EFFECTIVENESS OF PAVING ON AIRBORNE PARTICULATE MATTER: A PRELIMINARY ASSESSMENT OF FUGITIVE DUST FROM ROADS IN KOTZEBUE, ALASKA

Project Report (2002-2008)

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ABSTRACT

The Department of Environmental Conservation (DEC) performed a research study to evaluate the levels of fugitive dust emissions from roads in Kotzebue, Alaska. The investigation was designed to look at summer dust levels before and after the gravel "test" road was paved to determine the overall effectiveness of paving as a dust control strategy for rural Alaska.

The evaluation of PM_{10} size particulate emissions was conducted from June 2002 through July 2007. During the period before paving, the monitors recorded more than twenty exceedances of the 150 $\mu g/sm^3$ federal, 24-hour PM_{10} standard. After the road was paved, no elevated PM_{10} values were recorded along Second Avenue.

Supplemental monitoring for PM_{10} was conducted during the summer of 2007 and 2008 to assess dust levels on the north side of town outside the paving area. While no exceedances were recorded in 2007, the 2008 sampling did find six days with PM_{10} levels above the NAAQS three of which had levels more than twice the standard. In addition, background monitoring was performed at a site south of town to identify Kotzebue's background dust level. The average monthly dust levels at this site ranged from 2 to 22 $\mu g/sm^3$ with a maximum 24-hour reading of 42 $\mu g/sm^3$.

SUMMARY OF PROJECT FINDINGS

The data presented in this report describe the air quality along Second Avenue in Kotzebue, Alaska during a typical summer, which normally experiences several very dry episodes. Filter based dust monitors were positioned on both sides of Second Avenue at two locations to monitor fugitive dust from the unpaved road. During the multi-year monitoring project, six different sampling sites were installed close to or along Second Avenue with Sites 1 and 2 installed every sampling season. The location of Site 1 remained the same each year, but Site 2 was relocated east one and a half blocks to the Wells Fargo Bank parking lot because the landowner of the original site wanted to use the land for another purpose.

The state and federal 24-hour health based standard for dust size particulates is set at 150 $\mu g/sm^3$. During the pre-paving sampling projects between 2003 and 2005, a seasonal average of eleven exceedances of the standard was reported using the Federal Reference Monitors (FRM) and the Beta Attenuation Monitor (BAM). After paving, the monitoring programs in 2006 and 2007 found no samples exceeding the health based standard. The Department believes this demonstrates the effectiveness of paving as a control strategy for use in decreasing the amount of airborne road dust along paved roadways in Rural Alaska.

Supplemental monitoring was conducted in Kotzebue during the summers of 2007 and 2008 at the Kotzebue Bible Baptist Church located on the corner of Turf and Sixth Street. This monitoring was performed to address concerns from potentially affected residents who lived north of that portion of the city which had been paved. While monitoring during the summer of 2007 did not find high dust levels, 2008 sampling did identify six days with values above the air quality standard. Because the sample schedule followed the national 1 in 3 sampling frequency, the actual number of days when the standard was exceeded could be 2-3 times as high.

Staff reported observations of traffic during the monitoring season suggest a very high traffic volume, especially considering the size of the community. Unfortunately, a portion of the observed traffic was from four wheelers which did not register on the state's traffic counters. While volume is important, vehicle type, tire design, vehicle speed and road conditions all play an important part in dust generation. This report summarizes the results of the Kotzebue road dust study. Discussions of each individual year's data can be found in the Appendices at the end of this report.

CHAPTER 1: INTRODUCTION AND RESEARCH APPROACH

Introduction

The Kotzebue Road Dust Study was originally scheduled to be a two year monitoring project, one summer of sampling before paving and one summer after paving. Delays in the paving schedule resulted in the extension of the pre-paving monitoring to a multi-summer project. This report represents the final update on the study and includes the results from all years of the monitoring in Kotzebue. Specific yearly results are located in the Appendices.

Background

Dust levels have increased dramatically over the past twenty to thirty years in rural villages as modern modes of transportation made their way to Bush Alaska. While levels of dust vary from village to village, dust has become a real problem in regional "hub" communities such as Bethel, Nome and Kotzebue. To address an ever increasing dust problem, these communities have come to the State for help. The Department of Environmental Conservation's (DEC) Air Monitoring & Quality Assurance Program (AMQA) was contracted by the State of Alaska Department of Transportation & Public Facilities' (DOT&PF) Research Division in April 2002 to evaluate paving as a control strategy for the reduction of fugitive dust emissions from roads in Kotzebue, Alaska. In June of 2002 DEC installed four particulate monitoring (PM_{10}) sites along Second Avenue to characterize dust concentrations being generated from the unpaved road surface. No elevated levels of particulate matter were documented in 2002, which got off a relatively late start in sampling and resulted in low data capture. As DOT&PF's paving schedule for Second Avenue slipped, DEC was able to further evaluate summer dust levels by sampling each summer through the middle of July 2005 when DOT&PF paved the "test" roadway. In 2006 and 2007, DEC performed two complete summers of post-paving monitoring.

Site Description

Kotzebue, Alaska is located on the northern tip of the Baldwin Peninsula (66.89828° N Lat, 162.59585° W Long) roughly 26 miles above the Arctic Circle. The city is situated on a 3-mile-long silt based spit, which ranges in width from 1,100 to 3,600 feet. An aerial photo of the community is displayed in Figure 1. According to the Alaska Department of Community and Economic Development (DCED) the current population (2005) was recorded at 3,120 residents. The city contains roughly 1000 housing units, which are connected by 26 miles of roadway. The road system, which is mainly gravel/silt mixture, is used by cars, trucks, motorcycles, four wheelers (ATVs), bicycles and pedestrians to transport residents within the community. Four wheelers are also used throughout the day as "recreation vehicles". In the winter snow machines are also used for transportation making their way onto the road surface when it is snow covered. Previous to the start of any DEC monitoring, only Third Avenue had been paved. By the time Second Avenue was actually paved, Fifth Avenue, Ted Stevens Way and several side/cross streets had also been paved.

The Kotzebue roads have been constructed from local silt, western Alaska gravel and sand. During the summer months when streets are dry and the winds are light, vehicle traffic causes the silts and fine sands to become airborne. In addition to vehicle traffic, frequent and prolonged wind events also create coarse particulate loading of the ambient air, and thus affect air quality throughout the community. This airborne dust creates an overall unhealthy environment for residents to live and work in. To address the dust issue, the City of Kotzebue's Road Maintenance Section waters the streets during the summer months. Due to the silty makeup of the road surface and heat from the summer sun, watered streets typically dry out within several hours, providing effective, but limited relief from the dusty episodes. To further improve air quality, the city now applies water several times a day, even to the paved road surfaces which at times are now partially covered with fine dust due to track out. Weather patterns in the region typically result in west to northwesterly flow during the summer months and east to east southeasterly winds during the rest of the year. Mean wind speeds range from nine miles per hour in May to thirteen miles per hour in January. According to Kotzebue Air Weather Service Briefs, extreme gusts have exceeded thirty-four miles per hour every month of the year.

Figure 1: Kotzebue, Alaska – aerial photo looking southwest into the Chukchi Sea

Public Health

Under the authority of the Clean Air Act, the United States Environmental Protection Agency (USEPA) has issued National Ambient Air Quality Standards (NAAQS) for public exposure to safe levels of pollutants suspended in the air. The focus of these standards is the protection of public health and welfare. Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air.

Particles can range in size from large specks of soot to fine grains of dust and have diameters about one-tenth the diameter of a strand of human hair. Fine particles ($PM_{2.5}$) result from the combustion of fuel 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.

The state and federal air quality standards focus on "inhalable" size particulates, which include both fine and coarse particles. 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 with cardiopulmonary disease such as asthma, and children. In addition to health problems, particulate matter is the major cause of reduced visibility in many parts of the United States.

The NAAQS for PM_{10} is 150 $\mu g/sm^3$ for a 24-hour average and 50 $\mu g/sm^3$ averaged over a full calendar year. The annual average standard was rescinded in December 2006 and is not longer applicable. Prior to 2002, no monitoring projects had been performed in any community in the Northwest Arctic Borough to determine if local air quality complied with the National Ambient Air Quality Standard for coarse particulate matter (dust).

Monitoring Plan

To measure the effectiveness of paving as a dust control strategy, the DEC's air monitoring program was contracted to perform ambient air monitoring of coarse particulates (PM_{10}) both before (to establish existing baseline conditions) and after (to evaluate emission reductions) the DOT&PF contractor paved selected sections of Second Avenue (Figure 2). The initial plan called for monitoring at two locations along the road with each site evaluating dust impacts in the up wind and downwind directions. Baseline monitoring was to occur during the summer of 2002 and dust control effectiveness monitoring the following summer. An additional monitoring site, located outside of Kotzebue, was added later to the project to assess background levels of dust. This final project report includes four years of pre-paving assessment, two years of post–paving evaluation and 14 months of background monitoring.

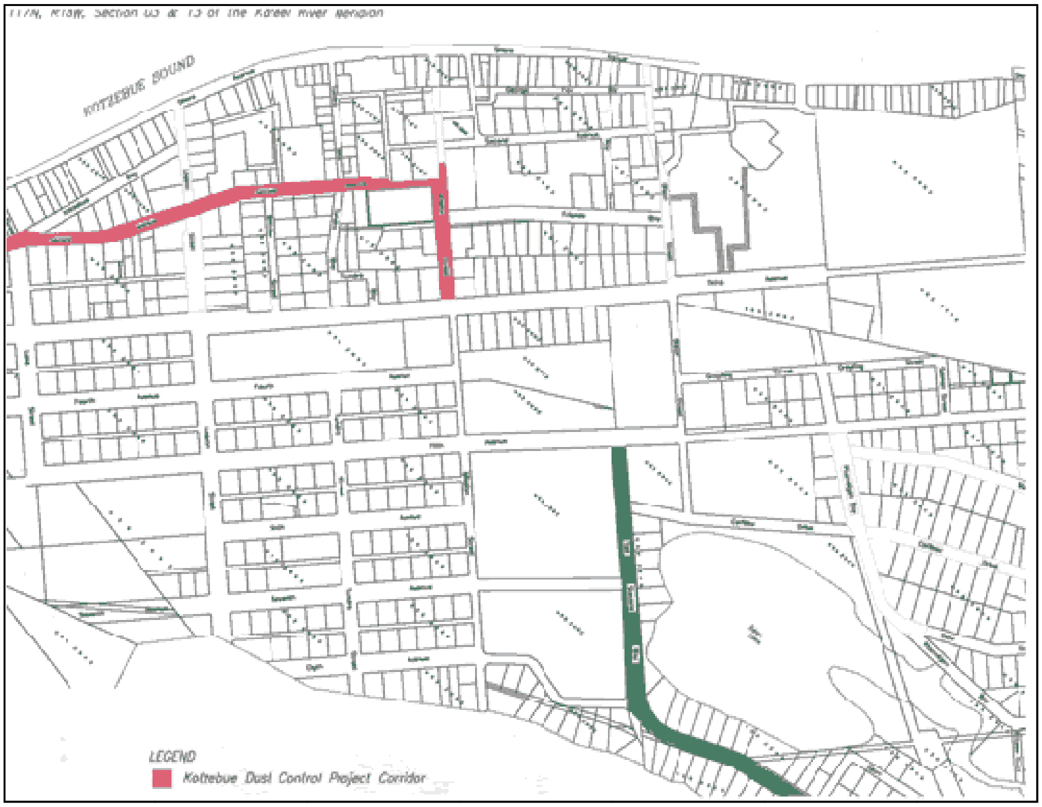

Figure 2: Kotzebue Dust Control Project Map, courtesy of DOT &PF, AK.

Monitoring Equipment

The main tool for evaluating the airborne concentration of dust size particles in the ambient air was the Andersen High-Volume (Hi Vol) PM_{10} sampler, an EPA designated Federal Reference Method monitor (FRM). FRM sampling followed a 1 in 2 monitoring schedule during the summers of 2002 and 2003 which meant that sampling took place every other day. Monitoring was switched to a 1 in 3 day schedule starting with the summer of 2004, resulting in a new sample filter being installed and exposed every third day. The sampler used a mechanical timer to turn it on at midnight 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 vacuum cleaner type motor with the airborne particulate becoming trapped on the filter. Lab analysis of the filter determined mass (weight) gain and subsequent 24 hour mass concentrations. A concentration is calculated in micrograms per standard cubic meter ($\mu g/sm^3$), which indicated the mass of particulates collected per volume of air under standard conditions for temperature and pressure. The advantage of the manual sampler is that they are relatively inexpensive, durable, simple to operate in even the most harsh of environments. The sample filter may be speciated to identify chemical compositions for the collected mass. The disadvantages of this type sampler are they are labor intensive, only run for 24 hours without filter change and results are not available on a real-time basis. An alternative to the manual PM_{10} sampler is the newer, continuous analyzer. This sampler is computer based and therefore more delicate, but can provide hourly information about dust levels in real time. This sampling media cannot be easily speciated.

The Beta Attenuation Monitor (BAM) is one of several continuous analyzers currently on the market and records hourly and daily averaged PM_{10} concentrations calculated from changes in the beta ray attenuation caused by continuous deposition of particulates on a filter strip. EPA recognizes this sampler as a Federal Equivalence Method (FEM) for evaluating the 24-hour levels of dust. The data are stored in an internal data logger and can be remotely downloaded to the DEC computers through a modem line.

The FRM monitor was used as the primary sampling tool during this project because the data it collects are considered to be the most accurate. When used in conjunction with a comparable BAM continuous analyzer, the two data sets could be used to provide a total picture of the dust pollution problem. This is important as the dust issue in Kotzebue is seasonal and can only be assessed when conditions are dry. When it rains or snows the precipitation all but eliminates the problem of road dust.

Monitoring Site Locations

Four monitoring sites were established along Second Avenue to evaluate ambient levels of coarse particulates: 2 sets of paired sites with monitors positioned on opposite sides of the road. These sites were designated as Site 1, 2, 3 and 4, respectively, with the odd numbered sites located on the north side of the road. A fifth site, Site 5, was added to the network at the request of the Maniilaq Association to serve as a training site/ background site. This site was located behind the Park Service bunkhouse on the corner of Mission Street and Fifth Avenue across from the hospital in 2002 and 2003. In 2005, at the request of EPA, monitoring Site 6 was installed in the KIC storage lot located east of Site 2 to determine if the dust problem was localized to the road corridor or being carried into the housing areas. During the 2006 monitoring, Site 2 was relocated 50 yards south of its original location after the paving eliminated the site and a background monitoring site was added to the project and located 1 mile south of town. In 2007, sampling was performed at both Site 1, and the new Site 2 along Second Avenue. Collocated FRMs were installed at Site 1, and a BAM was collocated with the FRM at Site 2. Two new sites were selected in 2007 to look at additional aspects of dust control measures in Kotzebue. Site 7 was located on Third Avenue next to the police station. Site 8 was located in a residential area on Turf Street near the Kotzebue Bible Baptist Church.

All sites were secured within a six foot, fenced enclosure to protect the local children. Site locations and years of operation (excluding Site 8 - located off the map to the right) are shown in Figure 3.

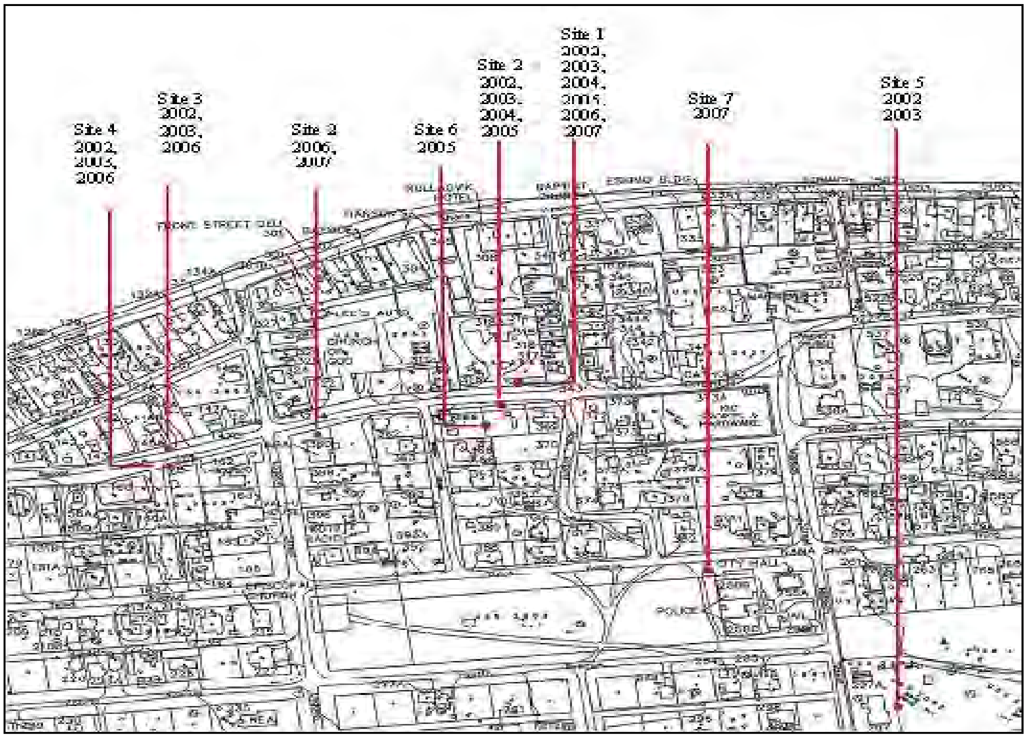

Figure 3: City map of Kotzebue with the locations of Sites 1-7 marked in red.

Site 1: Located outside the AT&T Alascom property line roughly fifteen feet from Second Avenue. This monitoring station was sited on the upwind side of the road and contained a PM_{10} FRM sampler. This site also contained a Met One Beta Attenuation Monitor (BAM) during the 2002 sampling season. Traffic counters were placed across the road at Site 1 during the summers of 2003, 2004, and 2006 to determine how many vehicles were using that section of the road. Unfortunately, DEC discovered that four wheelers do not have enough mass to register on the counters. Visual counts were made by Maniilaq staff in 2003. In 2007 collocated FRMs were installed at this location.

Site 2: Located opposite of Site 1 adjacent to the KIC storage lot approximately five feet from the street. The site contained a PM_{10} FRM sampler in 2002. From 2003 on, the site also included the Met One BAM. In 2004 a second PM_{10} FRM sampler was added for precision analysis. In 2006 Site 2 was relocated one and a half blocks south on Second Avenue in the Wells Fargo Bank parking lot after the paved sidewalk was constructed over the original Site 2 location. The monitor was set up 120 feet north of Lagoon Street, twenty feet from the edge of Second Avenue, and eight and a half feet from the newly paved walkway which now runs along the east side of Second Avenue. This monitoring station contained one PM_{10} FRM and one continuous BAM configured to monitor for PM_{10}. The same site and sampler configuration was used again in 2007.

Site 3: Located a quarter of a mile south of Site 1 on Second Avenue adjacent to building 145A. The monitor was located roughly sixteen feet from the road. This site contained a PM_{10} FRM and provided an evaluation of dust on a less traveled section of the road. Traffic counters set up at Site 3 and used during the summer of 2003, 2004, and

2006 to see if we could determine how many vehicles were using that section of the road. Visual counts were made by Maniilaq staff in 2003.

Site 4: Located a quarter of a mile south of Site 2 on Second Avenue adjacent to building 161. The monitor was located roughly thirteen feet from the road and contained a PM_{10} FRM while providing an evaluation of dust on a less traveled section of the road. Site 3 and 4 were located forty-eight feet apart. Both of these sites were just north of the US Fish & Wildlife Service Office.

