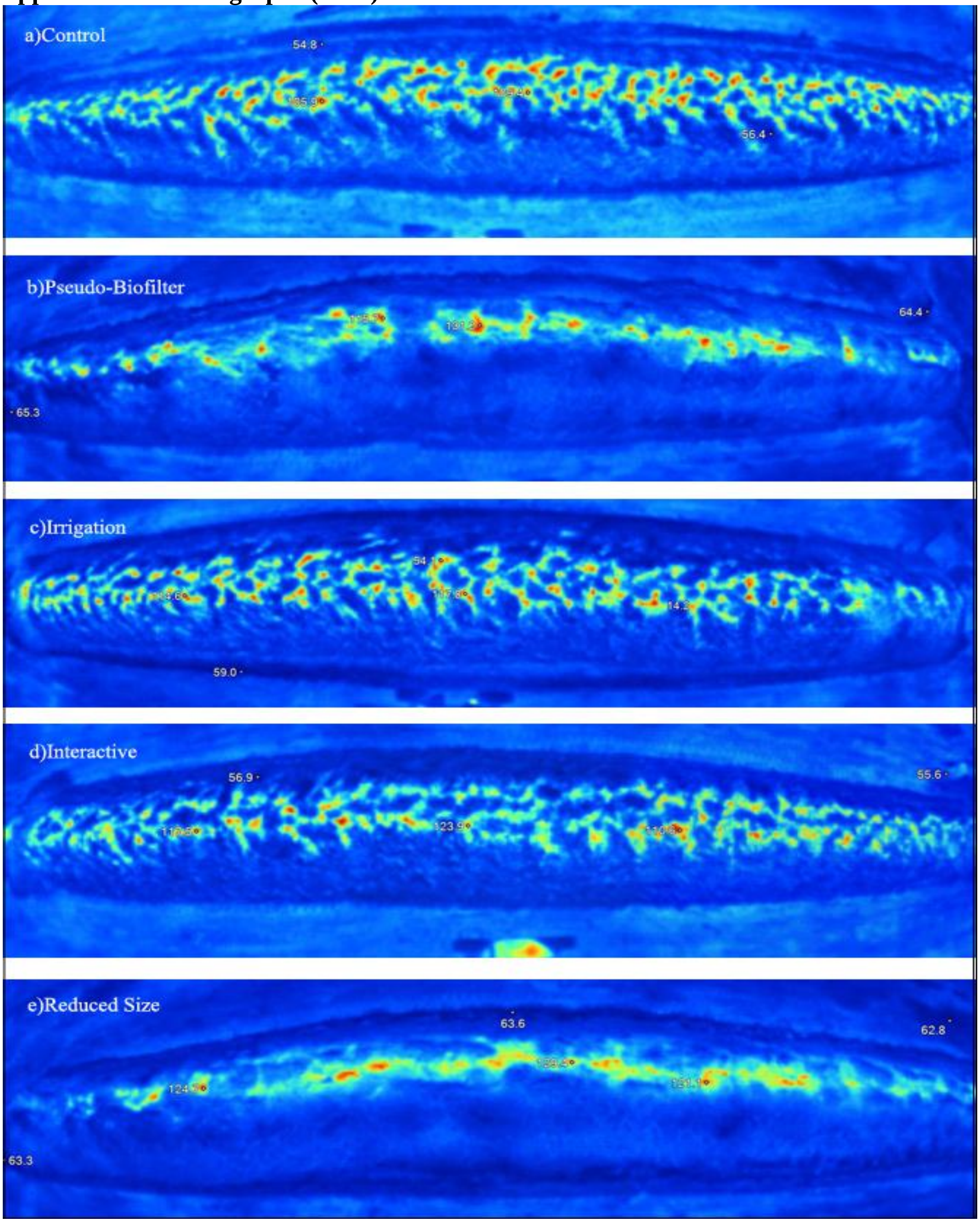

**Thermograph of windrows on June 22th.**

**Appendix K. Thermographs (cont.)**



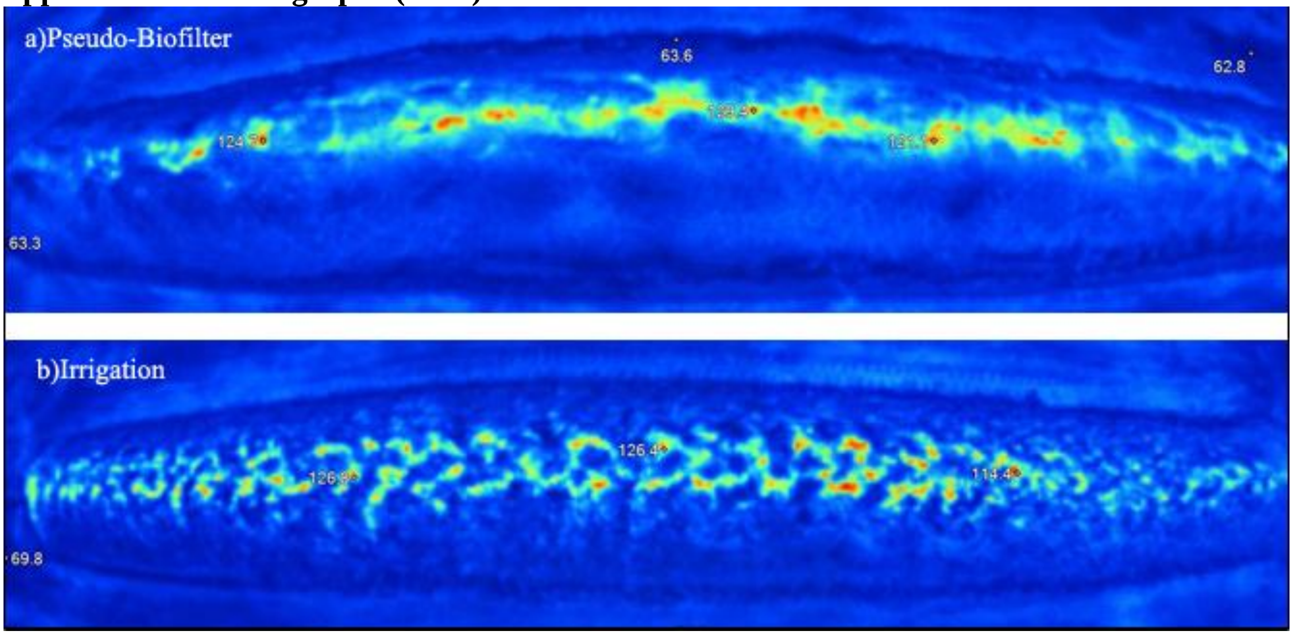

**Thermograph of windrows on June 29th.**

**Appendix K. Thermographs (cont.)**



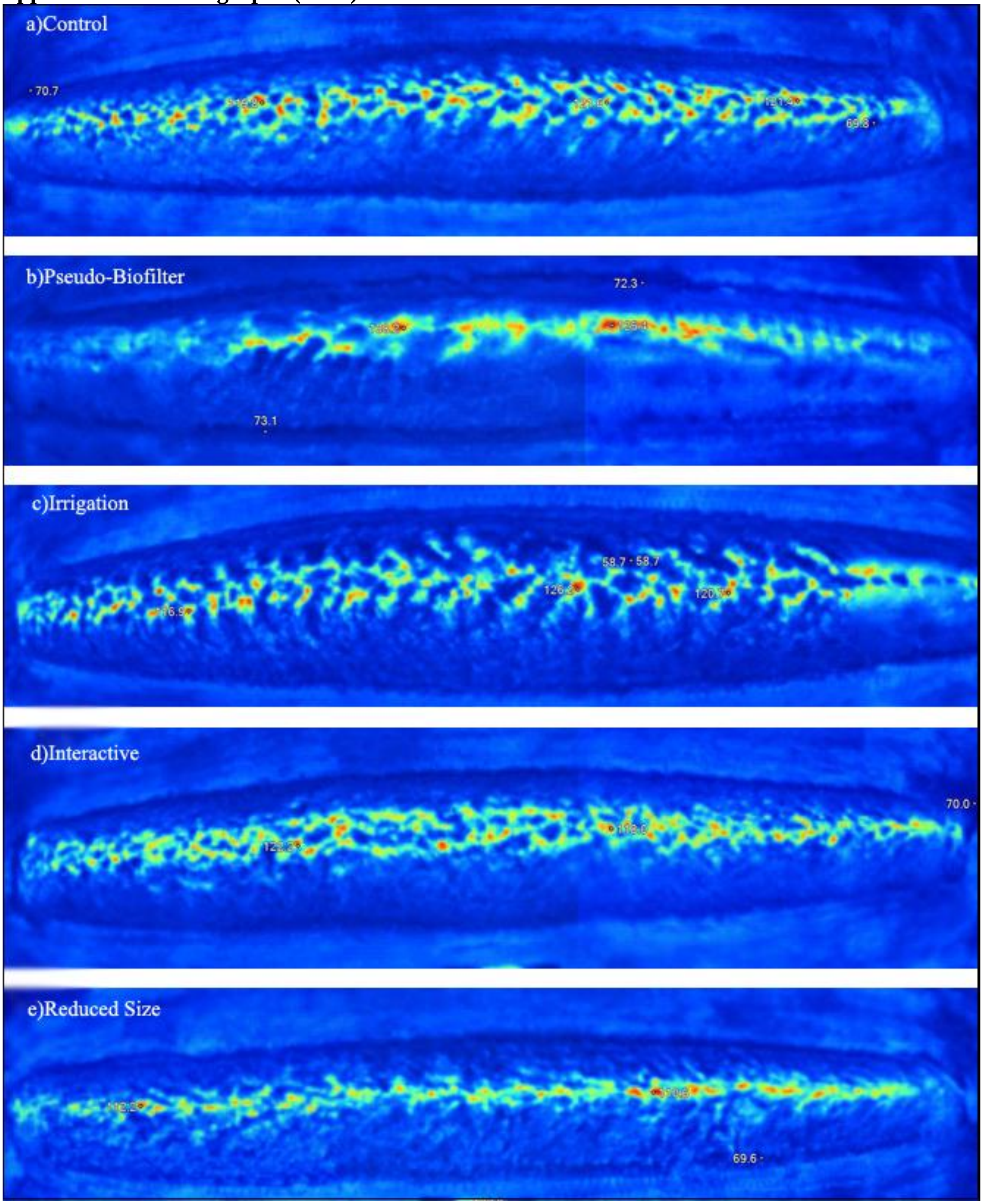

**Thermograph of windrows on July 6th.**

**Appendix K. Thermographs (cont.)**



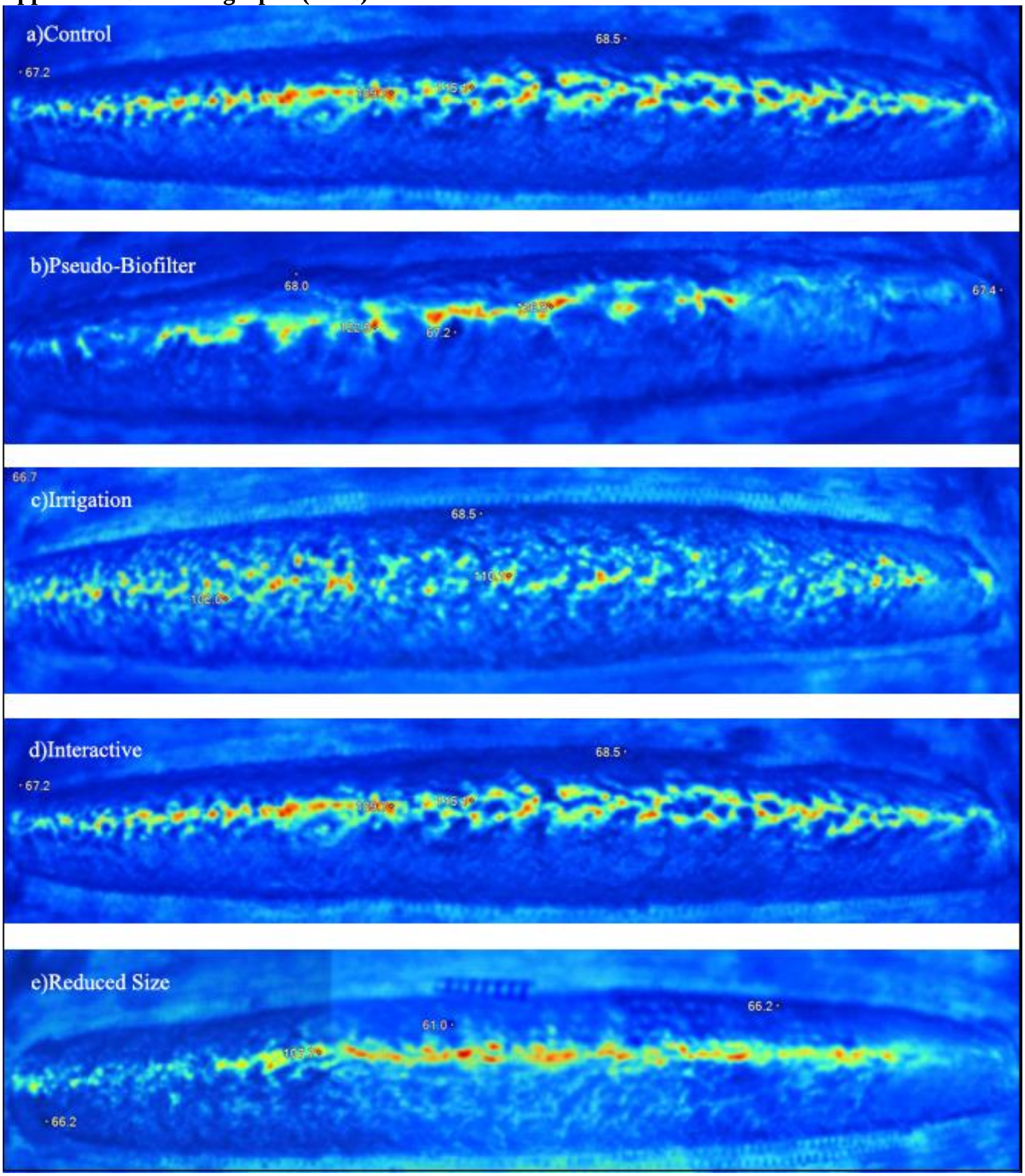

**Thermograph of windrows on July 13th. Due to the failure of the platform lift on this date, only two of the windrows could be scanned.**

