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Determination of Size Fractions and Concentrations of Airborne Particulate Matter Generated From Construction and Demolition Waste Processing Facilities

Jason M. Young
Virginia Commonwealth University

"Determination of Size Fractions and Concentrations of Airborne Particulate Matter Generated from Construction and Demolition Waste Processing Facilities"

A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Environmental Studies at Virginia Commonwealth University.

by

Jason Matthew Young, B.S. Virginia Tech, 1998

Director: Dr. Leonard Vance, Associate Professor, Department of Epidemiology and Community Health

Virginia Commonwealth University
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List of Abbreviations

1. (ADC) Alternate Daily Cover
2. (Airlite™) SKC Airlite™ Model 110-100 samplers
3. (C&D) Construction and Demolition
4. (EPA) United States Environmental Protection Agency
5. (l/m) Liters Per Minute
6. (mg) Milligrams
7. (mg/m^3) Milligrams Per Cubic Meter of Air
8. (mm) Millimeter
9. (MSW) Municipal Solid Waste
10. (NAAQS) National Ambient Air Quality Standards
11. (NIOSH) National Institute of Occupational Safety and Health
12. (OSHA) United States Occupational Safety and Health Administration
13. (Partisol®) Partisol® FRM Model 2000 Air Sampler
14. (PEL) Permissible Exposure Limits
15. (PM) Particulate Matter
16. ($PM_{2.5}$) Particulate Matter 2.5
17. (PM_{10}) Particulate Matter 10
18. (PVC) Poly Vinyl Chloride
19. (SAS) Statistical Analysis Software version 8.2
20. (TWS) Time-Weighted Average
21. ($\mu g/m^3$) Micrograms Per Cubic Meter of Air
22. (um) Micron

Abstract

DETERMINATION OF SIZE FRACTIONS AND CONCENTRATIONS OF AIRBORNE PARTICULATE MATTER GENERATED FROM CONSTRUCTION AND DEMOLITION WASTE PROCESSING FACILITIES

By Jason Young, M.S.

A Thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science at Virginia Commonwealth University.

Virginia Commonwealth University, 2007

Major Director: Dr. Leonard Vance, Associate Professor, Department of Epidemiology and Community Health

Construction and Demolition (C&D) processing and recycling facilities accept waste materials that are generated during construction and demolition activities. The processing facility sorts, processes, and transfers the material to another operation. A consequence of these processes is the generation of particulate matter.

This study involved quantifying and qualifying airborne particulates at three C&D processing facilities. Active stationary particulate sampling devices were employed to quantify the particle sizes of interest. Results were compared to United States Environmental Protection Agency (EPA) National Ambient Air Quality Standards (NAAQS) and United States Occupational Safety and Health Administration (OSHA) standards.

The results from this study are not valid for determination of compliance with NAAQS or OSHA standards. However, the data indicate that C&D processing facilities may exceed current NAAQS at certain locations, but do not exceed OSHA standards. These results can be used by the industry as an engineering tool to reduce airborne particulate levels during normal operations of C&D facilities.

Introduction

According to the Construction Materials Recycling Association, more than 325 million tons of recoverable construction and demolition materials are generated in the United States annually (CMRA 2006). C&D debris consists of the materials generated during the construction, renovation, and demolition of buildings, roads, and bridges (USEPA 2007a). Construction and Demolition processing and recycling facilities accept waste materials such as concrete, wood, gypsum, asphalt, shingles, glass, and steel. This material is typically processed and either recycled or taken to a C&D or municipal solid waste landfill. Typical operations at these facilities include sorting, shredding, and grinding. They may also manufacture Alternate Daily Cover (ADC) or mulch. C&D landfills often use front-end processing facilities to remove recoverable portions of the waste stream and to reduce the material's size to improve landfill airspace management.

The use of C&D processing facilities is a growing trend. Recent estimates by Mr. Bill Turley of the Construction Materials Recycling Association estimate that there are over 3500 C&D recycling facilities (Turley 2007). However, a consequence of this process is the generation of particulate matter (PM). Particulate matter is a mixture of extremely small particles and liquid droplets in the air (USEPA 2006). Fine particles are less than 2.5 micrometers in diameter ($PM_{2.5}$) and often result from fuel combustion (USEPA 2006). Coarse dust is between 2.5 and 10 micrometers in diameter

(USEPA 2006). Particulate Matter 10 includes both fine and coarse dust particles and is generally emitted by sources (USEPA 2006). Potential sources of PM_{10} at C&D processing facilities include sorting, grinding, and shredding operations, materials handling, unpaved roads, and windblown dust. The potential impacts to health, aesthetics, air quality, and manufacturing equipment as a result of the generation of airborne particulates from C&D processing facilities are unknown.

The size of particles is linked to their potential for causing health problems. Evidence from numerous toxicological studies has indicated that the type and strength of adverse health effects due to exposure to ambient PM vary as the attributes of PM change (Oberdorster 2001, Saldiva 2002, and Samet 2000). The attribute studied was particle size, which often varies with particle source, and often with the atmospheric conditions through which particles are transported. Understanding the generation of particles and the relative contributions of particulate matter from these facilities is important for understanding the links between these facilities and possible adverse health effects associated with exposure to PM. Not only do particle attributes vary with source type, but impacts on size fractions result from differences in design or operation of various C&D processing facilities. To better understand the links from source and exposure to dose and effects, it is necessary to tie the key particle attributes (including, but not limited to, size distribution) to specific facilities' source types, including across different designs and operating conditions.

The particle sizes of interest in this study were PM_{10} and $PM_{2.5}$. These were studied since PM_{10} and $PM_{2.5}$ are the particulate sizes of interest regulated under the

Clean Air Act. The Clean Air Act requires the EPA to set NAAQS for pollutants considered harmful to public health and environment. Primary standards set limits to protect public health, while secondary standards set limits to protect public welfare. As such, PM_{10} and $PM_{2.5}$ have current Ambient Air Quality Standards promulgated by the United States Environmental Protection Agency (see Table 1). These standards are found in the Code of Federal Regulations 40CFR50.6 and 40CFR50.13 and on the EPA website (NARA 2007 and USEPA 2007b).

Table 1 - EPA NAAQS

Pollutant	Primary Standards	Averaging Times	Secondary Standards
Particulate Matter (PM_{10})	Revoked[(1)]	Annual[(1)] (Arith. Mean)	
	150 $\mu g/m^3$	24-hour[(2)]	
Particulate Matter ($PM_{2.5}$)	15 $\mu g/m^3$	Annual[(3)] (Arith. Mean)	Same as Primary
	35 $\mu g/m^3$	24-hour[(4)]	

Units of measure for the standards are micrograms per cubic meter of air ($\mu g/m^3$).
Footnotes:
[(1)] Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the agency revoked the annual PM_{10} standard in 2006 (effective December 17, 2006).
[(2)] Not to be exceeded more than once per year on average over 3 years.
[(3)] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 $\mu g/m^3$.
[(4)] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 $\mu g/m^3$ (effective December 17, 2006).

In addition to PM_{10} and $PM_{2.5}$, inert or nuisance dust levels were also quantified according to OSHA standards. These standards are for particulates that are not otherwise regulated by OSHA and consider total dust (NIOSH 0500) and respirable fraction (NIOSH 0600) concentrations (see Table 2) (DOL 2006). Total dust includes all airborne particles, regardless of their size, while respirable dust refers to dust particles that are small enough to penetrate deep into the lungs (DOL 2006). OSHA regulates exposure under the Code of Federal Regulations 29CFR1910.1000. These standards are found in the Code of Federal Regulations and on the OSHA website (NARA 2007 and DOL 2006). Under these regulations, allowable exposure is quantified as permissible exposure limits (PELs), or time-weighted averages (TWSs) that are not to be exceeded for an 8-hour workday within a 40-hour workweek. These were of interest in order to better understand worker exposure levels and pathways.

Table 2 - OSHA Standards

Substance	ppm (a) (1)	mg/m^3 (b) (1)
Total Dust	....	15
Respirable Fraction	....	5

Footnote (1) The PELs are 8-hour TWAs unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.
Footnote (a) Parts of vapor or gas per million parts of contaminated air by volume at 25 degrees C and 760 torr.
Footnote (b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

Opacity measurements were also collected at various locations periodically during the study. Opacity is the amount of light which is blocked by a medium, in this case dust. Opacity was determined through visual observation; however, the observer was not certified as a visible emission observer.

Three different C&D processing facilities, located in the mid-Atlantic, the southeast, and the northeast United States were studied. Each of these facilities shared common features and had distinctive differences. The following sections detail the study and the sampling results. The information gathered during this study should be useful to C&D processing facility owners, health professionals, communities, and environmental regulators in identifying possible impacts to health, aesthetics, air quality, and manufacturing equipment.

Sampling Methodology

This study employed active stationary particulate sampling devices to accurately quantify the size fractions and concentrations of particulate matter generated by the operation of C&D processing facilities. Particulate monitors were located near facility boundaries as well as near potential sources of contamination, such as areas of processing operations or dusty roads, in order to capture the impact of such sources. The particle sizes of interest were those with diameters less than 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$) and total and respirable dust levels.

For comparison with United States Environmental Protection Agency National Ambient Air Quality Standards (see Table 1), Partisol® FRM Model 2000 Air Samplers (Partisol®) were used to sample for PM_{10} and $PM_{2.5}$ (Thermo Scientific 2006). This equipment has an EPA reference method for both PM_{10} (RFPS-1298-126) and $PM_{2.5}$ (RFPS-0498-117). Filter based monitors such as the Partisol® provide one 24-hour average concentration based on an integrated sample.

Time weighted average measurements were calculated by dividing the total weight of the PM_{10} or $PM_{2.5}$ collected in the sample by the volume of air associated with that sample. The concentration of this average measurement was reported in units of micrograms per cubic meter of air ($\mu g/m^3$). EPA NAAQS specify that the 24-hour PM_{10} standard of 150 $\mu g/m^3$ not be exceeded more than once per year on average over 3 years.

The 24-hour $PM_{2.5}$ standard specifies that the 3-year average of the 98^{th} percentile of 24-hour concentrations at each population-oriented monitor within an area not exceed the standard of 35 $\mu g/m^3$. Because sampling only took place over a period of two weeks at each sampling location, results are not valid for the demonstration of compliance with NAAQS. Furthermore, NAAQS typically do not apply to indoor air quality whereas some of the results presented in this report were collected under roof. Sampling locations were also biased towards areas of high activity rather than near typical ambient locations.

Five Partisol® air sampling devices were employed at each of the three sampling sites. The devices were calibrated prior to sampling. Attempts were made to place the devices in similar types of locations at each site in order to obtain representative and comparative measurements. One unit was positioned under roof, typically in the tipping area. Another device was stationed outside and directly opposite of the under roof unit in order to access the effectiveness of the building's ability to reduce dust. The three other units were positioned at various locations along each facility's perimeter to quantify particulates at property boundaries. See Appendix A for a general diagram of a C&D processing facility and general sampling locations of the Partisol® air monitoring equipment.

Pre-weighed 47 mm Teflon® filters with a 2.0 micron (um) pore size were used with the Partisol® air sampling devices to collect airborne particulate matter. Filters were inspected for imperfections and loaded into clean filter cassettes in a clean room environment prior to deployment into the field. Each Partisol® device was programmed to sample for 24 consecutive hours at a rate of 16.7 liters per minute (l/m). Immediately prior to the start of the sampling period, the filter cassette was loaded into each sampling device. At the end of each sampling period, the filter cassette was collected and placed into a sealed metal carrying case. The filter was later removed from the filter cassette in a clean room environment and placed into its respective Petri dish for transport. A visual assessment of the amount of particulates collected on each filter was documented to compare to the laboratory results.

Filter identification numbers were used to track each sample and to ensure that the correct filter was placed into its representative Petri dish. Nitrile gloves were worn during handling of the filters. A rubber band was placed around the Petri dishes to ensure that they did not open during transport and the dishes were placed inside of a plastic bag to ensure contamination did not occur. A trip blank was collected during each sampling event to help ensure proper sampling procedures. The samples were then shipped, under chain-of-custody control, to a certified laboratory for analysis using gravimetric testing techniques. Each filter was weighed by the laboratory before and after sample collection to determine the net gain due to the particulate matter. Time weighted average results were calculated using volume data. The laboratory level of quantitation was 0.1 milligrams (mg). There were no quantified detections in the trip blanks during the study.

The status of each Partisol® unit was accessed periodically throughout the day and at the conclusion of each 24-hour sampling period. Various parameters were accessed in order to ensure that an accurate sample was collected. These parameters include but are not limited to; total sample time, average flow, ambient temperature, average pressure, and status codes. See Appendices B-F for the complete list of assessment parameters and the status report for each Partisol® sampling unit.

An EPA designed $PM_{2.5}$ WINS Impactor sampling device was used with the Partisol® air sampling units when collecting $PM_{2.5}$ data. A new 37 millimeter (mm) borosilicate glass fiber filter was installed inside the WINS Impactor prior to each sampling event. Forty-two to forty-four drops of impactor oil were placed on the fiber filter prior to installing it into the WINS Impactor.

National Institute of Occupational Safety and Health (NIOSH) analytical methods for total nuisance dust and respirable fraction nuisance dust levels were used for comparison with the United States Occupational Safety and Health Administration standards (see Table 2). SKC Airlite™ Model 110-100 air samplers (Airlite™) were used to measure total nuisance dust (NIOSH 0500) and respirable fraction nuisance dust (NIOSH 0600) levels (SKC 2007).

Time weighted average measurements were calculated by dividing the weight of the total nuisance dust or respirable nuisance dust collected in the sample by the volume of air associated with that sample. The concentration of this average measurement was reported in units of milligrams per cubic meter of air (mg/m^3). OSHA standards specify that permissible exposure limits are 8-hour time weighted averages. Because these units were not placed directly on workers, the results are not valid for the demonstration of compliance with OSHA standards. However, the equipment was placed in areas where personnel typically worked.

Two Airlite™ air sampling devices were employed at each of the three sampling locations. The devices were calibrated prior to sampling. Both units were positioned under roof, typically in the receiving building, near the Partisol® devise that was placed under roof. Both Airlite™ units were placed about four feet from one another and the sample inlets were located approximately five feet above ground level (in the typical breathing zone). See Appendix A for a general diagram of a C&D processing facility and general locations of the Airlite™ air monitoring equipment.

Pre-weighed polyvinyl chloride (PVC) filters with a 5 um pore size were used with the Airlite™ air sampling devices to collect total and respirable dust measurements. Each device was manually started at the beginning of the workday and manually stopped after 8 hours of sampling. Total nuisance dust was sampled at a rate of 2.0 l/m and respirable nuisance dust was sampled at a rate of 2.5 l/m. Immediately prior to the start of the sampling period, a filter was installed in the sampling device to collect the dust. All filters were inspected for imperfections. At the end of each sampling period, the filters were collected and placed into a plastic bag for transport. The status of each Airlite™ air sampling device was accessed periodically and at the conclusion of each 8 hour sampling period. An aluminum cyclone was used to restrict the particle size collected for the respirable dust samples.

Filter identification numbers were used to track each sample. Nitrile gloves were worn during handling of the filters. The filters were placed inside of a plastic bag to ensure contamination did not occur. A trip blank was collected during each sampling event to help ensure proper sampling procedures. The samples were then shipped under chain-of-custody control to a certified Laboratory for analysis using gravimetric testing techniques. Each filter was weighed by the laboratory before and after sample collection to determine the net gain due to the particulate matter. Time weighted average results were calculated using volume data. The laboratory level of quantitation was 0.05 mg. There were no quantified detections in the trip blanks during the study.

Each of the three sampling locations was sampled during two different time periods. The sampling events were staggered in order to collect data during different periods of operation. $PM_{2.5}$ data were collected during the first two sample days during each sampling period. PM_{10} data were collected during the last two sample days during each sampling period. Total and respirable dust level samples were collected each of the four days of each sampling period. See Appendices G-I for the sampling dates and analytical results of each sampling event.

In addition to these measurements, opacity measurements using EPA methods were used to quantify opacity at each facility. Measurements were collected at various locations periodically during the study at points of interest (i.e. receiving buildings, roadways, etc.). The opacity measurements were collected in order to estimate the amount of light which was blocked by dust. This was determined through visual observation; however, the observer was not certified as a visible emission observer.

Information on variables that may have possibly influenced the sample results was collected. Records indicating the types and quantities of materials entering and exiting the facilities were obtained from each facility during each sampling period (see Appendices J-L). Daily weather measurements including average wind direction and speed, temperature, humidity, total precipitation, and barometric pressure were collected (see Appendices M-O). The total distance of each sampling unit from various points of interest (i.e. tipping area, roadways, etc.) was also measured.

Statistical Methods

The data collected were entered into Statistical Analysis Software (SAS) version 8.2 (SAS 2001). SAS software was used for all statistical analyses and a 5% significance level was used for all tests. Analysis of variance (ANOVA) tests were used to compare data. Normality of the data was checked prior to running the ANOVAs to compare all of the units at each site. To do this, the data from each individual unit were checked separately for normality, with p-values from a Shapiro Wilk test greater than .05 indicating normality. Normality was expected to be difficult to achieve due to the small sample sizes and daily operational differences at the facilities.

All of the data were normal except for the PM_{10} data of Unit 4 at Site B, which had a Shapiro Wilk p-value of <0.0001 and the PM_{10} data of Unit 4 at Site C, which had a Shapiro Wilk p-value of 0.0043. Due to an equipment malfunction, the PM_{10} data of Unit 4 at Site B only contained three samples, which made it difficult to achieve normality. One data point from the PM_{10} data of Unit 4 at Site C was significantly higher than the other three data points; however, neither the laboratory nor the field notes indicated any problems with the data.

In cases when the laboratory did not report a quantified detection, half of the quantitation limit was used for analysis. Due to equipment malfunctions, three samples collected from Site B were not submitted to the laboratory. These samples are identified in the results section of Site B. The total dust value collected during the 2nd sampling event at Site A was also excluded from analysis because loose particles present inside of the cassette were included in the laboratory analysis.

Each site was studied individually to determine statistical significance of various fields of interest. At each site, the PM_{10} and $PM_{2.5}$ data collected from the five Partisol® air sampling devices were compared to determine if a significant difference existed between the measurements collected in the Units. Multiple comparison tests were run to determine which means were different. Tukey's Studentized Range Test was used to identify which means were significantly different in these cases. Duncan's Multiple Range Test was also used in one case.

The sites were also compared to one another in order to determine statistical significance of various fields of interest. The means of the PM_{10} and $PM_{2.5}$ data collected from the Units located near roadways at Site A and Site C were compared to determine if there was a significant difference between different types of roads. PM_{10} and $PM_{2.5}$ data collected from the indoor Units at each site were compared to one another to determine if there was a significant difference between the results. Total and respirable dust level concentrations at each site were also compared to one another. If a statistically significant difference appeared to exist, then multiple comparison tests were run to determine which means were different. Tukey's Studentized Range Test was used to identify which means were significantly different in these cases.