Site 5: Established at the request of the Maniilaq Association's environmental coordinator to serve as a training site for his staff and to provide a "city background" dust value. The PM_{10} FRM monitor was installed at a site across from the Kotzebue hospital on National Park Service land. This site also contained two continuous analyzers: a TEOM and a BAM which were lent by the vendors for Maniilaq to test. The state did not receive data from these samplers. This site was operational during the summers of 2002 and 2003.

Site 6: This alternate site was placed inside the KIC storage lot approximately 35 feet east of the initial Site 2 monitor. The additional monitoring was added in 2005 at the request of EPA to see if dust emissions were being transported away from the road corridor and into the adjacent housing area.

Site 7: This 2007 site was located on Third Avenue next to the Kotzebue Police Station about thirty-five feet from 3rd Avenue. Site 7 was selected to examine potential "track-out" of material from unpaved to paved surfaces and its effect on dust control. Third Avenue was paved before 1999 and was constructed with minimal paved shoulders and without a sidewalk. Many unpaved neighborhood streets and drive ways enter onto Third Avenue and dust was visible at times.

Site 8: Located in a residential area along Turf Street at the Kotzebue Bible Baptist Church. Roads in this area of Kotzebue are unpaved. This site was selected based on complaints of dust related issues as well as to identify additional areas that might experience high particulate matter concentrations.

Background Site: A background site was established adjacent to the OTZ Telephone site a mile south of town. The monitor was located on the east side of the site to try to minimize direct impacts from local road dust. The site contained an FRM sampler and a continuous BAM.

Field Sampling

Daily field operations start with the set up of sample filters in the office environment. The site operator carefully removes pre-weighed sample filters from their storage container and places them in the filter cassette. A pre-sampling filter identification number and sampling date are logged on the sample sheets and the filters are covered for transport to the field. In the field, the operator checks and records the sampler flow rate and elapse time to complete the data record for the filter that previously sampled before exchanging the sampled filter with the new filter. Once the new filter is mounted onto the instrument the elapse timer is set to zero and the flow rate re-checked and logged on the log sheets. Exposed filters are taken back to the office where they are stored and the post sample data are logged. Exposed filters are sent to the state's filter weighing lab in Juneau for equilibration and weighing. This process normally takes three – five days or more depending on how often filters are shipped, transport time, and time to equilibrate in the lab. This sampling method is not very effective when trying to provide data for protecting the public on a daily basis, but is when documenting dust problems. Continuous samplers do not require daily filter changes and do provide real-time hourly/24 hour concentrations. These analyzers do not require daily servicing other than to download the data and check for errors. Monthly flow checks are required to validate data.

For the Kotzebue dust monitoring project, DEC elected to conduct the first year of sampling (2002) as a cooperative effort between DEC, the Maniilaq Association and the local community. Working through the science teacher at the high school, two high school students were selected to help with the field monitoring. The day to day operations were managed by Maniilaq Association Environmental staff with project oversight from DEC. Running into more logistical challenges than anticipated, sampling did not get started until late June, but did run through the end of September. The 2003 monitoring effort was also managed by the Maniilaq Environmental staff, with the support of two summer college intern students. Sampling began in early May, aided by an early winter breakup and previously installed power, and ran through late August. The 2004 sampling season started without an operator as staff turnover at Maniilaq caused us to look elsewhere. We were fortunate to find support for the field monitoring at the Kotzebue IRA where Alex Whiting provided us with enthusiastic assistance. Under his leadership and participation we successfully captured the final two years of pre-paving dust monitoring.

CHAPTER 2: MONITORING RESULTS

The Federal Reference Monitor (FRM) data from each monitoring season were compared to the National Ambient Air Quality Standard (NAAQS) 24 hour health-based standard of 150 µg/sm^3 to determine if road dust concentrations in Kotzebue were at levels considered detrimental to human health. During the four years of pre-paving monitoring, 24-hour dust concentrations, from the manual and continuous samplers, ranged from 1 µg/sm^3 to 560 µg/sm^3 with summer sampling averages ranging between 37 µg/sm^3 and 93µg/sm^3. Despite an active watering program, Kotzebue still averaged eleven exceedances per summer along 2nd Avenue prior to paving. During the two years of post-paving monitoring, no exceedances were recorded. The maximum24 hour dust concentrations recorded was 64 µg/sm3, with summer site averages between 13 µg/sm^3 and 38 µg/sm^3.

Supplemental monitoring was conducted during the summers of 2007 and 2008 to assess the potential for high dust levels along remaining unpaved roads. The summer of 2007 was fairly wet and dust levels did not exceed the standard. With a return to a more normal, drier summer, Kotzebue did record six exceedances of the standard during the summer of 2008 with the highest value reported at 398 µg/sm^3.

In 2006 a background site for the sampling project was installed outside of the city to put city dust levels into perspective with regional dust concentrations. The sampling site was operated for 14 months and during this time the highest value collected by the FRM was 33 µg/sm^3. The average 24 hour concentration collected by the BAM in the 14 month period was 6 µg/m^3 with a maximum 24 hour concentration of 42 µg/m^3 in September of 2006. The average value during summer months (Jun-Aug 2006 and Jul – Aug 2007) was 11 µg/m^3. Although it was the intent to establish a true background monitoring site, funding restraints forced the state to locating the site far enough outside the city limits, but still within the proximity to power and road access. Visual observations in addition to the sporadic occurrence of high daily summer values corroborate the influence of vehicle generated road dust even at this site. The results of pre, post supplemental and background monitoring season sampling can be found in the appendices at the end of this report

CHAPTER 3: DATA INTERPRETATION

The state's dust monitoring project confirmed what visual observations suggested; Kotzebue had a dust problem related to its unpaved roads and at times had dust levels which exceeded state and federal air quality standards. By definition, these high dust levels posed a health threat to the portion of the public with higher respiratory sensitivity. A comparison of the pre and post paving monitoring data results collected from sites along Second Avenue during this project found that paving as a control strategy successfully controlled high dust levels in the community. For this study, the road paving resulted in a 64% reduction in dust concentrations on the upwind side of the street and 71% on the downwind side. Dust levels measured in background conditions were never found to reach levels that could be considered problematic. This was likely expected as the site was distanced from the road and traffic and the ground surrounding the sight was covered with vegetation.

Efforts to track and correlate dust levels with vehicle type were not successful as the traffic counters could not identify four wheelers. This data would have been of value as visual surveys concluded that four wheelers raised more dust than the car and truck traffic. The monitoring data did show that monitors on the downwind side of the street had higher particulate loading than the up wind samplers which is what one would expect given the transport of dust in Kotzebue's windy environment. Staff did not develop a correlation between dust levels and traffic volume because the study did not have sufficient detail on site specific wind speed and direction, soil moisture, daily weather and traffic.

Supplemental monitoring conducted in 2007 and 2008 reinforced the need for effective study design and comprehensive analysis when developing an effective dust control plan. Too many environmental and anthropogenic factors may exist to simply assume that dust is not a problem. This decision requires a comprehensive study plan including assessing the impacts of growth. In the case of Kotzebue, a section of town which was not considered to pose a dust threat ended up having a dust problem that may have been overlooked had monitoring not been performed a second year in 2008. The variability in monitoring results between 2007 and 2008 is an example of what can happen if data collection occurs in an atypical meteorological year. It also showed the importance of being able to define the true aerial extent of the pollution problem, developing an effective control strategy and then have the means to implement that plan. While traditional big city knowledge says that if you pave the main streets the problem will go away, dust control in the remote villages may require a lot more planning and understanding of local conditions.

CHAPTER 4: CONCLUSIONS AND SUGGESTED RESEARCH

The Kotzebue Dust Study was undertaken to determine how effective paving would be in reducing airborne dust levels. During the first four years of dust monitoring along Second Avenue, the pre-paving phase (2002-2005), the state documented 31 days with dust levels above the health based coarse particulate standard of 150 $\mu g/sm^3$. These results occurred despite regular watering by the City which applied water to Second Avenue and other local streets as many as three times a day. Characteristic low humidity and constant winds resulted in dried out road surfaces less than an hour after watering. The paving of Second Avenue occurred in July 2005 and post-paving monitoring was conducted in 2006 and 2007. An analysis of the collected data clearly shows that the paving significantly reduced dust levels to well below the health based standard.

While these results indicate that paving can be an effective solution for a road dust problem, a review of other paved and unpaved roads in the community suggest that a final communitywide solution is more complex. Staff observations found that depending on local traffic levels, the amount of paved surfaces, the level of dust track-out, the amount of residual winter sanding material present and natural deposition, the community may have some post-paving dust impacts. The DEC believes that while future dust impacts are a possibility, effective road maintenance including sufficient watering, street sweeping and timely road repairs, is the key to controlling road dust sources so they do not result in future problems. A good example of a success is Third Avenue's Site 7 which is located on Kotzebue's first paved road (1997). The street is watered and swept as part of the summer road maintenance program and in 2007 reported a lower 24 hour maximum concentration than Site 2 on Second Avenue. These results are encouraging in that both these sites are located on the downwind side of their respective streets and in the same general area of town. One unknown is the impact of street gutters like the ones which were installed on Second and Fifth Avenue. These features trap fine materials for later re-entrainment and will require specific attention to make sure accumulated dust does not become a problem. Third Avenue, which was constructed without curbs and gutters, had no dust collecting along the edge of the paved road. While it is not known if/how much this will affects the airborne dust levels, it is a subject for future investigation.

In summary, based on the results of the Department's analysis of dust monitoring data collected before and after the paving of Second Avenue in Kotzebue Alaska, the DEC found that paving dirt roads significantly reduces airborne coarse particulate levels. When coupled with an effective post-paving, sweeping and watering program, the control measures will provide an effective strategy for reducing the health risks posed to the community by airborne dust.

Suggested Research

The Department has conducted additional studies in other villages in the Northwest Arctic Borough which have shown the dust problem to be more widespread than just the regional hub like Kotzebue. For that reason, any additional research/studies into dust control should include the other affected communities. While paving is an effective means to reduce road dust, it is expensive and not necessarily the best solution for all communities in Alaska.

This report represents the final findings of this monitoring study. Recommendations on further research include studying the effects of: increased traffic in Kotzebue, vehicle types, paved-road design on re-entrainment (i.e. curbs and gutter versus flat shoulder) and effectiveness of watering and sweeping programs. This information would be very valuable when considering that roughly two thirds of Kotzebue remains unpaved and much of the unpaved roads are located in residential areas.

APPENDIX A: 2002 MONITORING SEASON

The state initiated the Kotzebue dust monitoring project in June 2002 to examine dust levels along Second Avenue as part of a state road paving project. The field monitoring did not start actual sampling until June 29th due to the logistical challenges associated with conducting ambient monitoring in rural Alaska for example a late winter breakup. During the 2002 sampling (Jun 29 – Aug 25), 103 filters were analyzed including nine complete sets of filters for the five Kotzebue monitors and 14 sets for the four Second Avenue monitors. None of the 24 hour concentrations measured was above the health based standard for coarse particulate matter. Average concentrations over the entire monitoring period ranged from 21 $\mu g/sm^3$ to 50 $\mu g/sm^3$ with the two highest concentrations being 121 and 114 $\mu g/sm^3$ at Sites 2 and 4 respectively. Concentrations over 100 $\mu g/sm^3$ were only observed four times during the sampling and overall, dust levels were much lower than expected given the visible dust production observed during the project set up. Several reasons may exist for these relatively low concentrations. First, June is normally the driest month of the summer and when we would expect to see most of the dust, so a June 29 start up could have missed most of the dry, dusty days. Second, as an oversight, the continuous monitor was installed on the upwind side of the road which meant that the mostly prevailing west to northwesterly winds was carrying the dust to the opposite side of the road. This was evident when looking at which fencing was covered with dust.

Data Capture

The four measurement sites along Second Avenue operated from June 29, 2002 through September 30, 2002. Site 5 located next to the National Park Service warehouse and bunkhouse on Fifth Avenue, started sampling on July 13, 2002 and continued beyond the September 30 project end date at the Maniilaq Association's request. The total possible number of sample filters from all five sites using the every-other-day run schedule was 228 filters. Gaps in the data, attributed to logistical and communication hurdles, as well as insufficient training limit the overall data capture to 103 filters (roughly 45%). The 1-in-2-days schedule was chosen deliberately to overcome some of the challenges of a remote monitoring project and the need to maximize data capture, but might also have contributed to a loss in data. Such a sampling frequency leaves no room for errors, as a filter, that was not retrieved on schedule would run for a second 24 hour sampling period. Thus in effect a double-exposed filter results in two lost samples: first, the filter that ran beyond its 24 hour specification and second, the run day that did not have a fresh filter.

Overall, the quality of the data suggests that the filters retrieved are sufficient to adequately represent the air quality adjacent to Second Avenue during the summer of 2002. This is discussed in more details below.

Site Comparisons

Sites 1 and 3 were located on west side of Second Avenue and Sites 2 and 4 were on the east. The paired sites, 1 & 2 and 3 & 4 were chosen to represent both ends of Second Avenue and were separated by Lagoon Street which ran east-west. Sites 1 and 3 consistently had lower concentrations than those found at Sites 2 and 4. The prevailing wind in the summer is from the W to NW and so these results are not surprising. Sample analysis from Site 1 and 3 indicated that these locations on average had similar concentrations over the summer, though daily variations exist.

Site 5 was selected by the Maniilaq Association and intended to represent the community as a whole. The "average community" particulate matter concentration during the summer fell between the results of the upwind (Sites 1 & 3) and downwind (Sites 2 & 4) sites, mostly displaying low values, but with few elevated exceptions. Table 2 summarizes the monitoring results. The average particulate concentration calculated from all sites over the entire sampling period is 27 µg/sm^3. This value includes "averaged" data from filters with multi-day exposure. While used to determine an average concentration, these doubly exposed filters were not used in the detailed analysis, as it is impossible to verify the daily deposition rates.

Table 1: PM_{10} concentrations (µg/sm^3) during the summer of 2002.

Sample Date	Site 1	Site 2	Site 3	Site 4	Site 5
6/29/2002	25	103	25	113	
7/9/2002	23	73	24	47	
7/11/2002	15	50	8	54	
7/17/2002	27	37	8	13	
7/23/2002	10	13	6	28	14
7/31/2002	31	121	20	114	52
8/2/2002	39	101	15	55	29
8/4/2002	24	51	19	26	49
8/6/2002	21	48	18	38	39
8/10/2002	34	100	21	80	86
8/22/2002	19	46	6	31	17
8/24/2002	90	65	41	29	18
8/26/2002	84	39	52	54	35
8/25/2002		7	20	13	
Average	29	49	21	50	34

An analysis of the data in respect to wind speed and directions did not yield any conclusive results although the data did show that on a given day, one side of the street produced higher levels of particulate loading at each pair of monitors. Overall the daily particulate concentration is a function of many factors including wind direction and wind speed, temperature and precipitation/relative humidity (dryness of the road) and vehicle traffic - both in numbers and in type. A time series of all samples collected is shown in Figure 4.

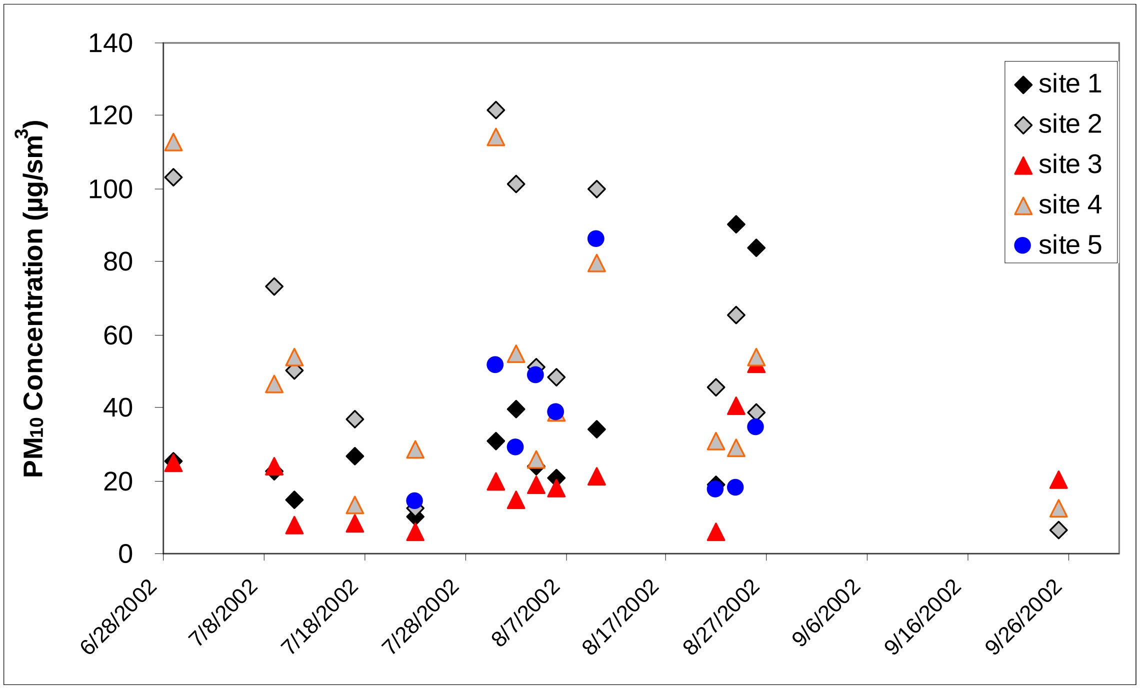

Figure 4: PM_{10} concentration (µg/sm^3) at all five sites in Kotzebue during the summer of 2002.

Filters with multi day exposure

During the summer we can identify five periods where the filters were exposed more than the allowed 25 hours (7/2/02, 7/18/02, 7/26/02, 9/12/02, 9/20/02). Analysis of those periods shows the same pattern as discussed above. Typically the sites on the same side of Second Avenue show similar values, with less variation compared to the difference between paired sites. Site 5 in general shows lower values than Sites 1 - 4. These double-exposed samples were not included in the overall data analysis except in calculating the summer average for Kotzebue's coarse particulate concentration from all sites combined.

Comparison of Measurement Techniques

Two separate measurement techniques were used to determine coarse particulate loading in the ambient air adjacent to Second Avenue at Site 1. A comparison of the continuous BAM sampler and the manual FRM sampler shows that daily averages match up very closely. The values at Site 1 ranged from 2 µg/sm^3 to roughly 100 µg/sm^3. The correlation coefficient (R value) between both data sets 95% and is shown in Figure 5.

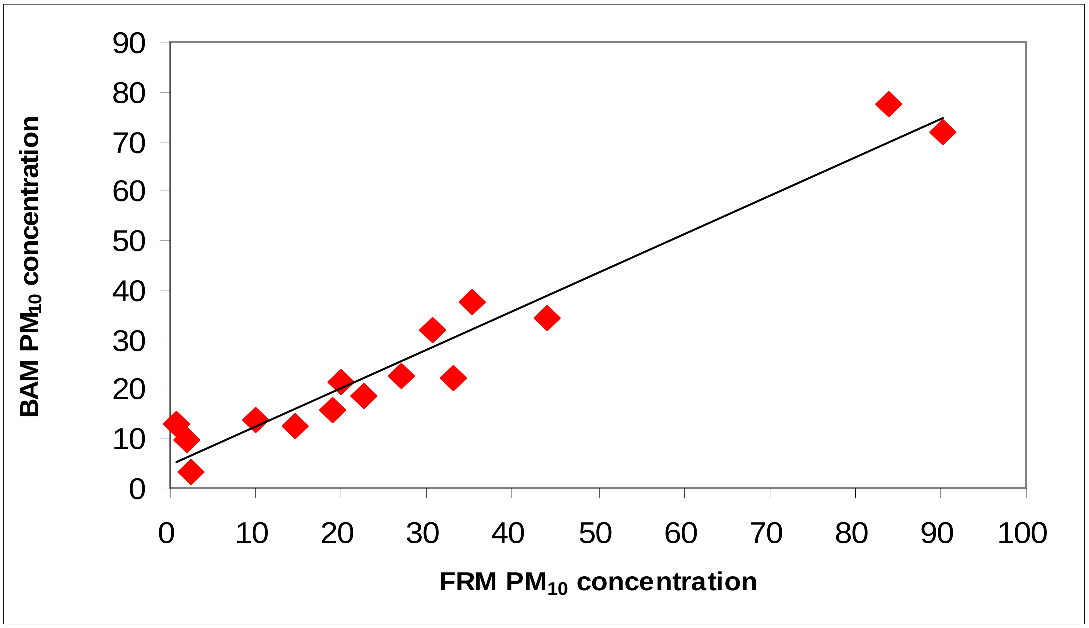

Figure 5: Correlation of PM_{10} concentration (µg/sm^3) as measured with the manual (FRM) and continuous (BAM) analyzers during the summer of 2002.

