A PRELIMINARY ASSESSMENT OF FUGITIVE DUST FROM ROADS IN EIGHT ALASKAN VILLAGES IN THE NORTHWEST ARCTIC BOROUGH

Project Report (2003-2005)

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Abstract

The Alaska Department of Environmental Conservation (ADEC) partnered with the Maniilaq Association to evaluate the level of fugitive dust emissions from unpaved roads in eight villages in Alaska's Northwest Arctic Borough during the summer seasons of 2003, 2004, and 2005. The villages of Selawik, Ambler, Kiana, Buckland, Kotzebue, Kivalina, Noatak, and Noorvik participated in the project with the initial intent of determining if a dust problem existed, and the extent of such a problem. The results of this sampling project were to be used to assess the amount of fugitive dust, to compare that amount to the National Ambient Air Quality Standard (NAAQS), and to help develop a dust control strategy for rural Alaskan native villages.

The state and federal 24-hour health based standard for dust particulate size was set at 150 $\mu g/m^3$ in 1987. During the sampling period between February 2003 and September 2005, 29 exceedances of the standard were reported using the Federal Reference Method Hi-Vol samplers. The maximum dust level reported was 608 $\mu g/m^3$ (in Noorvik on July 23rd, 2004). The greatest number of exceedances was observed in Noatak (9 validated samples). Kotzebue and Selawik both measured no exceedances, but Kotzebue had a higher average concentration of dust. For reference, the Federal Air Quality Standard for dust states that if a community has more than two exceedances of the standard in a year, averaged over a three-year period, the state and U.S. Environmental Protection Agency may declare the area non-attainment and require the community to take official steps to lower dust levels.

Introduction and Research Approach

The Maniilaq Association initiated a dust evaluation project with the support of the Alaska Department of Environmental Conservation (ADEC) in 8 native villages in Alaska's Northwest Arctic Borough. These villages are Selawik, Ambler, Kiana, Buckland, Kotzebue, Kivalina, Noatak, and Noorvik (see Figure 1). The initial phase of this effort began in February 2003 and ran during the summer seasons until September 2005. ADEC provided technical assistance to the Maniilaq Association in their effort to assess air quality and educate village residents on the potential health threat associated with the exposure to dust. Funding for the baseline assessment was provided through each village's Indian General Assistance Program (IGAP), and special grants from the Environmental Protection Agency (EPA) and the Bureau for Indian Affairs (BIA) to the Maniilaq Association. The day to day air monitoring was managed through the Maniilaq Association's environmental staff with project oversight from ADEC.

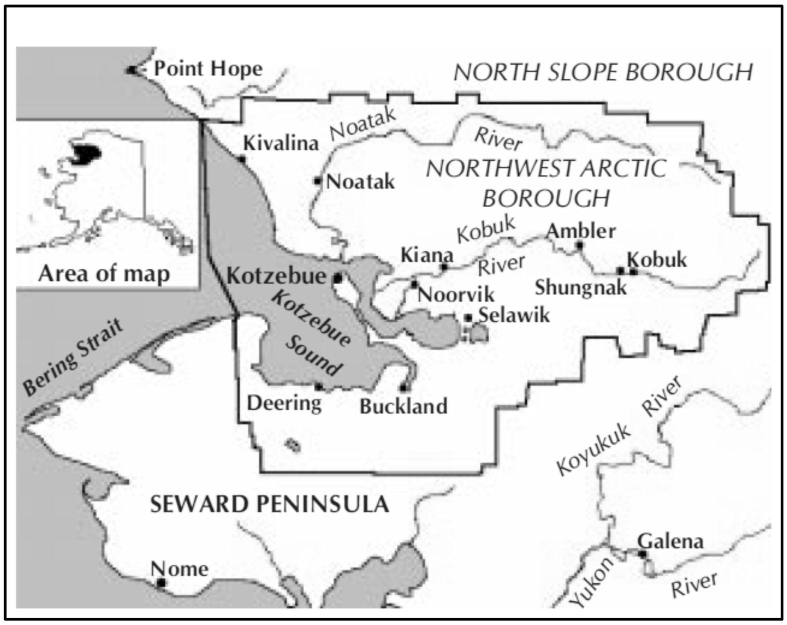

Figure 1: A map showing the eight Alaskan villages of the Northwest Arctic Borough that elected to participate in the road dust monitoring.