Site A

Site A Description

This section presents the results of PM_{10} and $PM_{2.5}$ and total and respirable dust level monitoring at a C&D processing facility located in mid-Atlantic United States. The site receives a combination of municipal solid waste (MSW), C&D material, cardboard, and mixed recyclables. The majority of the material brought to the site is sent to a landfill. Concrete, metal, cardboard, and mixed recyclables are sorted and sent to various locations. There are no grinding or mulching operations at the facility. There is no misting system in place nor do they spray down the waste stream. The receiving area and all roads are paved. The facility did not use street sweepers to remove material from the pavement during this study; however, they occasionally do use street sweepers. Approximately 3% of the waste stream is recycled.

The receiving building is indoors. The receiving building is covered and has openings on both ends for vehicles to enter and exit. Large amounts of concrete, metal, and cardboard are unloaded separately from the main waste stream, which allows the facility to more easily recycle these materials. The waste material is then pushed into piles by a dozer. An excavator then picks up the material from the debris piles and loads it into trucks, which take the material to a landfill.

Site A Sampling Locations

Partisol® Unit 1 was placed along the western perimeter of the site, approximately 435 feet west of the receiving building and 75 feet west of a paved road located inside of the facility. Unit 2 was placed along the northern perimeter of the site, approximately 141 feet north of the receiving building. Unit 3 was placed along the eastern perimeter of the site, approximately 487 feet east of the receiving building and 5 feet east of a paved road located inside of the facility. Unit 4 was placed approximately 50 feet south of the receiving building and was used to measure the effectiveness of the building's ability to reduce dust. Unit 5 was placed in the northeast corner of the receiving building approximately 35 feet away from the main tipping area. Two Airlite™ air sampling devices were placed near Unit 5 in the northeast corner of the receiving building.

Site A Results

The averages of the PM_{10} data between the five sampling units were not statistically significantly different at α=.05 (p-value=0.1488)(see Table 3); however, the averages of the $PM_{2.5}$ data between the five sampling events were marginally significantly different (p-value=0.0475)(see Table 4). Tukey's Studentized Range Test did not show any significant differences in the $PM_{2.5}$ data; however, Duncan's Test showed a significant difference between Unit 5 and the rest of the Units. Even though these results may not be statistically significantly different, the results may be practically significantly different.

Table 3: Statistical Comparison of PM_{10} Data at Site A

Tukey's Studentized Range Test for PM_{10} Data at Site A

Alpha	0.05
Error Degrees of Freedom	15
Error Mean Square	6334.7
Critical Value of Studentized Range	4.36699
Minimum Significant Difference	173.79

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Unit
A	167.50	4	5
A			
A	71.00	4	4
A			
A	52.25	4	3
A			
A	37.25	4	2
A			
A	29.00	4	1

Table 4: Statistical Comparison of $PM_{2.5}$ Data at Site A

Duncan's Multiple Range Test for $PM_{2.5}$ Data at Site A

Alpha	0.05
Error Degrees of Freedom	15
Error Mean Square	148.7717

Number of Means	2	3	4	5
Critical Range	18.38	19.27	19.82	20.20

Means with the same letter are not significantly different.

Duncan Grouping	Mean ($\mu g/m^3$)	N	Unit
A	41.75	4	5
B	18.53	4	4
B			
B	17.95	4	3
B			
B	17.58	4	2
B			
B	16.90	4	1

The greatest concentrations of PM_{10} and $PM_{2.5}$ were measured in the receiving building by Unit 5. Unit 4, which was placed 50 feet from the building's entrance/exit, generally recorded the second greatest concentrations of PM_{10} and $PM_{2.5}$. See Figure 1 for graphical results of PM_{10} data and Figure 2 for graphical results of $PM_{2.5}$ data.

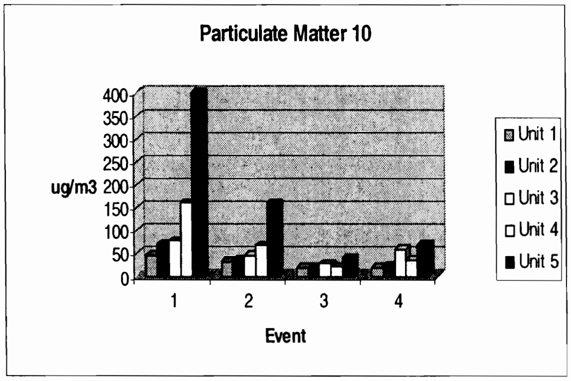


Figure 1 – Site A PM_{10}

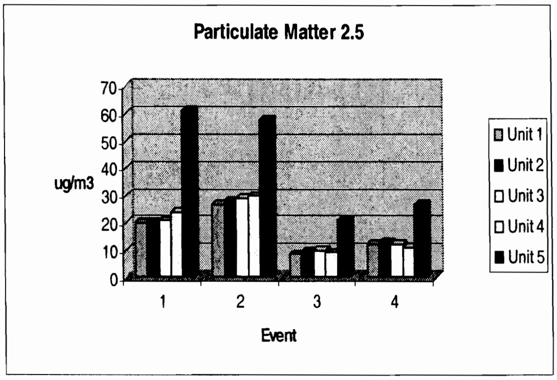


Figure 2 – Site A $PM_{2.5}$

The PM_{10} measurements exhibited a slight positive linear trend to the volume of inbound and outbound material (see Figure 3). Unit 5, in particular, displayed a positive linear trend. However, there was not a clear linear trend between the $PM_{2.5}$ measurements and the volume of material (see Figure 4). Although concentrations of PM_{10} and $PM_{2.5}$ dust levels varied considerably between sample events, the relationship of the measurements between each Unit remained similar.

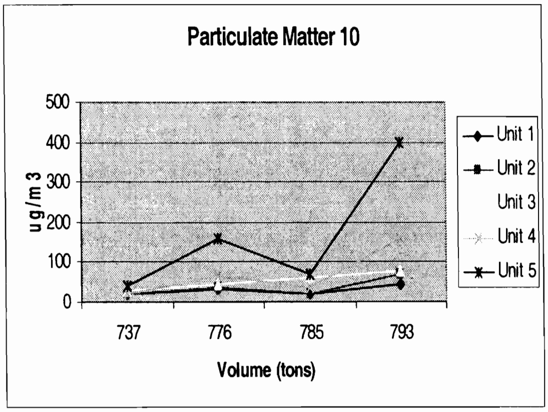


Figure 3 – Site A PM_{10} and Material Volume Correlation

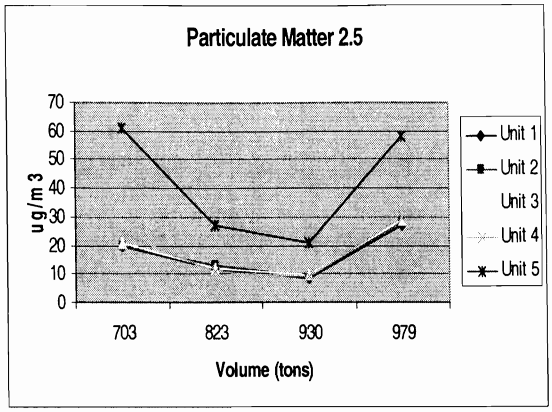


Figure 4 – Site A $PM_{2.5}$ and Material Volume Correlation

Samples were not collected to determine compliance with NAAQS and these results should not be used to determine compliance with NAAQS. However, if these results were valid for determination of compliance, then several possible exceedances occurred. When these results were compared to EPA PM_{10} NAAQS, Unit 5 exceeded the 24-hour standard of 150 $\mu g/m^3$ during sampling events 1 and 2. Unit 4 exceeded the standard during sampling event 1. When these results were compared to EPA $PM_{2.5}$ NAAQS, Unit 5 exceeded the 24-hour standard of 35 $\mu g/m^3$ during sampling events 1 and 2 collected inside of the receiving building.

Total and respirable dust level measurements were not collected to determine compliance with OSHA standards and these results should not be used to determine compliance with OSHA standards. However, if these results were valid for determination of compliance, then neither the total nor respirable dust level measurements would have exceeded OSHA total or respirable dust level standards (see Figures 5 and 6) (note: the total dust value collected during the 2[nd] sampling event at Site A was excluded from analysis because loose particles present inside of the cassette were included in the laboratory analysis). Both total and respirable dust measurements exhibited a positive linear trend to the volume of inbound and outbound material (see Figures 7 and 8). Furthermore, total and respirable dust levels tended to follow increasing and decreasing trends similar to the PM_{10} and $PM_{2.5}$ measurements.

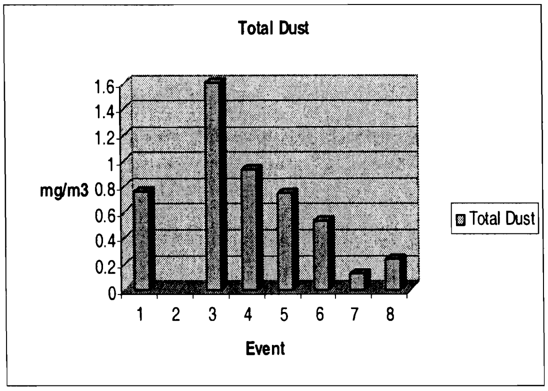


Figure 5 – Site A Total Dust

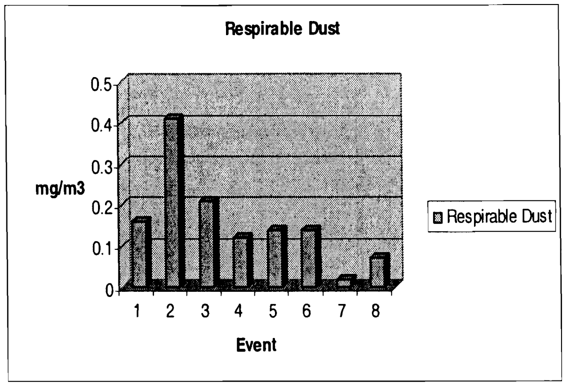


Figure 6 – Site A Respirable Dust

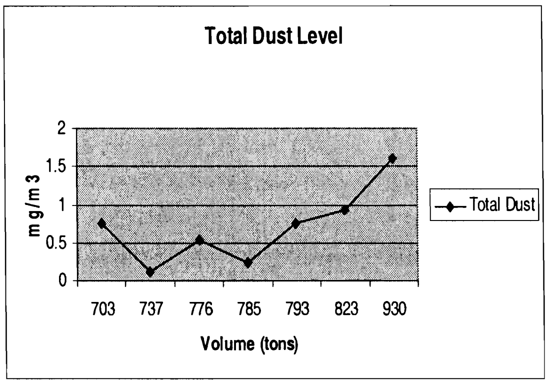


Figure 7 – Site A Total Dust and Material Volume Correlation

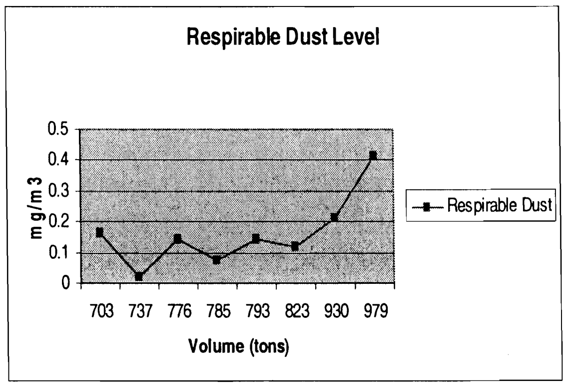


Figure 8 – Site A Respirable Dust and Material Volume Correlation

Opacity inside of the receiving building was around 30%; however, during tipping activities measurements temporarily reached levels as high as 70%. Opacity measured directly outside of the receiving building, near Unit 4, reached levels around 30% when vehicles entered or exited the building or when wind caused dust to exit the receiving building through the openings on either end. Opacity levels measured near perimeter sampling devices were near 0% until vehicles drove on nearby roadways. This vehicle activity caused opacity to reach levels around 20% in the vicinity of the perimeter Units. However, during rain events, levels remained near 0% even during vehicle activity.

Site A Conclusion

As expected, the highest concentrations of PM_{10} and $PM_{2.5}$ were measured inside of the receiving building. If these results were valid for determination of compliance with NAAQS, then several possible exceedances occurred. Unit 5 exceeded the 24-hour EPA PM_{10} NAAQS during sampling events 1 and 2. Unit 4, located just outside of the receiving building, exceeded the 24-hour EPA PM_{10} NAAQS during sampling event 1. Unit 5 also exceeded the 24-hour EPA $PM_{2.5}$ NAAQS during sampling events 1 and 2. None of the total or respirable dust measurements exceeded OSHA total dust or respirable fraction standards. Measurements collected from the Partisol® unit inside of the receiving building corresponded to the measurements collected from the Airlite™ units during respective days.

Generally, dust level concentrations exhibited a positive linear trend to the volume of inbound and outbound material. However, dust levels cannot be explained by volume of material alone. There are several other factors that may have influenced the sampling results. Perhaps the biggest contributor to airborne particulate levels was dust on the roadways. Even though the roads were paved dust was still present on the roads. This dust was stirred into the air by vehicle activity and collected by the sampling units located near the roadways.

Weather conditions may have had an effect on sampling results as well. Dust levels tended to be lower during the second week of sampling than during the first. This corresponded with higher humidity and lower temperatures during the second week of sampling. The wind direction also shifted from predominantly coming from the south to predominantly from the east or north between the first and second weeks of sampling. Rain events occurred during both sampling weeks that temporarily reduced dust generated from the roadways, which likely reduced airborne particulate concentrations on those days. Opacity measurements at the perimeter sampling locations decreased during and after these rain events and were influenced by vehicle activity and facility operations as expected.

Site B

Site B Description

This section presents the results of PM_{10} and $PM_{2.5}$ and total and respirable dust level monitoring at a C&D processing facility located in the southeastern United States. The site receives a combination of C&D material, concrete, and mixed recyclables. The facility also manufacturers a cover product, which is exported for use as an alternate daily cover (ADC). Some of the material brought to the site is sent to a landfill for disposal. Concrete, metal, cardboard, and plastic are sorted and sent to various reclamation facilities. They bale cardboard and plastic onsite, but do not have any grinding or mulching operations. They periodically use a sprinkler to spray the receiving area down with water, but do not operate a misting system. The receiving area and all roads are paved. The facility uses a street sweeper to remove material and add water to the pavement. Approximately 75% of the waste stream is recycled, which is mainly attributed to concrete recycling.

The receiving area is outdoors. Materials brought to the facility are unloaded outside. A dozer pushes the waste material into a pile. Materials that are recyclable are brought into a covered building by a dozer. Large amounts of recyclables may be unloaded directly in the covered building. This material is then pushed by a dozer through the building and picked up by an excavator and placed onto a screen. Occasionally, recyclable material is pushed directly to the pile that is placed onto the screen without going through the building. The screen allows anything smaller than two inches to fall through. This material is used as ADC. Material larger than two inches is taken to a conveyor belt. The conveyor belt brings the larger material to a picking room. The material is then hand sorted according to type of recyclable material. The recyclable material is then sent to various locations. Material that was not moved inside of the building is picked up with an excavator and loaded into trucks, which take the material to a landfill.

Site B Sampling Locations

Partisol® Unit 1 was placed on the northern side inside of the material holding building. Unit 2 was placed directly outside of the entrance to the building and under a roof, approximately 190 feet northwest of the outside tipping area. Unit 2 was located near the baling operation and the end of the conveyor belt that droped unsorted material. Unit 3 was placed in the northeast corner of the property on top of a tractor trailer bed and approximately 50 feet northeast of the sorting operation and 150 feet northeast of the outside tipping area. It was not practical to position Unit 3 on the ground. Unit 4 was located along the eastern perimeter of the site, approximately 90 feet southeast of the outside tipping area and 150 feet southeast of the sorting area. Unit 5 was placed along the western perimeter of the site, approximately 220 feet west of the outside tipping area and 320 feet southwest of the sorting area. Two Airlite™ air sampling devices were placed near Unit 1 along the northern side of the material holding building.

Site B Results

The averages of the PM_{10} data between the five sampling units were significantly different at α=.05 (p-value=0.0002)(see Table 5); however, the average of the $PM_{2.5}$ data between the five sampling units were not significantly different (p-value=0.3927)(see Table 6).

Table 5: Statistical Comparison of PM_{10} Data at Site B

Tukey's Studentized Range Test for PM_{10} Data at Site B

Alpha	0.05
Error Degrees of Freedom	14
Error Mean Square	4017.155
Critical Value of Studentized Range	4.40661
Minimum Significant Difference	144.23
Harmonic Mean of Cell Sizes	3.75

NOTE: Cell sizes are not equal.

Means with the same letter are not significantly different.

Tukey Grouping		Mean ($\mu g/m^3$)	N	Unit
	A	322.50	4	2
	A			
B	A	262.50	4	1
B				
B	C	132.67	3	4
B	C			
B	C	125.75	4	3
	C			
	C	58.75	4	5

Table 6: Statistical Comparison of $PM_{2.5}$ Data at Site B

Tukey's Studentized Range Test for $PM_{2.5}$ Data at Site B

Alpha	0.05
Error Degrees of Freedom	14
Error Mean Square	132.1283
Critical Value of Studentized Range	4.40661
Minimum Significant Difference	26.157
Harmonic Mean of Cell Sizes	3.75

NOTE: Cell sizes are not equal.

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Unit
A	32.00	4	3
A			
A	27.50	4	2
A			
A	19.25	4	1
A			
A	19.23	3	4
A			
A	18.40	4	5

The greatest concentrations of PM_{10} were measured just outside of the entrance to the material holding building by Unit 2. Unit 1, located inside of the building, measured the second greatest concentrations of PM_{10}. Units 3 and 4 typically measured concentrations of PM_{10} less than the measurements sampled in Units 1 and 2. Unit 5 measured the lowest concentrations of PM_{10}. PM_{10} concentrations in Units 1 and 2 were significantly different from Unit 5. The greatest concentrations of $PM_{2.5}$ were measured closest to the sorting and ADC operations by Unit 3. Units 1 and 2 typically measured $PM_{2.5}$ concentrations less than that measured in Unit 3. Units 4 and 5 measured the lowest concentrations of $PM_{2.5}$. See Figure 9 for graphical results of PM_{10} data and Figure 10 for graphical results of $PM_{2.5}$ data (note: the PM_{10} sample from Unit 4 during the 1st sampling event and the $PM_{2.5}$ sample from Unit 4 during the 4th sampling event were not submitted to the laboratory due to equipment malfunctions).

