Summary Report

for the

North Pole

Saturation Study

February 2017

March 9, 2018

Air Quality Division

Air Monitoring
&
Quality Assurance
Program

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Executive Summary

The North Pole Saturation Study, conducted from February 1 - 21, 2017, was intended to determine how representative the regulatory air monitoring site was of the surrounding area. The North Pole site was initially selected to represent a neighborhood scale area (4 km diameter) within the non- attainment area that experiences the highest concentrations. Previous short term monitoring results indicated that the site experienced elevated $PM_{2.5}$ even when compared to concentrations recorded at other sites within the same neighborhood scale area. The North Pole Fire Station $PM_{2.5}$ concentrations drive regulatory decisions for the entire Fairbanks North Star Borough $PM_{2.5}$ Nonattainment Area, which encompasses both North Pole and Fairbanks, due to very high pollution levels. If the North Pole Fire Station site were not representative of a larger area, the saturation study could provide a basis for moving the site to a more representative location.

The saturation study was designed to provide information at a large number of monitoring sites in the area, an area with an approximately 2 km radius (represented by red circle) around the North Pole Fire Station regulatory site. The monitoring technology was capable of producing accurate data; however, it is not of regulatory quality and should not be compared directly to concentrations recorded by monitors collecting regulatory-quality data. Twelve stationary, fixed, sites were located throughout the study area and a mobile monitoring platform operating on a regular schedule provided information about concentrations on roads throughout the area. Figure ES-1 shows the 12 fixed site locations as the red circles. The mobile routes are displayed as orange lines. The combination of fixed and mobile sites provided information about the distribution of pollution in the area and the characteristics of pollution levels over varying periods of time.

Figure ES-1: North Pole Saturation Study Fixed Monitoring Sites (Large Red Dots) and Mobile Monitoring Routes (Orange Lines).

The meteorological conditions occurring during the study period encompassed a variety of conditions associated with both high pollution and low pollution events, from cold and clear days with strong inversions, to periods of snow and freezing rain. During the study, overall pollution levels throughout the area were impacted by meteorological conditions, inversions were associated with increased pollution levels, while precipitation events such as light snow and freezing rain lowered overall pollution levels.

Pollution levels observed over shorter periods of time indicated that pollution levels are complex and dependent on the behavior of many individual, small sources of pollution, rather than a single large source. Short term periods show transient behavior with numerous spikes in concentrations that quickly dissipate.

The North Pole Fire Station site did not record the highest concentrations among stationary sites, but also did not record the lowest. During periods of high concentrations, the North Pole Fire Station site recorded concentrations greater than the average concentrations of other sites.

A mobile monitoring vehicle operated between February 7 and 19, 2017 and recorded $PM_{2.5}$ concentrations during four 1-hour traverses, three times daily. There are localized high concentration areas and the concentrations change from one traverse to the next. The transient concentrations indicate that the area is impacted by many small localized sources. Concentrations are impacted by behavior patterns, weather conditions, and dispersion of the $PM_{2.5}$ pollution.

DEC has concluded that the results of the saturation study do not support a need to pursue relocation of the regulatory site. The study results also support previous findings that many small sources are responsible for the air quality problem in the North Pole area surrounding the North Pole Fire Station sampling site, rather one or several single large stationary sources.

Introduction

From February 1 -21, 2017, the Department of Environmental Conservation Air Quality (DEC), with support from Sierra Research (Sierra) and T&B Systems (T&B), conducted a saturation study in North Pole to evaluate the representativeness of the North Pole Fire Station monitoring site as a regulatory site and to better understand $PM_{2.5}$ concentrations in the larger North Pole area. A saturation study is a study in which an area is 'saturated' with numerous low cost monitors for a short period of time. Usually, the samplers are set up in a grid, as best as possible, to create a dense monitoring network.

Background

In 2006, the U.S. Environmental Protection Agency (EPA) tightened the 24-hour $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) to provide increased protection of public health in the United States. Within the City of Fairbanks, Alaska, on-going Federal Reference Method (FRM) monitoring established a design value that led to its designation as a 24-hour $PM_{2.5}$ nonattainment area in 2009. The non-attainment area boundaries include the neighboring city of North Pole and surrounding areas as shown in Figure 1-1.

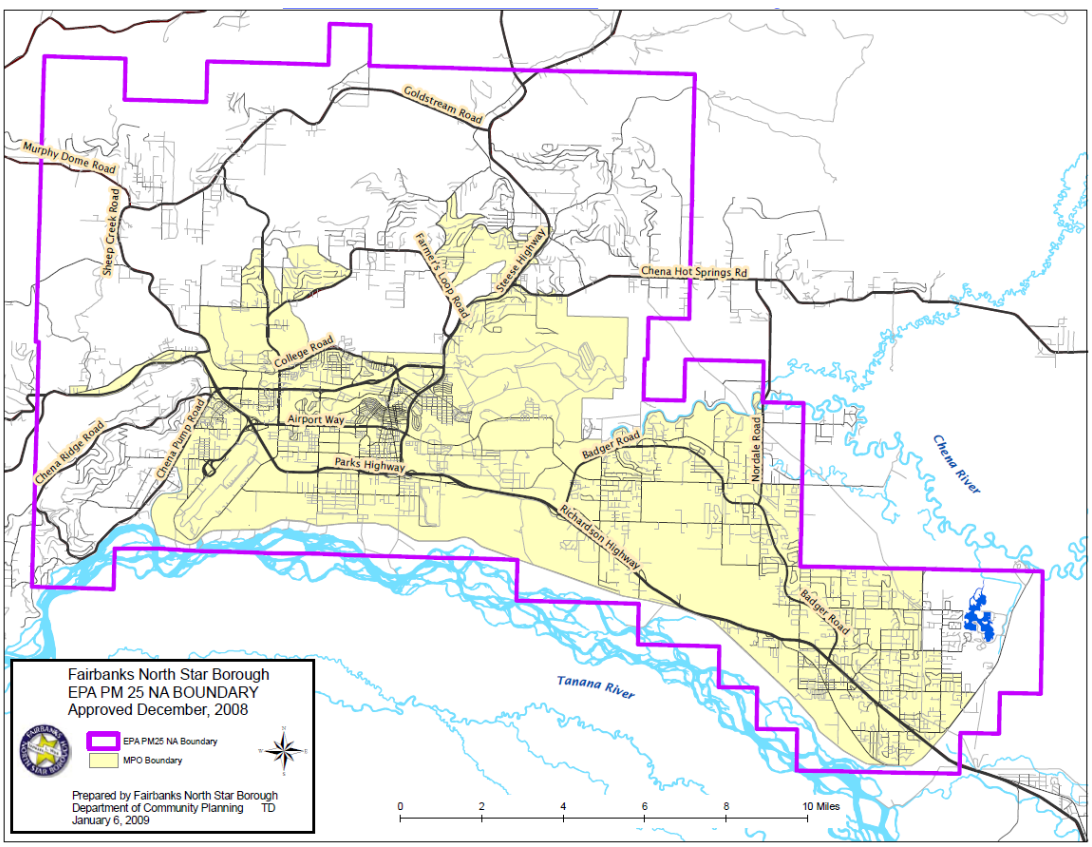

Figure 1-1. Fairbanks $PM_{2.5}$ Nonattainment Area Map.