Sources of Dust in Rural Communities

The road systems in the villages are used by cars, trucks, motorcycles and four wheelers (ATVs) to transport residents within the community. Four wheelers are a main means of transportation within the village, and are also used as "recreation vehicles" throughout the day. Four wheelers have knobbier tires than cars and trucks, and thus pick up more dust than most other vehicles. Local dirt roads are constructed from local silt, gravel and sand. During the summer months when streets are dry and the winds are light, vehicle traffic can cause the silts and fine sands to become airborne. In addition, frequent and prolonged wind events also load the ambient air with coarse particulates, and thus affect air quality throughout the community, potentially creating an unhealthy environment for the residents. During windy episodes dirt roads can serve as sources for large dust columns, which cover the community. Average wind speeds during the summer are 4 mph, with gusts over 13mph, according to Kiana wind data provided by ADEC. To address the dust issue, some village governments water the streets during the summer months. Due to the silty makeup of the road surface and heat from the summer sun, watered streets can dry out within several hours, therefore road watering provides an effective but only short term limited relief from road dust.

The roads in the village are heavily used by pedestrians, and children frequently play in and around them. In the communities, the road is a means of vehicle transport, a walkway, and a recreational site for children. There are no sidewalks, and no front yards set back from the road—front doors face and are near to the road. The silty dust is easily blown in all directions, and can linger in the air for a while (see Figure 2). Because many community members spend a substantial amount of their time in and around the roads, the air quality samplers were set up alongside the road.

Figure 2: Kotzebue on a dusty summer day.

Public Health

Under the authority of the Clean Air Act, the United States Environmental Protection Agency (USEPA) has issued air quality standards for public exposure to safe levels of particulate matter suspended in the air. The focus of these standards is the protection of public health and welfare.

The term "particulate matter" (PM) includes both solid particles and liquid droplets found in air. Many man-made and natural sources emit PM directly or emit other pollutants that react in the atmosphere to form PM. Particles can range in size from large specks of soot to fine grains of dust with diameters about one-tenth the diameter of a strand of human hair. Fine particles ($PM_{2.5}$) result from fuel combustion in motor vehicles, power generation units, and industrial facilities, as well as from residential fireplaces and wood stoves. Coarse particles (PM_{10}) are generally emitted from crustal sources, such as dust generated by vehicles traveling on unpaved roads, material handling, crushing and grinding operations, as well as natural windblown dust from river gravel bars or other exposed areas.

The State and Federal air quality standards focus on "inhalable" size particulates, which are both fine and coarse. These materials can accumulate in the respiratory system and are associated with numerous health-related impacts. Exposure to coarse particles is primarily associated with the aggravation of respiratory conditions, such as asthma. Fine particles are more closely associated with increased hospital admissions and emergency room visits for heart and lung disease, increased respiratory symptoms and disease, decreased lung function, and even premature death. Sensitive groups that appear to be at greatest risk to such effects include the elderly, individuals affected by cardiopulmonary diseases such as asthma, and children. In addition to health problems, PM is a major cause of reduced visibility in many parts of the United States.

In order to maintain a healthy breathing environment, the National Ambient Air Quality Standard for PM_{10} is set as 150 $\mu g/m^3$ for a 24-hour average, (one microgram is one millionth of a gram) of particulate matter per cubic meter of air. If air monitoring results show that the concentration of PM_{10} is greater than this amount, the EPA may demand that action is taken to reduce airborne particulate to protect the health of residents. This monitoring project was conducted in the Northwest Arctic Borough to determine if local air quality meets the National Ambient Air Quality Standard for coarse particulate matter (dust).

Monitoring Strategy

The amount of dust in rural villages was measured to determine the need for road dust palliatives or dust suppressants, which are chemicals that are applied to the road surface to reduce dust. The ADEC's air monitoring program partnered with the Maniilaq Association and the native villages to perform air monitoring to determine the extent of airborne coarse particulate matter (PM_{10}). The samplers were set up alongside dirt roads in the communities, near a reliable power source, and near frequently-used routes where the most individuals were expected to be exposed.