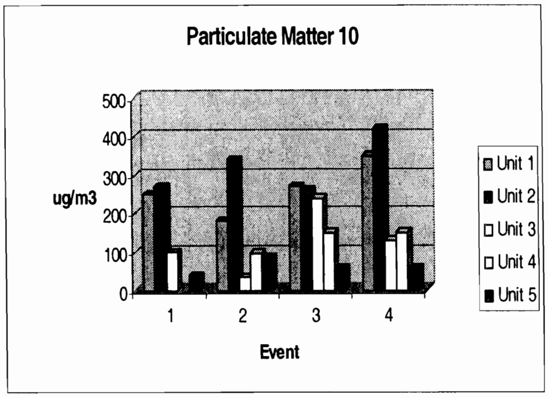


Figure 9 - Site B PM_{10}

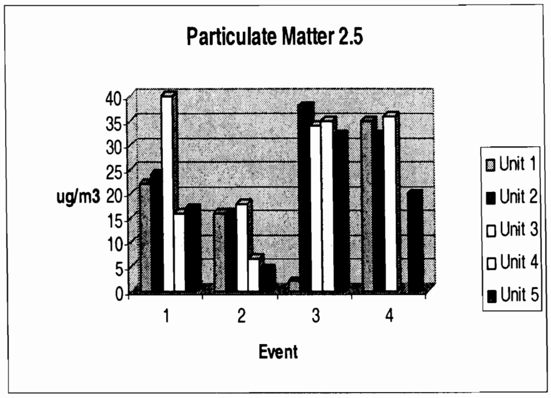


Figure 10 - Site B $PM_{2.5}$

Neither the PM_{10} nor the $PM_{2.5}$ measurements exhibited a strong linear trend to the volume of inbound and outbound material with the exception of Unit 1 (see Figures 11 and 12). Unit 1 displayed a slight positive linear trend. The relationship of the measurements between each Unit varied with both PM_{10} and $PM_{2.5}$ measurements.

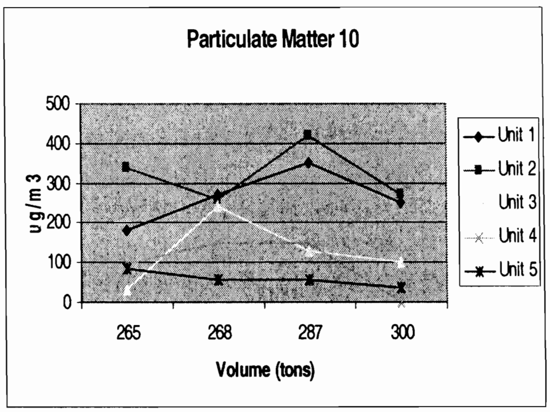


Figure 11 – Site B PM_{10} and Material Volume Correlation

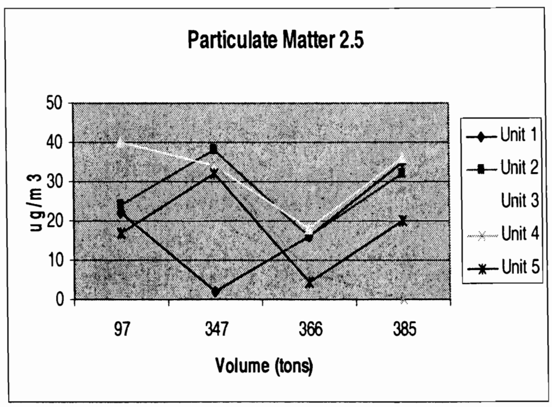


Figure 12 – Site B $PM_{2.5}$ and Material Volume Correlation

Samples were not collected to determine compliance with NAAQS and these results should not be used to determine compliance with NAAQS. However, if these results were valid for determination of compliance, then several possible exceedances occurred. When these results were compared to EPA PM_{10} NAAQS, Units 1 and 2 exceeded the 24-hour standard of 150 $\mu g/m^3$ during each sampling event and Unit 3 exceeded the standard during sampling event 3. When these results were compared to EPA $PM_{2.5}$ NAAQS, Unit 2 exceeded the 24-hour standard of 35 $\mu g/m^3$ during sampling event 3 and Unit 3 exceeded the standard during sampling events 1 and 4.

Total and respirable dust level measurements were not collected to determine compliance with OSHA standards and these results should not be used to determine compliance with OSHA standards. However, if these results were valid for determination of compliance, then neither the total nor respirable dust level measurements would have exceeded OSHA total or respirable dust level standards (see Figures 13 and 14) (note: the respirable dust sample from the 4th sampling event was not submitted to the laboratory due to an equipment malfunction). Neither total dust nor respirable fraction measurements exhibited a positive linear trend to the volume of inbound and outbound material (see Figures 15 and 16). Furthermore, total and respirable dust levels tended to increase and decrease as the levels recorded from Partisol® unit 1, which was located in the same area, increased and decreased.

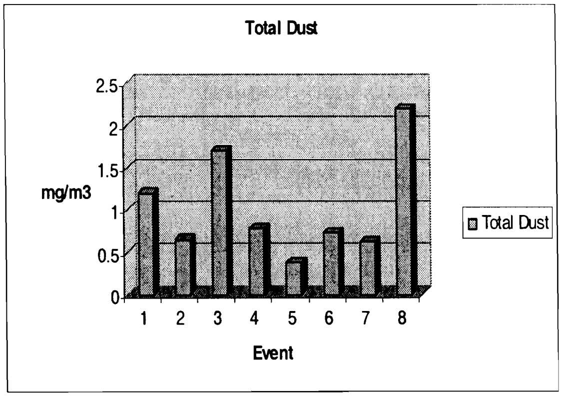


Figure 13 – Site B Total Dust

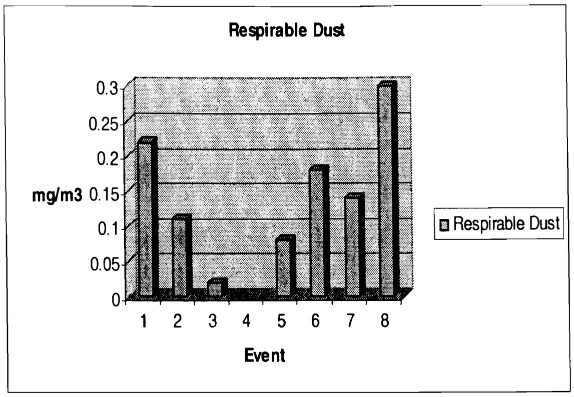


Figure 14 – Site B Respirable Dust

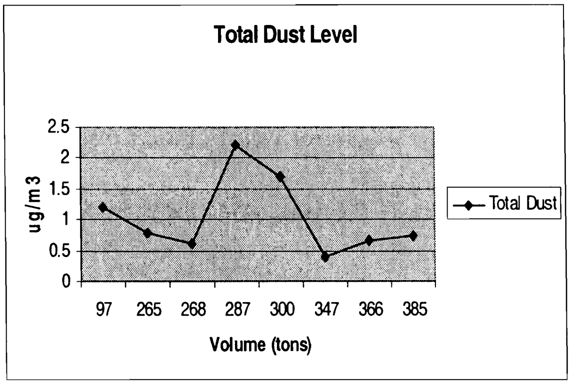


Figure 15 – Site B Total Dust and Material Volume Correlation

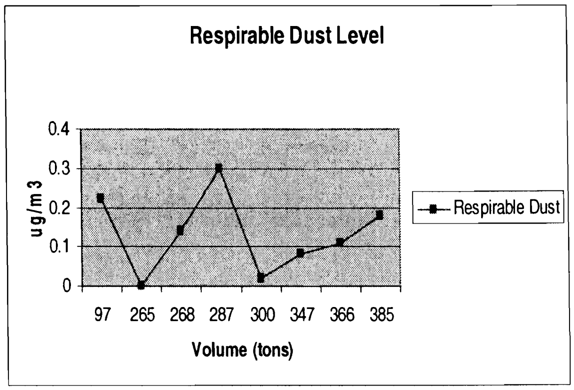


Figure 16 – Site B Respirable Dust and Material Volume Correlation

Opacity in the northeast corner of the facility, near Unit 3, reached levels as high as 40% when the excavator was loading material onto the screen. Opacity inside of the building was close to 0% until the dozer pushed material into the building. During dozer activity opacity levels would reach around 20%. Opacity levels near Unit 2, located just outside of the building, reached levels around 20% during dozer activity or when the conveyor belt would drop unsorted waste nearby. Opacity levels around the perimeter of the site were typically around 0%; however, vehicle activity and wind occasionally stirred up dust and temporarily increased opacity to minimal levels.

Site B Conclusion

Typically, the highest concentrations of airborne particulate matter are expected to be measured under roof. However, the majority of operations at this facility took place outside. The greatest concentrations of PM_{10} were measured just outside of the entrance to the building by Unit 2. The proximity of the baling operation and the drop off of material by the conveyor belt to Unit 2 likely contributed to the particulates collected by that unit. Unit 1, located inside of the material holding building, measured the second greatest concentrations of PM_{10}.

The greatest concentrations of $PM_{2.5}$ were measured closest to the sorting operation by Unit 3. Wind was typically blowing towards Unit 3 and opacity levels were usually the highest near that Unit. Unit 3 was also elevated approximately 20 feet in the air and was located near the sorting and ADC operations. The elevation of the unit may have reduced the quantity of larger particulates able to reach the sampling device while the proximity of the device to the sorting and ADC operations may have increased the amount of smaller sized particles near the Unit.

If these results were valid for determination of compliance with NAAQS, then several possible exceedances occurred. Units 1 and 2 exceeded the 24-hour EPA PM_{10} NAAQS during each sampling event and Unit 3 exceeded the standard during sampling event 3. Unit 2 exceeded the 24-hour EPA $PM_{2.5}$ NAAQS during sampling event 3 and Unit 3 exceeded the standard during sampling events 1 and 4. None of the total or respirable dust measurements exceeded OSHA total or respirable dust standards.

Dust level concentrations were not typically correlated to the volume of inbound and outbound material. Particulate concentrations between Partisol® Units seemed to be impacted by the type of operation that was taking place in the vicinity of each respective Unit. For example, Unit 1, located in the material holding building, exhibited very low $PM_{2.5}$ during the 3rd sampling event. This corresponded to low activity in the building on that day. Unit 2, located near the baling operation and conveyor belt showed higher particulate concentrations during baling activities and when the conveyor belt was operating. Dust on the roadways also contributed to particulate levels. Even though the roads were paved, dust was stirred into the air by vehicle activity and collected by the sampling units located near the roadways.

$PM_{2.5}$ and respirable dust levels tended to be higher during the second week of sampling than the first week. Although the total amount of inbound and outbound volume was similar during both weeks, over 270 tons of ADC material was exported during the second week of sampling, compared to 0 tons during the first week. This difference may help explain the increase in observed $PM_{2.5}$ and respirable dust concentrations during the second week of sampling.

Although it was slightly warmer and drier during the second week of sampling, weather did not appear to be a major factor influencing particulate measurements. There were; however, a couple of rain events that temporarily reduced dust on the roadways and likely led to the reduced concentration of PM_{10} collected on those days. The street sweeper would temporarily reduce the amount of dust being stirred into the air by wind or vehicles because of the water it added to the roadways; however, it did not seem to remove the dust and once the roads dried, conditions would resume to levels observed prior to sweeping. The street sweeper's main purpose was to remove nails from the roadways, not dust. The sprinkler that was used to spray water on the tipping pile appeared to slightly reduce dust levels migrating from that pile. Opacity levels were influenced by vehicle activity and facility operations as expected.

Site C

Site C Description

This section presents the results of PM_{10} and $PM_{2.5}$ and total and respirable dust level monitoring at a C&D processing facility located in northeastern United States. The site receives a combination of C&D material, MSW, concrete, wood products, cardboard, metal, gypsum, and sheetrock. The facility also manufacturers a cover product, which is exported to landfills for use as an ADC. They have a mulching operation where wood products are ground onsite and converted to mulch as well as a cardboard baling operation. They operate a misting system in the indoor receiving area and periodically use a hose to spray water on the tipped material. The receiving area and majority of roads are paved. There are a few gravel and dirt roads. The facility uses a street sweeper to remove material and add water to the pavement. Approximately 95% of the waste stream is recycled.

The receiving area is indoors. Materials brought to the facility are unloaded in the receiving building. The building is covered and has two openings on one side. Vehicles enter and exit through one of the openings. ADC material is removed by trucks from the other opening. A dozer pushes the tipped material into a pile. This material is then picked up by an excavator and placed onto a conveyor belt. The conveyor belt brings the material to a picking room. The material is then hand sorted according to the type of recyclable material. The recyclable material is then exported to various locations. Smaller pieces of material and fines that are not sorted as recyclable are placed through a grinder and dropped onto a concrete floor by a conveyor belt to be exported as ADC.

Site C Sampling Locations

Partisol® Unit 1 was located along the northwest perimeter of the site, approximately 485 feet north-northwest of the receiving area and 50 feet north of a paved road located inside of the facility. Unit 2 was located inside of the receiving building along the southeastern wall approximately 20 feet from the tipping area. Unit 3 was placed approximately 65 feet southeast of the receiving building and was used to measure the effectiveness of the building's ability to reduce dust. Unit 4 was located approximately 280 feet southeast of the receiving building. Unit 5 was placed along the southwest perimeter of the site, approximately 300 feet south of the receiving building and 15 feet southwest of a gravel road located inside of the facility. Two Airlite™ air sampling devices were placed near Unit 2 along the southeast side of the receiving building.

Site C Results

The averages of the PM_{10} and $PM_{2.5}$ data between the five sampling units were significantly different (p-values < 0.0001)(see Tables 7 and 8). The greatest concentrations of PM_{10} were measured inside of the receiving building by Unit 2.

Table 7: Statistical Comparison of PM_{10} Data at Site C

Tukey's Studentized Range Test for PM_{10} Data at Site C

Alpha	0.05
Error Degrees of Freedom	15
Error Mean Square	29855.27
Critical Value of Studentized Range	4.36699
Minimum Significant Difference	377.28

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Unit
A	1012.50	4	2
B	151.00	4	5
B			
B	91.50	4	3
B			
B	39.50	4	4
B			
B	31.00	4	1

Table 8: Statistical Comparison of $PM_{2.5}$ Data at Site C

Tukey's Studentized Range Test for $PM_{2.5}$ Data at Site C

Alpha	0.05
Error Degrees of Freedom	15
Error Mean Square	808.3178
Critical Value of Studentized Range	4.36699
Minimum Significant Difference	62.079

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Unit
A	192.50	4	2
B	32.00	4	3
B			
B	18.83	4	5
B			
B	18.60	4	4
B			
B	18.20	4	1

The second greatest concentrations of PM_{10} were typically measured by Unit 5 along the southwest perimeter; however, the difference between the concentrations in Unit 2 and Unit 5 was very significant. Unit 3, located just outside of the receiving building, typically measured the third greatest concentrations of PM_{10}. Units 1 and 4 measured similar concentrations of PM_{10}. Unit 2 also measured the greatest concentrations of $PM_{2.5}$. Unit 3 measured the second greatest concentrations of $PM_{2.5}$; however, the difference between the concentration of $PM_{2.5}$ in Unit 2 and 3 was significant. The other three units measured similar concentrations of $PM_{2.5}$. See Figure 17 for graphical results of PM_{10} data and Figure 18 for graphical results of $PM_{2.5}$ data.

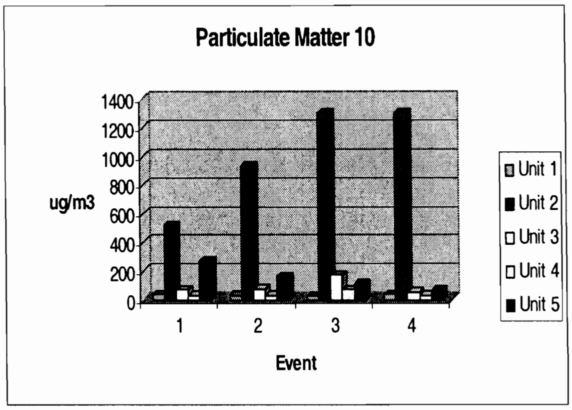


Figure 17 - Site C PM_{10}

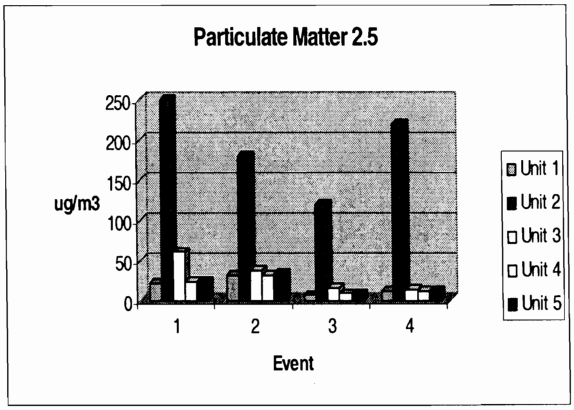


Figure 18 - Site C $PM_{2.5}$

Neither the PM_{10} nor the $PM_{2.5}$ measurements exhibited a strong linear trend to the volume of inbound and outbound material with the exception of Unit 2 (see Figures 19 and 20). Unit 2 displayed a slight positive linear trend. Although concentrations of PM_{10} and $PM_{2.5}$ dust levels varied between sampling events, the relationship of the measurements between each Unit remained relatively constant.

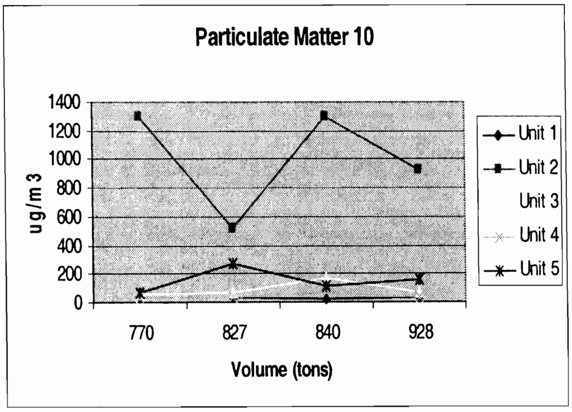


Figure 19 – Site C PM_{10} and Material Volume Correlation

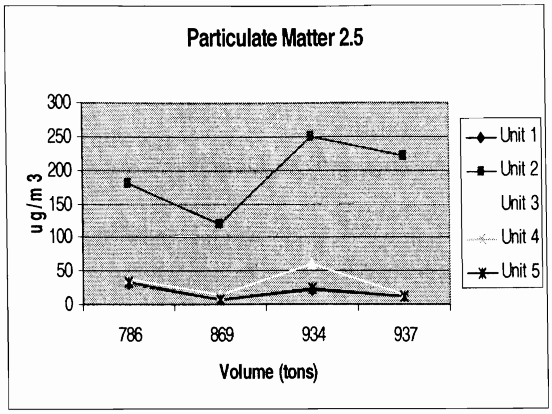


Figure 20 – Site C $PM_{2.5}$ and Material Volume Correlation

Samples were not collected to determine compliance with NAAQS and these results should not be used to determine compliance with NAAQS. However, if these results were valid for determination of compliance, then several possible exceedances occurred. When these results were compared to EPA PM_{10} NAAQS, Unit 2 exceeded the 24-hour standard of 150 $\mu g/m^3$ during each sampling event. Unit 3 exceeded the standard during sampling event 3 and Unit 5 exceeded the standard during sampling events 1 and 2. When these results were compared to EPA $PM_{2.5}$ NAAQS, Unit 2 exceeded the 24-hour standard of 35 $\mu g/m^3$ during each sampling event and Unit 3 exceeded the standard during sampling events 1 and 2.