In 2009, the Fairbanks North Star Borough (FNSB), with support from DEC, began ambient $PM_{2.5}$ monitoring in the North Pole portion of the nonattainment area, initially at the North Pole Elementary School. This site was intended only as a temporary site, while the search for a more permanent, long-term site was ongoing. By 2012, monitoring at the North Pole Elementary School was discontinued and monitoring equipment was relocated to the North Pole Fire Station (NPFS) site, located on the northwest corner of Hurst Road and Dawson Road (see Figure 1-2).

After the site had collected what was considered valid data for three years, EPA recommended designating the NPFS site as a regulatory site. When DEC complied, the NPFS site became the site providing the new design value for the entire non-attainment area. The North Pole design value was significantly higher than the Fairbanks value and DEC was concerned that the NPFS site might be in a hot-spot location that experiences significantly higher concentrations than the larger surrounding area. As funding became available in 2016, DEC decided to conduct additional short-term, intensified monitoring in the larger area surrounding the NPFS site. The intent of the study was to assess the spatial scale of ambient 24-hour $PM_{2.5}$ concentrations measured at the NPFS site, in order to evaluate if the site was representative for the area. A neighborhood scale site represents an area of approximately 4 km in diameter, and is not impacted by any single source or group of sources. Another objective of this saturation study was to better understand $PM_{2.5}$ levels across North Pole and surrounding neighborhoods.

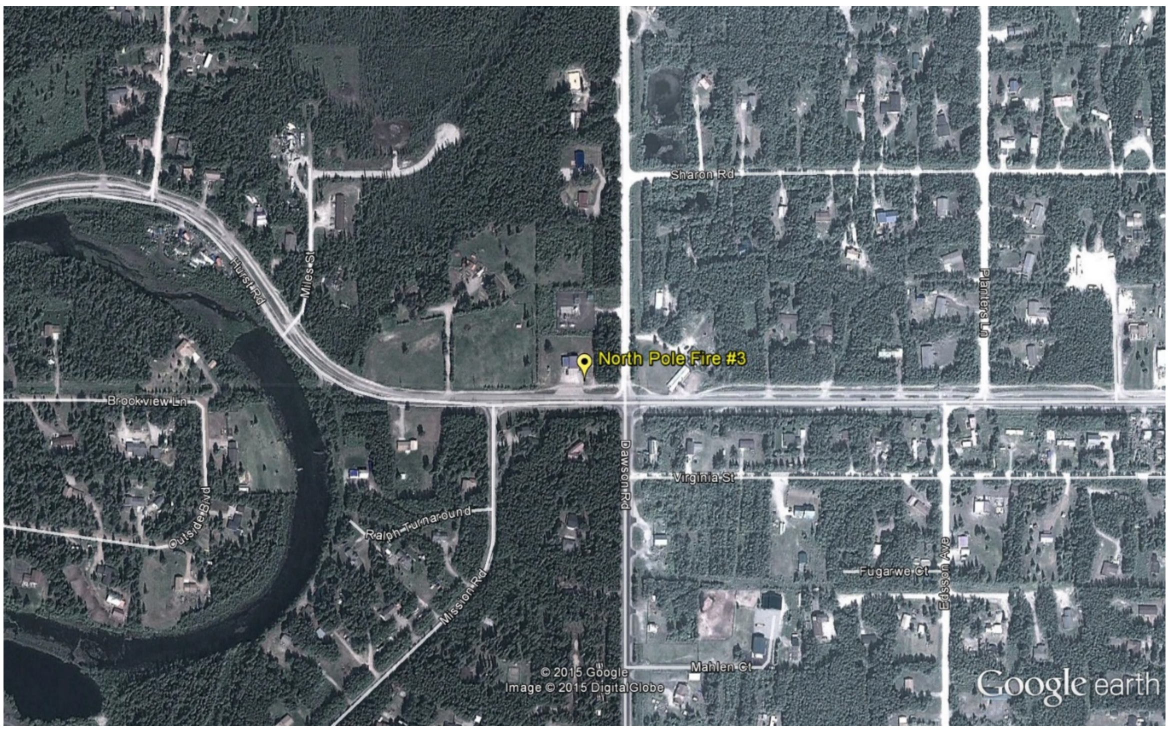

Figure 1-2: Location of the North Pole Fire Station Monitoring Site on Hurst Road, North Pole.

Previous to the saturation study, the FNSB air quality staff had operated short term monitors in the North Pole area to better understand pollution levels in North Pole. Between 2014 and 2016, FNSB collected data at 10 temporary Special Purpose Monitoring (SPM) sites: Table 1-1 lists the site names and the dates the sites were operational. Figure 1-3 shows the monitoring locations on a map. FNSB staff focused their monitoring efforts to locations where their mobile monitoring had indicated elevated readings, but also on areas that could logistically accommodate a sampling trailer. The data for these sites were summarized in DEC's 2016 Annual Monitoring Network plan, posted on the DEC website (http://dec.alaska.gov/air/air-monitoring/monitoring-plans).

Table 1-1: North Pole Short Term Monitoring Locations and Dates.

Site Name	Start Date	End Date	Site Name	Start Date	End Date
North Pole Water	10/1/2014	3/31/2015	**North Pole Pump Station**	1/6/2015	2/18/2015
Newby Park	1/29/2015	3/31/2015	**North Pole Water 5**	10/1/2015	12/30/2015
Ticasuk Brown Elementary	11/18/2015	12/30/2015	**Dixon Road**	11/20/2014	12/31/2014
Bright Electric	2/18/2015	4/1/2015	**Badger Road Elementary**	2/18/2016	4/1/2016
North Star Fire Station #2	9/29/2015	11/18/2015	**North Pole Water Stillmeyer**	1/5/2016	3/31/2016
Eielson AFB Clinic	6/24/2015	8/14/2015			

Figure 1-3: North Pole Short Term Monitoring Site Locations, 2014-2016.

In general, the wintertime data showed that concentrations measured at the North Pole short-term monitoring sites were, with some exceptions, lower than those measured at the NPFS, indicating that NPFS may itself be located in a hotspot area. Over the two winters between October 2014 and March 2016, the short-term SPM sites recorded 121 exceedances of the NAAQS, while the NPFS monitor recorded 110 concurrent exceedances. On days when an exceedance occurred at either the SPM or regulatory site, the 24-hour average value recorded at the SPM site was, on average, lower than the regulatory site, with the exception of the Dixon Road site.

Figure 1-4 shows the $PM_{2.5}$ concentrations recorded at the short term monitoring sites in color. The dots represent the 24-hour averaged concentration. The data for the NPFS site is shaded in gray. Whenever a dot is on a white background, the concentration measured at the site was higher than the concentration measured at the NPFS. When the colored dot is on a light gray background, the NPFS concentration was higher. As can be seen in Figure 1-4, there are two timeframes, during which the NPFS site did not measure the highest concentration: (1) the summer 2015 timeframe, when the SPM sampler at Eielson measured wildfire smoke, and (2) November to December 2014, when the Dixon Road sampler measured higher concentrations. (light blue dots).