## Appendix K. Thermographs (cont.)



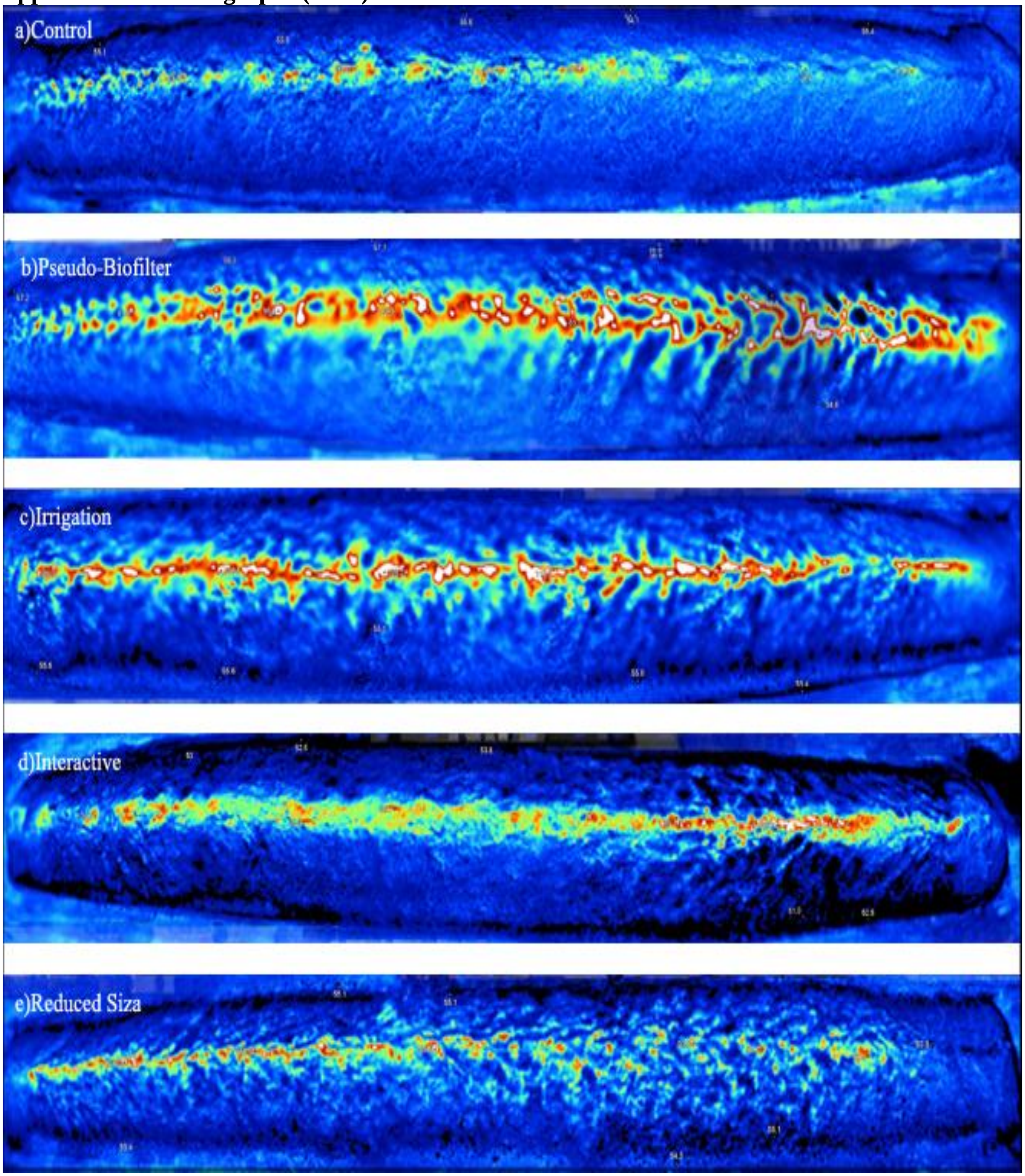

**Thermograph of windrows on July 18th.**

## Appendix K. Thermographs (cont.)



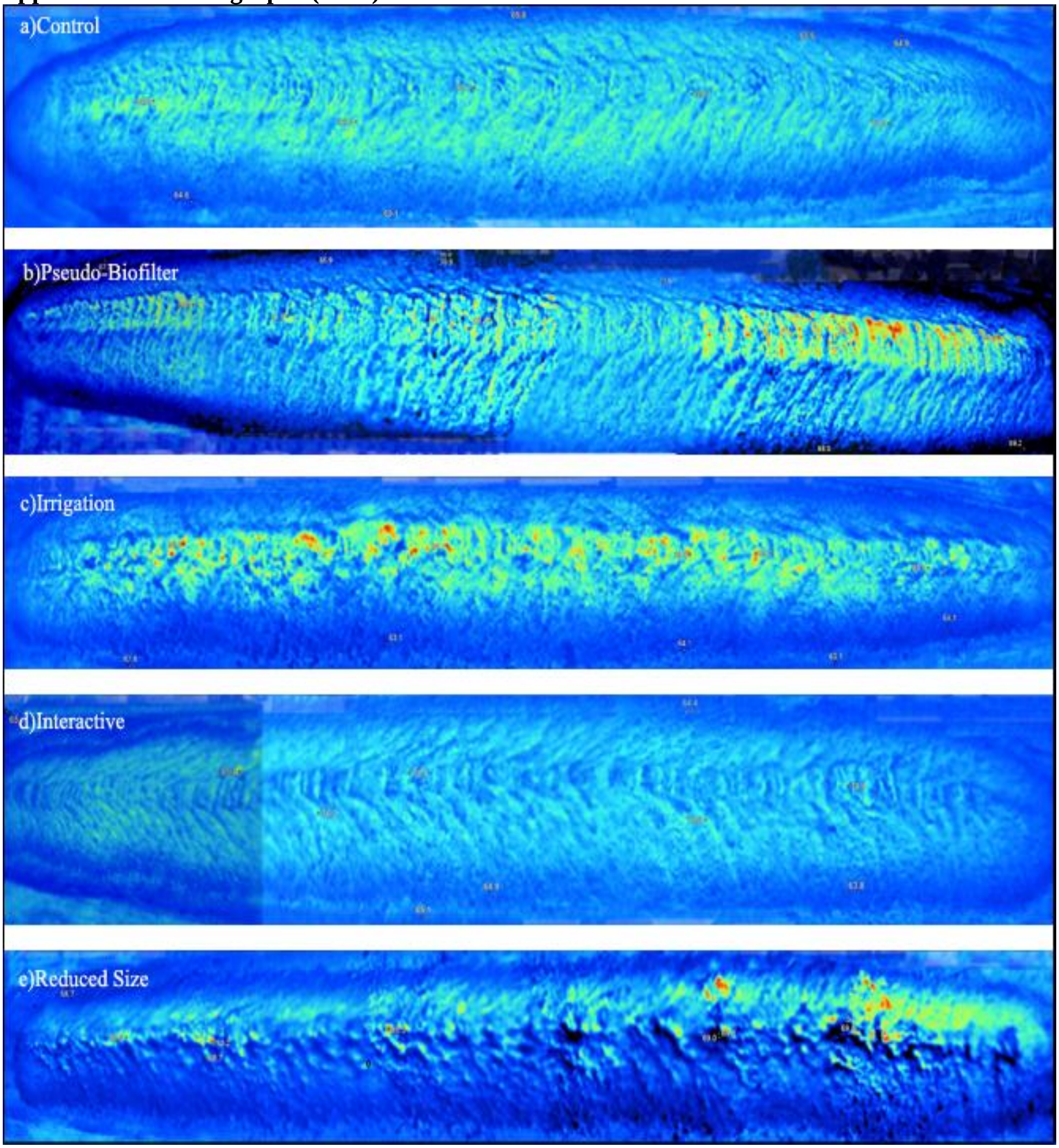

**Thermograph of windrows on July 27th.**

**Appendix K. Thermographs (cont.)**




**Thermograph of windrows on August 24th.**

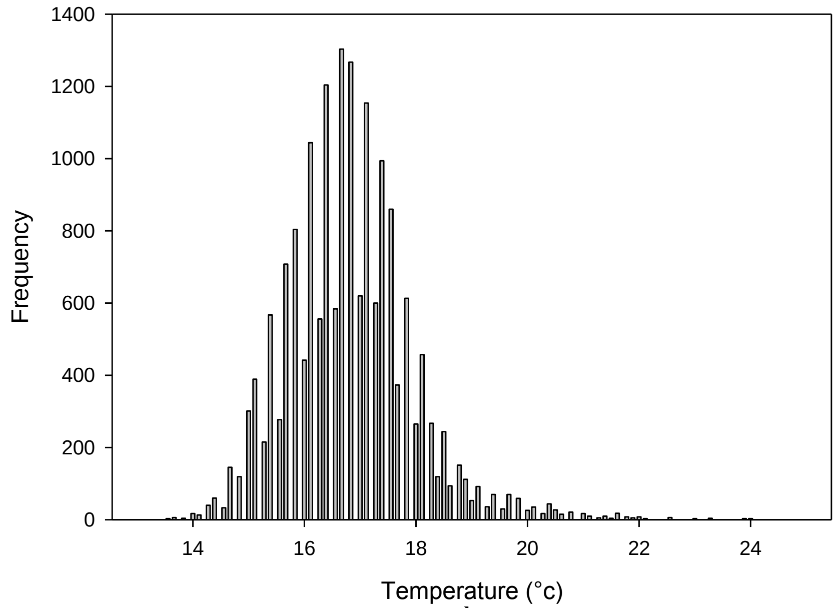
**Appendix K. Thermographs (cont.)**




**Thermograph of windrows on September 14th.**

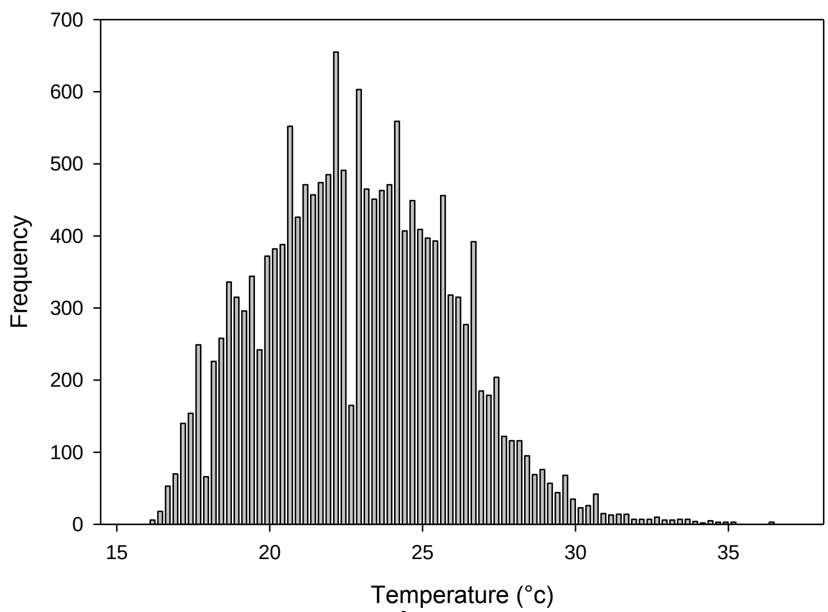
## Appendix L. Temperature Histograms

Control



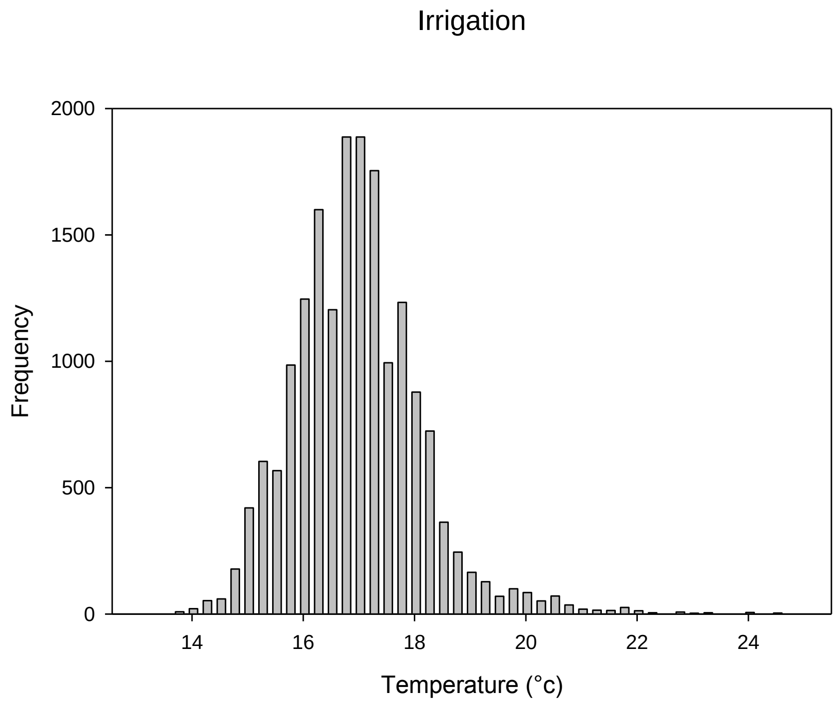

**Histograph on June 9th, Control Windrow**

Pseudo-Biofilter

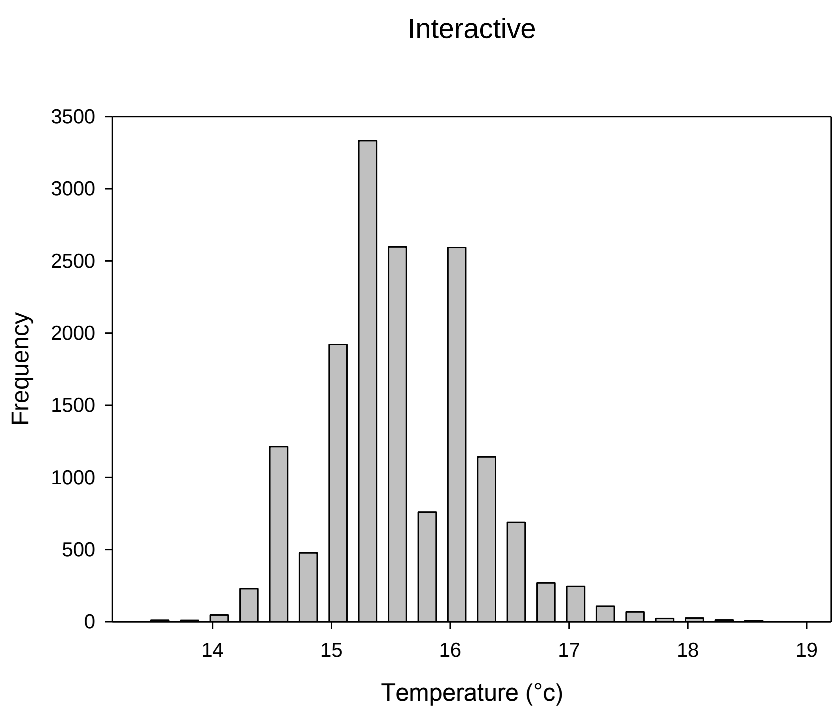



**Histograph on June 9th, Pseudo-Biofilter Windrow**

## Appendix L. Temperature Histograms (cont.)

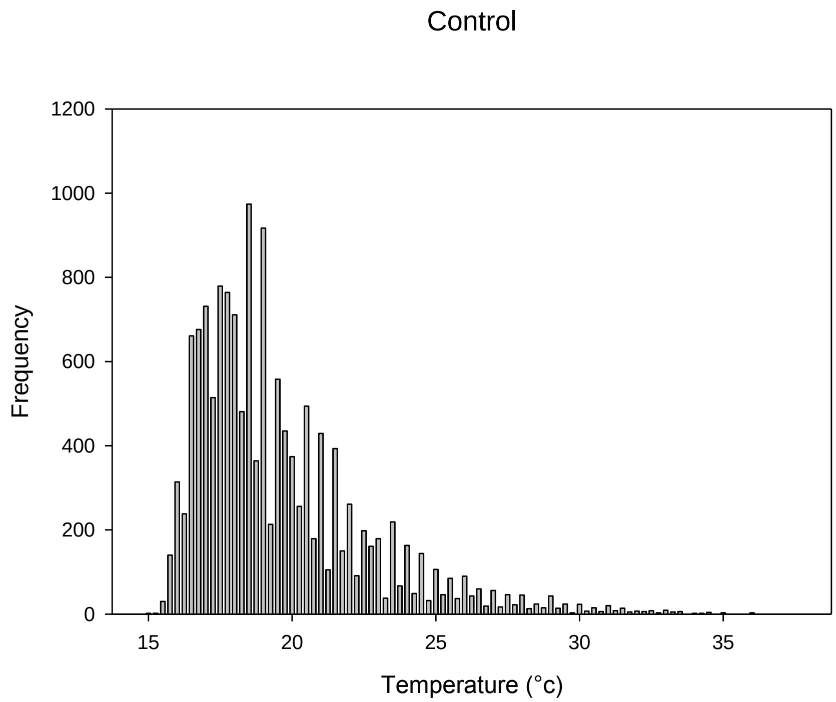



**Histograph on June 9th, Irrigation Windrow**

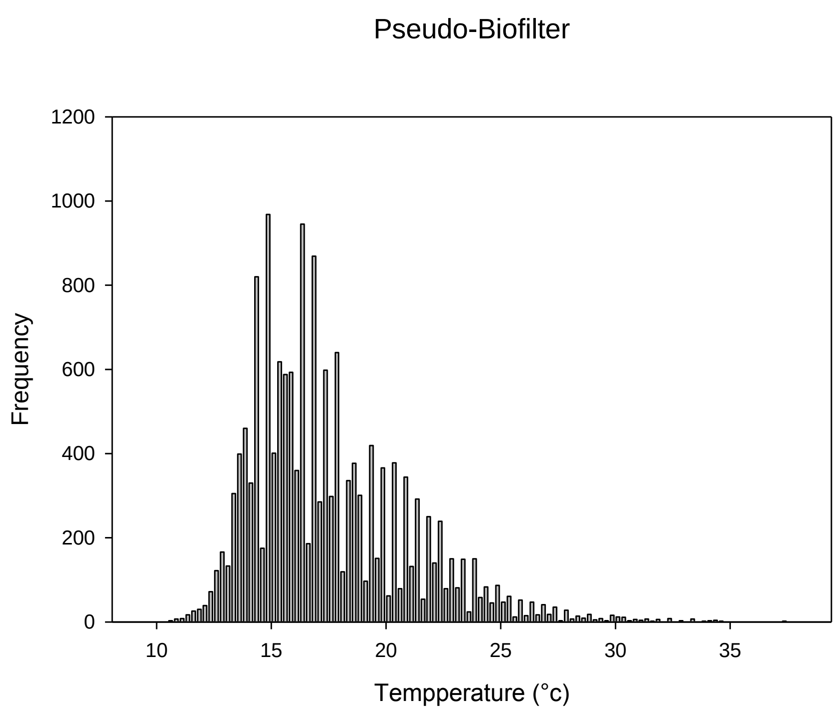



**Histograph on June 9th, Interactive Windrow**

## Appendix L. Temperature Histograms (cont.)

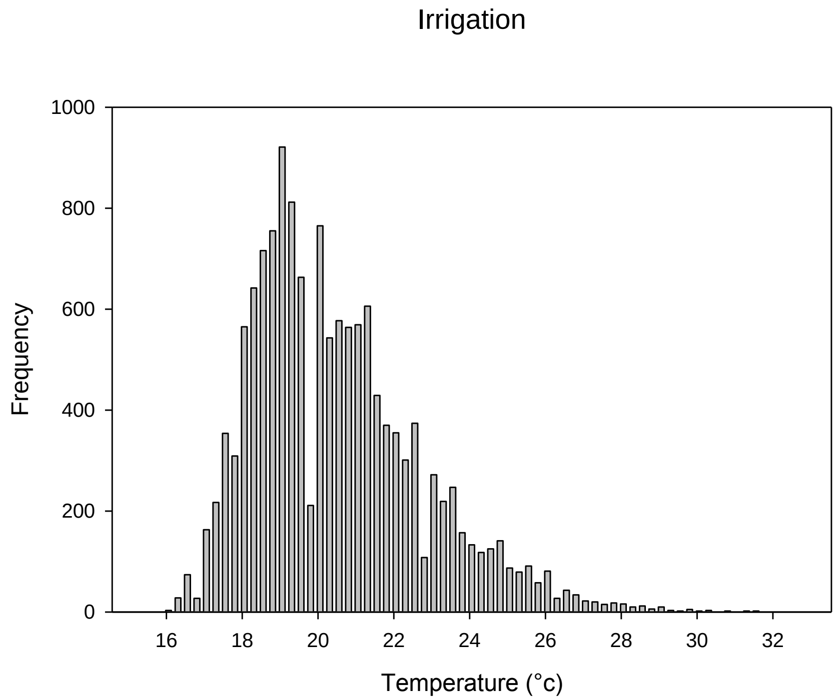



**Histograph on June 10th, Control Windrow**

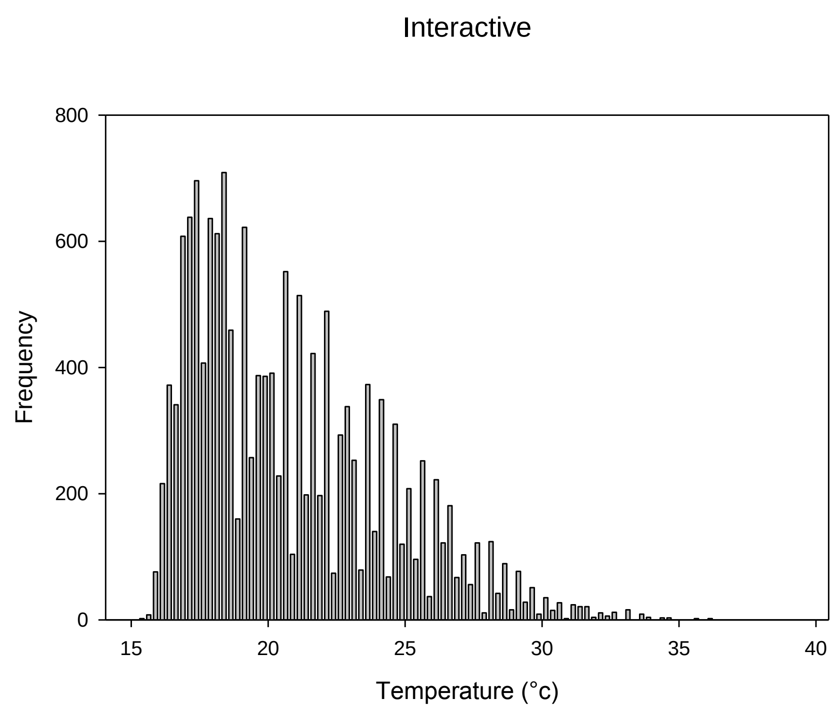



**Histograph on June 10th, Pseudo-Biofilter Windrow**

**Appendix L. Temperature Histograms (cont.)**

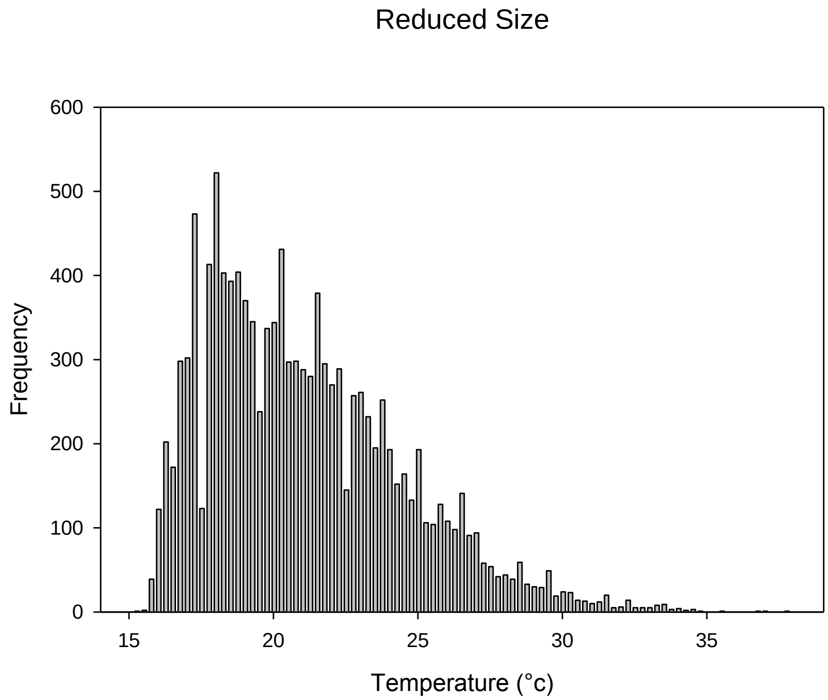



**Histograph on June 10th, Irrigation Windrow**

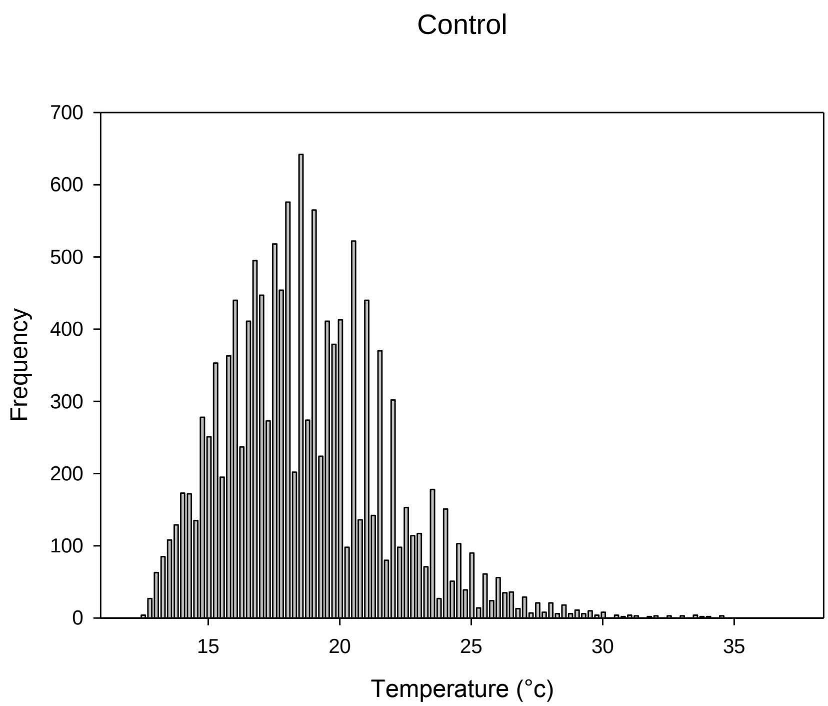



**Histograph on June 10th, Interactive Windrow**

**Appendix L. Temperature Histograms (cont.)**

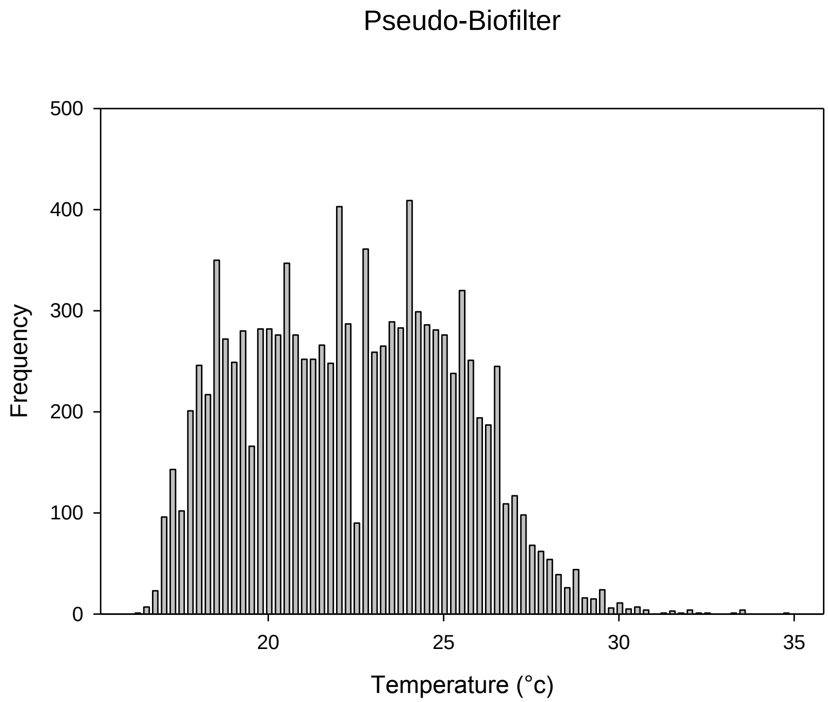



**Histograph on June 10th, reduced size windrow**

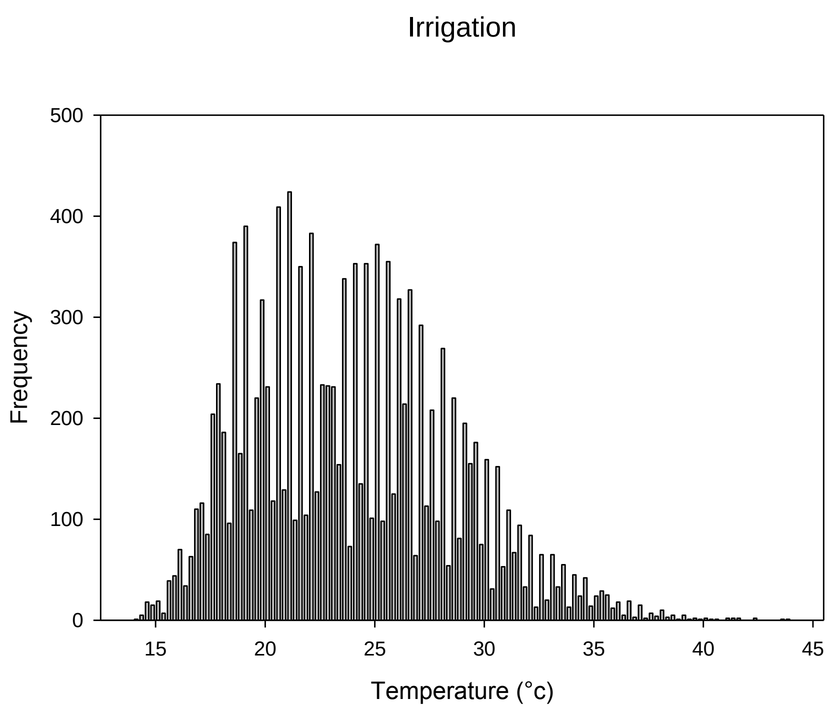



**Histograph on June 11th, control windrow**

## Appendix L. Temperature Histograms (cont.)



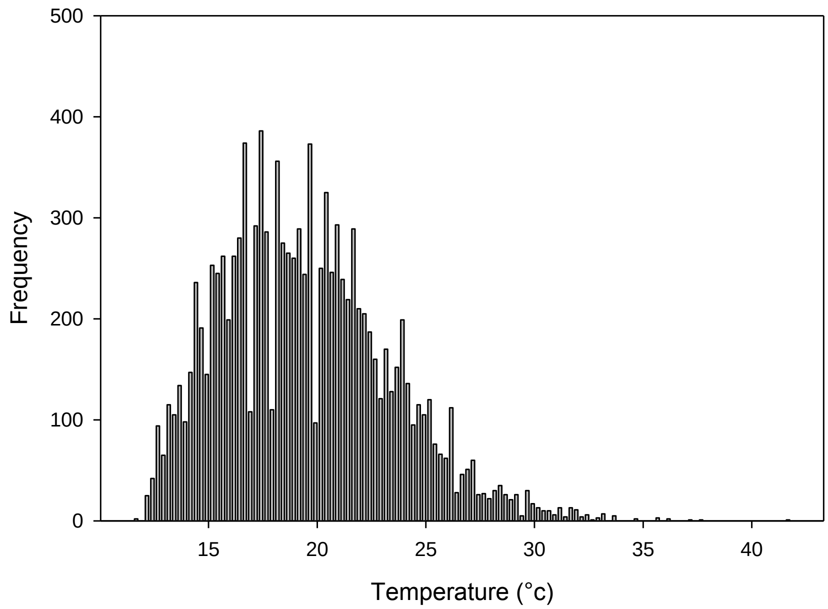

**Histograph on June 11th pseudo-biofilter windrow**




**Histograph on June 11th, irrigation windrow**

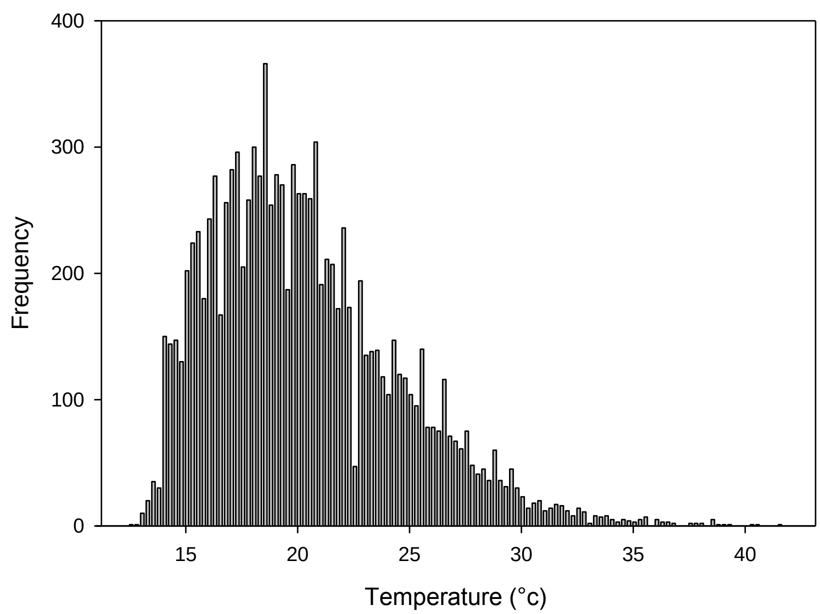
# Appendix L. Temperature Histograms (cont.)