Total and respirable dust level measurements were not collected to determine compliance with OSHA standards and these results should not be used to determine compliance with OSHA standards. However, if these results were valid for determination of compliance, then neither the total nor respirable dust level measurements would have exceeded OSHA total or respirable dust level standards (see Figures 21 and 22). Total and respirable dust measurements exhibited a slight positive linear trend to the volume of inbound and outbound material (see Figures 23 and 24).

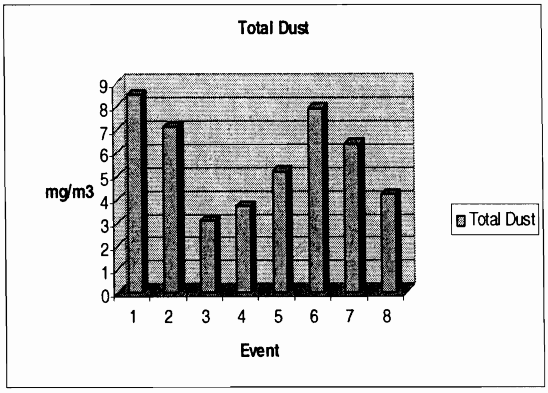


Figure 21 – Site C Total Dust

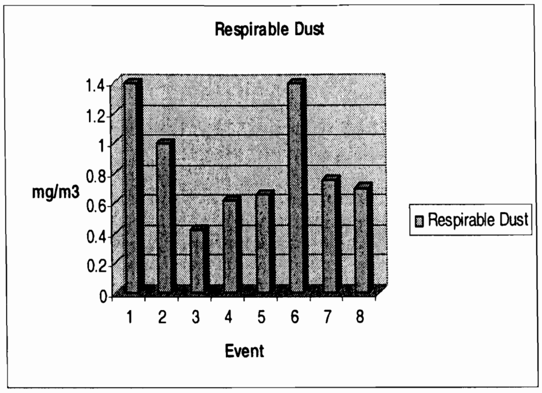


Figure 22 – Site C Respirable Dust

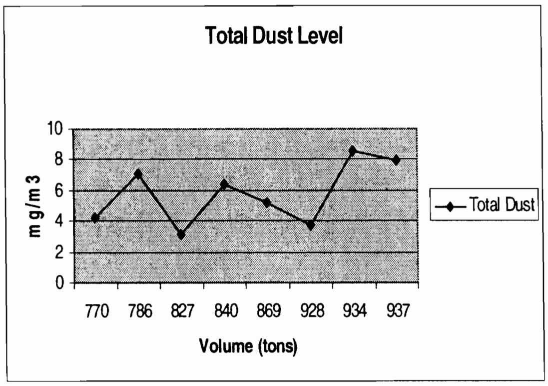


Figure 23 – Site C Total Dust and Material Volume Correlation

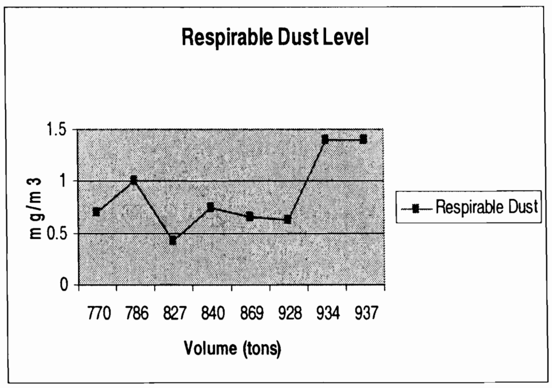


Figure 24 – Site C Respirable Dust and Material Volume Correlation

Opacity inside of the receiving area near Unit 2 maintained levels around 40%. When the misting system was not being used, opacity levels just outside of the building's door were around 10%; opacity was slightly lower than this when the misting system was being used. Opacity near Unit 5 was close to 0% until vehicles drove down the gravel roadway, which caused opacity levels to climb to around 20%. Opacity occasionally increased to low levels around Unit 1 when vehicles drove by on the nearby paved road and wind occasionally caused levels to slightly increase around Unit 4. Vehicle usage and wind increased opacity to minimal levels.

Site C Conclusion

As expected, the greatest concentrations of PM_{10} and $PM_{2.5}$ were measured inside of the receiving building by Unit 2. The second greatest concentrations of PM_{10} were measured by Unit 5, which was located away from the receiving building but next to a gravel road. However, the second greatest concentrations of $PM_{2.5}$ were measured by Unit 3, which was located just outside of the receiving building. The majority of particulates collected by Unit 5 appeared to be generated from the gravel road. The particulates from the gravel road may have been larger in size and may help explain the discrepancy between the particle sizes collected. The difference between concentrations of PM_{10} and $PM_{2.5}$ inside of the receiving building and just outside of the receiving building was significant (p-value=0.0027 and p-value=0.0018 respectively). The misting system and water hose appeared to reduce the quantity of particulates exiting the receiving building.

If these results were valid for determination of compliance with NAAQS, then several possible exceedances occurred. Unit 2 exceeded the 24-hour EPA PM_{10} NAAQS during each sampling event. Unit 3 exceeded the standard during sampling event 3 and Unit 5 exceeded the standard during sampling events 1 and 2. Unit 2 also exceeded the 24-hour EPA $PM_{2.5}$ NAAQS during each sampling event and Unit 3 exceeded the standard during sampling events 1 and 2. None of the total or respirable dust measurements exceeded OSHA standards.

Dust level concentrations were not typically correlated to the volume of inbound and outbound material. The Partisol® and Airlite™ units located within the receiving building exhibited a slight positive linear trend of particulate concentrations to volume of material. Measurements collected from the Partisol® unit inside of the receiving building corresponded to the measurements collected from the Airlite™ units during respective days.

Although it was slightly cooler with slightly less humidity during the second week of sampling, weather did not appear to be a major factor influencing particulate measurements. There were a couple of rain events that temporarily reduced dust on the roadways; however, the rain did not appear to significantly reduce particulate measurements on those days. The street sweeper would temporarily reduce the amount of dust being stirred into the air by wind or vehicles because of the water it added to the roadways; however, it did not seem to remove the dust. Also, once the water from the street sweeper dried, conditions would resume to levels prior to the sweeping. The street sweeper's main purpose was to remove nails from the roadways, not dust. Opacity levels were influenced by vehicle activity and facility operations as expected.

Site Comparison and General Conclusions

It is difficult to compare the three facilities that were studied in this report. Although each facility processes construction and demolition debris, numerous operational differences exist. For example, Sites A and C performed the majority of their operations under roof while Site B did not. Site A did not recycle as much of the total waste stream as the other two facilities. Site C operated a misting system inside of the receiving building and sprayed the tipping area with a hose while Site B used a sprinkler to spray the tipping area and Site A did neither. Record keeping also differed between facilities. Different classifications of material made it difficult to compare the possible impacts of the various types of materials being brought to and leaving the facilities.

In addition to these differences, it was also difficult to sample each facility in the same manner. For instance, the Partisol® and Airlite™ units that were placed under roof were located at different distances from the tipping area. It was not possible to locate the units at the same distances due to building designs and operational differences. The Units that were located outside also had to be placed at various distances from roads and points of interest due to facility operation considerations. However, despite these differences, several inferences can be made and trends analyzed.

PM_{10} and $PM_{2.5}$ concentrations recorded inside of the receiving building at Site C were significantly higher than concentrations measured at Sites A and B (p-value=0.0013 and p-value=0.0001)(see Tables 9 and 10).

Table 9: Statistical Comparison of PM_{10} Concentrations Indoors

Tukey's Studentized Range Test for PM10 Levels Indoors

Alpha	0.05
Error Degrees of Freedom	9
Error Mean Square	56574.11
Critical Value of Studentized Range	3.94850
Minimum Significant Difference	469.58

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Site
A	1012.50	4	C
B	262.50	4	B
B			
B	167.50	4	A

Table 10: Statistical Comparison of $PM_{2.5}$ Concentrations Indoors

Tukey's Studentized Range Test for PM2.5 Levels Indoors

Alpha	0.05
Error Degrees of Freedom	9
Error Mean Square	1250.722
Critical Value of Studentized Range	3.94850
Minimum Significant Difference	69.82

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Site
A	192.50	4	C
B	41.75	4	A
B			
B	19.25	4	B

Total and respirable dust level concentrations recorded inside of the receiving building at Site C were also significantly higher than concentrations measured at Sites A and B (p-values<.0001)(see Tables 11 and 12). However, the Partisol® and Airlite™ units were located closer to the tipping area at Site C and tipping did not occur under roof at Site B.

Table 11: Statistical Comparison of Total Dust Concentrations Indoors

Tukey's Studentized Range Test for Total Dust Levels Indoors

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	2.318342
Critical Value of Studentized Range	3.56463
Minimum Significant Difference	1.9189

NOTE: Cell sizes are not equal.

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Site
A	5.76	8	C
B	1.03	8	B
B			
B	0.70	7	A

Table 12: Statistical Comparison of Respirable Dust Concentrations Indoors

Tukey's Studentized Range Test for Respirable Dust Levels Indoors

Alpha	0.05
Error Degrees of Freedom	20
Error Mean Square	0.053355
Critical Value of Studentized Range	3.57794
Minimum Significant Difference	0.2991
Harmonic Mean of Cell Sizes	7.636364

NOTE: Cell sizes are not equal.

Means with the same letter are not significantly different.

Tukey Grouping	Mean ($\mu g/m^3$)	N	Site
A	0.87	8	C
B	0.16	8	A
B			
B	0.15	7	B

As expected, airborne particulate levels tend to be higher inside of buildings even when minimal activity is taking place. This was evident by the relatively high PM_{10} and $PM_{2.5}$ concentrations inside of the material storage building at Site B. If the results were valid for determination of NAAQS, then each of the three facilities would have exceeded the 24-hour EPA PM_{10} NAAQS at least one time in the sampling unit located inside of the building. However, despite the frequency of NAAQS exceedances, there were no OSHA total or respirable dust level exceedances inside of the buildings.

Also, as expected, airborne particulate levels tend to decrease as the distance between operational activity and the sampling devices increase. Concentrations of airborne particulate matter are higher in areas of high activity. Equipment usage, tipping, sorting, and baling all appeared to increase airborne particulate levels.

Road usage also seemed to impact airborne particulate levels. PM_{10} levels in Partisol units located next to roads were lower when the road was paved compared to gravel. Unit 3 at Site A was located approximately 5 feet away from a frequently used paved road and Unit 5 at Site C was located approximately 15 feet away from a frequently used gravel road. Even though the difference in PM_{10} concentrations was not significant at α=.05 (p-value= 0.0732) a noticeable difference exists. The mean PM_{10} concentration of Unit 3 at Site A was 52.25, whereas the mean PM_{10} concentration of Unit 5 at Site C was 151.00. However, $PM_{2.5}$ levels were not much different between paved and dirt or gravel roads (p-value=0.9109). The mean $PM_{2.5}$ concentration of Unit 3 at Site A was 17.95 whereas the mean $PM_{2.5}$ concentration of Unit 5 at Site C was 18.83. The particulates from the gravel road may have been larger in size and may help explain the discrepancy between the particle sizes collected. However, due to confounding variables between the sites, the results may be attributed to something other than the difference in road type.

Misting seems to significantly reduce the amount of airborne particulate matter exiting a building. The difference between PM_{10} and $PM_{2.5}$ measurements inside the receiving building at Site C and just outside of the receiving building was very significant at α=.05 (p-value=0.0027 and p-value=0.0018 respectively). The difference between PM_{10} and $PM_{2.5}$ measurements inside the receiving building in Site A and just outside of the receiving building was not significant at α=.05 (p-value=0.3114 and p-value=0.0902 respectively). These p-value results agree with the previous multiple comparison analyses performed for each individual site. However, these differences may also be attributed to differences in sampling locations (i.e. the distance between the indoor and outdoor sampling device, proximity to the building's opening, etc.) or to differences in building design (i.e. larger openings, position related to wind direction, etc.). Because Site B does not receive debris under roof it cannot be directly compared to the other two; however, the difference between PM_{10} and $PM_{2.5}$ measurements inside the material holding building and just outside of the building was not significant at α=.05 (p-value=0.2835 and p-value=0.3439 respectively).

The sampling events of this study took place during the summer months. Weather conditions did not vary much during the study and differed little between sampling events at respective sites. Therefore, it is difficult to predict the influence that weather may have on dust levels. It is possible that cooler temperatures, higher humidity, or increases in wind speed may impact measurements. A few minor rain events occurred during sampling that appeared to reduce observed dust levels. However, these reductions were temporary and conditions observed prior to the precipitation quickly returned. Reductions in airborne particulates caused by precipitation would most likely be observed in Units located outside and along roadways.

The total volume of waste for each site was compared to PM_{10} and $PM_{2.5}$ and total and respirable dust levels (see Figures 25-28). The total volume of waste was similar between Site A and Site C; however, airborne particulate levels were higher at Site C. Furthermore, the volume of waste was lower at Site B than at Sites A and C; however, airborne particulate levels were similar to levels observed at Site A. Due to the variables mentioned previously, it is difficult to come to any conclusions regarding these differences.

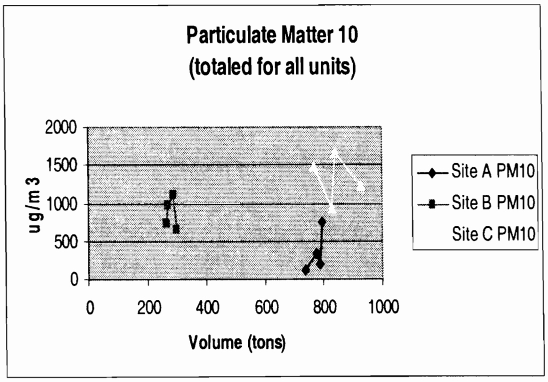


Figure 25 – PM_{10} and Material Volume Correlation for all Sites

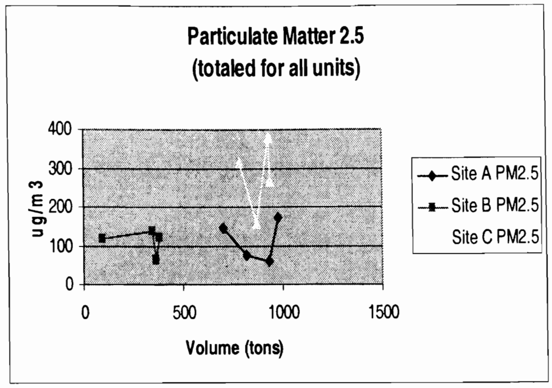


Figure 26 – $PM_{2.5}$ and Material Volume Correlation for all Sites

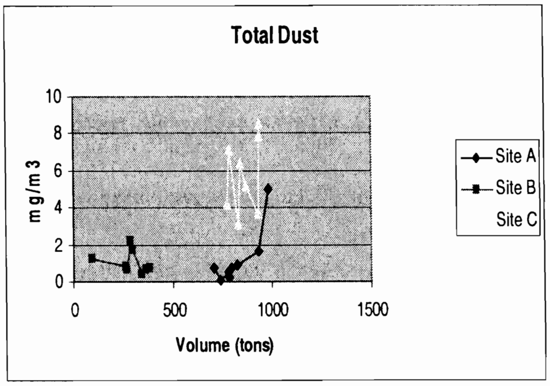


Figure 27 – Total Dust and Material Volume Correlation for all Sites

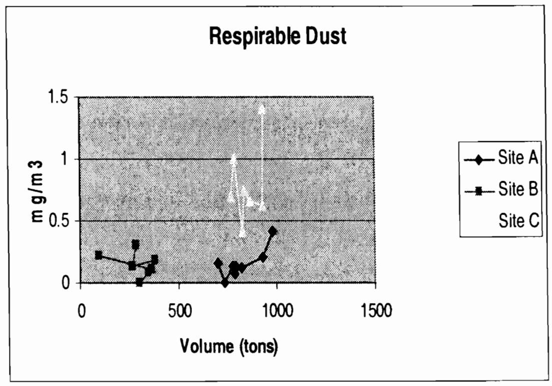


Figure 28 – Respirable Dust and Material Volume Correlation for all Sites

There are numerous variables that may impact results and these variables need to be accounted for when planning future studies. This study has hopefully laid the foundation for additional airborne particulate matter studies at C&D processing facilities. Future studies aimed at determining airborne particulate levels should take into account the sampling unit's proximity to operations and other possible sources of airborne particulates. It would be helpful if the study took place during various weather conditions. It would also be beneficial to collect more samples over a greater time period and during different operational periods. In order to directly compare sites, future studies should consider all facility operations and the sampling units' proximity to those operations. The type and amount of material coming into and leaving the facility should also be reported. Personal samples should also be collected to determine OSHA compliance directly.

Although these sampling results cannot be used to determine compliance with NAAQS, it appears that C&D processing facilities may potentially exceed air quality standards. However, most of the exceedances occurred inside of buildings, where NAAQS do not typically apply. Furthermore, no OSHA standard exceedances occurred despite the fact that all of the total and respirable dust level measurements were collected inside of buildings. However, personal samples were not collected, as required for assurance of OSHA compliance. Hopefully, the results from this study can be used by the industry as an engineering tool to locate, assess, and reduce the contributions from various sources of particulate matter during normal operations of their facilities.

Recommendations to Reduce Particulate Levels at C&D Processing Facilities

Each C&D processing facility will have its own circumstances to consider when considering measures to reduce airborne particulate levels. Operational differences, site layout, and building designs will all impact dust level concentrations. However, the data collected from this study combined with general observations lead to several possible methods of reducing airborne particulate levels.

According to OSHA, employee exposure to dust can be reduced in one of three ways: prevention, control systems, or dilution and isolation (DOL 2006). These broad concepts can be expanded to include the general reduction of airborne particulates across an entire site. Prevention involves preventive measures such as properly employed operational activities and properly designed buildings to prevent dust. For example, entry and exit doors should be made as small as possible in order to reduce dust migrating out of receiving buildings. A building's opening should not face a prevailing wind so that wind cannot sweep through the building and stir up dust. Dust curtains can be installed in areas where airborne particulates are generated to block the dust from migrating to more sensitive locations. If a facility uses a screen, the screen will produce less dust if it is agitated softer and slower (DOL 2006). Covers could also be placed over screens to prevent dust from migrating. A water truck could be used to continuously wet paved or unpaved roads in areas where high amounts of airborne particulates are observed. Trucks could go through a wash area that would saturate their load prior to tipping.