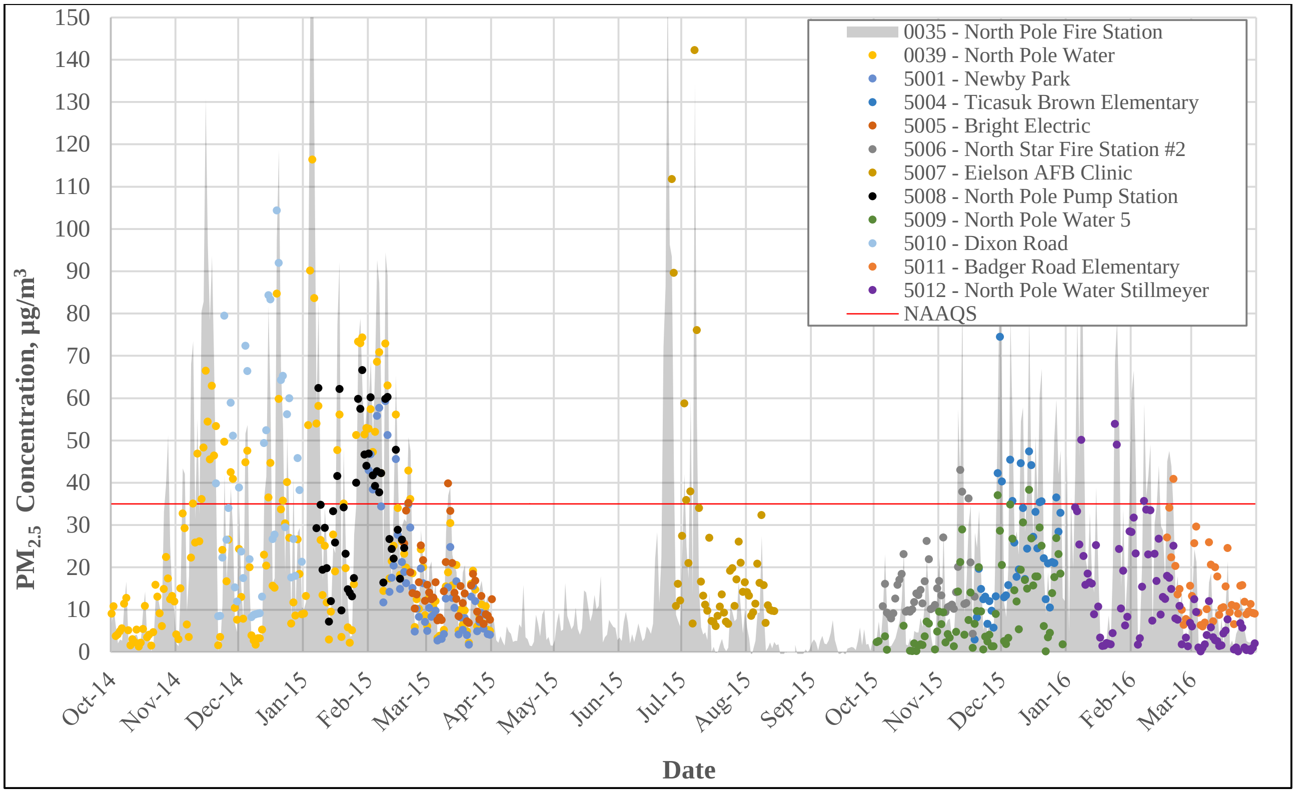

Figure 1-4: 24-Hour Average $PM_{2.5}$ Concentrations Measured in North Pole.

Additionally the graph shows that concentrations in the summer are usually lower than during the winter time, with the exception of the mid-June to mid-July timeframe, during which wildfire smoke moved through the North Pole area.

Study Design

DEC tasked their contractor Sierra Research (Sierra) with the project management and design. Sierra and their sub-contractor, T&B Systems (T&B), researched and selected the targeted monitoring site locations based on visual reviews of the North Pole area, guidance from and discussion with EPA, practical considerations of local conditions, and study objectives. A mixture of fixed and mobile monitoring sites/routes was defined. Sierra reviewed historical ambient monitoring and temperature data from the NPFS station to identify the window of calendar days during the winter months with the highest probability of episodic high concentration conditions. DEC, Sierra and T&B agreed on a late January to early February study period, to maximize time for planning, instrument purchase and testing, and to still target a period with cold enough temperatures to see pollution events. T&B and Sierra prepared a Quality Assurance Project Plan, available on the DEC web site at http://dec.alaska.gov/air/north-pole-study. T&B selected instrumentation in consultation with DEC and FNSB. DEC prepared information on the study purpose and operations and distributed it to the public via mail outs and door hangers. The Mayor of North Pole, FNSB air quality staff, and environmental organizations with North Pole membership assisted in the information distribution and encouraged property owner participation.

Fixed-Site Monitoring Objectives

A fixed-site monitoring network consisting of eleven sites, in addition to the North Pole Fire Station, was established and operated continuously during the study period with the objective of providing data to evaluate the spatial and temporal distribution of $PM_{2.5}$ surrounding the NPFS site, and to help determine if the NPFS site is unduly impacted by localized, sub-neighborhood scale sources.

The sites generally fell within a 2 kilometer radius of the NPFS defining an area sufficient to help verify the representativeness of the NPFS as a neighborhood scale monitoring location. At the beginning of the study, one site was located 40 meters north of the NPFS site to specifically measure gradients relative to the nearby roadway. Figure 2-1 shows the location of the fixed monitoring sites as red circles.

Mobile Monitoring Objectives

The goal of the mobile monitoring was to provide "virtual site" data collection using a vehicle equipped with a real-time $PM_{2.5}$ monitor making four identical 1-hour traverses per averaging period over the same route. This method emulates a very dense network of sites that directly addresses small scale variations associated with local sources and microscale phenomena in the region.

The specific objectives of the mobile monitoring were to:

- Determine any gradients in concentrations moving away from the primary roads in the vicinity of the NPFS site and to what extent any observed gradient might explain the higher concentrations close to the roadway;
- Collect data along non-well-traveled roadways to fill in data gaps and enhance the fixed-site network data collection;

- Measure concentrations on the primary roadway network around the NPFS site to evaluate any possible channeling of elevated $PM_{2.5}$ and what features might be causing the channeling such as dense forested areas blocking flow, etc.; and
- Utilize the mobile monitoring vehicle in a fixed site mode during off hours at key locations to compliment the fixed-site monitoring.