Monitoring Equipment

The equipment used in all communities to evaluate the concentration of airborne dust particles in ambient air was the Andersen High-Volume (Hi-Vol) PM_{10} sampler – an EPA designated Federal Reference Method (FRM) monitor. FRM sampling followed a 1 in 3 monitoring schedule for the majority of the time, meaning that a new sample filter was installed and the sampler operated every third day for 24 hours. Before being placed in the sampler, filters were pre-weighed on a high-precision scale in the laboratory to determine the weight of the filter without any dust deposit. The filter was then installed in the sampler, which used a mechanical timer to turn it on at midnight of the sample day and turn it off after it sampled for twenty-four hours. Ambient air was drawn in through the sampler head and filter media by a pump, similar to a vacuum cleaner motor so that airborne particulates were trapped on the filter. After sampling, the filter was returned to the laboratory and weighed again to determine how much dust was deposited on the filter. The difference between the two weights divided by the volume of air is the measurement that is used to determine 24-hour concentrations of PM_{10}.

Sampling Methods

Pre-weighed filters were set up for sampling in an office environment. The site operator carefully removed filters from their storage container and placed them in the filter cassette. The filter ID number and date were logged on the data sheets and the filters were covered for transport to the field. In the field the operator checked and recorded the sampler flow rate and elapsed time to complete the data record for the filter that was previously sampled before exchanging the old (now dirty) filter with the new filter. Once the new filter was mounted onto the instrument, the elapsed timer was set to zero and the flow rate re-checked and logged on the log sheets. Exposed filters were taken back to the office where they were stored. Exposed filters were then sent to the ADEC laboratory for post sampling weighing. This process normally took 5-7 days in the mail, and 3-5 days in the lab. This sampling method is not intended to provide data for protecting the public on a daily basis, but rather to document dust problems.

Results

During the summers of 2003, 2004, and 2005, 29 exceedances of the NAAQS were observed in six of the eight villages of Alaska's Northwest Arctic Borough. The greatest number of exceedances (nine) was witnessed in Kivalina. Selawik and Kotzebue both did not record any exceedances, although Kotzebue had some high readings, with a maximum measurement of 125µg/m³. A summary of the data is provided in Table 1. More detailed descriptions of the results from each community are included in the village summaries section of this report.

The concentrations recorded range from 0 to 608 µg/m^3. In the Native Village of Selawik, the values of PM_{10} concentration were all less than 13 µg/m³ because this village uses wooden boardwalks instead of dirt roads. As a result, these data serve as control measurements for this project, demonstrating expected dust concentrations if dirt roads were not present. Some high values may be attributed to smoky conditions. Wildfires are frequent during the summer season, and particulate matter from smoke may get trapped on a filter. Smoky filters turn gray in color and smell smoky; with dust, the filters turn brown.

Village Name	Number of NAAQS Exceedances (Valid Samples)	Maximum Value	Date of Max. Value
Selawik	0(8)	13 µg/m³	8/3/2005
Ambler	6(30)	269 µg/m³	8/2/2005
Kiana	2(9)	219 µg/m³	7/11/2005
Buckland	2(16)	164 µg/m³	7/11/2003
Kotzebue	0(40)	125 µg/m³	10/21/2003
Kivalina	No filters received		
Noatak	10(28)	472 µg/m³	8/2/2005
Noorvik	8(39)	608 µg/m³	7/23/2004

Table 1: A summary of maximum values and number of exceedances in the eight communities that participated in this project.

Challenges

Air quality monitoring is a complex field. Sampling instruments can break down and are vulnerable to malfunction. To document that the instrument is functioning in the intended way, every step in the monitoring process needs to be documented and checked. For results to be representative and repeatable, site operators need to adhere to standard operating procedures so that the collected data can be interpreted correctly and compared with similar measurements collected in other locations and to the NAAQS. To characterize an air quality problem, it is important to have representative data. Usually this means following a predetermined sampling schedule so as not to bias the measurements. In the case of road dust, this means not to sample the same day of the week. The EPA has set standards to ensure consistent and unbiased sampling; either a 1-in-3 sampling schedule or 1-in-6 sampling schedule was used during this project. There is a device within the sampler that automatically turns the machine on every 3 or 6 days, and off again after a sampling period of 24 hours. There is also a timer to check the time which the sampler actually ran for, as well as a device called a Dickson Chart recorder, which shows fluctuations in power delivery, a common issue in rural villages. In addition to the routinely encountered problems with monitoring equipment, there are many challenges unique to rural air quality sampling. It is expensive to transport materials and personnel out to the villages off the road system. It is critical that the local environmental technician is consistent and dedicated so that the maximum amount of valid data is collected. The EPA standard for monitoring projects is a data capture of at least 75%. The data capture rates for the data collected during this project are included in the individual village data reports. These values show the importance of a consistent technician; if a filter is run too long or installed improperly, that run is invalid and cannot be incorporated into the data set.