Information gathered from this study indicates that paved roads will likely reduce the amount of PM_{10}. The paved road should be wide enough to prevent trucks from driving off and creating a dirt area, especially in areas where vehicles will be making wide turns. Paved roads will still accumulate dust and wind or vehicle activity will cause this dust to become airborne; however, the dust generated is expected to be less than that on gravel or dirt roads. Street sweepers did not appear to reduce the long-term quantity of dust present on paved roads.

After preventive measures are considered, control systems should be used to reduce remaining dust concentrations (DOL 2006). A control system can consist of a dust collection system to capture airborne dust from the source, a wet dust suppression system that uses water to reduce dust, or dust capture through the use of water sprays (DOL 2006). Dust collection could be achieved inside of a receiving building by using a ventilation system. A properly designed ventilation system that captures and transports dust to a collector would likely reduce dust concentrations in an enclosed area. Wet dust suppression systems capture airborne particulates by using water to wet the entire product stream (DOL 2006). Such a system could be used to spray water onto material that is being dropped by a conveyor belt to help reduce the dust generated from the material being dropped by the belt. There are also water injection systems designed for use in shredders to reduce dust (Recycling Today 2006). A system such as this may be able to be employed to reduce dust generated from the shredding and grinding of debris in generating ADC. An airborne dust capture system typically involves spraying a water mist over an entire area to capture the dust and cause it to settle.

Information gathered from this study indicates that a continuous running misting system to capture dust employed under roof in the area where tipping is occurring will likely reduce the amount of particulate matter exiting the building. Spraying the waste pile with either a sprinkler or hose appeared to have minimal effects on reducing airborne particulates; however, heavy dosing of the waste pile from multiple sources may reduce dust concentrations.

Dilution and isolation is not as satisfactory for health hazard control; however, the principles could be employed when other control mechanisms are not practical (DOL 2006). These practices involve diluting the contaminated air with uncontaminated air or simply protecting workers from exposure to dust (DOL 2006). Exposure may be unavoidable so if it is necessary for workers to be in an area where high levels of particulate matter is likely to be encountered, then workers may need to be equipped with dust masks or respirators. Mechanized equipment such as dozers should be airtight and equipped with air conditioners to help protect the operators. Protocols should be in place to deal with dust suppression and monitoring and workers should be educated regarding the importance of adhering to their company's protocols. A company should also have a preventive maintenance program for all dust control systems.

Certain areas were more prone to high levels of airborne particulates than others during this study and efforts should be made to limit human exposure to these areas. For example, an ADC pile should not be located near an area where people spend much time.

Operations such as baling or mulching should not be located directly next to a conveyor drop off point of ADC or unsorted waste. It is impossible to eliminate all airborne particulates from C&D processing facilities. However, operational activities, facility design, and dust control measures can be altered to reduce the concentrations of airborne particulates.

References

References

Construction Materials Recycling Association, 2007. http://www.cdrecycling.org/. Accessed January 2007.

National Archives and Records Administration. 2007. http://www.gpoaccess.gov/cfr/about.html. Accessed February 2007.

Oberdorster G. 2001. Pulmonary effects of inhaled ultrafine particles. Int Arch Occup Environ Health 74:1–8.

Recycling Today. 2006. Spirit of Innovation. September.

Saldiva, P.H.N., R.W. Clarke, B.A. Coull, R.C. Stearns, J. Lawrence, G.G. Krishna Murthy, E. Diaz, P. Koutrakis, H. Suh, A. Tsuda and J.J. Godleski (2002). "Lung inflammation induced by concentrated ambient air particles is related to particle composition." Am J Resp Crit Care Med 165:1610-1617.

Samet J. M, S. L. Zeger, F. Dominici, F. Curriero, I. Coursac, D.W. Dockery, J. Schwartz, and A. Zanobetti (2000a). National morbidity, mortality, and air pollution study. Part II: morbidity and mortality from air pollution in the United States. Cambridge, MA: Health Effects Institute; Research Report No. 94.

SAS version 8.2. Cary, North Carolina, United States. 2001.

SKC Gulf Coast Incorporated. 2006. http://www.skcgulfcoast.com/products/Featured Products.asp ?Cat No= 110-100. Accessed October 2006.

Thermo Scientific. 2007. http://www.thermo.com/com/cda/product/detail/1,1055,1012 2674,00.html. Accessed October 2006.

Turley, William. Construction Materials Recycling Association. Personal Communication. January 2007.

United States Department of Labor, 2006. www.OSHA.gov. Accessed December 2006.

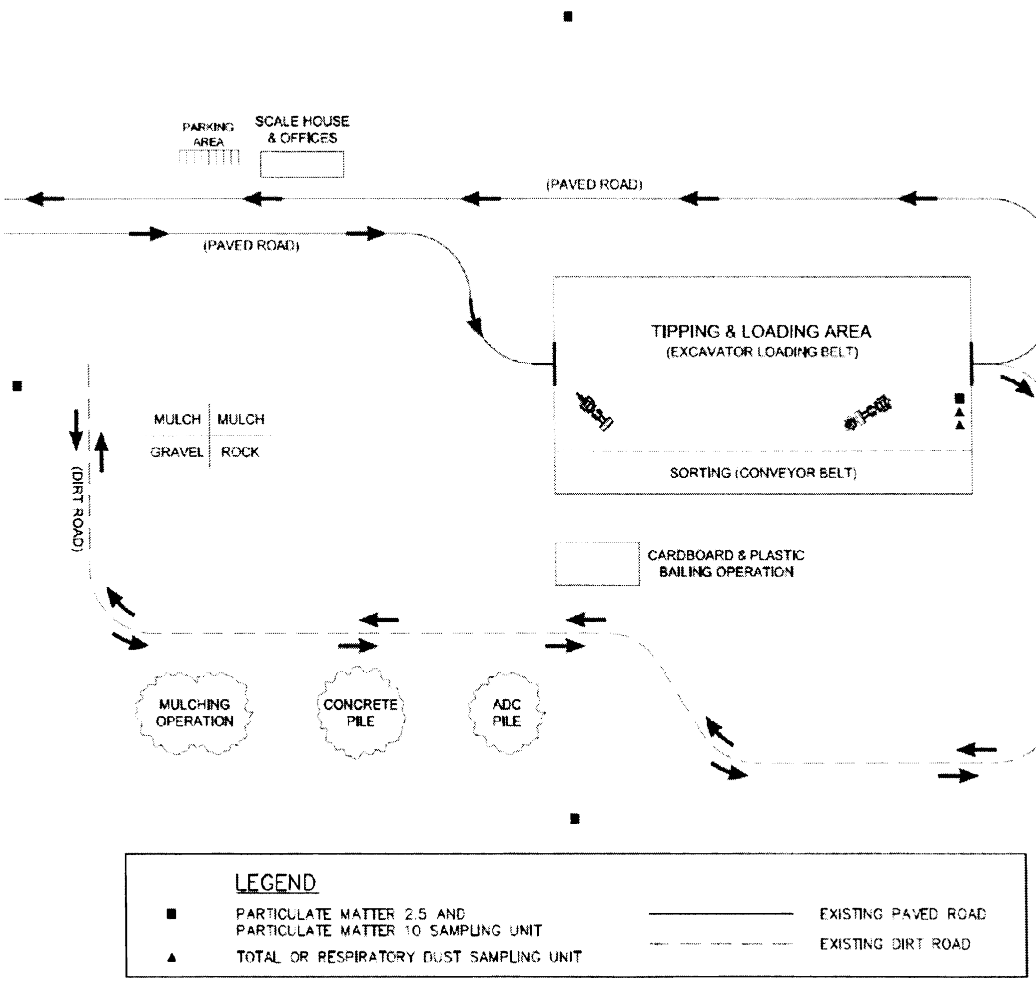
United States Environmental Protection Agency (USEPA). 2006. http://www.epa.gov/oecaagct/trur.html. Accessed December 2006.

USEPA. 2007(a). http://www.epa.gov/epaoswer/non-hw/debris-new/index.htm. Accessed January 2007.

USEPA, 2007(b). http://www.epa.gov/air/particlepollution/standards.html. Accessed February 2007.

Appendix A

C&D Processing Facility Diagram



Appendix B

Partisol®-FRM Model 2000 Unit 1

ID	Set Start Date	Set Start Time	Actual Start Date	Actual Start Time	Set Stop Date	Set Stop Time	Total Sample Time (hours)	Average Flow (l/min)
Site A								
1121	6/20/2006	8:10	6/20/2006	8:10	6/21/2006	8:10	24	16.7
1122	6/21/2006	8:15	6/21/2006	8:15	6/22/2006	8:15	24	16.7
1111	6/22/2006	8:20	6/22/2006	8:20	6/23/2006	8:20	18.07	16.7
1112	6/23/2006	8:27	6/23/2006	8:27	6/24/2006	8:27	24	16.7
1123	9/12/2006	7:30	9/12/2006	7:30	9/13/2006	7:30	24	16.7
1124	9/13/2006	7:35	9/13/2006	7:35	9/14/2006	7:35	18.42	16.7
1113	9/14/2006	9:00	9/14/2006	9:00	9/15/2006	9:00	22.4	16.7
1114	9/15/2006	7:45	9/15/2006	7:45	9/16/2006	7:45	24	16.7
Site B								
2121	7/3/2006	8:00	7/3/2006	8:00	7/4/2006	8:00	24	16.7
2122	7/5/2006	8:00	7/5/2006	8:00	7/6/2006	8:00	24	16.7
2111	7/6/2006	8:05	7/6/2006	8:05	7/7/2006	8:05	23.59	16.7
2112	7/7/2006	8:08	7/7/2006	8:08	7/8/2006	8:08	24	16.7
2123	8/1/2006	8:30	8/1/2006	8:30	8/2/2006	7:30	23	16.7
2124	8/2/2006	7:35	8/2/2006	7:35	8/3/2006	7:35	24	16.7
2113	8/3/2006	7:40	8/3/2006	7:40	8/4/2006	7:40	24	16.7
2114	8/4/2006	7:45	8/4/2006	7:45	8/5/2006	7:45	24	16.7
Site C								
3121	7/17/2006	7:30	7/17/2006	7:30	7/18/2006	7:30	24	16.7
3122	7/18/2006	7:35	7/18/2006	7:35	7/19/2006	7:35	24	16.7
3111	7/19/2006	7:40	7/19/2006	7:40	7/20/2006	7:40	24	16.7
3112	7/20/2006	7:45	7/20/2006	7:45	7/21/2006	7:45	24	16.7
3123	8/21/2006	7:20	8/21/2006	7:20	8/22/2006	7:20	24	16.7
3124	8/22/2006	7:25	8/22/2006	7:25	8/23/2006	7:25	24	16.7
3113	8/23/2006	7:27	8/23/2006	7:27	8/24/2006	7:27	24	16.7
3114	8/24/2006	7:30	8/24/2006	7:30	8/25/2006	7:30	24	0

Appendix B (Continued)

Partisol®-FRM Model 2000 Unit 1

ID	Flow cv (%)	Volume (m^3)	Ambient Temp Min (°C)	Ambient Temp Ave (°C)	Ambient Temp Max (°C)	Filter Temp Min (°C)	Filter Temp Ave (°C)	Filter Temp Max (°C)	Pressure Min (mmHg)	Pressure Ave (mmHg)
Site A										
1121	0.1	24	19.2	26.7	35.6	18.0	25.7	34.5	755	758
1122	0.1	24	21.8	28.4	36.0	20.7	27.6	35.6	758	760
1111	0.1	18.2	23.2	32.8	39.2	24.0	32.3	37.6	757	759
1112	0.1	24	22.3	26.9	33.3	21.9	26.4	32.6	757	760
1123	0.2	24	14.7	18.1	23.3	15.4	18.5	23.8	762	765
1124	0.2	18.7	15.3	18.4	21.4	15.6	18.9	22.1	759	760
1113	0.1	22.7	14.0	17.6	20.2	14.7	18.1	20.7	757	759
1114	0.1	24	14.7	20.4	24.5	15.5	21.1	25.3	758	760
Site B										
2121	0.1	24	24.7	29.2	34.5	25.5	29.9	35.2	761	763
2122	0.1	24	25.2	28.3	31.3	25.9	29.2	32.2	758	759
2111	0.2	24	21.4	25.4	35.3	22.3	26.2	36.3	756	761
2112	0.2	24	18.9	24.3	29.6	19.8	25.1	30.5	762	764
2123	0.1	23	27.6	31.6	36.2	27.8	31.8	36.2	758	759
2124	0	24	28.2	31.7	36.0	28.4	32.0	36.4	757	758
2113	0.1	24.1	28.6	32.3	37.8	28.9	32.6	37.1	755	757
2114	0.1	24.1	26.7	32.1	40.4	27.4	32.6	40.5	754	756
Site C										
3121	0.2	24	22.3	28.6	36.3	22.4	29.3	36.6	744	746
3122	0.2	24	21.4	27.8	35.5	22.0	28.6	36.0	744	748
3111	0.1	24	17.6	25.0	31.9	17.8	25.5	32.1	750	753
3112	0.1	24	19.4	24.2	30.8	19.9	24.8	30.9	747	750
3123	0.2	24	13.1	20.8	29.2	14.1	21.8	31.0	747	751
3124	0.3	24	13.8	21.5	30.4	14.7	22.5	32.5	747	750
3113	0.3	24	13.8	20.7	29.7	14.2	21.8	32.0	746	749
3114	0.1	24.1	14.4	20.0	28.2	14.9	20.7	28.7	747	750

Appendix B (Continued)

Partisol®-FRM Model 2000 Unit 1

ID	Pressure Max (mmHg)	Max Different Temp (°C)	Date of Different Temp	Time of Different Temp	Status Code	Time of Power Failure
Site A						
1121	763	2.9	6/20/2006	10:55	0	
1122	763	1.8	6/22/2006	4:45	0	
1111	762	1.8	6/22/2006	13:55	00C0	2:27
1112	763	2.0	6/23/2006	11:30	0	
1123	768	1.7	9/12/2006	14:50	0	
1124	763	1.1	9/13/2006	13:40	00C0	2:17
1113	761	2.3	9/14/2006	9:05	80	
1114	763	2.3	9/15/2006	10:05	0	
Site B						
2121	766	1.7	7/3/2006	13:25	0	
2122	762	1.5	7/5/2006	13:10	0	
2111	765	2.9	7/6/2006	15:15	0	
2112	766	1.1	7/7/2006	17:05	0	
2123	761	0.7	8/1/2006	13:50	0	
2124	761	1.2	8/2/2006	15:15	0	
2113	759	1.0	8/3/2006	14:00	0	
2114	759	2.0	8/4/2006	13:30	0	
Site C						
3121	750	1.9	7/17/2006	12:15	0	
3122	754	2.0	7/18/2006	19:20	0	
3111	756	2.1	7/19/2006	12:40	0	
3112	755	1.9	7/20/2006	12:10	0	
3123	754	2.7	8/21/2006	16:05	0	
3124	754	3.0	8/22/2006	16:05	0	
3113	752	3.4	8/23/2006	15:10	0	
3114	752	2.4	8/24/2006	13:35	0	

Status Code:
OOCO-Power Failure
80-Event Less Then 24 Hrs

Appendix C

Partisol®-FRM Model 2000 Unit 2

ID	Set Start Date	Set Start Time	Actual Start Date	Actual Start Time	Set Stop Date	Set Stop Time	Total Sample Time (hours)	Average Flow (l/min)
Site A								
1221	6/20/2006	8:20	6/20/2006	8:20	6/21/2006	8:20	24	16.7
1222	6/21/2006	8:25	6/21/2006	8:25	6/22/2006	8:25	23.59	16.7
1211	6/22/2006	8:30	6/22/2006	8:30	6/23/2006	8:30	24	16.7
1212	6/23/2006	8:35	6/23/2006	8:35	6/24/2006	8:35	24	16.7
1223	9/12/2006	7:50	9/12/2006	7:50	9/13/2006	7:50	24	16.7
1224	9/13/2006	7:55	9/13/2006	7:55	9/14/2006	7:55	22.49	16.7
1213	9/14/2006	8:00	9/14/2006	8:00	9/15/2006	8:00	24	16.7
1214	9/15/2006	8:05	9/15/2006	8:05	9/16/2006	8:05	24	16.7
Site B								
2221	7/3/2006	8:05	7/3/2006	8:05	7/4/2006	8:05	24	16.7
2222	7/5/2006	8:05	7/5/2006	8:05	7/6/2006	8:05	23.59	16.7
2211	7/6/2006	8:10	7/6/2006	8:10	7/7/2006	8:10	23.59	16.7
2212	7/7/2006	8:13	7/7/2006	8:13	7/8/2006	8:13	24	16.7
2223	8/1/2006	8:35	8/1/2006	8:35	8/2/2006	7:35	23	16.7
2224	8/2/2006	7:40	8/2/2006	7:40	8/3/2006	7:40	24	16.7
2213	8/3/2006	7:45	8/3/2006	7:45	8/4/2006	7:45	24	16.7
2214	8/4/2006	7:50	8/4/2006	7:50	8/5/2006	7:50	24	16.7
Site C								
3221	7/17/2006	7:35	7/17/2006	7:35	7/18/2006	7:35	24	16.7
3222	7/18/2006	7:40	7/18/2006	7:40	7/19/2006	7:40	24	16.7
3211	7/19/2006	7:45	7/19/2006	7:45	7/20/2006	7:45	24	16.7
3212	7/20/2006	7:50	7/20/2006	7:50	7/21/2006	7:50	24	16.7
3223	8/21/2006	7:25	8/21/2006	7:25	8/22/2006	7:25	24	16.7
3224	8/22/2006	7:30	8/22/2006	7:30	8/23/2006	7:30	24	16.7
3213	8/23/2006	7:33	8/23/2006	7:33	8/24/2006	7:33	24	16.7
3214	8/24/2006	7:35	8/24/2006	7:35	8/25/2006	7:35	24	16.7

Appendix C (Continued)