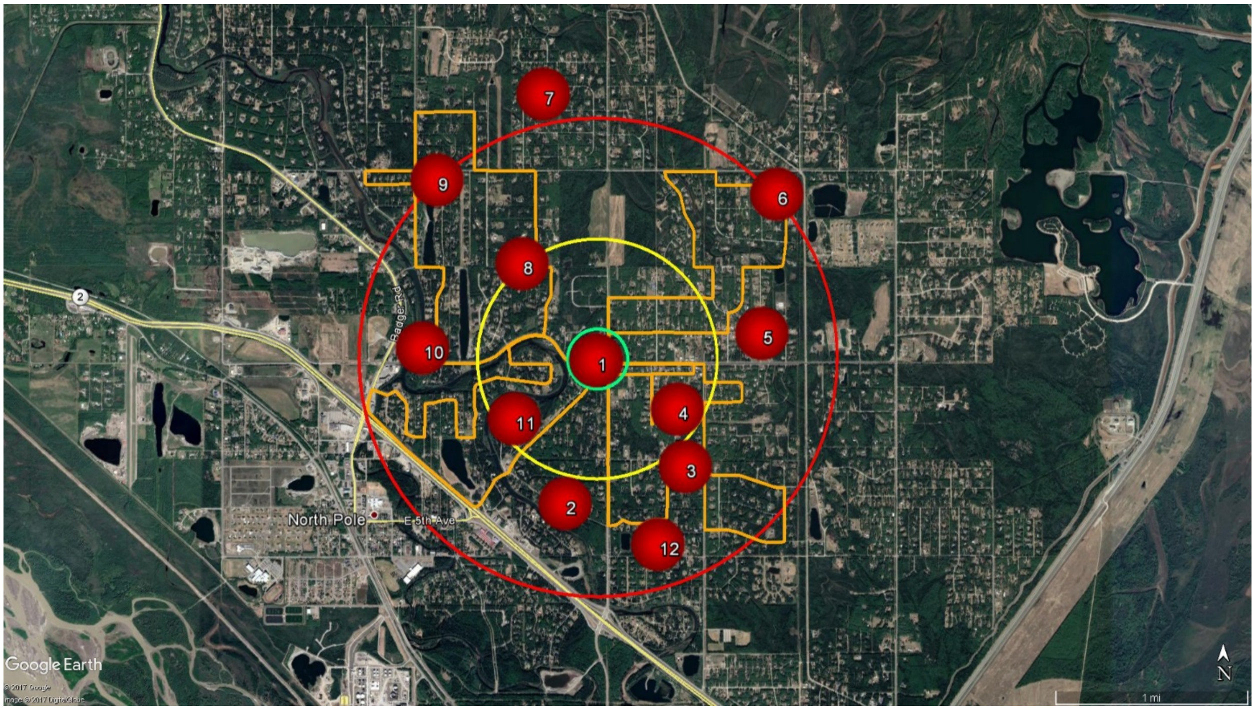

Figure 2-1: North Pole Saturation Study Fixed Monitoring Sites (Large Red Dots) and Mobile Monitoring Routes (Orange Lines).

Instrumentation and Monitoring Methods

Equipment

The monitoring and communications platform was identical for all samplers used in the study. The selection of equipment and design were guided by experience gained by the FNSB mobile monitoring "sniffer" vehicle program and a 2012 ambient air quality study performed in New Hampshire.

$PM_{2.5}$ Measurements

Thermo Personal DataRAM Model 1500 (pDR-1500) samplers were used for all $PM_{2.5}$ measurements. The pDR-1500 monitors were equipped with in-line inlet heaters to warm incoming air and "blue cyclones" that produce a 2.5 µm cut-point when operated at a flow of 1.5 liters per minute (lpm). The sample inlet was constructed of flexible copper tubing. The pDR-1500 detects particulate matter through light scattering and is capable of 1-second measurements of concentrations between 1 and 400,000 $\mu g/m^3$ in increments of 0.1 $\mu g/m^3$ with ± 5% accuracy.

Data Logger

Campbell Scientific CR300 Data Loggers were used to record measurements of $PM_{2.5}$ concentration, cooler temperature, and wind direction and wind speed at sites equipped with sonic anemometers. Additionally, the CR300 was used to power the cooler temperature control module and the sonic anemometer, transmit data to a cellular modem, and control a reset module.

Cellular Telemetry

Sierra Wireless AirLink Raven XT cellular modems were used with antennae to transmit data in real time to a remote T&B server capable of displaying data online.

Power

All units were powered by 110V AC power. Fixed sites were plugged into an outlet via extension cord, while the mobile monitor was connected to a 12V DC to 110V AC inverter that drew power from the vehicle. All units had battery backup power in the event of a power outage.

Fixed Site Deployment

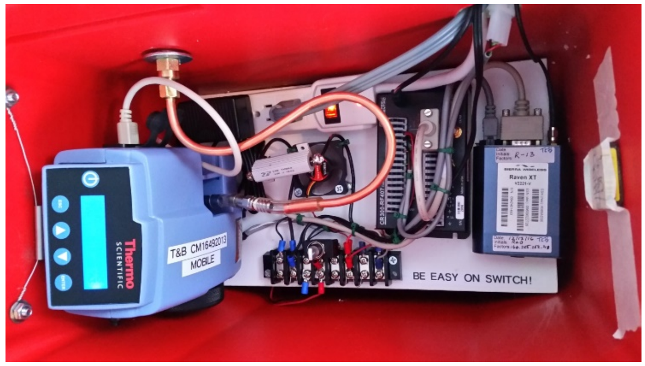

Figure 3-2: Instrument Configuration for the Mobile Monitoring Sample Enclosure.

A suitable enclosure for the sampling equipment was key to the fixed-site methodology, because of the low ambient temperatures associated with the anticipated $PM_{2.5}$ episodes. The basis of these enclosures was a conventional portable cooler, which provided easy deployment, protection from the elements, and insulation required to keep equipment warm. In addition to the Thermo inlet heater that heated incoming sample air by 15º to 20º C prior to entering the pDR-1500, the system included an enclosure heater that was controlled by the data logger in order to maintain a suitable enclosure temperature.

Figure 3-1: Typical Sample System Set-Up.

Figure 3-1 shows a typical deployment of the sampling system, including the plastic garbage bag that was used to disguise the cooler and provide additional protection from the elements. Figure 3-2 shows the instrument set-up inside the cooler.

Mobile Monitoring Deployment

Mobile monitoring was performed using a rental vehicle. The sampling system was packaged in an enclosure in essentially the same manner as the fixed sites (see Figure 3-2), with the exception that the inline sample heater was installed outside of the enclosure. This allowed for the rapid installation of the sampling system into the vehicle, with copper tubing leading to a TSI omni-directional aerosol inlet mounted on the roof of the sampling vehicle. The system was removed from the vehicle when not in use and stored indoors at room temperature.

The sampling vehicle was equipped with a 12 VDC to 120 VAC pure sine wave inverter and adequate AGM batteries to power the system for at least eight hours of continuous sampling. Provisions were made to make a rapid switch from vehicle to ground power when AC power was available. All data were collected using 1-second scans with both the individual scans and 1-minute averages recorded. Cellular telemetry allowed investigators to view data collection on a real time basis, as well as provide the primary method of importing the data into a useable database. Figure 3-3 is a view of the configured mobile monitoring SUV, showing the location of the sample inlet.

Figure 3-3: Mobile Sampling Vehicle with Sample Inlet on Top.

In designing the routes, a vehicle speed of approximately 25 MPH was assumed. This allowed the vehicle to cover the approximately 20 miles of travel necessary to cover all of the study area in one hour. Mobile monitoring on a study day was divided into three four-hour shifts: morning (06:00-11:00), midday (11:00-15:00), and evening (18:00-22:00). Midway through the study, the midday (11:00-15:00) shift was changed to a night (22:00-02:00) shift to investigate late-night concentrations. The routes are shown as orange lines in Figure 2-1. Over a four-hour shift, any given point would have been passed at least four times.