The continuous monitor provides real-time information and calculates hourly averages providing a better tool for investigating road dust issues. Air quality is often good for long periods of the day, only showing elevated levels of coarse particulates when vehicle traffic is intense or the roads are very dry. The manual sampler can only average PM_{10} concentrations over a 24 hour period and was not designed to provide real-time information. It is, however, the EPA federal reference method monitor and has been used extensively in health affect studies.

Figure 6 shows hourly averaged data for three dust events during the sampling period. Associated with traffic flow patterns and changing road conditions, these different dust episodes were recorded. On August 24th, the coarse particulate concentrations were below 25 µg/sm^3 for most of the previous night and early morning. As the day warmed, concentrations started to rise around noon reaching roughly 260 µg/sm^3 by 3 PM and peaking above 350 µg/sm^3 at 7 PM in the evening. These dusty periods are likely a combination of increased traffic, dryness of the road and wind conditions. Despite the high short-term dust levels in the afternoon, the daily average PM_{10} concentration for August 24, 2002 was measured as 87 µg/sm^3 on the BAM and 90 µg/sm^3 from the manual sampler. While not an exceedance of the coarse particulate standard, these short-term, elevated levels may cause a respiratory sensitive individual to have some level of health impact.

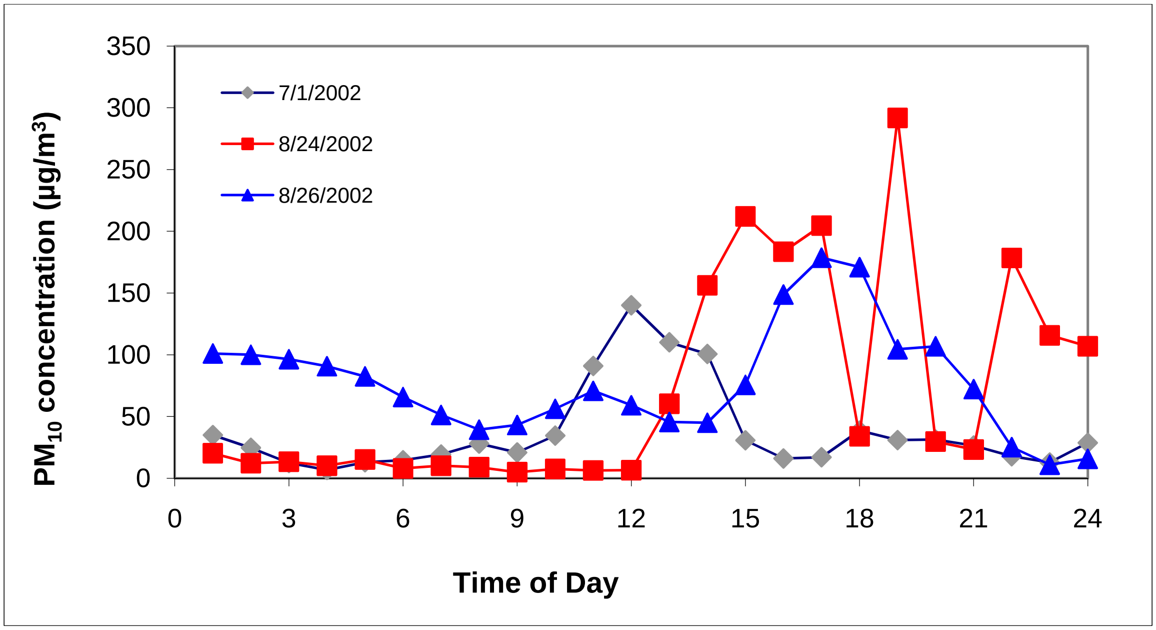

Figure 6: Diurnal particulate concentrations measured with the BAM for 3 days during the summer of 2002.

Traffic counts

During the sampling period DEC installed two traffic counters across Second Avenue, one at Site 1 and a second one near Site 3. Unfortunately, due to a memory error, all data from Site 1 were lost. DOT measured traffic counts at seventeen locations in Kotzebue during a two week period in September 2002. Figure 7 depicts the average diurnal traffic counts measured with these samplers along with data from DEC's Site 3, and three examples of specific DOT traffic counts from three selected locations in Kotzebue for comparison. Interestingly the average traffic counts and the traffic counts at site 3 showed similar patterns.

It is important to note that on gravel roads the traffic counters are only able to count cars and heavier vehicles. All terrain vehicles (ATV) are one of the most prevalent modes of summer transportation in Kotzebue and other rural communities. ATV tires are broad, low pressure tires which distribute the weight of the vehicle helping it travel in off-road environments. This tire design causes the ATV to not generate enough mass to register on the traffic counter. Thus none of the ATVs on Second Avenue were counted in these traffic counts. Once Second Avenue is paved, the DEC will conduct further vehicle counts in anticipation that the ATV will be counted on the harder surface. Care will be taken not to simply compare the vehicle numbers from pre and post paving traffic counts if ATV traffic is recordable in the paved surface.

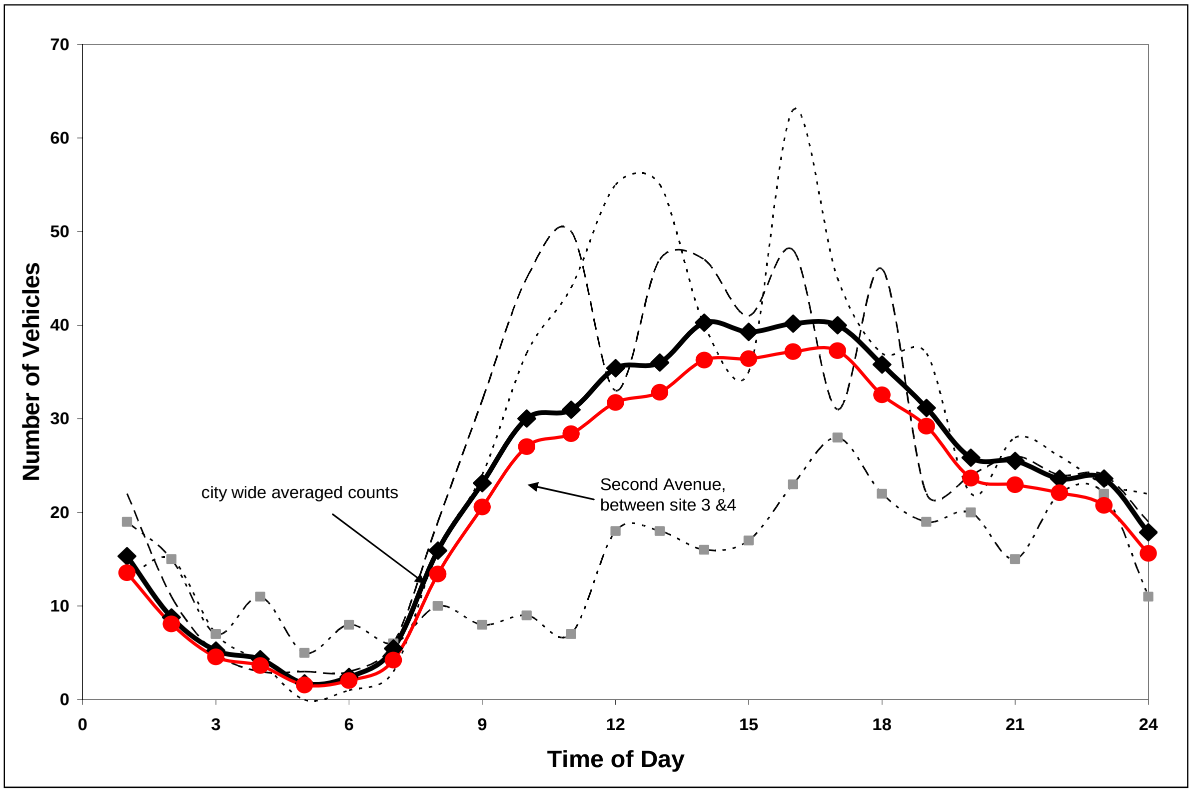

Figure 7: Diurnal Traffic Counts in Kotzebue during the summer of 2002.

Correlation of Traffic Counts to Particulate Concentration

Figure 8 shows the correlation of the average diurnal traffic counts to the averaged diurnal PM_{10} concentration measured at Site 1. In this correlation we have assumed that the traffic pattern at Site 1 (data missing) and Site 3 are similar. With this assumption, we see a clear positive correlation, with increased particulate concentration with increased traffic past the sampling site. At the same time this correlation is not strictly linear indicating the other factors play a role as well. Dryness of the road, precipitation, wind speed and wind direction all affect the particulate concentration at the air samplers.

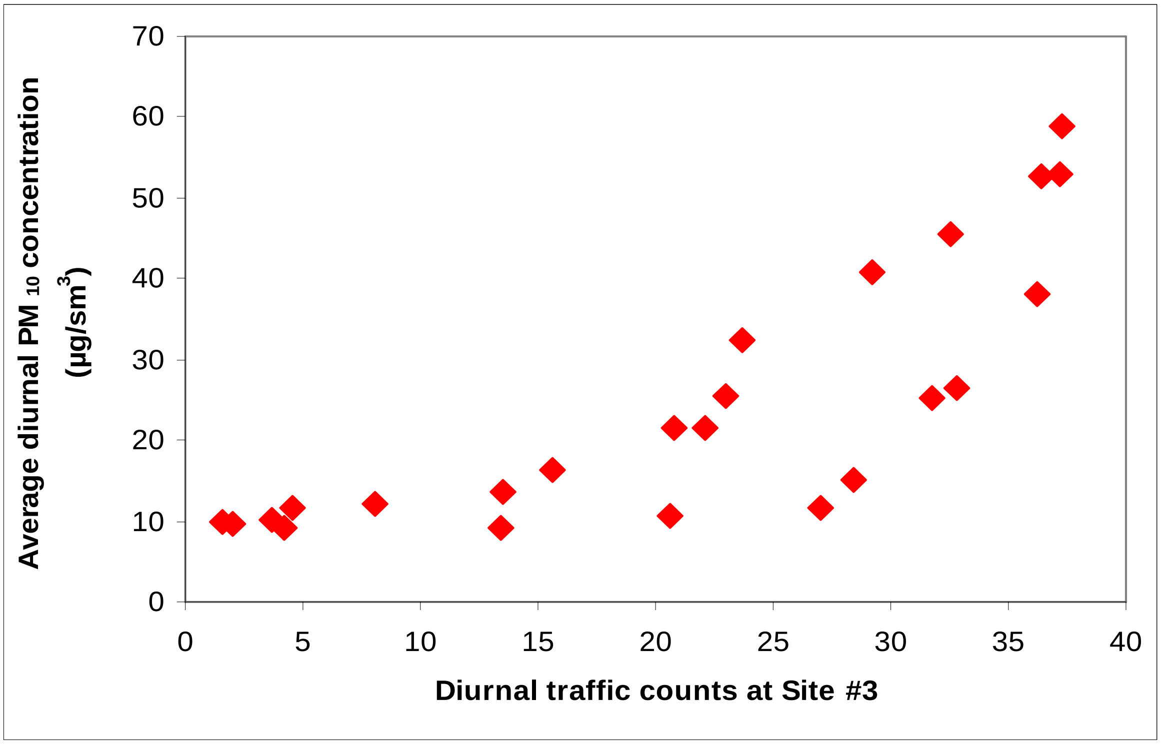

Figure 8: Correlation of the average hourly PM_{10} concentration measured with the BAM at Site 1 to the averaged diurnal traffic counts at Site 3 during the summer of 2002.

APPENDIX B: 2003 MONITORING SEASON

The 2003 monitoring season got an early start when summer came in May. Five monitoring sites were reinstalled in their original locations although the continuous analyzer was moved from Site 1 to Site 2 to better record maximum values. Based on the intent to pave Second Avenue in July, the samplers were only operated from May 31 through July 24. The total possible number of filters from all five sites using a one-in-two sampling schedule (every-other-day monitoring) during the sampling period was 140. Ten data points were missing, i.e. filters either were not returned to DEC for post-weighing, or instrument problems resulted in filter exposure less than the mandatory 23 hours per day and thus the data were eliminated from the dataset. Due to an operator error one sampling day's filters (5 sites) were double-exposed. Thus 125 filters were weighed for analysis. Data capture for the sampling project calculated to 86% if no double runs are counted. If the double runs are included and we assume half if the mass gain occurred on each day the data capture improves to 93%.

The results from the filter measurements along with corresponding road conditions are summarized in Table 3. According to the FRM Hi-Vol PM_{10} samplers, several days were documented with particulate matter concentrations above the national health standard. Due to operator error the filters were not changed after the 6/6/03 sampling run, thus the filters were exposed again on 6/8/03, following a one-in-two schedule (i.e. sampling every other day). Because it is impossible to determine the daily concentration deposited on these double-exposed filters, we assumed half of the filter weight occurred on each day. This is the reason why the values for 6/6/03 and 6/8/03 are recorded as identical in Table 3. This interpretation resulted in two exceedances of the standard at Site #2. Comparison with the continuous analyzers suggests that the time period between 6/5/03 and 6/9/03 was very dusty, with the BAM data for 6/6/03 showing PM_{10} levels almost four times the national standard (see Table 4). If on the other hand, we assume most of the exposure occurred on the first sample day alone, and assuming the second day only contributed minimally to the measured concentration, we also see two exceedances, one at Sites 2 and 4.

Table 2: PM_{10} concentrations ($\mu g/sm^3$) during the summer of 2003.

Sample Date	Site 1	Site 2	Site 3	Site 4	Site 5	Road Condition
5/31/2003	24.5	***204.4***	11.1	119.7	21.1	
6/2/2003	78.6	137.3	19.4	72.8		
6/4/2003	58.4	33.8	19.4	28.1	20.3	
6/6/2003	(63.4)	***185.5***	(96.6)	(131.3)	(30.2)	
6/8/2003						
6/10/2003	9.0	43.9	7.4	13.6	14.9	rain, road wet
6/12/2003	33.6	58.1	19.3	41.0		rain 6/11, road damp
6/14/2003	8.7	32.8	4.7	17.5		misty, road damp
6/16/2003	60.7	23.9		41.0		
6/18/2003	***188.4***	144.5	129.2	125.6	***220.2***	road watered at 15:30 and 17:30
6/20/2003	54.2	94.5	23.9	59.6	23.8	road watered on 6/19
6/22/2003	15.2		14.4	61.4	16.0	
6/24/2003	28.5	64.8	17.1	52.6	24.8	
6/26/2003	24.8	44.9		36.0	25.5	road watered 6/25 and 6/26
6/28/2003	38.7	40.9	59.2	60.7	31.0	road watered
6/30/2003	19.8	9.4	13.8	8.6	13.5	rain, roads wet
7/2/2003		40.3	4.1	5.6	18.7	road damp
7/4/2003	5.0	6.2	5.2	4.5	11.9	rain
7/6/2003	5.2	8.4	6.3	4.9	8.1	road watered
7/8/2003	8.8	49.0	9.1	17.8	14.1	
7/10/2003	3.6	7.4	3.4	3.9	5.4	rain
7/12/2003	4.9	22.9	4.3	5.4	7.8	
7/14/2003	5.6	51.7	6.8	30.2	24.6	rain, road wet
7/16/2003		***190.0***	21.2	109.8	29.2	road wet
7/18/2003	10.8	29.0	12.1	23.5	16.5	road watered
7/20/2003	25.8	27.3	36.0	31.7	21.5	road damp
7/22/2003		9.8	12.7	11.2	7.9	
7/24/2003	4.6	5.6	1.0	5.8	11.1	
Average	33.8	64.9	25.2	44.8	27.0	
Average						
(without double runs)	**31.2**	**55.2**	**19.2**	**38.2**	**26.7**	

The concentrations in large, bold, italic font indicate the dust levels exceeding the national health standard for coarse particulate matter. The numbers in parentheses indicate the double exposed filter data, which were calculated assuming even distribution of the concentration for both sampling days.

The average PM_{10} concentration was calculated with and without inclusion of the double exposed filters. The average particle concentrations for the sampling period ranged from 25µg/sm^3 at site 3 to 64.9 µg/sm^3 at Site 2. Figure 9 shows the time series of the PM_{10} concentrations at all five Kotzebue sites.

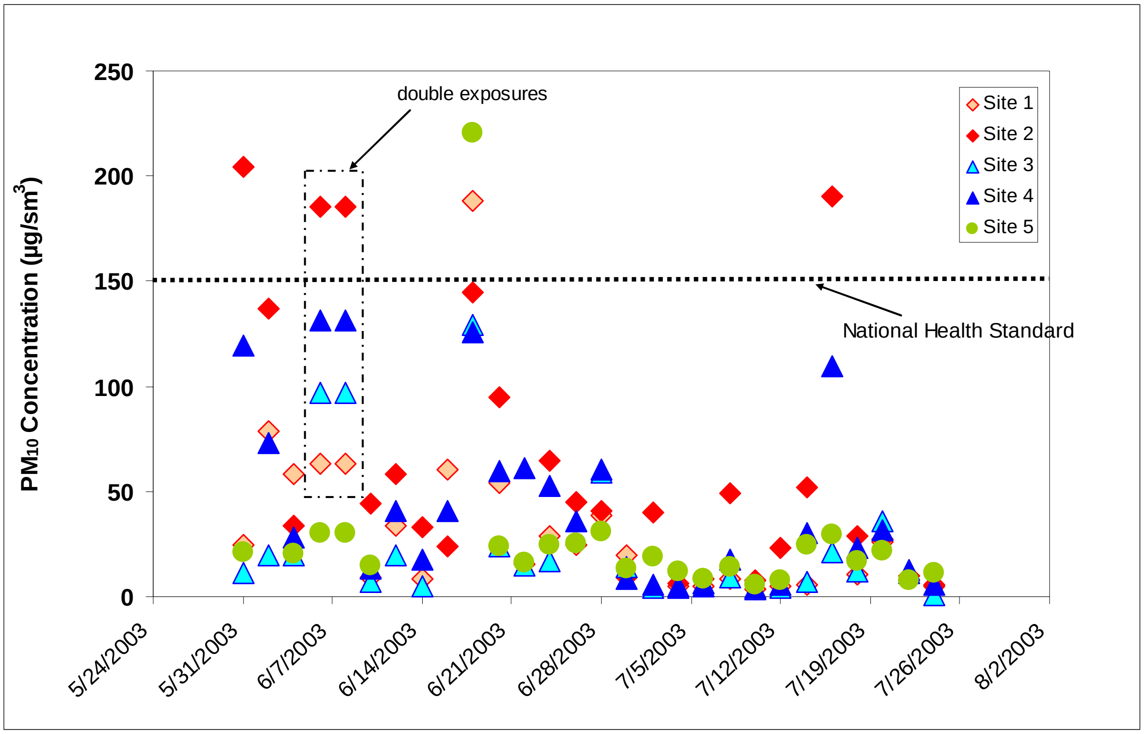

Figure 9: PM_{10} concentration (µg/sm^3) at all five sites in Kotzebue during the summer of 2003.