While more sophisticated sampling technology exists, the advantage of the manual samplers is that they are relatively inexpensive, durable, simple to use and easy to operate in even the most harsh of environments. The sample filter may be analyzed to identify chemical compositions of the collected mass. The main disadvantage of this type sampler is they are labor intensive, only run for 24 hours without filter change and data results are not available on a real-time basis.

Conclusion and Future Steps

The data collected shows the high amount of air-borne road dust particles in the communities of Alaska's Northwest Arctic Borough. Several communities measured values above the NAAQS. After the initial results, ADEC issued a survey to communities across the state of Alaska and the results are recorded on the map below (Figure 3). As can be seen on the map, road dust is a problem in many rural villages, not just those of the Northwest Arctic Borough where monitoring was conducted.

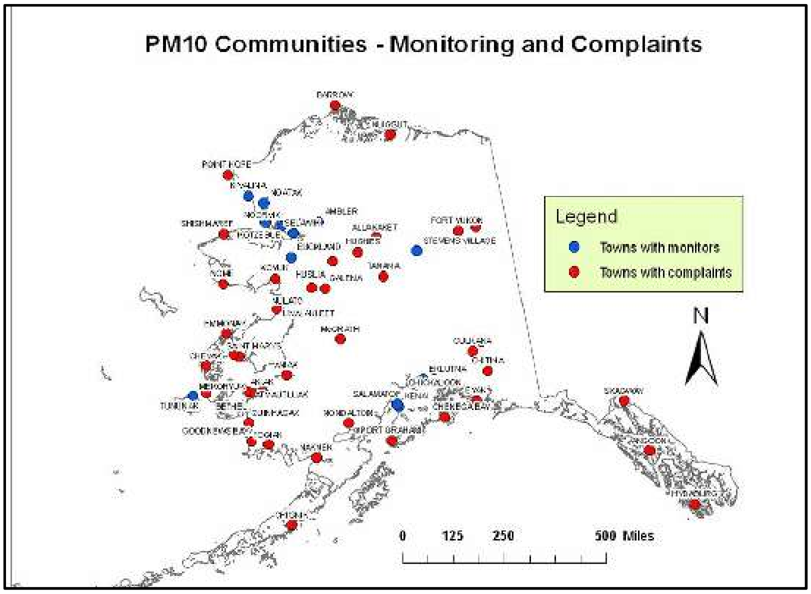

Figure 3: Survey results show that complaints about air quality in native villages are widespread throughout the state of Alaska.

As a result of this study, the State legislature has provided funds for a pilot study. The purpose of the study is to develop a sprayer that can be used in the communities to test a series of palliatives. This pilot study is to be conducted by the Alaska Department of Transportation and the Alaska Department of Environmental Conservation, in cooperation with eight communities six of which are in the Northwest Arctic Borough, to assess various palliatives for effectiveness and community satisfaction with the intent to develop a sustainable resolution for road dust in the communities.

Selawik

Photo taken 1980

Population: 829
Highest Value: 13 ug/m^3

Sample Date	Concentration $\mu g/m^3$
7/19/03	13
7/23/03	5
8/7/03	9
8/10/03	6
8/13/03	4
8/28/03	11
9/13/03	3
9/16/03	4

The Native Village of Selawik elected to participate in this project. The sampler was set up near the clinic on a short stretch of dirt road and set to run on a 1-in-3 sampling schedule (samples every 3rd day) from July 19th to September 16th, 2003. Out of 20 possible samples, 8 were valid for a capture rate of 40%.

The highest value for this site was 13 $\mu g/m^3$, far below the PM_{10} standard of 150 $\mu g/m^3$ for a 24 hour period because this village is located in an area that necessitates boardwalks instead of roads.