Study Period Meteorological Conditions

The study period was selected to capture periods of predicted high $PM_{2.5}$ concentrations, typical of cold wintertime days with stagnant air. Historical meteorological and pollution data were analyzed to predict periods most likely to contain the types of weather conditions typically associated with exceedances of the $PM_{2.5}$ standard. The conditions observed during the study period at the North Pole Fire Station were representative of a variety of different temperature, inversion, wind, and precipitation events.

Temperature

Ambient daily average temperatures ranged from -23° F to 20° F. Daily maximum average hourly temperatures during the study period ranged between -12° F and 39° F, while daily minimum hourly temperatures during the study period ranged between -35° F and 11° F. Two days had average temperatures below the study target of -15° F.

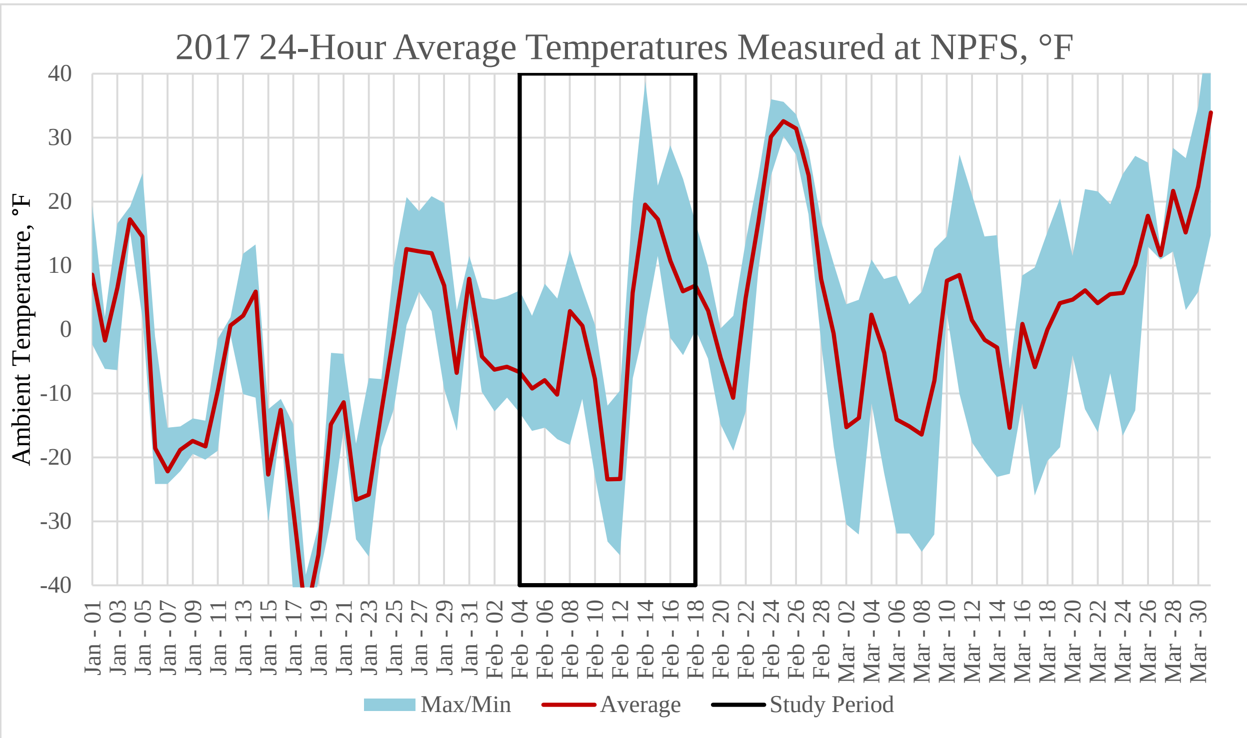

Figure 4-1: NPFS Temperature Data with Daily Averages and Maximum/Minimum Hourly Averages. The black rectangle marks the study period.

Inversions

Inversions are meteorological conditions characterized by a reversal of the normal decrease of air temperature with altitude. They are associated with elevated $PM_{2.5}$ concentrations because they can trap pollution close to the ground. Radiosonde launches at Fairbanks International Airport indicate the study period included multiple temperature inversions.

Wind

The 10-meter anemometer located at the North Pole Fire Station was used to develop the wind rose below and is considered to be representative of the study area conditions. All 5-minute average wind speeds were below 2.8 m/s and the average wind speed was 0.56 m/s, indicating predominantly stagnant conditions during the study period.

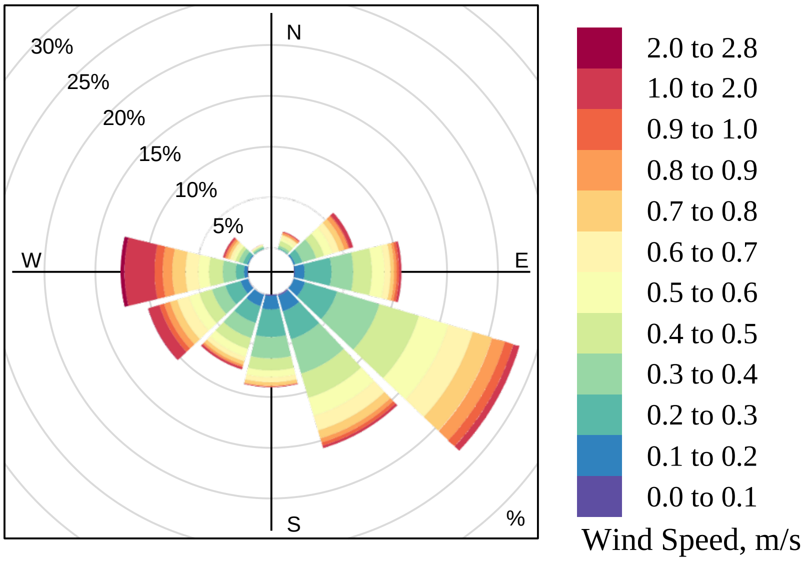

Figure 4-2: NPFS 10m Sonic Anemometer Frequency of Wind Speed by Wind Direction, displayed as stacked percentages by wind speed and wind origin directions.

Precipitation

Precipitation is associated with a decrease in particulate pollution concentrations due to particles adhering to precipitation and being removed from the atmosphere. There were two precipitation events and one fog event observed nearby at Fort Wainwright during the study period. Light snow was observed between February 8 and 10, light freezing rain was observed on February 14, and fog was observed on February 15, 2017. The precipitation events are associated with low $PM_{2.5}$ concentrations in the data. The remaining days were either clear or overcast.

Data Processing

Fixed Site Data

Fixed site data was collected in concurrent 5-minute averaging periods at each site for the duration of the study period. These data were used to calculate 1-hour, 4-hour, and 24-hour $PM_{2.5}$ average concentrations for comparisons between sites and with the mobile dataset.