On rainy days like July 10th, the concentrations dropped well below the 10 µg/sm^3 level for 24 hours. On average the particulate matter concentrations on days with rain was between 13 and 30 µg/sm^3 for Site 1 and 2, respectively. Note that no information about the amount of rain fall is available. Also no information on the dampness of the road or duration of the moist road conditions was included. So even though rain occurred during a sampling day, dry conditions prior to the rain resulted in PM_{10} deposition on the filter which could reach levels of up to 58.1 µg/sm^3 (Site 2, 6/12/03).

The Kotzebue City Works directed watering of the gravel roads during dry periods. Comparing the PM_{10} levels on days when it rained to days when roads were documented to have been watered show that the watering of the roads is only partially successful. Although it might help to reduce the dust for parts of the day, data show that during especially dry periods the roads dry out fast and dust levels rise. A good example is June 18th. Even though the roads were watered at least twice, once at 3:30 PM and once at 5:30 PM, the dust levels exceeded the NAAQS at Site 1 and Site 5 and show levels within 80% of the health standard at all other sites.

During instrument setup the continuous Beta Attenuation Monitor (BAM) was moved from Site 1 across the street to Site 2 at the end of April, to better capture windblown fugitive road dust. Data collection on the BAM started on May 1, but due to instrument problems only the data from May 29, 2003 on were included in this report. Maniilaq Association operated Sites 1 and 5 during the 2002/2003 winter season, so those sites did not need to be re-installed. Sites 3 and 4 were set-up again in May.

Site Comparisons

Sites 1 and 3 were on the same side of Second Avenue, as were Sites 2 and 4. The paired Sites 1 & 2 and 3 & 4 were separated by Lagoon Street, which is a main artery in Kotzebue's traffic pattern. Results from Site 1 and 3 indicate these locations consistently had lower concentrations than Sites 2 and 4. The prevailing wind in the summer is from the W to NW and so these results are not surprising. Sample analysis from Site 1 and 3 indicated that these locations on average had similar concentrations over the summer, though daily variations exist.

Site 5 was selected to represent the community as a whole. The average particulate concentration during the summer lies between the results of the upwind Sites 1 & 3 and downwind Sites 2 & 4, with overall low values with few elevated exceptions. The average particulate concentration calculated from all sites over the entire sampling period is 27 $\mu g/sm^3$. This value includes data from filters with multi-day exposure, which showed lower concentrations than shown in the table below. These doubly exposed filters were not used for the detailed analysis, as it is impossible to verify if the concentration was evenly deposited on both run days, or what the daily fraction was. This does not affect the calculation of an overall average.

An analysis of the data in respect to wind speed and directions did not yield any conclusive results. Overall the daily particulate concentration is a function of many factors including wind direction and wind speed, the temperature and precipitation, i.e. dryness of the road, passing vehicle traffic, both in numbers and in type.

Comparison of Measurement Techniques

Two separate measurement techniques were used to determine coarse particulate loading in the ambient air adjacent to Second Avenue at Site 2. A comparison of the continuous sampler (BAM) and the manual sampler shows that daily averages match up very closely. The values at Site 2 range from 5 $\mu g/m^3$ to roughly 190 $\mu g/m^3$. The correlation of both data sets is shown in Figure 10. The correlation coefficient (R value) is 95%.

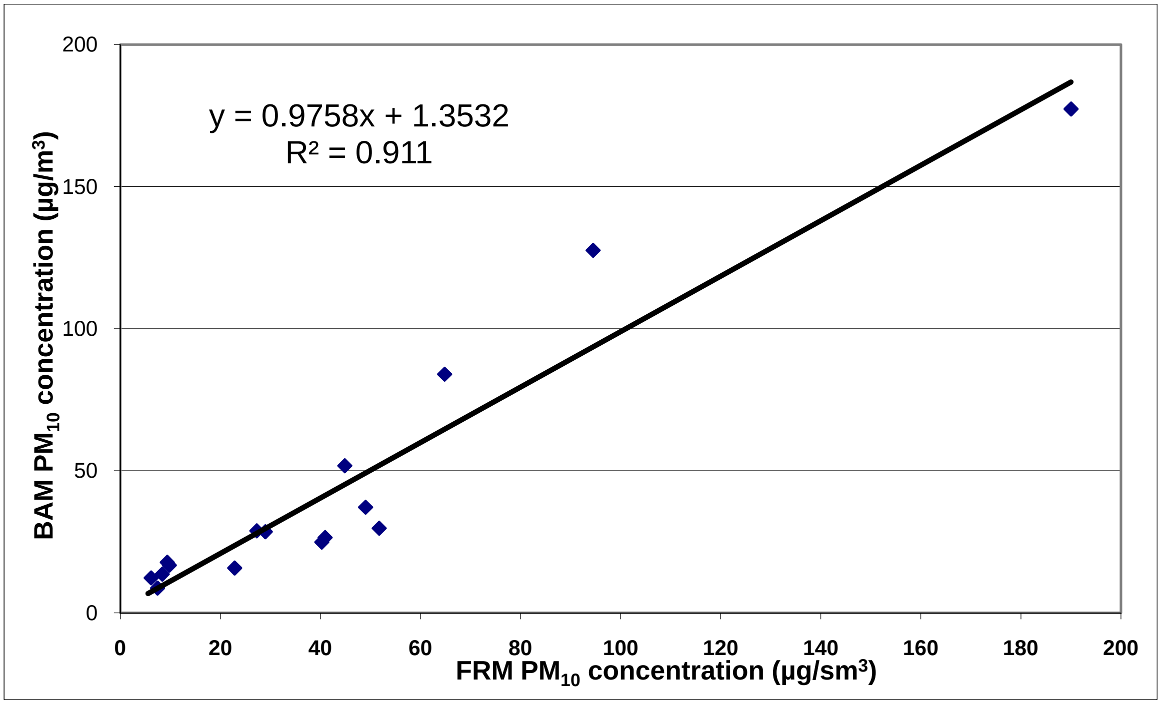

Figure 10: Correlation of PM_{10} concentration (µg/m^3) as measured with the manual (FRM) and continuous (BAM) analyzers during the summer of 2003.

The continuous monitor calculates hourly averages and is probably a better tool for investigating road dust issues. The air quality might be good for long periods of the day and only shows elevated levels of coarse particulates when vehicle traffic is intense or the roads are very dry. The manual sampler averages PM_{10} concentrations over a 24 hour period and is typically used whenever health effects are under investigation (EPA federal reference method). It should be noted that this correlation is only for comparing 24-hr averages, and that the continuous PM_{10} methods are only FEM equivalent when reporting as a 24-hr average.

Beta Attenuation Monitor Data

The BAM was moved to Site 2 after the 2002 sampling period confirmed the prevailing wind direction to be from the west and northwest during spring and summer. Continuous data were available from 5/1/03 to 7/24/03. During a site visit on May 21st DEC staff discovered instrument problems, which were later identified as a memory board failure of the data logger. Maniilaq Association agreed to lend us their BAM, located at Site 5, which was moved to Site 2 on May 28th. Any data before May 29 are unreliable due to the uncertainty caused by the data logger malfunction and was excluded from this report. After repair, the DEC BAM was re-installed at Site 2, and the Maniilaq Association BAM was returned to Site 5. The results are summarized in Table 3.

Table 3: PM_{10} concentrations ($\mu g/sm^3$) at Site 2 using the BAM during the summer of 2003.

DATE	Concentration ($\mu g/sm^3$)	DATE	Concentration ($\mu g/sm^3$)	DATE	Concentration ($\mu g/sm^3$)
5/29/2003	**387.55**	6/16/2003	no data	7/5/2003	24.34
5/30/2003	**348.48**	6/17/2003	no data	7/6/2003	13.62
5/31/2003	**163.86**	6/19/2003	91.42	7/7/2003	31.33
6/1/2003	64.48	6/20/2003	127.55	7/8/2003	37.17
6/2/2003	**202.63**	6/21/2003	no data	7/9/2003	20.51
6/3/2003	16.69	6/22/2003	no data	7/10/2003	8.70
6/4/2003	21.79	6/23/2003	no data	7/11/2003	104.28
6/5/2003	**380.94**	6/24/2003	83.98	7/12/2003	15.77
6/6/2003	**560.04**	6/25/2003	90.58	7/13/2003	no data
6/7/2003	**291.72**	6/26/2003	51.77	7/14/2003	29.77
6/8/2003	**261.48**	6/27/2003	51.71	7/15/2003	16.94
6/9/2003	**180.30**	6/28/2003	26.49	7/16/2003	**177.31**
6/10/2003	48.00	6/29/2003	no data	7/17/2003	10.17
6/11/2003	49.12	6/30/2003	17.78	7/18/2003	28.55
6/12/2003	68.01	7/1/2003	16.74	7/19/2003	30.16
6/13/2003	55.86	7/2/2003	24.86	7/20/2003	28.86
6/14/2003	36.31	7/3/2003	14.09	7/21/2003	37.54
6/15/2003	39.19	7/4/2003	12.29	7/22/2003	16.75

The data marked in large red and bold font show exceedances of the national PM_{10} health standard. Underlined concentrations indicate data from Maniilaq Associations BAM, which was moved to Site 2 while the DEC BAM was being repaired.

The PM_{10} concentrations recorded by the BAM on days when the NAAQS was exceeded ranged from 164 $\mu g/sm^3$ to 560 $\mu g/sm^3$. The average concentration for those days was 295 $\mu g/sm^3$, which is almost twice the national standard. The average concentration measured by the BAM during the entire sampling period was 94 $\mu g/sm^3$.

It should be noted that the values reported by the BAM might be skewed. The BAM has an upper cut-off limit at 1000 $\mu g/sm^3$ for the 5 minute averages. If the particulate loading exceeds this limit, the instrument advances the filter tape to a clean section of the tape. During the time the tape is repositioned, the instrument does measure PM_{10} levels. This can lead to averaging errors. Only recently DEC discovered significant problems with the operation of the Met One BAMs, especially in connection with averaging daily concentrations if errors occurred during the averaging period. DEC is in the process of evaluating these issues. In the meantime the BAM data are considered a good indicator for air quality trends. Decisions on how to interpret the concentration data will be made on a case by case review.

Data Quality

The Kotzebue Road Dust Study was setup as a cooperative project between DEC and the Maniilaq Association. The Maniilaq Environmental Program staff was responsible for operation and routine maintenance of the monitors in Kotzebue in exchange for training opportunities and use of the collected data. DEC staff was responsible for independent audits, troubleshooting and repairs and assisting with technical expertise and supplies. The Quality Assurance Project Plan (QAPP) spelled out all the necessary steps to ensure quality data.

Similar to the 2002 sampling season miscommunications and logistical problems lead to gaps in the quality assurance prescribed in the QAPP. The 2003 monitoring QAPP specified monthly flow checks for each monitor throughout the sampling season and two independent audits per sampling year. Due to scheduling issues none of the required audits were performed. Quality control (QC) flow checks for the month of July, which were scheduled for the Maniilaq Association Environmental Program staff, were never performed. DEC did not discover the missing QC checks until after the project ended. Final QC checks were performed on instruments at Site 3 and 4 in September before de-installation. Maniilaq Association requested to continue monitoring at Site1 and 2 during the winter season. DEC agreed not to de-install these sites.

The instruments were calibrated by DEC staff and subsequently flow-checked with different reference devices by Maniilaq staff. Instrument flow rates were within the required set points, which indicate that the accuracy of the instruments should be within the desired range. We still consider the data valid, even though it does not meet the stringent requirements set by our QAPP, which is based on the EPA SLAMS/NAMS data requirements.

To further affirm data validity, we correlated the continuous data with the manual sampler data. The correlation coefficient R2 = 0.91 (intercept = 0.9758, slope = 1.3532) indicates acceptable comparability between methods for the data from 6/16 to 7/23 as defined by EPA for showing comparability between manual and continuous PM monitors ($0.90 \geq R^2 \leq 1.00$).

Traffic counts

DEC installed two traffic counters across Second Avenue, one between Site 1 and 2 and a second one between Site 3 and 4. The traffic counter at Site 2 operated from 5/22 through the end of the sampling period, the counter at Site 4 operated from 5/27 though 7/14, when the road grater ripped the tubing. Figure 11 shows the daily counts at both locations. Site 1 and 2 see much more traffic than Site 3 and Site 4. The average counts at Sites 2 and 4 were 964 and 271 vehicles per day, respectively. The maximum number of vehicles counted in one day was 1433 at Site 2. The upper graph in Figure 11 shows a distinctive weekly pattern for the daily counts at Site 2. Traffic volume is fairly steady throughout the workweek and then drops significantly during the weekends. The lowest vehicle counts typically occurred on Sundays. Site 2 is close to a well used intersection in Kotzebue, which obviously is used frequently during business days.

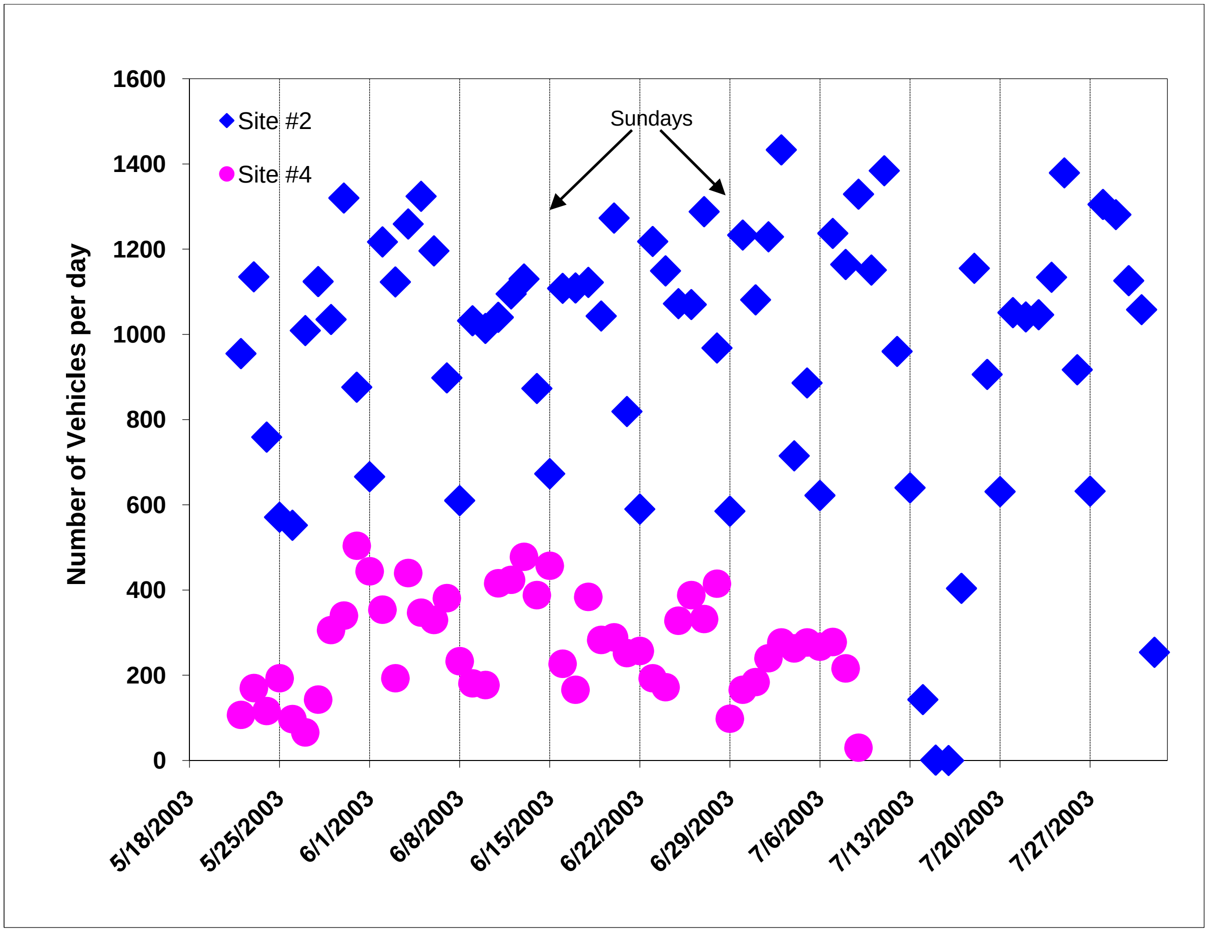

Figure 11: Daily traffic counts during the summer of 2003. The blue diamonds represent data from Sites 1 and 2. The pink dots represent data from Sites 3 and 4. Vertical gridlines intersect Sunday values.

It is important to note that on gravel roads the traffic counters may not consistently count regular cars and heavier vehicles. All terrain vehicles (ATV) are a prevalent mode of transportation in the summer. The tires on the ATV are broad and distribute the weight of the vehicle. Due to this wider distribution of the vehicle's weight and the soft road surface, ATVs typically do not generate a sufficient impulse on the counter tube to register the vehicle. It is unclear how many of the ATVs on Second Avenue were counted in these traffic counts. Once Second Avenue is paved the ATV will be counted on the harder surface and care has to be taken not to simply compare the vehicle numbers from pre and post paving traffic counts.

Maniilaq staff performed vehicle counts several times during the sampling periods. These counts provide a first estimate of the vehicle to ATV distribution on Second Avenue. During six separate timeframes, at different times of the days Maniilaq staff observed vehicle traffic along Second Avenue for one hour. The average ratio of ATVs to total number of vehicles observed was 20%, with a range of 10% to 44%.

Figure 12 shows the average vehicle count per hour of the day. The diurnal pattern is similar at both sites, with traffic starting to increase in the morning and peaking in the late afternoon and early evening. As Site 2 sees more traffic, the diurnal pattern is more pronounced than at Site 4. The average hourly traffic counts at Sites 2 and 4 were 40 and 11 vehicles, respectively.

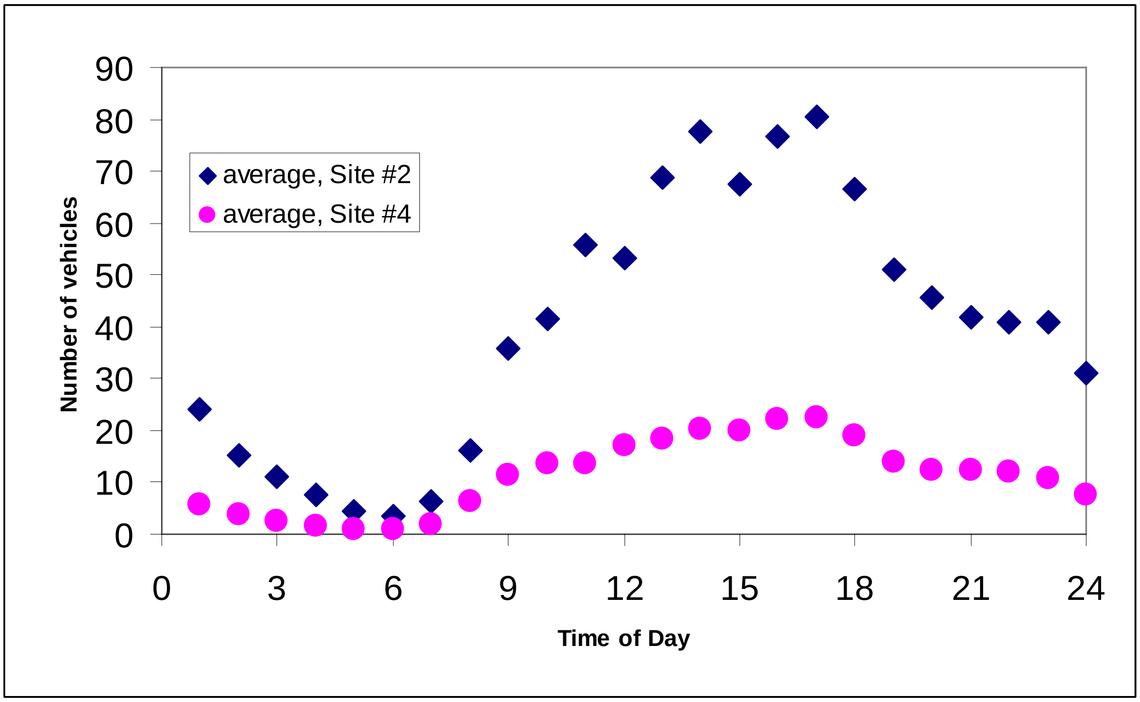

Figure 12: Averaged diurnal traffic counts in Kotzebue, summer 2003. The blue diamonds represent data from Sites 1 and 2. The pink dots represent data from Sites 3 and 4.