Partisol®-FRM Model 2000 Unit 2

ID	Flow cv (%)	Volume (m^3)	Ambient Temp Min (°C)	Ambient Temp Ave (°C)	Ambient Temp Max (°C)	Filter Temp Min (°C)	Filter Temp Ave (°C)	Filter Temp Max (°C)	Pressure Min (mmHg)	Pressure Ave (mmHg)
Site A										
1221	0	24	18.6	25.3	32.9	18.4	26.1	34.2	756	760
1222	0	24	20.7	26.7	33.2	20.7	27.9	34.6	761	762
1211	0.2	24	21.2	29.0	36.1	22.1	30.6	37.3	759	762
1212	0.2	24	21.7	25.5	30.2	22.0	26.7	31.7	760	762
1223	0.3	24	15.0	18.1	22.7	15.8	18.7	23.4	763	766
1224	0.2	22.8	15.3	18.1	21.0	16.1	18.8	21.8	759	762
1213	0.1	24	14.1	17.7	20.2	14.9	18.1	20.7	759	761
1214	0.2	24	15.8	20.4	24.6	16.1	21.0	25.9	761	763
Site B										
2221	0.1	24	24.5	28.6	34.3	25.4	29.7	35.2	764	765
2222	0	24	24.7	27.6	30.4	26.0	28.8	31.4	761	762
2211	0.1	24	21.2	24.9	35.2	22.3	26.1	36.5	760	764
2212	0	24	18.2	23.9	28.8	19.7	25.4	30.6	765	767
2223	0.3	23	26.8	30.5	35.5	27.7	31.5	36.4	761	762
2224	0.2	24	27.2	30.5	34.5	28.3	31.6	35.6	760	761
2213	0.2	24	27.7	31.2	36.7	28.9	32.4	37.3	758	760
2214	0.2	24	25.8	31.0	40.9	27.2	32.5	41.1	758	760
Site C										
3221	0.2	24	21.6	26.9	33.0	23.5	28.7	34.3	748	749
3222	0.3	24	21.3	26.7	33.0	25.1	30.0	35.3	748	751
3211	0.1	24	18.0	24.0	28.7	22.3	27.2	31.0	754	756
3212	0.1	24	19.5	23.5	28.1	23.4	26.7	30.3	750	752
3223	0.3	24	15.5	22.1	28.7	18.6	24.1	29.7	750	753
3224	0.2	24	15.7	22.3	29.0	19.6	25.3	30.5	750	752
3213	0.1	24	16.0	21.9	28.1	18.1	23.3	28.8	750	752
3214	0.1	24	17.0	21.1	26.3	19.0	22.9	27.6	750	752

Appendix C (Continued)

Partisol®-FRM Model 2000 Unit 2

ID	Pressure Max (mmHg)	Max Different Temp (°C)	Date of Different Temp	Time of Different Temp	Status Code	Time of Power Failure
Site A						
1221	764	3.4	6/20/2006	12:00	0	
1222	764	3.3	6/21/2006	12:05	0	
1211	765	3.0	6/22/2006	12:30	0	
1212	764	2.8	6/23/2006	10:35	0	
1223	769	2.0	9/12/2006	14:30	0	
1224	765	1.1	9/13/2006	13:20	00C0	6:42
1213	763	1.2	9/14/2006	8:00	0	
1214	765	2.5	9/15/2006	10:00	0	
Site B						
2221	766	2.2	7/3/2006	13:20	0	
2222	765	1.8	7/5/2006	13:10	0	
2211	767	3.9	7/6/2006	15:10	0	
2212	768	2.3	7/7/2006	13:35	0	
2223	764	1.8	8/1/2006	12:15	0	
2224	764	2.1	8/2/2006	15:15	0	
2213	762	2.2	8/3/2006	11:40	0	
2214	762	3.0	8/4/2006	13:20	0	
Site C						
3221	752	4.0	7/17/2006	15:40	0	
3222	756	4.6	7/19/2006	3:00	0	
3211	758	4.8	7/20/2006	1:30	0	
3212	758	5.1	7/20/2006	14:30	0	
3223	756	4.2	8/21/2006	21:20	0	
3224	756	4.8	8/22/2006	21:00	0	
3213	754	4.6	8/23/2006	14:45	0	
3214	754	3.0	8/24/2006	10:25	0	

Status Code:
OOCO-Power Failure

Appendix D

Partisol®-FRM Model 2000 Unit 3

ID	Set Start Date	Set Start Time	Actual Start Date	Actual Start Time	Set Stop Date	Set Stop Time	Total Sample Time (hours)	Average Flow (l/min)
Site A								
1321	6/20/2006	8:00	6/20/2006	8:00	6/21/2006	8:00	24	16.7
1322	6/21/2006	8:05	6/21/2006	8:05	6/22/2006	8:05	24	16.7
1311	6/22/2006	8:10	6/22/2006	8:10	6/23/2006	8:10	24	16.7
1312	6/23/2006	8:15	6/23/2006	8:15	6/24/2006	8:15	24	16.7
1323	9/12/2006	8:10	9/12/2006	8:10	9/13/2006	8:10	24	16.7
1324	9/13/2006	8:15	9/13/2006	8:15	9/14/2006	8:15	24	16.7
1313	9/14/2006	8:20	9/14/2006	8:20	9/15/2006	8:20	24	16.7
1314	9/15/2006	8:25	9/15/2006	8:25	9/16/2006	8:25	24	16.7
Site B								
2321	7/3/2006	8:10	7/3/2006	8:10	7/4/2006	8:10	23.58	16.7
2322	7/5/2006	8:10	7/5/2006	8:10	7/6/2006	8:10	23.58	16.7
2311	7/6/2006	8:15	7/6/2006	8:15	7/7/2006	8:15	23.55	16.7
2312	7/7/2006	8:20	7/7/2006	8:20	7/8/2006	8:20	24	16.7
2323	8/1/2006	8:40	8/1/2006	8:40	8/2/2006	7:40	22.59	16.7
2324	8/2/2006	7:45	8/2/2006	7:45	8/3/2006	7:45	23.51	16.7
2313	8/3/2006	7:50	8/3/2006	7:50	8/4/2006	7:50	23.56	16.7
2314	8/4/2006	7:55	8/4/2006	7:55	8/5/2006	7:55	23.59	16.7
Site C								
3321	7/17/2006	7:40	7/17/2006	7:40	7/18/2006	7:40	24	16.7
3322	7/18/2006	7:45	7/18/2006	7:45	7/19/2006	7:45	24	16.7
3311	7/19/2006	7:50	7/19/2006	7:50	7/20/2006	7:50	24	16.7
3312	7/20/2006	7:55	7/20/2006	7:55	7/21/2006	7:55	24	16.7
3323	8/21/2006	7:30	8/21/2006	7:30	8/22/2006	7:30	24	16.7
3324	8/22/2006	7:35	8/22/2006	7:35	8/23/2006	7:35	24	16.7
3313	8/23/2006	7:38	8/23/2006	7:38	8/24/2006	7:38	24	16.7
3314	8/24/2006	7:40	8/24/2006	7:40	8/25/2006	7:40	24	16.7

Appendix D (Continued)

Partisol®-FRM Model 2000 Unit 3

ID	Flow cv (%)	Volume (m^3)	Ambient Temp Min (°C)	Ambient Temp Ave (°C)	Ambient Temp Max (°C)	Filter Temp Min (°C)	Filter Temp Ave (°C)	Filter Temp Max (°C)	Pressure Min (mmHg)	Pressure Ave (mmHg)
Site A										
1321	0.2	24	17.9	25.4	34.4	18.8	26.3	36.4	755	757
1322	0.1	24	20.7	26.7	35.4	21.2	27.6	36.9	758	759
1311	0.2	24	21.2	29.3	38.8	21.7	30.4	41.3	757	759
1312	0.1	24	21.2	25.0	29.5	21.6	25.9	32.6	757	759
1323	0	24	15.4	18.2	23.2	16.3	19.2	25.6	760	762
1324	0.2	24	15.5	18.2	20.8	16.3	19.0	22.2	756	757
1313	0.2	24	14.9	18.1	20.7	14.9	18.2	21.2	756	757
1314	0	24	16.8	21.2	26.6	16.8	21.5	29.1	757	758
Site B										
2321	0	24	24.7	29.3	35.9	24.2	29.8	36.9	761	762
2322	0.2	24	24.8	28.5	32.5	25.1	29.3	33.9	757	759
2311	0.1	23.9	21.2	24.5	36.4	20.7	25.1	38.3	757	760
2312	0.2	24	18.2	23.2	28.6	17.3	23.4	30.5	762	763
2323	0	23	27.1	31.2	36.9	27.1	31.8	38.3	759	759
2324	0	23.9	27.6	31.3	37.4	28.1	32.7	39.8	757	758
2313	0.2	23.9	28.1	31.9	37.8	28.4	33.3	40.3	756	757
2314	0.2	24	25.6	31.0	39.3	26.0	32.7	42.7	755	756
Site C										
3321	0.1	24	23.2	29.8	40.3	22.7	30.5	41.3	746	747
3322	0.2	24	22.7	29.3	39.3	22.7	30.3	40.8	747	749
3311	0.2	24	19.8	26.7	35.4	19.2	27.8	38.8	751	753
3312	0.2	24	20.3	25.1	32.4	19.8	25.5	34.4	747	750
3323	0	24	13.9	21.4	31.0	14.9	22.8	33.5	748	750
3324	0.1	24	14.9	21.8	30.5	15.4	23.3	33.5	748	749
3313	0	24	14.4	21.4	30.0	14.9	23.1	34.4	747	748
3314	0	24	15.4	20.0	27.6	15.9	21.5	31.0	747	749

Appendix D (Continued)

Partisol®-FRM Model 2000 Unit 3

ID	Pressure Max (mmHg)	Max Different Temp (°C)	Date of Different Temp	Time of Different Temp	Status Code
Site A					
1321	760	2.9	6/20/2006	16:45	0
1322	760	3.4	6/21/2006	17:15	0
1311	761	4.0	6/22/2006	16:00	0
1312	760	3.5	6/23/2006	18:05	0
1323	765	3.0	9/12/2006	16:20	0
1324	760	1.5	9/13/2006	11:10	0
1313	758	0.9	9/14/2006	18:00	0
1314	760	2.8	9/15/2006	17:25	0
Site B					
2321	764	2.8	7/3/2006	13:15	0
2322	761	2.7	7/5/2006	11:30	0
2311	763	4.0	7/6/2006	10:45	0
2312	764	2.5	7/7/2006	16:50	0
2323	760	2.6	8/1/2006	12:30	80
2324	760	4.4	8/2/2006	15:15	0
2313	758	4.3	8/3/2006	11:30	0
2314	758	5.4	8/4/2006	11:30	0
Site C					
3321	749	2.9	7/17/2006	16:05	0
3322	752	3.8	7/18/2006	14:55	0
3311	755	4.7	7/19/2006	16:15	0
3312	754	3.0	7/20/2006	15:50	0
3323	751	3.6	8/21/2006	14:20	0
3324	751	4.1	8/22/2006	16:05	0
3313	750	5.3	8/23/2006	15:05	0
3314	750	4.2	8/24/2006	13:15	0

Status Code:
80-Event Less Then 24 Hrs

Appendix E

Partisol®-FRM Model 2000 Unit 4

ID	Set Start Date	Set Start Time	Actual Start Date	Actual Start Time	Set Stop Date	Set Stop Time	Total Sample Time (hours)	Average Flow (l/min)
Site A								
1421	6/20/2006	8:30	6/20/2006	8:30	6/21/2006	8:30	24	16.7
1422	6/21/2006	8:35	6/21/2006	8:35	6/22/2006	8:35	24	16.7
1411	6/22/2006	8:40	6/22/2006	8:40	6/23/2006	8:40	24	16.7
1412	6/23/2006	8:45	6/23/2006	8:45	6/24/2006	8:45	24	16.7
1423	9/12/2006	7:40	9/12/2006	7:40	9/13/2006	7:40	24	16.7
1424	9/13/2006	7:45	9/13/2006	7:45	9/14/2006	7:45	24	16.7
1413	9/14/2006	7:50	9/14/2006	7:50	9/15/2006	7:50	24	16.7
1414	9/15/2006	7:55	9/15/2006	7:55	9/16/2006	7:55	24	16.7
Site B								
2421	7/3/2006	8:15	7/3/2006	8:15	7/4/2006	8:15	24	16.7
2422	7/5/2006	8:15	7/5/2006	8:15	7/6/2006	8:15	24	16.7
2411	7/6/2006	8:20	7/6/2006	8:20	7/7/2006	8:20	3.47	16.7
2412	7/7/2006	8:37	7/7/2006	8:37	7/8/2006	8:37	24	16.7
2423	8/1/2006	8:35	8/1/2006	8:35	8/2/2006	7:35	23	16.7
2424	8/2/2006	7:50	8/2/2006	7:50	8/3/2006	7:50	4.19	16.7
2413	8/3/2006	8:12	8/3/2006	8:12	8/4/2006	8:12	24	16.7
2414	8/4/2006	8:14	8/4/2006	8:14	8/5/2006	8:14	24	16.7
Site C								
3421	7/17/2006	7:45	7/17/2006	7:45	7/18/2006	7:45	24	16.7
3422	7/18/2006	7:50	7/18/2006	7:50	7/19/2006	7:50	24	16.7
3411	7/19/2006	7:55	7/19/2006	7:55	7/20/2006	7:55	24	16.7
3412	7/20/2006	8:00	7/20/2006	8:00	7/21/2006	8:00	24	16.7
3423	8/21/2006	7:35	8/21/2006	7:35	8/22/2006	7:35	24	16.7
3424	8/22/2006	7:40	8/22/2006	7:40	8/23/2006	7:40	24	16.7
3413	8/23/2006	7:42	8/23/2006	7:42	8/24/2006	7:42	24	16.7
3414	8/24/2006	7:44	8/24/2006	7:44	8/25/2006	7:44	24	16.7

Appendix E (Continued)

Partisol®-FRM Model 2000 Unit 4

ID	Flow cv (%)	Volume (m^3)	Ambient Temp Min (°C)	Ambient Temp Ave (°C)	Ambient Temp Max (°C)	Filter Temp Min (°C)	Filter Temp Ave (°C)	Filter Temp Max (°C)	Pressure Min (mmHg)	Pressure Ave (mmHg)
Site A										
1421	0.3	24	18.3	26.7	34.9	18.4	27.1	37.4	756	760
1422	0.3	24	21.0	28.3	35.9	20.7	28.6	36.9	760	763
1411	0.2	24	21.7	30.5	39.8	22.0	31.2	42.1	758	761
1412	0.2	24	22.0	26.8	33.8	21.7	27.0	35.0	759	762
1423	0.1	24	15.1	18.7	25.0	16.0	19.5	26.0	763	765
1424	0.2	24	15.3	18.4	22.1	16.3	19.2	23.6	758	760
1413	0.1	24	14.1	18.3	21.7	14.6	18.4	22.0	758	759
1414	0.2	24	16.1	21.7	27.7	16.4	22.0	29.3	759	761
Site B										
2421	0.2	24	24.6	30.1	36.7	24.9	30.4	37.7	762	765
2422	0.3	24	25.1	29.6	36.2	25.2	30.0	37.3	759	762
2411	0.3	3.8	26.8	30.7	35.1	27.0	31.2	36.0	760	761
2412	1.9	24	18.5	24.4	32.7	18.6	24.5	33.8	763	766
2423	0.1	23	26.1	30.8	37.1	26.8	31.6	38.4	759	761
2424	0.3	4.3	27.6	31.5	35.3	27.8	32.2	36.7	761	762
2413	0.4	24	27.4	31.7	38.1	27.8	32.7	39.9	757	759
2414	0.2	24	24.6	31.0	40.0	25.3	32.0	41.8	756	759
Site C										
3421	0.2	24	22.7	29.4	37.5	22.2	29.7	38.2	747	749
3422	0.1	24	22.1	28.7	36.1	21.9	29.1	37.7	747	751
3411	0.3	24	18.4	25.8	32.2	18.5	26.3	33.7	753	756
3412	0.3	24	20.2	25.1	32.2	19.9	25.5	33.7	749	752
3423	0.1	24	14.3	21.8	30.0	14.6	22.4	31.4	750	752
3424	0.2	24	15.0	22.6	31.1	15.8	23.2	32.2	749	752
3413	0	24	14.4	21.9	30.0	15.0	22.6	31.8	749	751
3414	0.2	24	15.4	20.8	28.2	16.0	21.4	29.8	749	751

Appendix E (Continued)

Partisol®-FRM Model 2000 Unit 4

ID	Pressure Max (mmHg)	Max Different Temp (°C)	Date of Different Temp	Time of Different Temp	Status Code	Time of Power Failure
Site A						
1421	765	3.3	6/20/2006	16:45	0	
1422	765	3.8	6/21/2006	13:00	0	
1411	765	4.1	6/22/2006	15:25	0	
1412	764	2.4	6/23/2006	15:30	0	
1423	768	2.3	9/12/2006	14:20	0	
1424	763	2.2	9/13/2006	13:15	0	
1413	761	1.5	9/15/2006	0:25	0	
1414	763	2.3	9/15/2006	15:15	0	
Site B						
2421	767	2.0	7/3/2006	15:40	0	
2422	765	2.2	7/5/2006	15:05	0	
2411	762	1.3	7/6/2006	11:35	00C0	12:07
2412	768	2.1	7/7/2006	17:05	0	
2423	763	2.2	8/1/2006	15:00	0	
2424	763	1.8	8/2/2006	11:40	00C0	12:09
2413	761	3.1	8/3/2006	14:55	0	
2414	762	2.9	8/4/2006	13:20	0	
Site C						
3421	752	2.0	7/17/2006	12:50	0	
3422	756	2.3	7/18/2006	13:40	0	
3411	758	2.2	7/19/2006	12:40	0	
3412	758	2.6	7/20/2006	10:40	0	
3423	755	2.3	8/21/2006	11:10	0	
3424	755	2.3	8/22/2006	13:50	0	
3413	752	2.5	8/23/2006	10:35	0	
3414	753	2.4	8/24/2006	10:20	0	

Status Code:
OOCO-Power Failure

Appendix F

Partisol®-FRM Model 2000 Unit 5

ID	Set Start Date	Set Start Time	Actual Start Date	Actual Start Time	Set Stop Date	Set Stop Time	Total Sample Time (hours)	Average Flow (l/m)
Site A								
1521	6/20/2006	8:40	6/20/2006	8:40	6/21/2006	8:40	24	16.7
1522	6/21/2006	8:45	6/21/2006	8:45	6/22/2006	8:45	24	16.7
1511	6/22/2006	8:50	6/22/2006	8:50	6/23/2006	8:50	24	16.7
1512	6/23/2006	8:55	6/23/2006	8:55	6/24/2006	8:55	24	16.7
1523	9/12/2006	8:00	9/12/2006	8:00	9/13/2006	8:00	24	16.7
1524	9/13/2006	8:05	9/13/2006	8:05	9/14/2006	8:05	24	16.7
1513	9/14/2006	8:10	9/14/2006	8:10	9/15/2006	8:10	24	16.7
1514	9/15/2006	8:15	9/15/2006	8:15	9/16/2006	8:15	24	16.7
Site B								
2521	7/3/2006	8:20	7/3/2006	8:20	7/4/2006	8:20	24	16.7
2522	7/5/2006	8:20	7/5/2006	8:20	7/6/2006	8:20	24	16.7
2511	7/6/2006	8:25	7/6/2006	8:25	7/7/2006	8:25	23.59	16.7
2512	7/7/2006	8:30	7/7/2006	8:30	7/8/2006	8:30	24	16.7
2523	8/1/2006	8:50	8/1/2006	8:50	8/2/2006	7:50	23	16.7
2524	8/2/2006	7:55	8/2/2006	7:55	8/3/2006	7:55	24	16.7
2513	8/3/2006	8:00	8/3/2006	8:00	8/4/2006	8:00	24	16.7
2514	8/4/2006	8:05	8/4/2006	8:05	8/5/2006	8:05	24	16.7
Site C								
3521	7/17/2006	7:50	7/17/2006	7:50	7/18/2006	7:50	23.54	16.7
3522	7/18/2006	7:55	7/18/2006	7:55	7/19/2006	7:55	24	16.7
3511	7/19/2006	8:00	7/19/2006	8:00	7/20/2006	8:00	24	16.7
3512	7/20/2006	8:05	7/20/2006	8:05	7/21/2006	8:05	24	16.7
3523	8/21/2006	7:40	8/21/2006	7:40	8/22/2006	7:40	24	16.7
3524	8/22/2006	7:42	8/22/2006	7:42	8/23/2006	7:42	24	16.7
3513	8/23/2006	7:45	8/23/2006	7:45	8/24/2006	7:45	23.59	16.7
3514	8/24/2006	7:47	8/24/2006	7:47	8/25/2006	7:47	23.59	16.7