Mobile Data

Mobile data was collected in 1-second increments during mobile sampling, creating a large dataset of pairs of coordinates and $PM_{2.5}$ concentrations. To process the data to make direct comparisons to the fixed site 5-minute data, the data were grouped into 25-meter bins along the monitoring route. All data points that were collected within a 25-meter diameter bin during a 1-hour traverse were averaged. The resulting average concentration was assigned to that bin for that hour. The bin concentrations of each four one-hour traverses occurring during each mobile sampling period were averaged to produce a 4-hour average concentration. The three four-hour averages were averaged to determine a 24-hour average concentration. Figure 5-1 demonstrates the binning and averaging process; the grey rectangle and circles represent the road and the 25-meter bins, each colored point represents a 1-second measurement, each different color represents a separate 1-hour traverse, and the black rectangles represent different averaging periods.

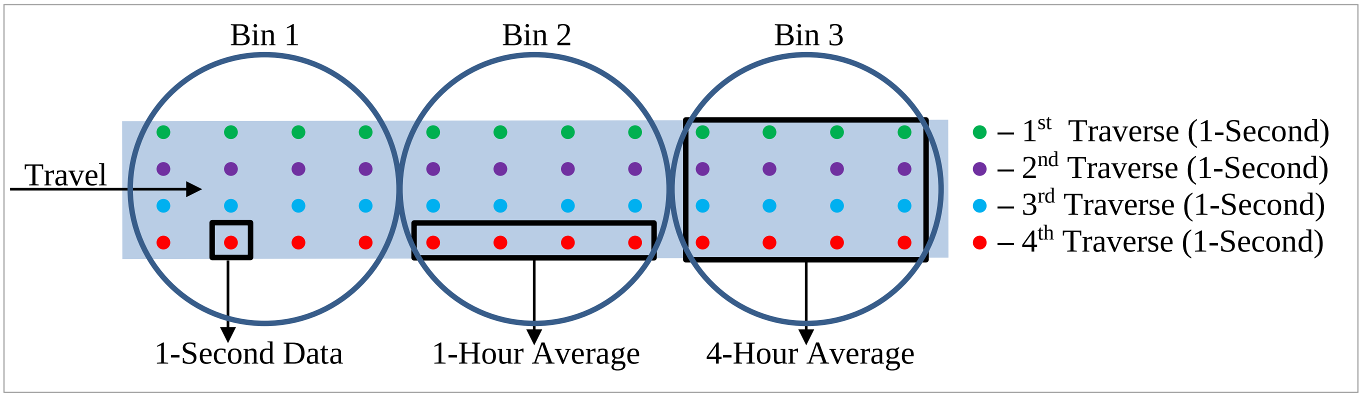

Figure 5-1: Mobile Data Processing.

Results

The section below summarizes the results for the fixed site and mobile monitoring. The field study period was from February 1 through February 19, 2017. Sampling at the fixed sites started on February 3 and 4. Prior to that, all sampling equipment was operated side-by-side for quality assurance purposes. Mobile monitoring started on February 7, 2017. At the end of the sampling period on February 19, all equipment again was operated side by side.

Fixed Site Monitoring Results

1. Comparison of $PM_{2.5}$ Concentrations at Sites 1 and 1a – Roadway Gradient

To assess the presence or absence of a concentration gradient as the distance between the road and the study monitors at NPFS increased, two monitors were deployed at Site 1 and 1a at the NPFS site. Sampling at Site 1a occurred between February 3 and 9, 2017. Site 1a was approximately 40 m north of the NPFS site. During the study period, there was no significant difference between the 5-minute average concentrations measured by the two monitors. The correlation statistics for the dataset were slope = 1.00, intercept = -0.167, and $r^2 = 0.969$. This means an average concentration of 35 µg/m³ near the regulatory site would, on average, be expected to correspond to a concentration of 34.8 µg/m³ at the site further from the road.

2. Comparisons of $PM_{2.5}$ Concentrations at Site 1 (NPFS) to Sites 2-12: 24-Hour

To assess whether the North Pole Fire Station regulatory site is representative of other fixed sites in the study area, the $PM_{2.5}$ concentrations measured at the NPFS Site 1 and Sites 2-12 were compared.

$PM_{2.5}$ measurements occurred at the 12 sites between February 3 and 19, 2017. The 14-day period experienced a variety of weather conditions and contained multiple days when the 24-hour average concentration exceeded the NAAQS of 35 µg/m³. Periods of atmospheric stagnation and cooler temperatures were associated with elevated $PM_{2.5}$ concentrations, while warmer weather and precipitation events resulted in lowered concentrations.

Figure 6-1 shows a summary of the 24-hour average $PM_{2.5}$ concentrations recorded at the fixed sites during the study period. The light blue shaded area shows the range of 24-hour $PM_{2.5}$ concentrations recorded at sites 2-12. The blue line shows the average of all 24-hour concentrations measured at Sites 2-12. The red line shows the 24-hour concentration at Site 1. The top and bottom lines of the blue shaded area are not associated with one specific site. No individual site was always highest or always lowest, it only demonstrates the extent of concentrations recorded at all sites.

The data show that, among the fixed sites, the NPFS does not experience the highest $PM_{2.5}$ concentrations or the lowest. During periods of elevated $PM_{2.5}$ concentrations, the NPFS site recorded concentrations equal to or above the average concentration of the other sites. The opposite was true during periods of lower concentrations. In the years that the NPFS site has been operating, the 98th percentile $PM_{2.5}$ concentration during the period 2012-2016 has ranged from 158.4 µg/m³ to 66.8 µg/m^3. Due to the lack of 24-hour concentrations in that range during the study period, it is impossible to assess the extent to which the NPFS site is representative of the study area during the severe periods that determine the 98th percentile concentration.

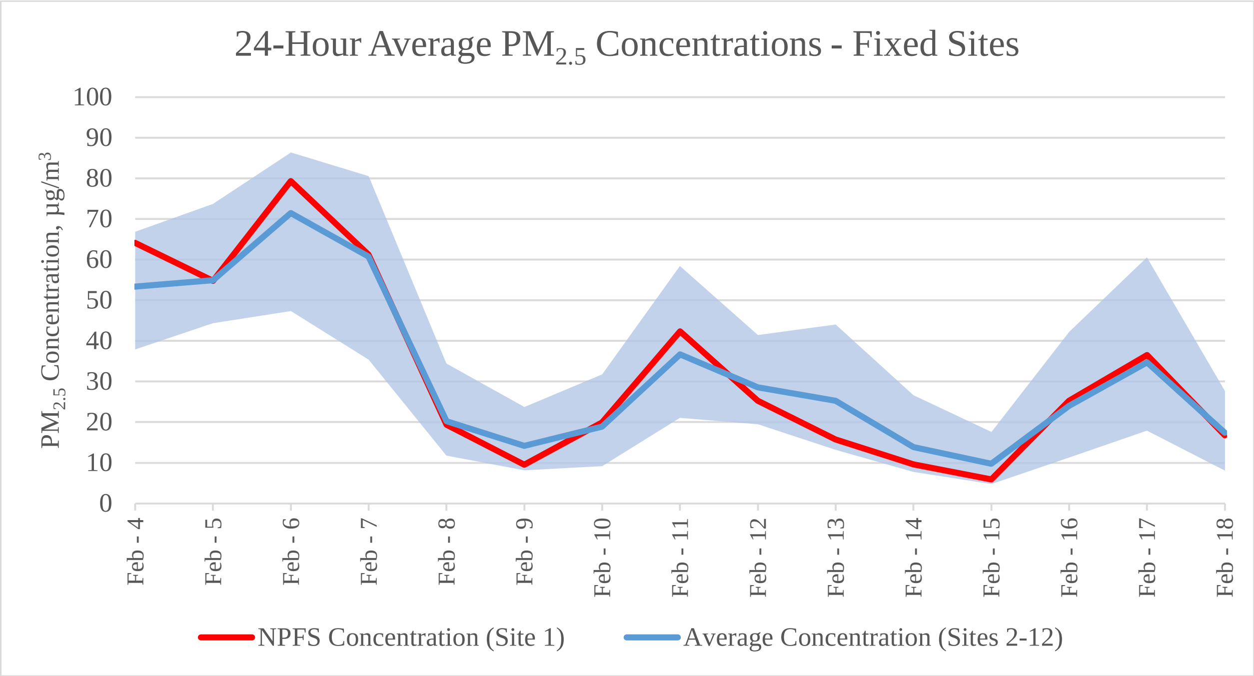

Figure 6-1: 24-hour $PM_{2.5}$ Concentrations Measured at Fixed Sites.