Correlation of Traffic Counts to Particulate Concentration

Figure 13 shows the correlation of the averaged daily PM_{10} concentration measured at Site 2 to the average daily traffic counts measured at Site 2. As expected we see a clear positive correlation, showing increased particulate concentration with increased traffic past the sampling site. Even so, the correlation paints a complicated picture as there is no simple relationship between traffic and fugitive dust. Factors influencing the correlation are amongst others, dryness of the road, precipitation, wind speed and wind direction, tire profile, vehicle speed and many more.

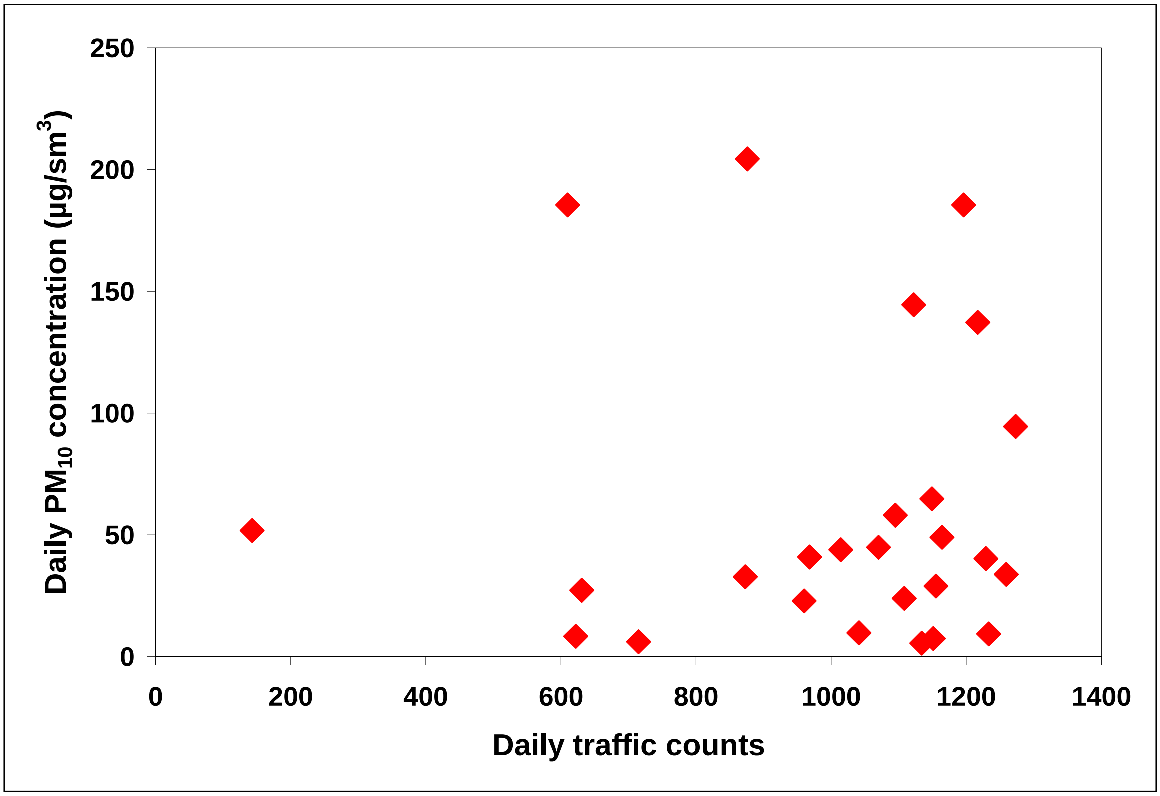

Figure 13: Correlation of the average daily PM_{10} measured with the FRM to the averaged diurnal traffic counts at Site 2 during the summer of 2003.

APPENDIX C: 2004 MONITORING SEASON

Filter Sampling

The 2004 sampling season started on May 26 and continued through July 20. During the 2004 sampling season, the Federal Reference Monitors (FRM) were only operated at two sites, Site 1 and 2. The network reduction was based on previous year monitoring results which showed this part of Second Avenue experienced the highest dust concentrations. An additional FRM sampler was position at Site 2 to capture precision information. The sites continued to operate on an every-other-day sampling schedule collecting filters on 28 days during that summer. The maximum number of exposed primary filters (excludes precision samples) was 56 and of those, 50 filters were returned to the Department for analysis. In addition, 25 precision filters were also collected during the sampling period.

From the first successful sample run on May 26, 2004 through the end of sampling on July 20, 2004, the FRM samplers recorded ten exceedances of the National Ambient Air Quality Standard. An additional three days of exceedances were recorded by the continuous monitor BAM on days when the FRM monitor was not scheduled. The average concentration for the monitoring season at Site 1 was 60 $\mu g/sm^3$ and 131 $\mu g/sm^3$ at Site 2. These results may be slightly skewed because of the high dust levels which occurred on the days when exceedances were recorded. A better description of the overall dust problem during the eight week sampling period may be the median concentration which showed Site 1 at 25 $\mu g/sm^3$ and Site 2 at 109 $\mu g/sm^3$. A summary of the data for Sites 1 and 2, including the collocated and continuous samplers is displayed in Table 4.

Table 4: PM_{10} concentrations (μg/sm^3), during the summer of 2004

Run Date 2004	Site 1 PM_{10} (ug/sm^3)	Site 2 PM_{10} (ug/sm^3)	Site 2 collocated PM_{10} (ug/sm^3)	Site 2 BAM (ug/sm^3)
5/26/2004	2			16
5/29/2004	18	118	126	152
5/31/2004	20	44	52	60
6/02/2004	6			65
6/04/2004	17		66	78
6/06/2004	19	44	38	48
6/08/2004	33	37	48	44
6/10/2004	15	16	14	18
6/12/2004	9	16	23	28
6/14/2004	50	**232**	**231**	**319**
6/16/2004	32	79	105	81
6/18/2004	**170**	**210**	**229**	**243**
6/20/2004	46	**202**	**191**	**224**
6/22/2004	**175**	129	127	125
6/24/2004	**198**		34	21
6/26/2004	148	**326**	**323**	**371**
6/28/2004	53	**180**	**231**	**185**
6/30/2004	**268**	**351**	**263**	**341**
7/02/2004	80	107	93	113
7/04/2004	16			24
7/06/2004	16	19	17	22
7/08/2004	9	50	25	27
7/10/2004	49	35	38	
7/12/2004		**331**	**285**	
7/14/2004	15	**185**	**178**	
7/16/2004	104	124	116	
7/18/2004	23	68	66	
7/20/2004	25	109	103	
average	60	131	121	118
median	25	109	103	72

The large red bolded concentrations indicate exceedances of the 24-hour health standard of 150 μg/sm^3. The BAM data displayed here documents only the concentrations measured on the FRM sampling schedule days.

The 2004 PM_{10} exceedances ranged from 170 µg/sm^3 to 351 µg/sm^3, with an average concentration of 239 µg/sm^3. This is more than 1.5 times the health based standard of 150 µg/sm^3. Of the ten exceedances, one might be partially attributable to smoke from wild land fires burning in northern Interior Alaska that summer. Smoke particulates, which are typically smaller in diameter than dust particles, are normally regulated under the fine particulate standard ($PM_{2.5}$) which was set at 65 µg/sm^3 for a 24 hour period. Because wild land fires fall under the heading of "natural events", exceedances caused by them may be waiver able due to their uncontrollable nature. On June 30th all four samplers registered an exceedance of the PM_{10} standard and the odor of smoke was evident. The National Weather Service weather data showed smoke intrusion and decreasing visibility starting late in the afternoon of June 30th and continuing through July 2nd. Figure 14 shows the time series of the all measurements performed along Second Avenue in 2004. It is important to note that the ten exceedances occurred despite the City of Kotzebue's strong road maintenance project which waters gravel roads at least twice a day during the dry periods.

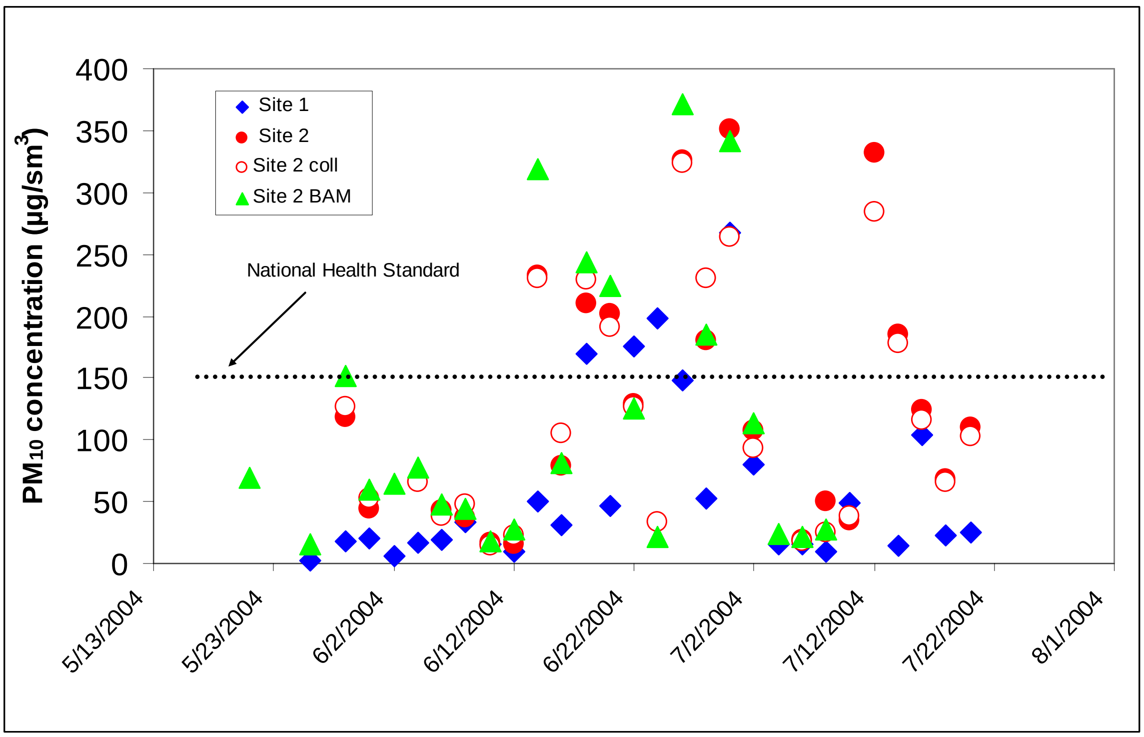

Figure 14: PM_{10} measurements (µg/sm^3) along Second Avenue during the summer of 2004.

Precision Data and Data Quality

In 2004 a precision monitor was collocated with (placed next to) the FRM monitor at Site 2. The collocated sampler was intended to assess the quality of data collected by the primary FRM sampler. In addition, adding a collocated sampler to a monitoring site can provide valuable information about potential sources of error such as problems with filter handling and site operation. The collocated monitor sampled 27 times during the project period. Two samples were lost due to power outages at both samplers. On two other sampling days, a comparison was impossible because of a power outage which affected the main sampler. In 2004 all quality control checks were performed according to the QAPP.

The primary and collocated FRM samplers at Site 2 showed a strong correlation during the 2004 sampling season. Figure 15 compares the data and shows the correlation between the two samplers at Site 2 to be 94 % (R^2 value)

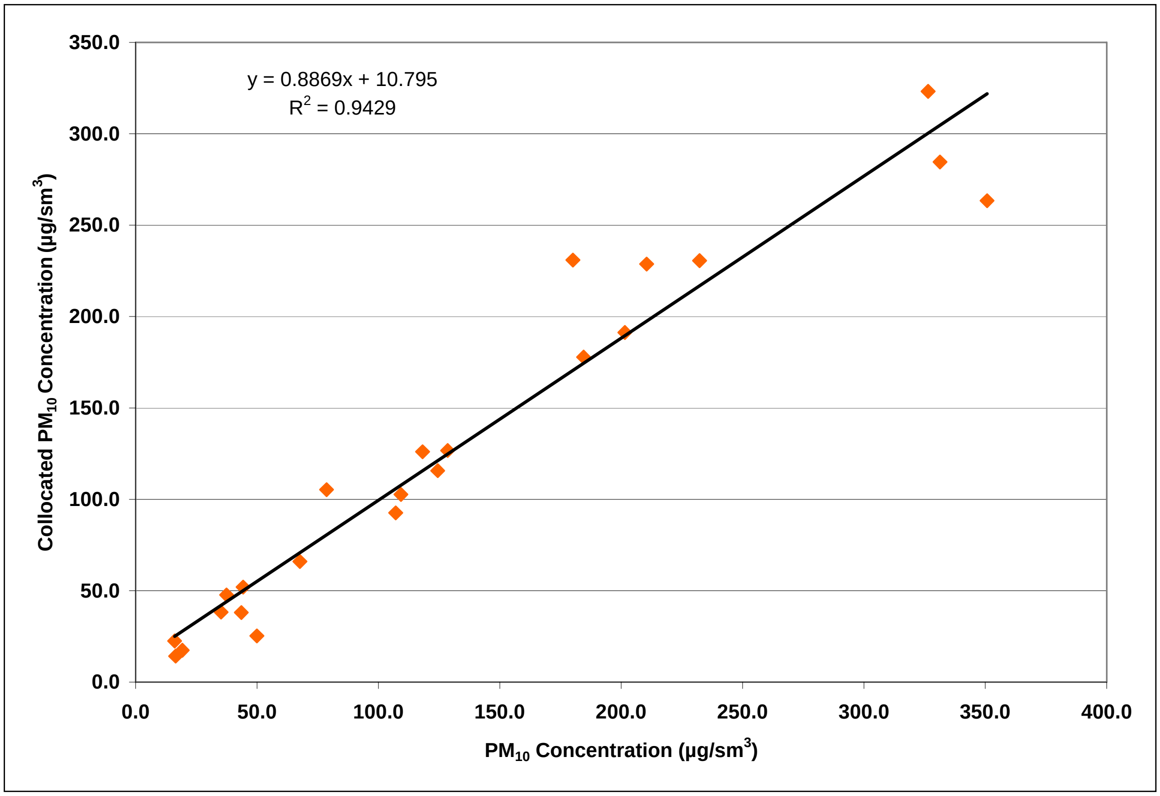

Figure 15: Precision comparison for the FRM PM_{10} monitors at Site 2, summer 2004.

Beta Attenuation Monitor Data

The Met One Beta Attenuation Monitor (BAM) operated from May 20, 2004 to July 8, 2004, when it was shut due to instrument problems. During this time period the continuous monitor recorded ten exceedances of the PM_{10} health standard. Six of these exceedances coincide with the filter measurements discussed above. One exceedance occurred on May 29 and showed slightly higher levels compared to the FRM samplers at the same site. The measured concentration was 152 µg/sm^3, which is barely above the standard and by definition rounds off to 150 µg/sm^3 and is not considered an exceedance. (Note: BAM units may read slightly higher than FRM units at higher dust concentrations.) The remaining three exceedances occurred on days not covered by the manual sampler run schedule. A summary of the BAM data can be viewed in Table 5.

The average and median concentrations measured by the BAM during the eight week period May 20 through July 8, 2004 was 93 µg/sm^3 and 60 µg/sm^3, respectively.

During the sampling period National Weather Service data was downloaded to correlate dust levels with wind speed and direction. The wind information was gathered from the Kotzebue Airport and represents the area wide wind pattern, but may not specifically characterize specific winds at the sites. A comparison found that the highest dust concentrations occurred during periods when the winds originated from the West (southwest to northwest). Elevated dust concentrations also showed good correlation with light to medium wind speeds (3 mph and 12 mph). At higher wind speed the dust levels tended to drop off significantly.

Table 5: PM_{10} concentrations (µg/m^3) at Site 2 using the BAM during the summer of 2004.

Run Date	Site #2 BAM (ug/m^3)	Run Date	Site #2 BAM (ug/m^3)	Run Date	Site #2 BAM (ug/m^3)
5/20/2004	14	6/6/2004	48	6/23/2004	25
5/21/2004	69	6/7/2004	**156**	6/24/2004	21
5/22/2004	6	6/8/2004	44	6/25/2004	104
5/23/2004	7	6/9/2004	35	6/26/2004	**371**
5/24/2004	2	6/10/2004	18	6/27/2004	**268**
5/25/2004	23	6/11/2004	79	6/28/2004	**185**
5/26/2004	16	6/12/2004	28	6/29/2004	132
5/27/2004	27	6/13/2004	87	6/30/2004	**341**
5/28/2004	38	6/14/2004	**319**	7/1/2004	138
5/29/2004	**152**	6/15/2004	**350**	7/2/2004	113
5/30/2004	57	6/16/2004	81	7/3/2004	59
5/31/2004	60	6/17/2004	45	7/4/2004	24
6/1/2004	14	6/18/2004	**243**	7/5/2004	10
6/2/2004	65	6/19/2004	120	7/6/2004	22
6/3/2004	64	6/20/2004	**224**	7/7/2004	11
6/4/2004	78	6/21/2004	64	7/8/2004	27
6/5/2004	54	6/22/2004	125		

The large red bolded values indicate concentrations above the 24-hour health standard of 150 µg/sm^3.

A comparison of data from the continuous BAM monitor and the FRM sampler at Site 2 showed good agreement. The correlation of both data sets is shown in Figure 16. The correlation coefficient (R^2) is 96%.

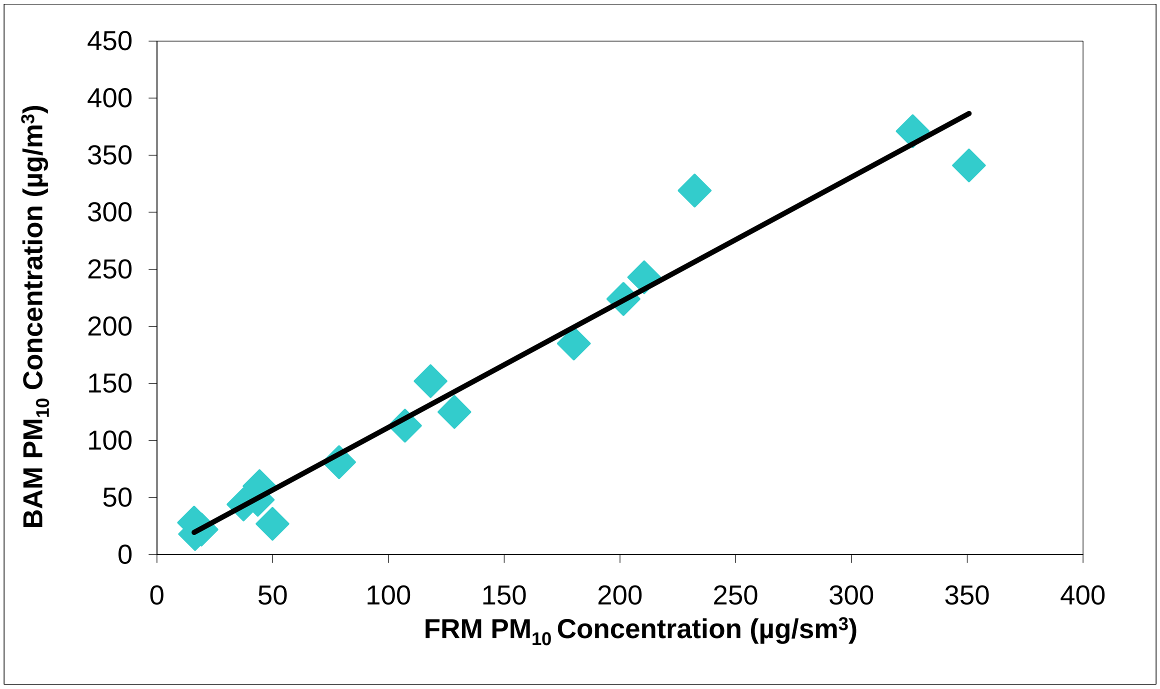

Figure 16: Correlation of PM_{10} concentration as measured with the manual and continuous analyzer, summer 2004.