Interactive

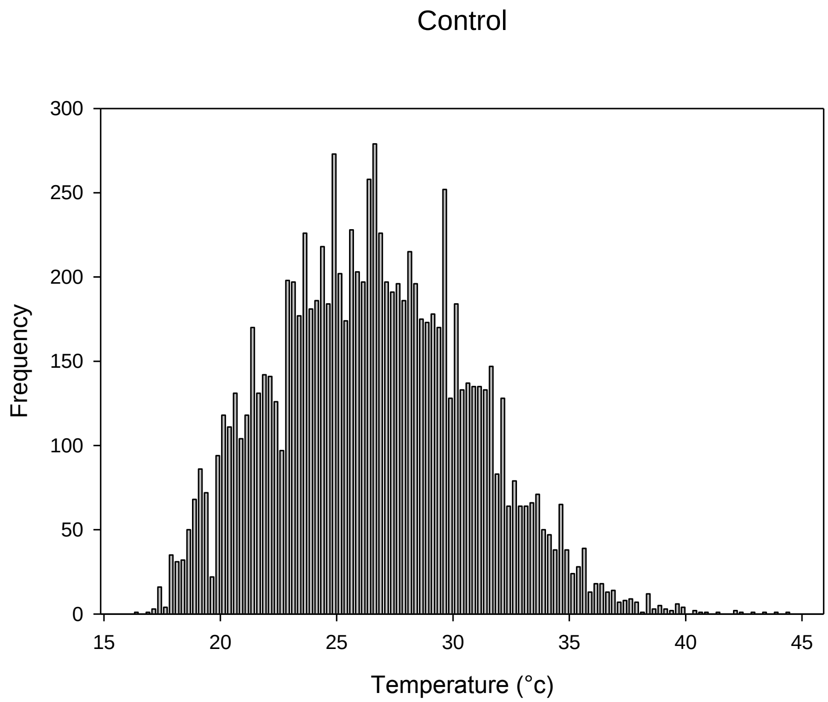



**Histograph on June 11th, interactive windrow**

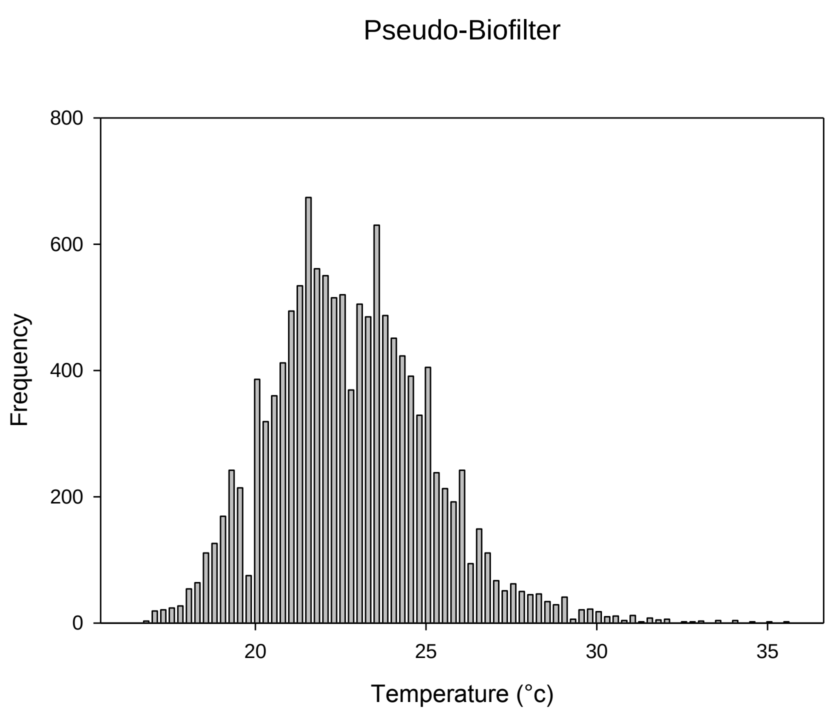
Reduced Size




**Histograph on June 11th, reduced-size windrow**

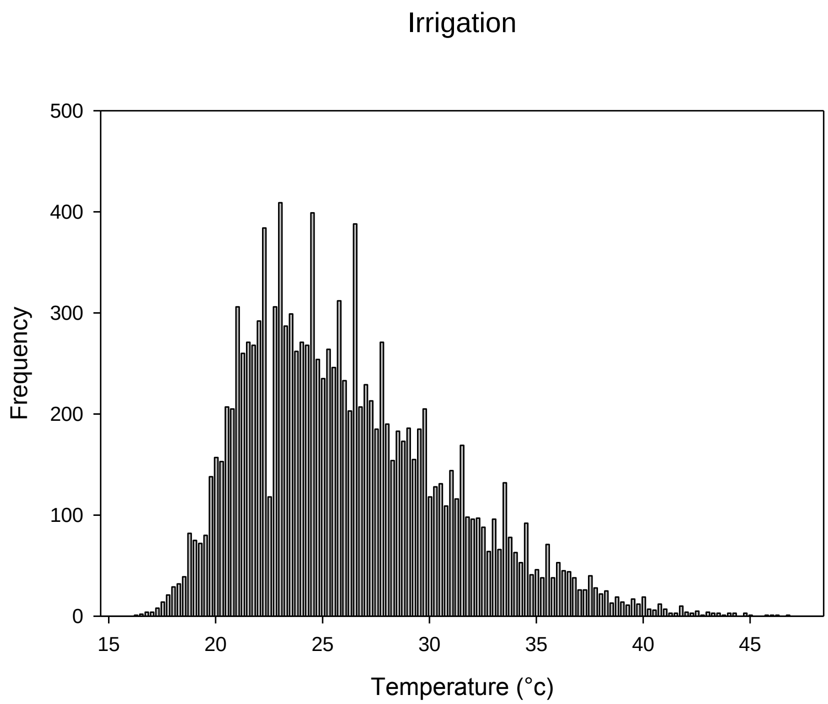



**Histograph on June 12th, control windrow**

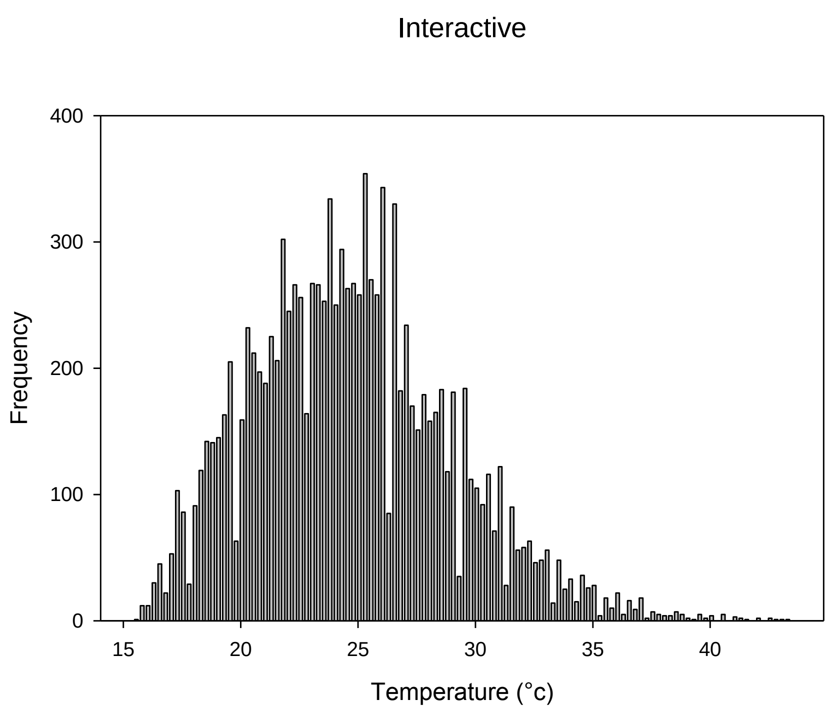



**Histograph on June 12th, pseudo-biofilter windrow**

## Appendix L. Temperature Histograms (cont.)



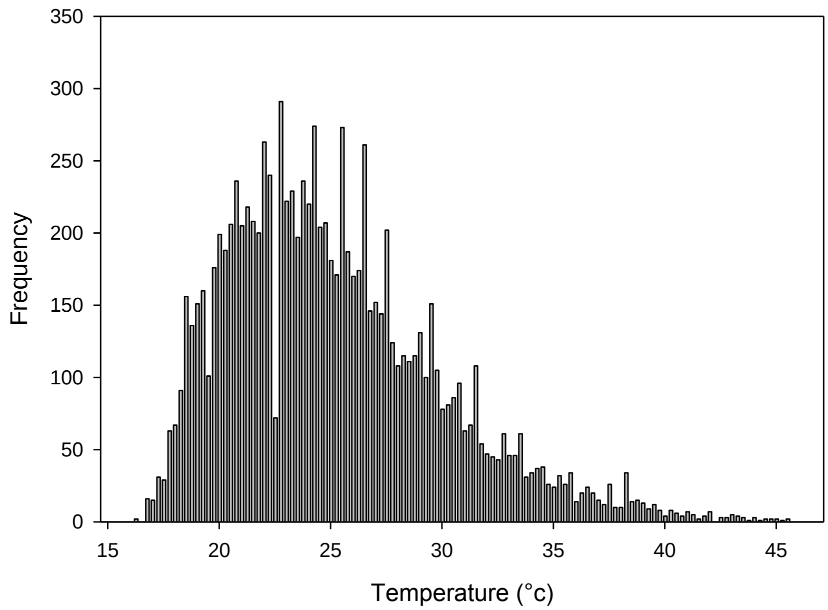

**Histograph on June 12th, irrigation windrow**




**Histograph on June 12th, interactive windrow**

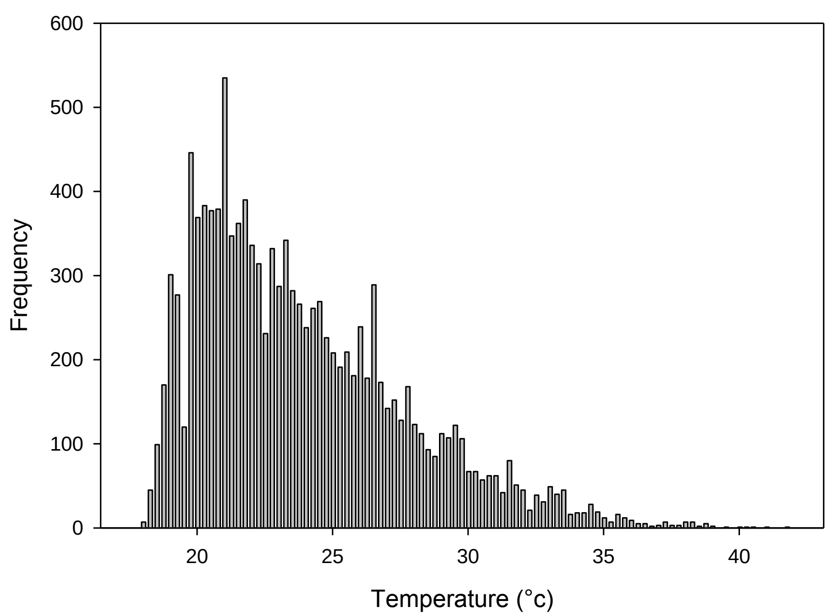
**Appendix L. Temperature Histograms (cont.)**

Reduced Size

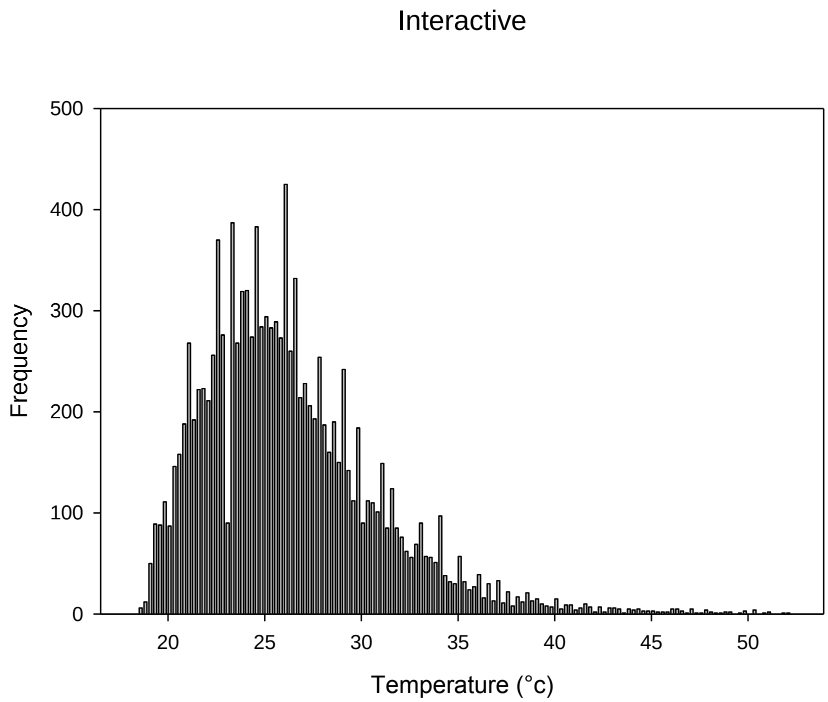



**Histograph on June 12th, reduced-size windrow**

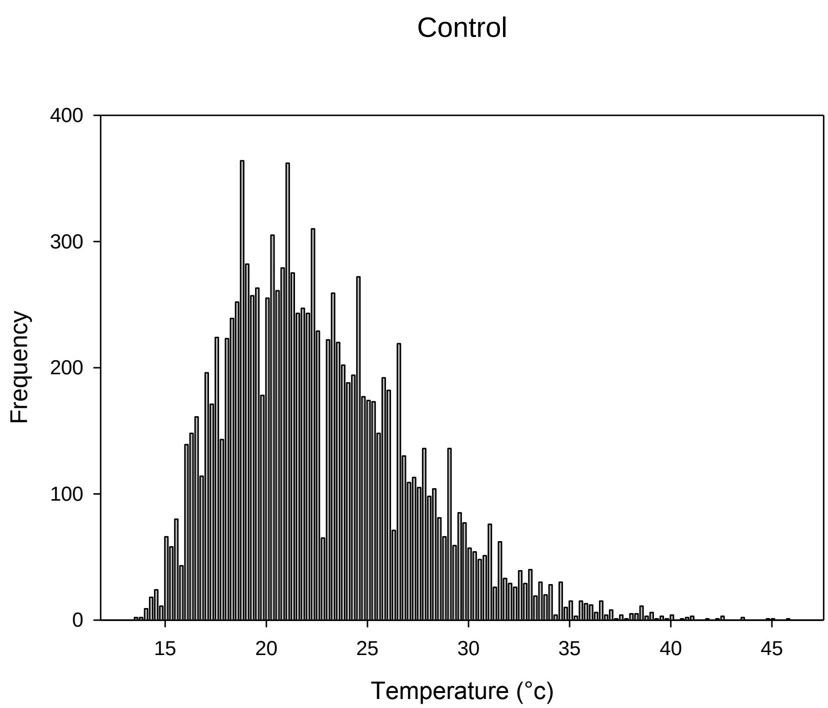
Control




**Histograph on June 13th, control windrow**



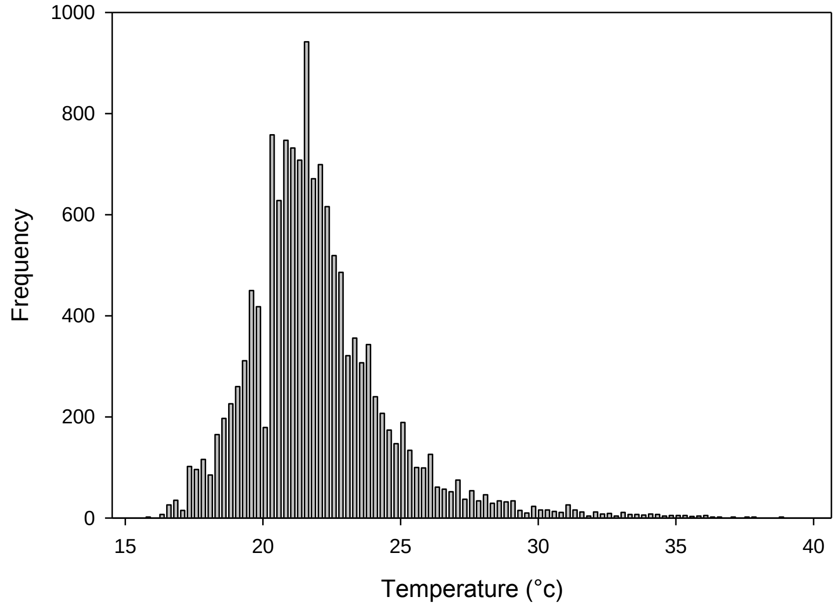

**Histograph on June 13th, interactive windrow**




**Histograph on June 14th, control windrow**

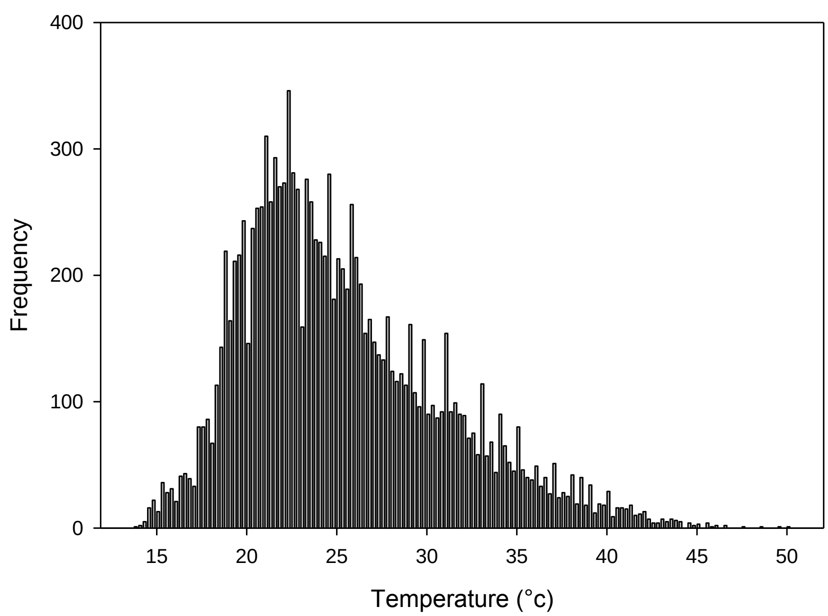
## Appendix L. Temperature Histograms (cont.)