Ambler

Photo taken 1990

Population: 258

Highest Value: 269 µg/m^3

Sample Date	Concentration µg/m³
8/1/04	11
8/4/04	14
8/11/04	12
8/14/04	9
8/17/04	45
8/20/04	132
8/24/04	**186**
6/17/05	**198**
6/19/05	22
6/22/05	69
6/25/05	112
7/1/05	79
7/4/05	104
7/7/05	32
7/10/05	7
7/19/05	8
7/22/05	74
7/25/05	**189**
7/28/05	131
7/31/05	**197**
8/3/05	**269**
8/6/05	36
8/9/05	54
8/12/05	31
8/18/05	**207**
8/24/05	5
8/27/05	20
8/30/05	16
9/2/05	15
9/9/05	19

The Native Village of Ambler elected to participate in this project. The sampler was set up outside the IRA office and set to run on a 1-in-3 sampling schedule (samples every 3rd day) during the summer season from August 1st, 2004 to September 10th, 2005. Sampling was discontinued on September 10th, 2005 due to extensive vandalism of the sampling equipment which prohibited future sampling during the summer and fall season. 30 samples were collected during the sampling period. Three samples (obtained on 6/28/05, 7/13/05, and 8/15/05) ran greater than the run time criteria. Out of 33 possible samples, 30 were valid for a capture rate of 90%. The sampler exceeded the 24 hour national health based standard six times (values shown bold and underlined). DEC assumes that most of these exceedances were caused by road dust during dry road conditions. Comments in the log sheet for July 25, 2005, July 31, 2005, and August 31, 2005 indicate smoky conditions. Smoke can act as a contributing factor to the PM_{10} exceedance. Without instrumentation to measure fire particulate (smoke) no conclusive determination can be made as to the actual amount of smoke particulates on each filter. The exceedances on July 25, 2005, July 31, 2005, and August 3, 2005 could have particulates from smoke from fires in interior Alaska. Those dates correlate with fire activity in the state for that time period.

The highest value for this site was 269 µg/m^3; this exceeds the PM_{10} standard of 150 µg/m^3 for a 24 hour period.

Kiana

Photo taken 1993

Population: 361

Highest Value: 200µg/m^3

Sample Date	Concentration µg/m^3
7/21/2005	**200**
7/24/2005	**188**
7/27/2005	100
7/30/2005	59
8/5/2005	10
8/11/2005	4.3
8/14/2005	76
8/17/2005	34
8/20/2005	11

The Native Village of Kiana elected to participate in this project. The sampler was set to run on a 1-in-3 sampling schedule (samples every 3rd day) from July 19th to August 20th, 2005. 9 samples were collected during the sampling period. The sampler exceeded the 24 hour national health based standard two times (values shown bold and underlined).

The highest value for this site was 200 µg/m^3; this exceeds the PM_{10} standard of 150 µg/m^3 for a 24 hour period.

Buckland

Photo taken 1999

Population: 416

Highest Value: 164 µg/m^3

Sample Date	Concentration µg/m^3
7/11/2003	**164**
7/13/2003	5
7/16/2003	6
7/19/2003	73
7/22/2003	10
7/25/2003	6
8/7/2003	133
8/10/2003	89
8/12/2003	7
9/5/2003	5
9/7/2003	9
9/22/2003	61
9/23/2003	75
4/26/2004	11
7/1/2004	**151**
7/9/2004	35

This sampler was set to run on a 1-in-3 sampling schedule (samples every 3rd day) from July 11th, 2003 to July 16th, 2004. The sampler ran on 27 run days of which 11 have been flagged and invalidated, many because of unplugged or cut power cords. The capture rate is 59%.
The sampler exceeded the 24 hour national health based standard two times (values shown bold and underlined). Comments in the log sheet for July 1st, 2001 indicate smoky conditions. Smoke can act as a contributing factor to the PM_{10} exceedance.

The highest value for this site was 164 µg/m^3; this exceeds the PM_{10} standard of 150 µg/m^3 for a 24 hour period.

Kotzebue

Photo taken 2007

Population: 3,201

Highest Value: 125 µg/m^3

Sample Date	Sampler #	Concentration µg/m³
8/16/2003	1	4
8/19/2003	1	3
	2	12
8/22/2003	1	5
8/25/2003	1	1
	2	2
8/28/2003	1	3
	2	10
8/31/2003	1	7
	2	9
9/3/2003		
	2	4
9/6/2003	1	6
	2	7
9/9/2003	1	6
	2	35
9/12/2003	1	5
	2	11
9/15/2003	1	43
	2	6
9/18/2003	1	9
	2	48
9/21/2003	1	8
	2	8
9/24/2003	1	61
	2	93
9/27/2003	1	11
	2	11
9/30/2003		
	2	2
10/3/2003	1	6
	2	6
10/6/2003		
	2	2
10/9/2003	1	2
	2	2
10/12/2003	1	3
	2	3
10/15/2003	1	12
	2	16
10/18/2003	1	21
	2	62
10/21/2003		
	2	125