APPENDIX D: 2005 MONITORING SEASON

Filter-based Sampling

In 2005, sampling was performed at three sites; the project's two main sites, Site 1 and 2 and a new, third site, Site 6, which was located east of Site 2 about 60 feet from the road. Filter-based sampling at the primary sites, using Federal Reference Monitors (FRM), started on May 21 and continued through July 16. The actual sampler calibrations took place on May 19th. The additional site was established on May 26 at the recommendation of EPA to investigate how far dust was being transported away from the street and into the community. Site 6 was calibrated on May 25th and first sampled on May 28th. Monitoring continued as normal until the state's paving contractor started grading Second Avenue in preparation for road surfacing which forced the closure of Site 2 on July 1st. The Site 2 BAM was moved inside the KIC storage lot (other side of the fence) when Site 2 should down and continued to operate until July 19th. All three monitoring sites were operated on a one-in-three schedule, which means a sample day every 3 days. When factoring in the different start up and shutdown dates, the total number of possible samples for all three sites was 50, of which 45 filters were considered valid resulting in a data capture was 90%.

The FRM samplers recorded two days of exceedances of the National Ambient Air Quality Standard (NAAQS) during the short sampling period. The Met One BAM which was set up again at Site 2, recorded eight days of exceedances, seven of which occurred on days when the FRM monitor was not scheduled to operate. The average concentration for the monitoring season was 36 $\mu g/sm^3$ at Site 1 and 114 $\mu g/sm^3$ at Site 2. Site 2 experienced a power failure on a day with high dust levels. Even though the sampler only ran for about 8 hours, the mass gained qualifies that concentration as an exceedance. The average concentration measured at Site 6 was 57 $\mu g/sm^3$. A summary of the data for all sites is displayed in Table 6.

Data quality issues

The 2005 monitoring started up with a normal installation although the desired start-up audit was not performed due to the short sampling period and staffing. During the shut-down audit in July it was discovered that the calibrator which was used to set up the sites had a slight bias which resulted in both samplers failing their flow accuracy checks and raising questions about data accuracy. A further investigation into the setup and audit process identified that both instruments did, however, meet the requirements for design flow which are intended to ensure only PM_{10} sized particles are captured on the filter. For this project, this meant that even though the samplers failed to meet the accuracy criteria, the sample mass being collected was still considered PM_{10} size particulate. Per EPA guidance, data that meet the design criteria but fail the accuracy criteria can be corrected for the flow discrepancies and flagged. The 2005 data was corrected by using the audit flow readings to calculate PM_{10} concentrations. Because of the data accuracy issues, the DEC decided to only use the 2005 PM_{10} data in qualitative comparisons with previous (and future) year monitoring to determine if previous dust trends still existed.

The department found that the filter data results combined with the results from the continuous monitor support the trend in dust levels seen in previous years of monitoring.

Note: While the accuracy of the 2005 data can be questioned, the trend in dust levels is accurate. From personal observation and operator comments, it was dusty on the days when high dust levels were reported and the downwind side of the road did record the higher impacts as would be expected. Despite these findings **flagged data has accuracy issues and should not be used to make attainment/non-attainment** decisions.

Table 6: PM_{10} concentrations (μg/sm^3), during the summer of 2005.

Date	Site 1 PM_{10} concentration [ug/sm^3]	Site 2 PM_{10} concentration [ug/sm^3]	Site 6 PM_{10} concentration [ug/sm^3]
5/21/2005	9	89	
5/24/2005	86	297	Site installed 5/25/05
5/28/2005	9	16	9
5/31/2005	5	44	39
6/3/2005	17	16	11
6/6/2005	15	83	80
6/9/2005	5	6	8
6/12/2005	10	24	35
6/15/2005	15	58	47
6/18/2005	257	656*	225
6/21/2005	10		
6/24/2005	38	69	63
6/27/2005	21	95	105
6/30/2005	23	32	49
7/3/2005	101		123
7/6/2005	15	site removed 7/5/05	34
7/9/2005	5		7
7/12/2005	10		11
7/16/2005	7		10
average	36	114	57

The red bolded concentrations indicate exceedances of the 24-hour health standard, which is set at 150 μg/sm^3. Underlined numbers indicate concentrations affected by power outages. The value marked with a * is the result of an eight hour run time which may or may not represent the actual 24 hour value.

FRM Monitoring Data

High PM_{10} values were reported by the FRM Samplers on two days during the summer and ranged from 225 μg/sm^3 to 297 μg/sm^3 (one and a half to two times the health based standard). All three samplers exceeded the standard on June 18th when a power failure at Site 2 limited that run to eight hours, an event which normally invalidates the sample. In this case, the mass gained during this short run was so high that the EPA data validation protocols require states to consider them "valid", making this run an exceedance of the standard. The concentration for the 8 hour period was listed at 656 μg/sm^3. When putting these high values in perspective given that the sampling did not pass the accuracy audit, the state found that data accuracy was sufficient to say that the days with elevated PM_{10} values were real exceedance of the standard.

On June 18th when all three samplers recorded exceedances of the standard, the wind was out of the east for most of the day and helped to re-entraining dust on both sides of the road. Elevated dust levels continued to be recorded despite the City of Kotzebue's regular watering of gravel roads at least twice a day during the dry periods. Low humidity, long summer days and constant winds help dry out watered road surfaces within an hour or two of application. Figure 17 shows the time series of daily measurements performed along Second Avenue during the 2005 sampling.

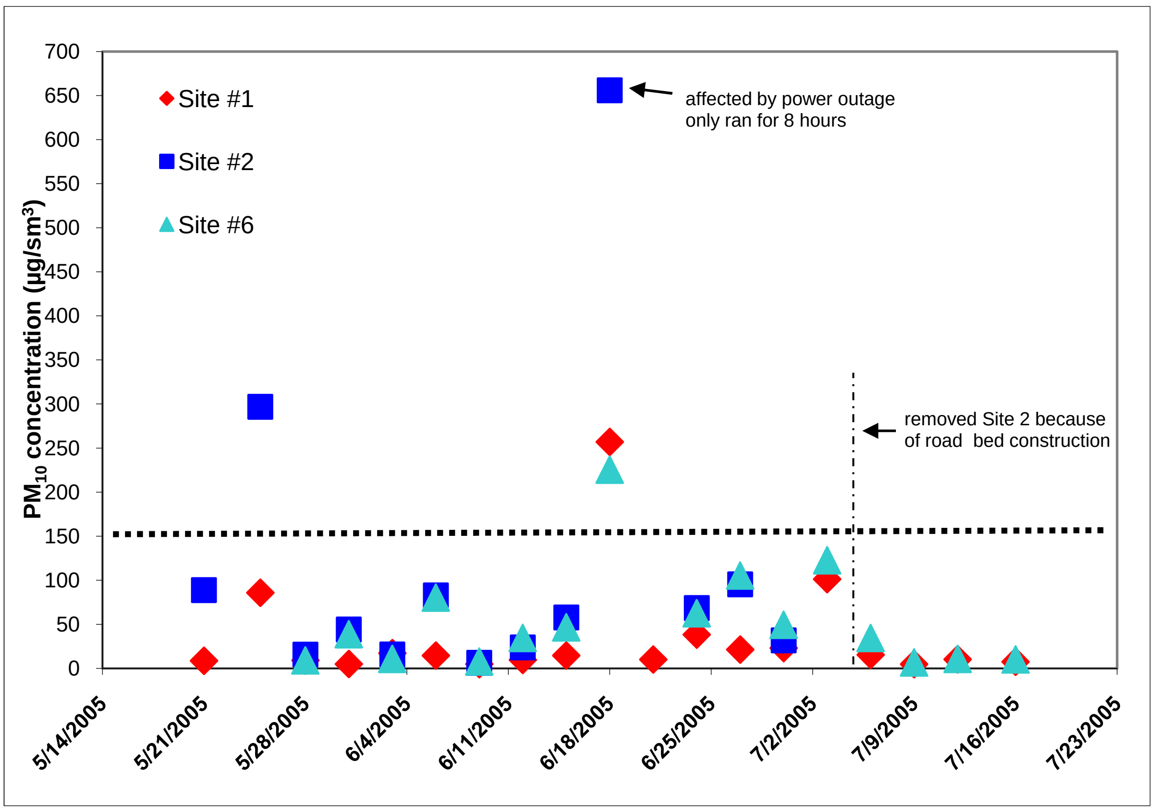

Figure 17: PM_{10} measurements (μg/sm^3) along Second Avenue during the summer of 2005.

Beta Attenuation Monitor Data

The Met One Beta Attenuation Monitor (BAM) operated from May 15, 2005 to July 19, 2005. During this time period the continuous monitor recorded eight days with exceedances of the PM_{10} health standard with one of these exceedances coinciding with manual filter measurements discussed above.

The average concentration for the nine week period between May 15 and July 19, 2005 was 67 µg/sm³. Values measured by the BAM ranged from 2 to 282 µg/sm³. Average Daily BAM values are displayed in Table 7.

Table 7: PM_{10} concentrations (µg/m³) at Site 2 using the BAM during the summer of 2005.

Run Date	Site 2 BAM (ug/m³)	Run Date	Site 2 BAM (ug/m³)	Run Date	Site 2 BAM (ug/m³)
5/20/2005	**175**	6/10/2005	58	7/1/2005	
5/21/2005	105	6/11/2005	35	7/2/2005	70
5/22/2005	31	6/12/2005	21	7/3/2005	**195**
5/23/2005	**196**	6/13/2005	20	7/4/2005	**282**
5/24/2005	**246**	6/14/2005	54	7/5/2005	64
5/25/2005	19	6/15/2005	53	7/6/2005	36
5/26/2005		6/16/2005	**178**	7/7/2005	26
5/27/2005	71	6/17/2005	**160**	7/8/2005	23
5/28/2005	9	6/18/2005	120	7/9/2005	
5/29/2005	17	6/19/2005		7/10/2005	
5/30/2005	3	6/20/2005		7/11/2005	
5/31/2005	44	6/21/2005		7/12/2005	11
6/1/2005	106	6/22/2005		7/13/2005	15
6/2/2005	**231**	6/23/2005	9	7/14/2005	10
6/3/2005	11	6/24/2005	9	7/15/2005	17
6/4/2005	120	6/25/2005		7/16/2005	20
6/5/2005	83	6/26/2005		7/17/2005	12
6/6/2005	84	6/27/2005		7/18/2005	10
6/7/2005	28	6/28/2005		7/19/2005	15
6/8/2005	4	6/29/2005	55		
6/9/2005	1	6/30/2005	41		

The red bolded concentrations indicate exceedances of the 24-hour health standard, which is set at 150 µg/m³.

A correlation data collected by the BAM continuous monitor and the FRM sampler at Site 2 showed good agreement and had a correlation coefficient (R^2) of 98%. This correlation is shown in Figure 18.

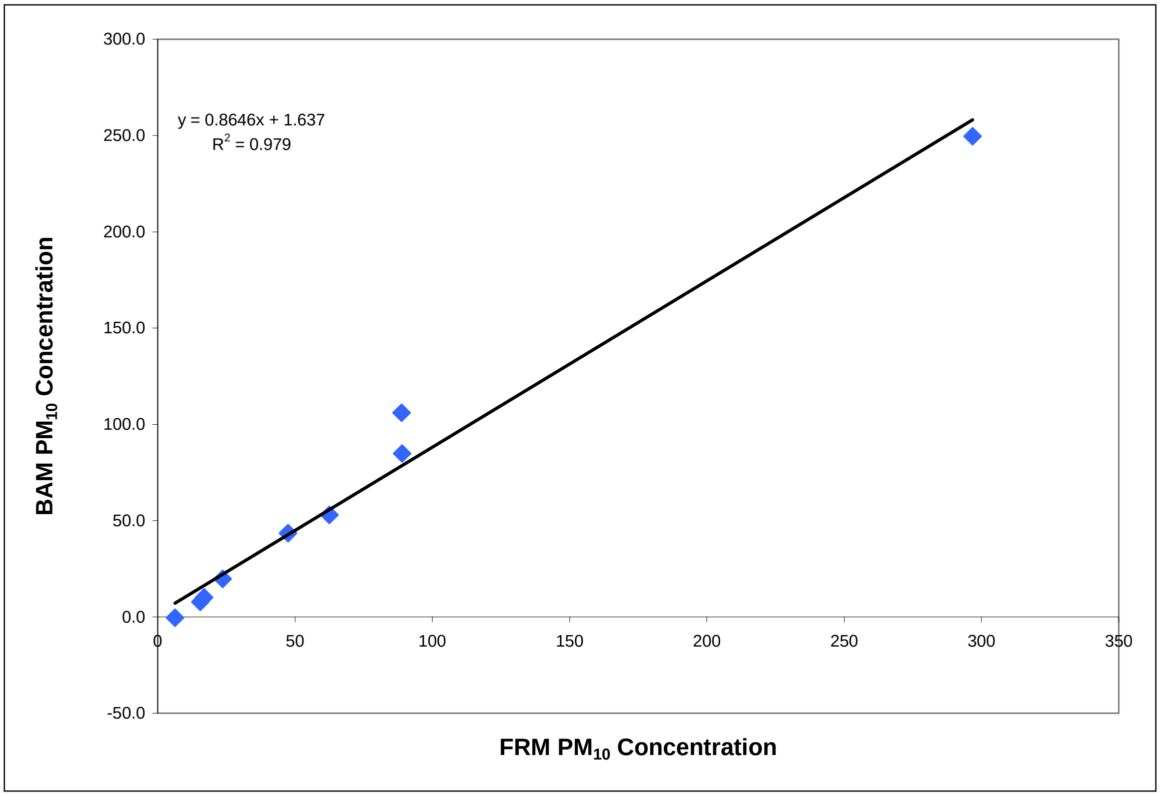

Figure 18: Correlation of PM_{10} concentration ($\mu g/sm^3$) as measured with the manual and continuous analyzer, summer 2005.

APPENDIX E: 2006 MONITORING SEASON

Quality Asphalt Paving began paving Second Avenue in July 2005. The paving formalized the placement of the road and added a sidewalk along the south side of the street. The 2006 sampling season started in early June after the snow had melted and the road surfaces had dried out. Overall, the summer of 2006 was wetter and cooler than the previous four summers. During the sampling period, no exceedances of the state and federal PM_{10} standard were recorded.

In 2006, sampling was performed at four sites along Second Avenue. Three sites were used in previous years (Site 1, 3 and 4) and Site 2 was relocated one and a half blocks west from its previous location. Setup of Site 2 was delayed until a new site could be located and access approved. The original intent was to move Site 2 just east of its original location inside the KIC storage lot, but KIC decided to develop the lot and   Site 2 was re-located further down the street. Filter sampling with FRMs began on June 4 and continued through August 18.

Filter Measurement

All four sites were operated on a one-in-three schedule, which means a sample day every 3rd day. The total number of possible samples days for all sites was 93, out of which 89 filters are collected and considered valid.   Overall data capture was 96% with the individual capture rates ranging from 88% (Site 1) to 100% (Site 4).

Sites 1, 3 and 4 were calibrated on June 1. Sampler 1 began sampling on June 4 and Samplers 3 and 4 began sampling on June 7. Site 2 was calibrated on June 28 and sampling began on July 1. The average concentrations for the monitoring season were between 13 $\mu g/sm^3$ (Site 3) and, 22 $\mu g/sm^3$ at Site 2 with the highest twenty-four hour value of 56 $\mu g/sm^3$ measured at site 1. The highest value for all of the samplers (manual and continuous) was recorded on July 7, 2006. A summary of the manual and continuous sampler data are displayed in Table 8 and 9 respectively. Figure 19 shows a time series of the measurements performed along Second Avenue.

Table 8: PM_{10} concentrations (μg/sm^3), during the summer of 2006.

Run Date	Site #1	Site #2	Site #3	Site #4
6/4/2006	9			
6/7/2006	10		3	25
6/10/2006	25		23	19
6/13/2006	18		15	24
6/16/2006	21		21	26
6/19/2006			15	1
6/22/2006			25	28
6/25/2006	15		14	20
6/28/2006	8		6	5
7/1/2006	5	5	5	5
7/4/2006	22	26	15	19
7/7/2006	56	46	32	38
7/10/2006	18	32	7	19
7/13/2006	4	37	2	17
7/16/2006	9	8	9	8
7/19/2006	39	36	31	19
7/22/2006	15	27	13	22
7/25/2006		28	15	25
7/28/2006	20	9	18	19
7/31/2006	4	26	3	17
8/3/2006	5	15	6	
8/6/2006	11	7	7	7
8/9/2006	12	5	11	10
8/12/2006	2	11	2	8
8/15/2006	8	26	5	12
8/18/2006	29	31	15	27
Average	16	22	13	17
High	56	46	32	38
% Capture	88	100	100	96

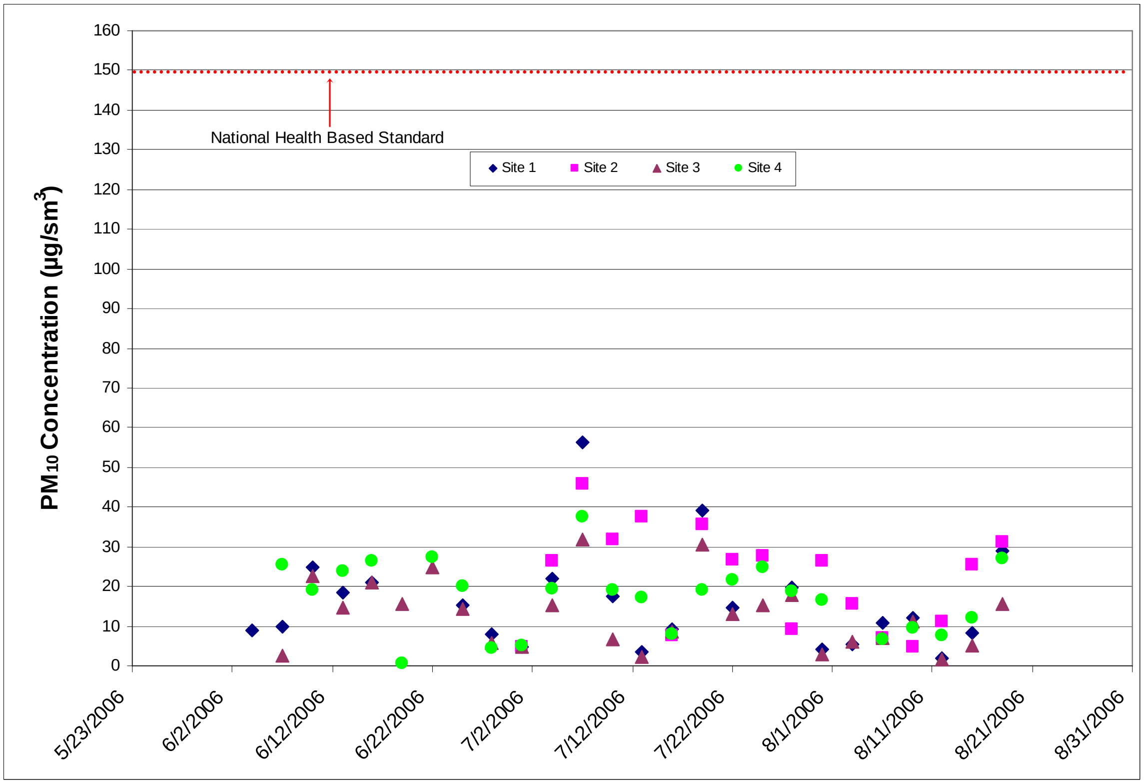

Figure 19: PM_{10} measurements (µg/sm^3) along Second Avenue during the summer of 2006.

