

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION



Boundary Area Designation Recommendation

Revised Primary Annual PM_{2.5} National Ambient Air Quality Standard

February 6, 2025

Mike Dunleavy, Governor

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Alaska Department of Environmental Conservation
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Boundary Area Designation

1. INTRODUCTION

On February 7, 2024, the United States Environmental Protection Agency (EPA) revised the primary annual National Ambient Air Quality Standard (NAAQS) for fine particulate matter (PM_{2.5}) from 12.0 micrograms per cubic meter (µg/m³) to 9.0 µg/m³. The State of Alaska is required to submit nonattainment area recommendations and appropriate boundaries to the U.S. EPA for the purpose of implementing the 2024 revised primary annual fine particulate matter standard and identifying areas that violate the standards¹.

All areas of the State are recommended as attainment/unclassifiable with the exception of North Pole. The recommended nonattainment area for the PM_{2.5} revised annual NAAQS includes the North Pole Air Quality Control Zone- an existing regulatory zone for the 24-hour PM_{2.5} nonattainment area. The boundary for the annual standard will be smaller than the current 24-hour PM_{2.5} Fairbanks North Star Borough (FNSB) nonattainment boundary. The rationale for this smaller recommended nonattainment area for the annual PM_{2.5} NAAQS is explained in detail in the following sections that evaluate and compare air quality, emissions and meteorology between the North Pole Air Quality Control Zone and adjacent areas and is summarized in Section 7 at the end of this document.

Alaska Department of Environmental Conservation (DEC) staff has performed an analysis using the U.S. EPA's guidance² to determine areas throughout the state not in attainment of the revised standard. Determination of attainment and nonattainment is established by comparing a three-year average of annual PM_{2.5} concentrations to the level of the standard³. The nonattainment area recommendations contained in this report are based on 2021-2023 PM_{2.5} air quality monitoring data. U.S. EPA guidance recommends that in making boundary recommendations for nonattainment areas, the states should evaluate and consider the following five factors:

1. Air Quality Data
2. Emissions and Emissions-Related Data
3. Meteorology
4. Geography and Topography
5. Jurisdictional Boundaries

¹ CAA 107(d)(1)(A).

² EPA Memorandum: Initial Area Designations for the 2024 Revised Primary Annual Fine Particle National Ambient Air Quality Standard(February 7, 2024), https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-designations-memo_2.7.2024_-jg-signed.pdf.

³ 40 CFR Part 50, Appendix N.

Design values based on the 2021-2023 PM_{2.5} monitoring data (Table 1-1) show that some areas in Alaska are already in attainment of the 9.0 µg/m³ standard, with the only violating monitor being in North Pole, Alaska. The city of North Pole lies within the FNSB located in the interior of Alaska. This area is susceptible to certain environmental and meteorological events throughout a yearly timespan that leaves the area prone to experience higher concentrations of suspended pollutants in the air. Among these events are extreme cold climates and low solar activity in the winter months, leading to the generation of a low inversion layer made of stagnant particle suspension, and forest fires in the summer months, leading to the dispersion of organic matter in the area. Further details and analysis contributing to these design values, the movement of particles in the area, the makeup of small particulate matter in the air, and the impact of weather and geographical features that contribute to higher PM_{2.5} concentrations are included in the following sections.

DEC is recommending that the boundaries for the 9.0 µg/m³ standard include the North Pole Air Quality Control Zone established by FNSB⁴ and currently regulated by DEC in efforts to curtail the area's existing violation of the 24-hour PM_{2.5} NAAQS. The boundary for the North Pole Air Quality Control Zone is included in the 24-hour PM_{2.5} State Implementation Plan (SIP)⁵, which has been fully approved by EPA⁶. This recommendation includes city limits along with surrounding residential areas that may contribute to the NAAQS violation as evaluated through five factors outlined above and assessed throughout this document.

Table 1-1 2023 annual design values from PM_{2.5} monitoring sites. Design values are in units: µg/m³.

PM _{2.5} Monitoring Sites	2023 Annual Design Value
Anchorage	5.1
Matanuska-Susitna Valley	5.2
Fairbanks NCore	6.9
Fairbanks A Street	7.5
North Pole Hurst Rd	9.5
Juneau	5.1

1.1 Reasoning for Recommended Boundary

The FNSB Nonattainment Area entered nonattainment status due to FNSB's violation of the 24-hour PM_{2.5} NAAQS upon EPA's revision in 2006⁷. Existing boundaries of the 24-hour PM_{2.5} nonattainment area include a larger portion of the FNSB surrounding the urban areas of Fairbanks

⁴ Fairbanks North Star Borough Ordinance No. 2015-01. (February 27, 2015).

⁵ SIP Section III.D.7.03 Nonattainment Boundary and Design Day Episode Selection (November 19, 2019). <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>.

⁶ 88 Fed. Reg. 84674 (December 5, 2023).

⁷ 74 Fed. Reg. 58688 (November 13, 2009).

and North Pole and their nearby residential areas, and became a designated nonattainment boundary effective December 2009 (Figure 1-1)⁸. The existing boundary was established based on the data of one monitoring unit located within the urban center of Fairbanks. Thus, very little insight and knowledge of the surrounding areas of Fairbanks and North Pole's air quality characteristics and contributing factors were understood at that time. Since the state and EPA last designated an area to address PM_{2.5} NAAQS violations, additional monitoring units at maximum impact sites have been established to better understand the complexity of air quality within the FNSB. Monitors in both the Fairbanks and North Pole urban centers have allowed Alaska DEC staff to evaluate factors that impact local air quality levels and have given valuable insight into the dynamic of PM_{2.5} emissions and its contributors. As a result of increased monitoring efforts and involvement within the Fairbanks North Star Borough, notable differences between the annual PM_{2.5} concentrations in the Fairbanks and North Pole areas are evident. Analysis from monitoring data in these areas coupled with modeling techniques support the State of Alaska's recommendation for a smaller nonattainment area around the city of North Pole and surrounding residential areas to address the revised annual PM_{2.5} NAAQS.

Surrounding locations outside of Fairbanks and North Pole with emissions-producing activity, namely Eielson Air Force Base to the southeast of North Pole, were evaluated in prior boundary designations and found to be of little influence on North Pole/Fairbanks air quality⁹. The impact from this area remains unchanged and was therefore excluded from this boundary recommendation; wintertime high PM_{2.5} days contributing to the annual standard violation occur during strong inversions, low wind speeds, and low transport from Eielson to the North Pole/Fairbanks area. Emissions inventory at Eielson was evaluated and determined to have little significant effect on the North Pole/Fairbanks emissions density¹⁰.

In considering a smaller boundary, DEC first evaluated characteristics in the entire area surrounding Fairbanks and North Pole. As noted in Table 1-1, average design values show that the only location in the state of Alaska in violation of the revised annual PM_{2.5} NAAQS is the North Pole area, with a design value of 9.5 µg/m³ at its maximum impact site (Hurst Rd). The neighboring city of Fairbanks has a design value average of 6.9 and 7.5 µg/m³ at its monitoring sites (NCore and A-Street). Emissions inventories show higher emission density of all combined sources in North Pole than in Fairbanks, with no significant contribution from regions outside these areas.¹¹ There are clear differences in design values and emission densities between Fairbanks and North Pole, however given the proximity of the two urban centers, the possibility exists where emissions from each neighboring town might influence the other. Due to this possibility, DEC staff analyzed

⁸ *Id.* at 58702.

⁹ SIP Section III.D.7.03 Nonattainment Boundary and Design Day Episode Selection (November 19, 2019). <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>

¹⁰ SIP Section III.D.7.06 Appendix. Emission Inventory Worksheet. <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>

¹¹ As shown in detail later in Table 3.1-11 and Table 3.1-13 of Section 3, total emissions within the Fairbanks North Star Borough but outside the existing 24-hour nonattainment area are much lower than emissions within the nonattainment area.

the contribution and influence of PM_{2.5} from Fairbanks and North Pole, respectively, through meteorology and rural monitoring data.

DEC took additional efforts to examine the quarterly averaged PM_{2.5} concentrations for the calendar years 2021-2023. Annual data is separated by quarters where Quarter 1 (Q1) includes January 1 through March 31; Quarter 2 (Q2) includes April 1 through June 30; Quarter 3 (Q3) includes July 1 through September 30; and Quarter 4 (Q4) includes October 1 through December 31. Seasonal patterns are evident within these quarters; summer and winter months exhibit noticeable differences in concentration levels, chemical speciation profiles, and meteorological analysis. Exceedances of the annual NAAQS occurred solely in winter months¹² and, coupled with the clear discrepancies at different times of year, DEC was led to analyze annual data through a seasonal lens to understand air quality in the North Pole and Fairbanks areas.

The close proximity of the two urban areas, yet noticeable differences in their respective design values, warrants considerable effort in understanding the transport, characteristics, make-up and projections of fine particulate matter and its precursors in both Fairbanks and North Pole. These are important to understand not only throughout the entire year, but also during specific seasons when violations occur. Through the examination of air quality data, emissions sources, meteorology, geography, and jurisdictional boundaries, it is DEC's evaluated conclusion that North Pole's air quality characteristics are attributed to local emission sources with little contribution from neighboring urban centers. This in-depth analysis aided in DEC's decision to recommend the North Pole Air Quality Control Zone as the annual PM_{2.5} nonattainment boundary.

1.2 Proposed Nonattainment Area

The State of Alaska recommends the existing North Pole Air Quality Control Zone as the nonattainment area for the revised annual PM_{2.5} NAAQS. The North Pole zone lies within the larger FNSB 24-hour PM_{2.5} nonattainment area and is one of three "Air Quality Control Zones" (AQCZs) dividing the existing nonattainment area¹³. These subareas are included in the 24-hour PM_{2.5} SIP,¹⁴ and have been approved by the EPA¹⁵. The larger nonattainment area, the three air quality control zones and the North Pole Zone are included in Figures 1-1 and 1-2, followed by a detailed description of the boundaries.

The North Pole AQCZ corresponds to the North Pole portion of the 24-hour nonattainment area described later in Section 3 within which controllable source emissions comparisons are shown between the North Pole portion and the remainder of the existing nonattainment area. Those emissions comparisons, as well as ambient monitoring data and air flow comparisons between the

¹² Excluding exceptional events in summer months, April through September.

¹³ 18 AAC 50.030.

¹⁴ SIP Section III.D.7.03 Nonattainment Boundary and Design Day Episode Selection (November 19, 2019).

<https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>

¹⁵ 40 CFR Part 52, 88 Fed. Reg. at 84674 (Dec. 5, 2023)

two portions of the existing 24-hour nonattainment area presented in Section 2 and Section 4, respectively are the basis for this proposed boundary for the annual PM_{2.5} nonattainment area.

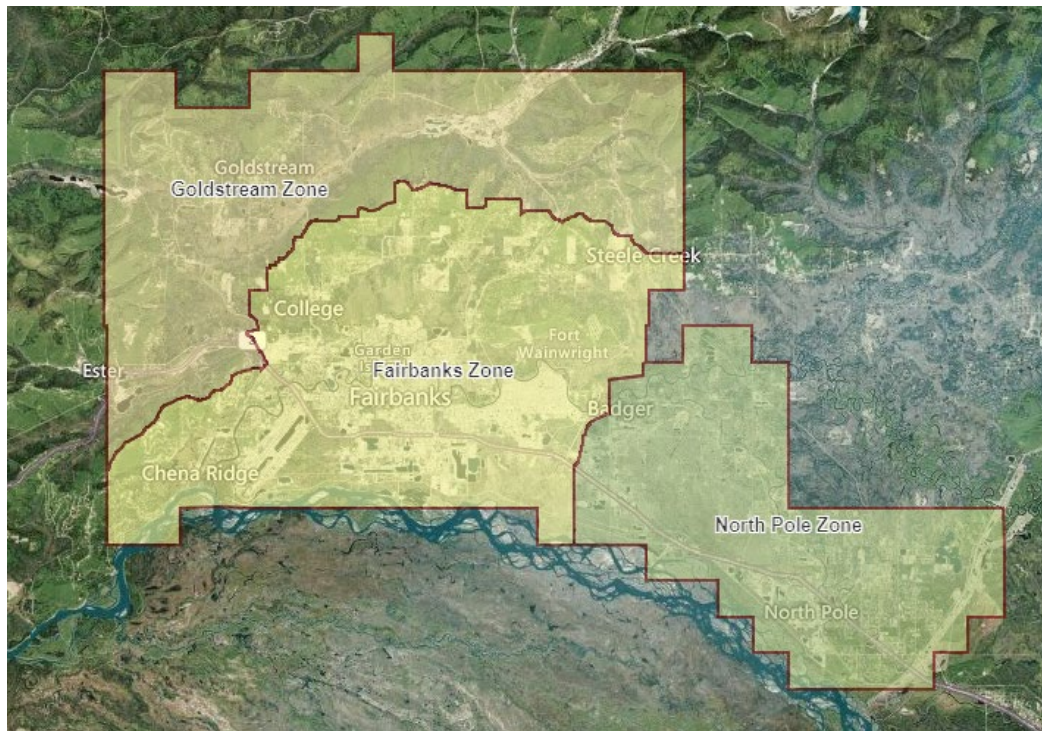


Figure 1-1 Current 24-hour PM_{2.5} Nonattainment area separated into three “Air Quality Control Zones”

The EPA rulemaking establishing the 24-hour PM_{2.5} nonattainment area¹⁶ included the following townships and ranges within the Fairbanks North Star Borough:

- MTRS F001N001W—All Sections;
- MTRS F001N001E—Sections 2–11, 14–23, 26–34;
- MTRS F001N002W—Sections 1–5, 8–17, 20–29, 32–36;
- MTRS F001S001E—Sections 1, 3–30, 32–36;
- MTRS F001S001W—Sections 1–30;
- MTRS F001S002E—Sections 6–8, 17–20, 29–36;
- MTRS F001S002W—Sections 1–5, 8–17, 20–29, 32–33;
- MTRS F001S003E—Sections 31–32;
- MTRS F002N001E—Sections 31–35;
- MTRS F002N001W—Sections 28, 31–36;
- MTRS F002N002W—Sections 32–33, 36;
- MTRS F002S001E—Sections 1–2;
- MTRS F002S002E—Sections 1–17, 21–24; and

¹⁶ 74 Fed. Reg. 58688, 58702 (November 13, 2009).

- MTRS F002S003E—Sections 5–8, 18

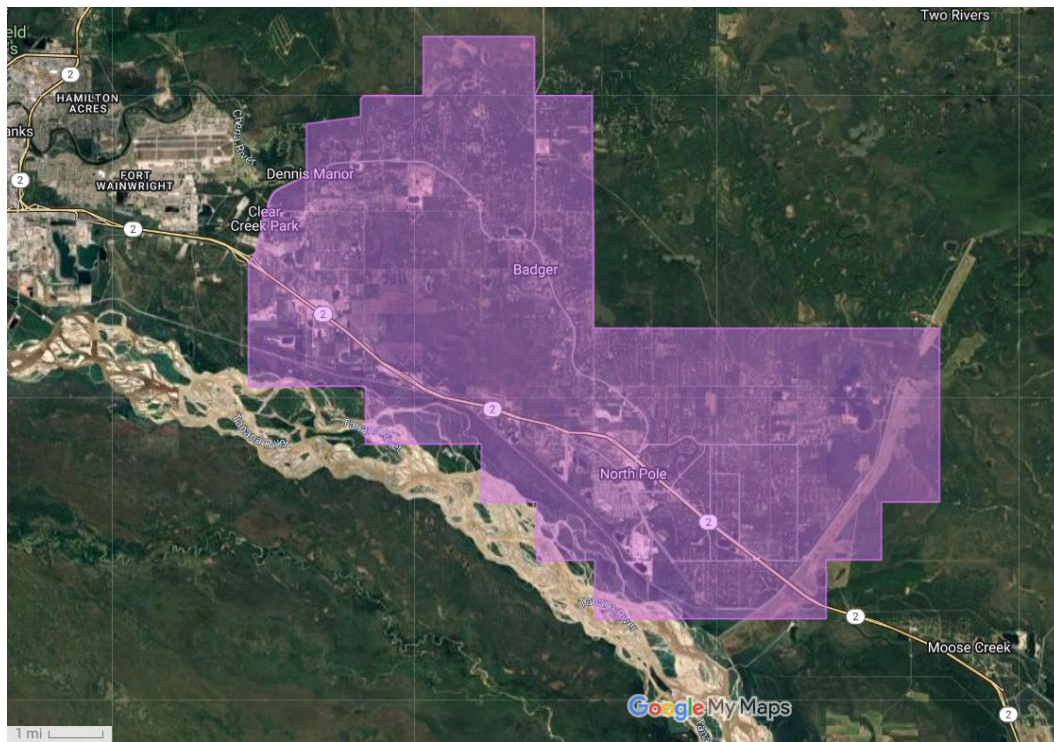


Figure 1-2 North Pole Air Quality Control Zone.

Within the larger nonattainment area, the formal boundary separating the Fairbanks and North Pole Air Quality Control Zones are as follows:^{17, 18}

- Beginning at the northeast corner of MTRS F001S001E Section 10;
- Southwest to Hobgoblin lane;
- South along Hobgoblin Lane to its intersection with Prester John Drive;
- West along Prester John Drive to its intersection with Sonja Street;
- South along Sonja Street and continuing along the section line to its intersection with Badger Road;
- Southwest along Badger Road to its intersection with the northern border of MTRS F001S001E Section 21;
- West along the northern border to the northwest corner of MTRS F001S001E Section 21 NE $\frac{1}{4}$ NW $\frac{1}{4}$;
- South along the western border of MTRS F001S001E Section 21 NE $\frac{1}{4}$ NW $\frac{1}{4}$ to its intersection with Badger Road;

¹⁷ SIP Amendment Vol. II: III.D.7.03, Nonattainment Boundary and Design Day Episode Selection (November 19, 2019), <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>.

¹⁸ 40 CFR Part 52, 88 Fed. Reg. at 84674 (Dec. 5, 2023).

- South on Badger Road to its intersection with the western border of MTRS F001S001E Section 21; and
- South along the section line and ending at the section line's intersection with the southern nonattainment area border at the southwest corner of MTRS F001S001E Section 33.

Figure 1-3 shows the demarcation line between the Fairbanks and North Pole AQCZs based on these boundary descriptions.

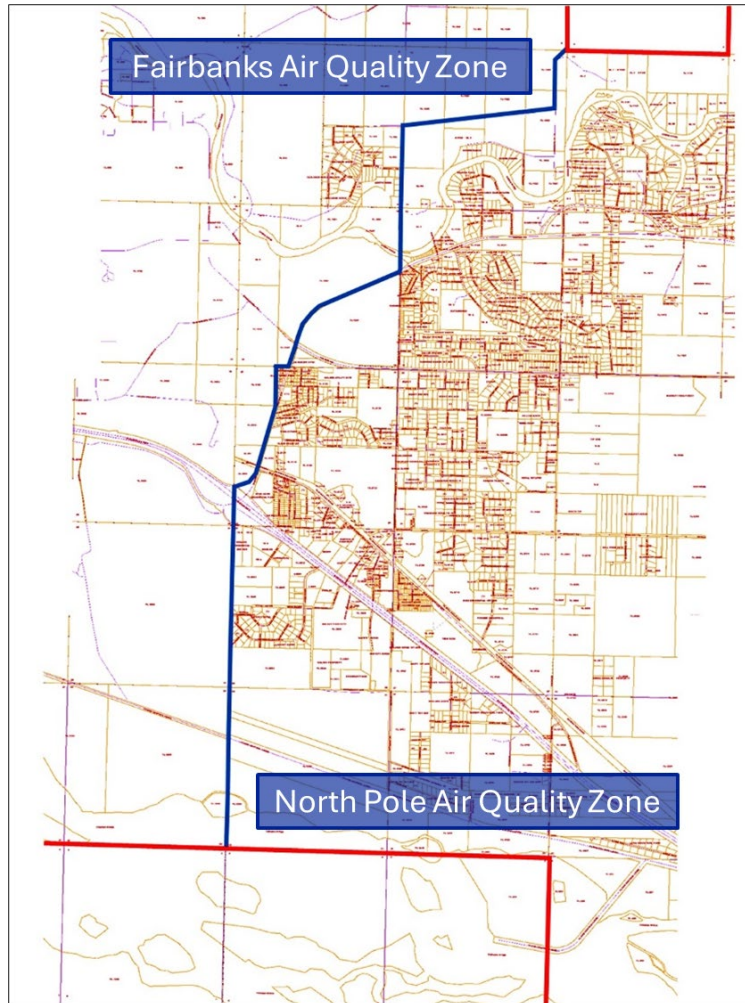


Figure 1-3 Residential boundaries between Fairbanks and North Pole nonattainment zones.

2. FACTOR 1- AIR QUALITY DATA

2.1 *PM_{2.5} Design Value Calculations*

The 24-hour and annual PM_{2.5} design values for areas represented by Alaska's PM_{2.5} monitoring network are summarized in Table 2.1-1. Some of the locations were impacted by wildland fire smoke. For those areas DEC has calculated the design values excluding exceptional events. The exceptional events waiver request documents for the 2022 and 2023 wildland fire seasons can be found on the DEC website, (<https://dec.alaska.gov/air/air-monitoring/guidance/exceptional-events/>).

Table 2.1-1 Design values excluding wildfire smoke exceptional events across Alaska

PM _{2.5} Monitoring Sites	98 th Percentile			Weighted Annual Mean			2023 Design Value	
	2023	2022	2021	2023	2022	2021	24-hour	Annual
Anchorage	14.2	24.0	18.7	4.2	4.9	6.0	19	5.1
Matanuska-Susitna Valley	17.5	21.2	21.2	4.1	4.4*	4.4	25*	5.2*
Fairbanks NCore	20	27.5	29.1	6.4	6.7	8.0	26	6.9
Fairbanks A Street	27.8	24.2	34.1**	7.4	6.7	8.9**	27**	7.5**
North Pole Hurst Rd	51.9	51.2	65.5	9.5	8.3	11.8	56	9.5
Juneau	16.8	23.0	17.1	5.3	5.3	4.7	19	5.1

* Maximum value substitutions applied due to data completeness criteria not being met. Substitutions were performed according to the procedures outlined in 40 CFR Part 50, Appendix N, § 4.2 (c) (i) and § 4.1 (c) (ii).

** Annual values did not meet data completeness criteria. This value is preliminary and subject to the maximum value substitution test as outlined in 40 CFR Part 50, Appendix N. A Street DVs cannot be officially calculated until 2024 monitoring data has been collected and verified.

Table 2.1-1 shows data for the metropolitan area of the state. DEC operates two State and Local Air Monitoring Station (SLAMS) sites in the Anchorage Metropolitan Statistical area, which includes the Municipality of Anchorage and the Matanuska-Susitna Borough. There are three SLAMS sites in the Fairbanks North Star Borough and one site in the City and Borough of Juneau.

As can be seen in the table above, only the North Pole monitor exceeds the 2024 annual design value (DV) of 9 µg/m³. The site is the maximum impact site for the 24-hour average PM_{2.5} nonattainment area. The nonattainment area is split into three air quality control zones, the North Pole, Fairbanks and Goldstream air quality zones. There are two additional monitoring sites in the Fairbanks air quality zone, the NCore and A-Street sites. The A-Street site is considered the maximum impact site for the Fairbanks air quality zone. Monitoring sites in Fairbanks and North Pole are shown in Figure 2.1-1.

DEC experienced some disruption of the normal monitoring process during the COVID-19 pandemic in 2021. During the first quarter of 2021 DEC reported less than 50% data capture for the A-Street SLAMS monitor to the EPA AQS database. While the instruments operated as normal, there was insufficient documentation to guarantee that all quality assurance and control procedures had been observed. DEC decided to flag the data as invalid so as not to bias future regulatory action. With data capture below the required threshold of 50%, no design value can be calculated for periods that include the calendar year 2021. Therefore, the earliest design value for this site will be available for 2024. A later review of the collected data and instrument performance indicates that the instruments continued to perform within the normal operating range. DEC concluded that the collected data is of sufficient quality for weight of evidence purposes and is therefore included in this analysis.



Figure 2.1-1 Monitoring sites located in Fairbanks and North Pole.

2.1.1 $PM_{2.5}$ Air Quality in Fairbanks and North Pole

Initial air quality monitoring in the FNSB for the 24-hour $PM_{2.5}$ nonattainment area was conducted by FNSB staff until September of 2016, when DEC assumed all monitoring activities. The 24-hour

PM_{2.5} nonattainment area was designated based on data from the only SLAMS monitor in the FNSB, the State Office Building site. To better understand the air quality problem, FNSB staff conducted mobile and short-term monitoring in various portions of the nonattainment area and established a long-term site in North Pole. The Hurst Road monitoring site was established in North Pole as the maximum impact site for the 24-hour average PM_{2.5} nonattainment area. Due to increased understanding of air quality in the area, the nonattainment area was split into three air quality zones: Goldstream, Fairbanks, and North Pole zones. Within the Fairbanks area, the 24-hour average PM_{2.5} design value for the NCore site has been below the standard since 2015, when exceptional events due to wildland fire smoke are excluded from the calculations (Table 2.1-2). Due to these observations, DEC established a maximum impact site for the Fairbanks air quality zone, the A-Street monitoring site, in 2018.

During the COVID-19 pandemic, DEC experienced some disruption of the normal monitoring process, specifically at the A-Street site. During the first few months of 2021, DEC staff observed social distancing practices, which caused some interference to normal site operations. While the routine data review indicated that all QA/QC processes were conducted, some of the documentation could not be independently verified. DEC flagged the data during this time as invalid, which resulted in a data capture rate of below 50% for the first quarter of 2021. Based on 40 CFR Part 50 Appendix N, no substitution is allowable for those quarters and therefore no official design value can be calculated. The earliest DV can be calculated using calendar years 2022-2024. A later review of the Quarter 1 collected data in 2021 and instrument performance indicates that the instruments continued to perform within the normal operating range. DEC concluded that the collected data is of sufficient quality for weight of evidence purposes and is therefore included in this analysis. The data for the 1st quarter of 2021 is included in the accompanying document: Appendix A.

Table 2.1-2 Design values excluding wildfire smoke exceptional events in the FNSB nonattainment area

Calendar years 2021-2023	Fairbanks Air Quality Zone	North Pole Air Quality Zone
24-hour PM_{2.5} design value	27*	56
Annual PM_{2.5} design value	7.5*	9.5

Note: Exceedance exceptional event values not included.

* Data from Fairbanks Air Quality Zone A-St monitoring site. Due to QA issues in the first Quarter of 2021, official data capture at the site was below 50% and insufficient data exist for calculating design values. . The information provided here is intended for weight of evidence discussion.

2.1.2 Seasonal Differences in Concentration

PM_{2.5} concentrations in the Interior of Alaska follow a seasonal trend; typically, spring, summer and early fall are characterized by clean ambient air, with the exception of wildland fire smoke

impacts, while the winter months (October to March) show higher daily concentrations into the moderate to unhealthy range depending on location. Wildland fires are a frequent occurrence in the Interior of Alaska, with a typical wildfire season starting in late May and continuing into August. Monitoring data for the past 20 years underscore these trends, with daily concentrations in the summer months in the lower single digits, unless impacted by wildland fire smoke. DEC has posted annual graphs for Fairbanks back to 2000 (<https://dec.alaska.gov/air/air-monitoring/alaska-concerns/community-data/fairbanks-stateofficebldg-ncore-pm25-data/>) and for North Pole back to 2015 on its website (<https://dec.alaska.gov/air/air-monitoring/alaska-concerns/community-data/northpole-pm25-data/>). The shoulder seasons experience higher concentrations typically when temperatures drop below freezing and inversions trap pollution close to the ground.

The same trends are depicted below. Figure 2.1-2 shows the timeseries of daily PM_{2.5} concentrations for 2021 to 2023 at the two Fairbanks monitoring sites, while Figure 2.1-3 shows the North Pole Hurst Road concentrations for the same years.

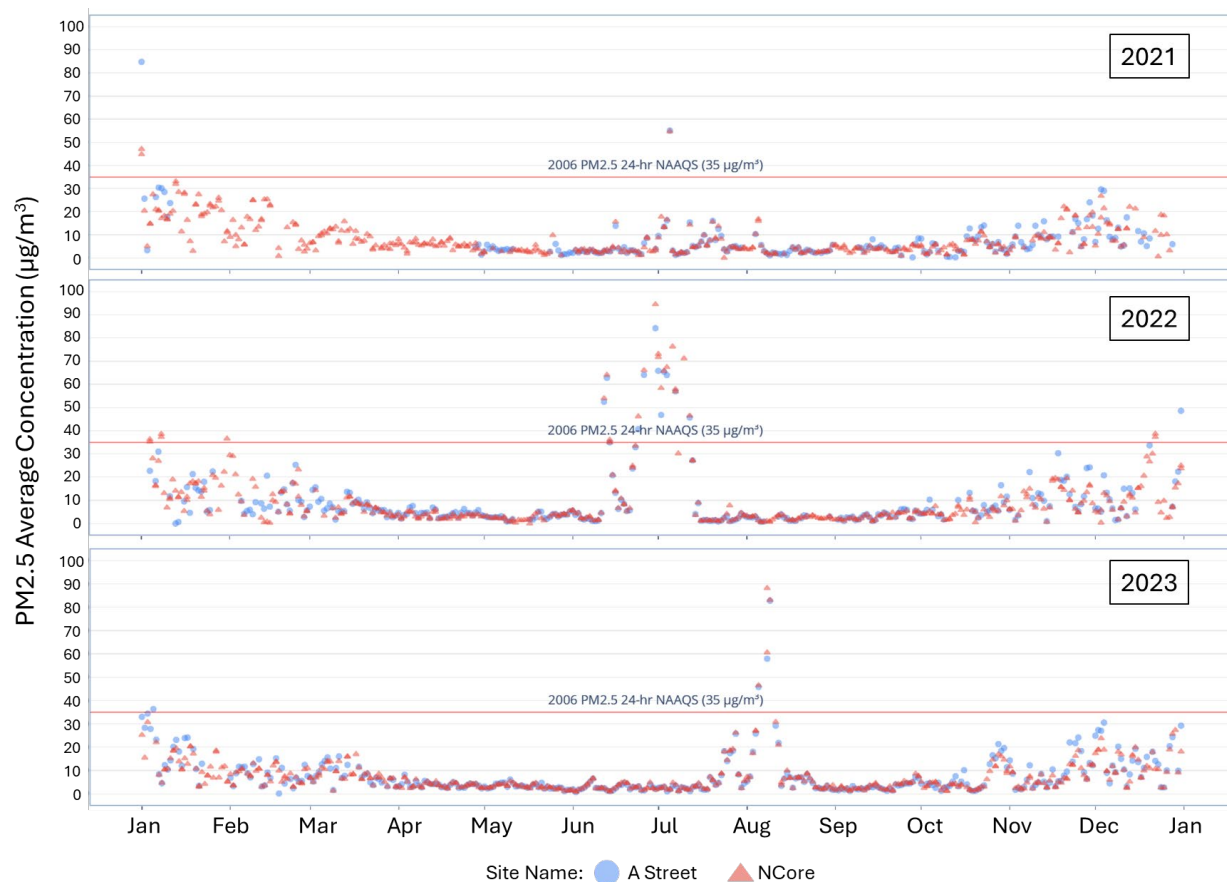


Figure 2.1-2 Timeseries of Fairbanks daily PM_{2.5} concentration in 2021-2023. The red triangles denote data from the NCore site, the blue dots represent A-Street monitoring site data.