Appendix F (Continued)

Partisol®-FRM Model 2000 Unit 5

ID	Flow cv (%)	Volume (m^3)	Ambient Temp Min (°C)	Ambient Temp Ave (°C)	Ambient Temp Max (°C)	Filter Temp Min (°C)	Filter Temp Ave (°C)	Filter Temp Max (°C)	Pressure Min (mmHg)	Pressure Ave (mmHg)
Site A										
1521	0.1	24	20.1	26.7	33.0	20.3	26.9	33.5	754	758
1522	0.1	24	22.2	28.2	33.8	23.2	28.9	34.9	758	760
1511	0	24	23.1	30.1	37.4	24.4	31.1	39.8	756	759
1512	0.1	24	23.1	26.9	31.8	24.5	28.3	33.5	757	759
1523	0	24	17.1	19.7	23.1	17.8	20.4	24.3	760	763
1524	0.3	24	16.3	19.4	22.3	17.4	20.3	23.5	756	759
1513	0.2	24	15.6	18.7	21.4	16.9	19.6	22.1	756	758
1514	0	24	17.5	21.3	25.2	17.8	21.7	25.8	757	759
Site B										
2521	0	24	24.2	29.2	36.2	24.5	29.7	37.2	761	763
2522	0.2	24	24.8	28.7	33.9	25.0	29.3	34.9	758	759
2511	0	24	20.9	25.1	36.4	21.2	25.7	37.9	757	761
2512	0.2	24	18.3	23.7	28.6	18.5	24.1	29.2	763	764
2523	0.1	23	27.1	31.2	37.4	26.9	31.4	37.8	758	760
2524	0	24	27.3	31.3	36.6	27.4	31.4	37.6	757	759
2513	0.1	24	28.1	32.0	37.8	27.9	32.3	38.9	755	757
2514	0.1	24	26.1	31.7	40.2	26.0	31.9	40.8	754	757
Site C										
3521	0.1	23.9	21.1	28.6	38.7	20.9	28.0	39.2	745	747
3522	0.1	24	21.3	28.5	39.1	20.9	27.9	38.6	746	749
3511	0.2	24	17.8	25.5	34.6	17.7	26.0	35.9	751	753
3512	0.2	24	19.6	25.1	33.7	19.3	25.7	34.9	747	750
3523	0.2	24	13.6	21.0	29.7	13.7	21.2	32.1	748	751
3524	0.2	24	14.6	21.7	30.4	14.5	21.5	31.8	749	750
3513	0.2	24	14.1	21.2	30.5	13.9	21.4	32.6	747	749
3514	0.2	24	15.1	20.2	28.3	15.1	20.5	30.2	748	749

Appendix F (Continued)

Partisol®-FRM Model 2000 Unit 5

ID	Pressure Max (mmHg)	Max Different Temp (°C)	Date of Different Temp	Time of Different Temp	Status Code	Time of Power Failure
Site A						
1521	761	0.7	6/20/2006	23:20	0	
1522	762	1.3	6/21/2006	18:00	0	
1511	762	2.5	6/22/2006	17:55	0	
1512	761	2.0	6/23/2006	18:05	0	
1523	767	1.7	9/12/2006	16:50	0	
1524	762	1.5	9/13/2006	14:20	0	
1513	759	1.3	9/15/2006	3:05	0	
1514	762	0.9	9/15/2006	12:50	0	
Site B						
2521	765	2.2	7/3/2006	13:20	0	
2522	762	2.4	7/5/2006	12:55	0	
2511	764	3.5	7/6/2006	15:10	0	
2512	766	1.6	7/7/2006	13:35	0	
2523	761	1.9	8/1/2006	14:05	0	
2524	761	2.0	8/2/2006	13:35	0	
2513	759	2.0	8/3/2006	13:40	0	
2514	759	2.0	8/4/2006	13:35	0	
Site C						
3521	749	2.3	7/17/2006	8:40	40	19:44
3522	753	2.4	7/18/2006	9:15	0	
3511	756	3.4	7/19/2006	12:40	0	
3512	755	3.5	7/20/2006	12:50	0	
3523	753	3.9	8/21/2006	13:10	0	
3524	753	2.7	8/22/2006	12:05	0	
3513	751	2.9	8/23/2006	13:40	0	
3514	751	3.3	8/24/2006	12:05	0	

Status Code
40-Event Less Then 24 Hrs

Appendix G

Site A Analytical Results

Analysis	Method	Sample ID	Date	Air Vol (m^3)	Total (mg)	Conc (mg/m^3)	Conc (ug/m^3)
Particulate Matter 10	PM10	1111	6/22/2006	18.1061	0.816	0.045	45
Particulate Matter 10	PM10	1112	6/23/2006	24.048	0.791	0.033	33
Particulate Matter 10	PM10	1113	9/14/2006	22.7454	0.442	0.019	19
Particulate Matter 10	PM10	1114	9/15/2006	24.048	0.460	0.019	19
Particulate Matter 10	PM10	1211	6/22/2006	24.048	1.70	0.071	71
Particulate Matter 10	PM10	1212	6/23/2006	24.048	0.872	0.036	36
Particulate Matter 10	PM10	1213	9/14/2006	24.048	0.485	0.020	20
Particulate Matter 10	PM10	1214	9/15/2006	24.048	0.521	0.022	22
Particulate Matter 10	PM10	1311	6/22/2006	24.048	1.89	0.078	78
Particulate Matter 10	PM10	1312	6/23/2006	24.048	1.09	0.045	45
Particulate Matter 10	PM10	1313	9/14/2006	24.048	0.659	0.027	27
Particulate Matter 10	PM10	1314	9/15/2006	24.048	1.43	0.059	59
Particulate Matter 10	PM10	1411	6/22/2006	24.048	3.85	0.16	160
Particulate Matter 10	PM10	1412	6/23/2006	24.048	1.61	0.067	67
Particulate Matter 10	PM10	1413	9/14/2006	24.048	0.516	0.021	21
Particulate Matter 10	PM10	1414	9/15/2006	24.048	0.870	0.036	36
Particulate Matter 10	PM10	1511	6/22/2006	24.048	9.62	0.40	400
Particulate Matter 10	PM10	1512	6/23/2006	24.048	3.87	0.16	160
Particulate Matter 10	PM10	1513	9/14/2006	24.048	0.992	0.041	41
Particulate Matter 10	PM10	1514	9/15/2006	24.048	1.66	0.069	69
Particulate Matter 10/2.5	PM10/2.5	1FB12	6/21-23/06	NA	<0.1	NA	NA
Particulate Matter 10/2.5	PM10/2.5	1FB13	9/12-15/06	NA	-0.235	NA	NA

Appendix G (Continued)

Site A Analytical Results

Analysis	Method	Sample ID	Date	Air Vol (m^3)	Total (mg)	Conc (mg/m^3)	Conc (ug/m^3)
Particulate Matter 2.5	PM2.5	1121	6/20/2006	24.048	0.472	0.020	20
Particulate Matter 2.5	PM2.5	1122	6/21/2006	24.048	0.647	0.027	27
Particulate Matter 2.5	PM2.5	1123	9/12/2006	24.048	0.208	0.0086	8.6
Particulate Matter 2.5	PM2.5	1124	9/13/2006	18.7374	0.236	0.012	12
Particulate Matter 2.5	PM2.5	1221	6/20/2006	24.048	0.488	0.020	20
Particulate Matter 2.5	PM2.5	1222	6/21/2006	24.048	0.664	0.028	28
Particulate Matter 2.5	PM2.5	1223	9/12/2006	24.048	0.224	0.0093	9.3
Particulate Matter 2.5	PM2.5	1224	9/13/2006	22.8456	0.300	0.013	13
Particulate Matter 2.5	PM2.5	1321	6/20/2006	24.048	0.503	0.021	21
Particulate Matter 2.5	PM2.5	1322	6/21/2006	24.048	0.703	0.029	29
Particulate Matter 2.5	PM2.5	1323	9/12/2006	24.048	0.236	0.0098	9.8
Particulate Matter 2.5	PM2.5	1324	9/13/2006	24.048	0.297	0.012	12
Particulate Matter 2.5	PM2.5	1421	6/20/2006	24.048	0.577	0.024	24
Particulate Matter 2.5	PM2.5	1422	6/21/2006	24.048	0.731	0.030	30
Particulate Matter 2.5	PM2.5	1423	9/12/2006	24.048	0.219	0.0091	9.1
Particulate Matter 2.5	PM2.5	1424	9/13/2006	24.048	0.266	0.011	11
Particulate Matter 2.5	PM2.5	1521	6/20/2006	24.048	1.46	0.061	61
Particulate Matter 2.5	PM2.5	1522	6/21/2006	24.048	1.39	0.058	58
Particulate Matter 2.5	PM2.5	1523	9/12/2006	24.048	0.497	0.021	21
Particulate Matter 2.5	PM2.5	1524	9/13/2006	24.048	0.655	0.027	27
Particulate Matter 10/2.5	PM10/2.5	1FB21	6/21/2006	NA	<0.1	NA	NA
Particulate Matter 10/2.5	PM10/2.5	1FB12	6/21-23/06	NA	<0.1	NA	NA
Particulate Matter 10/2.5	PM10/2.5	1FB13	9/12-15/06	NA	-0.235	NA	NA

Appendix G (Continued)

Site A Analytical Results

Analysis	Method	Sample ID	Date	Air Vol (m3)	Total (mg)	Conc (mg/m3)	Conc (ug/m3)
Total Dust	NIOSH 0500	1631*	6/20/2006	0.960	0.732	0.76	760
Total Dust	NIOSH 0500	1632**	6/21/2006	0.960	---	---	---
Total Dust	NIOSH 0500	1633	6/22/2006	0.960	1.58	1.6	1600
Total Dust	NIOSH 0500	1634	6/23/2006	0.960	0.895	0.93	930
Total Dust	NIOSH 0500	1635	9/12/2006	0.960	0.722	0.75	750
Total Dust	NIOSH 0500	1636	9/13/2006	0.960	0.509	0.53	530
Total Dust	NIOSH 0500	1637	9/14/2006	0.960	0.118	0.12	120
Total Dust	NIOSH 0500	1638	9/15/2006	0.960	0.226	0.24	240
Total/Resp Dust	NIOSH 0500/0600	1FB31	6/20/2006	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	1FB32	6/21-23/06	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	1FB33	9/12-15/06	NA	<0.05	NA	NA
Respirable Dust	NIOSH 0600	1741	6/20/2006	1.200	0.193	0.16	160
Respirable Dust	NIOSH 0600	1742	6/21/2006	1.200	0.492	0.41	410
Respirable Dust	NIOSH 0600	1743	6/22/2006	1.200	0.256	0.21	210
Respirable Dust	NIOSH 0600	1744	6/23/2006	1.200	0.150	0.12	120
Respirable Dust	NIOSH 0600	1745	9/12/2006	1.200	0.166	0.14	140
Respirable Dust	NIOSH 0600	1746	9/13/2006	1.200	0.163	0.14	140
Respirable Dust	NIOSH 0600	1747***	9/14/2006	1.200	<0.05	0.02	20
Respirable Dust	NIOSH 0600	1748	9/15/2006	1.200	0.088	0.073	73
Total/Resp Dust	NIOSH 0500/0600	1FB31	6/20/2006	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	1FB32	6/21-23/06	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	1FB33	9/12-15/06	NA	<0.05	NA	NA

Notes: * Visible particulates on the support pad. Results may be biased low.

** Loose particulates present inside the cassette were included in the dust weight; therefore, the value was not included in analysis.

*** Reported result less than the detection limit. Half of the detection limit was used in analysis.

Appendix H

Site B Analytical Results

Anaylsis	Method	Sample ID	Date	Air Vol (m^3)	Total (mg)	Conc (mg/m^3)	Conc (ug/m^3)
Particulate Matter 10	PM10	2111	7/6/2006	24.048	6.00	0.25	250
Particulate Matter 10	PM10	2112	7/7/2006	24.048	4.28	0.18	180
Particulate Matter 10	PM10	2113	8/3/2006	24.048	6.49	0.27	270
Particulate Matter 10	PM10	2114	8/4/2006	24.148	8.50	0.35	350
Particulate Matter 10	PM10	2211	7/6/2006	24.048	6.48	0.27	270
Particulate Matter 10	PM10	2212	7/7/2006	24.048	8.14	0.34	340
Particulate Matter 10	PM10	2213	8/3/2006	24.048	6.26	0.26	260
Particulate Matter 10	PM10	2214	8/4/2006	24.048	10.0	0.42	420
Particulate Matter 10	PM10	2311	7/6/2006	23.948	2.37	0.099	99
Particulate Matter 10	PM10	2312	7/7/2006	24.048	0.809	0.034	34
Particulate Matter 10	PM10	2313	8/3/2006	23.948	5.70	0.24	240
Particulate Matter 10	PM10	2314	8/4/2006	24.048	3.16	0.13	130
Particulate Matter 10	PM10	2411*	---	---	---	---	---
Particulate Matter 10	PM10	2412	7/7/2006	24.048	2.37	0.098	98
Particulate Matter 10	PM10	2413	8/3/2006	24.048	3.65	0.15	150
Particulate Matter 10	PM10	2414	8/4/2006	24.048	3.70	0.15	150
Particulate Matter 10	PM10	2511	7/6/2006	24.048	0.913	0.038	38
Particulate Matter 10	PM10	2512	7/7/2006	24.048	2.01	0.084	84
Particulate Matter 10	PM10	2513	8/3/2006	24.048	1.40	0.058	58
Particulate Matter 10	PM10	2514	8/4/2006	24.048	1.33	0.055	55
Particulate Matter 10/2.5	PM10/2.5	2FB11	7/3-7/06	NA	<0.1	NA	NA
Particulate Matter 10/2.5	PM10/2.5	2FB12	8/1-4/06	NA	<0.1	NA	NA

Notes: * Equipment malfunction; did not submit sample to laboratory.

Appendix H (Continued)

Site B Analytical Results

Anaylsis	Method	Sample ID	Date	Air Vol (m^3)	Total (mg)	Conc (mg/m^3)	Conc (ug/m^3)
Particulate Matter 2.5	PM2.5	2121	7/3/2006	24.048	0.535	0.022	22
Particulate Matter 2.5	PM2.5	2122	7/5/2006	24.048	0.382	0.016	16
Particulate Matter 2.5	PM2.5	2123**	8/1/2006	23.046	<0.1	0.002	2
Particulate Matter 2.5	PM2.5	2124	8/2/2006	24.048	0.840	0.035	35
Particulate Matter 2.5	PM2.5	2221	7/3/2006	24.048	0.579	0.024	24
Particulate Matter 2.5	PM2.5	2222	7/5/2006	24.048	0.381	0.016	16
Particulate Matter 2.5	PM2.5	2223	8/1/2006	23.046	0.879	0.038	38
Particulate Matter 2.5	PM2.5	2224	8/2/2006	24.048	0.769	0.032	32
Particulate Matter 2.5	PM2.5	2321	7/3/2006	24.048	0.966	0.040	40
Particulate Matter 2.5	PM2.5	2322	7/5/2006	24.048	0.425	0.018	18
Particulate Matter 2.5	PM2.5	2323	8/1/2006	23.046	0.794	0.034	34
Particulate Matter 2.5	PM2.5	2324	8/2/2006	23.948	0.854	0.036	36
Particulate Matter 2.5	PM2.5	2421	7/3/2006	24.048	0.394	0.016	16
Particulate Matter 2.5	PM2.5	2422	7/5/2006	24.048	0.161	0.0067	6.7
Particulate Matter 2.5	PM2.5	2423	8/1/2006	23.046	0.809	0.035	35
Particulate Matter 2.5	PM2.5	2424*	---	---	---	---	---
Particulate Matter 2.5	PM2.5	2521	7/3/2006	24.048	0.401	0.017	17
Particulate Matter 2.5	PM2.5	2522	7/5/2006	24.048	0.112	0.0046	4.6
Particulate Matter 2.5	PM2.5	2523	8/1/2006	23.046	0.736	0.032	32
Particulate Matter 2.5	PM2.5	2524	8/2/2006	24.048	0.470	0.020	20
Particulate Matter 10/2.5	PM10/2.5	2FB11	7/3-7/06	NA	<0.1	NA	NA
Particulate Matter 10/2.5	PM10/2.5	2FB12	8/1-4/06	NA	<0.1	NA	NA

Notes: * Equipment malfunction; did not submit sample to laboratory.
** Reported result less than the detection limit. Half of the detection limit was used in analysis.

Appendix H (Continued)

Site B Analytical Results

Anaylsis	Method	Sample ID	Date	Air Vol (m3)	Total (mg)	Conc (mg/m3)	Conc (ug/m3)
Total Dust	NIOSH 0500	2631	7/3/2006	0.750	0.894	1.2	1200
Total Dust	NIOSH 0500	2632	7/5/2006	0.960	0.627	0.65	650
Total Dust	NIOSH 0500	2633	7/6/2006	0.960	1.64	1.7	1700
Total Dust	NIOSH 0500	2634	7/7/2006	0.960	0.744	0.78	780
Total Dust	NIOSH 0500	2635	8/1/2006	0.960	0.369	0.38	380
Total Dust	NIOSH 0500	2636	8/2/2006	0.960	0.699	0.73	730
Total Dust	NIOSH 0500	2637	8/3/2006	0.960	0.592	0.62	620
Total Dust	NIOSH 0500	2638	8/4/2006	0.960	2.14	2.2	2200
Total/Resp Dust	NIOSH 0500/0600	2FB31	7/3-7/06	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	2FB32	8/1-4/06	NA	<0.05	NA	NA
Respirable Dust	NIOSH 0600	2741	7/3/2006	0.9375	0.210	0.22	220
Respirable Dust	NIOSH 0600	2742	7/5/2006	1.200	0.136	0.11	110
Respirable Dust	NIOSH 0600	2743**	7/6/2006	1.200	<0.05	0.02	20
Respirable Dust	NIOSH 0600	2744*	---	---	---		
Respirable Dust	NIOSH 0600	2745	8/1/2006	1.200	0.099	0.082	82
Respirable Dust	NIOSH 0600	2746	8/2/2006	1.200	0.212	0.18	180
Respirable Dust	NIOSH 0600	2747	8/3/2006	1.200	0.172	0.14	140
Respirable Dust	NIOSH 0600	2748	8/4/2006	1.200	0.355	0.30	300
Total/Resp Dust	NIOSH 0500/0600	2FB31	7/3-7/06	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	2FB32	8/1-4/06	NA	<0.05	NA	NA

Notes: * Equipment malfunction; did not submit sample to laboratory.
** Reported result less than the detection limit. Half of the detection limit was used in analysis.