Pseudo-Biofilter



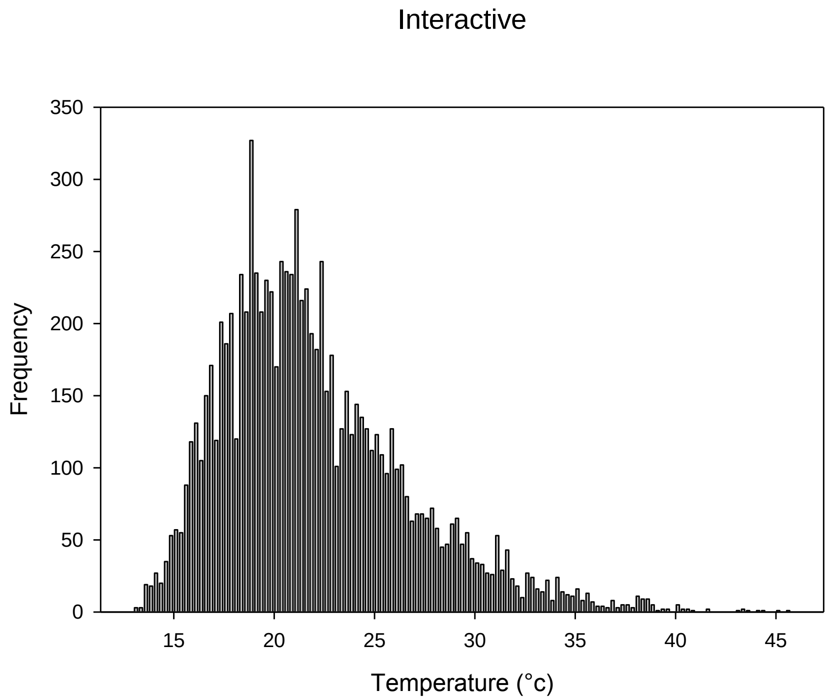

**Histograph on June 14th, pseudo-biofilter windrow**

Irrigation

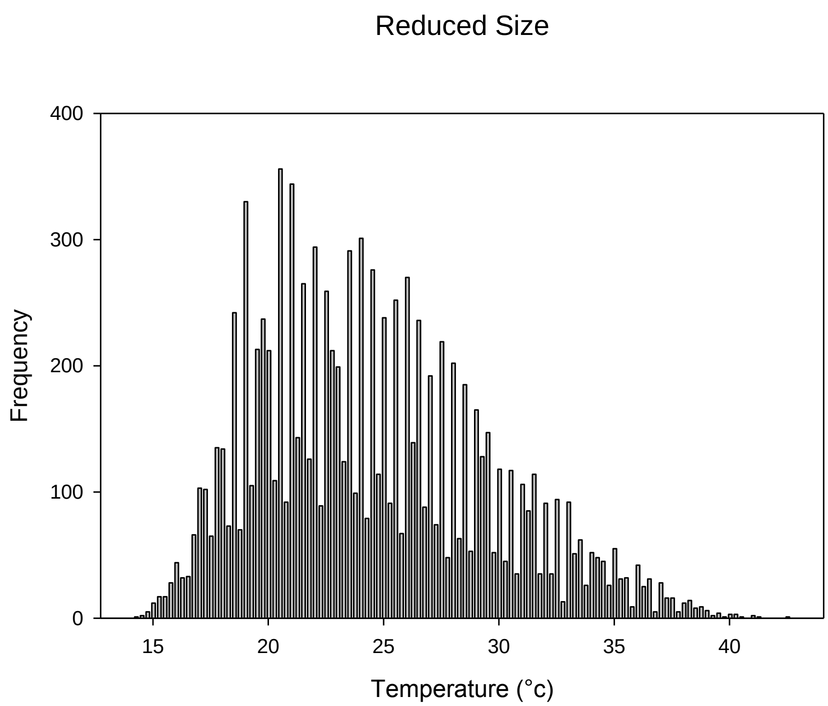



**Histograph on June 14th, irrigation windrow**

## Appendix L. Temperature Histograms (cont.)

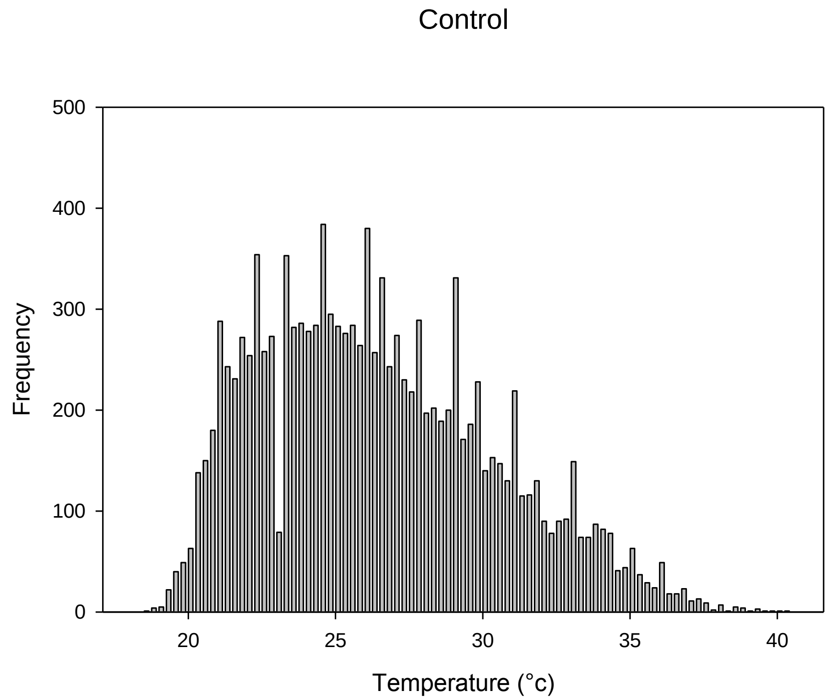



**Histograph on June 14th, interactive windrow**

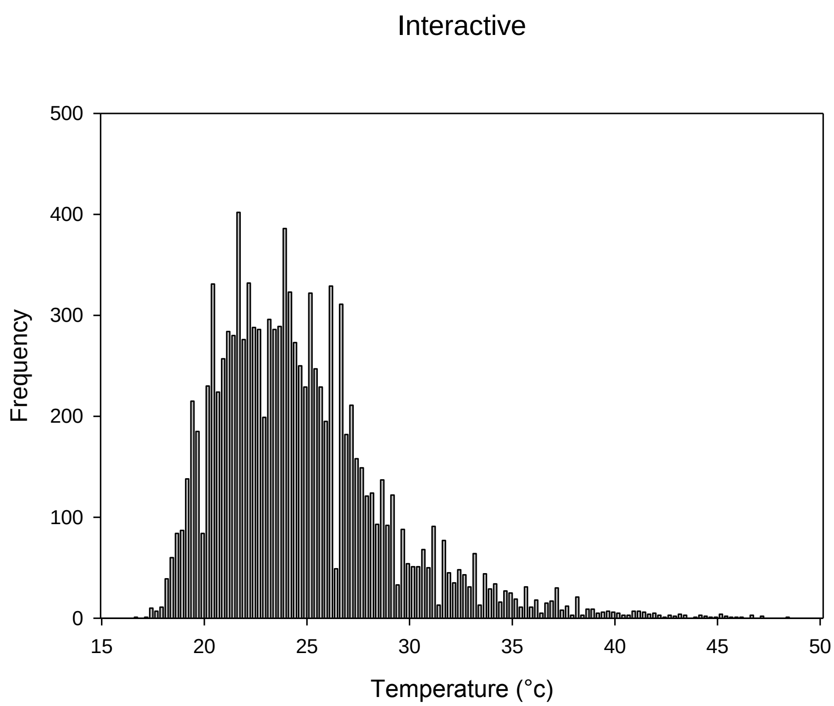



**Histograph on June 14th, reduced size windrow**

## Appendix L. Temperature Histograms (cont.)

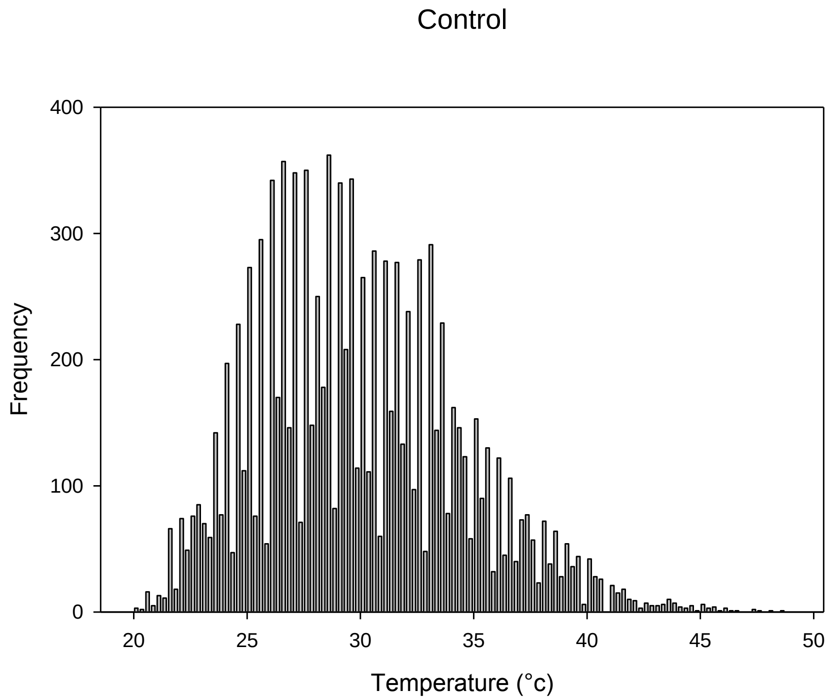



**Histograph on June 15th, control windrow**

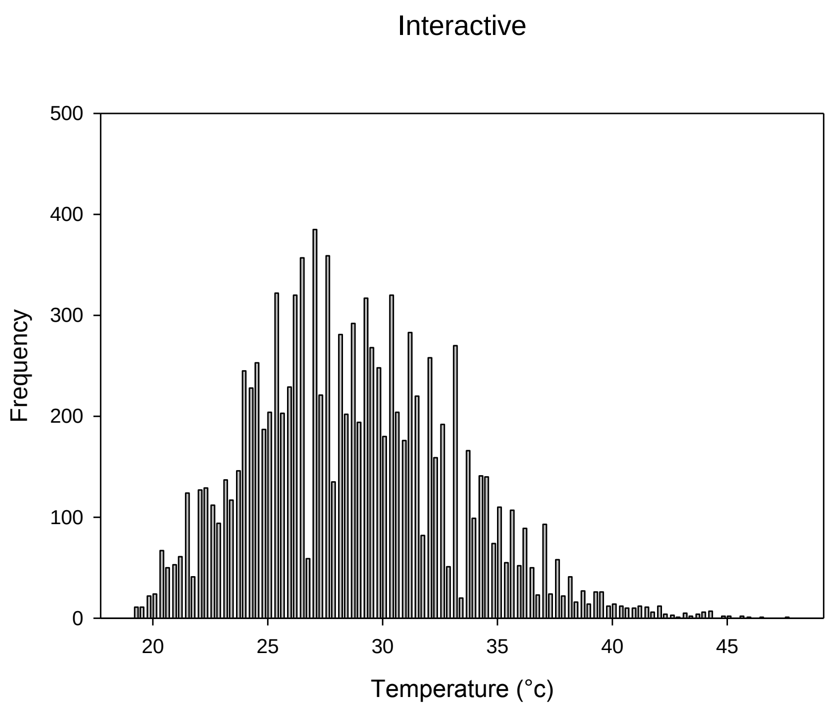



**Histograph on June 15th, interactive windrow**

**Appendix L. Temperature Histograms (cont.)**

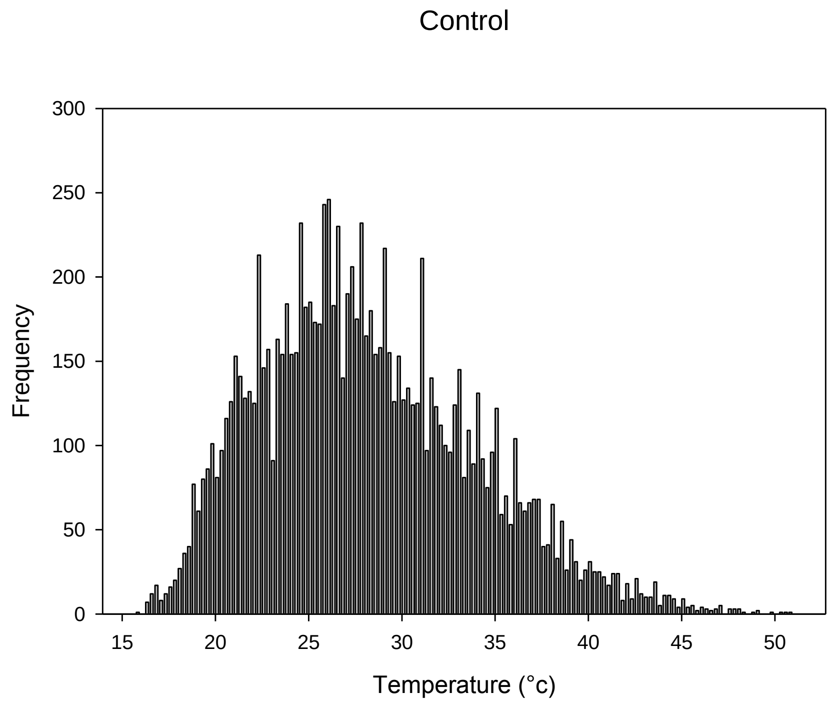



**Histograph on June 16th, control windrow**

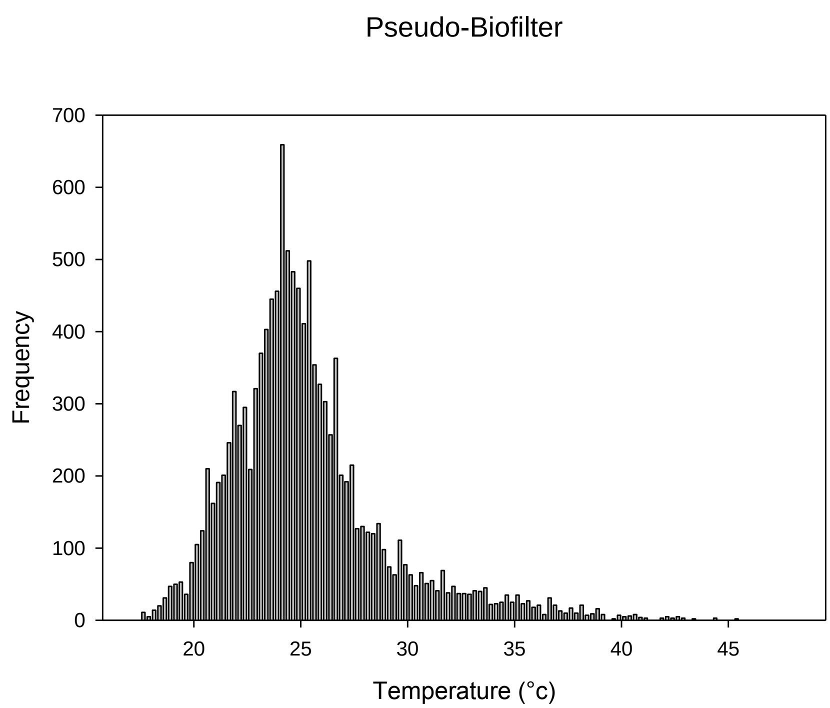



**Histograph on June 16th, interactive windrow**

**Appendix L. Temperature Histograms (cont.)**



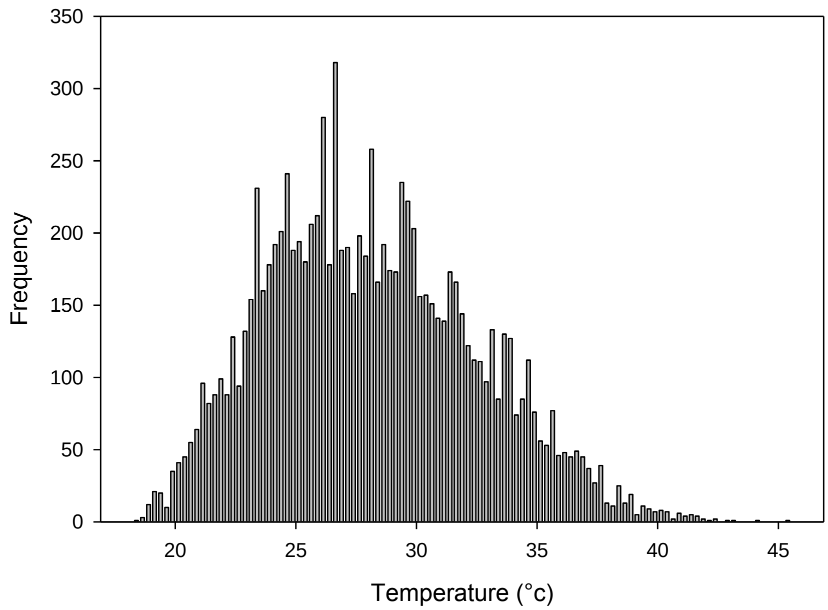

**Histograph on June 17th, control windrow**




**Histograph on June 17th, pseudo-biofilter windrow**

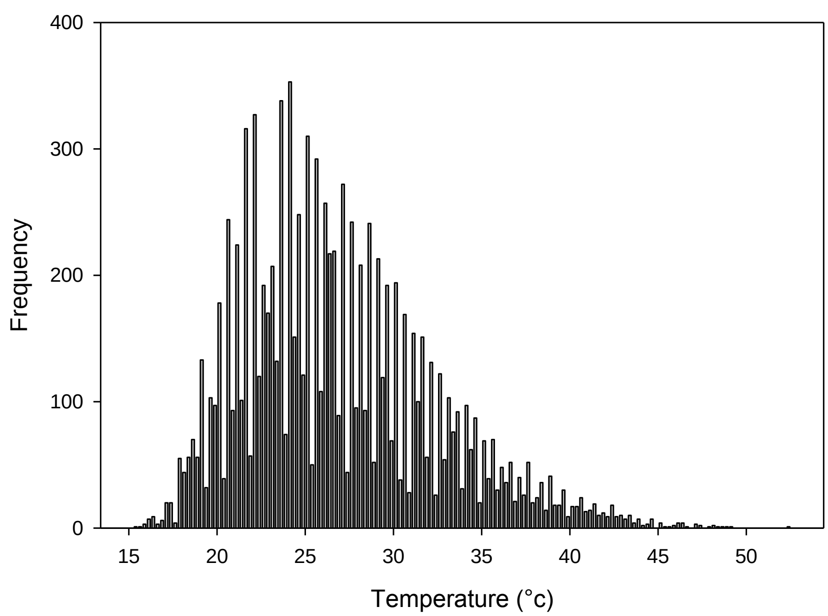
## Appendix L. Temperature Histograms (cont.)

Irrigation




**Histograph on June 17th, irrigation windrow**

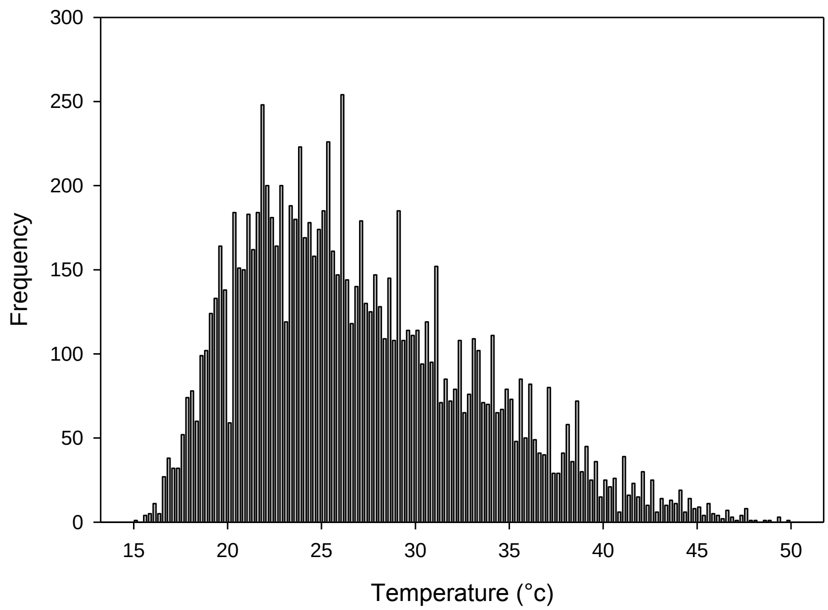
Interactive




**Histograph on June 17th, interactive ewindrow**

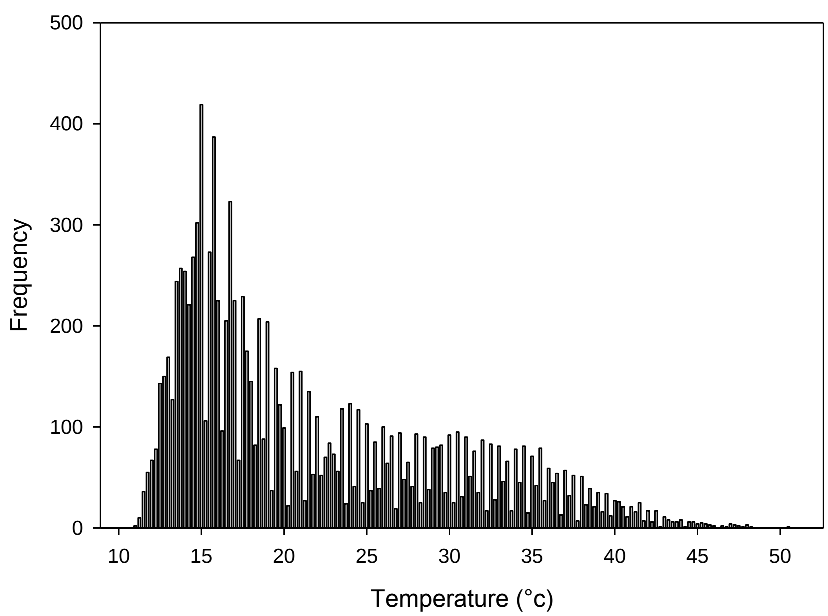
**Appendix L. Temperature Histograms (cont.)**