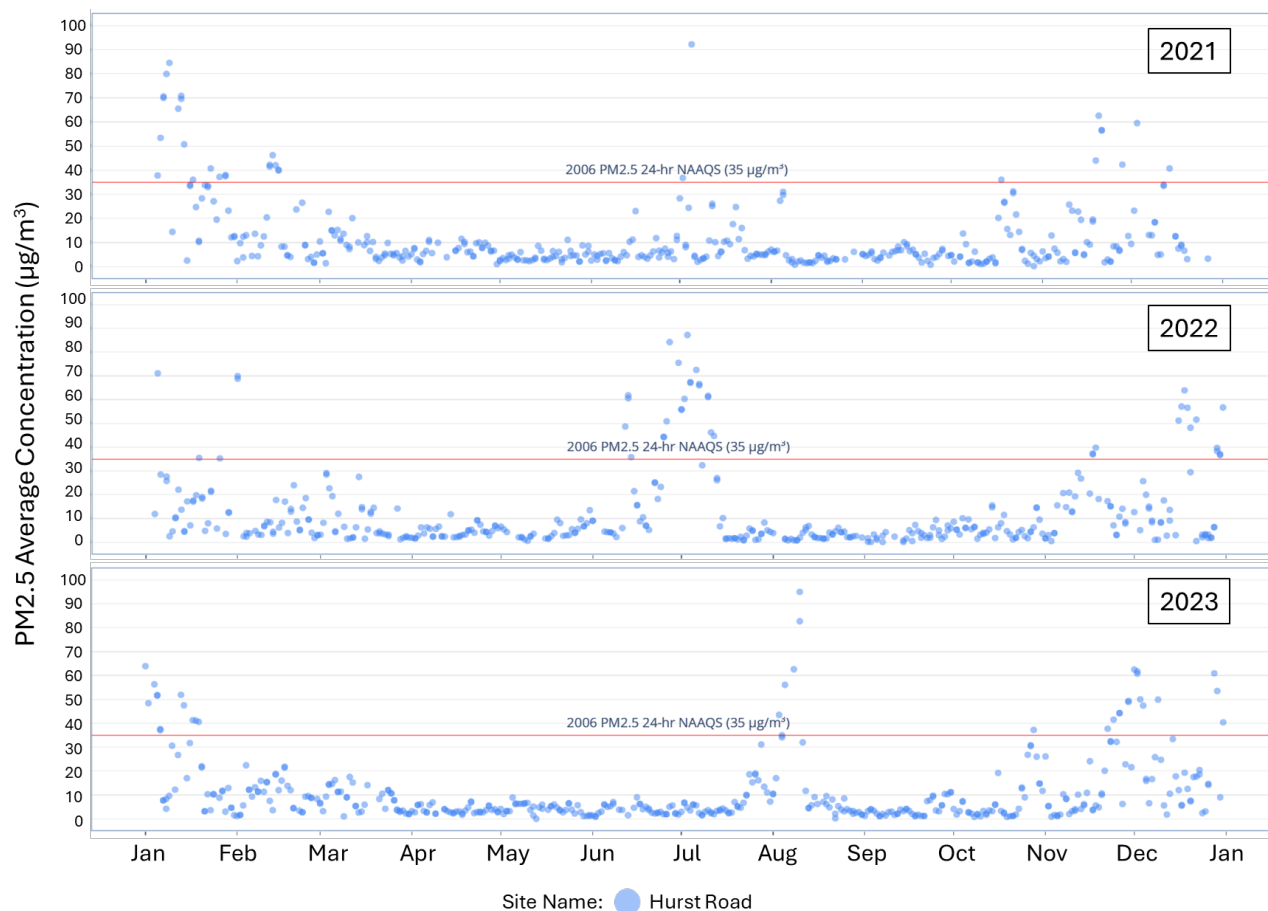


Figure 2.1-3 Timeseries of North Pole daily $PM_{2.5}$ concentration in 2021-2023. The blue dots represent Hurst Road site monitoring data.

The timeseries plots show that $PM_{2.5}$ concentrations follow a similar pattern for all sites and years. The beginning of each year is dominated by high concentrations, then followed by low springtime concentrations. In summer months during the last three years, wildland fire smoke impacted all three sites. The concentration outside of the smoke impact are low in the fall and then increase again towards the end of the year, as wintertime inversions coupled with wood heating emissions cause $PM_{2.5}$ concentrations to rise.

The $PM_{2.5}$ concentrations in the Fairbanks and North Pole areas are highly impacted by inversion events. During winter, the high daily concentrations lead to elevated quarterly concentration for Q1 and Q4, while the daily concentrations for the rest of the year are in the single digits, unless the area experiences wildland fire smoke. Table 2.1-3 shows the quarterly concentrations for the calendar years 2021 through 2023 for the three monitoring sites in Fairbanks and North Pole. The numbers in parentheses are quarterly averaged concentrations excluding days with wildfire flags. When wildfire impacted data is excluded, the quarterly averaged concentration for North Pole is $4.5 \mu\text{g}/\text{m}^3$ for Q2 and $3.8 \mu\text{g}/\text{m}^3$ for Q3. In Fairbanks the average concentration for Q2 and Q3 range from 3.4 to $3.6 \mu\text{g}/\text{m}^3$. (As explained later in Section 3, these quarterly differences in ambient

concentrations are driven almost exclusively by wildfire and prescribed fire emissions, which peak in Q2 and Q3, coupled with greater air flow and the lack of inversions in these quarters.

The non-winter quarterly concentrations are well below the annual standard of 9 µg/m³.

As mentioned above, the A-Street site experienced low data capture in the first quarter of 2021. The data in the table below for Q1 2021 is for weight of evidence use only. The data had been reported as nullified in AQS, because there was insufficient data to prove that the monthly required Quality Assurance (QA) checks had been conducted. The instrument performed normally during this timeframe and QA checks before and after Q1 are within the required ranges.

For the two Fairbanks sites, no daily 24-hour average concentrations were measured above 9 µg/m³ between April 1st to September 31st in 2021 to 2023 unless the sites were impacted by wildland fire smoke. In North Pole, only nine days were measured above 9 µg/m³ between April 1st to September 31st in 2021 to 2023 outside of the wildland fire season, out of which the three days in September were associated with slash burning and the remaining six occurred in April and were associated with nighttime inversions and most likely related to home heating emissions¹⁹. The data clearly indicates that non wildfire smoke impacted non-winter concentrations in the FNSB do not contribute to an exceedance of the annual PM_{2.5} standard.

Table 2.1-3: Quarterly averaged PM_{2.5} from 2021 -2023 in the FNSB

Hurst Rd, North Pole							
	Q1	Q2	Q3	Q4	Annual	DV	# days impacted by wildland fire smoke
2021	20.7	5.8 (5.0)	8.2 (4.3)	12.8	11.9 (10.7)		28
2022	11.8	12.8 (4.8)	12.9 (3.2)	13.3	12.7 (8.2)		28
2023	14.6	3.8	12.5 (3.8)	15.8	11.7 (9.5)	12.1 (9.5)	20
Averages		4.5	3.8				
A-St, Fairbanks							
	Q1	Q2	Q3	Q4	Annual	DV	# days impacted by wildland fire smoke
2021	17.7¹	3.5 (3.3)	5.5 (4.5)	8.7	8.9 (8.6)		11
2022	9.6	13.2 (3.7)	10.9 (2.7)	10.6	11.1 (6.7)		28
2023	11.2	3.3	9.6 (3.5)	10.1	8.6 (7)	9.3 (7.5)	16
Averages		3.4	3.6				
NCore, Fairbanks							
	Q1	Q2	Q3	Q4	Annual	DV	# days impacted by wildland fire smoke
2021	13.8	4.2 (4.0)	5.4 (3.8)	8.3	7.9 (7.5)		12
2022	11.7	12.7 (3.1)	11.3 (2.6)	9.4	11.3 (6.7)		27
2023	9.8	3.2	11.8 (3.7)	8.8	8.4 (6.4)	9.2 (6.9)	16
Averages		3.4	3.4				

¹ Data with QA flag used for weight of evidence purposes only.

¹⁹ Personal communication, DEC Monitoring Staff, September 2024.

DEC is in the process of developing the Exceptional Events Waiver Request for EPA review and approval for all wildland fire smoke impacted days in 2022 and 2023 in Fairbanks and North Pole. The data impacted by wildland fire smoke in the Fairbanks/North Pole nonattainment area during the 2022 and 2023 wildland fire season can be found in the accompanying document: Appendix A. DEC will request exclusion of 29 days in 2022 and 21 days in 2023. A full discussion of the exceptional events can be found at <https://dec.alaska.gov/air/air-monitoring/guidance/exceptional-events/>.

2.2 Chemical Speciation

2.2.1 Introduction

The air quality data available to analyze includes two super-SASS²⁰ speciation monitors in the FNSB nonattainment area, they are co-located with a Federal Reference Method (FRM) monitor at Hurst Road and NCore.²¹ The third monitor, A-Street, uses speciation from NCore and a local FRM monitor. An analysis of speciation for all three monitor locations is discussed below, including a description of the methodology used to create speciation plots and a seasonal comparison for wintertime (quarters 1 and 4) and summertime (quarters 2 and 3) speciation. For all three monitors, wintertime averages for quarter 1 and 4 are above the annual standard due to strong wintertime inversions and cold temperatures trapping pollutants near the ground. The speciation for PM_{2.5} in the winter is well studied from analysis done for the 24-hr PM_{2.5} nonattainment area²². The components of PM_{2.5} in the Fairbanks area are organic carbon (OC), elemental carbon (EC), sulfate (SO₄), nitrate (NO₃), ammonium (NH₄), other primary particulates (OPP) and lastly particle bound water (PBW) associated with the filter and the blank that must be accounted for to have the speciation filter equal the FRM filter. The process to make the filters equal and speciate the FRM PM_{2.5} data is an EPA method that was followed and approved in the PM_{2.5} 24-hr SIPs is called sulfate, adjusted nitrate, derived water, inferred carbonaceous material balance approach (SANDWICH.)^{23,24}

²⁰ Met One Instruments: Speciation Air Sampling System.

²¹ https://dec.alaska.gov/media/kmrfthes/adec_2024-annual-network-plan_final_20240627.pdf

²² ADEC, Amendments to: State Air Quality Control Plan, Vol. II: III.D.7.8, Modeling at III.D.7.8, <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-2024-amendment-serious-sip/>

²³ US EPA, 2017, Modeling Guidance for Demonstrating Air Quality Goals for Ozone, PM_{2.5} and Regional Haze [chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.epa.gov/sites/default/files/2020-10/documents/o3-pm-rh-modeling_guidance-2018.pdf](https://www.epa.gov/sites/default/files/2020-10/documents/o3-pm-rh-modeling_guidance-2018.pdf)

²⁴ Frank NH. Retained nitrate, hydrated sulfates, and carbonaceous mass in federal reference method fine particulate matter for six eastern U.S. cities. J Air Waste Manag Assoc. 2006 Apr;56(4):500-11. doi: 10.1080/10473289.2006.10464517. PMID: 16681214.

2.2.2 Methodology

Figures 2.2-1 through 2.2-6 exhibit the per-site species fraction and average concentrations for each quarter over 2021-2023. Each monitor has four plots, representing each of the four quarters (e.g. Hurst Q1 2021-2023, Hurst Q2 2021-2023, etc.). The R programming language was used to perform the analysis, and SANDWICH was used to correct for inherent differences in the measurement process. The SANDWICH algorithm and R scripts mirror the Excel spreadsheet developed by ADEC for the 24-hour Serious SIP²⁵.

First, two datasets containing speciation and FRM data for the entire country from 2021-2023 were downloaded from the EPA tool AirData and imported into the R development environment RStudio.²⁶ Next, the data was cleaned to produce a dataset that contained the data required for the analysis. The variables and EPA parameter codes required to produce the SANDWICH analysis are as follows:

- PM_{2.5} (88101)
- Ammonium Ion (88301)
- Nitrate (88306)
- Sulfate (88403)
- Organic Carbon TOR (88320)
- Elemental Carbon TOR (88321)
- Calcium (88111)
- Silicon (88165)
- Titanium (88161)
- Iron (88126)

The EPA parameter codes have only one method for each component except for the organic carbon which have two methods. The organic carbon method used in the analysis was Total Organic Reflectance (TOR), which is appropriate for the type of filter in the monitor. The SANDWICH algorithm was then applied to each day that contained both speciation and FRM data. This produced a dataset that contained corrected speciation data for every 3 days over the time span, except where data could not be collected or verified. Exceptional events (EEs) and fire days were compared to the SANDWICH dataset, so that each entry in the new dataset had a flag describing whether that day had been an exceptional event.

Each quarter's average PM_{2.5} for the years 2021-2023 was computed using the data from Table 2.1-3. The data from each monitor and these quarterly average PM_{2.5} values were passed through a statistics function that followed the annual standard guidance from the EPA to produce species fractions and concentrations for each quarter. These values were then plotted using the R package ggplot2 to produce Figures 2.2-1 through 2.2-6. The following symbols were used to represent the different species of PM_{2.5}:

²⁵ SIP Section III.D.7.08. <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>.

²⁶ https://aqs.epa.gov/aqsweb/airdata/download_files.html

- EC: Elemental Carbon
- NH₄^r: Ammonium Ion
- NO₃: Nitrate
- OC: Organic Carbon
- OPP: Other Primary Particulates
- PBW: Particle Bound Water
- SO₄: Sulfate

Hurst Road (North Pole)- Winter

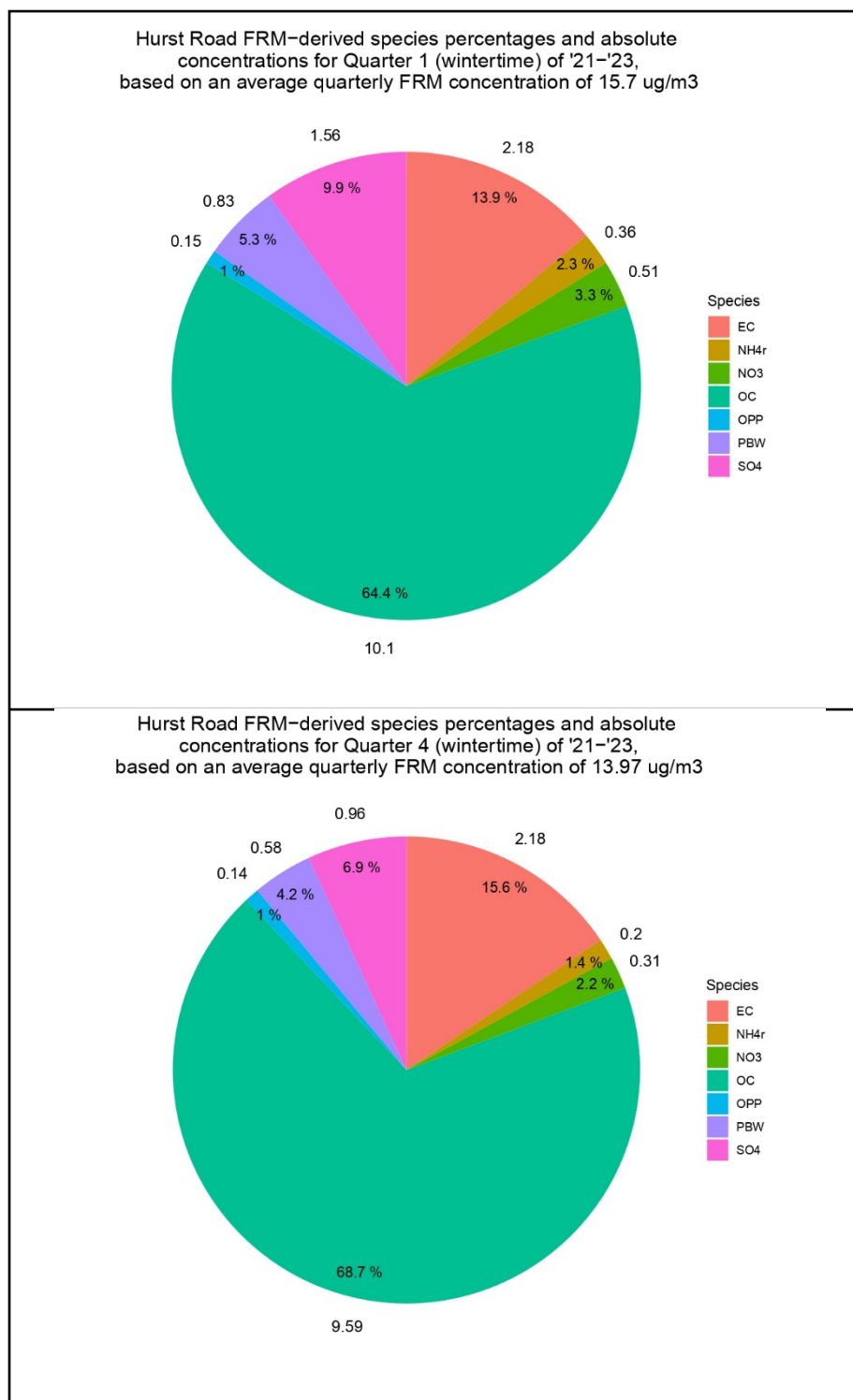
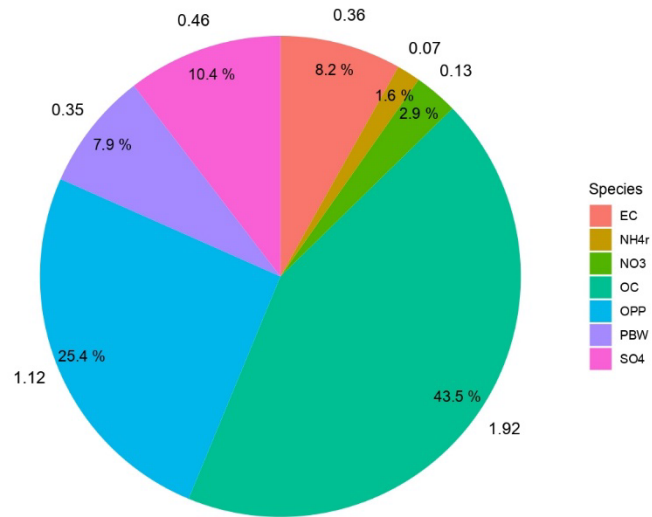


Figure 2.2-1: Hurst Road (North Pole) FRM-derived species percentages and absolute concentrations (located beside species type, ug/m³) for Quarters 1 and 4 of years 2021-2023, based on a quarterly FRM average for all three years for each quarter. Quarters 1 and 4 represent wintertime months.

Hurst Road (North Pole)- Summer

Hurst Road FRM-derived species percentages and absolute concentrations for Quarter 2 of '21-'23, based on an average quarterly FRM concentration of 4.4 ug/m3



Hurst Road FRM-derived species percentages and absolute concentrations for Quarter 3 of '21-'23, based on an average quarterly FRM concentration of 3.77 ug/m3

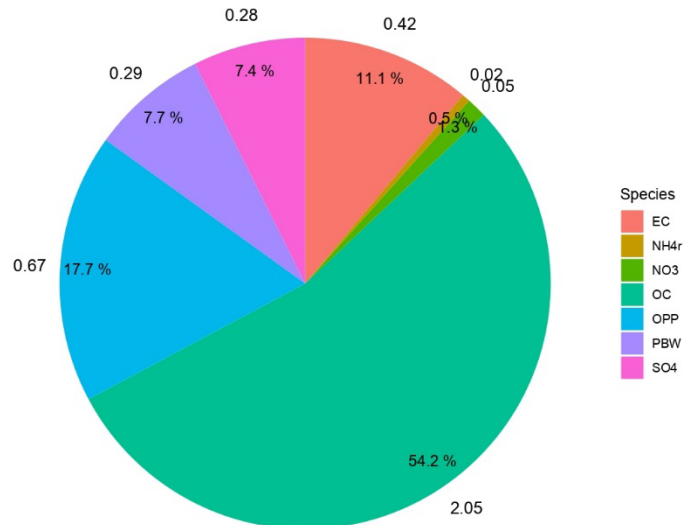


Figure 2.2-2: *Hurst Road (North Pole) FRM-derived species percentages and absolute concentrations (located beside species type, $\mu\text{g}/\text{m}^3$) for Quarters 2 and 3 of years 2021-2023, based on a quarterly FRM average for all three years for each quarter. Quarters 2 and 3 represent summertime months.*

NCore (Fairbanks)- Winter

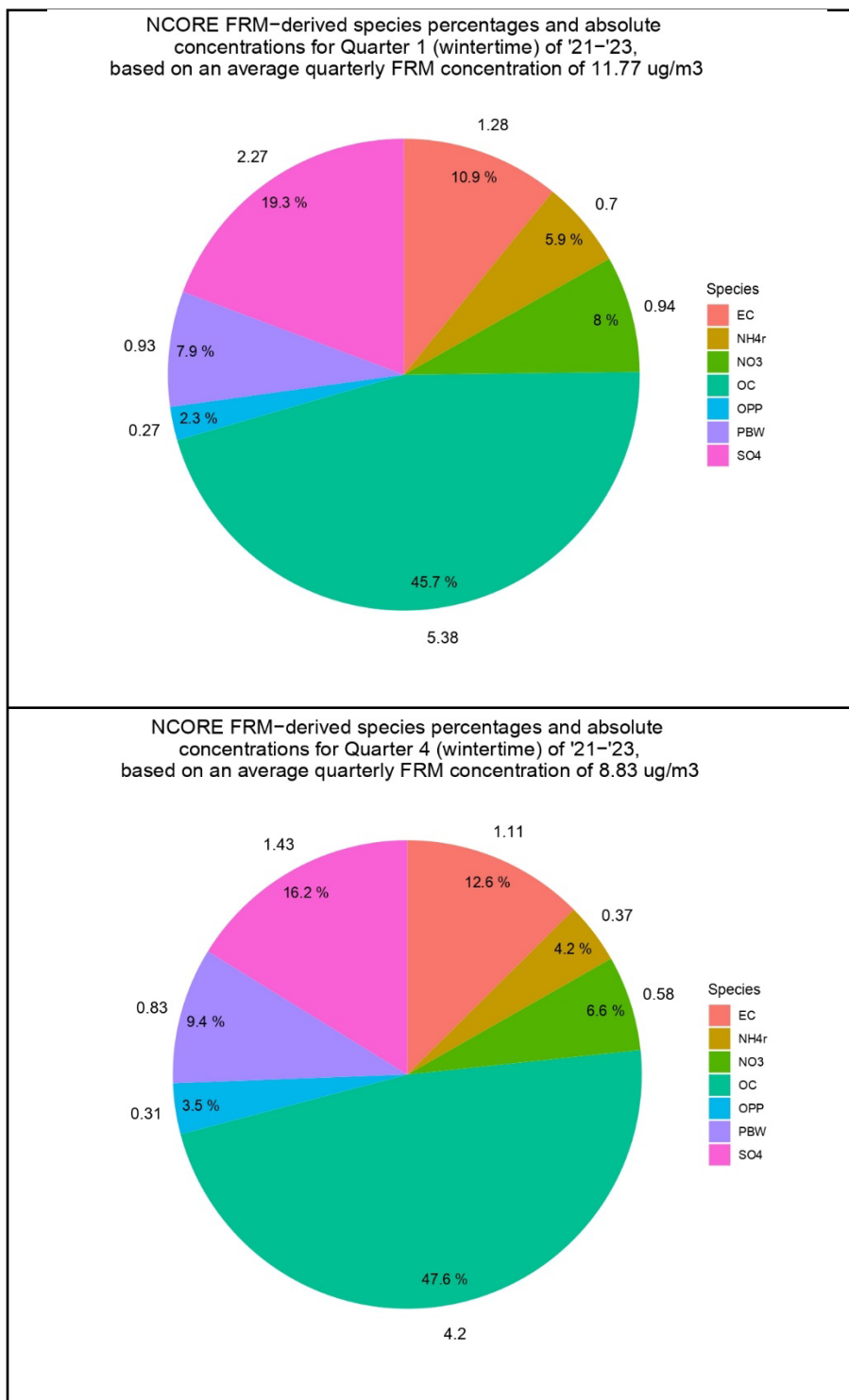


Figure 2.2-3: NCore (Fairbanks) FRM-derived species percentages and absolute concentrations (located beside species type, $\mu\text{g}/\text{m}^3$) for Quarters 1 and 4 of years 2021-2023, based on a quarterly FRM average for all three years for each quarter. Quarters 1 and 4 represent wintertime months.

NCore (Fairbanks)- Summer

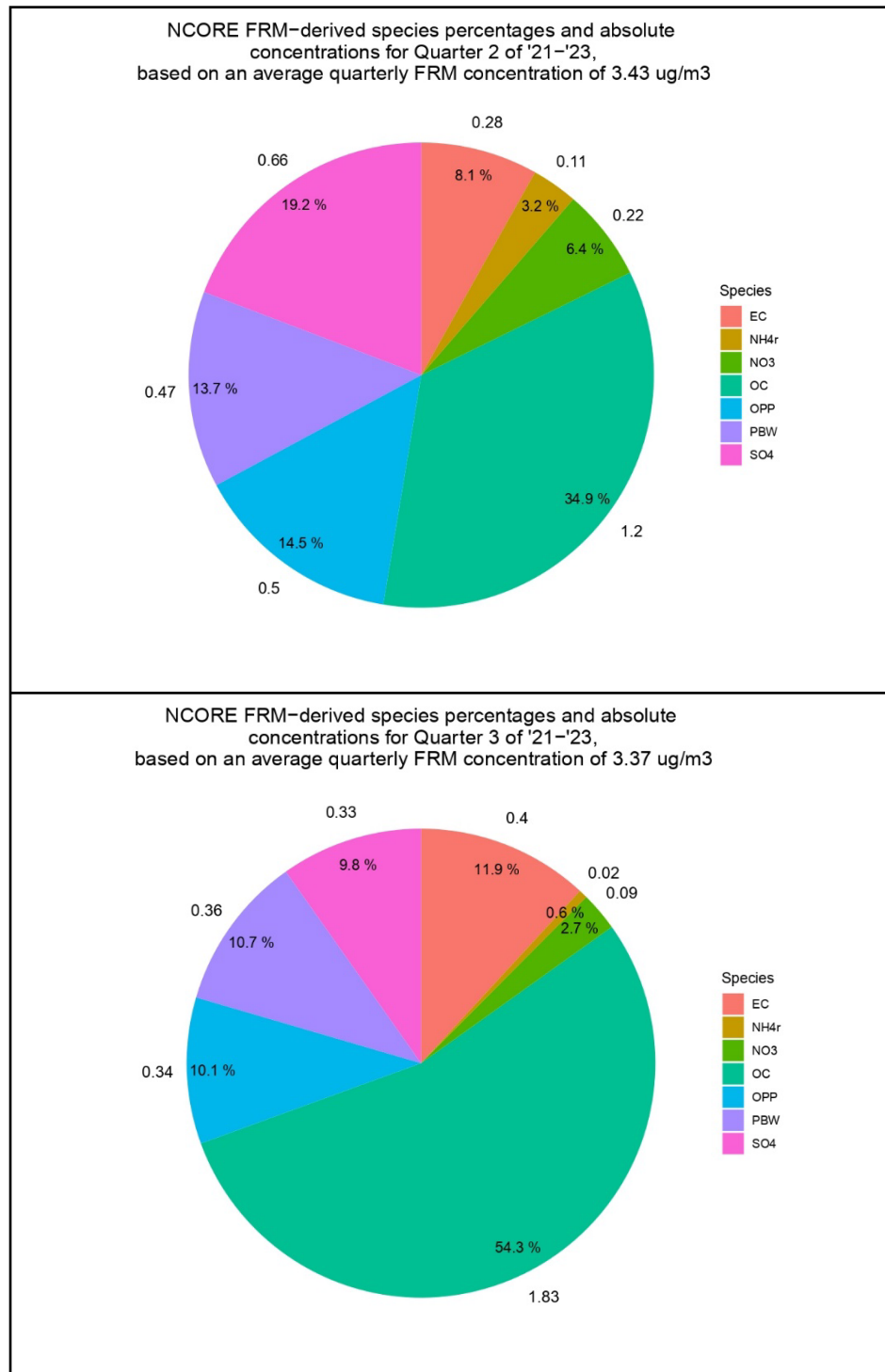


Figure 2.2-4: NCore (Fairbanks) FRM-derived species percentages and absolute concentrations (located beside species type, $\mu\text{g}/\text{m}^3$) for Quarters 2 and 3 of years 2021-2023, based on a quarterly FRM average for all three years for each quarter. Quarters 2 and 3 represent wintertime months.

A-Street (Fairbanks)- Winter

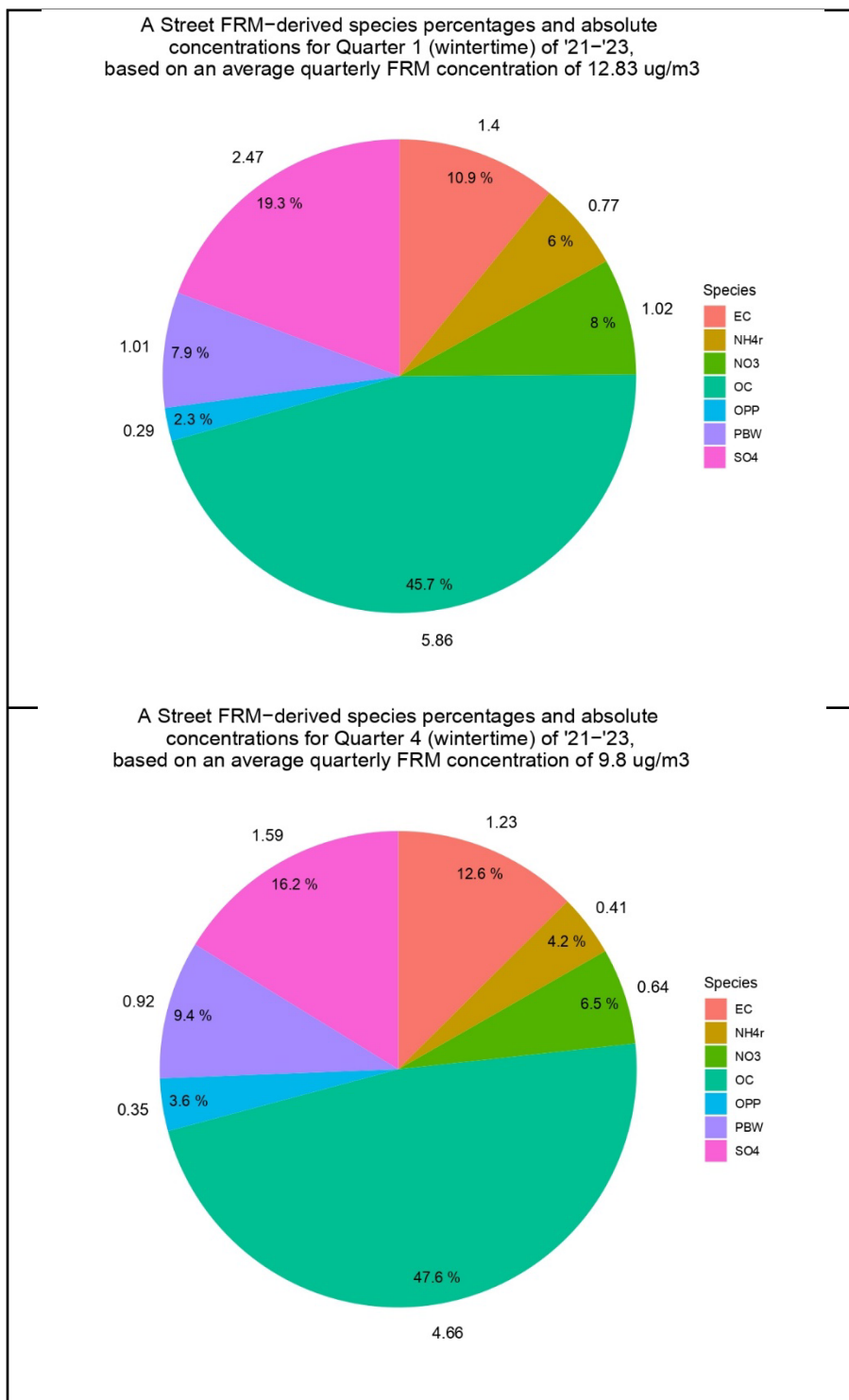


Figure 2.2-5 A-Street (Fairbanks) FRM-derived species percentages and absolute concentrations (located beside species type, $\mu\text{g}/\text{m}^3$) for Quarters 1 and 4 of years 2021-2023, based on a quarterly FRM average for all three years for each quarter. Quarters 1 and 4 represent wintertime months.