Beta Attenuation Monitor Data

The Met One Beta Attenuation Monitor (BAM) operated from June 30, 2006 to August 24, 2006. During this time period no exceedances of the PM_{10} health standard were recorded by the continuous monitor. Several daily averages were invalidated because less than 23 hours of valid data were collected. A summary of the BAM data can be viewed in Table 9. The average concentration measured by the BAM for the eight week period between June 30 and August 24, 2006 was 23 µg/m^3.

Table 9: PM_{10} concentrations ($\mu g/m^3$) at Site 2 using the BAM during the summer of 2006.

Run Date	BAM (ug/m^3)	Run Date	BAM (ug/m^3)	Run Date	BAM (ug/m^3)
6/30/2006	51	7/19/2006		8/7/2006	11
7/1/2006	6	7/20/2006		8/8/2006	30
7/2/2006	5	7/21/2006		8/9/2006	6
7/3/2006	50	7/22/2006	30	8/10/2006	12
7/4/2006	33	7/23/2006	27	8/11/2006	20
7/5/2006	53	7/24/2006	38	8/12/2006	
7/6/2006	43	7/25/2006	32	8/13/2006	10
7/7/2006	50	7/26/2006	25	8/14/2006	24
7/8/2006	16	7/27/2006	21	8/15/2006	24
7/9/2006	24	7/28/2006	9	8/16/2006	20
7/10/2006	33	7/29/2006	2	8/17/2006	23
7/11/2006	25	7/30/2006	6	8/18/2006	38
7/12/2006	8	7/31/2006	28	8/19/2006	
7/13/2006	39	8/1/2006	30	8/20/2006	15
7/14/2006	39	8/2/2006	27	8/21/2006	11
7/15/2006	14	8/3/2006	18	8/22/2006	5
7/16/2006	8	8/4/2006	36	8/23/2006	26
7/17/2006	10	8/5/2006	11	8/24/2006	
7/18/2006	9	8/6/2006	8		

A correlation between the continuous monitor and the FRM sampler at Site 2 showed good agreement. The correlation of the data sets is shown in Figure 20. The correlation coefficient (R^2) is 96%.

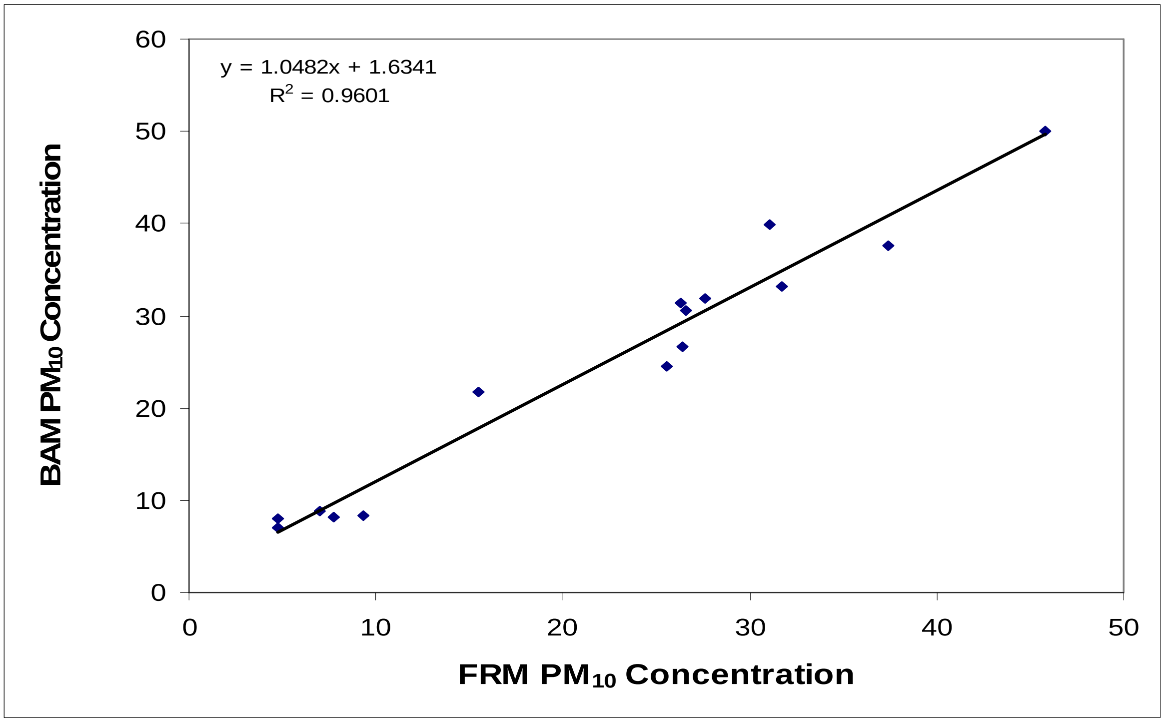

Figure 20: Correlation of PM_{10} concentration as measured with the manual and continuous (BAM) analyzer during the summer of 2006.

Traffic Count Data

In addition to air monitors, traffic counters were again installed at Sites 2 and 4. Data was collected from July 19th through August 23rd. Traffic volumes differed between the two sites. At Site 2, total daily traffic volumes ranged from 587 to 1369 vehicles and averaged 1036 vehicles per day for the summer. Hourly traffic volumes at Site 2 ranged from 0 to 132 vehicles with an average of 43 vehicles per hour.

At Site 4, the total daily traffic volumes ranged from 447 to 875 vehicles and averaged 691 vehicles per day for the project. Hourly traffic volumes at Site 4 ranged from 0 to 89 vehicles with an average of 29 vehicles per hour.

It was not determined if the traffic counters were able to detect four wheeler traffic, and there did not seem to be a significant increase in the number of vehicles between the pre-paving assessment and post paving evaluation.

APPENDIX F: 2007 MONITORING SEASON

The second year of post paving monitoring began May 27, after the snow had melted and the road surfaces had dried, and continued through August 16. Sampling was performed at Site 1 using collocated High Volume samplers (Hi Vols) and at Site 2 where the Hi Vol was collocated with a continuous Beta Attenuation Monitor 1020 (BAM).

Two additional sites were selected for use in 2007 to look at additional aspects of dust control measures in Kotzebue. Site 7 was located on Third Avenue next to the police station. Third Avenue was paved before 1999 and was constructed with minimal paved shoulders and without a sidewalk. Many unpaved neighborhood streets enter onto Third Avenue. Site 7 was selected with the purpose of looking at "track-out" from unpaved to paved surfaces and its effect on dust control. Site 8 was located in a residential area on Turf Street near the Kotzebue Bible Baptist Church. Site 8 was selected based on complaints of dust as well as to evaluate if additional areas in the community might be experiencing high particulate matter concentrations.

Filter Measurement

All four sites operated on a one-in-three schedule. The total number of possible samples for all sites was 108, out of which 88 filters were considered valid. The average data capture was 81% with individual capture rates ranging from 88% to 96%. A low capture rate of 54% at Site 2 was caused by the invalidation of the July 20 through August 16 filters which did not meet the quality assurance requirements. As a result, the data, which was flagged, cannot be used for determining compliance with the NAAQS, although it can be used in a qualitative comparison with the pre-paving results.

Sites 1, 2 and 7 were calibrated on May 23 and began sampling on May 27. Site 8 was calibrated on June 6 and sampling began on June 8. Between May 27 and August 16 no exceedances of the NAAQS were recorded using the FRM samplers or Met One BAM continuous monitor. The average concentrations for the monitoring season ran between 15 $\mu g/sm^3$ (Site 1) and 38 $\mu g/sm^3$ (Site 8) with the highest twenty-four hour value of 106 $\mu g/sm^3$ measured at Site 8 on July 8. A summary of the manual sampler data for all sites is displayed in Table 10 and Figure 21 shows the time series of data collected from all samples in 2007. In 2007 all quality control checks were performed according to the QAPP.

Table 10: PM_{10} concentrations (μg/sm^3), during the summer of 2007.

Run Date	Site #1	Site #2	Site #7	Site #8
5/27/2007	2			
5/30/2007	21			
6/2/2007	9	45	38	
6/5/2007	19	32	23	
6/8/2007	41	23	24	12
6/11/2007	16	51	49	55
6/14/2007	14	29	31	25
6/17/2007	15	22	17	102
6/20/2007	33	64	50	83
6/23/2007	9	25	23	
6/26/2007	6	21		
6/29/2007	9	49	39	94
7/2/2007	11	31	22	27
7/5/2007	15	64	48	80
7/8/2007	19	40	42	106
7/11/2007	16	26	29	31
7/14/2007	30		15	40
7/17/2007		30	24	26
7/20/2007	10	*23	21	15
7/23/2007	20	*21	12	18
7/26/2007	9	*21	21	31
7/29/2007	2	*12	14	5
8/1/2007	26	*28	10	10
8/4/2007	8	*6	5	3
8/7/2007	5	*18	15	17
8/10/2007	11	*23	20	
8/13/2007	9	*15	14	9
Average	**15**	**37**	**25**	**38**
High	**41**	**64**	**50**	**106**
% Capture	**96**	**54**	**89**	**88**

* Indicates flagged data due to final audit results

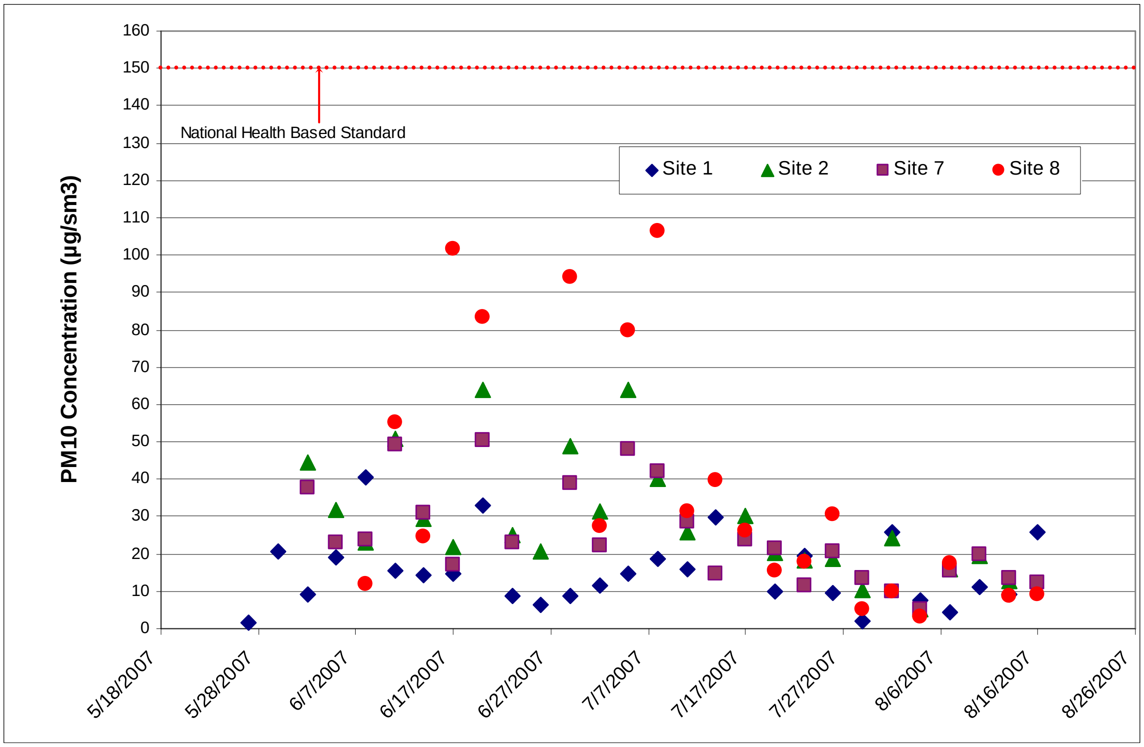

Figure 21: PM_{10} measurements (µg/sm^3) during the summer of 2007.

Precision Data and Data Quality

In 2007, a collocated precision monitor was placed next to the FRM monitor at Site 1. The collocated sampler was intended to assess precision for the data collected by the primary FRM sampler at that site. Collocated samplers can also provide information on potential error sources such as problems with filter handling.

The collocated monitor sampled 26 times during the project period with 10 sample pairs above method detection limits (>15 µg/sm^3). Figure 22 shows the precision between the ten sample pairs from the two FRM samplers at Site 1 (R^2=99 %).

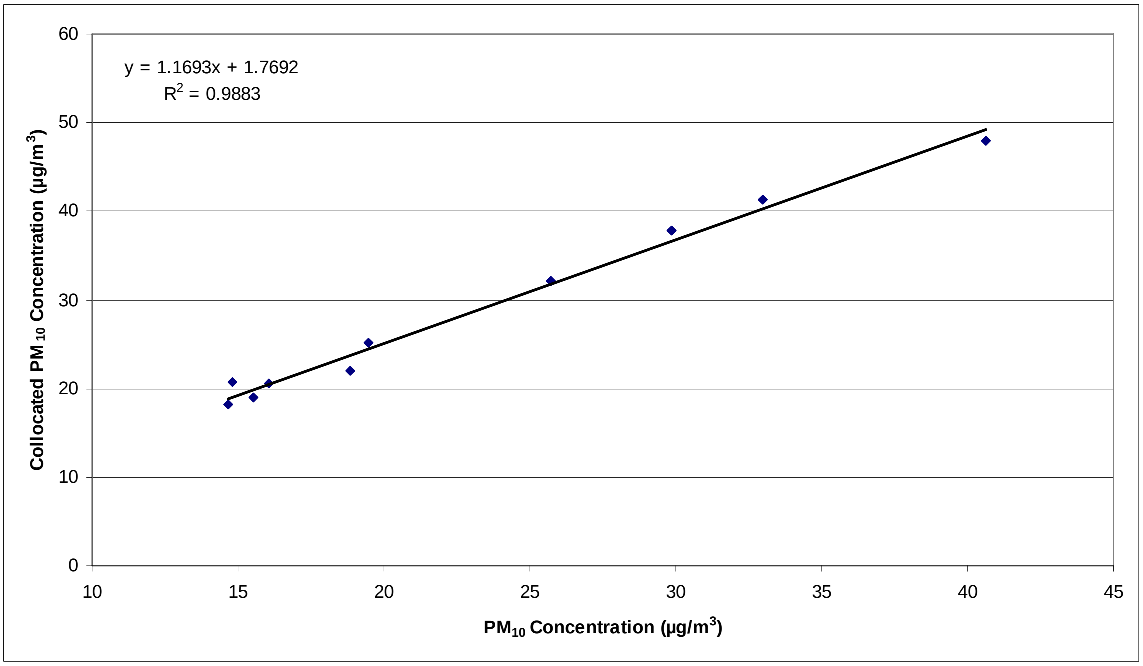

Figure 22: Precision comparison for the FRM PM_{10} monitors at Site 1, summer 2007.

The Met One Beta Attenuation Monitor (BAM) operated at Site 2 from June 4, 2007 to August 13, 2007. During this time period no exceedances of the PM_{10} health standard were recorded by the continuous monitor. Data was not collected for several days in July when the monitor ran out of filter tape. The average concentration measured by the BAM for the 11 week period was 25 µg/m^3. The highest BAM value (67 µg/m^3) was measured on June 15, 2007. A summary of the BAM data can be viewed in Table 11. Figure 23 shows a time series of 2007 BAM measurements. Figure 24 shows the comparison of the continuous monitor and the FRM sampler at Site 2. 20 data pairs were analyzed, showing good agreement between the two data sets (R^2=91%).

Table 11: PM_{10} concentrations (µg/m^3) at Site 2 using the BAM during the summer of 2007.

Run Date	BAM (ug/m^3)	Run Date	BAM (ug/m^3)	Run Date	BAM (ug/m^3)
6/5/2007	39	6/28/2007	11	7/22/2007	15
6/6/2007	30	6/29/2007	49	7/23/2007	21
6/7/2007	45	6/30/2007	25	7/24/2007	32
6/8/2007	29	7/1/2007	17	7/25/2007	34
6/9/2007	34	7/2/2007	30	7/26/2007	19
6/10/2007	25	7/3/2007		7/27/2007	12
6/11/2007	48	7/4/2007		7/28/2007	7
6/12/2007	29	7/5/2007		7/29/2007	11
6/13/2007	28	7/6/2007		7/30/2007	20
6/14/2007	32	7/8/2007		7/31/2007	29
6/15/2007	67	7/9/2007		8/1/2007	23
6/16/2007	23	7/10/2007		8/2/2007	11
6/17/2007	23	7/11/2007		8/3/2007	15
6/18/2007	46	7/12/2007	17	8/4/2007	6
6/19/2007	47	7/13/2007	32	8/5/2007	7
6/20/2007	54	7/14/2007	22	8/6/2007	12
6/21/2007	4	7/15/2007	23	8/7/2007	15
6/22/2007	36	7/16/2007	25	8/8/2007	17
6/23/2007	24	7/17/2007	26	8/9/2007	20
6/24/2007	11	7/18/2007	20	8/10/2007	18
6/25/2007	32	7/19/2007	26	8/11/2007	10
6/26/2007	24	7/20/2007	23	8/12/2007	11
6/27/2007	18	7/21/2007	17	8/13/2007	
			2007 Summer Average Value		**25**

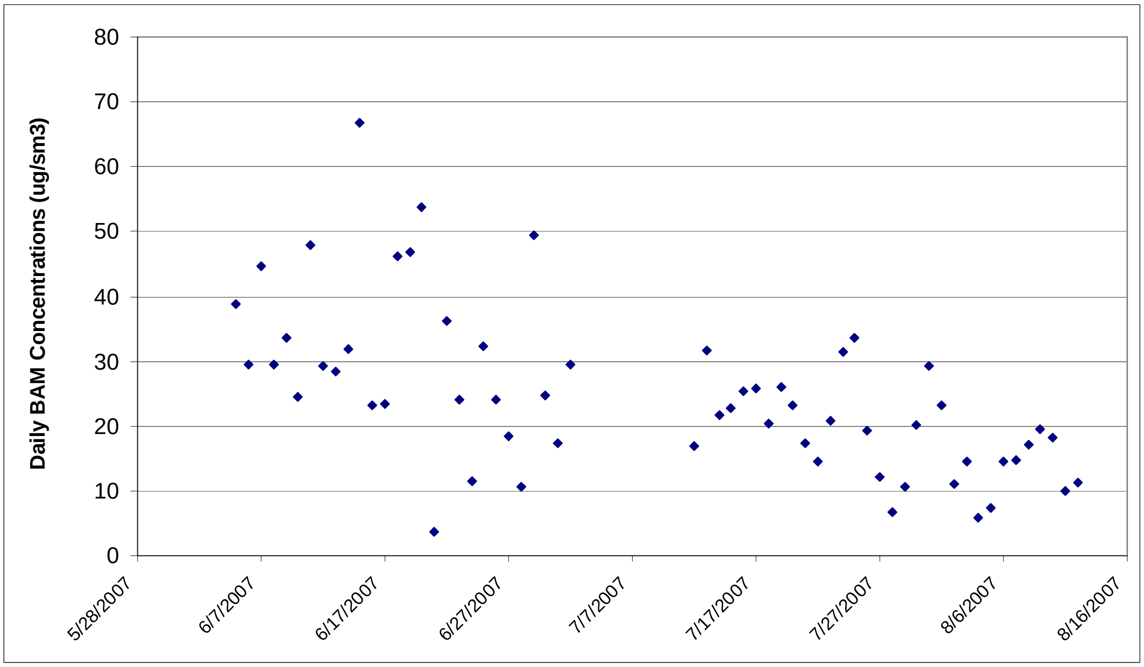

Figure 23: Continuous PM_{10} BAM measurements in 2007.