Reduced Size



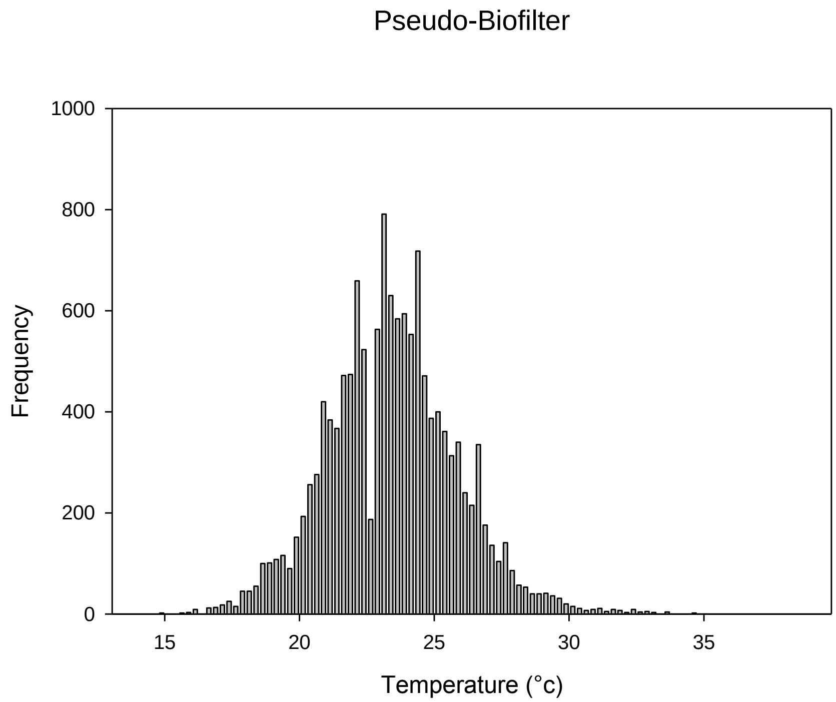

**Histograph on June 17th, reduced size windrow**

Control

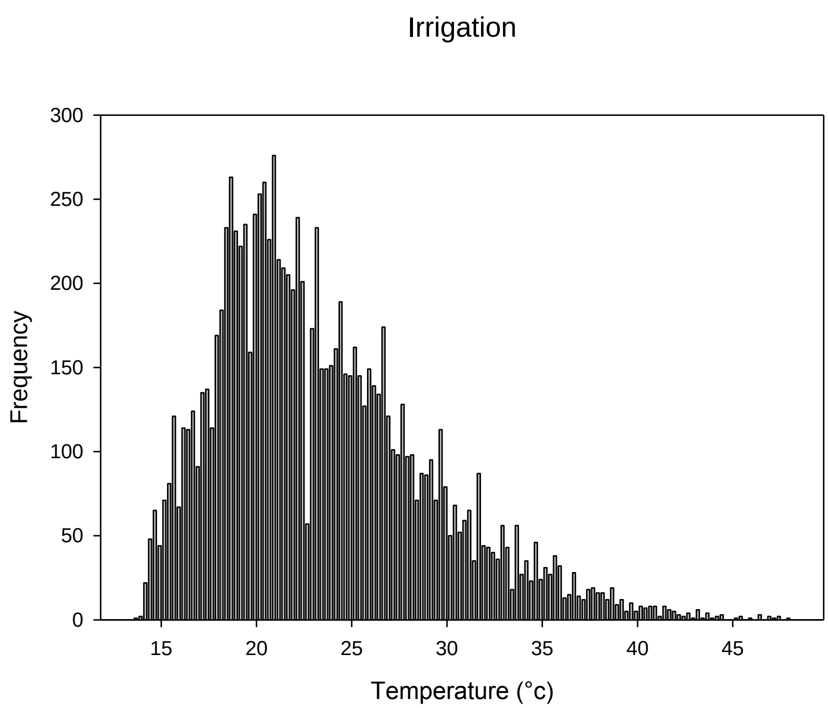



**Histograph on June 22th, control windrow**

**Appendix L. Temperature Histograms (cont.)**

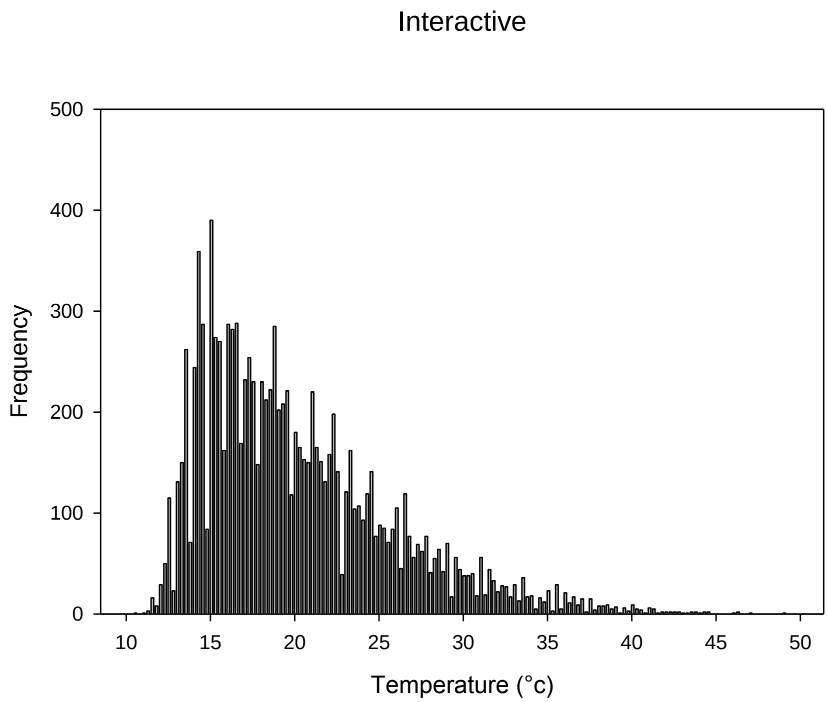



**Histograph on June 22th, pseudo-biofilter windrow**

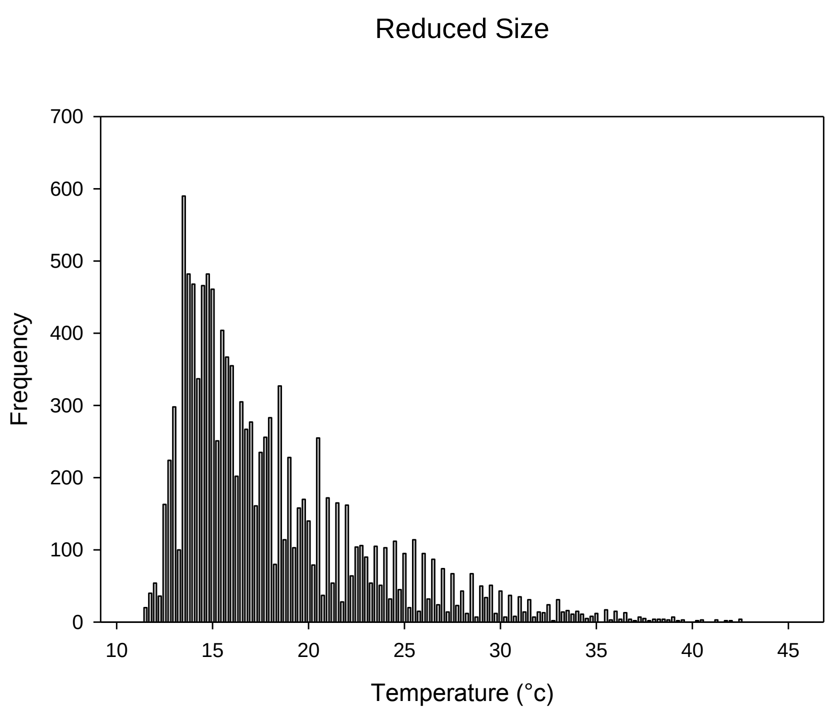



**Histograph on June 22th, irrigation windrow**

## Appendix L. Temperature Histograms (cont.)

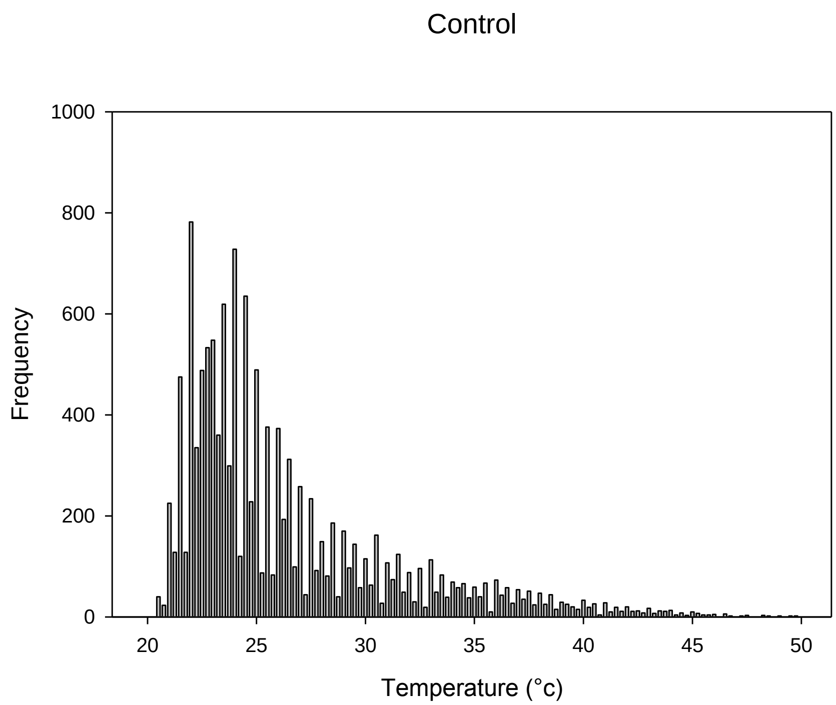



**Histograph on June 22$^{th}$, interactive windrow**

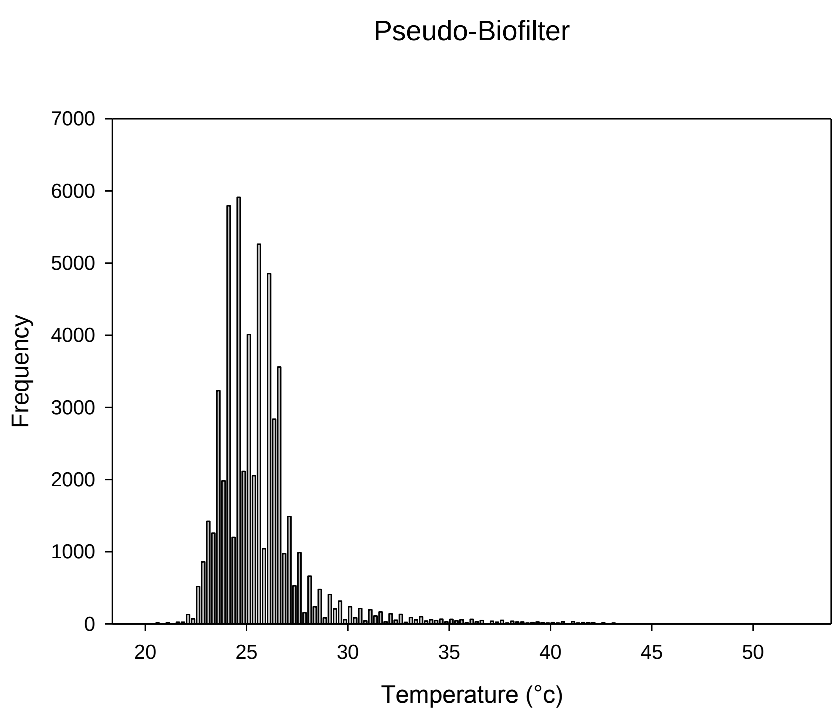



**Histograph on June 22$^{th}$, reduced size windrow**

## Appendix L. Temperature Histograms (cont.)

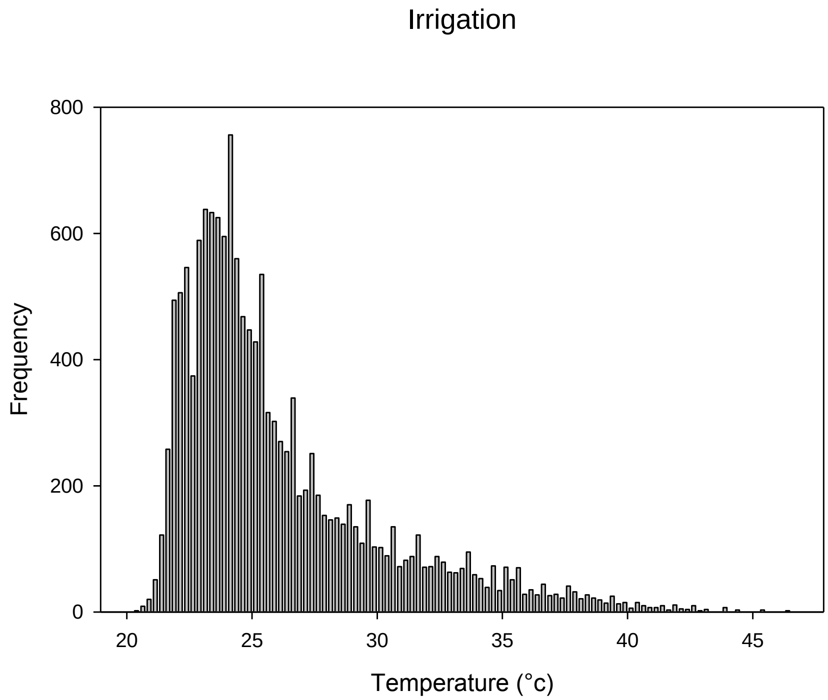



**Histograph on June 29th, control windrow**

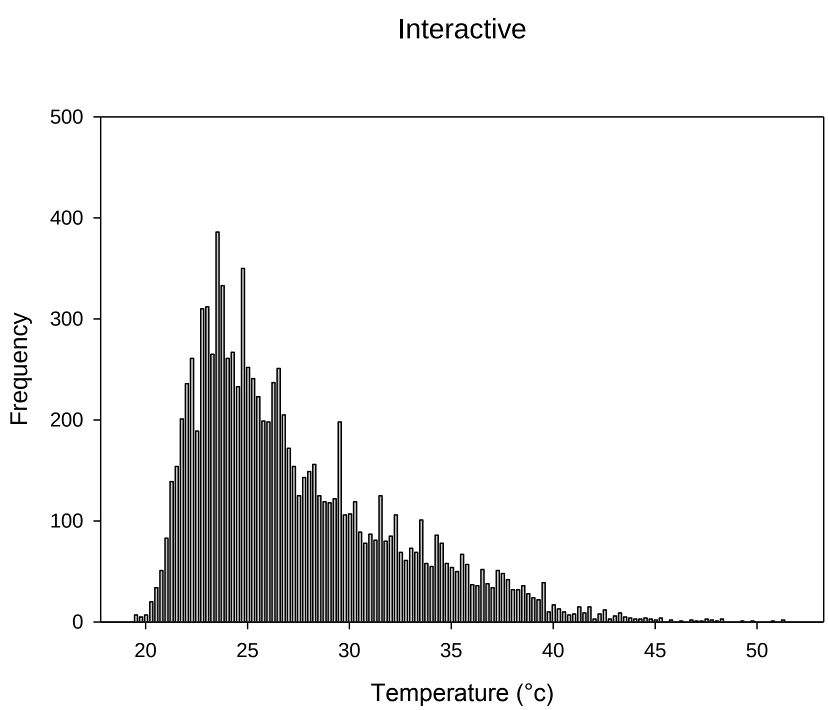



**Histograph on June 29th, pseudo-biofilter windrow**

## Appendix L. Temperature Histograms (cont.)

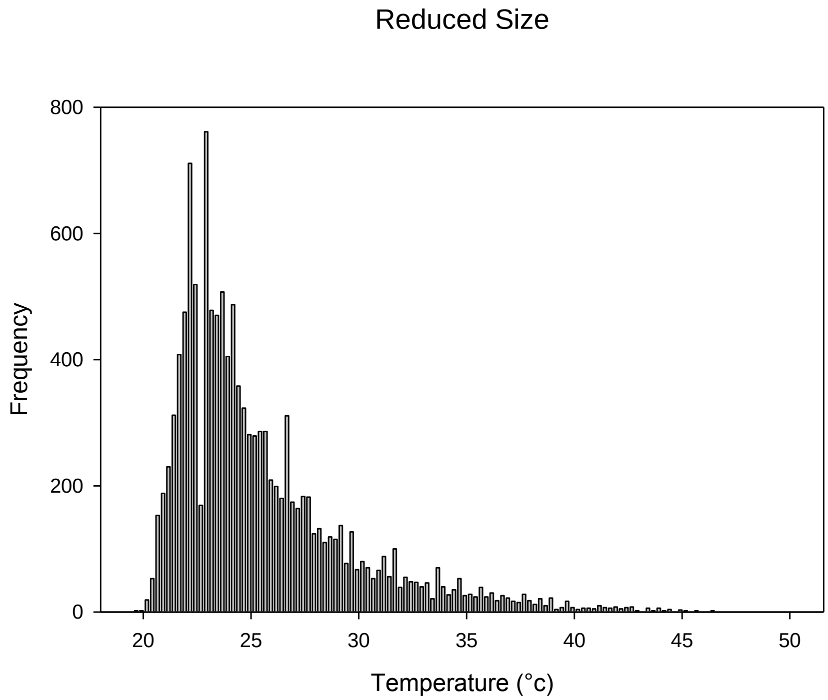



**Histograph on June 29th, irrigation windrow**

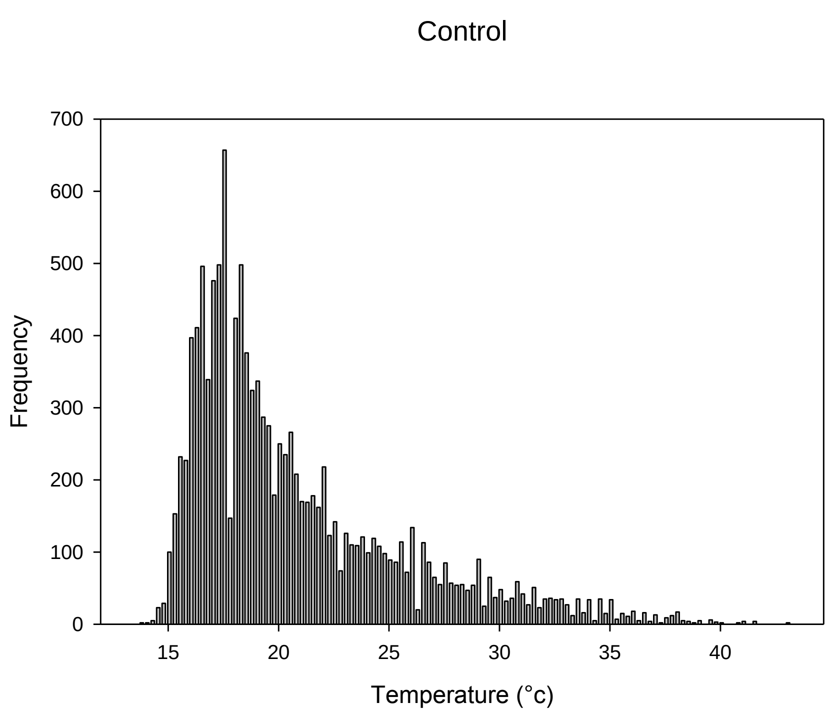



**Histograph on June 29th, interactive windrow**

## Appendix L. Temperature Histograms (cont.)

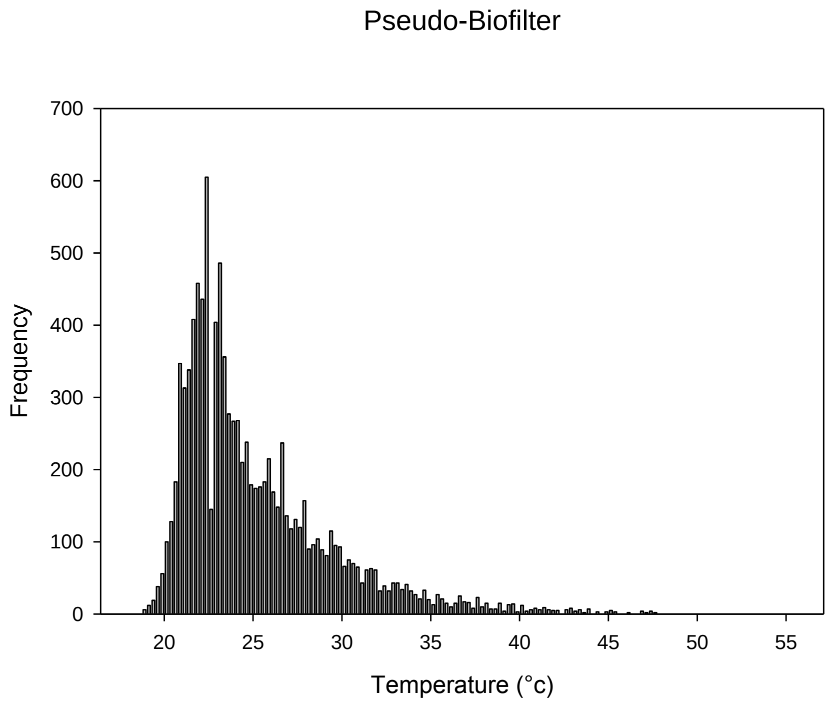



**Histograph on June 29th, reduced size windrow**

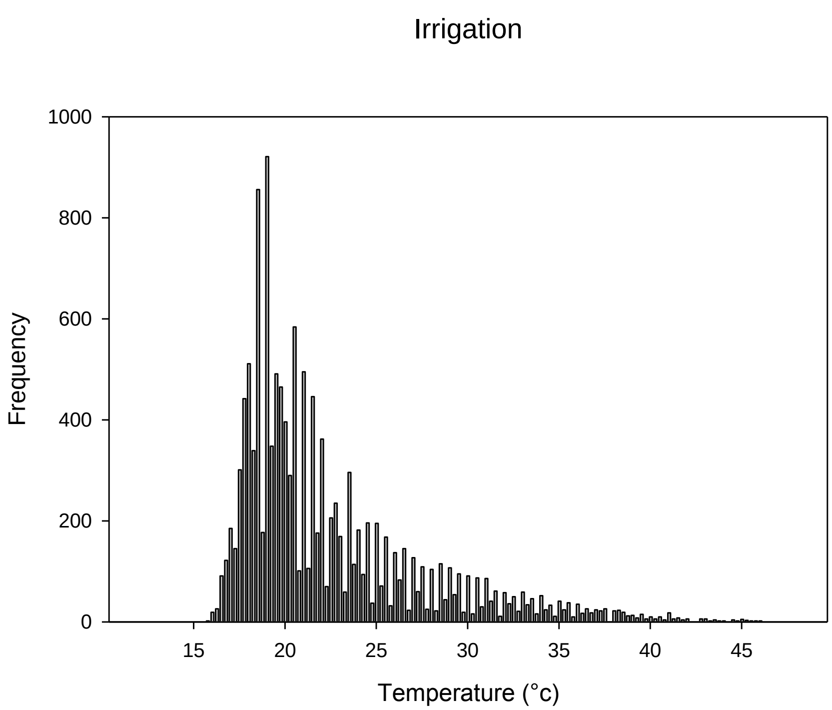



**Histograph on July 6th, control windrow**

## Appendix L. Temperature Histograms (cont.)

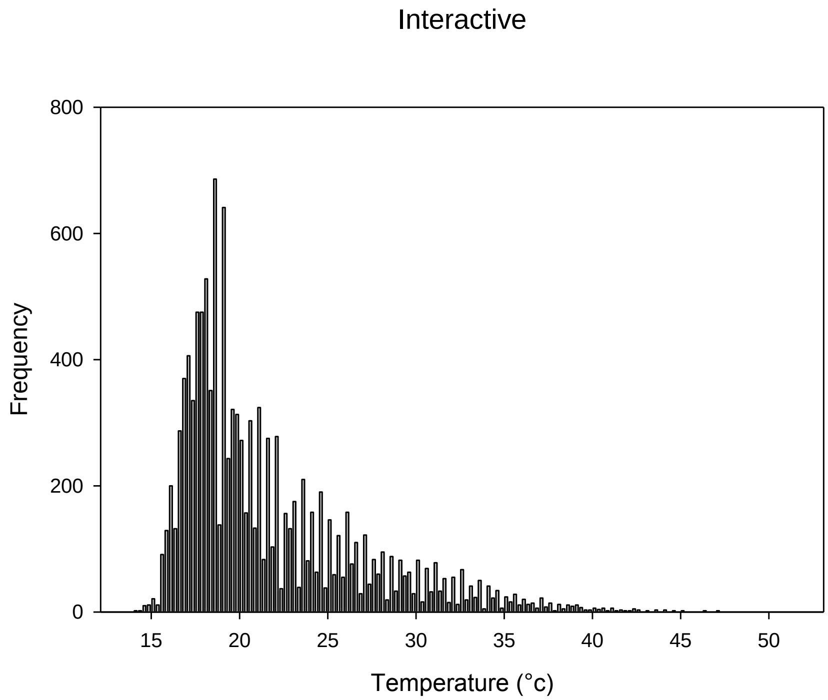



**Histograph on July 6th, pseudo-biofilter windrow**

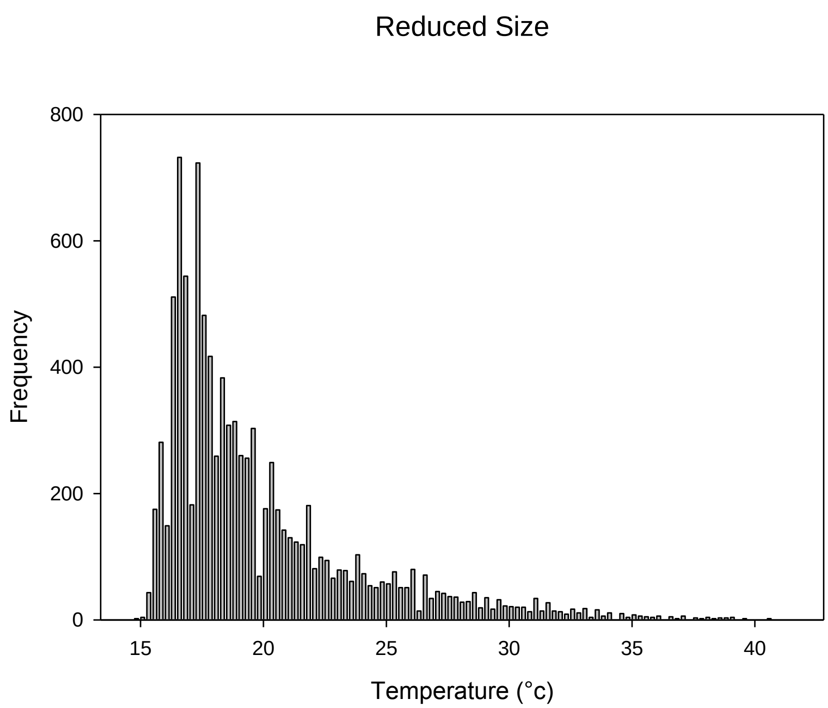



**Histograph on July 6th, irrigation windrow**

## Appendix L. Temperature Histograms (cont.)

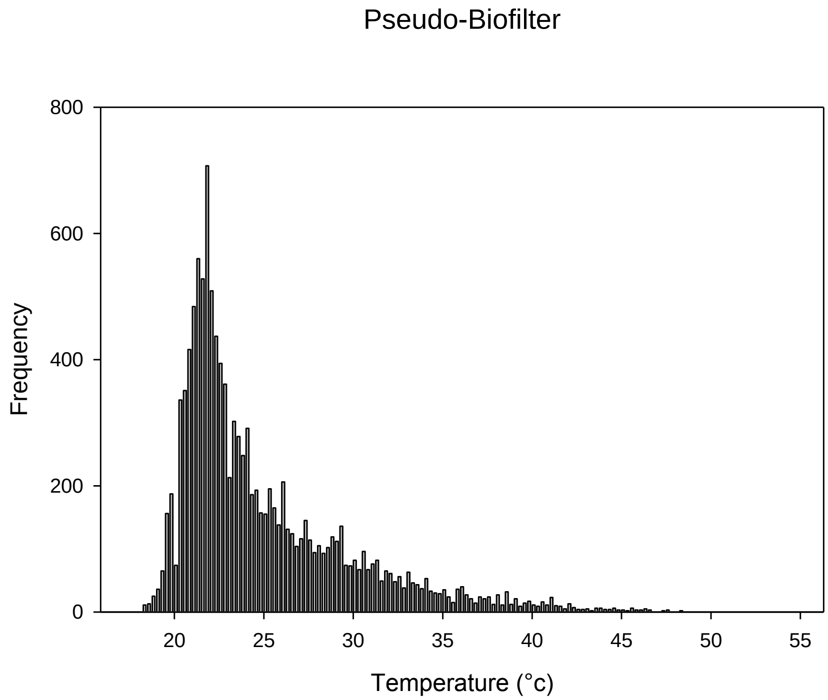



**Histograph on July 6th, interactive windrow**

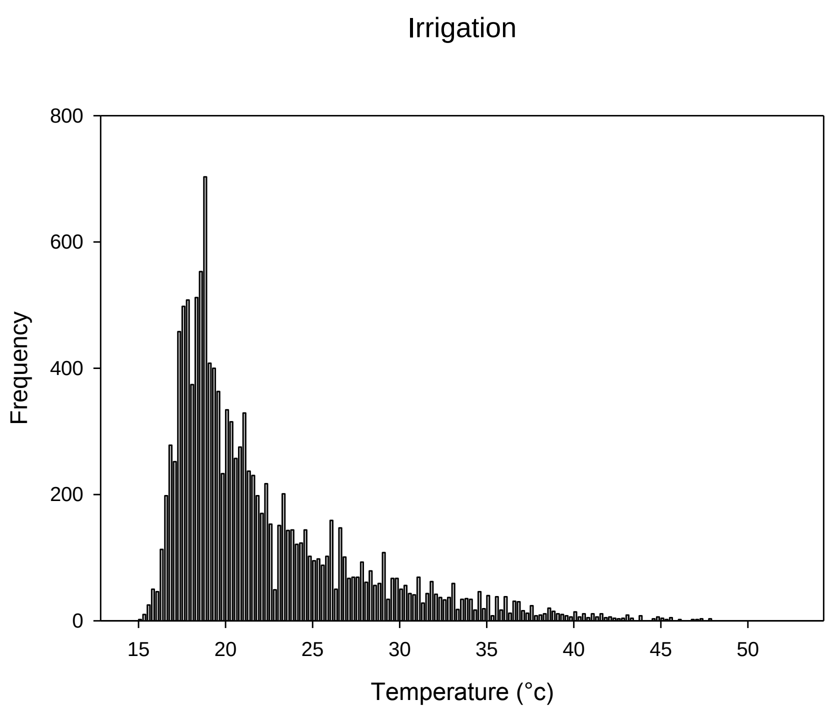



**Histograph on July 6th, reduced size windrow**

## Appendix L. Temperature Histograms (cont.)



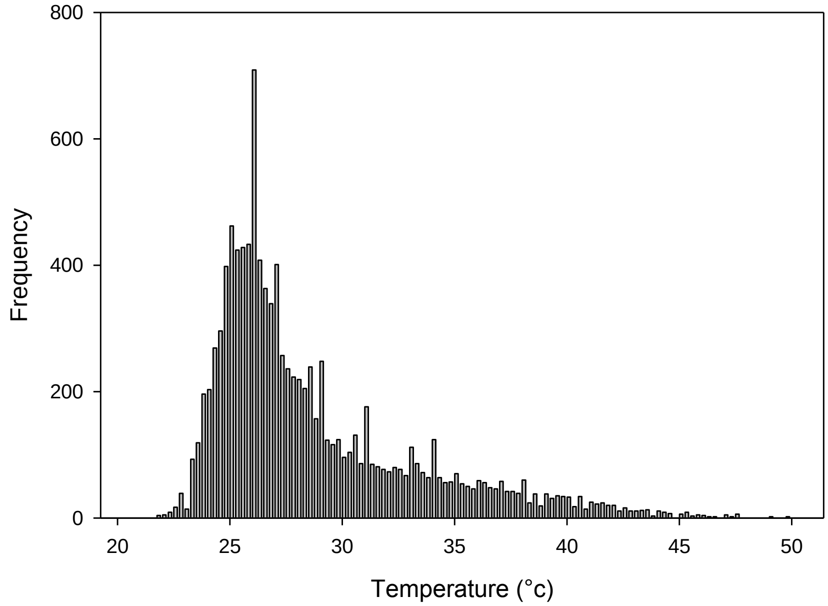

**Histograph on July 13th, control windrow**




**Histograph on July 13th, irrigation windrow**

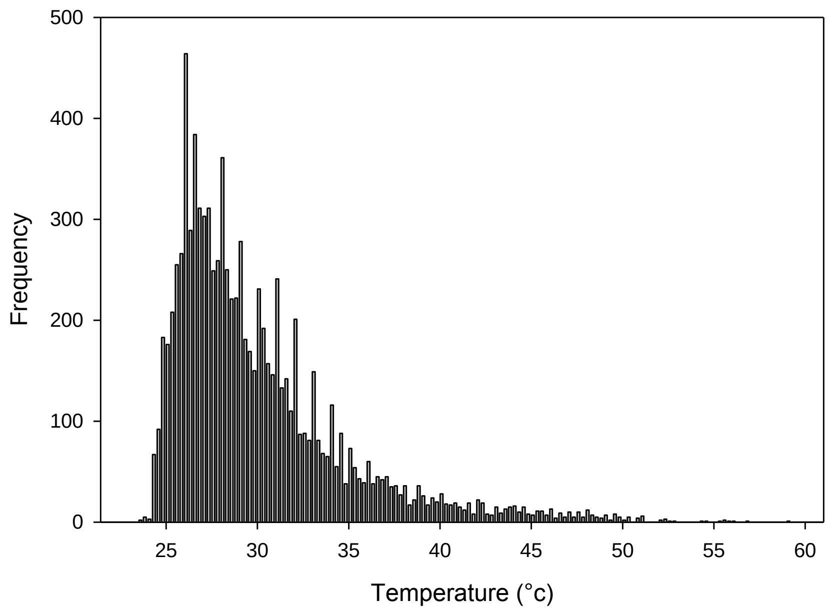
## Appendix L. Temperature Histograms (cont.)