A-Street (Fairbanks)- Summer

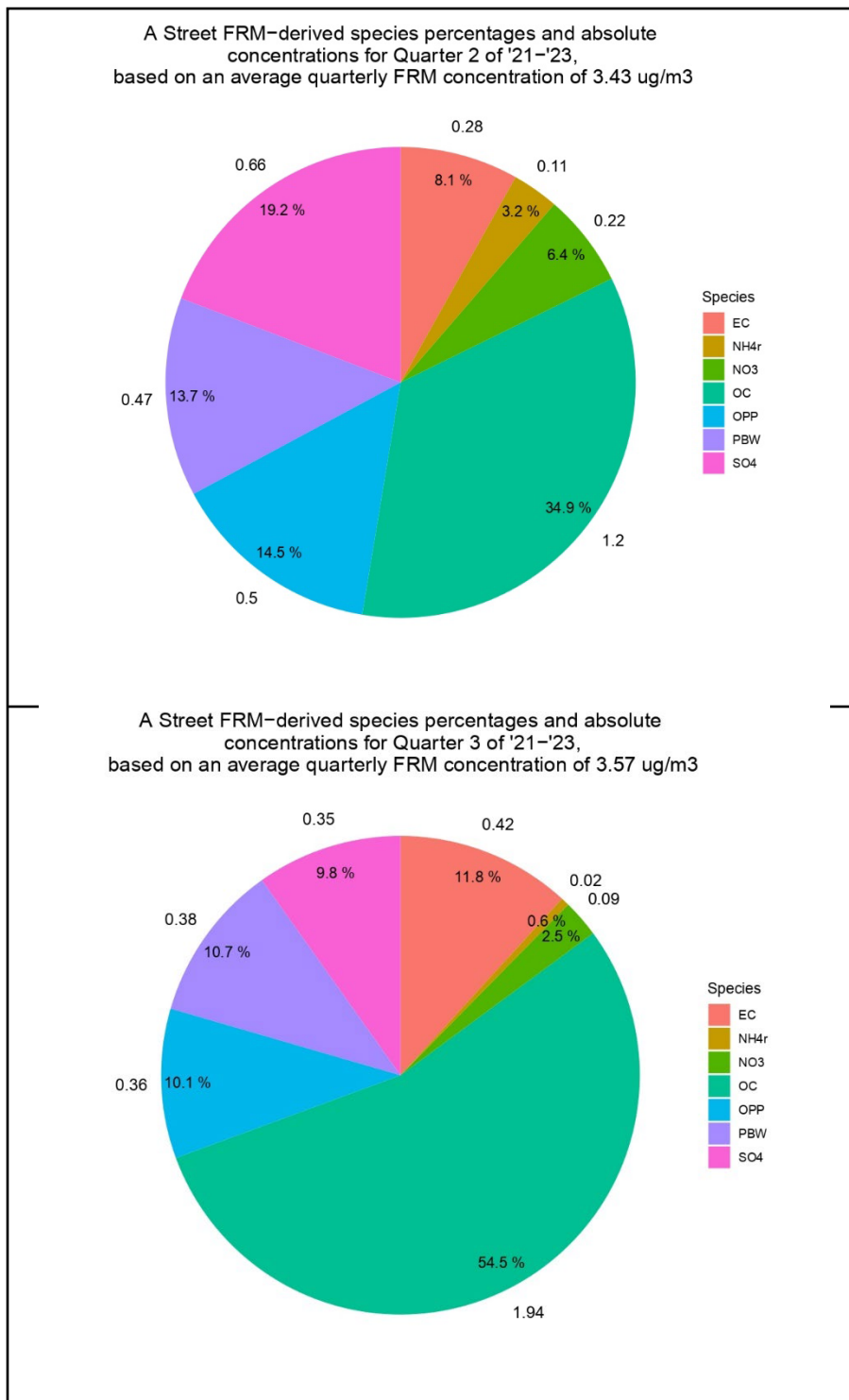


Figure 2.2-6 *A-Street (Fairbanks) FRM-derived species percentages and absolute concentrations (located beside species type, $\mu\text{g}/\text{m}^3$) for Quarters 2 and 3 of years 2021-2023, based on a quarterly FRM average for all three years for each quarter. Quarters 2 and 3 represent summertime months.*

2.2.3 Speciation analysis

In order to characterize what contributes to the high $\text{PM}_{2.5}$ days for the annual standard $> 9 \mu\text{g}/\text{m}^3$, the components of $\text{PM}_{2.5}$ are analyzed. All four quarters for years 2021-2023 are averaged for the winter and summer for the Hurst Road and NCore monitors in North Pole and Fairbanks, respectively. For both monitors, the averages of the summer quarters (Q2 and Q3) range between 3 and 5 $\mu\text{g}/\text{m}^3$ and wintertime quarters (Q1 and Q4) range between 10 and 15 $\mu\text{g}/\text{m}^3$. The largest contributing source sector to high $\text{PM}_{2.5}$ days in the winter is space heating (70% at the Hurst Road monitor in North Pole for years 2017-2021 high winter-time days), which includes wood stoves and fuel oil. The wood stove and fuel oil components of $\text{PM}_{2.5}$ are characterized by organic carbon and sulfate. The dominant species monitored at Hurst Road, NCore, and A-Street in wintertime months (Q1 and Q4) are organic carbon, elemental carbon, and sulfate (Figures 2.2-1 to 2.2-6). The speciation in the summer months (Q2 and Q3) is on average 48% organic carbon, similar in composition to Denali National Park monitor results (see Figure 2.3-3). The total organic carbon in winter months (Q1 and Q4) at the violating monitor in North Pole of 10 $\mu\text{g}/\text{m}^3$ compared to 2 $\mu\text{g}/\text{m}^3$ in the summer (Q2 and Q3). During the winter months when the average of $\text{PM}_{2.5}$ is 15 $\mu\text{g}/\text{m}^3$, a majority of the exceedance is organic carbon.

The difference from winter to summer is a much larger fraction from other primary particulates (OPP) in the summer months at all three monitors. The OPP component makes up 12-15% of $\text{PM}_{2.5}$ in quarter 2 (April-June) and 6 - 9% in quarter 3 (July-September). These percentages are higher in summer months, but even higher in April through June from the long-range transport, a trend that is similar to the makeup of SOIL at Denali National Park throughout the year (Figure 2.3-3). The primary particulates in winter are very low at 2 - 4% of the $\text{PM}_{2.5}$ in the winter and one of the main seasonal differences. The other primary particulates ($\text{OPP} = \text{Si} \times 3.72 + \text{Ca} \times 1.63 + \text{Fe} \times 2.42 + \text{Ti} \times 1.94$) contain silica, calcium, iron and titanium and are generally associated with soil, road dust and long-range transport of dust from Asia²⁷. The OPP fraction in the Fairbanks and North Pole areas speciation monitors is similar to SOIL in the IMPROVE monitors used for visibility in the Regional Haze plan ($\text{SOIL} = 2.42 \times \text{Fe} + 2.49 \times \text{Si} + 1.94 \times \text{Ti} + 1.63 \times \text{Ca}$). Overall, the summer months with increased OPP, the average total $\text{PM}_{2.5}$ is 3-5 $\mu\text{g}/\text{m}^3$, and not in exceedance of the standard. The summer quarters 2 and 3 have the $\text{PM}_{2.5}$ components similar as winter, but at much lower concentrations. The portion of the sulfate in the summer is associated with background concentrations, modeling for the 24-hr standard shows the background for sulfate at 0.4 $\mu\text{g}/\text{m}^3$ in the winter according to the EQUATES²⁸ model used for the background conditions²⁹. In addition, the Denali monitor has been analyzed for the Regional Haze plan,³⁰ using back trajectory modeling, GEOSCHEM and photochemical grid modeling completed by EPA in 2016 and a

²⁷ <https://dec.alaska.gov/air/anpms/regional-haze-planning/>

²⁸ <https://www.epa.gov/cmaq/equates>

²⁹ III.D.7.09 Modeling Chapter, <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-proposed-serious-sip-amendments-2024/>

³⁰ <https://dec.alaska.gov/air/anpms/regional-haze/sip/>

majority of the sulfate, up to 50% of PM_{2.5} is attributed to long range transport of international pollution.

The wintertime speciation associated with quarters 1 and 4 are similar to the 24-hr PM_{2.5} standard with high organic carbon and sulfate. The moderate and serious area state implementation plans for the 24-hr PM_{2.5} standard and associated control strategies lower the PM_{2.5} for the annual standard as well and therefore lower the absolute concentration of organic carbon and sulfate.^{31,32}

³¹ <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>, Section III.D.7.07

³² <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip/>, Section 5.07

2.3 Rural Contributions

This section aims to estimate the rural contribution to urban PM_{2.5} concentration, measured at violating regulatory monitor sites, and thereby provide additional evidence to consider in deciding which nearby areas should be included in a designated nonattainment area. To establish background PM_{2.5} concentration levels from regional sources, DEC employed the use of urban increment analysis released by EPA as well as additional aerosol data from monitors located in rural locations in Alaska. Aerosol data is collected by the Monitoring of Protected Visual Environment (IMPROVE) network, a multi-agency, nation-wide visibility monitoring network which began in support of the EPA's Regional Haze Rule (RHR). Each IMPROVE monitor is located in a Federal Class I area (CIA) in the state. These monitors exist in five areas: Denali National Park (Denali NP), Trapper Creek, Tuxedni Wildlife Area (WA), Simeonof WA, and Bering Sea WA (Figure 2.3-1 and Table 2.3-1). The monitor in closest proximity to the Fairbanks North Star Borough is located in Denali National Park, which lies approximately 90 miles southwest from the urban centers of Fairbanks and North Pole in the center of the Alaska Range. This monitoring unit will be used to broadly examine PM_{2.5} in rural sources.

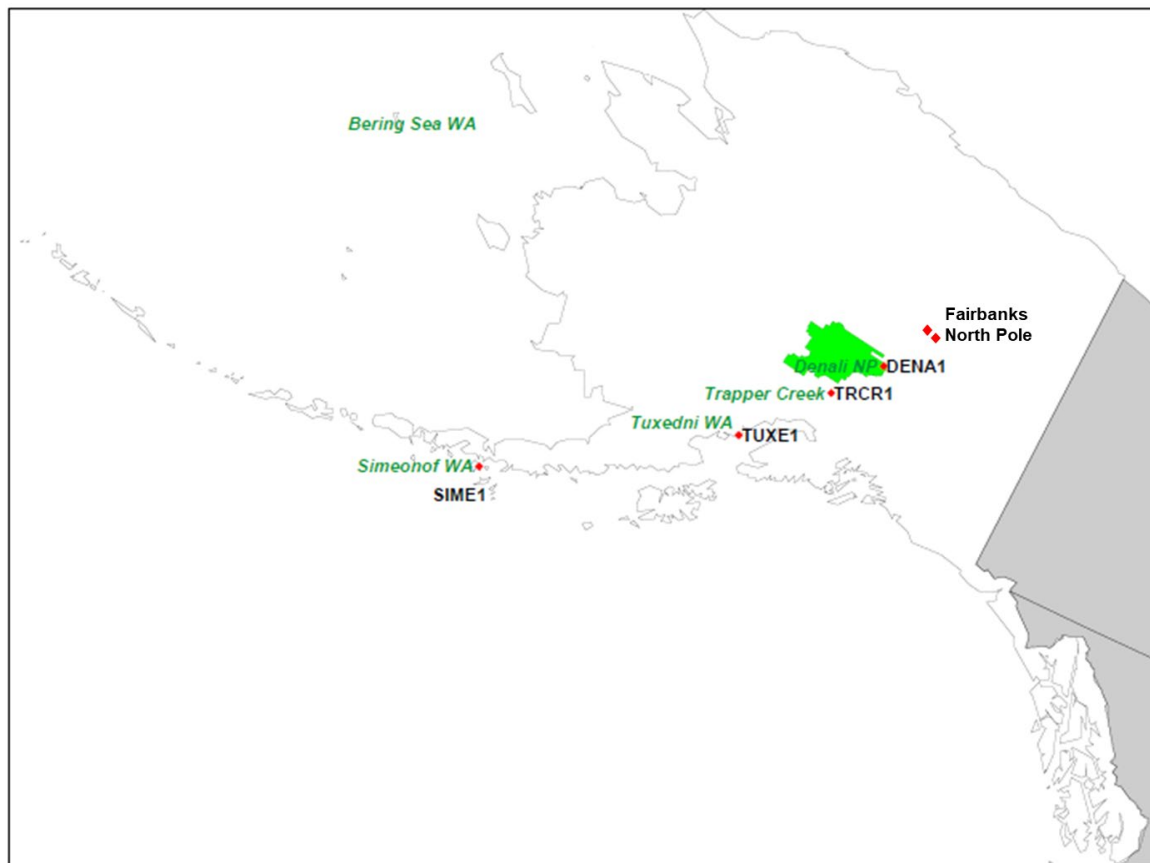


Figure 2.3-1 Map of Federal CIAs and Representative IMPROVE Monitors in Alaska.

Table 2.3-1 Alaska CIAs and Representative IMPROVE Monitors³³

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Denali NP	DENA1	63.72	-148.97	658
Simeonof WA	SIME1	55.33	-160.51	57
Tuxedni WA	TUXE1	59.99	-152.67	15
Bering Sea WA*	N/A			
Trapper Creek**	TRCR1	62.32	-150.32	155

*Federal Class I area with no IMPROVE monitoring site

**Not a Federal Class I area

Aerosol PM_{2.5} concentration averages from Denali NP over a 24-year period are shown in Figure 2.3-2. Yearly averages in Denali between the years of 2021-2024 range from 0.71 – 2.99 µg/m³. PM_{2.5} concentrations between 2021 and 2023 do not exceed 2.0 µg/m³, well below the 9.0 µg/m³ standard.

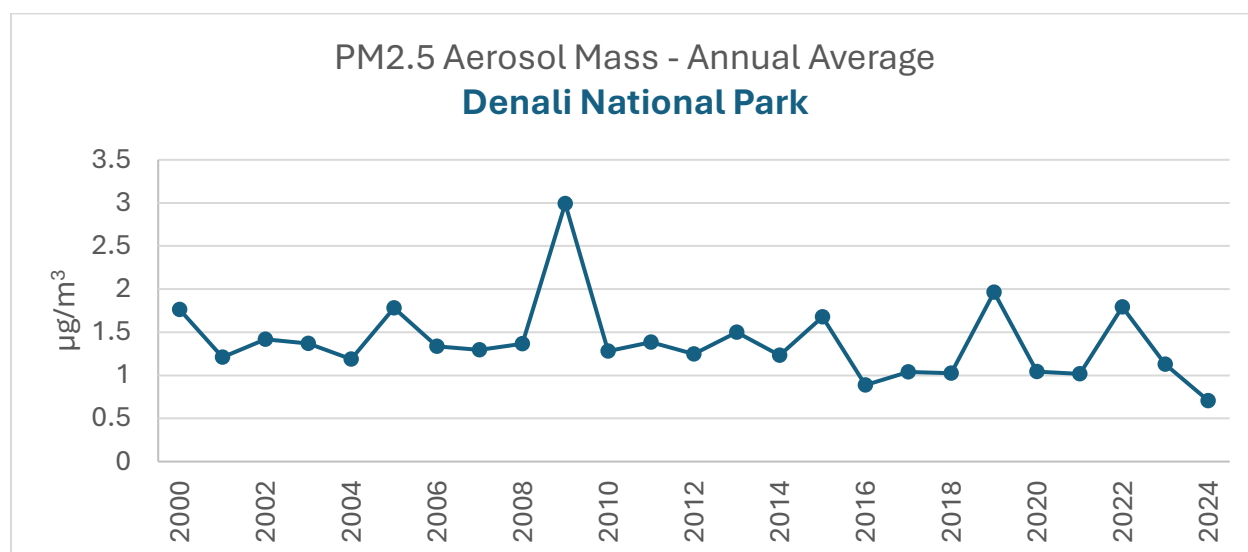


Figure 2.3-2 Fine particulate matter (PM_{2.5}) concentrations from Denali National Park over the years 2000 – 2024.³⁴

Urban increment analysis provided by EPA³⁵ uses annual PM_{2.5} averages from Chemical Speciation Network (CSN) sites as well as IMPROVE monitors to estimate the regional contribution to urban PM_{2.5} monitors. An “urban concentration” value is calculated by subtracting a regional PM_{2.5} concentration from the nearest IMPROVE site (Denali NP) from that of the CSN monitors located in North Pole (Hurst Rd) and Fairbanks (NCore). The final urban concentration

³³ 2015 Regional Haze Progress Report. Volume III: Appendix III.K.10. <https://dec.alaska.gov/air/anpms/regional-haze/sip>.

³⁴ <https://views.cira.colostate.edu/fed/>

³⁵ <https://www.epa.gov/particle-pollution-designations/particle-pollution-designations-memorandum-and-data-2024-revised#A>

represents PM_{2.5} concentrations without regional influence. In EPA’s urban increment analysis, concentrations are speciated into chemical components of PM_{2.5}: ammonium sulfate, ammonium nitrate, organic mass, elemental carbon, and a crustal component. For purposes of viewing overall regional influence for the PM_{2.5} mass, DEC summated EPA’s speciated elements to represent total PM_{2.5} urban increment. Totaled PM_{2.5} urban increment concentrations are exhibited in Table 2.3-2. Average urban concentrations in Fairbanks are 6.75 µg/m³ while average urban concentrations in North Pole are 9.65 µg/m³, highlighting a low contribution from regional sources and clear differences between locations. DEC used EPA’s urban increment analysis to observe overall regional influence on urban monitors, but carried out a more in-depth analysis on IMPROVE monitor chemical speciation in the following sections.

Table 2.3-2 Urban increment analysis of North Pole and Fairbanks showing average annual PM_{2.5} urban concentrations.

	Average Annual PM _{2.5} Urban Increment Analysis (µg/m ³)	
	Fairbanks	North Pole
CSN	7.62	10.58
IMPROVE	0.87	0.93
Urban Concentration	6.75	9.65

*Values are not a mass balance representation but are a totaled value from adding speciated components.

The chemical composition of PM_{2.5} mass is measured by IMPROVE aerosol samplers; these monitors collect 24-hour integrated filter samples every third day. Each monitoring location operates four samplers designed to quantify aerosol species that are related to visibility impairment. The aerosol species collected for regional haze purposes include ammonium sulfate (AmmSO₄), ammonium nitrate (AmmNO₃), organic mass (OM), elemental carbon (EC), fine soil, coarse mass (CM), soil (SOIL) and sea salt. Time series plots showing daily mass budgets for aerosol speciation in Denali NP are exhibited in Figure 2.3-3. Examination of specific days throughout the 2021-2023 time period show that in Denali NP, there were zero days in 2021, eight days in 2022, and two days in 2023 that exceeded the annual NAAQS of 9.0 µg/m³. Exceedances of the annual NAAQS only occur in the summer months and are directly correlated to exceptional events due to wildfires. Chemical composition of the PM_{2.5} mass further supports this conclusion; suspended aerosol during these days is largely comprised of organic mass which is a byproduct of burning and transport of organic matter from wildfires (Figure 2.3-3). Aerosol concentration for all days outside of exceptional events between the years 2021-2023 are well below the annual NAAQS.

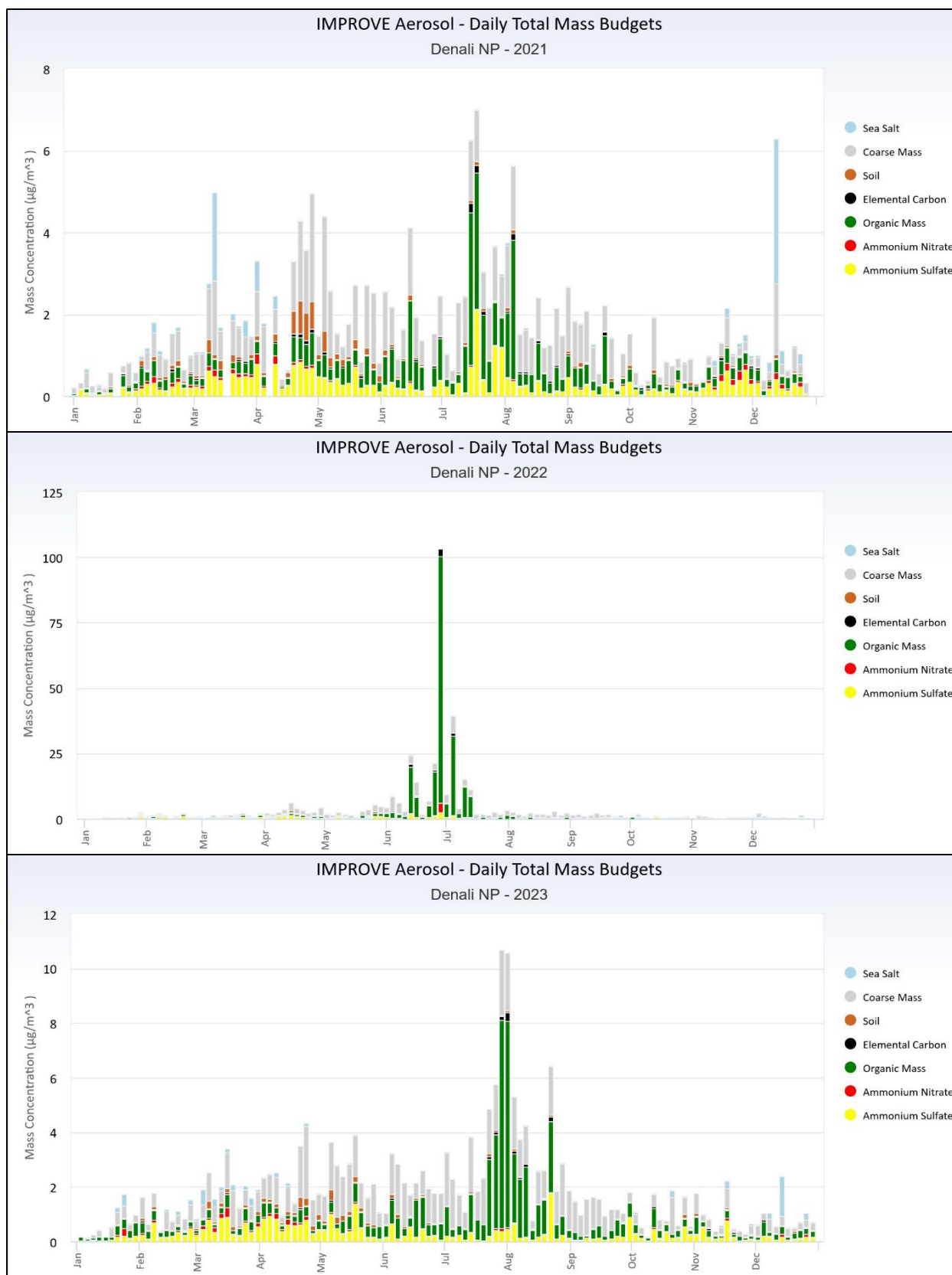


Figure 2.3-3 Daily total mass budgets (in $\mu\text{g}/\text{m}^3$) at Denali National Park for the years 2021-2023.

Additionally, speciation differences are evident between summer and winter months for the Denali Park IMPROVE monitor (Figure 2.3-4). Winter months are defined with high compositions of coarse mass (Q1 and Q4: 35%), ammonium sulfate (Q1: 24% and Q4: 22%) and organic mass (Q1: 20% and Q4: 22%). Summer months are defined with high compositions of organic mass (Q2: 48% and Q3: 47%) and coarse mass (Q2: 31% and Q3: 40%). The higher relative percentage of organic mass and, in part, coarse mass in Q3 at Denali NP's IMPROVE monitor is consistent with suspended organic particles due to wildfire activity. The higher percentage of sulfate during winter months is consistent with speciation studies in prior sections of this document (Section 2.2) and in analysis completed for the 24-hour PM_{2.5} Serious SIP³⁶. The similarity in speciation profiles between the FNSB area and Denali NP is expected due to similarity in summer and winter time events that affect both areas: wildfires in summer and space heating sources in winter.

It is not likely that pollution sources in Denali NP contribute towards the PM_{2.5} concentrations measured in Fairbanks and North Pole due to separation by geographical features and wind patterns during days and seasons where the NAAQS are exceeded, most notably in the winter months. A more in-depth analysis on bulk transport due to wind transport during the winter months can be found in Factor 3: Meteorology.

In addition to rural contributions of PM_{2.5} monitored by neighboring IMPROVE monitors, considerable effort has been given to understanding contributions of suspended pollutants from sources outside of Alaska in the Alaska Regional Haze State Implementation Plan.³⁷ Research shows that a portion of the measured PM_{2.5} concentration in the state can be attributed to international sources; the state is heavily impacted by international emissions generated in the Russian Far East and Siberia, East Asia, Canada, and Europe, along with international marine traffic conducting trade between North America and Asia^{38,39}. International anthropogenic emissions contribute 0.5 – 1.3 µg/m³ (approximately 13% - 50%) to annual average PM_{2.5} in Alaska, meaning that a portion of the measured PM_{2.5} in the Fairbanks and North Pole areas, as well as at the Denali NP IMPROVE monitor, are subject to background contribution from international sources. PM_{2.5} concentrations at monitors in these areas reflect this contribution.

³⁶ <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>

³⁷ <https://dec.alaska.gov/air/anpms/regional-haze/>, Second Implementation Period Combined SIP Section

³⁸ <https://dec.alaska.gov/air/anpms/regional-haze/sip#appendices>, Appendix III.K.13.I

³⁹ A representation of Alaska's geographic proximity to neighboring countries can be found in Appendix A, Section A3.

IMPROVE Monitors Quarterly Data – Denali Park 2021-2023

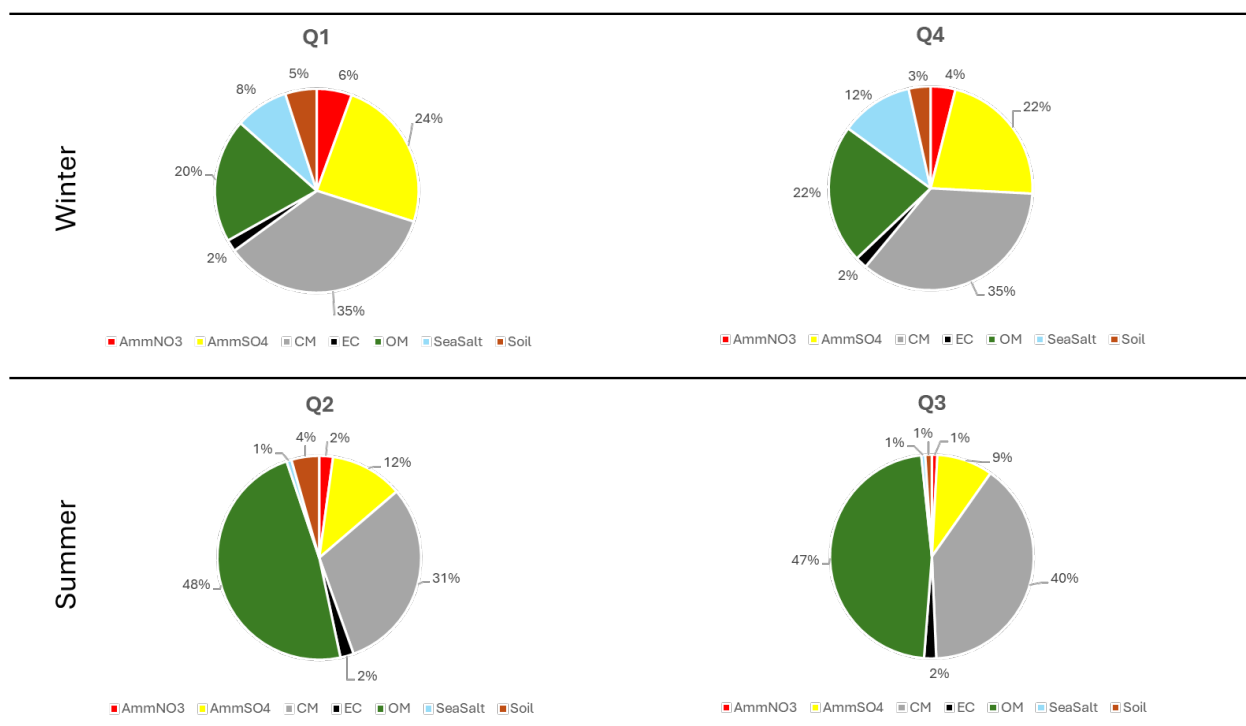


Figure 2.3-4: Speciation percentages for the years 2021-2023 in Denali Park by quarter. Quarter 1 (Q1) represents monitored data from January 1 – March 31; Quarter 2 (Q2) represents from April 1 – June 30; Quarter 3 (Q3) represents July 1 – September 30; and Quarter 4 (Q4) represents October 1 – December 31. Q1 and Q4 signify “winter months” while Q2 and Q3 signify “summer months”.

2.4 Summary

Analysis of all PM_{2.5} monitors throughout the state shows that North Pole is the only location in violation of the revised annual PM_{2.5} NAAQS, with a design value of 9.5 µg/m³ at its maximum impact site. The closest neighboring urban center is Fairbanks with design values of 7.5 and 6.9 µg/m³ at its monitoring units. Seasonal data at all sites are similar; high concentrations of PM_{2.5} are evident during the winter months but not during summer months. Exceptional events are taken into account during summer months at all three sites and are due to the occurrence of wildfires.

Chemical speciation profiles echo the seasonal differences observed from monitoring results. Winter PM_{2.5} mass consists mostly of organic carbon, elemental carbon and sulfate, due to emissions from space heating; wood stoves and fuel oil. In contrast, summer PM_{2.5} mass mostly consists of organic carbon, likely due to the prevalence of wildfires in the area. Speciation results solidify the conclusion that the annual standard is violated in North Pole due to wintertime emissions.

All analysis was compared against the closest rural PM_{2.5} monitor to the Fairbanks North Star Borough—an IMPROVE monitor located in Denali National Park, approximately 90 miles to the southwest—in order to estimate rural contribution to the urban PM_{2.5} violating monitor in North Pole. At the Denali NP monitor, PM_{2.5} concentration levels are extremely low and have not exceeded 2.0 µg/m³ in the past 15 years. Urban increment analysis shows little contribution from regional sources to the overall urban concentrations of North Pole and Fairbanks. Speciation profiles at Denali NP are similar to those of the North Pole and Fairbanks areas because emission sources are similar; summertime profiles can be attributed to wildfires while wintertime profiles can be attributed to space heating emissions. Contribution of PM_{2.5} to North Pole from the Denali NP area is extremely slim due to distance, separation by geographical features, and wind patterns. Additionally, some background PM_{2.5} levels are attributed to international sources that cannot be controlled by Alaska measures. This analysis exhibits a low possibility that contribution from rural sources aids in violating the annual standard at the North Pole monitor.

3. FACTOR 2- EMISSIONS AND EMISSIONS-RELATED DATA

Following EPA's guidance, Factor 2 examines emissions and emissions-related data and metrics. As described within this section, this includes examination of the magnitude and spatial extent of both directly emitted PM_{2.5} as well as applicable precursor pollutants. These precursor pollutants consist of sulfur dioxide (SO₂), oxides of nitrogen (NO_x), volatile organic compounds (VOC) and ammonia (NH₃). It also includes discussions of population density and degree of urbanization as well as traffic and commuting patterns throughout the spatial extent considered.

Unlike the rest of the U.S., Alaska is sparsely populated. Sources of PM_{2.5} and potential precursor emissions generally correlate with populated areas or travel corridors with some exceptions such as wildland fires. As explained in the following subsection, the overall approach to evaluating emission sources and locations relevant to determining nonattainment boundaries for the annual PM_{2.5} NAAQS consisted of the development and examination of a set of inventories of different spatial extents and robustness.

3.1 Overview of Emissions Inventory Approach

The existing Fairbanks nonattainment area for the 2006 24-hour PM_{2.5} NAAQS is a 244 square mile area in the western portion of the Fairbanks North Star Borough (FNSB). The evaluation of emission sources and locations germane to determining appropriate boundaries for the nonattainment area for the annual PM_{2.5} NAAQS began with analyzing emissions over a broad spatial extent that included the FNSB plus the three surrounding boroughs: Denali Borough, Southeast Fairbanks Census Area, and Yukon-Koyukuk Census Area.

This four-borough area is termed the "Outer Inventory" and is shown as the yellow shaded boroughs in Figure 3.1-1. For spatial context, the existing 24-hour Fairbanks nonattainment area is the small tan area in Figure 3.1-1. The Outer Inventory encompasses over 190,000 square miles, bigger than the state of California.⁴⁰ And as seen from the scale at the top of Figure 3.1-1, transport distances to the 24-hour nonattainment area from Outer Inventory area can exceed 200 miles.

⁴⁰ California is 163,695 square miles. World Population Review, <https://worldpopulationreview.com/states/california/how-big>.

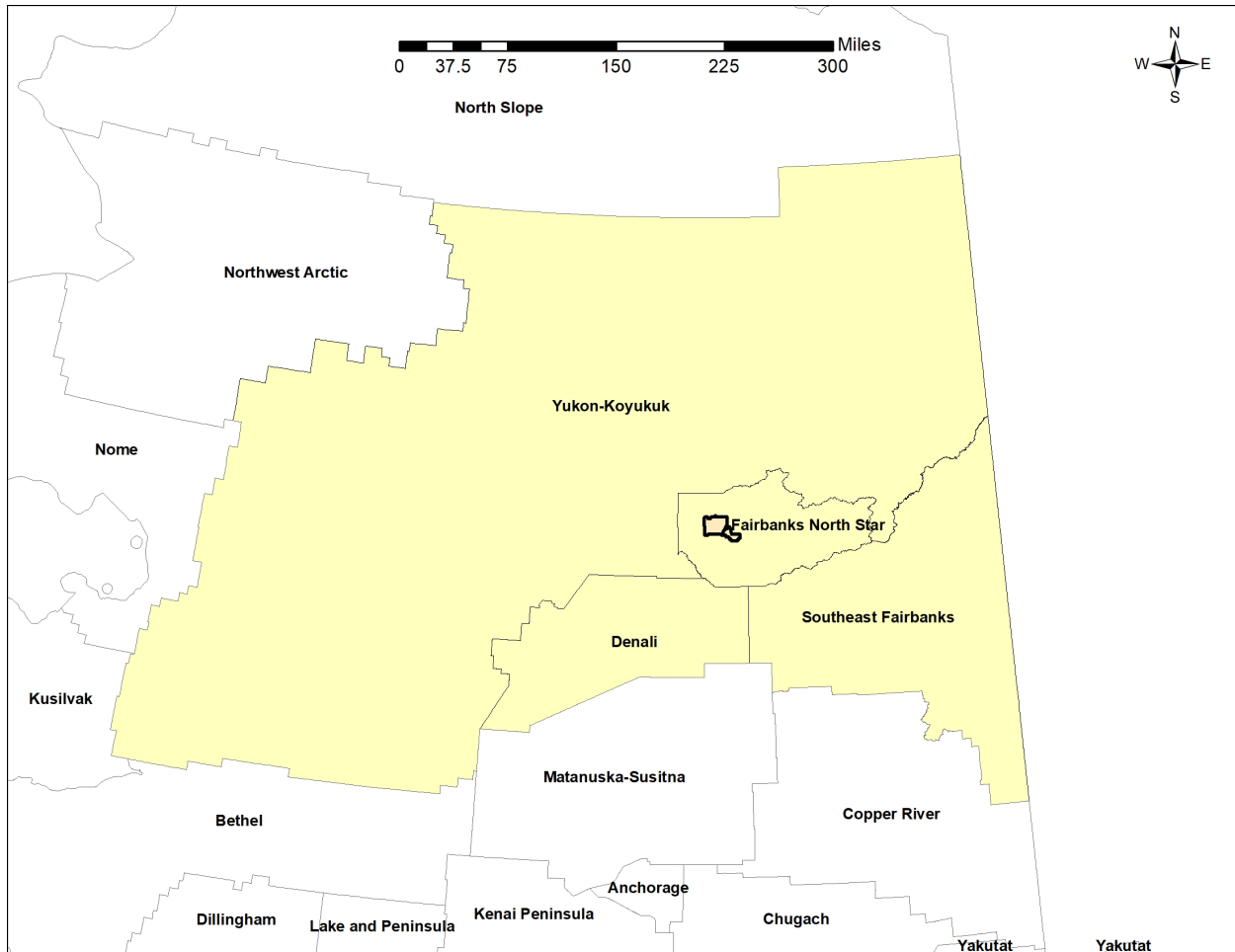


Figure 3.1-1: Four Borough Outer Inventory Extent

In addition to the Outer Inventory, emissions within a “Middle Inventory” consisting of the entire Fairbanks North Star Borough were also evaluated. The FNSB Middle Inventory area is 7,335 square miles.