Appendix I

Site C Analytical Results

Analysis	Method	Sample ID	Date	Air Vol (m^3)	Total (mg)	Conc (mg/m^3)	Conc (ug/m^3)
Particulate Matter 10	PM10	3111	7/19/2006	24.048	0.838	0.035	35
Particulate Matter 10	PM10	3112	7/20/2006	24.048	0.710	0.030	30
Particulate Matter 10	PM10	3113	8/23/2006	24.048	0.567	0.024	24
Particulate Matter 10	PM10	3114	8/24/2006	24.148	0.845	0.035	35
Particulate Matter 10	PM10	3211	7/19/2006	24.048	12.4	0.52	520
Particulate Matter 10	PM10	3212	7/20/2006	24.048	22.4	0.93	930
Particulate Matter 10	PM10	3213	8/23/2006	24.048	30.5	1.3	1300
Particulate Matter 10	PM10	3214	8/24/2006	24.048	31.2	1.3	1300
Particulate Matter 10	PM10	3311	7/19/2006	24.048	1.67	0.069	69
Particulate Matter 10	PM10	3312	7/20/2006	24.048	1.75	0.073	73
Particulate Matter 10	PM10	3313	8/23/2006	24.048	4.06	0.17	170
Particulate Matter 10	PM10	3314	8/24/2006	24.048	1.31	0.054	54
Particulate Matter 10	PM10	3411	7/19/2006	24.048	0.757	0.031	31
Particulate Matter 10	PM10	3412	7/20/2006	24.048	0.705	0.029	29
Particulate Matter 10	PM10	3413	8/23/2006	24.048	1.66	0.069	69
Particulate Matter 10	PM10	3414	8/24/2006	24.048	0.709	0.029	29
Particulate Matter 10	PM10	3511	7/19/2006	24.048	6.57	0.27	270
Particulate Matter 10	PM10	3512	7/20/2006	24.048	3.73	0.16	160
Particulate Matter 10	PM10	3513	8/23/2006	24.048	2.58	0.11	110
Particulate Matter 10	PM10	3514	8/24/2006	24.048	1.54	0.064	64
Particulate Matter 10/2.5	PM10/2.5	3FB11	7/17-20/06	NA	<0.1	NA	NA
Particulate Matter 10/2.5	PM10/2.5	3FB12	8/21-24/06	NA	<0.1	NA	NA

Appendix I (Continued)

Site C Analytical Results

Analysis	Method	Sample ID	Date	Air Vol (m3)	Total (mg)	Conc (mg/m3)	Conc (ug/m3)
Particulate Matter 2.5	PM2.5	3121	7/17/2006	24.047	0.542	0.022	22
Particulate Matter 2.5	PM2.5	3122	7/18/2006	23.948	0.759	0.032	32
Particulate Matter 2.5	PM2.5	3123	8/21/2006	24.048	0.164	0.0068	6.8
Particulate Matter 2.5	PM2.5	3124	8/22/2006	24.048	0.284	0.012	12
Particulate Matter 2.5	PM2.5	3221	7/17/2006	24.047	6.12	0.25	250
Particulate Matter 2.5	PM2.5	3222	7/18/2006	24.048	4.27	0.18	180
Particulate Matter 2.5	PM2.5	3223	8/21/2006	24.048	2.95	0.12	120
Particulate Matter 2.5	PM2.5	3224	8/22/2006	24.048	5.38	0.22	220
Particulate Matter 2.5	PM2.5	3321	7/17/2006	24.047	1.46	0.061	61
Particulate Matter 2.5	PM2.5	3322	7/18/2006	24.048	0.916	0.038	38
Particulate Matter 2.5	PM2.5	3323	8/21/2006	24.048	0.364	0.015	15
Particulate Matter 2.5	PM2.5	3324	8/22/2006	24.048	0.351	0.014	14
Particulate Matter 2.5	PM2.5	3421	7/17/2006	24.047	0.582	0.024	24
Particulate Matter 2.5	PM2.5	3422	7/18/2006	24.048	0.742	0.031	31
Particulate Matter 2.5	PM2.5	3423	8/21/2006	24.048	0.203	0.0084	8.4
Particulate Matter 2.5	PM2.5	3424	8/22/2006	24.048	0.276	0.011	11
Particulate Matter 2.5	PM2.5	3521	7/17/2006	24.047	0.565	0.023	23
Particulate Matter 2.5	PM2.5	3522	7/18/2006	24.048	0.831	0.034	34
Particulate Matter 2.5	PM2.5	3523	8/21/2006	24.048	0.175	0.0073	7.3
Particulate Matter 2.5	PM2.5	3524	8/22/2006	24.048	0.276	0.011	11
Particulate Matter 10/2.5	PM10/2.5	3FB11	7/17-20/06	NA	<0.1	NA	NA
Particulate Matter 10/2.5	PM10/2.5	3FB12	8/21-24/06	NA	<0.1	NA	NA

Appendix I (Continued)

Site C Analytical Results

Analysis	Method	Sample ID	Date	Air Vol (m3)	Total (mg)	Conc (mg/m3)	Conc (ug/m3)
Total Dust	NIOSH 0500	3631	7/17/2006	0.960	8.18	8.5	8500
Total Dust	NIOSH 0500	3632	7/18/2006	0.960	6.83	7.1	7100
Total Dust	NIOSH 0500	3633	7/19/2006	0.960	2.95	3.1	3100
Total Dust	NIOSH 0500	3634	7/20/2006	0.960	3.56	3.7	3700
Total Dust	NIOSH 0500	3635	8/21/2006	0.960	4.98	5.2	5200
Total Dust	NIOSH 0500	3636	8/22/2006	0.960	7.59	7.9	7900
Total Dust	NIOSH 0500	3637	8/23/2006	0.960	6.13	6.4	6400
Total Dust	NIOSH 0500	3638	8/24/2006	0.960	4.00	4.2	4200
Total/Resp Dust	NIOSH 0500/0600	3FB31	7/17-20/06	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	3FB32	8/21-24/06	NA	<0.05	NA	NA
Respirable Dust	NIOSH 0600	3741	7/17/2006	1.200	1.66	1.4	1400
Respirable Dust	NIOSH 0600	3742	7/18/2006	1.200	1.25	1.0	1000
Respirable Dust	NIOSH 0600	3743	7/19/2006	1.200	0.508	0.42	420
Respirable Dust	NIOSH 0600	3744	7/20/2006	0.975	0.603	0.62	620
Respirable Dust	NIOSH 0600	3745	8/21/2006	1.200	0.789	0.66	660
Respirable Dust	NIOSH 0600	3746	8/22/2006	1.200	1.62	1.4	1400
Respirable Dust	NIOSH 0600	3747	8/23/2006	1.050	0.785	0.75	750
Respirable Dust	NIOSH 0600	3748	8/24/2006	0.9875	0.687	0.70	700
Total/Resp Dust	NIOSH 0500/0600	3FB31	7/17-20/06	NA	<0.05	NA	NA
Total/Resp Dust	NIOSH 0500/0600	3FB32	8/21-24/06	NA	<0.05	NA	NA

Appendix J

Site A Inbound and Outbound Volumes

Material	Date	Inbound weight (tons)	Outbound weight (tons)	Total
MSW	6/20/2006	137.62	0	137.62
	6/21/2006	237.06	0	237.06
	6/22/2006	147.40	0	147.40
	6/23/2006	164.21	0	164.21
	9/12/2006	153.59	0	153.59
	9/13/2006	195.29	0	195.29
	9/14/2006	187.77	0	187.77
	9/15/2006	191.76	0	191.76
C&D	6/20/2006	222.12	0	222.12
	6/21/2006	249.24	0	249.24
	6/22/2006	227.47	0	227.47
	6/23/2006	186.29	0	186.29
	9/12/2006	268.22	0	268.22
	9/13/2006	224.82	0	224.82
	9/14/2006	143.78	0	143.78
	9/15/2006	160.84	0	160.84
Mixrecycle	6/20/2006	0.41	0	0.41
	6/21/2006	0	0	0.00
	6/22/2006	0.46	0	0.46
	6/23/2006	0.11	0	0.11
	9/12/2006	2.25	0	2.25
	9/13/2006	0	0	0.00
	9/14/2006	2.11	0	2.11
	9/15/2006	0.18	0	0.18

Appendix J (Continued)

Site A Inbound and Outbound Volumes

Material	Date	Inbound weight (tons)	Outbound weight (tons)	Total
Cardboard	6/20/2006	23.41	12.54	35.95
	6/21/2006	6.36	13.71	20.07
	6/22/2006	20.92	11.23	32.15
	6/23/2006	13.51	0	13.51
	9/12/2006	24.33	10.60	34.93
	9/13/2006	7.37	11.72	19.09
	9/14/2006	21.51	12.74	34.25
	9/15/2006	7.91	12.81	20.72
Miscelaneous	6/20/2006	0	306.66	306.66
	6/21/2006	0	472.30	472.30
	6/22/2006	0	385.82	385.82
	6/23/2006	0	412.35	412.35
	9/12/2006	0	471.05	471.05
	9/13/2006	0	383.80	383.80
	9/14/2006	0	369.05	369.05
	9/15/2006	0	411.81	411.81
Combined Total	6/20/2006	383.56	319.20	702.76
	6/21/2006	492.66	486.01	978.67
	6/22/2006	396.25	397.05	793.30
	6/23/2006	364.12	412.35	776.47
	9/12/2006	448.39	481.65	930.04
	9/13/2006	427.48	395.52	823.00
	9/14/2006	355.17	381.79	736.96
	9/15/2006	360.69	424.62	785.31

Appendix K

Site B Inbound and Outbound Volumes

Material	Date	Inbound weight (tons)	Outbound weight (tons)	Total
C&D	7/3/2006	97.19	0	97.19
	7/5/2006	344.07	0	344.07
	7/6/2006	255.90	0	255.90
	7/7/2006	251.64	0	251.64
	8/1/2006	282.01	0	282.01
	8/2/2006	303.08	0	303.08
	8/3/2006	204.75	0	204.75
	8/4/2006	224.05	0	224.05
Concrete	7/3/2006	0	0	0
	7/5/2006	0	21.84	21.84
	7/6/2006	0	43.69	43.69
	7/7/2006	0	13.17	13.17
	8/1/2006	0	0	0
	8/2/2006	0	0	0
	8/3/2006	0	0	0
	8/4/2006	0	0	0
ADC	7/3/2006	0	0	0
	7/5/2006	0	0	0
	7/6/2006	0	0	0
	7/7/2006	0	0	0
	8/1/2006	0	64.73	64.73
	8/2/2006	0	81.42	81.42
	8/3/2006	0	63.44	63.44
	8/4/2006	0	63.23	63.23

Appendix K (Continued)

Site B Inbound and Outbound Volumes

Material	Date	Inbound weight (tons)	Outbound weight (tons)	Total
Combined Total	7/3/2006	97.19	0	97.19
	7/5/2006	344.07	21.84	365.91
	7/6/2006	255.90	43.69	299.59
	7/7/2006	251.64	13.17	264.81
	8/1/2006	282.01	64.73	346.74
	8/2/2006	303.08	81.42	384.50
	8/3/2006	204.75	63.44	268.19
	8/4/2006	224.05	63.23	287.28

Appendix L

Site C Inbound and Outbound Volumes

Material	Date	Inbound weight (tons)	Outbound weight (tons)	Total
MSW	7/17/2006	2.13	24.89	27.02
	7/18/2006	0.79	57.37	58.16
	7/19/2006	0.48	92.83	93.31
	7/20/2006	1.23	69.50	70.73
	8/21/2006	0	31.98	31.98
	8/22/2006	0	74.30	74.30
	8/23/2006	0.25	48.02	48.27
	8/24/2006	0.53	67.45	67.98
C&D	7/17/2006	328.48	0	328.48
	7/18/2006	303.15	0	303.15
	7/19/2006	323.91	0	323.91
	7/20/2006	315.77	0	315.77
	8/21/2006	355.73	0	355.73
	8/22/2006	334.82	0	334.82
	8/23/2006	345.36	0	345.36
	8/24/2006	305.56	0	305.56
Wood Products	7/17/2006	30.07	133.96	164.03
	7/18/2006	35.12	61.54	96.66
	7/19/2006	0.14	45.95	46.09
	7/20/2006	50.18	54.72	104.90
	8/21/2006	10.45	10.96	21.41
	8/22/2006	125.87	50.06	175.93
	8/23/2006	96.50	67.10	163.60
	8/24/2006	39.04	108.23	147.27

Appendix L (Continued)

Site C Inbound and Outbound Volumes

Material	Date	Inbound weight (tons)	Outbound weight (tons)	Total
Gypsum & Sheetrock	7/17/2006	16.15	0	16.15
	7/18/2006	7.00	0	7.00
	7/19/2006	0	29.52	29.52
	7/20/2006	0.54	0	0.54
	8/21/2006	6.42	0	6.42
	8/22/2006	0	23.05	23.05
	8/23/2006	0	0	0
	8/24/2006	0	5.75	5.75
Metal	7/17/2006	0.35	13.43	13.78
	7/18/2006	0	60.63	60.63
	7/19/2006	0.05	25.21	25.26
	7/20/2006	0.12	55.94	56.06
	8/21/2006	0	30.62	30.62
	8/22/2006	0	27.19	27.19
	8/23/2006	0	29.55	29.55
	8/24/2006	0	15.20	15.20
Concrete/Asphalt or Brick	7/17/2006	64.50	0	64.50
	7/18/2006	27.86	0	27.86
	7/19/2006	5.38	0	5.38
	7/20/2006	21.38	36.92	58.30
	8/21/2006	155.44	0	155.44
	8/22/2006	45.82	0	45.82
	8/23/2006	36.54	0	36.54
	8/24/2006	1.13	0	1.13

Appendix L (Continued)

Site C Inbound and Outbound Volumes

Material	Date	Inbound weight (tons)	Outbound weight (tons)	Total
Cardboard	7/17/2006	0	0	0
	7/18/2006	0	0	0
	7/19/2006	0	0	0
	7/20/2006	0	22.73	22.73
	8/21/2006	0	0	0
	8/22/2006	0	1.50	1.50
	8/23/2006	0	1.28	1.28
	8/24/2006	0	0	0
Alternate Daily Cover	7/17/2006	0	320.04	320.04
	7/18/2006	0	232.51	232.51
	7/19/2006	0	303.91	303.91
	7/20/2006	0	299.34	299.34
	8/21/2006	0	267.47	267.47
	8/22/2006	0	254.51	254.51
	8/23/2006	0	215.50	215.50
	8/24/2006	0	226.98	226.98
Combined Total	7/17/2006	441.68	492.32	934.00
	7/18/2006	373.92	412.05	785.97
	7/19/2006	329.96	497.42	827.38
	7/20/2006	389.22	539.15	928.37
	8/21/2006	528.04	341.03	869.07
	8/22/2006	506.51	430.61	937.12
	8/23/2006	478.65	361.45	840.10
	8/24/2006	346.26	423.61	769.87

Appendix M

Site A Weather Conditions

Date	Avg Temp	Avg Humidity	Precipitation	Pressure	Avg Wind Speed	Wind Direction
June 20, 2006	78	65	0	29.94	4	SW
June 21, 2006	78	55	0	30.01	0	SW
June 22, 2006	84	59	Yes *	30.08	3	SSW
June 23, 2006	79	75	0	30.05	8	S
September 12, 2006	68	70	0	30.29	3	ESE
September 13, 2006	64	78	Yes *	30.14	5	S
September 14, 2006	66	88	Yes *	29.96	0	NNW
September 15, 2006	68	79	0	29.96	1	NNW

Weather information from historical data on Weatherunderground.com

Note: * Historical weather data indicates no precipitation; however, field records indicate precipitation.

Appendix N

Site B Weather Conditions

Date	Avg Temp	Avg Humidity	Precipitation	Pressure	Avg Wind Speed	Wind Direction
July 3, 2006	80	75	0	30.19	6	SW
July 5, 2006	80	76	0	30.08	7	SSW
July 6, 2006	78	82	0.37	29.98	7	NNE
July 7, 2006	72	79	0.01	30.12	6	NNE
August 1, 2006	84	76	0	30.02	5	SW
August 2, 2006	84	80	0	30.04	5	SSW
August 3, 2006	85	78	0	29.98	9	SSW
August 4, 2006	86	73	0	29.93	7	SW

Weather information from historical data on Weatherunderground.com

Appendix O

Site C Weather Conditions

Date	Avg Temp	Avg Humidity	Precipitation	Pressure	Avg Wind Speed	Wind Direction
July 17, 2006	80	69	0	29.96	3	WSW
July 18, 2006	82	69	0	29.93	3	SW
July 19, 2006	76	70	0	30.11	4	ENE
July 20, 2006	74	76	Yes *	30.1	3	NE
August 21, 2006	72	58	0	29.99	9	WNW
August 22, 2006	70	61	0	30.09	1	WSW
August 23, 2006	70	58	0	30.02	7	WNW
August 24, 2006	68	69	Yes *	30.01	0	ESE

Weather information from historical data on Weatherunderground.com

Note: * Historical weather data indicates no precipitation; however, field records indicate precipitation.

Vita

Jason Matthew Young was born on November 4, 1975, in Petersburg, Virginia. He graduated from Colonial Heights High School, Colonial Heights, Virginia in 1993. He received his Bachelors of Science from Virginia Tech, Blacksburg, Virginia in 1998. He majored in Fisheries Science and minored in Communications and Biology at Virginia Tech. He has been employed as a fisheries technician with the Virginia Department of Game and Inland Fisheries, an environmental specialist with Johnson & Johnson, the senior aquarist with Maymont Foundation, and is currently an environmental scientist with Joyce Engineering, Inc. He published an article titled "Snakehead at Maymont?" in the Fall 2004 James River Reach. He currently lives in Chesterfield County, Virginia.

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