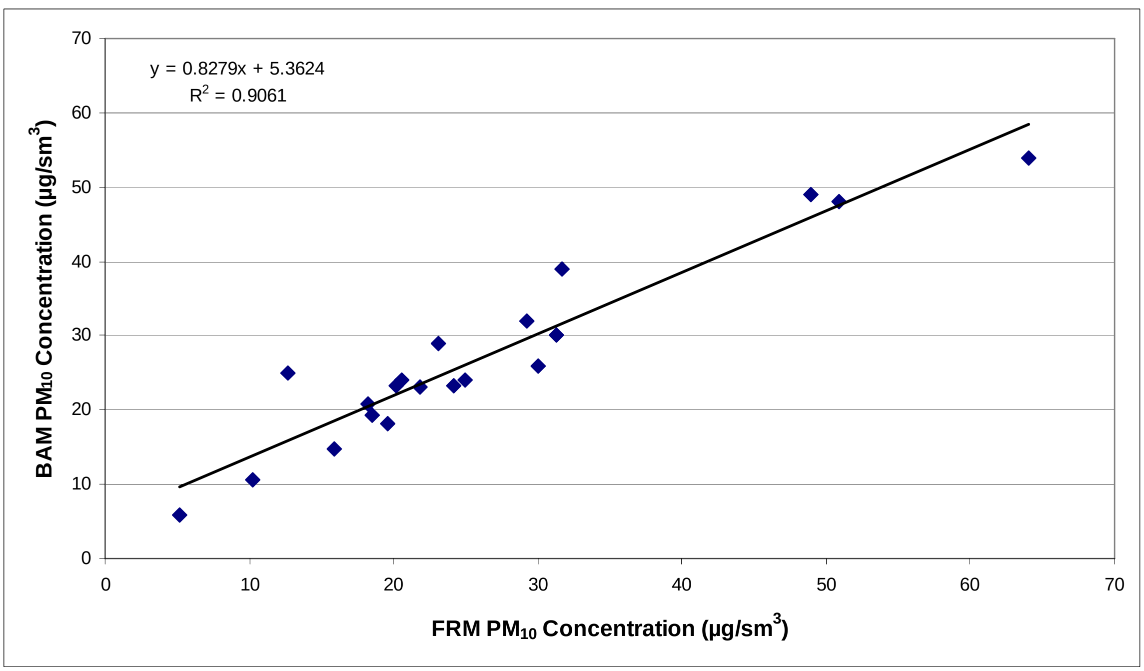

Figure 24: C**omparison of PM_{10} concentrations (µg/sm^3) as measured with the manual and continuous analyzer, summer 2007.**

APPENDIX G: 2008 MONITORING SEASON

The 2008 monitoring season began on June 28, 2008. Site 8 was re-installed at the Kotzebue Bible Baptist Church on Turf Street. The site was operated to determine if the results of the 2007 monitoring were actually representative of local dust levels or more an artifact of 2007 being a wetter summer. Sampling at the site was performed using a High Volume (Hi Vol) sampler.

Filter Measurement

The Tuff Street monitoring site was operated on a one-in-three schedule (sample day every 3 days) from June 29th through September 10th. Sampling switched to every other day from September 11th through 21st at the option of the site operator. No filters were run on July 14th, August 4th-13th and September 10th. The total number of possible samples was 31, out of which 25 filters are considered valid. The data capture rate for this summer was 81%. Two runs were double runs where the PM_{10} filter is sampled on twice. The four missed sample runs in August occurred when the field operator ran out of filters.

The Turf Street monitoring site was calibrated on June 27th/28th and began sampling on June 29th. Despite missing most of the normal summer dry season (June), Site 8 reported six exceedances of the NAAQS with five of the days occurring in July. The maximum concentration was 398 $\mu g/sm^3$ and four of the high values were over 250 $\mu g/sm^3$. The average concentration for the monitoring season was 96 $\mu g/sm^{3,}$ with over 30 percent of the high values over 50% of the standard. A summary of the 2008 sampling data is listed in Table 12 Figure 25 displays a time series of data collected in 2008.

Table 12: PM_{10} concentrations (µg/sm^3), measured in 2008.

Run Date	Site 8	Run Date	Site 8	Run Date	Site 8
6/29/2008	398	7/29/2008	7	9/6/2008	34
7/2/2008	170	8/1/2008	12	9/9/2008	Double run
7/5/2008	240	8/4-13/2008	No sample runs	9/11/2008	51
7/8/2008	285	8/16/2008	16	9/13/2008	27
7/11/2008	77	8/19/2008	97	9/15/2008	49
7/14/2008	Double run	8/22/2008	58	9/17/2007	12
7/17/2008	8	8/25/2008	332	9/19/2008	3
7/20/2008	45	8/28/2008	70	9/21/2008	8
7/23/2008	315	8/31/2008	25		
7/26/2008	13	9/3/2008	42		
Average	**96**	**High**	**398**	**% Capture**	**81**

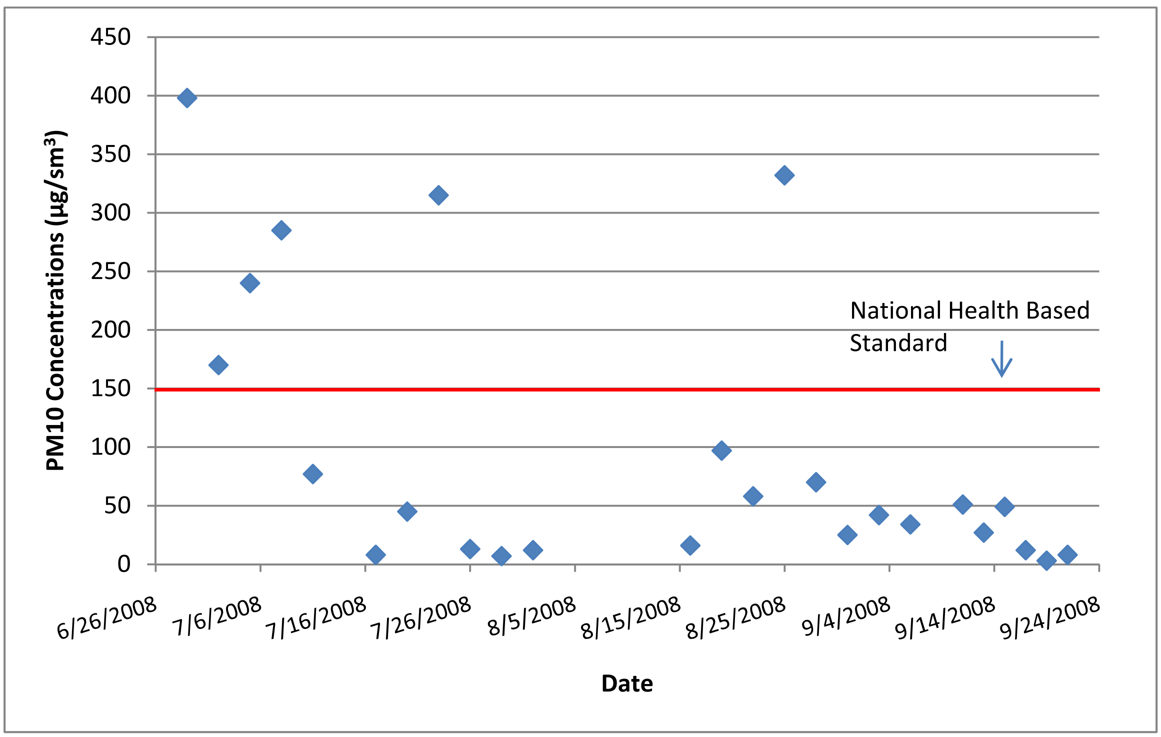

Figure 25: PM_{10} measurements (µg/sm^3) during the summer of 2008.

Data Quality

The 2008 sampling did not employ a collocated precision monitor, so no precision data is available. The intent of all short monitoring projects is to have a start up and shut down audit and monthly flow checks. During the summer of 2008, none of these were performed do to a staff shortage and no experienced staff available to support the site. A full multi-point calibration was performed at the time of startup and a one point flow check was performed the next day. While past performance by the site operator gives us good confidence that the data collected is good, no QA checks or audits are available to confirm our assumptions.

APPENDIX H: BACKGROUND MONITORING SITE

At the request of the Alaska DOTPF, DEC installed an air monitoring background site in 2006 for the purpose of investigating background particulate concentrations in the Kotzebue area. This background site was located roughly 1 mile south of Kotzebue at the OTZ telephone building. The monitoring site was located about 200 yards to the east of Air Force Road (a dirt road), 500 yards east of a bluff overlooking Norton Sound and 50 yards south of the dirt loop road which connected Air Force Road to Ted Stevens Way. A single Hi Vol sampler was collocated with a BAM at the background site. No exceedances of the state and federal PM_{10} standard were measured during the monitoring period.

BAM Monitoring

The continuous monitor ran from June 27, 2006 through September 4, 2007. The average 24 hour value measured by the BAM was 6 $\mu g/m^3$ with a high value of 42 $\mu g/m^3$ recorded on September 1, 2006.   Table 13 gives monthly average values for; highest 24 hour average, monthly average and data capture. Figure 26 shows all 24 hour averages collected during the 14 month monitoring period.

Table 13: Monthly PM_{10} data ($\mu g/sm^3$) collected by the BAM at the Kotzebue Background site during 2006 and 2007.

	Highest 24-Hr Average	Monthly Average	Data Capture
July 2006	9	3	48%
August	28	8	77%
September	42	4	90%
October	34	5	94%
November	11	2	80%
December	6	2	97%
January	17	3	74%
February	5	2	43%
March	8	3	81%
April	4	2	37%
May 2007	35	11	90%
June 2007	39	12	83%
July 2007	35	22	19%
August	30	11	68%
Overall	42	6	70%

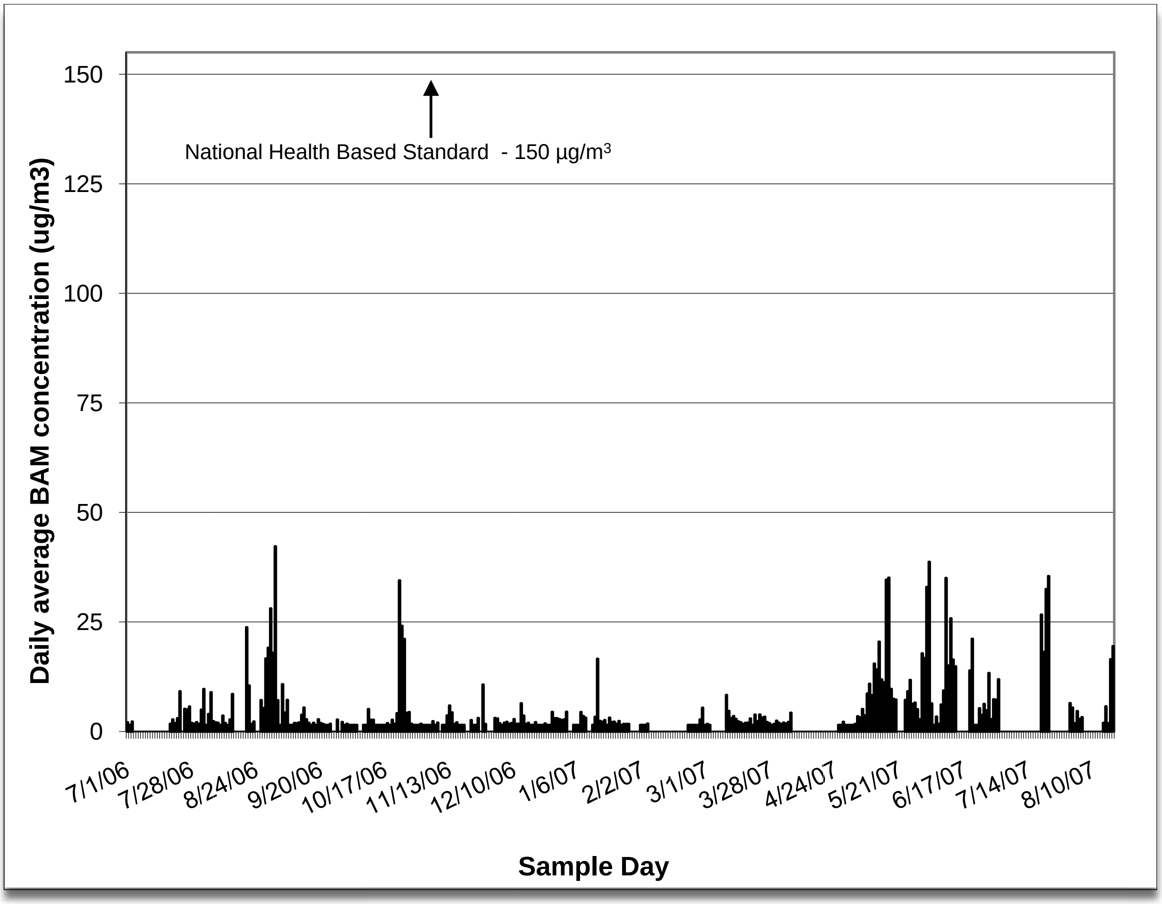

Figure 26: Background 24 hour averages of PM10 (µg/sm^3) from the BAM during July 1, 2006 through August 31, 2007.

2006/07 BAM Monitoring:

Annual data capture for the period July 2006 through June 2007 was 75% while the data capture for the 14 month monitoring period was 70%. Data losses were symptomatic of operating a remote monitoring site without a full-time trained operator; instrument running out of tape, changes in flow rate which were outside the operating limits, unexpected power losses, and misc other instrument malfunctions. When the filter tape ran out a local operator could be contacted to install a new tape. Unfortunately, issues with other instrument malfunctions could not be corrected by the onsite operator who was not familiar with the instrument. They also could not help with the numerous hours of data losses which occurred as a result of power outages and/or overloading the circuit breaker. The project's power was supplied through an outside outlet on the OTZ telephone building with power carried through two, heavy duty, low temperature grade extension cords. When the breaker tripped, power was lost until the OTZ Telephone Company site operator could come out and reset the system. While this problem plagued the monitoring throughout the project, we were never able to prove exactly what the cause was. One thought was that simultaneous activation of the BAM pump and the Hi

Vol in conjunction with temperature and moisture may have cause a power spike which tripped the breaker.

Problems:

On July 2, 2006 the BAM ran out of tape. The problem was not discovered and corrected until July 19 because remote telephone contact with the monitor had not yet been established.

On February 5, 2007 a flow issue was discovered by a technician that could not be resolved in the field. The BAM was removed and returned to Anchorage. A new BAM was installed on February 20.

On April 6, 2007 a remote download was performed. Subsequent remote download attempts were unsuccessful. A site visit on April 24 by a state technician found the BAM to be operating within acceptable parameters; however, the data from April 6 through April 24 was never recovered.

On July 2, 2007 a remote download was performed. Subsequent remote download attempts were unsuccessful. A site visit on July 18 by a state technician found the BAM software was "frozen" at a date of 7-3-2007 at 13:24. The BAM was restarted and calibrated; however, the data from July 3 through July 18 was never recovered.

Hi Vol Monitoring

Hi Vol filter sampling began on August 9, 2006 and continued through August 16, 2007 and loosely followed a 1 in 12 day sampling schedule. During this time a total of 25 sample filters were collected of which 16 are considered valid. The highest concentration collected during the monitoring period was 33 $\mu g/m^3$. Table 14 shows the values of Hi-Vol filters collected during the monitoring period.

Table 14: PM_{10} concentrations (µg/sm³), measured at the Kotzebue Background site.

Run Date	µg/sm³	Run Date	µg/sm³
10/17/2006	1	5/18/2007	6
12/10/2006	2	5/30/2007	14
1/30/2007	7#	6/11/2007	27
2/23/2007	1*	6/20/2007	21
3/7/2007	16*	7/14/2007	33
4/21/2007	3*	7/20/2007	21
4/30/2007	0	7/29/2007	4
5/6/2007	2	8/4/2007	6

#-data flagged but included. A final bracketing flow check was not possible due weather.

*-data adjusted based on flow-check information

Comparison of BAM and Hi Vol

A comparison of the continuous monitor and FRM sampler at the Background site showed good agreement. The correlation of 11 data points is shown in Figure 27. The correlation coefficient (R2) is 97%.

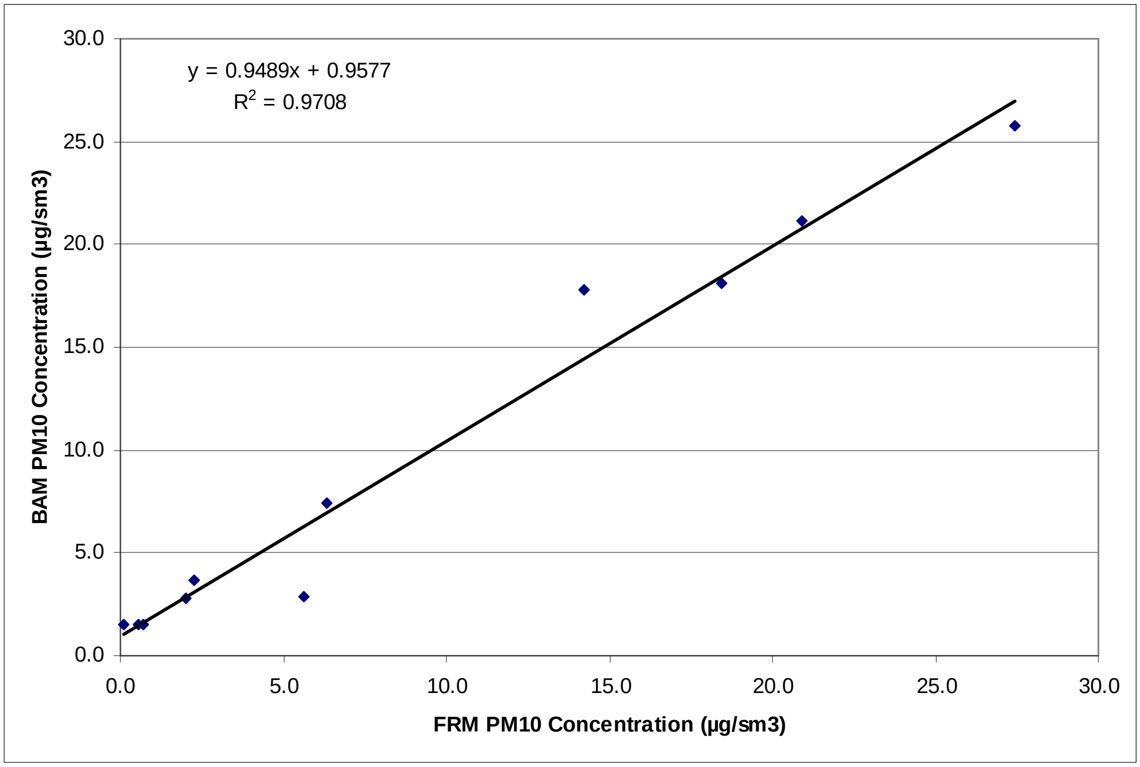

Figure 27: Correlation of PM_{10} concentrations (µg/sm^3) as measured with the manual and continuous analyzers (2006-07).

Over a 14 month period the average 24 hour value collected by the Background Site BAM was 6 µg/m^3. The 5 month summer average for the BAM (July through August, 2006 and June through August 2007) was 11 µg/m^3. In comparison, the BAM on Second Avenue in Kotzebue had a pre-paving summer average of 85 µg/m^{3}and a post paving summer average of 24 µg/m^3