Finally, emissions and source locations within an “Inner Inventory” that comprised the existing 24-hour nonattainment area (of 244 square miles) were examined.

Table 3.1-1 provides an overview of the data sources and methodologies used to develop emission estimates by source category for each of the three spatial inventories. Emissions were generally estimated based on calendar year 2020 source activity and emission factors except where noted.

And as shown in Table 3.1-1, the rigor or use of local data generally increases from the Outer to the Inner Inventory. The Four Borough Outer Inventory was based entirely on the 2020 NEI, which for a number of key source categories (other than stationary point and on-road mobile source) includes Source Classification Code (SCC)-specific estimates based on data from other regions of the U.S. that are extrapolated to Alaska boroughs based on source activity surrogates.

Table 3.1-1 Overview of Data Sources and Inventory Methods for Layered Inventories by Source Sector and Key Source Category

Source Sector	Category	Four Borough	Fairbanks North Star Borough	24-Hour PM _{2.5} Nonattainment Area
		Outer Inventory	Middle Inventory	Inner Inventory
Point	All	2020 NEI	2020 NEI, SIP EI - Annual Extrapolation	2020 NEI, SIP EI - Annual Extrapolation
Area (Non-Point)	Biogenics		2020 NE, Spatial Allocation	2020 NEI, Spatial Allocation
	Construction Dust		2020 NE, Spatial Allocation	2020 NEI, Spatial Allocation
	Paved & Unpaved Road Dust		2020 NEI, ADOT&PF Road Surface VMT	2020 NEI, ADOT&PF Road Surface VMT
	Fires - Prescribed Fires		2020 NEI, Spatial Allocation	2020 NEI, Spatial Allocation
	Fires - Wildfires		2020 NEI, Spatial Allocation	2020 NEI, Spatial Allocation
	Fuel Combustion - Residential - Wood		SIP EI - Annual Extrapolation	SIP EI - Annual Extrapolation, Spatial Allocation
	Other Space Heating		SIP EI - Annual Extrapolation	SIP EI - Annual Extrapolation, Spatial Allocation
	Waste Disposal		2020 NEI, Spatial Allocation	2020 NEI, Spatial Allocation
	All Others		2020 NEI, Spatial Allocation	2020 NEI, Spatial Allocation
On-Road Mobile	All		2020 NEI, Spatial Allocation	2020 NEI, Spatial Allocation
Nonroad Mobile	All		2020 NEI, Spatial Allocation	2020 NEI, Spatial Allocation

For the Middle Inventory (encompassing the entire Fairbanks North Star Borough), refinements to 2021 NEI estimates by source category are highlighted in green. For these source categories, local data from the 2024 Amendment 24-hour Fairbanks PM_{2.5} SIP inventory were used for key source categories (e.g., residential space heating and point sources within the 24-hour nonattainment area). Their source activity was extrapolated from winter episodic to annual estimates based on throughput data specific to each category that is described later in Section 3.3. In Table 3-1.1 these instances are denoted as “SIP EI – Annual Extrapolation.”

The rightmost column of Table 3.1-1 highlights further emission estimation refinements used in generating the Inner Inventory (which corresponds to the existing Fairbanks 24-hour PM_{2.5}

nonattainment area). These refinements generally consisted of using appropriate spatial surrogates to allocate emissions from the Middle Inventory into the Inner Inventory. Where feasible, emissions within the Inner Inventory were then further spatially allocated to the Fairbanks and North Pole portions of the 24-hour nonattainment area.

The following three subsections present and discuss the resulting Outer, Middle and Inner inventories, respectively.

3.2 Outer Emissions Inventory Analysis

Outer Inventory emissions for directly emitted PM_{2.5} as well as all potential precursor gases (SO₂, NO_x, VOC and NH₃) were developed for calendar year 2020 based entirely on the 2020 NEI. Sector wide emissions were provided for the Point, On-Road Mobile and Non-Road Mobile source sectors. Within the Non-Point sector, emissions were tabulated by key source categories that reflect differences in emissions, both by source category as well as by borough within the four borough Outer Inventory.

Direct PM_{2.5} Emissions – Table 3.1-2 shows the breakdown of Outer Inventory direct PM_{2.5} emissions by source category and borough. Fairbanks North Star Borough (FNSB) is highlighted as the “reference borough” for comparison as the Middle and Inner inventories zoom to and within the FNSB. As seen in Table 3.1-2, direct PM_{2.5} emissions are four to nearly twenty times higher in the Fairbanks North Star Borough (FNSB) than the other three boroughs. Within the FNSB, Prescribed Fires represent 86.3% of annual PM_{2.5} emissions, with secondary contributions from Residential Wood Combustion (8.0%), Wildfires (2.6%) and Waste Disposal (2.5%). Emissions of All Stationary Point, On-Road and Non-Road Mobile, and the remaining Non-Point sources comprise only 0.6% of annual PM_{2.5} emissions in the FNSB.

Table 3.1-2 Outer Inventory PM_{2.5} Emissions by Borough and Key Source Category

Sector	Source Category	PM _{2.5} (tons/year)			
		Fairbanks North Star	Denali	Southeast Fairbanks	Yukon- Koyukuk
Point	All	118	16	44	22
NonPoint	Biogenics	0	0	0	0
NonPoint	Construction, Paved & Unpaved Road Dust	318	29	101	150
NonPoint	Fires - Prescribed Fires	95,371	6	0	0
NonPoint	Fires - Wildfires	2,839	912	228	25,253
NonPoint	Fuel Comb - Residential - Wood	8,859	205	689	859
NonPoint	Waste Disposal	2,733	64	181	89
NonPoint	All Others	173	10	12	21
OnRoad	All	34	3	5	6
NonRoad	All	29	1	2	3
TOTALS		110,473	1,246	1,262	26,403

Apart from the splits between Prescribed Fires and Wildfires and lower shares of Residential Wood Combustion and Waste Disposal, annual PM_{2.5} emissions in Denali, Southeast Fairbanks, and Yukon-Koyukuk boroughs have similar relative amounts to total borough emissions as in the FNSB.

Prescribed Fire emissions are those from scheduled or controlled burns with the goal of managing wildlife habitat by mimicking natural wildfires in a controlled manner, reducing fuel buildup, and minimizing the risk of large uncontrolled wildfires. They are significant in the FNSB but largely non-existent in the other sparsely populated boroughs. Within the FNSB, they tend to occur in areas around the Fairbanks metropolitan area and the Tanana River Plain to the south of Fairbanks. The military has extensive training grounds within the Tanana Plain. Thus, prescribed fires occur actively in this area to reduce fuel buildup and minimize uncontrolled wildfire risks.

The Alaska Division of Forestry and Fire Protection conducts and oversees Prescribed Fire burns in Alaska in conjunction with the U.S. Bureau of Land Management, Alaska Fire Service (BLM AFS). Prescribed burns are conducted only in the Spring and sometimes early Fall during periods of favorable air quality. They are conducted in these periods to reduce fuel loads before the summer wildfire season and again in early Fall as needed before ambient PM_{2.5} air quality worsens during winter.

An interagency website (AKFireInfo.com) developed and maintained by several state and federal agencies (including those noted above), is used to communicate information regarding scheduled prescribed fire burns to the public. It also contains historical information on prescribed burns,⁴¹ listing the spring and fall periods in each year during which the burns occur. Spring prescribed burns typically begin in mid to late April (depending on snowpack/soil moisture) and last about three to four weeks. Fall burns begin in late September or early October and are generally completed by mid-October.

Treatment of Wildland Fires – Wildland Fires consist of two components: 1) Wildfires, and 2) Prescribed Fires. Wildfires generally fall under the category of naturally occurring Exceptional Event source activity, and thus are excluded or discounted from consideration of the source categories that impact determination of appropriate nonattainment area boundaries for the annual PM_{2.5} standard.

Similarly (but not identically) Prescribed Fires, although they are not naturally occurring emissions, are part of a wildland management strategy intended to significantly reduce the magnitude and extent of Wildfire emissions. Moreover, their activity is generally limited to 2-to-4-week windows in Spring and early Fall. As can be seen from Figure 2.1-1 through Figure 2.1-6, presented earlier in within Section 2.1.2, ambient PM_{2.5} concentrations in the Fairbanks 24-hour nonattainment area are below the revised 9 µg/m³ annual PM_{2.5} standard. Thus, Prescribed Fire source activity and emissions do not materially contribute to violation of the annual standard within the Fairbanks-North Pole area.

⁴¹ <https://akfireinfo.com/category/prescribed-fire/#:~:text=By%20BLM%20Alaska%20Fire%20Service,May%201%2C%E2%80%A6%20Read%20More%20E2%80%BA>

Variability of Wildland Fires – Another important aspect of wildland fires is their significant year to year variability within Interior Alaska. Table 3.1-3 presents a comparison of Wildland Fire PM_{2.5} emissions for each of the four outer inventory boroughs in calendar years 2020 and 2022, broken down by the Prescribed Fire and Wildfire subcategories.

Table 3.1-3 Outer Inventory Wildland Fire PM_{2.5} Emissions by Borough and Subcategory – 2022 vs. 2020

Sector	Source Category	Wildland Fire PM _{2.5} (tons/year)			
		Fairbanks North Star	Denali	Southeast Fairbanks	Yukon- Koyukuk
2020 Wildland Fire Emissions					
NonPoint	Fires - Prescribed Fires	95,371	6	0	0
NonPoint	Fires – Wildfires	2,839	912	228	25,253
TOTAL 2020 WILDLAND FIRES		110,473	1,246	1,262	26,403
2022 Wildland Fire Emissions					
NonPoint	Fires - Prescribed Fires	1,228	43	87,117	90
NonPoint	Fires – Wildfires	43,088	97,324	49,773	1,238,219
TOTAL 2022 WILDLAND FIRES		44,316	97,367	136,890	1,238,309

Sources: 2020 emissions from 2020 NEI, 2022 emissions from Alaska Interagency Coordination Center
<https://fire.ak.blm.gov/content/aicc/Statistics%20Directory/Previous%20Years%20Data%20and%20FFR%20Handouts/2022%20Fire%20Data/Current%20Alaska%20Fires%20Data%202022-12-31%201700.xlsx>

As shown in Table 3.1-3, PM_{2.5} emissions for both Wildland Fire components (Prescribed Fires and Wildfires) varied dramatically between the two years. For example, within the FNSB Prescribed Fire emissions dropped from 95,371 tons/year to 1,228 tons/year while Wildfire emissions changed in the opposite direction, increasing from 2,829 tons/year in 2020 to 43,088 tons/year in 2022. Similarly significant swings in Wildland Fire emissions in the other boroughs was also seen between 2020 and 2022.

These large variations in year-to-year Wildland Fire emissions in Interior Alaska are the result of differences in weather from one year to the next (wind patterns, precipitation and soil moisture, etc.), coupled with the fact that wildfires in these areas are generally triggered by summer thunderstorms and lightning strikes. The locations of the wildfire origin also significantly impact resultant emissions as they tend to occur in remote areas with little or no roadway access. Prescribed fires (though man-made) are an important land management tool used to mitigate activity and emissions from naturally occurring wildfires. Due to the source and nature of these burning activities, DEC believes that neither wildfires nor prescribed burns should be included when determining annual nonattainment area boundaries.

Precursor Pollutant Emissions – Table 3.1-4 through Table 3.1-7 provide similar Outer Inventory tabulations for potential precursor pollutants SO₂, NO_x, VOC and NH₃, respectively.

Common to the 2020 NEI-based Outer Inventory emissions for each of the precursor pollutants is the fact that Prescribed Fires are the largest source category in the FNSB, ranging from 45% (for NO_x) to 96% (for NH₃).

Table 3.1-4 Outer Inventory SO₂ Emissions by Borough and Key Source Category

Sector	Source Category	SO ₂ (tons/year)			
		Fairbanks North Star	Denali	Southeast Fairbanks	Yukon- Koyukuk
Point	All	1,913	391	22	49
NonPoint	Biogenics	0	0	0	0
NonPoint	Construction, Paved & Unpaved Road Dust	0	0	0	0
NonPoint	Fires - Prescribed Fires	6,328	0	0	0
NonPoint	Fires - Wildfires	186	59	16	1,713
NonPoint	Fuel Comb - Residential - Wood	158	3	12	15
NonPoint	Waste Disposal	185	4	11	7
NonPoint	All Others	46	28	2	2
OnRoad	All	2	0	0	0
NonRoad	All	0	0	0	0
TOTALS		8,818	486	62	1,785

Table 3.1-5 Outer Inventory NO_x Emissions by Borough and Key Source Category

Sector	Source Category	NO _x (tons/year)			
		Fairbanks North Star	Denali	Southeast Fairbanks	Yukon- Koyukuk
Point	All	4,474	301	414	276
NonPoint	Biogenics	1,000	1,182	3,449	17,262
NonPoint	Construction, Paved & Unpaved Road Dust	0	0	0	0
NonPoint	Fires - Prescribed Fires	7,806	1	0	0
NonPoint	Fires - Wildfires	225	70	21	2,205
NonPoint	Fuel Comb - Residential - Wood	987	22	74	481
NonPoint	Waste Disposal	1,015	24	68	76
NonPoint	All Others	879	138	115	604
OnRoad	All	774	90	135	180
NonRoad	All	192	7	10	37
TOTALS		17,352	1,835	4,286	21,121

Unlike with direct PM_{2.5}, Biogenics are a significant source of emissions for VOC (from plants), and NO_x (from soil) to a lesser extent. However, like Wildfires, Biogenics are a natural emission source. Control of their emissions through an air quality plan is thus not practical. To the extent that VOC and NO_x are precursors of significance for annual PM_{2.5} in interior Alaska, biogenic emissions would likely be addressed within the background component of an air quality model.

Thus, like the earlier arguments for Prescribed Fires and Wildfires, DEC believes that Biogenic emission sources should be excluded or discounted in evaluating source categories and emissions toward determination of appropriate annual PM_{2.5} nonattainment area boundaries.

Table 3.1-6 Outer Inventory VOC Emissions by Borough and Key Source Category

Sector	Source Category	VOC (tons/year)			
		Fairbanks North Star	Denali	Southeast Fairbanks	Yukon- Koyukuk
Point	All	290	10	134	82
NonPoint	Biogenics	34,490	35,733	56,794	464,399
NonPoint	Construction, Paved & Unpaved Road Dust	0	0	0	0
NonPoint	Fires - Prescribed Fires	275,838	18	0	0
NonPoint	Fires - Wildfires	8,225	2,646	654	72,758
NonPoint	Fuel Comb - Residential - Wood	797	11	47	48
NonPoint	Waste Disposal	60	1	25	2
NonPoint	All Others	1,778	104	178	210
OnRoad	All	494	29	56	68
NonRoad	All	646	49	73	121
TOTALS		322,620	38,600	57,960	537,689

Table 3.1-7 Outer Inventory NH₃ Emissions by Borough and Key Source Category

Sector	Source Category	NH ₃ (tons/year)			
		Fairbanks North Star	Denali	Southeast Fairbanks	Yukon- Koyukuk
Point	All	2	15	1	0
NonPoint	Biogenics	0	0	0	0
NonPoint	Construction, Paved & Unpaved Road Dust	0	0	0	0
NonPoint	Fires - Prescribed Fires	19,189	1	0	0
NonPoint	Fires - Wildfires	572	184	45	5,061
NonPoint	Fuel Comb - Residential - Wood	40	0	2	2
NonPoint	Waste Disposal	41	0	4	1
NonPoint	All Others	19	0	1	1
OnRoad	All	28	3	4	6
NonRoad	All	1	0	0	0
TOTALS		19,892	204	57	5,071

Emission Density by Borough – A final means of evaluating Outer Inventory emissions and their importance in establishing nonattainment area boundaries consisted of tabulating and comparing emission densities (in tons per year per square mile) by borough and pollutant.

Table 3.1-8 shows total Outer Inventory emissions and land area of each borough. Again, FNSB is highlighted for comparison to the other boroughs.

Table 3.1-8 Outer Inventory Borough Land Area and Total Emissions by Pollutant

Borough Name	Area (sq mi)	Emissions (tons/year)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Fairbanks North Star	12,238	110,473	8,818	17,352	322,620	19,892
Denali	7,201	1,246	486	1,835	38,600	204
Southeast Fairbanks	24,283	1,262	62	4,286	57,960	57
Yukon-Koyukuk	143,618	26,403	1,785	21,121	537,689	5,071

Emission densities for each borough were then calculated by dividing total borough emissions by its land area. The resulting emission densities (in tons per year per square mile) are presented below in Table 3.1-9.

Table 3.1-9 Outer Inventory Borough Emission Densities by Pollutant

Borough Name	Area (sq mi)	Emission Densities (tons/year/sq mi)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Fairbanks North Star	12,238	9.03	0.72	1.42	26.36	1.63
Denali	7,201	0.17	0.07	0.25	5.36	0.03
Southeast Fairbanks	24,283	0.05	0.00	0.18	2.39	0.00
Yukon-Koyukuk	143,618	0.18	0.01	0.15	3.74	0.04

As seen in Table 3.1-9, emission densities for both direct PM_{2.5} and all potential precursor pollutants are generally orders of magnitude higher in the FNSB than in the other three boroughs. And as noted earlier, transport distances from these other boroughs to the Fairbanks area within the FNSB can approach up to 200 miles. These emission density comparisons, coupled with the transport distances to FNSB and the IMPROVE monitor-based rural ambient PM_{2.5} concentrations presented earlier in Section 2.3, clearly indicate that emissions from Denali, Southeast Fairbanks and Yukon-Koyukuk boroughs do not significantly impact ambient PM_{2.5} concentrations in the Fairbanks-North Pole area.

Thus, it is believed these findings provide clear evidence that these three boroughs (or portions thereof) should not be included within the North Pole annual PM_{2.5} nonattainment area boundaries.

3.3 Middle Emissions Inventory Analysis

As explained in Section 3.1, the Middle Emissions Inventory extent is the entire FNSB. As summarized earlier in Table 3.1-1, it starts with 2020 NEI emissions (like the Outer Inventory) but includes more refined estimates for several source categories based on the 24-hour Fairbanks PM_{2.5} SIP and other local sources. These refinements included source activity and emissions based on local (non-NEI) data as well as spatial allocations of emissions within the FNSB. The key refinements are summarized as follows:

- *Point* – Point source emissions for facilities within the existing 24-hour Fairbanks PM_{2.5} nonattainment area were estimated based on winter episodic emissions for the 2020

Baseline year from DEC's 2024 Amendment to the Fairbanks Serious Area PM_{2.5} SIP. As part of SIP development, activity data was obtained from each facility by emission unit that included fuel throughput percentages by quarter (Winter=Dec-Feb, Spring=Mar-May, Summer=Jun-Aug, Fall=Sep-Nov). The winter throughput fractions were assumed to be representative of the SIP modeling episodes. The remaining throughput fractions (Spring through Fall) were then used to extrapolate SIP episodic point source emissions for each facility and emission unit to an annual basis. For facilities outside the nonattainment area, the 2020 NEI data were used.

- *Paved and Unpaved Road Dust* – A GIS-based road surface layer⁴² was obtained from the Alaska Department of Transportation and Public Facilities (ADOT&PF) that identified the road surface type (paved or unpaved) for over 3,800 freeway and arterial road segments across the state. This layer was merged with another spatial layer⁴³ from ADOT&PF that contained 2021⁴⁴ Annual Average Daily Traffic (AADT) and segment length. The merged dataset was then filtered to segments within the FNSB, and 2021 daily vehicle miles traveled (VMT) was calculated for each road segment by multiplying its AADT by its length. The 2021 VMT estimates were then tabulated by road surface and subarea (either within or outside the 24-hour nonattainment area) and used to develop spatial allocation factors for both paved and unpaved road dust emissions by subarea (Inside NAA or Outside NAA). These spatial allocation factors were then applied to the 2020 NEI estimates of paved and unpaved road dust emissions for the FNSB to apportion them by subarea.
- *Residential Space Heating* – The 2024 Amendment SIP episodic emissions inventory was also used to provide a locally-based estimate of residential space heating emissions across the FNSB. Space heating emissions were divided into two subcategories: 1) Wood-burning devices, and 2) All other heating devices. Winter and annual fuel and energy use data collected under a 2023 Residential Home Heating survey that supported the SIP residential space heating inventory were used to extrapolate episodic wintertime space heating emissions to an annual basis. These local estimates were used to replace the 2020 NEI emissions for the residential space heating source categories.
- *Waste Disposal, Municipal Landfills* – The Waste Disposal source category reflects emissions from several subcategories that include municipal landfills, open burning (e.g., yard waste), municipal and industrial wastewater treatment, and commercial/institutional incineration. In comparing FNSB waste disposal emissions between the 2020 NEI and the 2024 Amendment SIP inventory, it was observed that the 2020 NEI estimated the Municipal Landfill subcategory PM_{2.5} emissions to be three orders of magnitude higher than contained in the SIP inventory (2,521 tons/year NEI vs. 0.47 tons/year from the SIP for calendar year 2020). The SIP emissions estimate for municipal landfill emissions in the

⁴² <https://data-soa-akdot.opendata.arcgis.com/maps/85eda5cf21ef4014b03d1819dd388869>

⁴³ https://data-soa-akdot.opendata.arcgis.com/datasets/3c6be4c726ae462aa9f67a392af35e2c_0/explore?location=60.784994%2C26.000000%2C5.60

⁴⁴ Due to impacts of COVID-19 that affected vehicle travel in 2020, 2021 AADT were used to provide a better representation of normal traffic patterns across Alaska.

FNSB came from the 2017 NEI. And the only municipal landfill in the FNSB is in Fairbanks; the South Cushman Landfill south of the downtown area. A review of EPA's earlier 2014 NEI found that municipal landfill PM_{2.5} emissions for FNSB were estimated to be at a similar level to that in the 2017 NEI (0.15 tons/year). DEC then reviewed EPA's technical documentation published in conjunction with the 2020 NEI⁴⁵ and found no reported changes in the methods used to estimate municipal landfill emissions relative to earlier NEIs. DEC also contacted the South Cushman Landfill⁴⁶ in Fairbanks and determined that there had been no significant changes to the amount of disturbed acreage (a key source of landfill PM_{2.5} emissions) or other operations at the facility since 2017. Therefore the 2017 NEI estimate for FNSB municipal landfill PM_{2.5} emissions (0.45 tons/year) was used and population growth projected to 0.47 tons/year in 2020 as in the SIP.

Based on these refinements, Table 3.1-10 summarizes emissions by pollutant and key source category for the Middle Inventory area, the entire FNSB. The Biogenics, Prescribed Fires and Wildfires category are shaded to reflect the fact that they represent natural, exceptional event or related sources that would not be considered "Controllable sources" as they relate to developing an appropriate nonattainment area boundary and SIP-based control measures. This classification does not mean these categories would be excluded from a SIP inventory, but rather represent source categories that are not practicable to control under SIP attainment planning.

Table 3.1-10 Middle Inventory Emissions by Pollutant and Key Source Category – Entire FNSB

Sector	Source Category	FNSB Emissions (tons/year)				
		PM _{2.5}	SO ₂	NOx	VOC	NH ₃
Point	All	214	1,815	4,057	284	23
NonPoint	Biogenics	0	0	1,000	34,490	0
NonPoint	Construction Dust	93	0	0	0	0
NonPoint	Paved Road Dust	8	0	0	0	0
NonPoint	Unpaved Road Dust	217	0	0	0	0
NonPoint	Fires - Prescribed Fires	95,371	6,328	7,806	275,838	19,189
NonPoint	Fires - Wildfires	2,839	186	225	8,225	572
NonPoint	Fuel Comb - Residential - Wood	363	9	48	1,237	13
NonPoint	Fuel Comb - Residential - Other Space Heating	10	613	238	15	1
NonPoint	Waste Disposal - Municipal Landfills	0.47	5	3	0	212
NonPoint	Waste Disposal - Other	212	19	71	51	41
NonPoint	All Others	173	46	879	1,778	19
OnRoad	All	34	2	774	494	28
NonRoad	All	29	0	192	646	1
TOTALS		99,562	9,022	15,292	323,060	20,100

⁴⁵ <https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-technical-support-document-tds>

⁴⁶ Personal communication, Elizabeth Whisenant, Alaska Department of Environmental Conservation and Fairbanks South Cushman Landfill, November 4, 2024.

CONTROLLABLE SOURCE TOTALS	1,352	2,508	6,262	4,506	339
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Thus, at the bottom of Table 3.1-10 totals of all and controllable emissions are shown, the latter excluding the shaded source categories. The source categories in Table 3.1-10 have also been expanded where needed to represent selective adjustments to 2020 NEI-based emissions. Overall, Middle Inventory emissions are generally similar to those for the FNSB within the 2020 NEI-based Outer Inventory, although NEI-based Residential Wood Combustions emissions are significantly higher than those estimated from the SIP. For example, NEI and SIP-based PM_{2.5} emissions for FNSB are 8,859 tons/year and 316 tons/year, respectively. Waste Disposal PM_{2.5} emissions in the Middle Inventory are also significantly lower than for FNSB in the Outer Inventory due to the correction to the apparent error in 2020 NEI emissions for the Municipal Landfill subcategory.

Beside these revisions, the other improvements to the Middle Inventory included spatially allocating emissions into two subareas within the FNSB: 1) the region inside the existing 24-hour PM_{2.5} nonattainment area (NAA), and 2) that portion outside the 24-hour PM_{2.5} NAA. These subareas within the FNSB Middle Inventory are shown below in Figure 3.1-2 along with key roadway system segments. The Inside NAA subarea highlighted in yellow comprises 234 square miles, or 3% of the total FNSB land area.

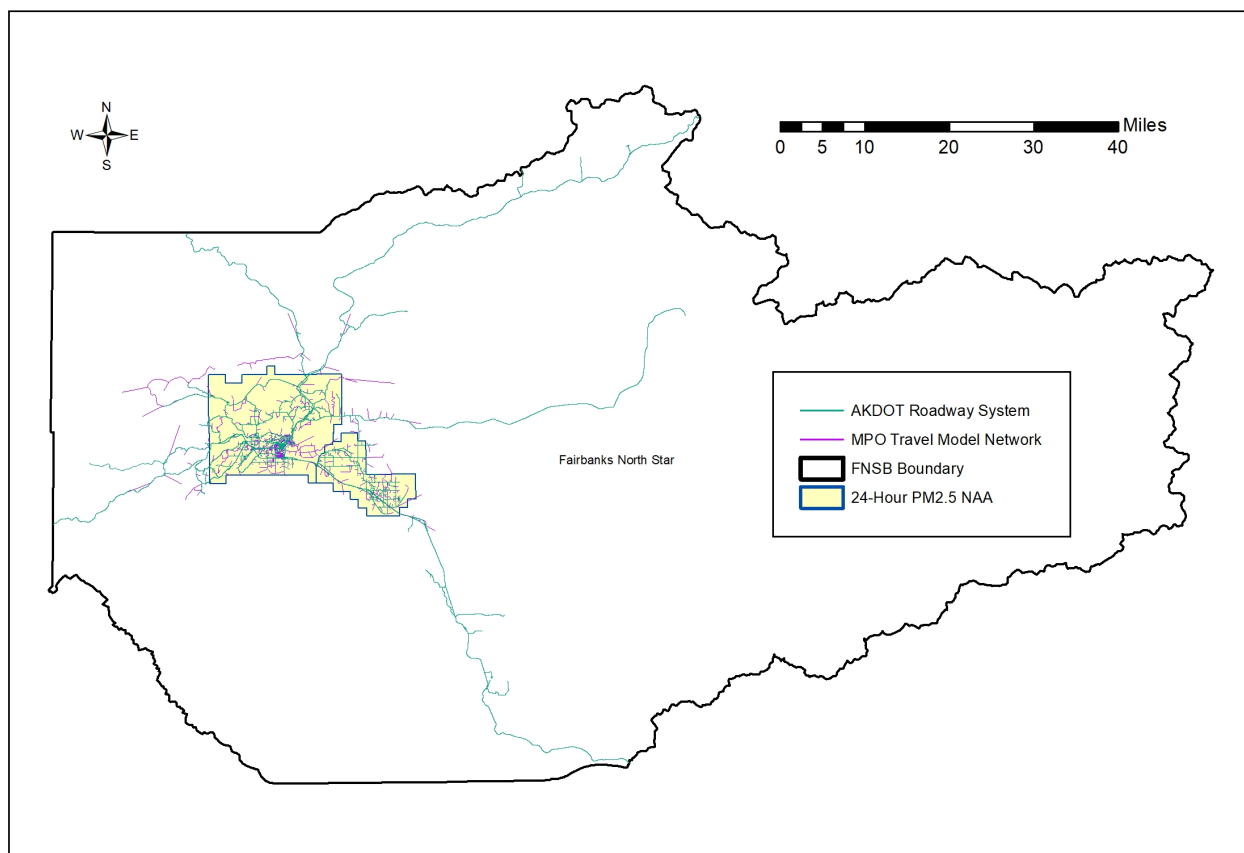


Figure 3.1-2: FNSB Middle Inventory Area and Subareas

Source category-specific activity surrogates were assembled and used to perform these subarea emissions allocations, and are summarized below in Table 3.1-11. For example, 2.3% of Biogenic emissions in the entire FNSB Middle Inventory were assumed to occur within the NAA, with the remaining 97.7% occurring outside the NAA based on the distribution of rural land area within the FNSB.

Table 3.1-11 Middle Inventory Subarea Spatial Allocation Fractions by Source Category

Sector	Source Category	Spatial Surrogate	Inside NAA %	Outside NAA %
Point	All	Source Location	Varies	Varies
NonPoint	Biogenics	Rural Land Area	2.3%	97.7%
NonPoint	Construction Dust	Population	87.3%	12.7%
NonPoint	Paved Road Dust	Paved Road VMT	82.1%	17.9%
NonPoint	Unpaved Road Dust	Unpaved Road VMT	83.2%	16.8%
NonPoint	Fires - Prescribed Fires	2020 Fire Locations	98.1%	Varies
NonPoint	Fires - Wildfires	2020 Fire Locations	0%	100%
NonPoint	Fuel Comb - Residential – Wood	Occupied Households	87.0%	13.0%
NonPoint	Fuel Comb - Residential - Other Space Heating	Occupied Households	87.0%	13.0%
NonPoint	Waste Disposal - Municipal Landfills	Source Location	100.0%	0.0%
NonPoint	Waste Disposal - Other	Population	87.3%	12.7%
NonPoint	All Others	Population	87.3%	12.7%
OnRoad	All	Roadway VMT	82.2%	17.8%
NonRoad	All	Rural Land Area	2.3%	97.7%

Summaries of each of the spatial surrogates and their sources are presented below, with the source categories they were applied to listed in parentheses.

Source Location (Point Sources) – Point sources were allocated either within or outside the nonattainment area using their latitude and longitude coordinates from the 2020 NEI or SIP inventory. As shown in subsequent tables, most of the point source emissions occur within the nonattainment area (75% or more, although it varies by pollutant).

Rural Land Area (Biogenics, All Non-Road Mobile Sources) – An urban vs. rural land area GIS shapefile from the 2020 Census for the FNSB was spatially merged with the NAA boundary to determine the fractions of Rural land area within and outside the NAA. It was used as a simple spatial surrogate to allocate Biogenic and Non-Road Mobile source emissions within the Middle inventory. Biogenic emissions occur in vegetated non-urbanized areas. Non-road NEI emissions in FNSB are dominated by recreational equipment that is typically operated in rural areas.

Population (Construction, Waste Disposal-Other, All Other NonPoint Sources) – A GIS shapefile containing 2020 Census population data by census block for the FNSB was spatially merged with the NAA boundary to calculate the population percentages within and outside the NAA. As shown

in Table 3.1-11, 87.3% of the FNSB population is located within the NAA, with the remaining 12.3% outside the NAA. These population percentages were used to allocate total FNSB emissions for Construction Dust, Other Waste Disposal and All Other Nonpoint sources to the Within NAA and Outside NAA subareas.

Paved Road VMT (Paved Road Dust) – As described earlier, GIS shapefiles were obtained from ADOT&PF containing the road surface type⁴² (paved vs. unpaved) and 2021 AADT⁴³ for over 3,800 road segments across Alaska. These shapefiles were merged and filtered to produce estimates of 2021 Daily VMT for each segment within the FNSB, including identification of the road surface type for the segment. The resulting dataset was tabulated to determine the fractions of paved road VMT across the FNSB that occurred inside and outside the NAA and allocate paved road dust emissions to each subarea based on these fractions. As shown in Table 3.1-11, 82.1% of paved road dust emissions were allocated to the Inside NAA subarea, with the remaining 17.9% allocated to the Outside NAA subarea.