Control



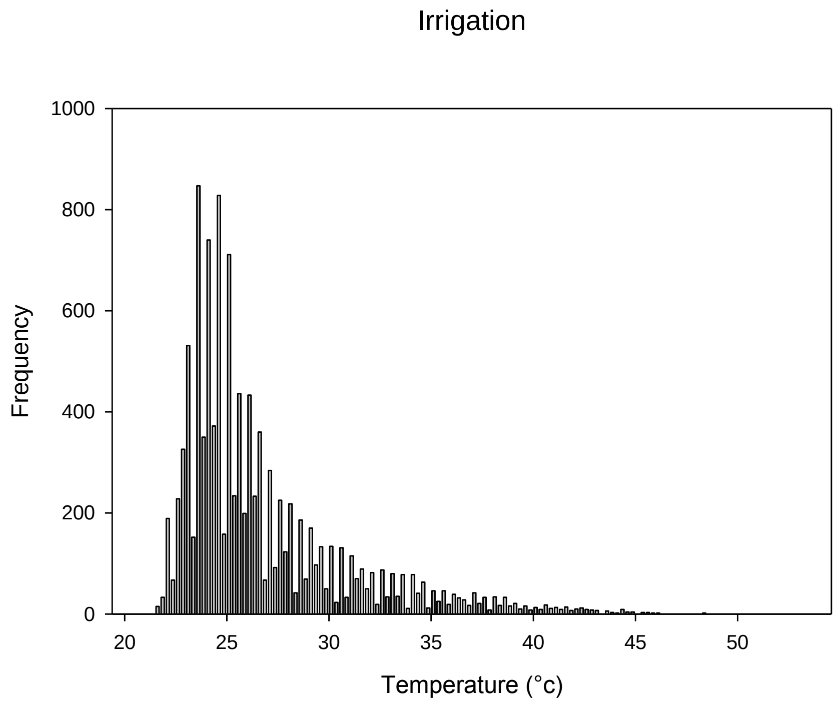

**Histograph on July 18th, control windrow**

Pseudo-Biofilter

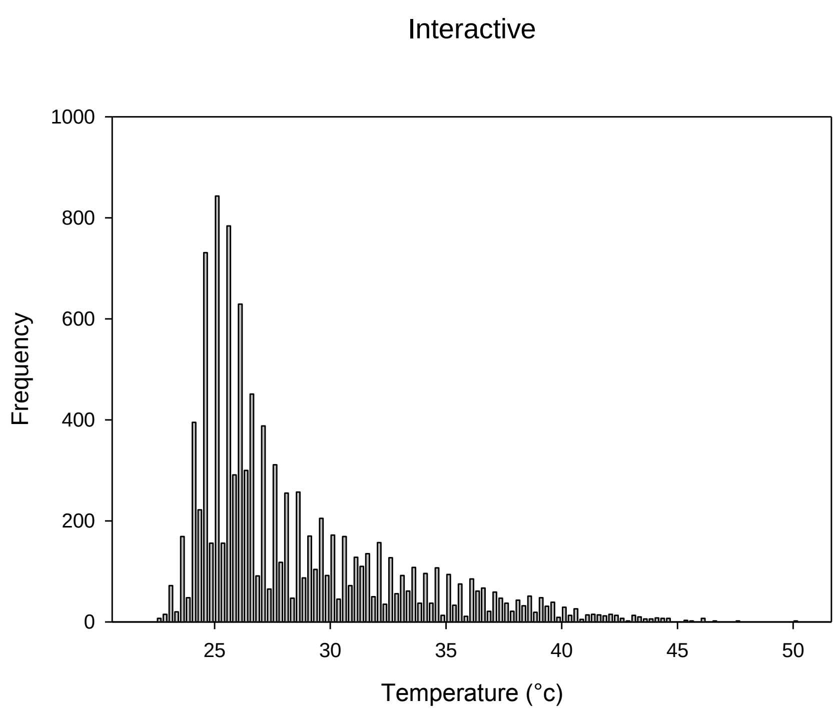



**Histograph on July 18th, pseudo-biofilter windrow**

## Appendix L. Temperature Histograms (cont.)

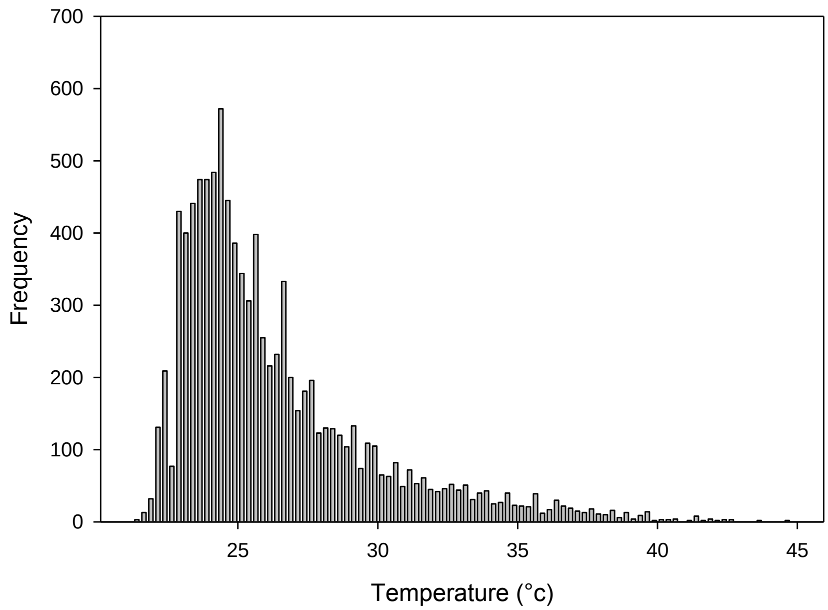



**Histograph on July 18th, irrigation windrow**



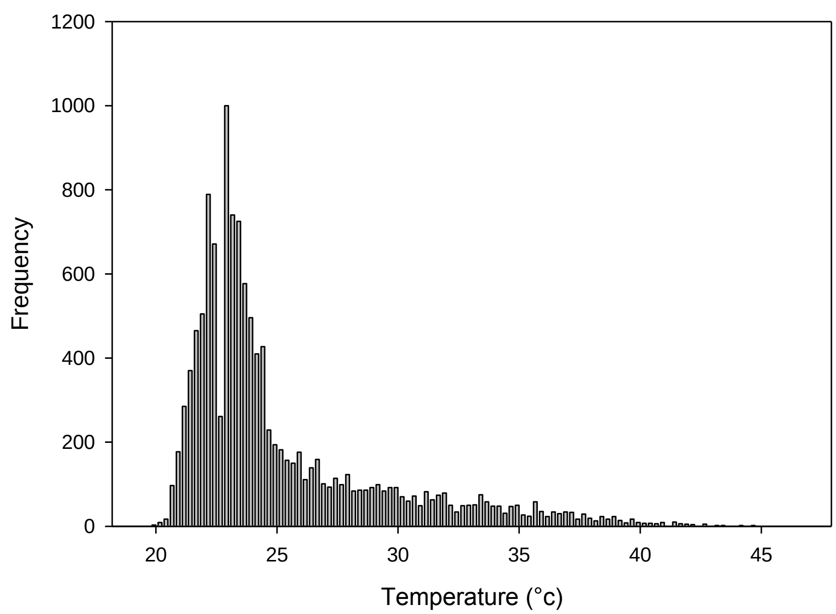

**Histograph on July 18th, interactive windrow**

Reduced Size



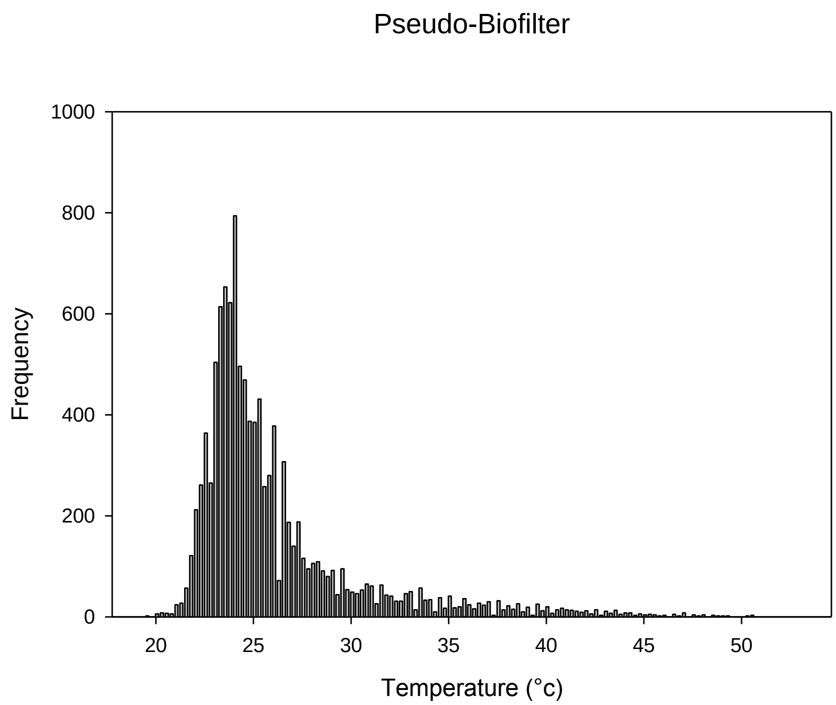

**Histograph on July 18th, reduced size windrow**

Control

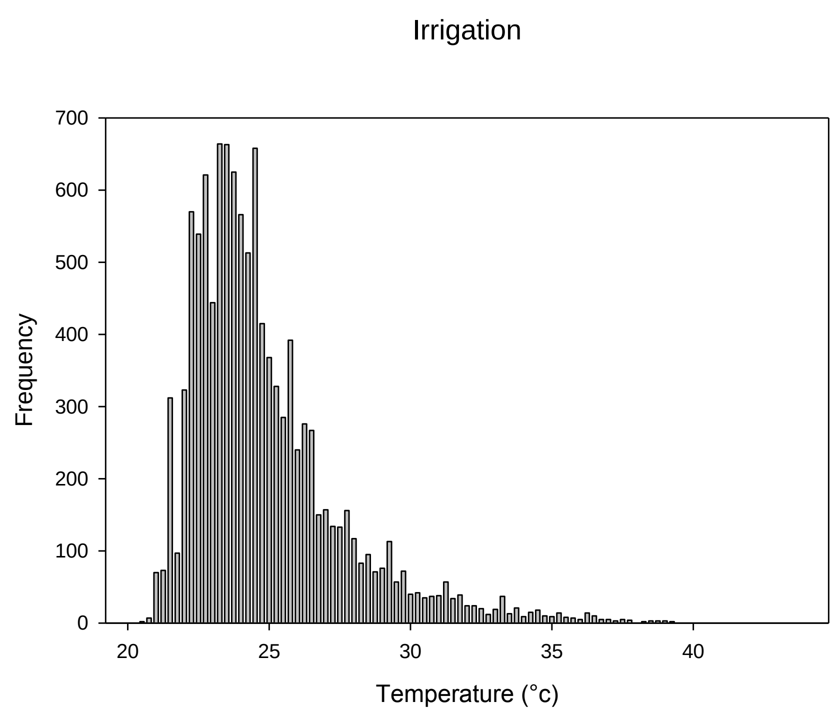



**Histograph on July 27th, control windrow**

# Appendix L. Temperature Histograms (cont.)

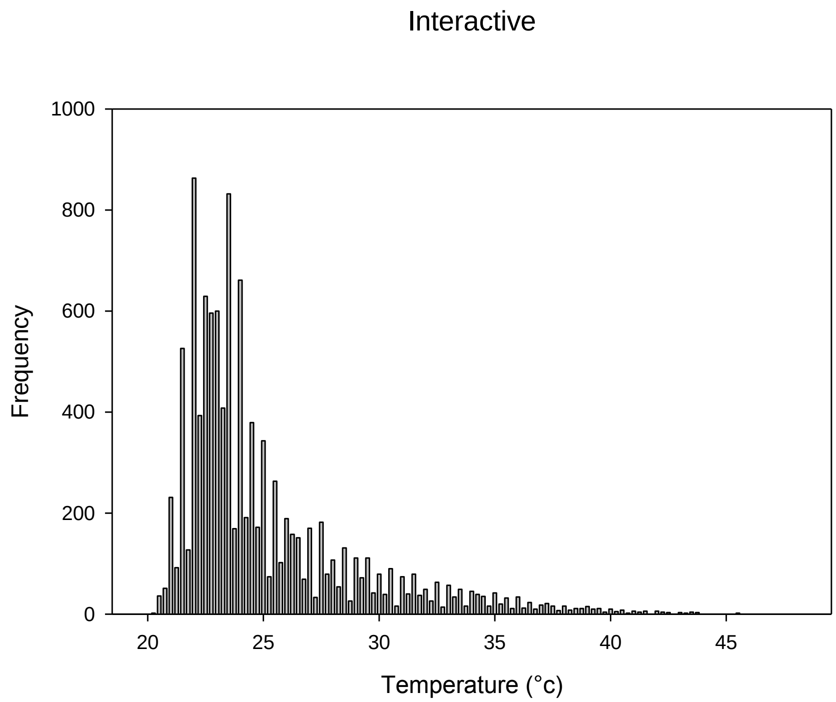



**Histograph on July 27th, pseudo-biofilter windrow**

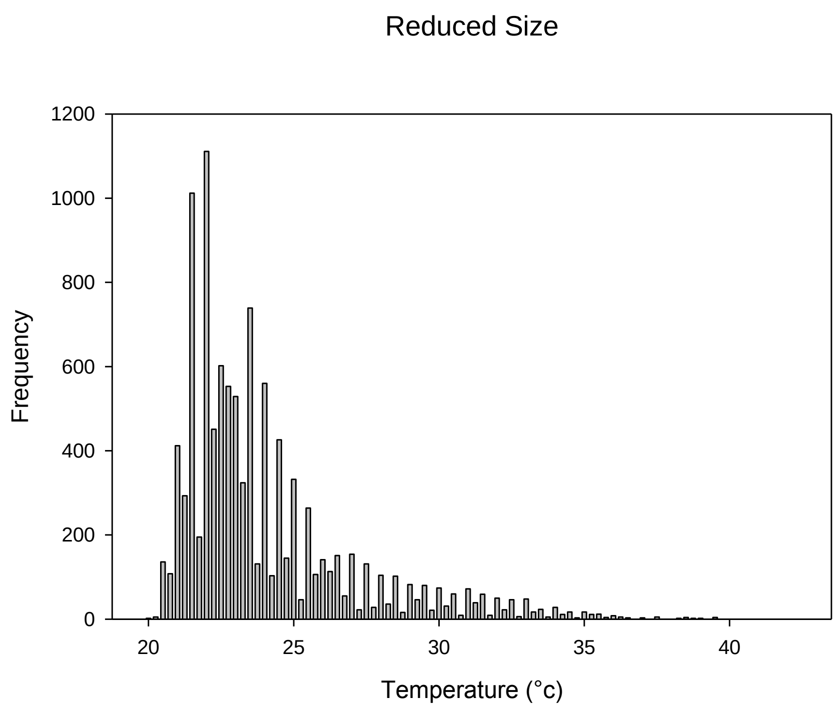



**Histograph on July 27th, irrigation windrow**

## Appendix L. Temperature Histograms (cont.)

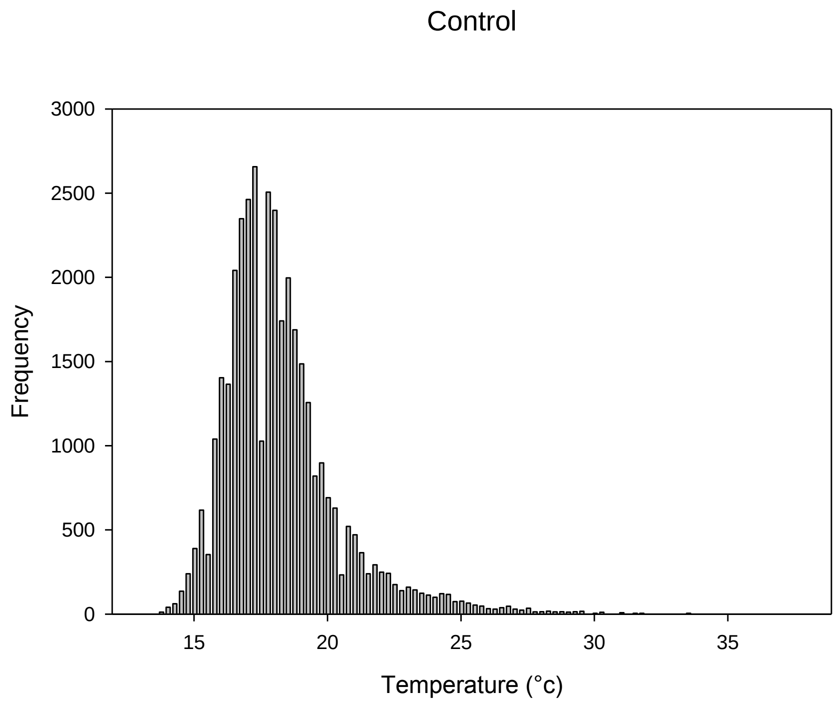



**Histograph on July 27th, interactive windrow**

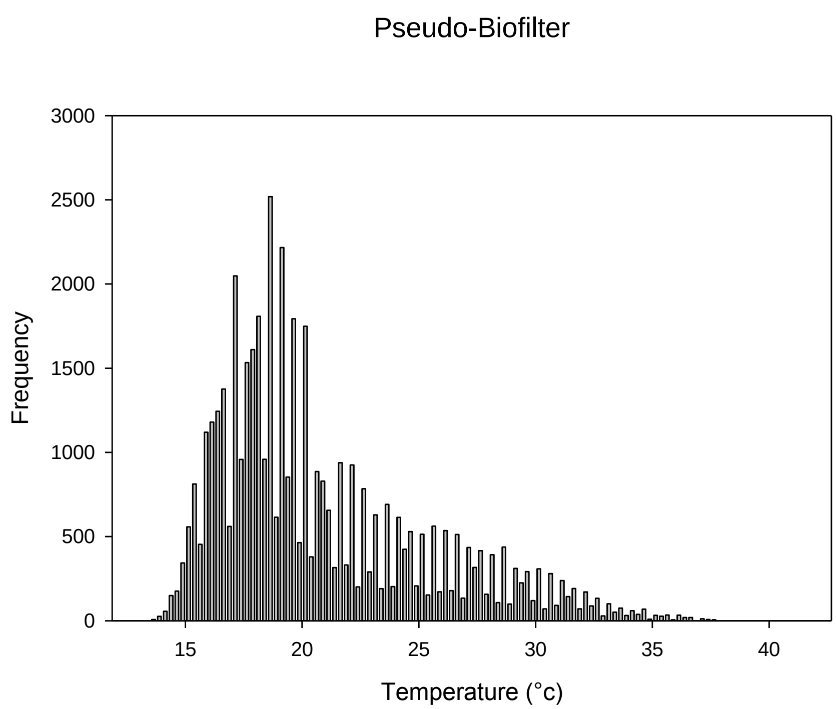



**Histograph on July 27th, reduced size windrow**

## Appendix L. Temperature Histograms (cont.)

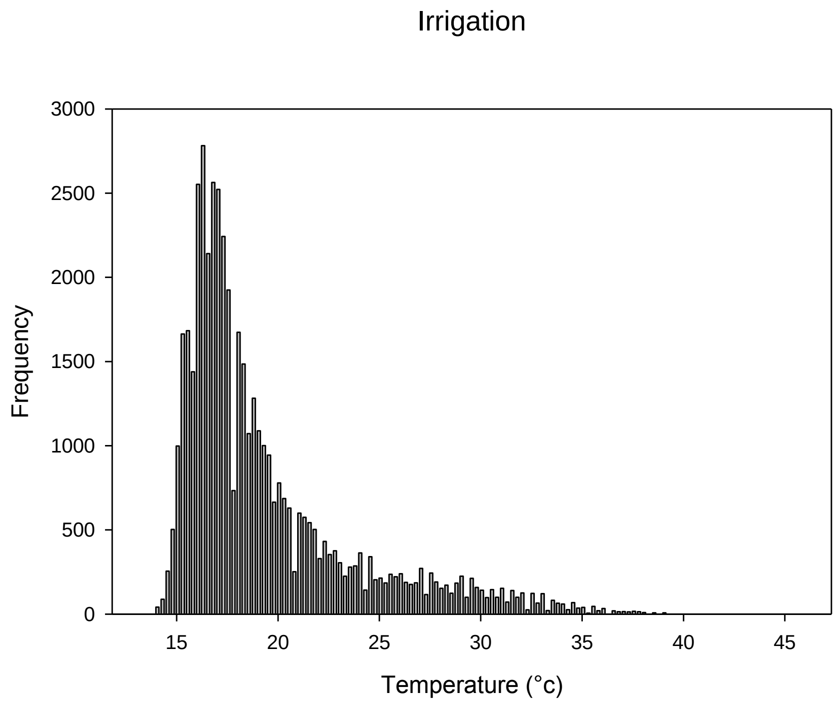



**Histograph on August 24th, control windrow**

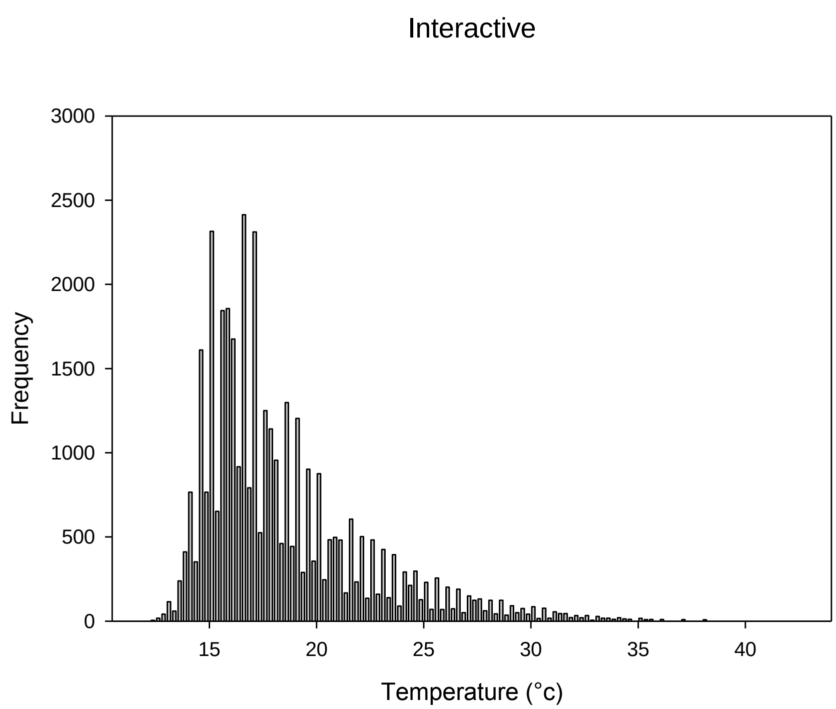



**Histograph on August 24th, pseudo-biofilter windrow**

## Appendix L. Temperature Histograms (cont.)

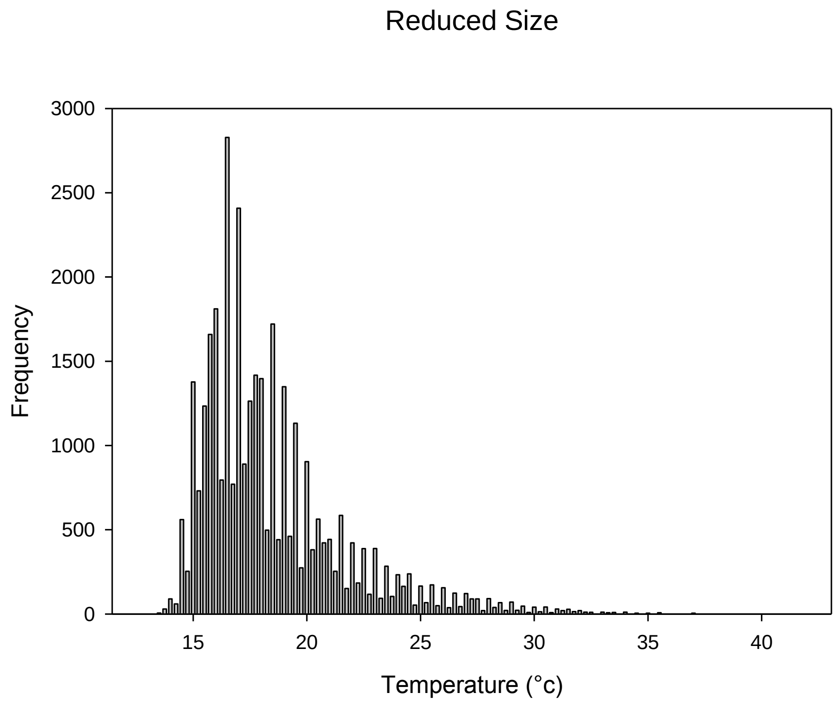



**Histograph on August $24^{th}$, irrigation windrow**

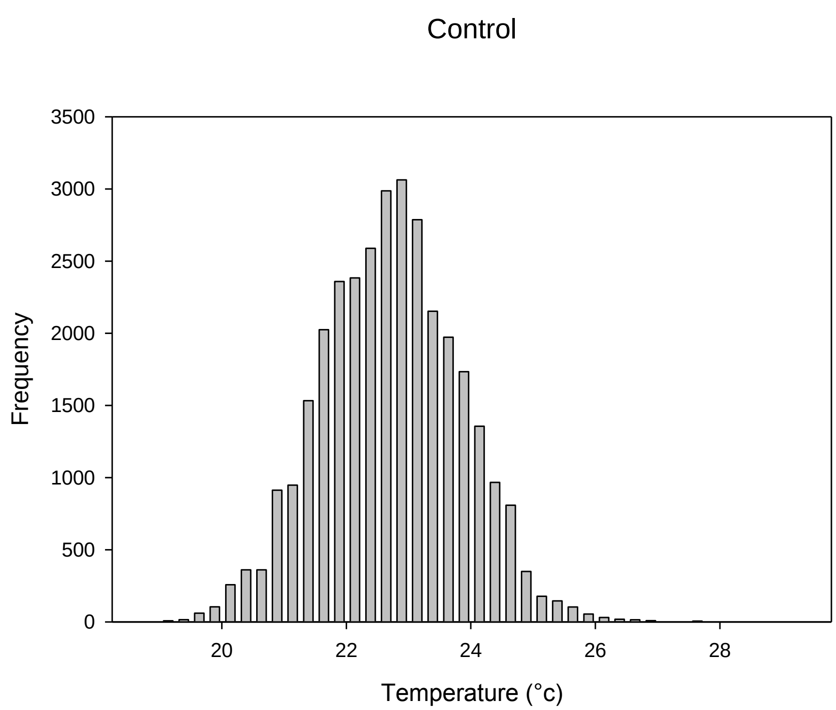



**Histograph on August $24^{th}$, interactive windrow**

## Appendix L. Temperature Histograms (cont.)

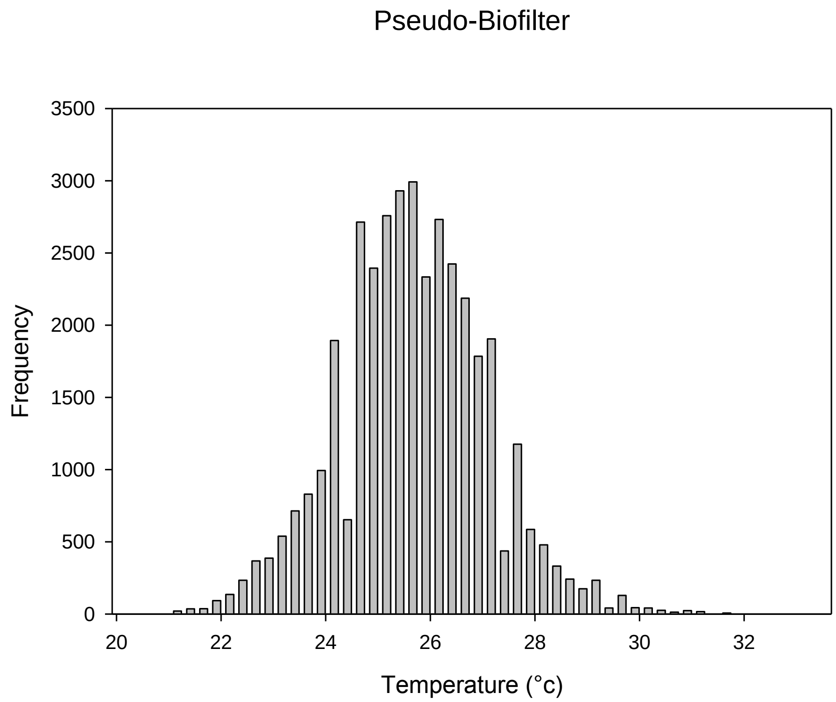



**Histograph on August 24th, reduced size windrow**

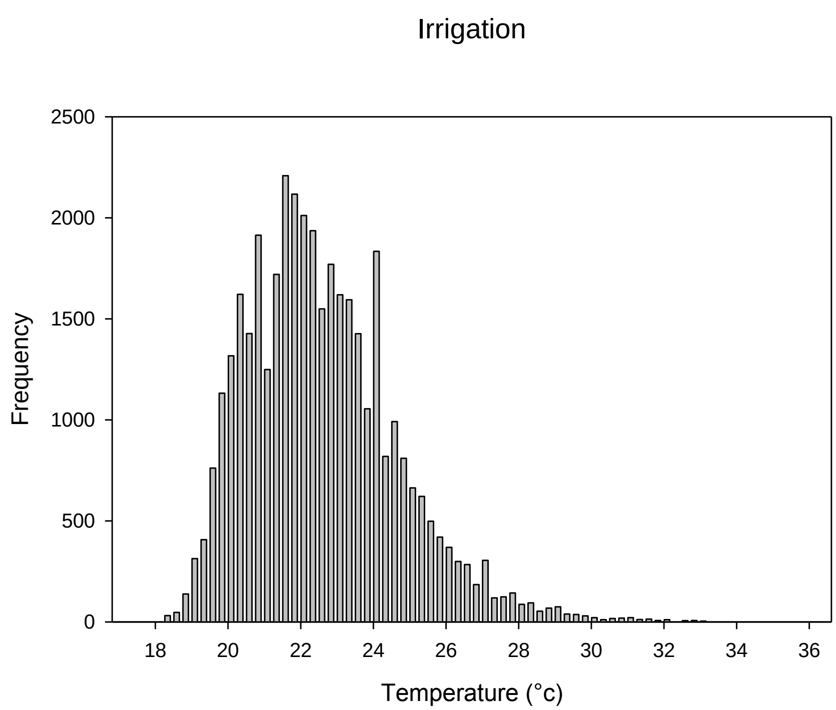



**Histograph on September 24th, control windrow**

**Appendix L. Temperature Histograms (cont.)**

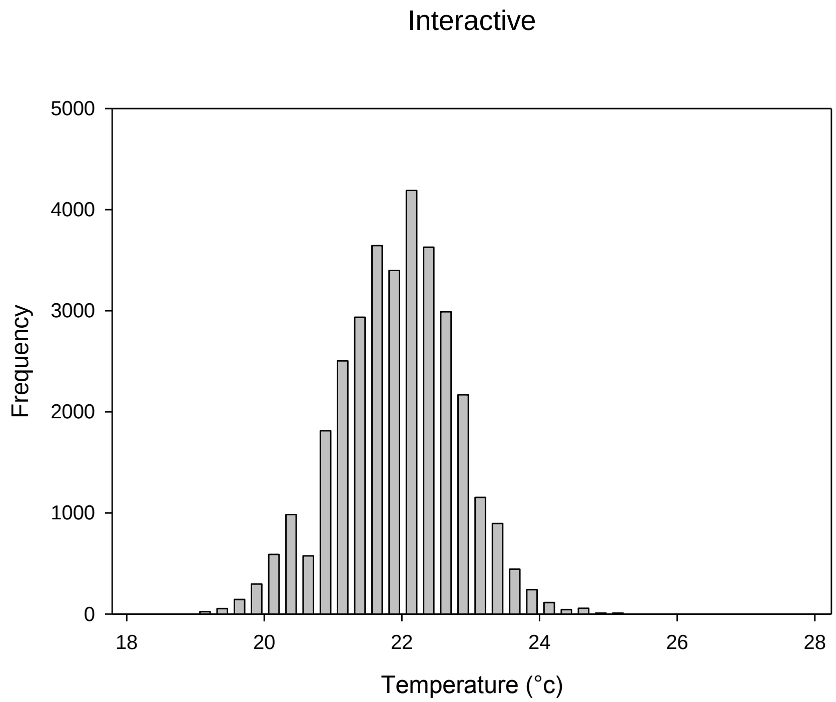



**Histograph on September 24th, pseudo-biofilter windrow**

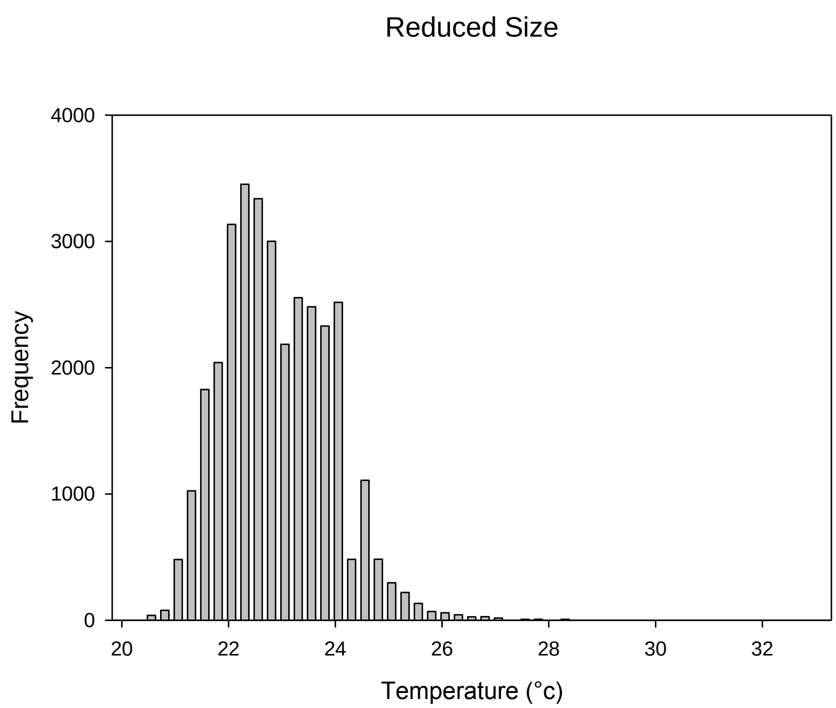



**Histograph on September 24th, irrigation windrow**

## Appendix L. Temperature Histograms (cont.)

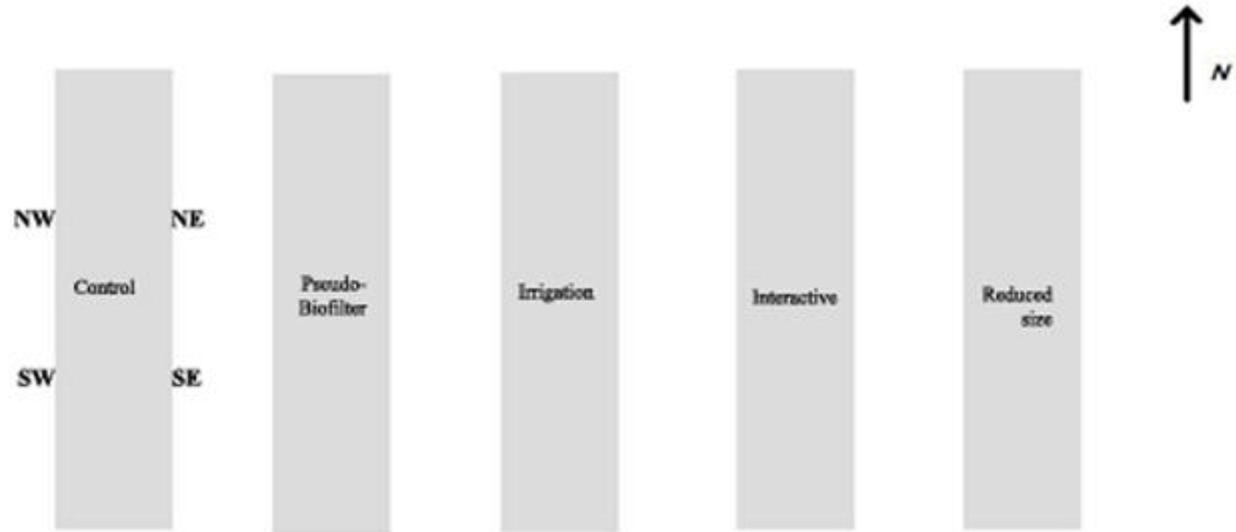



**Histograph on September 24th, interactive windrow**




**Histograph on September 24th, reduced size windrow**

## Appendix M. On-Site Field Readings




**DAY 2 (June 09)**

| | T (°C) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE complete | 39 | 0 | 6 | 0 | 0.2 |
| Control SE complete | 42 | 0 | 5 | 0 | 0.3 |
| Control NW complete | 38 | 0 | 5 | 0 | 0.1 |
| Control SW complete | 40 | 0 | 5 | 0 | 0.2 |
| Interactive NE complete | 38 | 0 | 7 | 0 | 0.1 |
| Interactive SE complete | 40 | 0 | 6 | 0 | 0.1 |
| Interactive NW complete | 38 | 0 | 6 | 0 | 0.1 |
| Interactive SW complete | 39 | 0 | 5 | 0 | 0.2 |
| Reduced Size E Center | 34 | 0 | 6 | 0 | 0.2 |
| Reduced Size W Center | 36 | 0 | 6 | 0 | 0.3 |
| Irrigation E Center | 41 | 0 | 6 | 0 | 0.6 |
| Irrigation W Center | 41 | 0 | 6 | 0 | 0.3 |
| Pseudo-Biofilter E Center | 41 | 0 | 8 | 0 | 0.2 |
| Pseudo-Biofilter W Center | 43 | 0 | 8 | 0 | 0.3 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 3 (June 10)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2ft inside | 38 | 0 | 6 | 0 | 7.6 |
| Control NE 3ft inside | 43 | 0 | 7 | 0 | 3.1 |
| Control NE 4ft inside | 44 | 0 | 7 | 0 | 1.2 |
| Control NE complete | 44 | 0 | 7 | 0 | 0.4 |
| Control SE 2ft inside | 42 | 0 | 6 | 0 | 8.3 |
| Control SE 3ft inside | 44 | 0 | 7 | 0 | 4.6 |
| Control SE 4ft inside | 45 | 0 | 7 | 0 | 2.4 |
| Control SE complete | 45 | 0 | 7 | 0 | 2.1 |
| Control NW 2ft inside | 48 | 0 | 7 | 0 | 0.3 |
| Control NW 3ft inside | 45 | 0 | 6 | 0 | 2 |
| Control NW 4ft inside | 49 | 0 | 6 | 0 | 1.4 |
| Control NW complete | 49 | 0 | 7 | 0 | 1.1 |
| Control SW 2ft inside | 45 | 0 | 5 | 0 | 2.1 |
| Control SW 3ft inside | 45 | 0 | 5 | 0 | 1.1 |
| Control SW 4ft inside | 44 | 0 | 6 | 0 | 0.8 |
| Control SW complete | 43 | 0 | 6 | 0 | 0.8 |
| Interactive NE 2ft inside | 44 | 7 | 5 | 24 | 0.6 |
| Interactive NE 3ft inside | 40 | 11 | 7 | 13 | 0 |
| Interactive NE 4ft inside | 38 | 8 | 16 | 43 | 0 |
| Interactive NE complete | 40 | 6 | 8 | 40 | 0 |
| Interactive SE 2ft inside | 44 | 2 | 5 | 2 | 0 |
| Interactive SE 3ft inside | 43 | 0 | 5 | 0 | 0 |
| Interactive SE 4ft inside | 43 | 0 | 5 | 0 | 0 |
| Interactive SE complete | 41 | 0 | 6 | 0 | 0 |
| Interactive NW 2ft inside | 44 | 7 | 9 | 0 | 0 |
| Interactive NW 3ft inside | 43 | 0 | 8 | 0 | 0 |
| Interactive NW 4ft inside | 42 | 0 | 7 | 0 | 0 |
| Interactive NW complete | 44 | 0 | 7 | 0 | 0 |
| Integrated SW 2ft inside | 45 | 0 | 11 | 0 | 0.9 |
| Interactive SW 3ft inside | 44 | 0 | 11 | 0 | 0.4 |
| Interactive SW 4ft inside | 43 | 0 | 10 | 0 | 0.3 |
| Interactive SW complete | 43 | 0 | 9 | 0 | 0.2 |
| Reduced Size E Center | 41 | 0 | 8 | 0 | 0 |
| Reduced Size W Center | 40 | 0 | 7 | 0 | 0.1 |
| Irrigation E Center | 45 | 0 | 7 | 0 | 0.1 |
| Irrigation W Center | 45 | 0 | 7 | 0 | 0.2 |
| Pseudo-Biofilter E Center | 46 | 0 | 8 | 0 | 0.1 |
| Pseudo-Biofilter W Center | 49 | 0 | 8 | 0 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 4 (June 11)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2ft inside | 40 | 1 | 10 | 0 | 1.2 |
| Control NE 3ft inside | 39 | 2 | 10 | 0 | 0.2 |
| Control NE 4ft inside | 41 | 3 | 10 | 0 | 0 |
| Control NE complete | 41 | 4 | 10 | 0 | 0 |
| Control SE 2ft inside | 40 | 3 | 11 | 0 | 0.9 |
| Control SE 3ft inside | 41 | 3 | 10 | 0 | 0.2 |
| Control SE 4ft inside | 44 | 4 | 15 | 0 | 1.1 |
| Control SE complete | 44 | 4 | 16 | 0 | 0.9 |
| Control NW 2ft inside | 40 | 5 | 12 | 7 | 1.6 |
| Control NW 3ft inside | 40 | 7 | 13 | 6 | 0.4 |
| Control NW 4ft inside | 42 | 4 | 11 | 2 | 0.1 |
| Control NW complete | 41 | 3 | 9 | 0 | 0 |
| Control SW 2ft inside | 42 | 8 | 9 | 0 | 0 |
| Control SW 3ft inside | 41 | 6 | 12 | 0 | 0.6 |
| Control SW 4ft inside | 41 | 4 | 10 | 0 | 0 |
| Control SW complete | 42 | 3 | 12 | 0 | 0 |
| Interactive NE 2ft inside | 36 | 58 | 17 | 31 | 0 |
| Interactive NE 3ft inside | 38 | 42 | 29 | 20 | 1.7 |
| Interactive NE 4ft inside | 38 | 38 | 21 | 45 | 0.3 |
| Interactive NE complete | 39 | 41 | 11 | 39 | 0 |
| Interactive SE 2ft inside | 39 | 26 | 15 | 37 | 0 |
| Interactive SE 3ft inside | 38 | 33 | 16 | 17 | 0 |
| Interactive SE 4ft inside | 40 | 35 | 17 | 18 | 0 |
| Interactive SE complete | 41 | 40 | 13 | 10 | 0 |
| Interactive NW 2ft inside | 44 | 56 | 13 | 16 | 0 |
| Interactive NW 3ft inside | 41 | 30 | 19 | 0 | 0 |
| Interactive NW 4ft inside | 40 | 25 | 12 | 0 | 0 |
| Interactive NW complete | 38 | 24 | 12 | 0 | 0 |
| Integrated SW 2ft inside | 42 | 66 | 14 | 43 | 0 |
| Interactive SW 3ft inside | 40 | 76 | 16 | 45 | 0 |
| Interactive SW 4ft inside | 41 | 69 | 19 | 43 | 0 |
| Interactive SW complete | 40 | 56 | 15 | 81 | 0 |
| Reduced Size E Center | 38 | 112 | 18 | 4 | 0 |
| Reduced Size W Center | 39 | 105 | 18 | 3 | 0 |
| Irrigation E Center | 46 | 11 | 14 | 0 | 0 |
| Irrigation W Center | 47 | 19 | 18 | 0 | 0 |
| Pseudo-Biofilter E Center | 41 | 36 | 19 | 0 | 0.1 |
| Pseudo-Biofilter W Center | 49 | 35 | 15 | 0 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 5 (June 12)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 45 | 28 | 20 | 32 | 0.2 |
| Control NE 3.5ft inside | 44 | 33 | 18 | 39 | 0.2 |
| Control NE 4.5ft inside | 42 | 34 | 17 | 50 | 0.1 |
| Control SE 2.5ft inside | 47 | 5 | 22 | 16 | 3 |
| Control SE 3.5ft inside | 46 | 4 | 18 | 15 | 0.9 |
| Control SE 4.5ft inside | 45 | 3 | 13 | 20 | 0.1 |
| Control NW 2.5ft inside | 47 | 3 | 12 | 12 | 0.1 |
| Control NW 3.5ft inside | 44 | 2 | 11 | 20 | 0 |
| Control NW 4.5ft inside | 43 | 2 | 15 | 22 | 0.7 |
| Control SW 2.5ft inside | 50 | 3 | 9 | 22 | 1.9 |
| Control SW 3.5ft inside | 47 | 3 | 9 | 35 | 3.7 |
| Control SW 4.5ft inside | 45 | 2 | 11 | 22 | 1.9 |
| Interactive NE 2.5ft inside | 46 | 7 | 16 | 7 | 4 |
| Interactive NE 3.5ft inside | 43 | 12 | 14 | 8 | 0 |
| Interactive NE 4.5ft inside | 42 | 13 | 12 | 7 | 0 |
| Interactive SE 2.5ft inside | 49 | 41 | 14 | 26 | 0.2 |
| Interactive SE 3.5ft inside | 49 | 28 | 14 | 33 | 0 |
| Interactive SE 4.5ft inside | 45 | 35 | 14 | 45 | 0 |
| Interactive NW 2.5ft inside | 50 | 137 | 22 | 45 | 0.9 |
| Interactive NW 3.5ft inside | 46 | 35 | 18 | 0 | 0.1 |
| Interactive NW 4.5ft inside | 44 | 18 | 15 | 0 | 0.1 |
| Interactive SW 2.5ft inside | 48 | 37 | 18 | 45 | 0.4 |
| Interactive SW 3.5ft inside | 45 | 25 | 18 | 72 | 0.3 |
| Interactive SW 4.5ft inside | 41 | 21 | 23 | 78 | 0.5 |
| Reduced Size E Center | 46 | 28 | 18 | 0 | 0.3 |
| Reduced Size W Center | 44 | 20 | 33 | 0 | 1.8 |
| Irrigation E Center | 49 | 1 | 21 | 0 | 0.6 |
| Irrigation W Center | 51 | 6 | 16 | 0 | 6.1 |
| Pseudo-Biofilter E Center | 48 | 51 | 16 | 0 | 0 |
| Pseudo-Biofilter W Center | 43 | 49 | 21 | 22 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 6 (June 13)**