3. Comparisons of $PM_{2.5}$ Concentrations at Site 1 (NPFS) to Sites 2-12: 1-Hour

The 1-hour average concentration distribution among the fixed sites, shown in Figure 6-2, shows a similar trend to the 24-hour average concentrations compared to the average of sites 2-12, with the NPFS site recording elevated $PM_{2.5}$ concentrations during periods of elevated $PM_{2.5}$ concentrations and lower concentrations during periods of depressed $PM_{2.5}$ concentrations.

The NPFS concentration is shown as a red line in Figure 6-2 and is often higher than the average study area values, depicted as a blue line. The maximum and minimum hourly values at sites 2-12 are shown as a light blue area. There are other sites that have significantly higher hourly concentrations than what is measured at the NPFS site.

During times when the hourly concentrations were lower, February 13-16, the average area concentrations are higher than the NPFS site. During this timeframe there are several sites that read significantly higher than the NPFS and other sites that increase the area average above the NPFS site concentration.

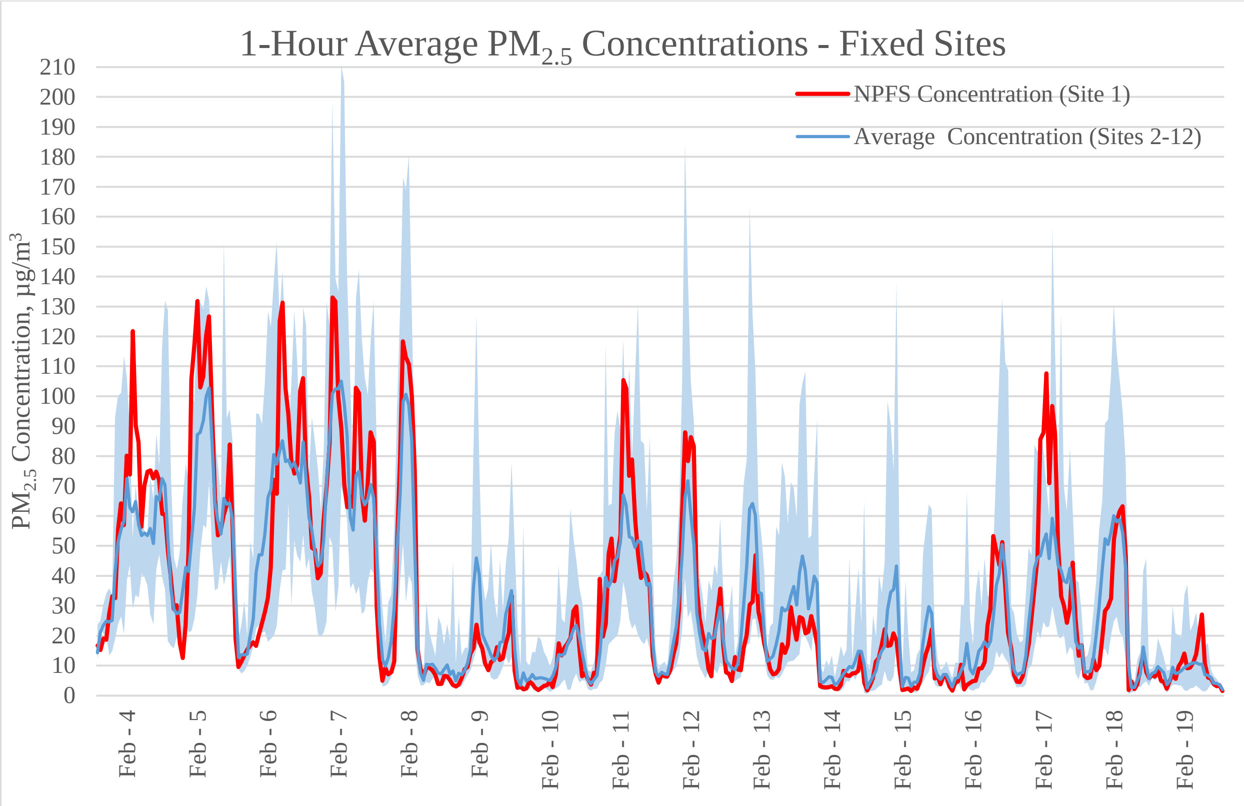

Figure 6-2: Hourly Average $PM_{2.5}$ Data from Fixed Monitoring Sites.

The hourly data show great variability over short periods of time. This pattern indicates that many small localized sources contribute to the air quality problem at varying emission times, rather than a distant industrial source or a small number of high-emitting local sources. Most of the sites exhibit a diurnal pattern where concentrations drop off during the middle of the day and rise during the evening and night. This pattern may be explained by either differences in atmospheric mixing affecting pollution dispersion or behavioral patterns leading to different pollution emission rates.

Mobile Monitoring Results

For the mobile monitoring, samples were taken every second during four 1-hour traverses three times daily, between February 7 and 19, 2017. The three shifts were morning (06:00-10:00), midday (11:00-15:00) and evening (18:00-22:00). On February 14, a night (22:00-02:00) shift was substituted for the midday sampling. The 1-second sampling data was grouped into 'virtual sites' of roughly 25 meters and averaged over the 1-hour and 4-hour periods of each traverse and shift. For data consistency, averages for a few of the 'virtual sites' were compared the same time period for the fixed sites that were close to the traverse. There was good correlation between the two measurement techniques.

Because of the high variability of the data, it is difficult to display the results in a simple summary graph. Figure 6-3 shows a sample, the morning shift on February 11, of the analysis performed for each mobile monitoring shift. The North Pole Fire Station site recorded an exceedance of the 24-hour $PM_{2.5}$ standard on this day. On the left side of Figure 6-3, the 1-hour average concentrations at each of the 'virtual sites' are depicted using an AQI color scale for each of the four 1-hour traverses. On the right, 4-hour average data is presented on a map of the area. In each chart, small dots represent average concentrations at fixed sites over the same averaging period. In the bottom right, below the 4-hour average chart, is a histogram showing the frequency of 25-meter bins that recorded 4-hour concentrations at varying concentration levels. All colors represent a concentration on a color scale that is modelled after the AQI system, shown on the bottom right.