Unpaved Road VMT (Unpaved Road Dust) – The same spatial dataset was similarly used to calculate unpaved road VMT fractions inside and outside the NAA and allocate FMSB unpaved road dust emissions to each subarea. As listed in Table 3.1-11, 83.2% of total FNSB unpaved road dust emissions were allocated to the Inside NAA subarea, with the remaining 16.8% allocated to the Outside NAA subarea.

2020 Fire Locations (Prescribed Fires, Wildfires) – Supporting data compiled by EPA for the 2020 NEI includes wildland fire emissions and locations based on data submitted by state, local and tribal agencies. These data include data by individual fire event, latitude and longitude locations, the type of fire (RX=Prescribed Fire, WF=Wildfire) and emissions. The dataset for Alaska⁴⁷ was filtered to events within the FNSB and then spatially analyzed (using latitude/longitude coordinates for each fire event record) to separately determine Prescribed Fire and Wildfire emissions that occurred within and outside the NAA. Although the spatial emissions allocations vary by pollutant, between 98.1% and 98.7% of Prescribed Fire emissions occurred outside the NAA in 2020, with only 1.3% to 1.9% occurring within the NAA. All (100%) wildfire emissions were found to occur outside the NAA.

Occupied Households (Residential Wood Combustion, Other Residential Space Heating) – A GIS shapefile containing 2020 Census occupied household data by census block for the FNSB was spatially merged with the NAA boundary to calculate the population percentages within and outside the NAA. As shown in Table 3.1-11, 87.0% of the occupied households were located within the NAA, with the remaining 12.0% outside the NAA. These occupied household percentages were used to allocate total FNSB emissions for Residential Wood Combustion and Other Residential Space Heating sources to the Within NAA and Outside NAA subareas.

Source Location (Waste Disposal, Municipal Landfills) – As noted earlier, the single municipal landfill in the FNSB is the Fairbanks South Cushman Landfill, located south of downtown Fairbanks but within the NAA.

⁴⁷ https://gaftp.epa.gov/air/nei/2020/doc/supporting_data/events/2020FireLoc_Alaska.csv

Roadway VMT (All On-Road Mobile) – The merged 2021 Daily VMT roadway segment dataset developed from the ADOT&PF GIS shapefiles was tabulated to determine the amounts of total VMT (paved plus unpaved roads) that occurred within the Inside and Outside NAA subareas. As shown in Table 3.1-11, the Inside and Outside NAA roadway VMT fractions were 82.2% and 17.8%, respectively, and were used to allocate total FNSB on-road mobile source emissions to each subarea.

Using the source category-specific surrogate metrics described above, the Middle Inventory emissions for both direct PM_{2.5} and each potential precursor pollutant were spatially distributed into the Within NAA and Outside NAA subareas. Table 3.1-12 and Table 3.1-13 present the results for the Inside and Outside NAA subareas, respectively. Both tables are structured similarly to the Middle Inventory summary for the entire FNSB provided earlier in Table 3.1-11 except they also include percentages of Controllable emissions within each subarea at the bottom of each table.

As seen in Table 3.1-12 and Table 3.1-13, most of the Middle Inventory emissions occur within the existing 24-hour nonattainment area. Except for VOC, Inside NAA Controllable emissions are 79% or more of total FNSB emissions.

As shown in Table 3.1-12, major sources of controllable PM_{2.5} emissions within the NAA include Residential Wood Combustion (316 tons/year), Waste Disposal other than Landfill (185 tons/year), Unpaved Road Dust (181 tons/year) and Point Sources (156 tons/year). For SO₂ and NO_x, the majority (roughly 70%) of controllable emissions within the NAA come from Point Sources.

Given that most of the Middle Inventory emission occur from sources within the existing 24-hour PM_{2.5} nonattainment area, emissions within a third extent—the existing nonattainment area—were also examined further. This was termed the Inner Inventory and is discussed in the following subsection.

Table 3.1-12 Middle Inventory Emissions by Pollutant and Key Source Category – Inside NAA Portion

Sector	Source Category	Inside Nonattainment Area Emissions (tons/year)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Point	All	156	1,534	3,250	8	22
NonPoint	Biogenics	0	0	23	803	0
NonPoint	Construction Dust	81	0	0	0	0
NonPoint	Paved Road Dust	6	0	0	0	0
NonPoint	Unpaved Road Dust	181	0	0	0	0
NonPoint	Fires - Prescribed Fires	1,275	97	152	3,591	250
NonPoint	Fires - Wildfires	0	0	0	0	0
NonPoint	Fuel Comb - Residential - Wood	316	8	42	1,076	11
NonPoint	Fuel Comb - Residential - Other Space Heating	9	533	207	13	1
NonPoint	Waste Disposal - Municipal Landfills	0.47	5	3	0	212
NonPoint	Waste Disposal - Other	185	17	62	44	36
NonPoint	All Others	151	40	767	1,552	17
OnRoad	All	28	2	636	406	23
NonRoad	All	1	0	4	15	0
TOTALS		2,388	2,235	5,147	7,511	572
CONTROLLABLE SOURCE TOTALS		1,113	2,138	4,972	3,116	322
PCT OF MIDDLE INVENTORY CONTROLLABLE EMISSIONS		82%	85%	79%	69%	95%

Table 3.1-13 Middle Inventory Emissions by Pollutant and Key Source Category – Outside NAA Portion

Sector	Source Category	Outside Nonattainment Area Emissions (tons/year)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Point	All	58	281	807	276	1
NonPoint	Biogenics	0	0	977	33,687	0
NonPoint	Construction Dust	12	0	0	0	0
NonPoint	Paved Road Dust	1	0	0	0	0
NonPoint	Unpaved Road Dust	36	0	0	0	0
NonPoint	Fires - Prescribed Fires	94,096	6,230	7,654	272,246	18,939
NonPoint	Fires - Wildfires	2,839	186	225	8,225	572
NonPoint	Fuel Comb - Residential - Wood	47	1	6	160	2
NonPoint	Fuel Comb - Residential - Other Space Heating	1	79	31	2	0
NonPoint	Waste Disposal - Municipal Landfills	0	0	0	0	0
NonPoint	Waste Disposal - Other	27	2	9	6	5
NonPoint	All Others	22	6	112	226	2
OnRoad	All	6	0	138	88	5
NonRoad	All	29	0	187	631	1
TOTALS		97,174	6,787	10,145	315,549	19,528
CONTROLLABLE SOURCE TOTALS		239	371	1,290	1,390	17
PCT OF MIDDLE INVENTORY CONTROLLABLE EMISSIONS		18%	15%	21%	31%	5%

3.4 Inner Emissions Inventory Analysis

As explained in Section 3.1, the Inner Inventory extent is the existing 24-hour PM_{2.5} Fairbanks NAA. Emissions within the Inner Inventory were spatially distributed into two subareas: 1) the Fairbanks portion of the NAA (which includes the Goldstream Valley), and 2) the North Pole portion of the NAA. Figure 3.1-3 shows each of these subareas within the Inner Inventory area as well as key roadways within the region. The Fairbanks and North Pole subareas are 175.60 square miles and 61.12 square miles in size, respectively. (The entire NAA encompasses 236.73 square miles.)

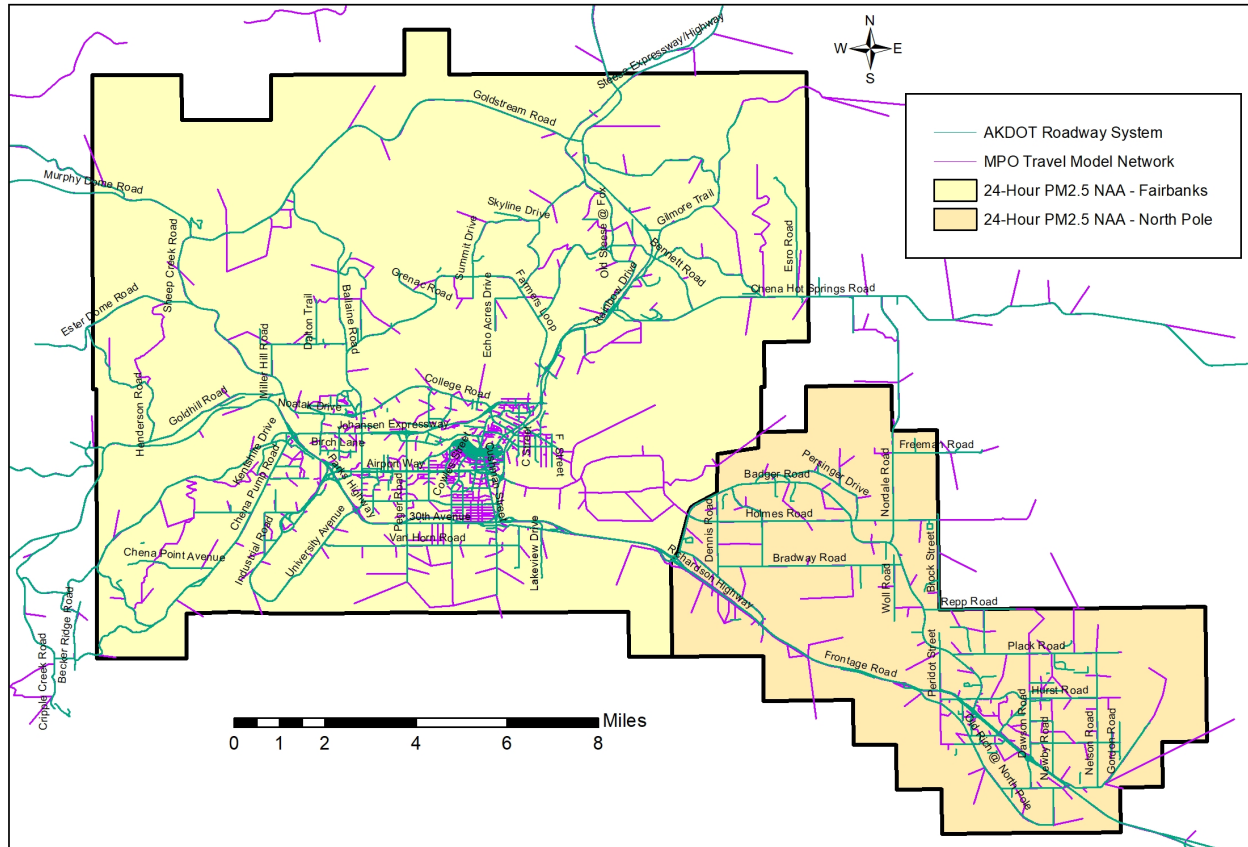


Figure 3.1-3: 24-Hour Nonattainment Inner Inventory Area and Fairbanks and North Pole Subareas

Table 3.1-14 shows emissions for the Inner Inventory area, the existing 24-hour nonattainment area, by pollutant and source category. Since the Inner Inventory only reflects spatial refinements, not source activity or emission refinements, its emissions are identical to those presented earlier in Table 3.1.12 for the “Inside NAA” portion of the Middle Inventory. As with the earlier Middle Inventory tables, the Biogenics, Prescribed Fires, and Wildfires source categories were shaded to reflect the fact that due to either their natural origin or treatment as exceptional events, they are not included within the Controllable Emissions subtotals at the bottom of the table.

Table 3.1-14 Inner Inventory Emissions by Pollutant and Key Source Category – Entire 24-Hour NAA

Sector	Source Category	24-Hour Nonattainment Area Emissions (tons/year)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Point	All	156	1,534	3,250	8	22
NonPoint	Biogenics	0	0	23	803	0
NonPoint	Construction Dust	81	0	0	0	0
NonPoint	Paved Road Dust	6	0	0	0	0
NonPoint	Unpaved Road Dust	181	0	0	0	0
NonPoint	Fires - Prescribed Fires	1,275	97	152	3,591	250
NonPoint	Fires - Wildfires	0	0	0	0	0
NonPoint	Fuel Comb - Residential - Wood	316	8	42	1,076	11
NonPoint	Fuel Comb - Residential - Other Space Heating	9	533	207	13	1
NonPoint	Waste Disposal - Municipal Landfills	0.47	5	3	0	212
NonPoint	Waste Disposal - Other	185	17	62	44	36
NonPoint	All Others	151	40	767	1,552	17
OnRoad	All	28	2	636	406	23
NonRoad	All	1	0	4	15	0
TOTALS		2,388	2,235	5,147	7,511	572
CONTROLLABLE SOURCE TOTALS		1,113	2,138	4,972	3,116	322

As performed with the Middle Inventory, a series of similar surrogate metrics were tabulated to spatially allocate total NAA emissions into the Fairbanks and North Pole subareas. Table 3.1-15 presents these Inner Inventory surrogates and allocations to the Fairbanks and North Pole subareas.

Table 3.1-15 Inner Inventory Subarea Spatial Allocation Fractions by Source Category

Sector	Source Category	Spatial Surrogate	Fairbanks NAA %	North Pole NAA %
Point	All	Source Location	Varies	Varies
NonPoint	Biogenics	Rural Land Area	77.5%	22.5%
NonPoint	Construction Dust	Population	84.3%	15.7%
NonPoint	Paved Road Dust	Paved Road VMT	76.8%	23.2%
NonPoint	Unpaved Road Dust	Unpaved Road VMT	36.0%	64.0%
NonPoint	Fires - Prescribed Fires	2020 Prescribed Fire Locations	100.0%	0.0%
NonPoint	Fires - Wildfires	2020 Wildfire Locations	0.0%	0.0%
NonPoint	Fuel Comb - Residential - Wood	SIP Gridded 2020 Inventory	Varies	Varies
NonPoint	Fuel Comb - Residential - Other Space Heating	SIP Gridded 2020 Inventory	Varies	Varies
NonPoint	Waste Disposal - Municipal Landfills	Source Location	100.0%	0.0%
NonPoint	Waste Disposal - Other	Population	84.3%	15.7%
NonPoint	All Others	Population	84.3%	15.7%
OnRoad	All	Roadway VMT	75.1%	24.9%
NonRoad	All	Rural Land Area	77.5%	22.5%

With the exception described below, the same spatial surrogates were analyzed to allocate Inner Inventory emissions into the Fairbanks and North Pole subareas as were used to allocate Middle Inventory emissions to the Inside NAA and Outside NAA areas. Although the resulting spatial allocation factors were different (comparing Table 3.1-11 to Table 3.1.15), the data sources and analysis approaches were the same.

The exception was for the Residential Wood Combustion and Other Residential Space Heating categories. As indicated in Table 3.1-15, the gridded emissions inventory from the SIP (based on 1.33 km square grid cells) was used to spatially allocate total NAA emissions for both space heating categories into the Fairbanks and North Pole subareas. Although the SIP gridded inventory represented winter episodic emissions, it was assumed that the change in space heating fuels between winter and summer (i.e., less relative wood use in summer) and resultant emissions was the same across the entire Inner Inventory nonattainment area. Thus, the winter spatial allocation factors were also applicable to the summer.

As indicated by the “Varies” entries in Table 3.1-15, the spatial allocation factors for the two residential space heating source categories are pollutant specific as the mixture of heating devices and fuels differs across the nonattainment area. For direct PM_{2.5}, 53% of the Inner Inventory emissions were allocated to the Fairbanks subarea (with the remaining 47% allocated to the North Pole subarea). The SO₂, NO_x, VOC and NH₃ allocation factors for the Fairbanks subarea were 70%, 74%, 47% and 64%, respectively, with complementary percentages allocated to the North Pole subarea.

Table 3.1.16 and Table 3.1.17 contain the resulting Inner Inventory emissions for the Fairbanks and North Pole subareas, respectively.

As highlighted at the bottom of Table 3.1-16, most of the Controllable emissions of the Inner Inventory are estimated to occur within the Fairbanks subarea, with direct PM_{2.5} emissions representing 66% of the Inner Inventory total. Allocated emissions in the Fairbanks subarea for the precursor pollutants range from 51% for NO_x to 88% for NH₃.

The emissions by source category and resultant Controllable emissions percentages for the North Pole subarea are presented in Table 3.1-17 and expectedly reflect complementary lower fractions of Inner Inventory emissions. However, the lower Controllable emissions fractions in North Pole are a product of its size.

Table 3.1-18 compares Controllable emissions densities by pollutant (in tons/year per square mile) for the Fairbanks and North Pole subareas (along with the subarea size). As highlighted at the bottom of Table 3.1-18, Controllable source emission densities for all pollutants are higher in North Pole than Fairbanks, and by a significant margin for all pollutants except NH₃. Though not shown in Table 3.1-18, this is a product of higher residential wood burning emissions density in North Pole for PM_{2.5} and higher point source emissions densities for SO₂ and NO_x.

So, although emissions are greater in the Fairbanks subarea than the North Pole subarea, emissions of direct PM_{2.5} and key precursor pollutants SO₂ and NO_x are significantly more concentrated in North Pole based on these Controllable emissions density comparisons.

Table 3.1-16 Inner Inventory Emissions by Pollutant and Key Source Category – Fairbanks NAA Portion

Sector	Source Category	Fairbanks NAA Portion Emissions (tons/year)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Point	All	118	888	1,170	7	1
NonPoint	Biogenics	0	0	18	623	0
NonPoint	Construction Dust	68	0	0	0	0
NonPoint	Paved Road Dust	5	0	0	0	0
NonPoint	Unpaved Road Dust	65	0	0	0	0
NonPoint	Fires - Prescribed Fires	1,275	97	152	3,591	250
NonPoint	Fires - Wildfires	0	0	0	0	0
NonPoint	Fuel Comb - Residential - Wood	168	5	31	502	7
NonPoint	Fuel Comb - Residential - Other Space Heating	5	375	153	6	1
NonPoint	Waste Disposal - Municipal Landfills	0.47	5	3	0	212
NonPoint	Waste Disposal - Other	156	14	52	37	30
NonPoint	All Others	127	34	646	1,308	14
OnRoad	All	21	1	478	305	17
NonRoad	All	1	0	3	12	0
TOTALS		2,008	1,420	2,707	6,392	532
CONTROLLABLE SOURCE TOTALS		733	1,323	2,537	2,178	283
PCT OF INNER INVENTORY CONTROLLABLE EMISSIONS		66%	62%	51%	70%	88%

Table 3.1-17 Inner Inventory Emissions by Pollutant and Key Source Category – North Pole NAA Portion

Sector	Source Category	North Pole NAA Portion Emissions (tons/year)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Point	All	39	645	2,080	1	21
NonPoint	Biogenics	0	0	5	180	0
NonPoint	Construction Dust	13	0	0	0	0
NonPoint	Paved Road Dust	1	0	0	0	0
NonPoint	Unpaved Road Dust	116	0	0	0	0
NonPoint	Fires - Prescribed Fires	0	0	0	0	0
NonPoint	Fires - Wildfires	0	0	0	0	0
NonPoint	Fuel Comb - Residential - Wood	147	2	11	574	4
NonPoint	Fuel Comb - Residential - Other Space Heating	4	158	54	7	0
NonPoint	Waste Disposal - Municipal Landfills	0	0	0	0	0
NonPoint	Waste Disposal - Other	29	3	10	7	6
NonPoint	All Others	24	6	121	244	3
OnRoad	All	7	0	158	101	6
NonRoad	All	0	0	1	3	0
TOTALS		380	815	2,440	1,118	39
CONTROLLABLE SOURCE TOTALS		380	815	2,435	938	39
PCT OF INNER INVENTORY CONTROLLABLE EMISSIONS		34%	38%	49%	30%	12%

Table 3.1-18 Inner Inventory Controllable Emissions Density by Subarea and Pollutant

Subarea	Subarea Size (sq mi)	Controllable Emissions Density (tons/year per sq mi)				
		PM _{2.5}	SO ₂	NO _x	VOC	NH ₃
Fairbanks	175.60	4.18	7.53	14.45	12.40	1.61
North Pole	61.12	6.21	13.33	39.84	15.34	0.65

3.5 Population Density and Degree of Urbanization

Population and Occupied Households - This subsection presents comparisons of population and household counts within the two sub-areas of the current PM_{2.5} nonattainment area compiled from block-level data in the 2020 Census. Population and household counts compiled at the Census block level across the 24-Hour PM_{2.5} NAA were examined within GIS maps that included base layers identifying the boundaries of the NAA and the Fairbanks and North Pole subareas. Because the size of the census blocks varies significantly across the FNSB PM_{2.5} NAA, the Census data were plotted on a density basis (e.g., population per square mile).

Figure 3.1-4 and Figure 3.1-5 present spatial comparisons of 2020 population and occupied household density (per sq. mi), respectively for the entire FNSB Middle Inventory area. Within each figure, the Fairbanks and North Pole subareas are shown as separate, blue-edged boundaries that comprise the entire 24-Hour NAA. Population density (in Figure 3.1-4) and household density (in Figure 3.1-5) are plotted using successively dark color shading from yellow to brown, as denoted in the map legends.

As seen in both Figure 3.1-4 and Figure 3.1-5, population and occupied households are clustered within the 24-Hour NAA. Outside the NAA, population per square mile rarely exceeds 100 people. Thus, the regions outside the NAA are very sparsely populated.

Zooming in to the NAA, Figure 3.1-6 and Figure 3.1-7 show the 2020 population and occupied household densities over the Inner Inventory area. Within these figures, the Fairbanks subarea is larger blue bounded polygon to the left; the North Pole areas is the smaller blue bounded polygon to the lower right within the NAA.

At this scale, population and occupied household densities vary more significantly across the NAA. As shown in Figure 3.1-6, the highest population densities (over 5,000 per square mile) are largely concentrated in and around downtown Fairbanks, also extending westward. Occupied household density exhibits similar spatial patterns as shown in Figure 3.1-7.

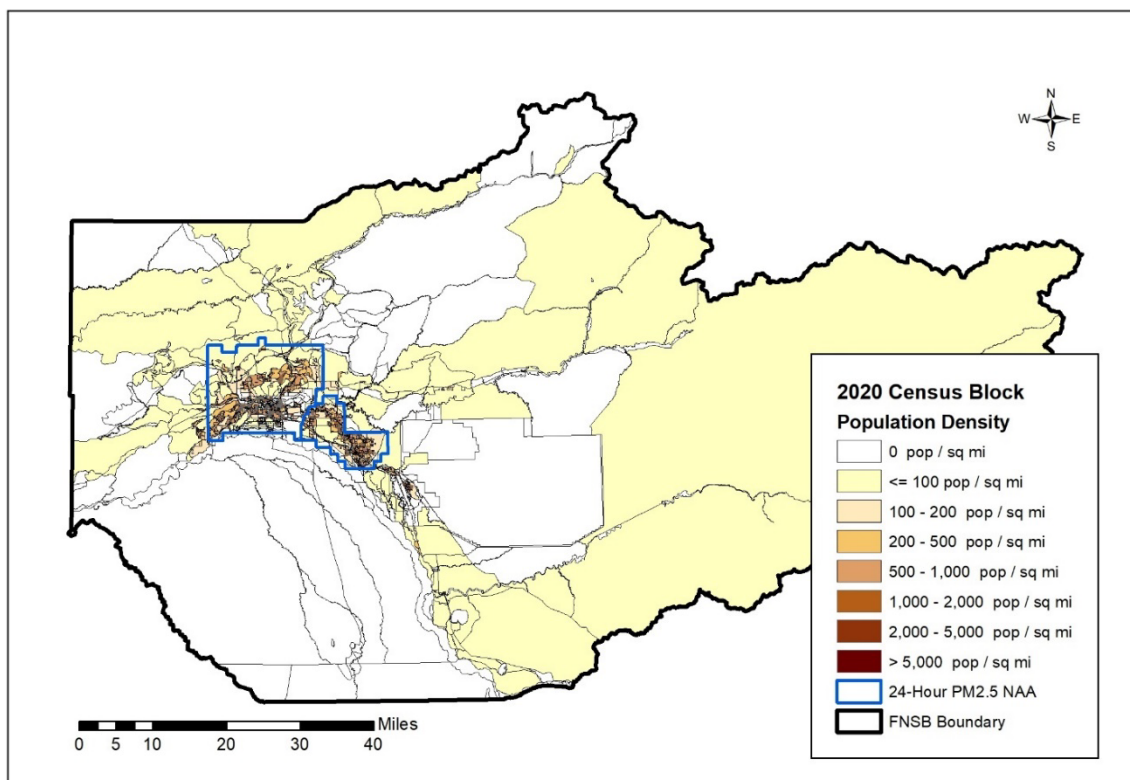


Figure 3.1-4: 2020 Census Population Density - FNSB Middle Inventory Area

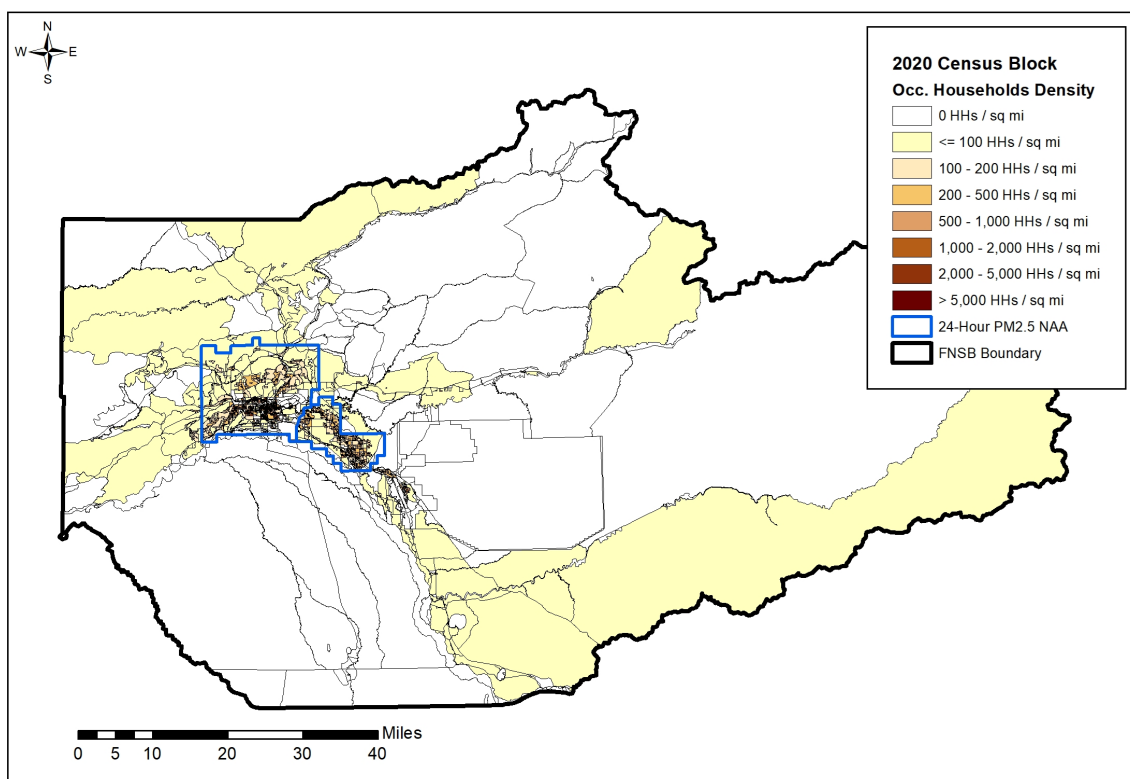


Figure 3.1-5: 2020 Census Occupied Households Density - FNSB Middle Inventory Area

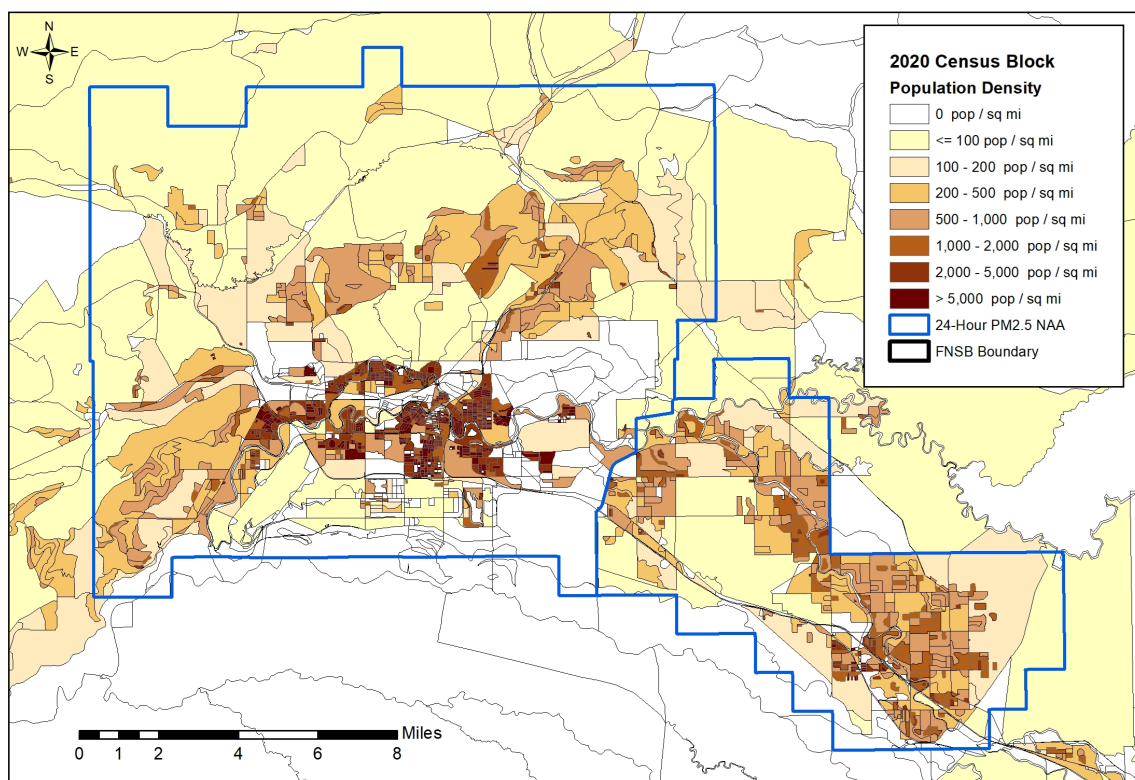


Figure 3.1-6: 2020 Census Population Density – 24-Hour NAA Inner Inventory Area

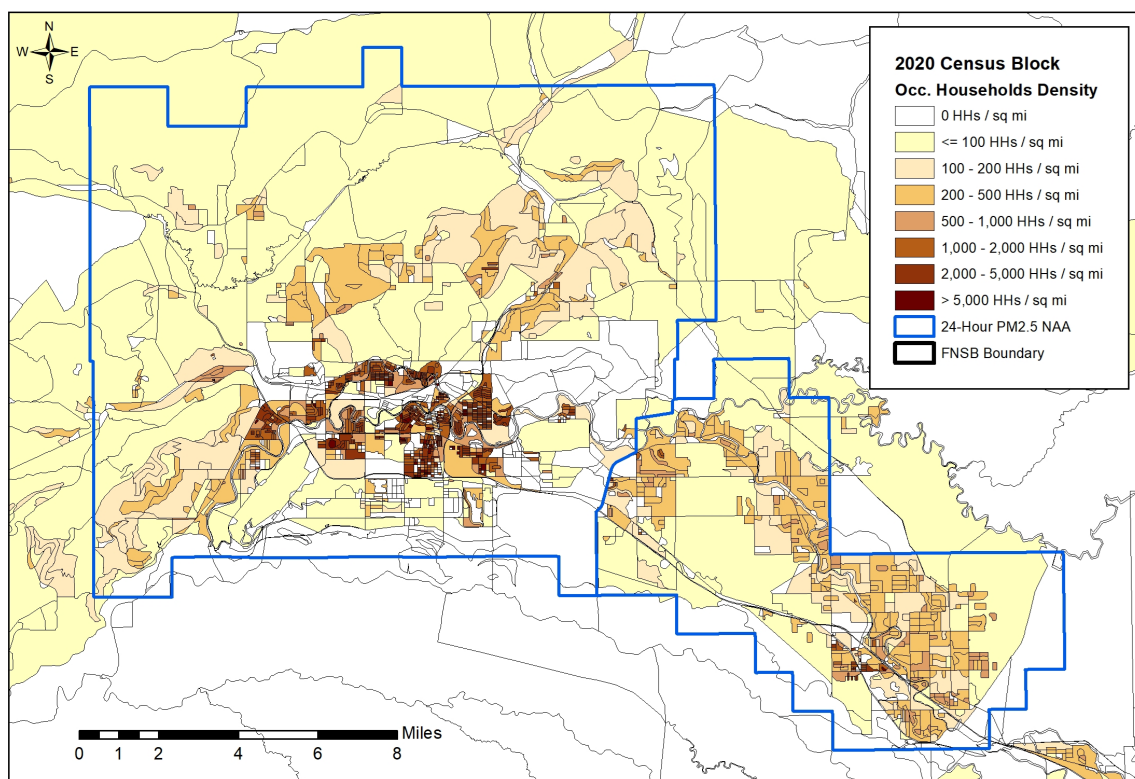


Figure 3.1-7: 2020 Census Occupied Households Density – 24-Hour NAA Inner Inventory Area

Table 3.1-19 summarizes these FNSB spatial population and occupied household totals by subarea, showing 2020 totals of each within the Fairbanks and North Pole portions of the NAA, as well as totals outside the NAA. The rightmost two columns of Table 3.1-19 provide population and occupied households densities (per square mile) based on the subarea sizes also shown in the table.