| | T (°C) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 49 | 92 | 16 | 45 | 0 |
| Control NE 3.5ft inside | 50 | 61 | 19 | 34 | 0 |
| Control NE 4.5ft inside | 50 | 49 | 16 | 21 | 0 |
| Control SE 2.5ft inside | 47 | 42 | 22 | 38 | 0.1 |
| Control SE 3.5ft inside | 49 | 46 | 20 | 48 | 0 |
| Control SE 4.5ft inside | 49 | 47 | 15 | 47 | 0 |
| Control NW 2.5ft inside | 49 | 43 | 17 | 58 | 0 |
| Control NW 3.5ft inside | 48 | 32 | 16 | 54 | 0 |
| Control NW 4.5ft inside | 49 | 26 | 15 | 35 | 0 |
| Control SW 2.5ft inside | 51 | 51 | 17 | 96 | 0 |
| Control SW 3.5ft inside | 50 | 72 | 20 | 91 | 0 |
| Control SW 4.5ft inside | 50 | 87 | 18 | 80 | 0 |
| Interactive NE 2.5ft inside | 49 | 16 | 13 | 32 | 0 |
| Interactive NE 3.5ft inside | 46 | 14 | 13 | 48 | 0 |
| Interactive NE 4.5ft inside | 43 | 11 | 17 | 47 | 0 |
| Interactive SE 2.5ft inside | 57 | 9 | 26 | 26 | 0.8 |
| Interactive SE 3.5ft inside | 52 | 14 | 13 | 34 | 0 |
| Interactive SE 4.5ft inside | 47 | 17 | 12 | 52 | 0 |
| Interactive NW 2.5ft inside | 46 | 26 | 14 | 35 | 0 |
| Interactive NW 3.5ft inside | 45 | 31 | 13 | 78 | 0 |
| Interactive NW 4.5ft inside | 44 | 28 | 12 | 77 | 0 |
| Interactive SW 2.5ft inside | 57 | 10 | 17 | 25 | 0 |
| Interactive SW 3.5ft inside | 57 | 24 | 16 | 39 | 0 |
| Interactive SW 4.5ft inside | 51 | 12 | 12 | 31 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 7 (June 14)**

| | T ( ℃ ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 54 | 28 | 14 | 13 | 0 |
| Control NE 3.5ft inside | 50 | 38 | 17 | 12 | 0 |
| Control NE 4.5ft inside | 50 | 45 | 18 | 12 | 0.1 |
| Control SE 2.5ft inside | 53 | 24 | 16 | 15 | 0 |
| Control SE 3.5ft inside | 51 | 29 | 16 | 24 | 0 |
| Control SE 4.5ft inside | 50 | 46 | 16 | 34 | 0 |
| Control NW 2.5ft inside | 57 | 42 | 17 | 27 | 0 |
| Control NW 3.5ft inside | 52 | 71 | 16 | 58 | 0 |
| Control NW 4.5ft inside | 50 | 39 | 16 | 34 | 0 |
| Control SW 2.5ft inside | 56 | 30 | 14 | 38 | 0 |
| Control SW 3.5ft inside | 53 | 55 | 16 | 50 | 0 |
| Control SW 4.5ft inside | 50 | 39 | 17 | 26 | 0 |
| Interactive NE 2.5ft inside | 54 | 11 | 13 | 30 | 0 |
| Interactive NE 3.5ft inside | 49 | 8 | 21 | 32 | 0.1 |
| Interactive NE 4.5ft inside | 47 | 7 | 12 | 29 | 0 |
| Interactive SE 2.5ft inside | 60 | 1 | 28 | 9 | 3 |
| Interactive SE 3.5ft inside | 58 | 6 | 31 | 18 | 0.9 |
| Interactive SE 4.5ft inside | 53 | 10 | 23 | 24 | 0.5 |
| Interactive NW 2.5ft inside | 54 | 4 | 18 | 2 | 9.6 |
| Interactive NW 3.5ft inside | 53 | 10 | 35 | 13 | 4.3 |
| Interactive NW 4.5ft inside | 49 | 11 | 21 | 24 | 0.4 |
| Interactive SW 2.5ft inside | 58 | 3 | 19 | 16 | 1.7 |
| Interactive SW 3.5ft inside | 56 | 9 | 28 | 34 | 1.1 |
| Interactive SW 4.5ft inside | 51 | 11 | 13 | 42 | 0 |
| Reduced Size E Center | 51 | 33 | 19 | 0 | 0 |
| Reduced Size W Center | 50 | 17 | 21 | 0 | 0.4 |
| Irrigation E Center | 49 | 1 | 21 | 0 | 0.6 |
| Irrigation W Center | 51 | 6 | 16 | 0 | 6.1 |
| Pseudo-Biofilter E Center | 48 | 51 | 16 | 0 | 0 |
| Pseudo-Biofilter W Center | 43 | 49 | 21 | 22 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 8 (June 15)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 55 | 7 | 21 | 0 | 0.6 |
| Control NE 3.5ft inside | 53 | 4 | 37 | 0 | 1.6 |
| Control NE 4.5ft inside | 53 | 1 | 42 | 0 | 3.5 |
| Control SE 2.5ft inside | 56 | 18 | 32 | 0 | 1.3 |
| Control SE 3.5ft inside | 53 | 27 | 14 | 0 | 0 |
| Control SE 4.5ft inside | 52 | 22 | 5 | 0 | 2.6 |
| Control NW 2.5ft inside | 59 | 3 | 17 | 0 | 0.1 |
| Control NW 3.5ft inside | 56 | 8 | 20 | 6 | 0.3 |
| Control NW 4.5ft inside | 53 | 9 | 13 | 11 | 0 |
| Control SW 2.5ft inside | 60 | 15 | 33 | 0 | 0.9 |
| Control SW 3.5ft inside | 56 | 27 | 16 | 3 | 0 |
| Control SW 4.5ft inside | 52 | 32 | 15 | 11 | 0 |
| Interactive NE 2.5ft inside | 56 | 0 | 30 | 7 | 4.9 |
| Interactive NE 3.5ft inside | 52 | 1 | 31 | 12 | 1.2 |
| Interactive NE 4.5ft inside | 47 | 2 | 13 | 18 | 0 |
| Interactive SE 2.5ft inside | 57 | 0 | 36 | 4 | 2.8 |
| Interactive SE 3.5ft inside | 57 | 0 | 34 | 10 | 1.5 |
| Interactive SE 4.5ft inside | 55 | 5 | 24 | 20 | 0.3 |
| Interactive NW 2.5ft inside | 53 | 3 | 21 | 11 | 1.8 |
| Interactive NW 3.5ft inside | 57 | 8 | 17 | 22 | 0 |
| Interactive NW 4.5ft inside | 54 | 6 | 20 | 20 | 0 |
| Interactive SW 2.5ft inside | 60 | 1 | 17 | 8 | 2.5 |
| Interactive SW 3.5ft inside | 58 | 5 | 22 | 23 | 0.1 |
| Interactive SW 4.5ft inside | 54 | 4 | 25 | 22 | 0.5 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 8 (June 15) After turning over**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 52 | 0 | 22 | 0 | 1.3 |
| Control NE 3.5ft inside | 53 | 0 | 19 | 0 | 0.4 |
| Control NE 4.5ft inside | 53 | 0 | 22 | 0 | 2.4 |
| Control SE 2.5ft inside | 52 | 0 | 22 | 0 | 1.3 |
| Control SE 3.5ft inside | 53 | 0 | 19 | 0 | 0.4 |
| Control SE 4.5ft inside | 53 | 0 | 22 | 0 | 2.4 |
| Control NW 2.5ft inside | 51 | 0 | 15 | 0 | 4.7 |
| Control NW 3.5ft inside | 52 | 0 | 21 | 0 | 1.8 |
| Control NW 4.5ft inside | 51 | 0 | 20 | 0 | 1.2 |
| Control SW 2.5ft inside | 51 | 0 | 14 | 0 | 1.9 |
| Control SW 3.5ft inside | 51 | 0 | 19 | 0 | 0.9 |
| Control SW 4.5ft inside | 49 | 0 | 25 | 0 | 0.8 |
| Interactive NE 2.5ft inside | 56 | 0 | 30 | 7 | 4.9 |
| Interactive NE 3.5ft inside | 52 | 1 | 31 | 12 | 1.2 |
| Interactive NE 4.5ft inside | 47 | 2 | 13 | 18 | 0 |
| Interactive SE 2.5ft inside | 57 | 0 | 36 | 4 | 2.8 |
| Interactive SE 3.5ft inside | 57 | 0 | 34 | 10 | 1.5 |
| Interactive SE 4.5ft inside | 55 | 5 | 24 | 20 | 0.3 |
| Interactive NW 2.5ft inside | 48 | 0 | 19 | 0 | 4.4 |
| Interactive NW 3.5ft inside | 48 | 0 | 21 | 0 | 1.3 |
| Interactive NW 4.5ft inside | 48 | 0 | 18 | 0 | 1.8 |
| Interactive SW 2.5ft inside | 51 | 1 | 29 | 0 | 4.8 |
| Interactive SW 3.5ft inside | 49 | 3 | 26 | 0 | 5.3 |
| Interactive SW 4.5ft inside | 49 | 2 | 24 | 0 | 2.5 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 9 (June 16)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 54 | 1 | 16 | 0 | 0.1 |
| Control NE 3.5ft inside | 54 | 0 | 32 | 0 | 1.4 |
| Control NE 4.5ft inside | 53 | 0 | 33 | 0 | 1.5 |
| Control SE 2.5ft inside | 53 | 0 | 24 | 0 | 0.7 |
| Control SE 3.5ft inside | 52 | 0 | 18 | 0 | 0.2 |
| Control SE 4.5ft inside | 52 | 1 | 16 | 0 | 0.1 |
| Control NW 2.5ft inside | 58 | 1 | 34 | 0 | 3.1 |
| Control NW 3.5ft inside | 55 | 2 | 26 | 0 | 0.8 |
| Control NW 4.5ft inside | 55 | 4 | 21 | 0 | 0.3 |
| Control SW 2.5ft inside | 59 | 2 | 26 | 0 | 1.3 |
| Control SW 3.5ft inside | 56 | 8 | 16 | 0 | 0.1 |
| Control SW 4.5ft inside | 51 | 17 | 27 | 0 | 0.8 |
| Interactive NE 2.5ft inside | 50 | 0 | 22 | 0 | 6.5 |
| Interactive NE 3.5ft inside | 48 | 0 | 24 | 0 | 5.8 |
| Interactive NE 4.5ft inside | 48 | 0 | 28 | 0 | 2.2 |
| Interactive SE 2.5ft inside | 55 | 3 | 33 | 0 | 2.7 |
| Interactive SE 3.5ft inside | 50 | 0 | 19 | 0 | 15.7 |
| Interactive SE 4.5ft inside | 50 | 4 | 31 | 0 | 7.9 |
| Interactive NW 2.5ft inside | 50 | 5 | 19 | 0 | 9.8 |
| Interactive NW 3.5ft inside | 51 | 10 | 30 | 7 | 1.4 |
| Interactive NW 4.5ft inside | 50 | 10 | 23 | 8 | 0.6 |
| Interactive SW 2.5ft inside | 53 | 32 | 29 | 12 | 1 |
| Interactive SW 3.5ft inside | 52 | 44 | 19 | 33 | 0.1 |
| Interactive SW 4.5ft inside | 52 | 81 | 20 | 4 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 10 (June 17)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 61 | 0 | 42 | 0 | 4.8 |
| Control NE 3.5ft inside | 57 | 0 | 18 | 0 | 11.1 |
| Control NE 4.5ft inside | 58 | 0 | 32 | 0 | 10.1 |
| Control SE 2.5ft inside | 58 | 1 | 26 | 0 | 0.9 |
| Control SE 3.5ft inside | 55 | 1 | 43 | 0 | 2 |
| Control SE 4.5ft inside | 54 | 0 | 22 | 0 | 0.5 |
| Control NW 2.5ft inside | 60 | 0 | 39 | 0 | 2.1 |
| Control NW 3.5ft inside | 56 | 0 | 51 | 0 | 3.2 |
| Control NW 4.5ft inside | 54 | 0 | 19 | 0 | 0.6 |
| Control SW 2.5ft inside | 60 | 0 | 38 | 0 | 2.2 |
| Control SW 3.5ft inside | 55 | 0 | 19 | 0 | 1.8 |
| Control SW 4.5ft inside | 55 | 0 | 25 | 0 | 1.2 |
| Interactive NE 2.5ft inside | 60 | 1 | 35 | 0 | 3.9 |
| Interactive NE 3.5ft inside | 54 | 0 | 41 | 0 | 2.9 |
| Interactive NE 4.5ft inside | 52 | 0 | 30 | 0 | 1.3 |
| Interactive SE 2.5ft inside | 60 | 15 | 37 | 4 | 1.8 |
| Interactive SE 3.5ft inside | 56 | 12 | 20 | 1 | 0.1 |
| Interactive SE 4.5ft inside | 55 | 13 | 25 | 0 | 0.6 |
| Interactive NW 2.5ft inside | 63 | 13 | 38 | 13 | 3.3 |
| Interactive NW 3.5ft inside | 59 | 16 | 45 | 27 | 3.2 |
| Interactive NW 4.5ft inside | 56 | 4 | 45 | 29 | 2.3 |
| Interactive SW 2.5ft inside | 61 | 12 | 56 | 23 | 3.2 |
| Interactive SW 3.5ft inside | 57 | 30 | 28 | 29 | 0.9 |
| Interactive SW 4.5ft inside | 55 | 114 | 3 | 254 | 0 |
| Reduced Size E Center | 54 | 0 | 32 | 0 | 0 |
| Reduced Size W  Center | 59 | 0 | 21 | 0 | 0 |
| Irrigation E Center | 56 | 0 | 18 | 0 | 0 |
| Irrigation W  Center | 54 | 0 | 22 | 0 | 0 |
| Pseudo-Biofilter E Center | 55 | 0 | 30 | 0 | 0.1 |
| Pseudo-Biofilter W  Center | 55 | 0 | 56 | 0 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 15 (June 22)**