The AQI color system is a standardized system used to communicate air quality information to the public. In general, green represents good air quality, yellow represents moderate air quality, orange represents air quality that is unhealthy for sensitive groups, red represents unhealthy air quality, purple represents very unhealthy air quality, and maroon represents hazardous air quality.

For the Saturday, February 11 morning shift, the air quality for the area was between moderate to unhealthy depending on location within the study area. Most of the concentrations measured were in the range of moderate to unhealthy for sensitive groups.

The concentration maps for all the traverses can be found in Appendix A. In general, the mobile data demonstrate that the concentrations are not homogeneous within the study area. There are localized high areas and the concentrations change from one traverse to the next. The transient concentrations indicate that the area is impacted by many small localized sources. Concentrations are impacted by behavior patterns, weather conditions, and dispersion of the $PM_{2.5}$ pollution.

Saturday February 11 – Morning Run (06:00 to 10:00)

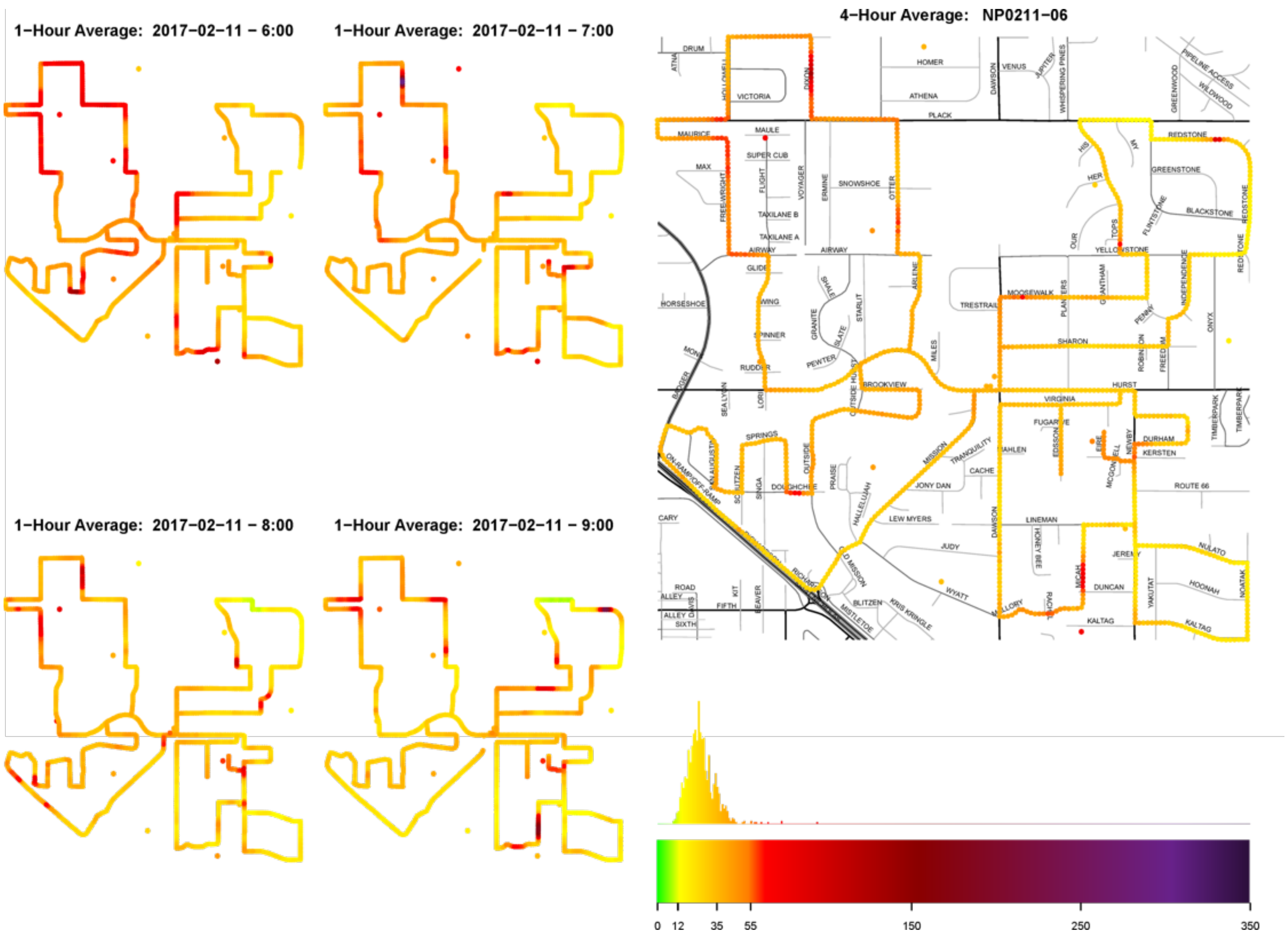

Figure 6-3: Concentrations Displayed by AQI Colors as Measured During the February 11, 2017 Morning Traverses.

Comparability of Fixed and Mobile Data

To determine the comparability of the mobile data to the fixed data for different averaging periods, the average concentrations of bins located adjacent to fixed sites were compared to the average concentrations recorded at the fixed site during the same averaging period. There are six fixed site locations that are close enough to the routes to compare the binned data to the fixed site data. These sites are Site 1, 3, 4, 6, 8, and 10. The 1-hour averaging periods showed moderate correlation, the 4-hour averaging period showed good correlation, and the 24-hour averaging period showed poor correlation. Site 8 shows poor correlation, which may be due to its location being farther from the road than the other sites.

	1-Hour			4-Hour			24-Hour		
Site	Slope	Intercept ($\mu g/m^3$)	r^2	Slope	Intercept ($\mu g/m^3$)	r^2	Slope	Intercept ($\mu g/m^3$)	r^2
1	0.978	2.3	0.928	0.993	2.3	0.923	0.715	3.6	0.564
3	0.872	0.5	0.786	0.894	-0.5	0.907	0.613	15.9	0.153
4	1.029	2.7	0.818	1.151	0.5	0.932	0.953	2.3	0.510
6	1.173	-2.4	0.877	1.126	-0.8	0.907	1.693	-13.9	0.795
8	0.982	2.4	0.528	0.996	2.4	0.577	0.923	1.9	0.348
10	1.116	-0.1	0.878	1.119	0.0	0.927	0.796	2.3	0.813

Table 6-1: Correlations between Fixed Sites and Mobile Data over 1-Hour, 4-Hour, 24-Hour Periods.

Conclusion

The saturation study objective was to determine if the North Pole Fire Station site was representative for the larger North Pole are. Our data show that the air quality problem is widespread.

The data also indicate many individual localized sources of pollution, reaffirming the conclusion that it is primarily local sources including woodstoves that contribute to high concentrations and not large stationary sources outside of study area.

The methodology used allowed for adequate data collection to draw conclusions about the nature of pollution in the study area. It could be used in the future to assess a different or expanded study area.

A regulatory site typically represents the average concentrations measured in an area of approximately 4km in radius, which is the size of the study area. The North Pole Fire Station site does not record the highest or the lowest values in the study area, but is somewhere in the middle. The site is therefore fairly representative of study area concentrations. The data from this study does not support the need to relocate the NPFS regulatory monitoring site.