Table 3.1-19 FNSB 2020 Populations, Occupied Households and Densities by Subarea

Subarea	Subarea Size (sq mi)	Totals		Density (per sq mi)	
		Population	Occ. Hhlds	Population	Occ. Hhlds
Fairbanks	175.60	70,380	26,919	400.8	153.3
North Pole	61.12	13,132	4,869	214.9	79.7
Outside NAA	7,098.08	12,143	4,733	1.7	0.7

On a subarea wide basis, Table 3.1-19 shows that the Fairbanks and North Pole portions of the NAA have population and occupied household densities that are more than two orders of magnitude higher than the region of the FNSB outside the NAA. Within the NAA, the Fairbanks subarea exhibits population and occupied household densities that are roughly double that of the North Pole subarea per the 2020 Census.

Degree of Urbanization – Finally, another relevant metric compiled under the 2020 Census consists of the spatial distribution and extent of urbanized areas (as classified under the Census) both across the entire FNSB (Middle Inventory) and NAA (Inner Inventory) areas.

Figure 3.1-8 and Figure 3.1-9 show these urbanized areas plotted over both the Middle and Inner Inventory areas, respectively. As seen in Figure 3.1-8, the only urbanized area outside the NAA is located to its southeast and includes the Moose Creek and Eielson Air Force Base areas.

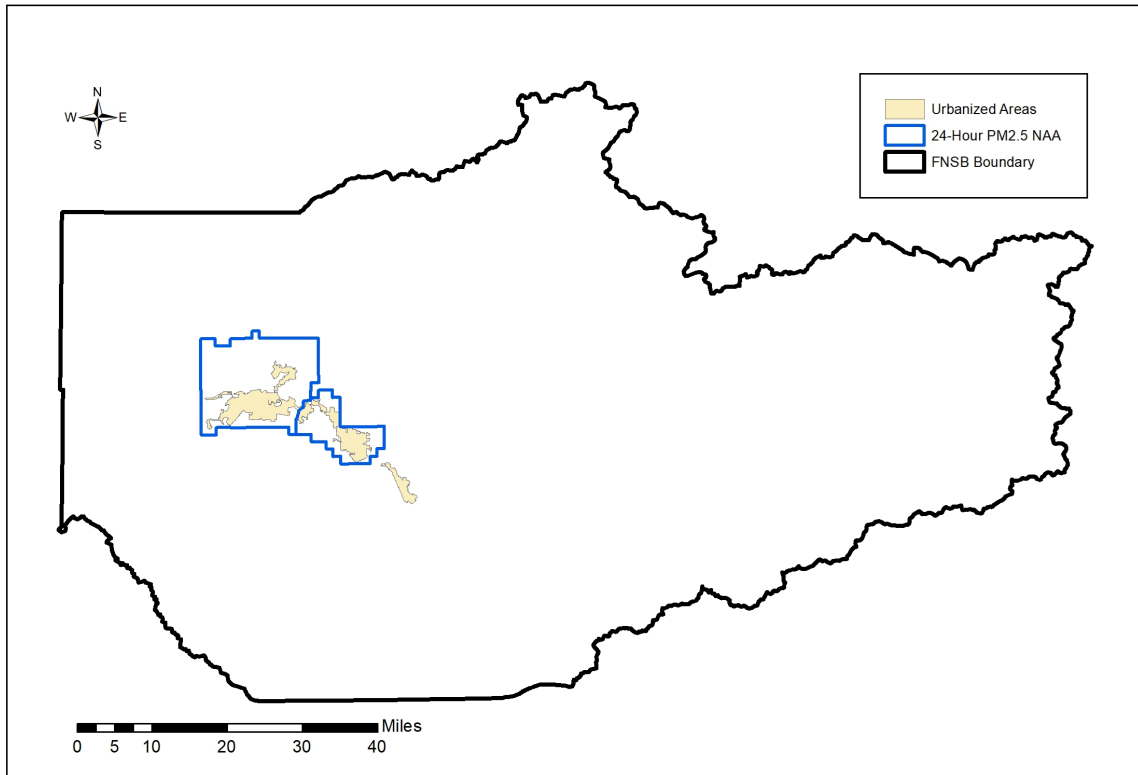


Figure 3.1-8: 2020 Census Urbanized Area - FNSB Middle Inventory Area

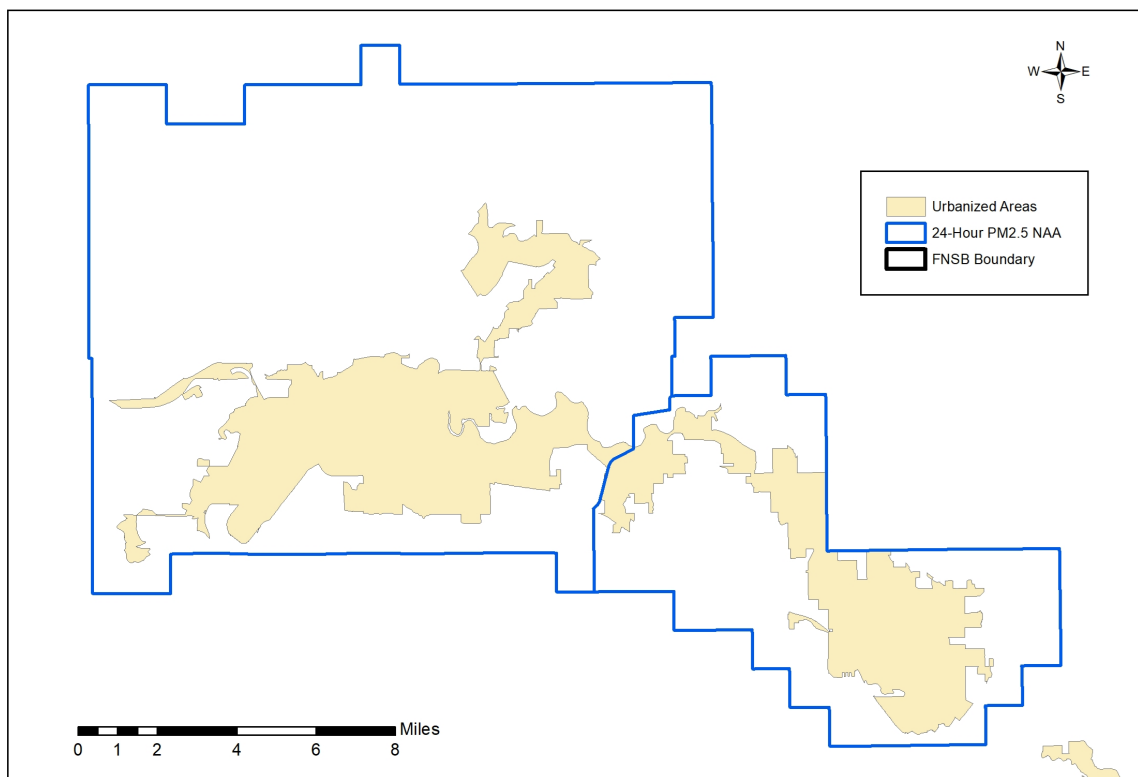


Figure 3.1-9: 2020 Census Urbanized Area - 24-Hour NAA Inner Inventory Area

Table 3.1-20 compares the degree of urbanization (as total and fractional land area) across the regions of the entire FNSB: Entire NAA and Outside NAA, as well as the Fairbanks and North Pole subareas within the NAA.

Table 3.1-20 FNSB 2020 Populations, Occupied Households and Densities by Subarea

Subarea	Area Type (sq mi)		Area Type Fraction (%)	
	Urban	Rural	Urban	Rural
Fairbanks	44.51	131.09	25.3%	74.7%
North Pole	23.15	37.98	37.9%	62.1%
Entire NAA	67.66	169.07	28.6%	71.4%
Outside NAA	6.77	7091.31	0.1%	99.9%

As seen in Table 3.1-20, the degree of urbanization within and outside the NAA are dramatically different at 28.6% and 0.1% of land area, respectively. Within the NAA, urbanized area fractions within the Fairbanks and North Pole subareas are similar, although higher in North Pole (37.9%) than Fairbanks (25.3%).

3.6 Traffic and Commuting Patterns

Traffic and Vehicle Miles Traveled - Metrics related to traffic and commuting patterns across the Middle and Inner Inventory areas were also examined and are presented in this subsection. Over the entire Middle Inventory (FNSB) area, traffic patterns were based on 2021 Annual Average Daily Traffic (AADT) levels compiled by ADOT&PF and contained in a road segment spatial GIS database. Within the Inner Inventory (NAA) area, spatial traffic patterns were compiled from travel model outputs from the most recent 2045 MTP Update regional transportation conformity analysis⁴⁸ completed in March 2023 by FAST Planning. The Fairbanks Area Surface Transportation (FAST) Planning is the Metropolitan Planning Organization for the urbanized areas of the FNSB. The FAST Planning travel modeling network encompasses the entire NAA and just beyond.

Figure 3.1-10 shows AADT-based traffic levels across the Middle Inventory area. As shown, AADT levels outside the NAA are generally below 1,000 vehicles per day. Within the NAA, the large majority of the roadways exhibit AADT levels below 10,000 vehicles per day.

This can be seen more clearly in Figure 3.1-11, which shows traffic levels for the smaller NAA based on FAST Planning travel model outputs for calendar year 2021. As seen in Figure 3.1-11, the segments with traffic levels above 10,000 or 15,000 vehicles per day are the highway (Parks, Steese, Richardson) corridors or major arterial roadways.

⁴⁸ <https://fastplanning.us/mtpupdate/>

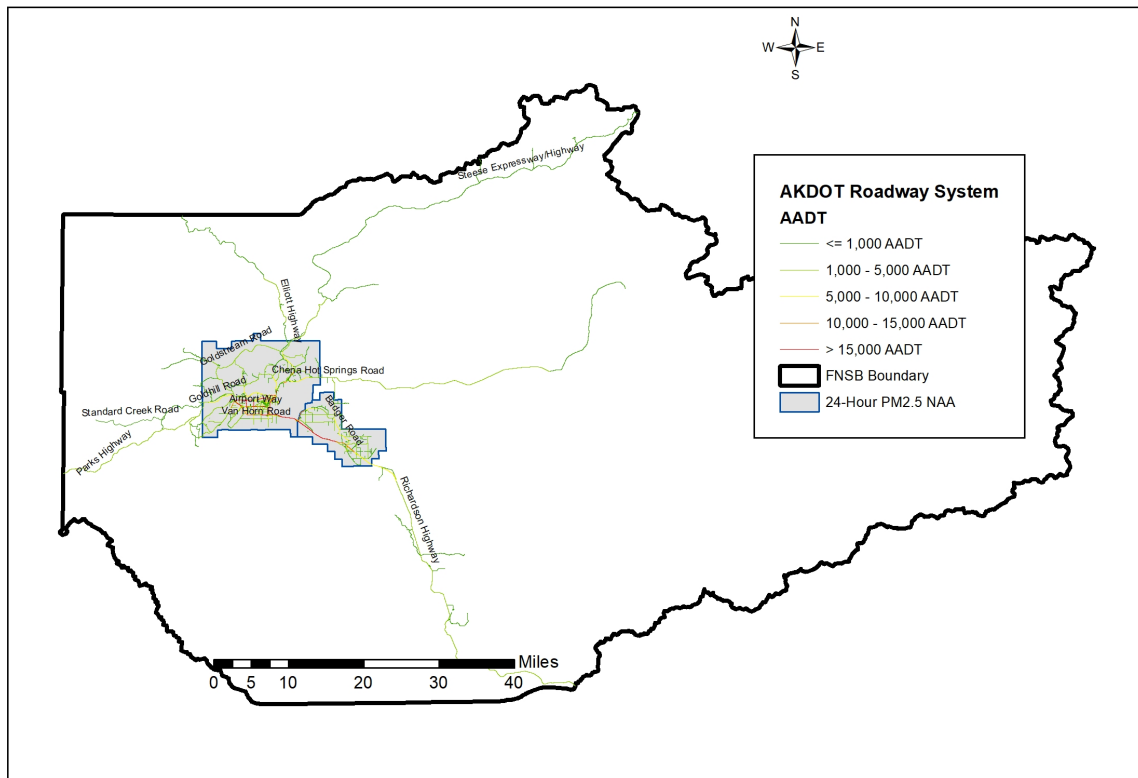


Figure 3.1-10: 2021 Annual Average Daily Traffic (AADT) – FNSB Middle Inventory Area

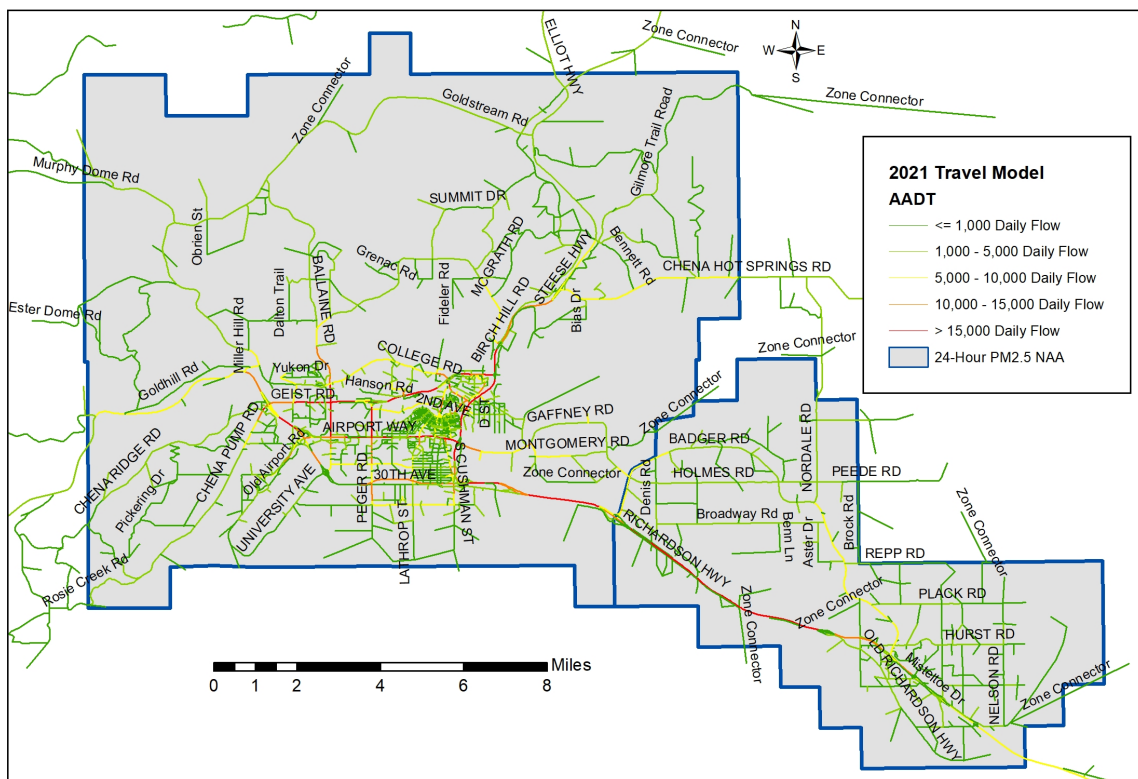


Figure 3.1-11: 2021 Annual Average Daily Traffic (AADT) – 24-Hour NAA Inner Inventory Area

Vehicle miles traveled data for the NAA and Fairbanks and North Pole subareas by time of day from the travel model are tabulated in Table 3.1-21. As shown in Table 3.1-21, most of the VMT (81%) in the NAA occurs within the Fairbanks subarea.

Table 3.1-21 Inner Inventory (NAA) 2021 Travel Model Daily VMT by Subarea and Time of Day

Daily Time Period	PM2.5 Nonattainment Area Daily VMT		
	Fairbanks	North Pole	Total
AM 2-Hour	149,350	42,360	191,710
PM 3-Hour	295,126	42,345	337,471
Off Peak 19 Hours	800,588	199,142	999,730
TOTAL	1,245,065	283,846	1,528,911
NAA VMT Fraction (%)	81.4%	18.6%	100%

Traffic Congestion – Another characteristic of vehicle travel within both the Fairbanks and North Pole portions of the NAA that distinguishes it from other larger metropolitan areas is its lack of traffic congestion. Volume to capacity ratios (or V/C) are one of several metrics used in transportation planning to measure congestion levels across a roadway network. They are calculated by dividing traffic volumes by the traffic capacity of a road segment. V/C data from the FAST Planning 2021 travel model outputs were analyzed to characterize traffic congestion within the NAA. A V/C ratio of 1 indicates that traffic volume is equal to the design capacity of the roadway and generally reflects modest congestion. V/C ratios well below 1 indicate little or no congestion while V/C ratios over 1 reflect traffic congestion.

Histograms of V/C across all roadway segments within the Fairbanks and North Pole subareas were tabulated and are plotted in Figure 3.1-12 for the two-hour AM Peak period and in Figure 3.1-13 for the three-hour PM peak period.

As shown in both Figure 3.1.12 and Figure 3.1.13, an overwhelming majority of road segments in both the Fairbanks and North Pole subareas operate at V/C ratios less than 0.5, indicating little congestion in both subareas during both AM and PM peak commute traffic periods.

Comparing the histograms for the two subareas shows that the North Pole area experiences less congestion (based on V/C ratio distributions) than in Fairbanks.

Figure 3.1-12: 24-Hour NAA Volume to Capacity Ratios by Subarea – AM Peak

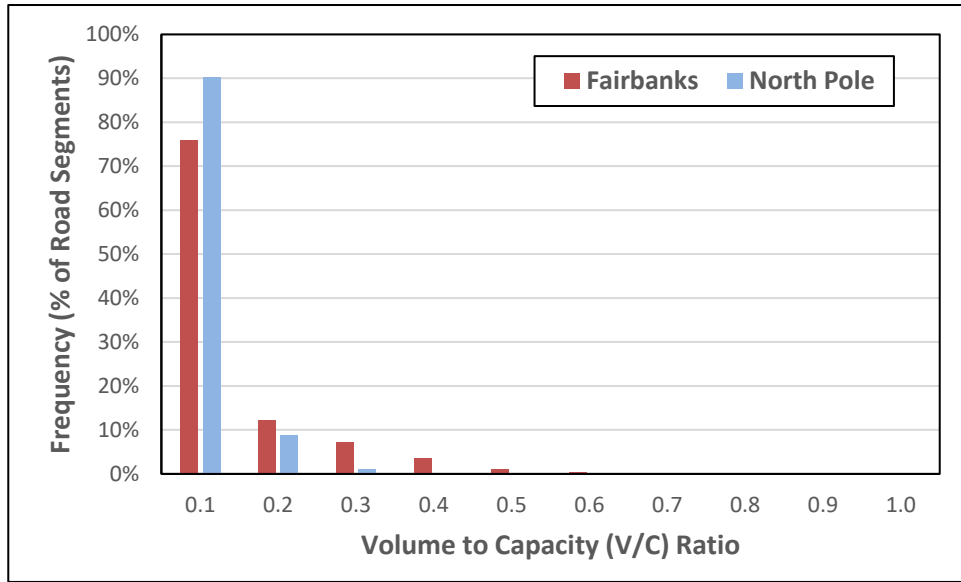
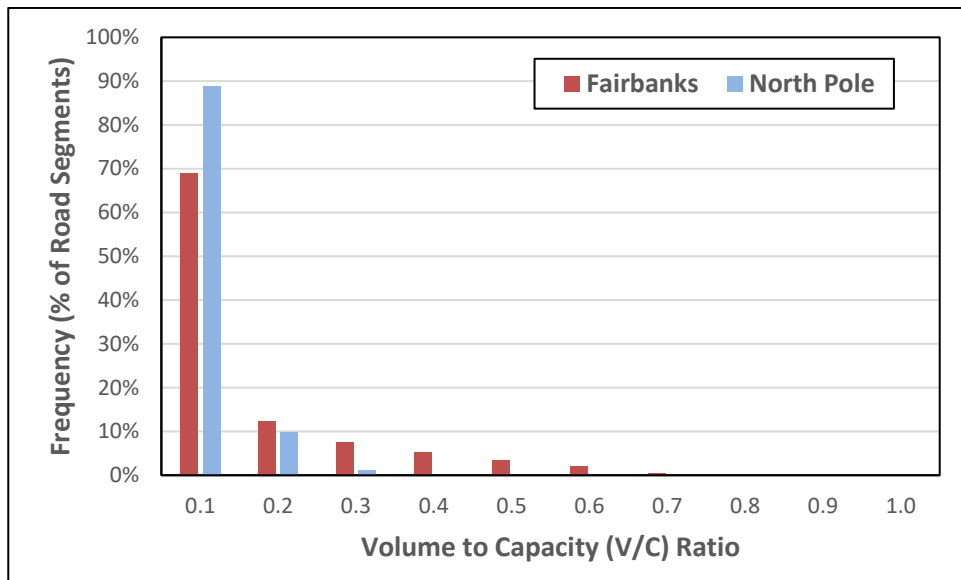


Figure 3.1-13: 24-Hour NAA Volume to Capacity Ratios by Subarea – PM Peak



3.7 Summary

Annual emissions inventories were developed for three extents within Interior Alaska to provide insight into the levels and locations of directly emitted PM_{2.5} and precursor pollutant emissions within each extent by source category under the Factor 2 analysis. The three extents were called the Outer, Middle, and Inner Inventories. The Outer Inventory included the Fairbanks North Star Borough (FNSB) and the three surrounding boroughs: Denali, Southeast Fairbanks, and Yukon-

Koyukuk. The Middle Inventory was defined as the FNSB and included spatial breakouts of emissions both within and outside the existing 24-hour PM_{2.5} nonattainment area (NAA). Finally, the Inner Inventory represented the NAA and examined sources within both the Fairbanks and North Pole portions of the NAA.

Emissions data for the Outer Inventory were tabulated from EPA's 2020 NEI. Activity estimates and emissions were successively refined for key source categories for the Middle and Inner inventories where data from the 2024 Amendment to the Fairbanks Serious Area PM_{2.5} SIP could be reasonable extrapolated from a winter episodic to an annual basis. Source categories that represent naturally occurring or exceptional event-based emissions included Biogenics, Prescribed and Wildfire Wildland Fires. Emissions were tabulated both with and without these source categories to provide insight as to which portion of total emissions originate from likely controllable emission sources. Moreover, a series of spatial surrogates were analyzed to estimate emissions by subarea within the Middle and Inner inventories.

These emissions analyses suggest that the nonattainment boundaries do not need to extend beyond the boundaries of the existing 24-hour NAA. Within the existing NAA, analysis of controllable source emissions densities (tons per square mile) found that the North Pole subarea exhibits emissions densities for PM_{2.5} and precursor pollutants SO₂ and NO_x that are 49%, 77% and 176% higher than the Fairbanks subarea, respectively. The Fairbanks and North Pole subarea emissions within the Inner Inventory can be examined in conjunction with ambient monitoring and meteorological data and modeling to assess further refinement to the boundaries for the annual PM_{2.5} nonattainment area.

The Factor 2 evaluation also included analysis of population and occupied household densities, degree of urbanization and traffic and commuting patterns that strongly indicate that emission sources that spatially align with these metrics are largely contained within the existing 24-hour NAA.

4. FACTOR 3- METEOROLOGY

The Interior of Alaska, where the Fairbanks North Star Borough is located, annually experiences large temperature swings. Temperatures have been recorded as low as -78°F in mid-winter, and as high as 93°F in summer. Average annual precipitation is 11.3 inches, and ice fog is common during the winter. The extremes in day length in the FNSB range from 21 hours of direct sunlight between May 10 and August 2 to less than four hours of direct sunlight between November 18 and January 24. Extended solar radiation and variable winds during the summer result in good vertical and horizontal air mixing and pollutant dispersion. As mentioned in Chapter 2, summertime PM_{2.5} concentrations are usually low unless impacted by wildland fire smoke.

Fairbanks North Star Borough winters are dominated by a pattern of cold, stable air that supports the buildup of air pollutants. Temperatures typically range between -20°F and +20°F, with several periods of -40°F each winter. Occasionally, temperatures can extend to much colder temperatures (e.g., -55°F in Jan 2012). A combination of high albedo and the low solar elevation that occurs in northern latitudes during the winter months creates little heating of the ground and weak vertical mixing between the surface and overlying air. Fairbanks and North Pole frequently experience ground-based inversions of considerable strength (40°F/100m) topped by weaker inversion zones such that the layer of inverted lapse rate often reaches as high as 1-2 kilometers. During strong inversions, the warm air cap/lid can be at a height of 300 feet above ground level. This condition, together with local emissions of PM_{2.5}, can cause episodes of significantly elevated PM_{2.5} concentrations.

Meteorological parameters are measured at the three regulatory monitoring sites as well as the Fairbanks International Airport and the two military bases, Fort Wainwright and Eielson Air Force Base. Below is a discussion of the airflow patterns at the three regulatory monitoring sites from 2021 to 2023. The first section discusses the annual hourly wind patterns, followed by a discussion of the seasonal variation in wind patterns and an analysis of meteorology on days when daily PM_{2.5} concentrations were above 9 µg/m³.

4.1 Annual Wind Patterns

In general, the wind regime in the FNSB PM_{2.5} 24-hour nonattainment area is characterized by relatively low wind speeds year-round. During the winter months, low wind speeds combined with extreme low temperatures and stable atmospheric conditions lead to severe inversions, with the Fairbanks North Star Borough (FNSB) experiencing among the steepest lapse rates in the United States.

4.1.1 NCore Monitoring Site

Figure 4.1-1 illustrates the distribution of hourly wind speeds and directions measured at the FNSB NCore monitoring site in Fairbanks from 2021 to 2023. The radial lines indicate wind direction, while the concentric circles represent the percentage frequency of wind occurrences. The chart indicates that the most frequent wind direction is from the southwest (210°) accounting for 12.73% of the total observations, followed closely by a wind direction from the east (90°) with 11.58% of occurrences, and from the west (240°) with 11.42% of occurrences. These patterns suggest a prevailing wind flow from the eastern and southwestern quadrants of the area.

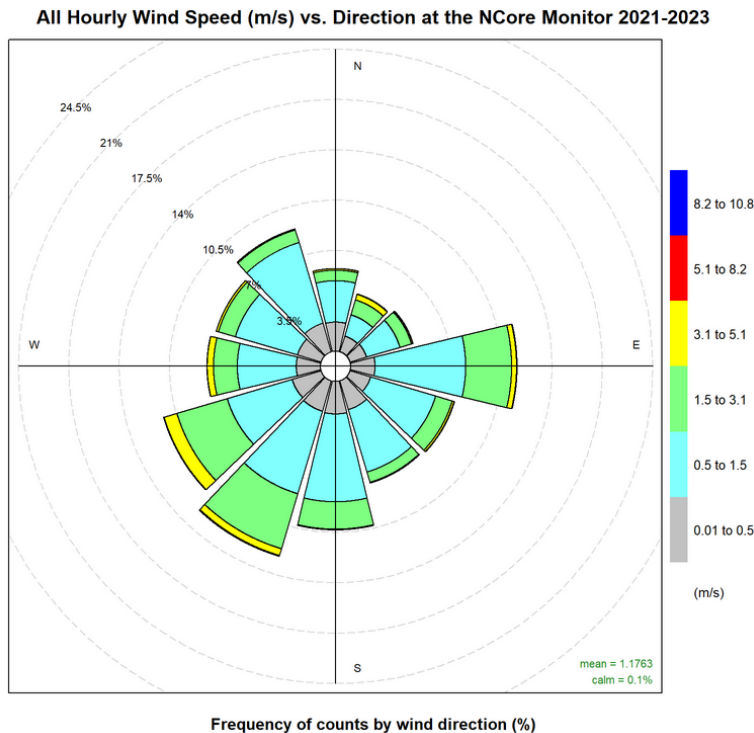


Figure 4.1-1 Hourly Wind Rose for the NCore Monitoring Site, 2021-2023

Wind speeds are color-coded, ranging from light gray representing calm conditions (0.01 to 0.5 m/s) to dark blue for the strongest winds (8.2 to 10.8 m/s). The average wind speed across all directions at NCore is approximately 1.2 m/s, with calm conditions occurring 0.1% of the time. Most of the wind speeds at NCore fall into the lower speed categories, predominantly between 0.5 to 3.1 m/s, as depicted by the light blue and green colors. Higher wind speeds occur occasionally, mostly from the west and southwest, with wind speeds in the range of 3.1 to 5.1 m/s as depicted by the yellow bands.

4.1.2 A-Street Monitoring Site

Figure 4.1-2 shows the three-year wind rose at the A-Street monitoring site in Fairbanks, indicating patterns that are similar to those observed at the NCore site but with notable distinctions that influence air quality in the A-Street area. The most frequent wind directions are from the east (90°) and southeast (120°), contributing 10.88% and 12.75% of the total wind observations, respectively. Winds from these directions are predominantly within the 0.5 to 1.5 m/s range, as indicated by the light blue sections of the wind rose. These light winds are often insufficient to disperse pollutants, particularly during temperature inversion conditions when PM_{2.5} levels increase. As such, the relatively low wind speeds from the east and southeast play a significant role in the accumulation of pollutants at the A-Street Monitor site, which often experiences higher PM_{2.5} concentrations than the NCore site. (The A-Street site is the maximum impact site for the Fairbanks Air Quality Control Zone.)

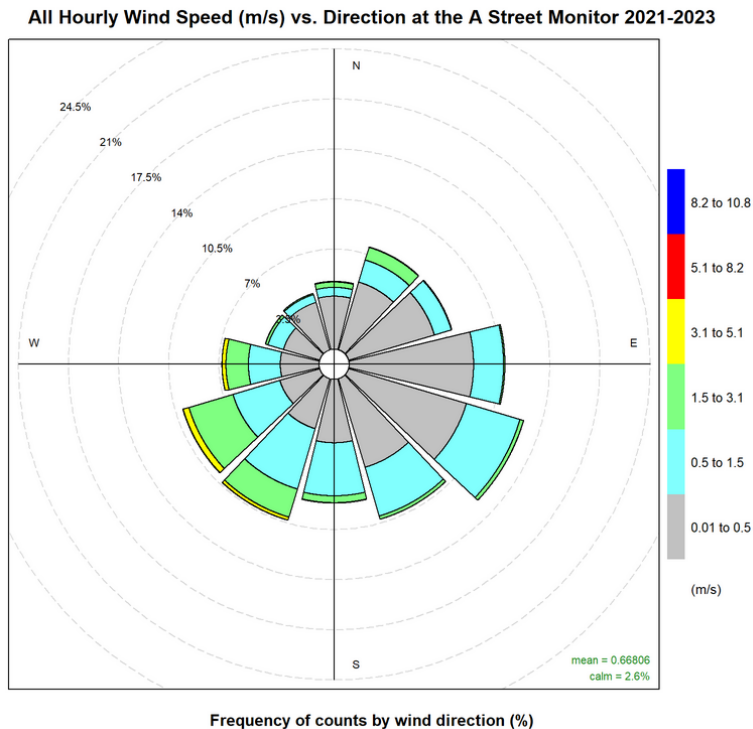


Figure 4.1-2 Hourly Wind Rose for the A-Street Monitoring Site, 2021-2023

Winds from the southwest (210°) and west (240°) also have a notable presence, with the west contributing 10.32% of the wind occurrences and the southwest accounting for 9.97%. Like the easterly winds, these western and southwestern winds tend to have low wind speeds, generally under 1.5 m/s, which further limits the dispersion of pollutants. These westerly winds tend to have slightly higher speeds, with some instances reaching above 3.1 m/s, but such events are relatively infrequent. West (270°) winds account for 6.78% of the observations, and like the westerly winds, they bring somewhat higher speeds. The mean wind speed at the A-Street Monitor is 0.67 m/s, with calm conditions occurring 2.6% of the time which reflects the slow-moving air patterns typical of the site.

4.1.3 Hurst Road Monitoring Site

Figure 4.1-3 depicts the hourly wind rose at the FNSB Hurst Road monitoring site in North Pole from 2021 to 2023. The most frequent wind directions recorded at the Hurst Road monitor sites are from the southeast (120°) and northeast (60°), with northeast winds being the most prominent, contributing approximately 14.69% to the overall wind distribution. Winds from the west (270°) and southwest (240°) also play a role in shaping behavior at the Hurst Road monitor with winds contributing 9.8% and 13.6% of the observed directions. Although less dominant than the easterly flows, winds from these directions still influence local wind patterns, particularly during shifts in regional airflow or changing weather conditions.

Wind speeds at the Hurst Road monitor are mainly concentrated in the 0.5 to 3.1 m/s range, with speeds above 3.1 m/s being rare. The mean wind speed observed at the Hurst Road monitor is 0.60 m/s, indicating predominantly low wind conditions, with calm periods accounting for 2.2% of the

data. The southeast winds generally fall within this low-speed range, which limits their capacity to disperse pollutants effectively especially during inversion conditions. This dynamic makes the region more susceptible to PM_{2.5} buildup, particularly during colder months, when low wind speeds prevent the efficient dispersal of airborne pollutants.