| | T (°C) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 47 | 5 | 36 | 2 | 9.7 |
| Control NE 3.5ft inside | 60 | 13 | 85 | 8 | 7.1 |
| Control NE 4.5ft inside | 60 | 14 | 100< | 7 | 0.4 |
| Control SE 2.5ft inside | 62 | 3 | 31 | 4 | 12.4 |
| Control SE 3.5ft inside | 59 | 18 | 23 | 20 | 0.2 |
| Control SE 4.5ft inside | 58 | 4 | 24 | 3 | 13.7 |
| Control NW 2.5ft inside | 59 | 0 | 8 | 0 | 13.4 |
| Control NW 3.5ft inside | 58 | 2 | 16 | 7 | 7.6 |
| Control NW 4.5ft inside | 60 | 24 | 22 | 25 | 0.1 |
| Control SW 2.5ft inside | 60 | 0 | 28 | 0 | 9.1 |
| Control SW 3.5ft inside | 60 | 8 | 36 | 7 | 1.5 |
| Control SW 4.5ft inside | 60 | 7 | 67 | 9 | 5.4 |
| Interactive NE 2.5ft inside | 61 | 0 | 30 | 0 | 4.7 |
| Interactive NE 3.5ft inside | 58 | 0 | 24 | 4 | 0.8 |
| Interactive NE 4.5ft inside | 56 | 2 | 14 | 8 | 0 |
| Interactive SE 2.5ft inside | 61 | 0 | 36 | 0 | 5.7 |
| Interactive SE 3.5ft inside | 60 | 0 | 47 | 1 | 2.9 |
| Interactive SE 4.5ft inside | 57 | 0 | 34 | 2 | 1.6 |
| Interactive NW 2.5ft inside | 59 | 0 | 25 | 1 | 6.8 |
| Interactive NW 3.5ft inside | 60 | 0 | 41 | 2 | 4.2 |
| Interactive NW 4.5ft inside | 57 | 0 | 35 | 6 | 2.1 |
| Interactive SW 2.5ft inside | 62 | 0 | 41 | 1 | 4 |
| Interactive SW 3.5ft inside | 59 | 0 | 38 | 3 | 2.3 |
| Interactive SW 4.5ft inside | 58 | 0 | 54 | 2 | 3.7 |
| Reduced Size E Center | 61 | 59 | 100< | 0 | 0 |
| Reduced Size W Center | 62 | 92 | 100< | 0 | 0.5 |
| Irrigation E Center | 59 | 49 | 100< | 24 | 0.3 |
| Irrigation W Center | 57 | 42 | 100< | 21 | 0.2 |
| Pseudo-Biofilter E Center | 60 | 37 | 84 | 112 | 6.5 |
| Pseudo-Biofilter W Center | 55 | 102 | 100< | 349 | 2.7 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 22 (June 29)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 64 | 9 | 100< | 12 | 0.3 |
| Control NE 3.5ft inside | 62 | 29 | 100< | 38 | 0.1 |
| Control NE 4.5ft inside | 61 | 21 | 100< | 18 | 0 |
| Control SE 2.5ft inside | 65 | 10 | 33 | 3 | 1.1 |
| Control SE 3.5ft inside | 61 | 26 | 20 | 18 | 0.1 |
| Control SE 4.5ft inside | 59 | 20 | 100< | 10 | 0.1 |
| Control NW 2.5ft inside | 65 | 2 | 41 | 1 | 3.2 |
| Control NW 3.5ft inside | 64 | 6 | 21 | 6 | 0.6 |
| Control NW 4.5ft inside | 62 | 44 | 100< | 49 | 0.1 |
| Control SW 2.5ft inside | 66 | 2 | 37 | 2 | 2.4 |
| Control SW 3.5ft inside | 63 | 30 | 29 | 24 | 1.2 |
| Control SW 4.5ft inside | 60 | 85 | 18 | 55 | 0 |
| Interactive NE 2.5ft inside | 64 | 1 | 24 | 7 | 0.9 |
| Interactive NE 3.5ft inside | 64 | 5 | 16 | 14 | 0.1 |
| Interactive NE 4.5ft inside | 64 | 2 | 19 | 6 | 0.4 |
| Interactive SE 2.5ft inside | 64 | 0 | 30 | 2 | 6.8 |
| Interactive SE 3.5ft inside | 64 | 2 | 27 | 6 | 1.1 |
| Interactive SE 4.5ft inside | 63 | 3 | 55 | 7 | 4.3 |
| Interactive NW 2.5ft inside | 60 | 3 | 28 | 7 | 1 |
| Interactive NW 3.5ft inside | 62 | 7 | 19 | 14 | 0.2 |
| Interactive NW 4.5ft inside | 60 | 29 | 17 | 40 | 0.1 |
| Interactive SW 2.5ft inside | 63 | 0 | 27 | 2 | 5.6 |
| Interactive SW 3.5ft inside | 64 | 1 | 30 | 4 | 1.3 |
| Interactive SW 4.5ft inside | 63 | 7 | 17 | 13 | 0.2 |
| Reduced Size E Center | 58 | 113 | 100< | 0 | 0 |
| Reduced Size W Center | 58 | 120 | 100< | 0 | 0.1 |
| Irrigation E Center | 61 | 52 | 100< | 13 | 0.5 |
| Irrigation W Center | 60 | 79 | 100< | 45 | 0 |
| Pseudo-Biofilter E Center | 64 | 105 | 100< | 0 | 4.4 |
| Pseudo-Biofilter W Center | 62 | 112 | 100< | 0 | 3.8 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 29 (06 July)**

| | T ( ̊C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 64 | 1 | 41 | 4 | 2.4 |
| Control NE 3.5ft inside | 63 | 47 | 100< | 71 | 1.3 |
| Control NE 4.5ft inside | 63 | 13 | 100< | 28 | 0.2 |
| Control SE 2.5ft inside | 62 | 1 | 16 | 0 | 3.6 |
| Control SE 3.5ft inside | 63 | 2 | 32 | 24 | 1.6 |
| Control SE 4.5ft inside | 64 | 6 | 34 | 34 | 1 |
| Control NW 2.5ft inside | 62 | 0 | 20 | 1 | 9 |
| Control NW 3.5ft inside | 64 | 2 | 35 | 6 | 1.6 |
| Control NW 4.5ft inside | 62 | 29 | 17 | 37 | 0.2 |
| Control SW 2.5ft inside | 60 | 0 | 13 | 0 | 10.2 |
| Control SW 3.5ft inside | 64 | 2 | 38 | 5 | 2.2 |
| Control SW 4.5ft inside | 63 | 3 | 28 | 9 | 1.5 |
| Interactive NE 2.5ft inside | 61 | 0 | 32 | 0 | 2 |
| Interactive NE 3.5ft inside | 62 | 2 | 22 | 7 | 0.5 |
| Interactive NE 4.5ft inside | 63 | 4 | 100< | 31 | 0.4 |
| Interactive SE 2.5ft inside | 62 | 0 | 33 | 2 | 8.2 |
| Interactive SE 3.5ft inside | 63 | 1 | 53 | 6 | 3.8 |
| Interactive SE 4.5ft inside | 63 | 1 | 33 | 5 | 1.6 |
| Interactive NW 2.5ft inside | 61 | 0 | 34 | 0 | 5.9 |
| Interactive NW 3.5ft inside | 63 | 3 | 24 | 10 | 0.5 |
| Interactive NW 4.5ft inside | 62 | 19 | 100< | 39 | 0.2 |
| Interactive SW 2.5ft inside | 63 | 1 | 36 | 3 | 6.9 |
| Interactive SW 3.5ft inside | 63 | 2 | 60 | 8 | 4.3 |
| Interactive SW 4.5ft inside | 62 | 2 | 52 | 10 | 3.4 |
| Reduced Size E Center | 62 | 230 | 100< | 164 | 0 |
| Reduced Size W Center | 61 | 206 | 100< | 135 | 0.4 |
| Irrigation E Center | 63 | 18 | 100< | 29 | 0.4 |
| Irrigation W Center | 62 | 188 | 100< | 157 | 0.4 |
| Pseudo-Biofilter E Center | 65 | 59 | 100< | 50 | 8.5 |
| Pseudo-Biofilter W Center | 64 | 24 | 78 | 20 | 8.4 |

## Appendix M. On-Site Field Readings (cont.)

**DAY 36 (July 13)**

| | T ( °C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 61 | 216 | 100< | 153 | 0.3 |
| Control NE 3.5ft inside | 60 | 229 | 100< | 210 | 0 |
| Control NE 4.5ft inside | 61 | 127 | 100< | 104 | 0 |
| Control SE 2.5ft inside | 66 | 9 | 36 | 12 | 1.7 |
| Control SE 3.5ft inside | 64 | 10 | 100< | 24 | 0.4 |
| Control SE 4.5ft inside | 64 | 6 | 100< | 11 | 0.5 |
| Control NW 2.5ft inside | 64 | 0 | 46 | 1 | 4.2 |
| Control NW 3.5ft inside | 64 | 1 | 100< | 7 | 0 |
| Control NW 4.5ft inside | 62 | 283 | 100< | 233 | 0 |
| Control SW 2.5ft inside | 63 | 0 | 22 | 0 | 5.9 |
| Control SW 3.5ft inside | 64 | 0 | 31 | 2 | 1.3 |
| Control SW 4.5ft inside | 63 | 21 | 16 | 33 | 0 |
| Interactive NE 2.5ft inside | 65 | 0 | 33 | 7 | 1.3 |
| Interactive NE 3.5ft inside | 64 | 1 | 100< | 10 | 1.1 |
| Interactive NE 4.5ft inside | 67 | 3 | 100< | 9 | 0.8 |
| Interactive SE 2.5ft inside | 65 | 1 | 41 | 6 | 1.8 |
| Interactive SE 3.5ft inside | 64 | 1 | 59 | 9 | 3.9 |
| Interactive SE 4.5ft inside | 66 | 0 | 33 | 4 | 1.5 |
| Interactive NW 2.5ft inside | 63 | 0 | 44 | 1 | 4 |
| Interactive NW 3.5ft inside | 64 | 8 | 22 | 20 | 0.4 |
| Interactive NW 4.5ft inside | 63 | 113 | 100< | 109 | 0 |
| Interactive SW 2.5ft inside | 66 | 2 | 29 | 5 | 0.9 |
| Interactive SW 3.5ft inside | 64 | 17 | 100< | 27 | 0 |
| Interactive SW 4.5ft inside | 63 | 15 | 100< | 20 | 0 |
| Reduced Size E Center | 62 | 5 | 24 | 3 | 8.6 |
| Reduced Size W Center | 62 | 160 | 100< | 136 | 2.1 |
| Irrigation E Center | 60 | 351 | 100< | 323 | 0 |
| Irrigation W Center | 62 | 268 | 100< | 246 | 0 |
| Pseudo-Biofilter E Center | 64 | 38 | 100< | 38 | 16.3 |
| Pseudo-Biofilter W Center | 61 | 106 | 100< | 72 | 11.2 |

## Appendix M. On-Site Field Readings (cont.)

**Day 50 (July 27)**

| | T ( °C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 61 | 113 | 100< | 174 | 0.4 |
| Control NE 3.5ft inside | 62 | 116 | 100< | 186 | 0 |
| Control NE 4.5ft inside | 64 | 64 | 100< | 90 | 0 |
| Control SE 2.5ft inside | 65 | 111 | 100< | 168 | 0 |
| Control SE 3.5ft inside | 63 | 135 | 100< | 196 | 0 |
| Control SE 4.5ft inside | 63 | 63 | 75 | 103 | 0 |
| Control NW 2.5ft inside | 65 | 14 | 100< | 20 | 0.4 |
| Control NW 3.5ft inside | 63 | 185 | 100< | 233 | 0 |
| Control NW 4.5ft inside | 62 | 127 | 100< | 168 | 0 |
| Control SW 2.5ft inside | 65 | 9 | 100< | 19 | 0.8 |
| Control SW 3.5ft inside | 64 | 131 | 100< | 158 | 0.2 |
| Control SW 4.5ft inside | 63 | 167 | 100< | 159 | 0 |
| Interactive NE 2.5ft inside | 65 | 37 | 100< | 42 | 0.3 |
| Interactive NE 3.5ft inside | 62 | 118 | 100< | 153 | 0 |
| Interactive NE 4.5ft inside | 61 | 68 | 100< | 88 | 0 |
| Interactive SE 2.5ft inside | 64 | 29 | 22 | 33 | 0.4 |
| Interactive SE 3.5ft inside | 63 | 173 | 100< | 239 | 0 |
| Interactive SE 4.5ft inside | 63 | 131 | 100< | 160 | 0 |
| Interactive NW 2.5ft inside | 63 | 0 | 35 | 0 | 4 |
| Interactive NW 3.5ft inside | 64 | 216 | 21 | 215 | 0 |
| Interactive NW 4.5ft inside | 64 | 10 | 23 | 12 | 0.5 |
| Interactive SW 2.5ft inside | 65 | 11 | 22 | 19 | 0.5 |
| Interactive SW 3.5ft inside | 64 | 202 | 100< | 272 | 0 |
| Interactive SW 4.5ft inside | 63 | 141 | 100< | 146 | 0 |
| Reduced Size E Center | 58 | 6 | 18 | 7 | 6.7 |
| Reduced Size W Center | 59 | 50 | 22 | 51 | 0.4 |
| Irrigation E Center | 66 | 114 | 100< | 237 | 0 |
| Irrigation W Center | 66 | 154 | 100< | 263 | 0 |
| Pseudo-Biofilter E Center | 61 | 123 | 100< | 134 | 0 |
| Pseudo-Biofilter W Center | 64 | 47 | 100< | 63 | 1 |

## Appendix M. On-Site Field Readings (cont.)

**Day 64 (August 10)**

| | T ( °C ) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 60 | 204 | 20 | 275 | 0 |
| Control NE 3.5ft inside | 60 | 254 | 100< | 353 | 0 |
| Control NE 4.5ft inside | 60 | 187 | 100< | 250 | 0 |
| Control SE 2.5ft inside | 63 | 168 | 100< | 345 | 0 |
| Control SE 3.5ft inside | 61 | 278 | 100< | 346 | 0 |
| Control SE 4.5ft inside | 61 | 216 | 100< | 206 | 0 |
| Control NW 2.5ft inside | 62 | 99 | 20 | 226 | 0.1 |
| Control NW 3.5ft inside | 61 | 187 | 18 | 331 | 0 |
| Control NW 4.5ft inside | 62 | 117 | 15 | 189 | 0 |
| Control SW 2.5ft inside | 62 | 245 | 18 | 297 | 0.1 |
| Control SW 3.5ft inside | 60 | 412 | 18 | 349 | 0 |
| Control SW 4.5ft inside | 59 | 337 | 16 | 327 | 0 |
| Interactive NE 2.5ft inside | 61 | 155 | 16 | 271 | 0 |
| Interactive NE 3.5ft inside | 61 | 97 | 16 | 124 | 0 |
| Interactive NE 4.5ft inside | 62 | 18 | 19 | 35 | 0.3 |
| Interactive SE 2.5ft inside | 62 | 141 | 19 | 281 | 0 |
| Interactive SE 3.5ft inside | 61 | 141 | 18 | 207 | 0 |
| Interactive SE 4.5ft inside | 61 | 77 | 15 | 104 | 0 |
| Interactive NW 2.5ft inside | 60 | 85 | 15 | 157 | 0 |
| Interactive NW 3.5ft inside | 59 | 138 | 18 | 217 | 0 |
| Interactive NW 4.5ft inside | 60 | 102 | 16 | 122 | 0 |
| Interactive SW 2.5ft inside | 62 | 89 | 16 | 184 | 0 |
| Interactive SW 3.5ft inside | 61 | 162 | 18 | 230 | 0.1 |
| Interactive SW 4.5ft inside | 59 | 209 | 16 | 235 | 0 |
| Reduced Size E Center | 58 | 14 | 18 | 11 | 3.1 |
| Reduced Size W Center | 55 | 72 | 18 | 29 | 0.1 |
| Irrigation E Center | 58 | 114 | 100< | 165 | 2.8 |
| Irrigation W Center | 60 | 176 | 100< | 184 | 0 |
| Pseudo-Biofilter E Center | 59 | 115 | 17 | 165 | 0.1 |
| Pseudo-Biofilter W Center | 60 | 142 | 20 | 184 | 0 |

## Appendix M. On-Site Field Readings (cont.)

**Day 78 (August 24)**

| | T (°C) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 59 | 61 | 18 | 95 | 0 |
| Control NE 3.5ft inside | 56 | 183 | 19 | 222 | 0 |
| Control NE 4.5ft inside | 53 | 169 | 19 | 121 | 0 |
| Control SE 2.5ft inside | 59 | 90 | 19 | 153 | 0 |
| Control SE 3.5ft inside | 56 | 256 | 18 | 185 | 0 |
| Control SE 4.5ft inside | 53 | 365 | 20 | 100 | 0 |
| Control NW 2.5ft inside | 59 | 115 | 16 | 120 | 0 |
| Control NW 3.5ft inside | 57 | 114 | 18 | 168 | 0.1 |
| Control NW 4.5ft inside | 54 | 138 | 18 | 141 | 0 |
| Control SW 2.5ft inside | 59 | 55 | 18 | 89 | 0 |
| Control SW 3.5ft inside | 56 | 120 | 18 | 160 | 0 |
| Control SW 4.5ft inside | 54 | 212 | 20 | 130 | 0.1 |
| Interactive NE 2.5ft inside | 62 | 1 | 20 | 3 | 1.2 |
| Interactive NE 3.5ft inside | 60 | 14 | 15 | 29 | 0 |
| Interactive NE 4.5ft inside | 59 | 1 | 20 | 2 | 3.5 |
| Interactive SE 2.5ft inside | 62 | 2 | 13 | 4 | 0 |
| Interactive SE 3.5ft inside | 60 | 25 | 13 | 46 | 0 |
| Interactive SE 4.5ft inside | 60 | 7 | 15 | 15 | 0 |
| Interactive NW 2.5ft inside | 58 | 0 | 15 | 0 | 3.3 |
| Interactive NW 3.5ft inside | 58 | 13 | 13 | 23 | 0 |
| Interactive NW 4.5ft inside | 55 | 20 | 14 | 32 | 0 |
| Interactive SW 2.5ft inside | 62 | 0 | 17 | 0 | 0 |
| Interactive SW 3.5ft inside | 61 | 12 | 12 | 21 | 0 |
| Interactive SW 4.5ft inside | 60 | 5 | 13 | 9 | 0 |
| Reduced Size E Center | 51 | 15 | 18 | 12 | 0 |
| Reduced Size W Center | 50 | 11 | 17 | 10 | 0.4 |
| Irrigation E Center | 57 | 58 | 18 | 72 | 0 |
| Irrigation W Center | 60 | 18 | 18 | 21 | 0 |
| Pseudo-Biofilter E Center | 63 | 68 | 18 | 12 | 0 |
| Pseudo-Biofilter W Center | 50 | 11 | 17 | 10 | 0.4 |

## Appendix M. On-Site Field Readings (cont.)

**Day 99 (Sep 14)**

| | T (°C) | $H_2S$ (ppm) | LEL (%) | NO (ppm) | O2 (%) |
|---|---|---|---|---|---|
| Control NE 2.5ft inside | 50 | 112 | 13 | 64 | 0 |
| Control NE 3.5ft inside | 49 | 174 | 12 | 24 | 0 |
| Control NE 4.5ft inside | 47 | 111 | 30 | 10 | 3.9 |
| Control SE 2.5ft inside | 53 | 261 | 12 | 61 | 0 |
| Control SE 3.5ft inside | 49 | 230 | 14 | 31 | 0 |
| Control SE 4.5ft inside | 47 | 185 | 13 | 18 | 0 |
| Control NW 2.5ft inside | 53 | 25 | 15 | 19 | 0.5 |
| Control NW 3.5ft inside | 50 | 31 | 16 | 16 | 0.5 |
| Control NW 4.5ft inside | 48 | 24 | 17 | 8 | 0.6 |
| Control SW 2.5ft inside | 52 | 224 | 14 | 36 | 0.3 |
| Control SW 3.5ft inside | 49 | 221 | 14 | 32 | 0 |
| Control SW 4.5ft inside | 47 | 30 | 19 | 7 | 0.8 |
| Interactive NE 2.5ft inside | 51 | 496 | 12 | 273 | 0 |
| Interactive NE 3.5ft inside | 51 | 92 | 11 | 250 | 0 |
| Interactive NE 4.5ft inside | 50 | 446 | 9 | 122 | 0 |
| Interactive SE 2.5ft inside | 53 | 383 | 10 | 325 | 0 |
| Interactive SE 3.5ft inside | 51 | 330 | 16 | 294 | 0.1 |
| Interactive SE 4.5ft inside | 50 | 263 | 13 | 82 | 0 |
| Interactive NW 2.5ft inside | 53 | 500 | 13 | 210 | 0 |
| Interactive NW 3.5ft inside | 51 | 492 | 13 | 260 | 0 |
| Interactive NW 4.5ft inside | 48 | 480 | 14 | 260 | 0.2 |
| Interactive SW 2.5ft inside | 52 | 364 | 14 | 254 | 0.1 |
| Interactive SW 3.5ft inside | 52 | 500 | 16 | 317 | 0 |
| Interactive SW 4.5ft inside | 52 | 467 | 14 | 367 | 0 |
| Reduced Size E Center | 44 | 21 | 10 | 3 | 0.9 |
| Reduced Size W Center | 42 | 32 | 16 | 6 | 0.8 |
| Irrigation E Center | 48 | 267 | 11 | 106 | 0 |
| Irrigation W Center | 50 | 262 | 12 | 93 | 0 |
| Pseudo-Biofilter E Center | 55 | 160 | 12 | 254 | 0 |
| Pseudo-Biofilter W Center | 53 | 58 | 12 | 89 | 0.3 |