Two samplers were set to run on a 1-in-3 sampling schedule (samples every 3rd day) from August 16th to October 21st, 2003 at two different sites in Kotzebue. For sampler 1, 19 out of 23 possible samples were valid for a capture rate of 88%. The sampler did not exceed the 24 hour national health based standard. For sampler 2, 21 out of 22 possible samples were valid for a capture rate of 95%.

The highest value for this site was 125 µg/m^3; this does not exceed the PM_{10} standard of 150 µg/m^3 for a 24 hour period.

Note: A separate study on road dust funded by the Alaska Department of Transportation was conducted in Kotzebue during the summers of 2002 through 2008 and was written up in a separate report.

Kivalina

Photo taken 2007

Population: 374

One sampler was set to on a 1-in-3 sampling schedule in 2005. No filters were received from the village.

Noatak

Photo taken 1990

Population: 514

Highest Value: 472 µg/m^3

Sample Date	Concentration µg/m³
3/4/2003	4
3/11/2003	16
5/7/2003	1
7/9/2003	21
7/22/2003	**152**
8/22/2003	6
9/2/2003	90
9/9/2003	17
9/12/2003	16
7/3/2005	**318**
7/7/2005	**202**
7/9/2005	**150**
7/16/2005	101
7/19/2005	51
7/23/2005	**331**
7/27/2005	**402**
7/30/2005	**231**
8/2/2005	**472**
8/9/2005	10
8/11/2005	24
8/14/2005	**188**
8/17/2005	**247**
9/1/2005	4
9/7/2005	40
9/13/2005	5
9/18/2005	3
9/20/2005	4
9/25/2005	1

The Native Village of Noatak sampled between February 2003 and September 2005. 28 samples were collected during the sampling period. The sampler exceeded the 24 hour national health based standard ten times.

There was one sampler running in 2003 and two samplers in 2005, which were set to run on a 1-in-3 sampling schedule (samples every 3rd day) from July 3rd to August 17th, 2005, and change to a 1-in-6 sampling schedule on September 1st. The validated data of both samplers is shown at left. DEC assumes that most of these exceedances were caused by road dust during dry road conditions because the dirty filters were brown in color, an indicator of road dust. During smoky conditions, filters can become loaded with particulate from wood smoke. Exposure to smoke is indicated by a smoke smell and blackish-gray coloring on the filter.

The highest value for this site was 472µg/m^3; this exceeds the PM_{10} standard of 150 µg/m^3 for a 24 hour period.

Noorvik

Photo taken 1990

Population: 668

Highest Value: 608 µg/m^3

Sample Date	Concentration µg/m³
7/1/2003	4
7/4/2003	4
7/10/2003	7
7/12/2003	50
7/18/2003	135
7/21/2003	**374**
7/25/2003	3
8/3/2003	8
8/6/2003	17
8/11/2003	63
8/14/2003	5
8/17/2003	6
8/21/2003	21
8/24/2003	4
8/26/2003	3
9/10/2003	4
9/19/2003	13
9/23/2003	32
9/26/2003	68
10/5/2003	2
10/9/2003	11
10/22/2003	50
11/6/2003	3
4/12/2004	4
4/20/2004	5
4/22/2004	6
4/28/2004	31
5/5/2004	3
5/17/2004	20
6/4/2004	**568**
6/10/2004	**162**
6/16/2004	6
6/22/2004	2
7/14/2004	**478**
7/17/2004	**229**
7/20/2004	**332**
7/23/2004	**608**
7/26/2004	**254**
7/29/2004	60

This sampler was set to run on a 1-in-3 sampling schedule (samples every 3rd day) from July 1st to July 29th, 2004. Out of 63 possible samples, 39 were valid for a capture rate of 60%.

The sampler exceeded the 24 hour national health based standard eight times (values shown bold and underlined). It was discovered that the flows were erratic during sampling due to a missing gasket in the sampler.

The highest value for this site was 608 µg/m^3; this exceeds the PM_{10} standard of 150 µg/m^3 for a 24 hour period.