In the Hurst Road area, wind speeds above 1.5 m/s are crucial for reducing pollution levels, particularly PM_{2.5} concentrations. However, most wind speeds recorded are below this critical threshold, thereby limiting dispersion of pollutants effectively (Figure 4.1-3). This issue is particularly pronounced during inversion periods, where stagnant air traps pollutants close to the surface. The fact that wind speeds above 1.5 m/s are relatively infrequent underscores the tendency of pollution buildup in the North Pole Air Quality Control Zone, particularly in the winter months when inversions are more common. These limited air movements make it difficult to clear pollutants, leading to elevated PM_{2.5} levels, until stronger winds eventually break the inversion and clean out the area. Understanding this dynamic is critical when analyzing air quality issues in the North Pole area, as the relationship between low wind speeds and pollution accumulation is a defining feature of the wind patterns observed at the Hurst Road monitoring site.

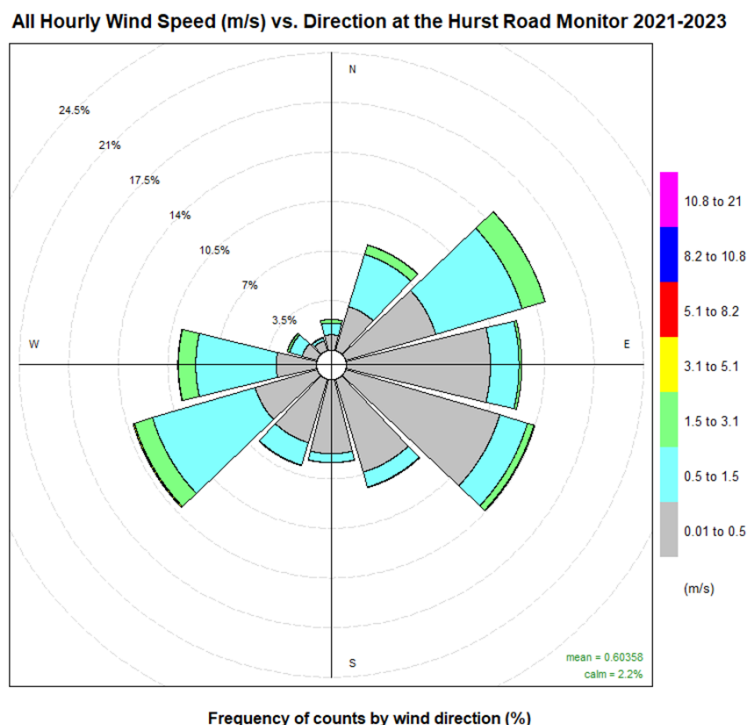


Figure 4.1-3 Hourly Wind Rose for the FNSB Hurst Road Monitoring Site, 2021-2023

The overall wind behavior in Figure 4.1-3 also reflects the significant influence of regional topography and drainage flows on wind patterns in North Pole. These patterns are essential for understanding how pollutants are trapped or dispersed under various weather conditions, especially during periods of low wind and temperature inversions.

4.2 Drainage Flow Patterns

The North Pole area is heavily influenced by regional drainage flows from the Upper Chena River and the Tanana River. The frequency of the prominent northeast winds at the Hurst Road monitor aligns well with the Upper Chena River drainage, which channels cold air down Angel Creek into the southeastern portion of North Pole. Similarly, prominent southeast winds in North Pole are likely to be influenced by the Tanana River drainage, which moves air from the southeast along the Tanana River Valley, contributing to the regional airflow (Figure 4.2-1).

In contrast to the North Pole area, the Fairbanks portion of the borough is affected by several drainage flows during the winter, as depicted in Figure 4.2-1. Cold air flows out of the Goldstream, Ester, and other valleys behind Cranberry and Chena Ridges into the University of Alaska Fairbanks area before emptying into the Tanana River valley. Relatively clean air comes from these directions, which helps to limit PM_{2.5} concentrations in the western portion of Fairbanks during inversion periods. Cold air also drains off Birch Hill and Mt. Lulu into the eastern Fairbanks area.

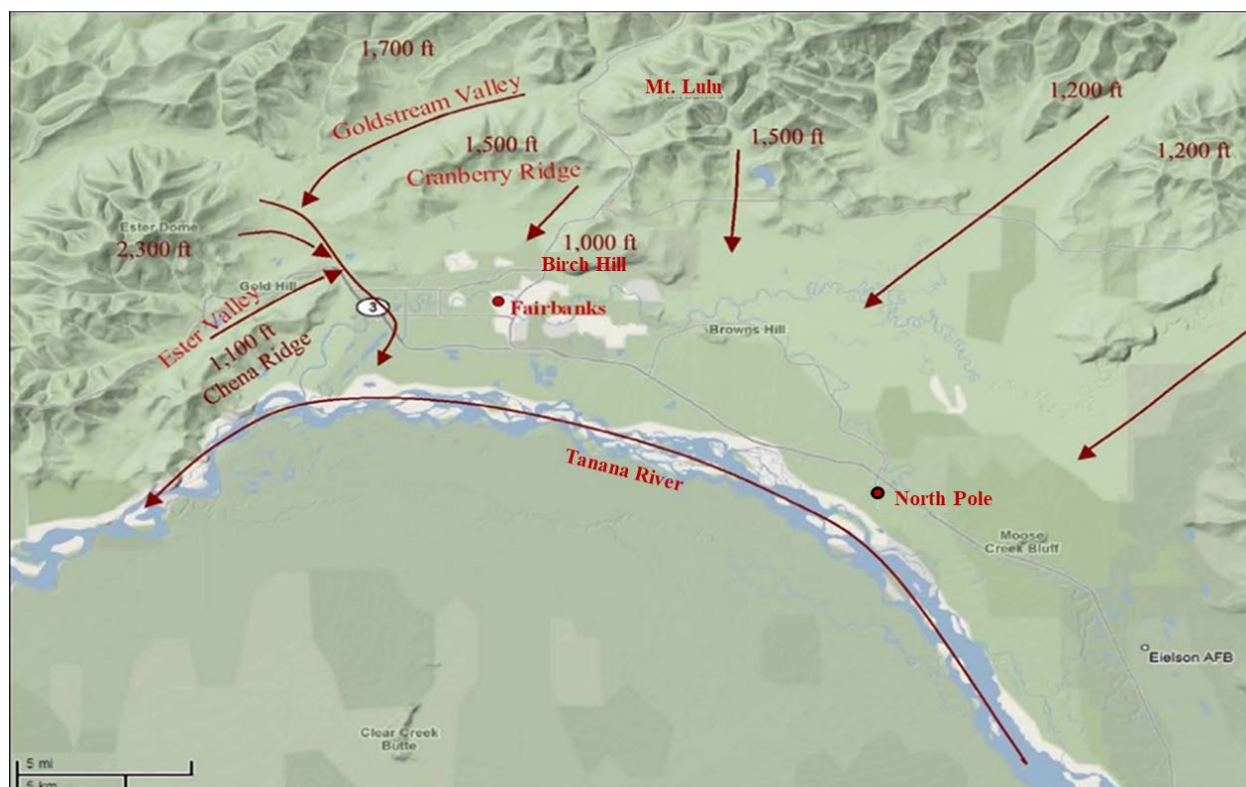


Figure 4.2-1 Drainage Flow into Fairbanks North Star Borough Nonattainment Area

4.3 Seasonal Wind Patterns

The section below contains a comparison of the wind patterns during the four calendar quarters at all three monitoring sites in the Fairbanks North Star Borough. As discussed in Factor 1: Air

Quality Data, PM_{2.5} concentrations during the second and third calendar quarters are far below the annual standard and therefore do not contribute to elevated pollution levels at or above the annual standard. The wind roses below are separated into calendar quarters with Q1 representing January through March 2021- 2023; Q2 indicating April through June 2021-2023, Q3, July through August 2021-2023; and Q4, October through December 2021-2023.

4.3.1 NCore Monitoring Site

Figure 4.3-1 represents the hourly wind rose for the NCore monitoring site from Q1 to Q4 (2021-2023). The figure highlights the seasonal differences in wind behavior and is organized with Q1 and Q4 (representing the winter months) on the left, and Q2 and Q3 (representing the summer months) on the right. As mentioned previously, wind speeds greater than 1.1-1.5 m/s are necessary to begin reducing PM_{2.5} concentrations at the NCore monitor, as speeds below this threshold tend to allow pollutants to accumulate, especially during inversion periods. During the winter months (October through March, Q1 and Q4), lower wind speeds and more frequent inversions typically trap pollutants near the surface, resulting in higher PM_{2.5} levels. In contrast, the summer months (Q2 and Q3) tend to see more frequent winds exceeding this threshold, dispersing pollutants more effectively.

During Q1, the mean wind speed is 0.92 m/s, with most wind speeds falling below the critical 1.1-1.5 m/s range. This explains why pollution levels often remain elevated during the winter months, as these low speeds do little to disperse pollutants. Cold air drainage from the surrounding valleys provides some relief, bringing in cleaner air, but this effect is not enough to fully disperse PM_{2.5}. In Q2, wind speeds increase slightly, with a mean of 1.61 m/s, allowing for more frequent occurrences of speeds above the 1.1-1.5 m/s threshold. This results in better pollutant dispersion, reducing PM_{2.5} levels more effectively during the spring months. As a result, pollution events are less frequent, though occasional inversions can still occur during periods of lower wind speeds, leading to daily concentrations in the moderate AQI range. The Q3 wind rose shows winds with slightly lower mean wind speeds than during Q2, at 1.28 m/s, with calm winds at 0.0% for the quarter. Higher overall temperatures and less frequent inversions ultimately lead to lower concentrations, although calm periods and low temperature in late fall can contribute occasionally to elevated pollution levels. In Q4, as the region transitions back into colder temperatures, wind speeds once again drop to an average of 0.93 m/s, similar to Q1. This results in frequent inversion conditions where pollutants are trapped near the surface, and wind speeds below the necessary threshold contribute to elevated pollution levels, especially in areas where local sources of PM_{2.5} are significant.

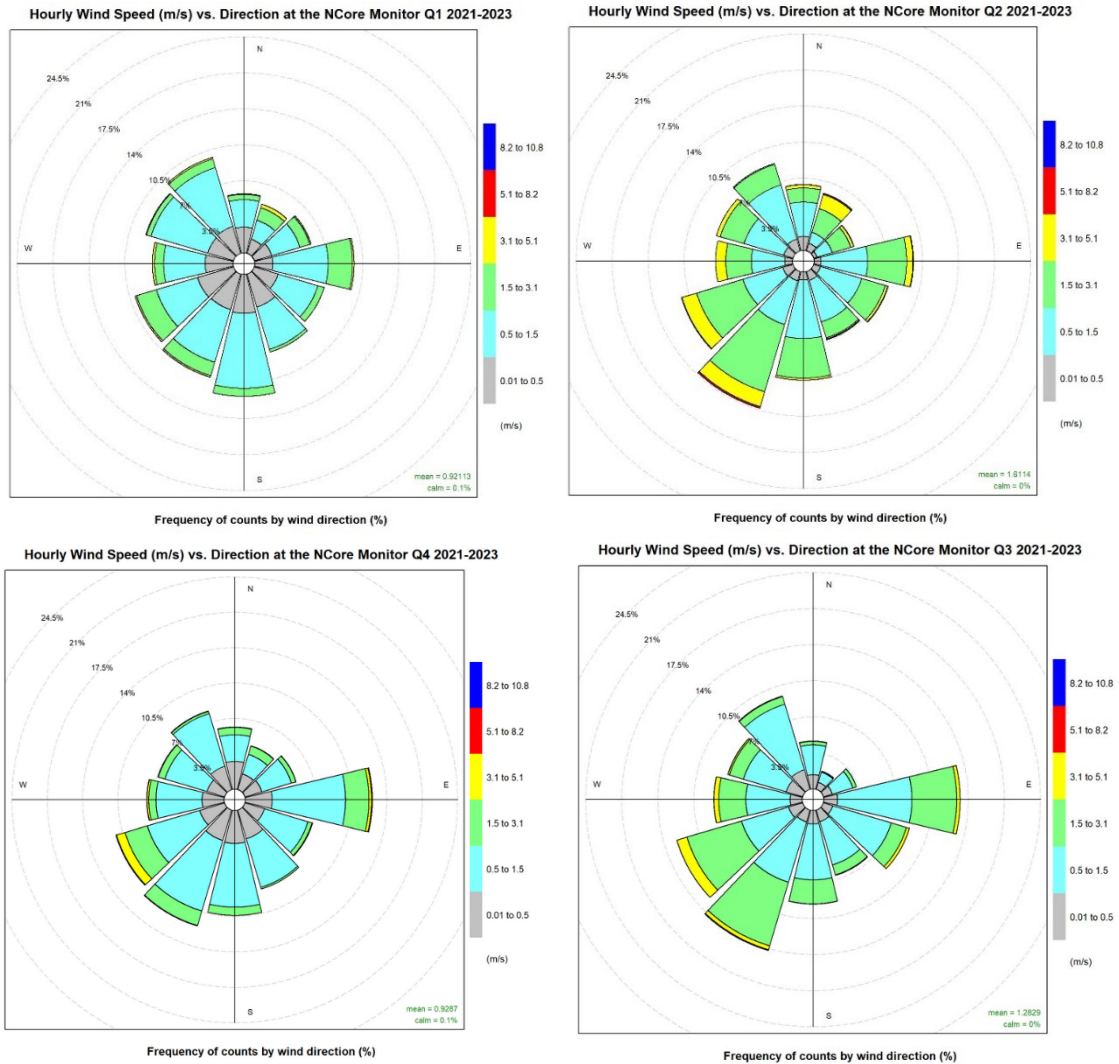


Figure 4.3-1 Hourly Wind Roses for the NCore Monitoring Site by calendar quarters, 2021-2023

Figure 4.3-2 shows the wind rose for the NCore monitoring site in Fairbanks from 2021 to 2023, for days when $\text{PM}_{2.5}$ concentrations exceeded $9 \mu\text{g}/\text{m}^3$. The wind rose shows that on days with elevated $\text{PM}_{2.5}$ levels, the prevailing wind directions are primarily from a southerly component. This direction accounts for a significant portion of the wind distribution, with a frequency of 51%. Winds from the south (180°) have the highest individual frequency at 12.17% of the wind distribution. Winds from the southeast (120°) and southwest (240°) are notable but occur less frequently, with frequencies of 7.73% and 9.36%, respectively, indicating additional, though lesser, pollutant transport from these directions. These winds influence air quality at the NCore monitor, suggesting potential pollution sources to the south and southwest that increase $\text{PM}_{2.5}$ concentrations under low-wind conditions.

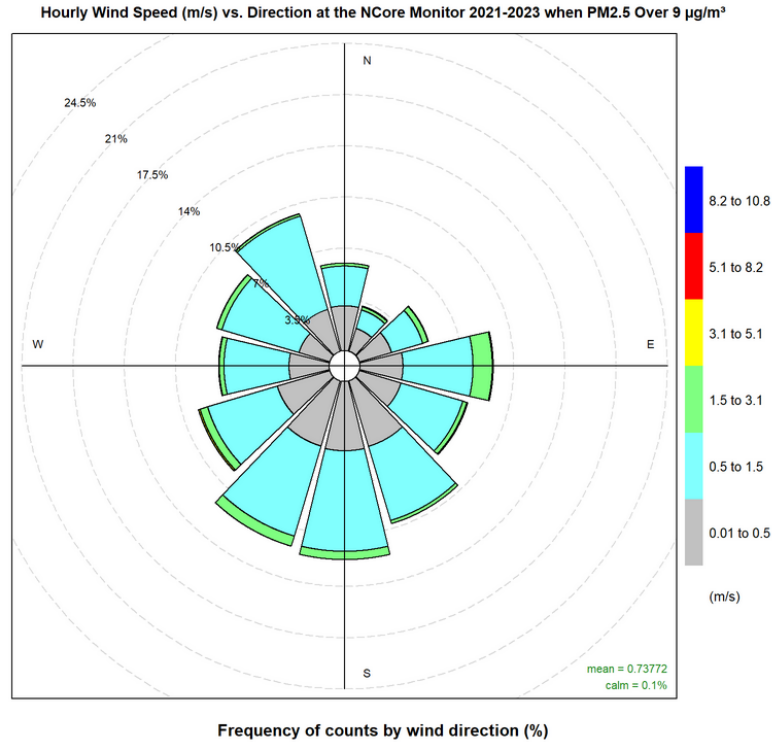


Figure 4.3-2. Hourly Wind Rose for the NCore Monitoring Site when PM_{2.5} > 9 µg/m³, 2021-2023

The wind speeds at NCore on days when PM_{2.5} concentrations exceeded the annual NAAQS are predominantly within the 0.5 to 1.5 m/s range. The mean wind speed for this dataset is 0.74 m/s, with calm conditions occurring about 0.1% of the time. This low average wind speed suggests that the dispersion of pollutants is generally insufficient on these days, contributing to the elevated PM_{2.5} levels recorded at the monitor.

In comparing the NCore wind rose for Figure 4.3-2 (representing days when PM_{2.5} concentrations exceeded 9 µg/m³) and the Q1 wind rose (January to March) in Figure 4.3-1, both wind roses share not only similar dominant wind directions from the south and southwest, but also exhibit comparable patterns across a wider range of directions. The overall distribution of low wind speeds suggest that the conditions present on days of elevated PM_{2.5} concentrations closely mimic typical winter wind behavior in Fairbanks. The consistency across directions highlights the role of the winter season's impact on air quality, as both figures capture the same fundamental airflow patterns that lead to elevated PM_{2.5} concentrations during inversion periods in Fairbanks.

4.3.2 A-Street Monitoring Site

Figure 4.3-3 represents wind patterns and highlights seasonal differences in wind behavior at the A-Street monitoring site in Fairbanks from 2021-2023 where Q1 and Q4 (representing the winter months) is shown on the left, and Q2 and Q3 (representing the summer months) is shown on the right. The winter months, covering Q1 (January to March) and Q4 (October to December), display consistently low wind speeds.

In Q1, the mean wind speed is 0.48 m/s with predominant wind directions from the east (90°) and southeast (120°), which account for 10.2% and 11.5% of the total wind occurrences, respectively. These winds are largely within the 0.5 to 1.5 m/s range, contributing to limited pollutant dispersion during the winter months, especially when inversion conditions are present. Calm conditions occur 1.4% of the time, reflecting the still air that can exacerbate PM_{2.5} accumulation.

As the region transitions into Q2 (April to June), wind speeds slightly increase, with a mean of 1.02 m/s. Winds from the southwest (210°) and west (240°) become more prominent, contributing 13.2% and 13.5% of the total wind observations, while the southeast (120°) and east (90°) directions continue to play a significant role. Despite this slight increase in wind speed, most winds remain below 1.5 m/s, although the number of calm days decreases, indicating better airflow compared to Q1. This allows for some dispersion of pollutants, but lower speeds combined with low temperatures and inversions occasionally could lead to elevated PM_{2.5} concentrations in the moderate AQI range.

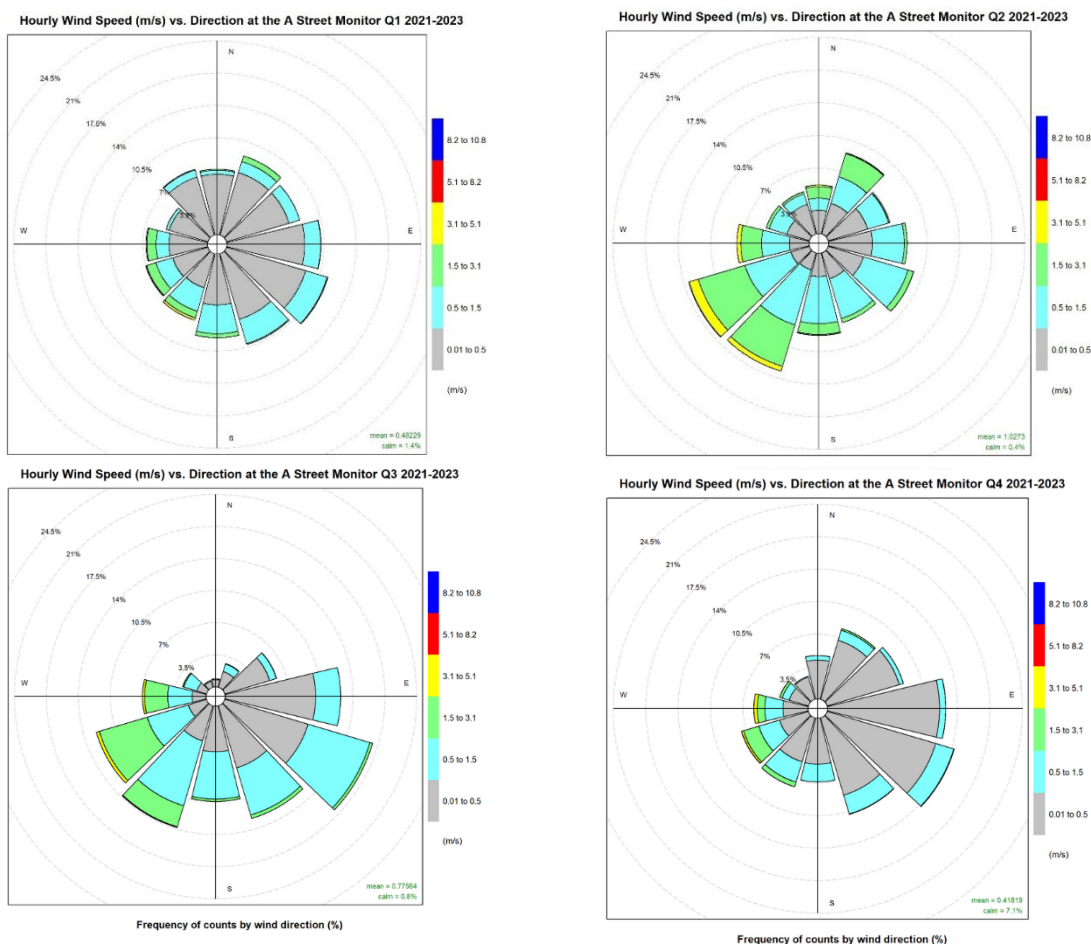


Figure 4.3-3 Hourly Wind Roses for the A-Street Monitoring Site by calendar quarters 2021-2023

Q3 (July to September) reflects the summer months, with the highest wind speeds observed across all quarters. The mean wind speed decreases to 0.78 m/s, even though there were more occurrences of winds exceeding 1.5 m/s, particularly from the southwest (210°) and west (240°), which

dominate the wind distribution. These stronger winds contribute significantly to pollutant dispersion, reducing $PM_{2.5}$ levels more effectively during this period. Winds from the east (90°) and southeast (120°) remain notable but play a lesser role in Q3 as compared to Q1 and Q2. Calm conditions also increased slightly to 0.08%.

Finally, in Q4 (October to December), as temperatures drop again, wind patterns return to those seen in Q1. The mean wind speed falls back to 0.42 m/s, and winds from the east (90°) and southeast (120°) regain their dominance, contributing 12.75% and 14.29% of the total, respectively. Wind speeds remain predominantly within the 0.5 to 1.5 m/s range, similar to Q1, with calm conditions occurring around 7.1% of the time. The lower wind speeds and frequent calm periods in Q4 suggest that pollutant buildup into the moderate AQI range is likely, especially during inversion events.

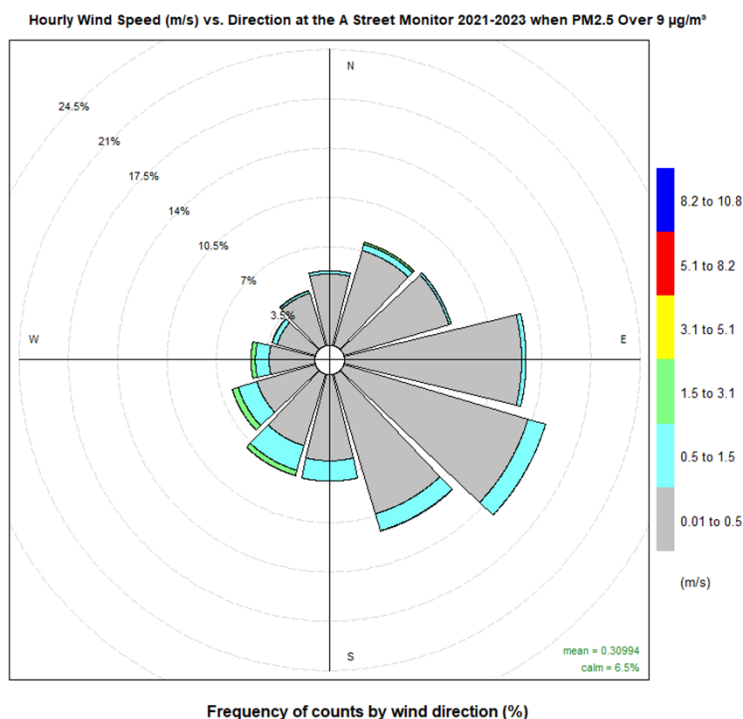


Figure 4.3-4. Hourly Wind Rose for the A-Street Monitoring Site when $PM_{2.5} > 9 \mu g/m^3$, 2021-2023

Figure 4.3-4 depicts wind speeds and directions at the A-Street Monitor during high pollution events (when $PM_{2.5}$ levels exceed $9 \mu g/m^3$) from 2021 to 2023. The mean wind speed during these high pollution periods is 0.31 m/s, illustrating the dominance of stagnant air, which is typical during temperature inversions. Calm conditions, defined by wind speeds below 0.5 m/s, account for 6.5% of the observations, further emphasizing the inability of the wind to disperse accumulated pollutants effectively.

The most frequent wind directions during these high $PM_{2.5}$ events are from the southeast (120°) and east (90°), collectively accounting for over 27% of the wind observations. The southeast wind, in particular, is the most prevalent, contributing 14.9% of the total, while winds from the east contribute 12.9%. Both directions predominantly feature wind speeds within the 0.5 to 1.5 m/s

range, which is insufficient to clear out pollutants, allowing PM_{2.5} levels to rise. Winds from the south (150°) and southwest (210°) are also frequent, contributing 11.6% and 7.5%, respectively, but these winds remain below the 1.5 m/s threshold needed for effective pollutant dispersion.

When comparing Figure 4.3-4 to Figure 4.3-3, similarities to the typical winter wind patterns are apparent. This similarity suggests that during winter months, when inversion conditions are common, wind speeds below 1.5 m/s allow pollutants to accumulate, leading to elevated PM_{2.5} concentrations in the moderate AQI range. The cold temperatures, combined with topographical influences such as cold air drainage from surrounding valleys, trap pollutants near the surface during these inversion events. In both figures, winds greater than 1.5 m/s are rare, reinforcing the conclusion that low wind speeds are a primary driver of moderate air quality events.

4.3.3 Hurst Road Monitoring Site

Figure 4.3-5 displays the hourly wind speeds and directions at the FNSB Hurst Road monitoring site in North Pole for Q1 through Q4 (2021-2023). The Hurst Road monitor is the only violating monitor in the State for the annual standard. The figure, organized by quarter, allows for a detailed analysis of wind patterns across different times of the year, with winter quarters (Q1 and Q4) on the left side and summer quarters (Q2 and Q3) on the right.

In Q1, representing the coldest months of the year (January to March), the mean wind speed at the Hurst Road monitoring site is 0.56 m/s, reflecting relatively low wind activity, with calm conditions accounting for 2.4% of the data. Winds from the southeast (120°) and northeast (60°) are the most frequent during this period, with contributions of 12.58% and 19.58%, respectively. These directions are heavily influenced by cold air drainage from the Upper Chena River and Tanana River valleys, creating patterns typical of inversion periods. Winds from the west (270°) and northwest (300°) also appear, but with much lower frequencies of 6.8% and 1.5%. Wind speeds tend to remain below 1.5 m/s, which is insufficient to clean out pollution during inversion periods.

In Q2 (April to June), representing the early summer period, there is a noticeable increase in wind activity, with a mean speed of 0.85 m/s and calm conditions making up 0.6% of the data. The southeast (120°) and northeast (60°) winds continue to dominate but show reduced frequencies compared to Q1, contributing 11.55% and 14.24%. This slight reduction aligns with the seasonal transition from winter to summer, where the regional drainage flows become less pronounced as temperatures rise. Winds from the west (270°) become more frequent in Q2, accounting for 13.34% of the data, indicating the increased influence of larger-scale weather systems during the summer months.

Figure 4.3-5. Hourly Wind Roses for the Hurst Road Monitoring Site by calendar quarters 2021-2023

By Q3 (July to September), the height of summer, wind speeds decrease slightly, with a mean of 0.5429 m/s and calm conditions contributing 1.1%. Winds from the northeast (60°) and southeast (120°) remain the dominant directions, contributing 10.68% and 15.51%, respectively. However, the data also shows increased frequencies of winds from the west (270°) and southwest (240°), contributing 12.17% and 13.92% of the total wind distribution. These changes suggest that regional

drainage flows from the Upper Chena and Tanana Rivers still play a significant role but are now complemented by larger-scale synoptic systems that bring winds from a broader range of directions.

In Q4 (October to December), as temperatures drop and winter approaches, wind patterns begin to resemble those of Q1, with a mean wind speed of 0.44 m/s and calm conditions occurring 1.7% of the time. Winds from the southeast (120°) dominate this period, contributing 16.31% of the total wind distribution, followed by winds from the northeast (60°), which account for 13.95%. These patterns reflect the increased influence of cold air drainage from the Upper Chena and Tanana River valleys as inversion conditions become more frequent during the colder months. Winds from the west (270°) and southwest (240°) continue to contribute, but at lower frequencies than during the summer months, accounting for 7.11% and 11.81%, respectively.

Across all quarters, the southeast (120°) and northeast (60°) directions consistently dominate, reflecting the persistent influence of regional drainage flows on the wind patterns at the Hurst Road monitor. However, wind speeds rarely exceed 1.5 m/s, particularly during the winter months (Q1 and Q4), when inversion conditions are most common. These low wind speeds hinder the dispersion of pollutants, leading to the moderate to poor air quality during inversion events.

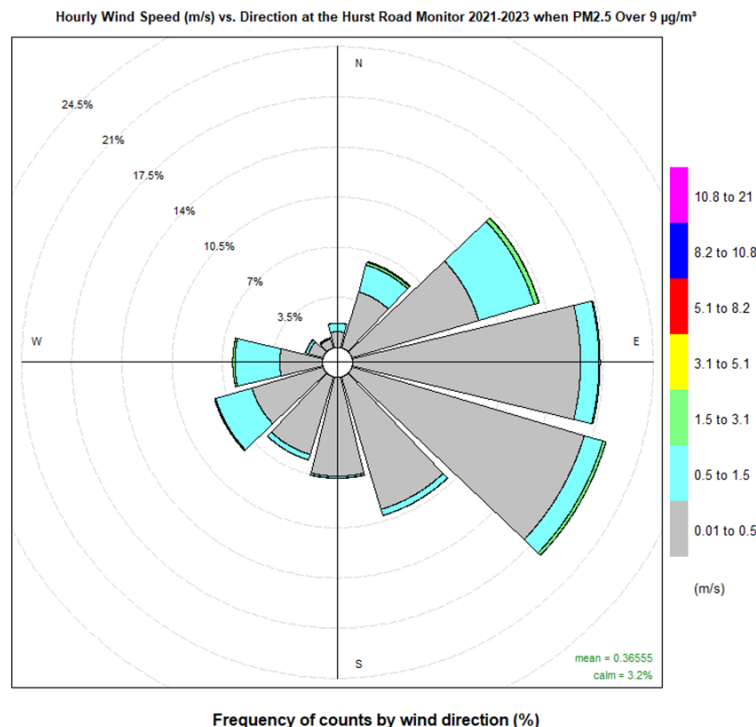


Figure 4.3-6 Hourly Wind Rose for the Hurst Road Monitoring Site when PM_{2.5} > 9 µg/m³, 2021-2023

Figure 4.3-6 illustrates the wind speeds and directions at the Hurst Road Monitor from 2021 to 2023, when daily PM_{2.5} concentrations exceeded 9 µg/m³. The dominant wind directions during high PM_{2.5} periods are from the southeast (120°) and east (90°), together accounting for a

substantial portion of the wind occurrences. Winds from the southeast make up 13.9%, and from the east, they contribute 12.4%. These winds primarily fall within the 0.5 to 1.5 m/s range, a speed insufficient to clear out pollutants effectively, especially during inversion conditions when the atmosphere becomes stagnant. In addition to the southeast and east winds, the southern (150°) and southwestern (210°) directions also contribute to the overall wind patterns, though they remain less frequent and similarly low in speed. The mean wind speed during these high pollution events is 0.37 m/s, with calm conditions (wind speeds below 0.5 m/s) occurring 3.2% of the time. This low mean wind speed, along with the frequent calm periods, suggests a significant correlation with inversion conditions that often trap pollutants close to the surface, limiting their dispersion. Given the low average wind speeds and their distribution, it is evident that during periods of elevated PM_{2.5}, the area experiences limited air movement. This contributes to the persistence of poor air quality, preventing adequate pollutant dispersion.

In comparing Figure 4.3-6 to Q1 and Q4 of Figure 4.3-5, it is evident that these wind roses share many similarities, especially in terms of wind direction and speed at the Hurst Road monitor. All three wind roses display dominant wind directions from the southeast (120°) and east (90°), which reflect the consistent regional drainage flows from the Upper Chena River and Tanana River. However, the regional drainage flows are not sufficient to disperse local space heating emissions during elevated PM episodes. During the winter, empirical evidence—based on eight years of observations and forecasting air alerts by DEC air alert forecasting staff—shows that inversion conditions dominate the area and drainage flows tend to ride above the inversion layer rather than significantly impacting surface-level air quality. The wind speeds in these three wind roses tend to stay below 1.5 m/s, reinforcing the correlation between winter conditions and limited air movement. This leads to frequent inversions, trapping pollutants close to the surface. The consistency of these wind patterns across both Q1 and Q4 and Figure 4.2-6 supports the conclusion that the North Pole area experiences air quality challenges during the winter months, where inversion periods and low wind speeds exacerbate PM_{2.5} concentration levels into the moderate to poor air quality range.

4.4 Summary

The analysis of airflow patterns and pollutant dispersion across the Fairbanks and North Pole areas reveals distinct seasonal and regional differences, influenced by topography and drainage flows. Meteorological conditions that lead to PM_{2.5} concentration in the moderate air quality range occur predominantly during the winter months when temperatures are very low, and inversions can generate. During wintertime inversion periods, cold air drainage dominates both areas, but the origin and direction of the flows differ significantly between Fairbanks and North Pole. In Fairbanks, cold air flows out of the Goldstream and other valleys behind the Cranberry and Chena Ridges into the western part of the city, where it moves toward the Tanana River. This relatively clean air helps limit PM_{2.5} concentrations in the western part of Fairbanks during inversion periods. In the eastern part, drainage off Birch Hill and from the Chena River brings air toward downtown Fairbanks. However, during inversions, this drainage tends to decouple and remain aloft, with surface drainage following the terrain and pushing pollutants into the Chena River basin.

Regional drainage flows during inversion periods provide the primary means of horizontal dispersion, particularly in Fairbanks, where air is moved out of the city to the west and southwest, along the Tanana River. The wind roses from the NCore and A-Street monitoring sites reflect this

pattern, showing dominant winds from the southwest and west. Wind speeds greater than 1.1–1.5 m/s help raise the inversion layer, allowing for the mixing of pollutants with higher air masses, thereby diluting PM_{2.5} concentrations.

In contrast, North Pole experiences regional drainage from the Upper Chena River to the northeast and the Tanana River to the southeast. During inversions, this air typically rides up and over the inversion layer rather than dispersing pollutants at ground level. The wind rose for the Hurst Road monitoring site shows a predominant southeast wind that, despite its sustained presence, is ineffective in clearing pollution. Instead, it pushes air towards the northwest, where there are open areas for limited pollutant dispersion. This suggests that airflows from North Pole do not significantly influence Fairbanks, and vice versa, supporting the observation that pollutants remain largely confined within their respective areas during inversion periods.

During the summer months, the inversion conditions that trap pollutants are less prevalent, and the region experiences higher wind speeds, particularly in Q2 and Q3. Wind roses for this period show increased variability in wind directions and speeds, which contributes to better air mixing and the dispersal of pollutants. Both Fairbanks and North Pole benefit from these dynamic wind patterns, which allow for more effective pollutant removal compared to the stagnant winter months. The differences in wind behavior between summer and winter highlight the seasonal variability in air quality, particularly in areas like North Pole, where inversion events lead to severe PM_{2.5} pollution during winter months.

5. FACTOR 4- GEOGRAPHY AND TOPOGRAPHY

The state's proposed PM_{2.5} nonattainment area boundaries surround the North Pole city limits and its neighboring residential areas. North Pole is located in the Fairbanks North Star Borough and lies approximately 20 miles southeast of the city of Fairbanks. The area is defined by the Tanana, Chena and Salcha River drainages and is surrounded by mountains and ridges, ranging in size from 1,000 ft to 2,500 ft, forming a semicircular barrier to the east, north and west of the Fairbanks and North Pole areas.

The city of North Pole sits at approximately 490 ft above sea level (ASL)⁴⁹ with the closest surrounding hills existing approximately 10 miles from city center to the north and to the east. These surrounding ridges rise to about 1,000 ft ASL while further away ridges reach as much as 2,500 ft ASL (Figure 5-1). The North Pole nonattainment area slopes upwards from west to east; the western border with the Fairbanks nonattainment area lies at approximately 460 ft while the eastern border along the Moose Creek Dam lies at 510 ft (Figure 5-2). The low elevation of the city center with respect to the distant surrounding ridges causes air pollution build up within the bowl during stagnant air conditions.

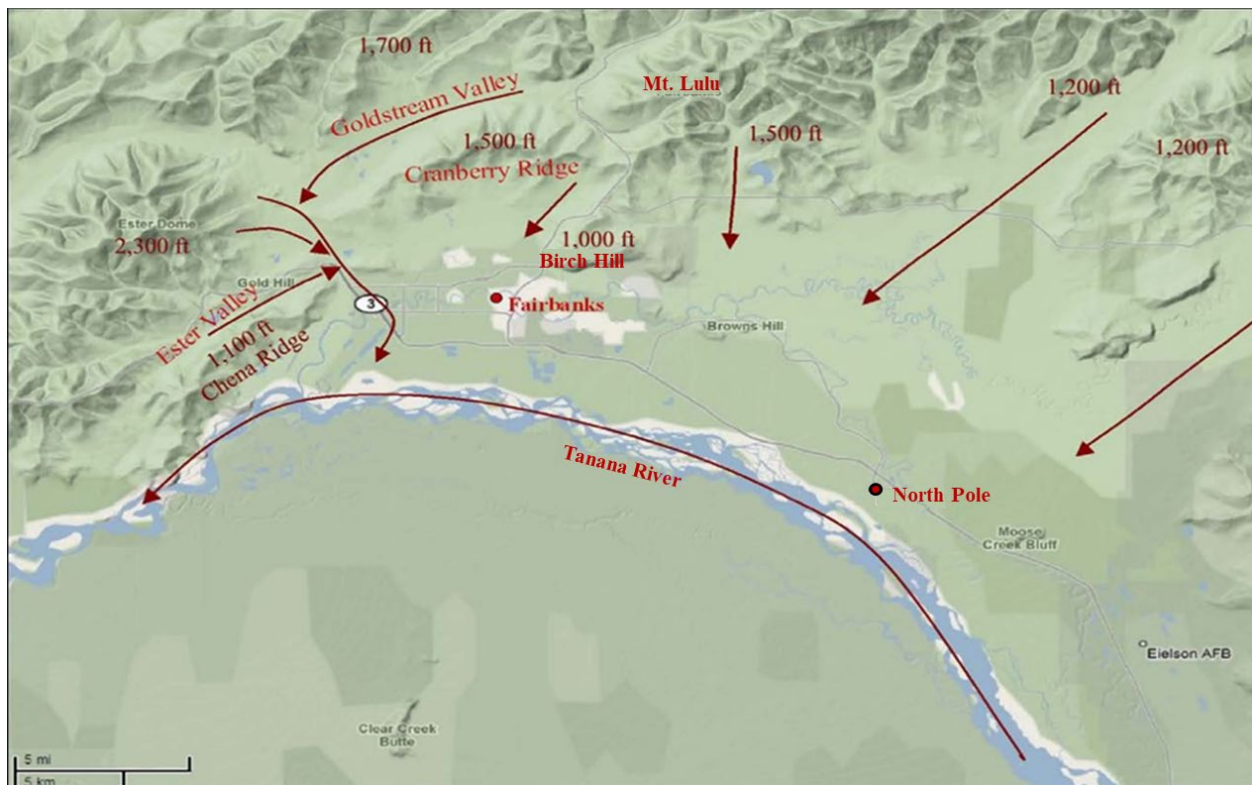


Figure 5-1 Coarse topography and regional drainage flows in the Fairbanks and North Pole area.

⁴⁹ <https://en-us.topographic-map.com/map-plt1mt/North-Pole/?center=64.77017%2C-147.27928&popup=64.74852%2C-147.39756>

In comparison, Fairbanks experiences notable differences in topographical features; the city of Fairbanks sits approximately 50 ft lower than North Pole at its lowest point of 440 ft ASL. Ridges surround the urban center to the west, north, and east and reach a height of 1,000 to 2,500 ft ASL. The immediate enclosure of ridges around the Fairbanks bowl aids in the formation of the inversion layer during cold and calm conditions.

Highly resolved topographic maps show surface gradients that exist throughout much of the Fairbanks and North Pole portions of the current 24-hour $PM_{2.5}$ FNSB nonattainment area. Due to the extreme nature of the inversions that persist during high particulate concentration episodes (wintertime months), small elevation changes influence the direction and nature of bulk transport between the sub-areas of Fairbanks and North Pole (Figures 5-2 through 5-4).

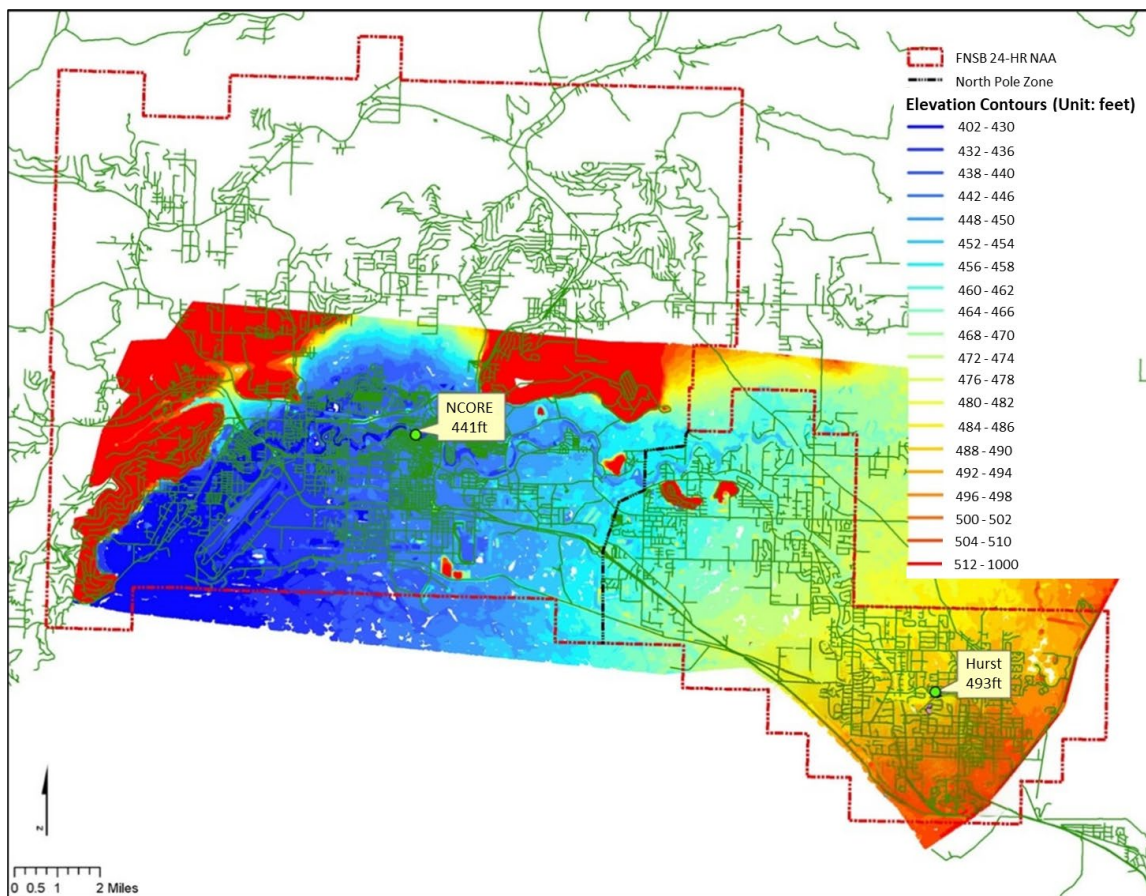


Figure 5-2 FNSB $PM_{2.5}$ nonattainment area 2-ft contour topographic map.

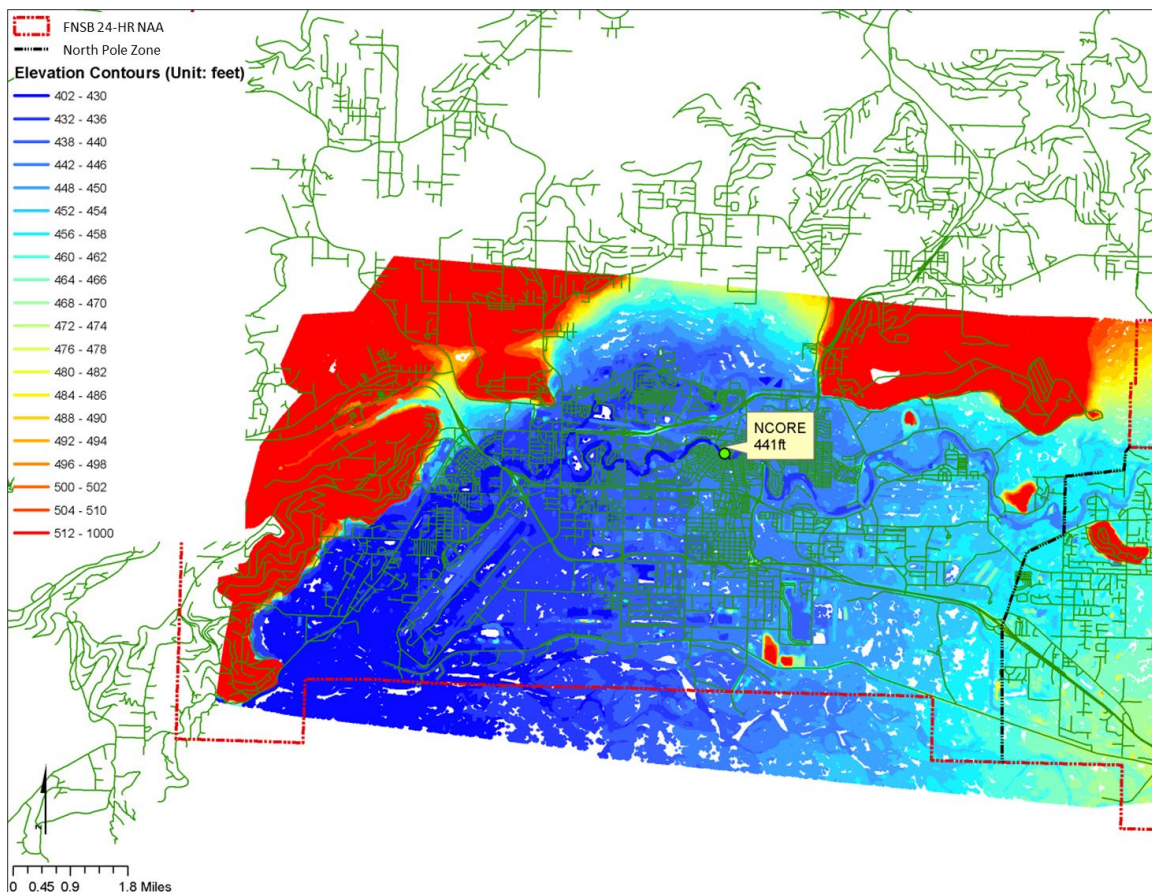


Figure 5-3 Fairbanks nonattainment area southern portion 2-ft contour topographic map.

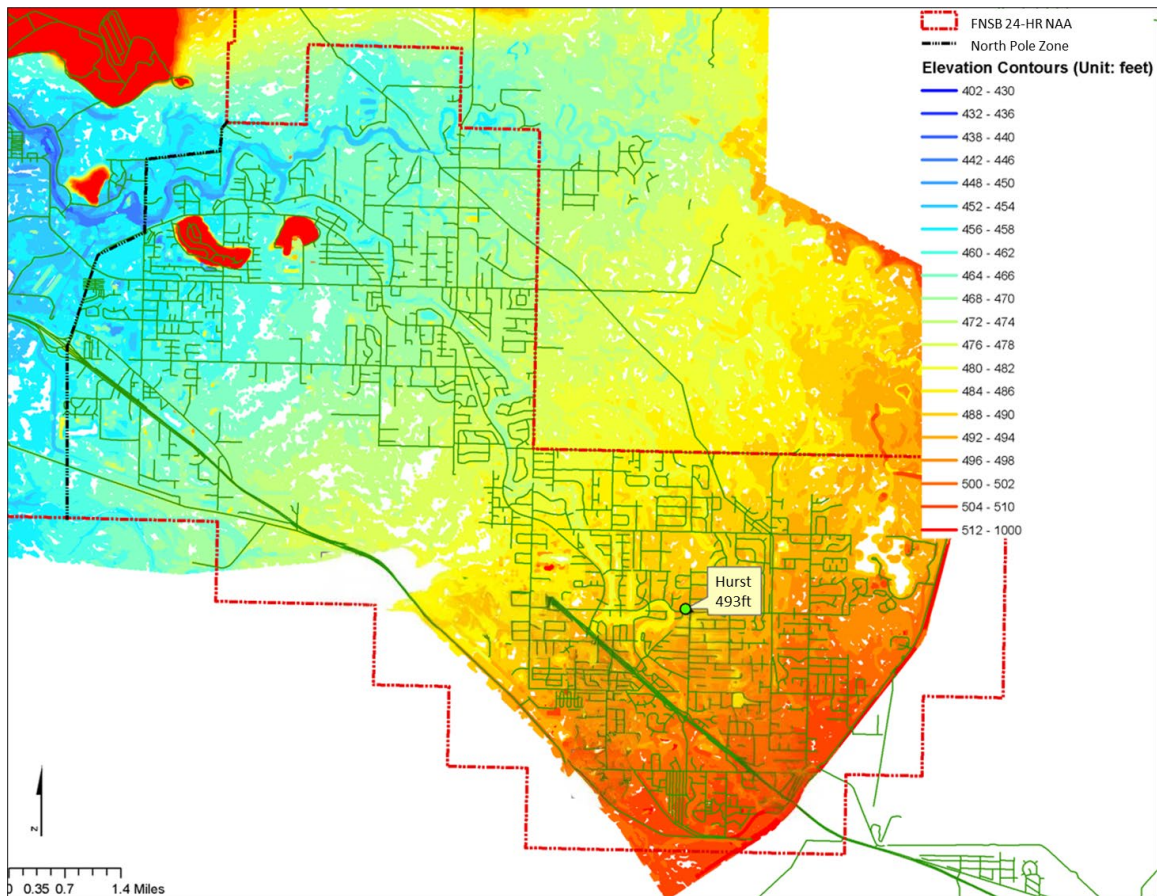


Figure 5-4 North Pole nonattainment area portion 2-ft contour topographic map.

In concert with geographic features, drainage flow patterns closely follow the topographic changes. The larger-scale flow patterns and topographic features are shown in Figure 5-1. Under cold and calm conditions, drainage flows originate from the south and southeast regions on the border with the Tanana River and follow the direction and gradient of the topography. Drainage flows may also form off the ridges surrounding the urban centers of Fairbanks and North Pole and follow the path of the valleys into the urban centers of Fairbanks and North Pole. These drainage patterns coupled with topographic slopes easily match with meteorological data presented in Factor 3. Wind speeds in these areas are extremely low and most frequently originate from the south and southeast direction, consistent with drainage patterns along the Tanana River drainage, and from the northeast in North Pole, which is consistent with the Upper Chena River drainage. Low wind speeds and the direction of transport limit the dispersion of pollutants effectively into the North Pole area, showing that emissions localized to Fairbanks have a minimal effect on the air quality levels in North Pole due to the patterns of bulk transport in the area.

5.1 Summary

The geographical and topographical features of Fairbanks and North Pole provide further insight into the air quality characteristics of the two regions and broadly explain how air quality levels may be subject to bulk transport patterns. The two urban areas are located in a valley surrounded by geographic features that aid in the generation of an inversion layer during cold and calm conditions that traps pollutants around the low-lying urban areas. Drainage flows that may form during extremely cold events, coupled with winter-time wind patterns, suggest that pollutants in Fairbanks would drain away from North Pole. Given the distance and direction of the North Pole drainage flow, the emissions from sources in North Pole are likely to disperse locally and follow the larger drainage patterns along the Tanana River. The topographical features, in combination with the extreme severe winter-time inversions and drainage patterns, serve to isolate the respective North Pole and Fairbanks nonattainment subareas during air quality episodes.

6. FACTOR 5- JURISDICTIONAL BOUNDARIES

The Fairbanks North Star Borough is located in the heart of Interior Alaska at approximately 64.833330° North Latitude and -147.716670° West Longitude (Figure 6-1). The area encompasses 7,338.0 sq. miles of land and 105 sq. miles of water. The Borough seat is located in the city of Fairbanks. A less densely urbanized area extends from Fairbanks along the Richardson Highway corridor through the city of North Pole to the southeast. The Borough also contains other smaller outlying residential areas (i.e., Ester, Fox, etc.) as well as two military bases (Fort Wainwright and Eielson Air Force Base). Fairbanks has a metropolitan planning organization, FAST, whose boundary includes both Fairbanks and North Pole and extends further into populated areas within the vicinity of both communities.

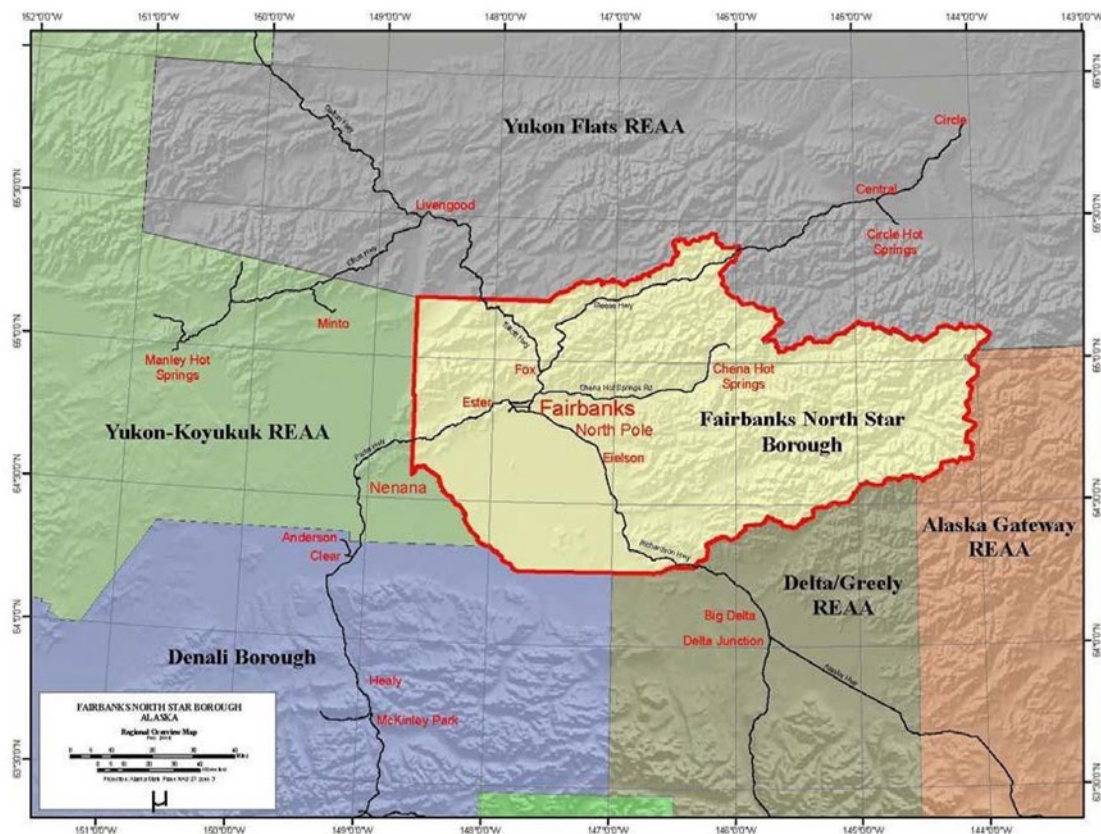


Figure 6-1 Fairbanks North Star Borough

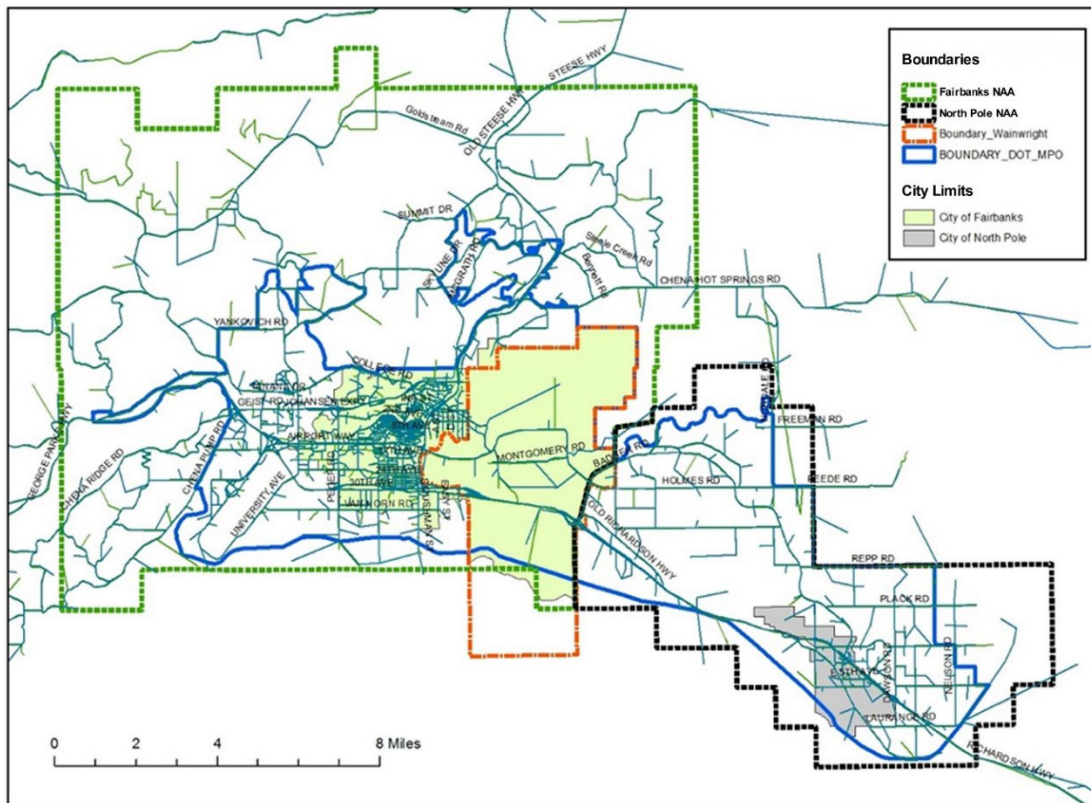


Figure 6-2 Boundaries of Political Entities Located within the FNSB PM_{2.5} Nonattainment Area.

6.1 Presentation of Boundaries

Political entities located within the existing FNSB nonattainment area include the City of Fairbanks, the City of North Pole, Fairbanks Area Surface Transportation (FAST) Planning, and Fort Wainwright. Figure 6-2 and Figure 6-3 depicts the boundaries for each, which are described in more detail below.

- The *City of North Pole* is situated 13 miles (21 km) to the southeast of Fairbanks on the Richardson Highway. The city is about 1,700 mi (2,700 km) south of Earth's geographic North Pole. According to the U.S. Census Bureau, the city has a total area of 4.2 square miles (11 km²), of which 4.2 square miles (11 km²) is land and 0.04 square miles (0.10 km²) (0.47%) is water. The city is located to the north and east of the Tanana River, although access to the river is not easily made due to the extensive system of levees. Beaver Springs Slough meanders through the heart of the city, emptying into Chena Slough.
- The *City of Fairbanks* is located in the central Tanana Valley, straddling the Chena River near its confluence with the Tanana River. Immediately north of the city is a chain of hills that rises gradually until it reaches the White Mountains and the Yukon River. The southern border of the city is the Tanana River. To the east and west are low valleys separated by

ridges of hills up to 3,000 feet (910 m) above sea level.⁵⁰ According to the U.S. Census Bureau, the city has a total area of 32.7 square miles (85 km²), 31.9 square miles (83 km²) of which is land and 0.8 square miles (2.1 km²) of which (2.48%) is water.

- *FAST (Fairbanks Area Surface Transportation)* is the local Metropolitan Planning Organization (MPO). FAST was established after the previous MPO, a consensus-based transportation policy-making body, was reorganized in September 2018 as an independent organization compatible with Section 501(c)(3) of the Internal Revenue Code.⁵¹ The purpose of the FAST Nonprofit Corporation is to coordinate transportation planning and programs, serve as a state designated MPO, and undertake any other lawful acts or activities for which nonprofit corporations may engage under the Alaska Nonprofit Corporation Act⁵². The FAST Metropolitan Planning Organization Boundary Map was determined by the MPO and the Governor⁵³. Per federal regulation, the MPO boundaries encompass, at a minimum, the entire existing urbanized area (as defined by the Bureau of the Census) plus the contiguous area expected to become urbanized within a 20-year forecast period for the metropolitan transportation plan (Figure 6-3)⁵⁴.
- *Fort Wainwright* is a U.S. Army Post that encompasses over one million acres and includes three separate areas: the Main Post is co-located with the City of Fairbanks and consists of 13,700 acres; the Tanana Flats Training Area is located south of the Main Post and covers over 655,000 acres; and the Yukon Training area is located 16 miles east-southeast of the City of Fairbanks and covers 247,952 acres. Figure 6-2, above, displays the boundaries of only the Main Post.

⁵⁰ https://en.wikipedia.org/wiki/Fairbanks,_Alaska#cite_note-USGS110-15.

⁵¹ Resolution 4847, Fairbanks City Council (September 2018). <https://www.fairbanksalaska.us/media/25796>.

⁵² FAST Planning Certificate of Incorporation, *State of Alaska Department of Commerce, Community, and Economic Development, Division of Corporations, Business, and Professional Licensing* (June 25, 2018). <https://fastplanning.us/planning/operatingdocs/>.

⁵³ FAST Planning, Operating Agreement at 8 (April 5, 2019). <https://fastplanning.us/planning/operatingdocs/>.

⁵⁴ FAST Planning, Metropolitan Planning Area Boundary Update Methodology, at 3 (December 2023), https://fastplanning.us/wp-content/uploads/2024/01/20231221_Boundary_Update_Methodology_FINAL.pdf.

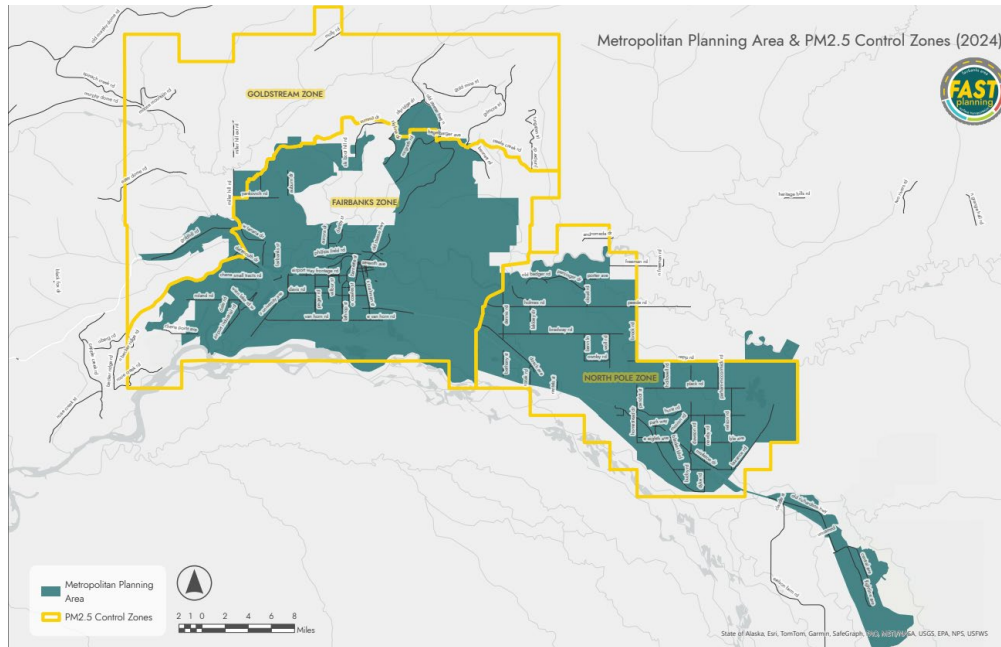


Figure 6-3 Map of FAST metropolitan planning area and existing PM_{2.5} air quality control zones.

In 2018, residents of the Fairbanks North Star Borough voted to end the Borough’s regulatory authority over home heating devices, thus transferring regulatory duties to the DEC⁵⁵. DEC adopted 18 AAC 50.025(d), which established three “air quality control zones” within the current 24-hour PM_{2.5} nonattainment area to allow sub-area specific control measures. The zones are based on an ordinance adopted by the Fairbanks North Star Borough and developed by the FNSB Air Quality Control Program, which sought to produce three nonattainment sub-areas expected to have different air quality levels during winter months⁵⁶. These regulatory zones are known as the Goldstream zone, Fairbanks zone, and North Pole zone (Figure 6-4).

The air quality control zones were selected due to the large variety of residential, geographic, and jurisdictional areas within the larger nonattainment area and used public rights-of-way, subdivision boundaries, and individual lot boundaries to determine the zones, while following the intended geographic features as closely as possible.⁵⁷ The boundary between the Fairbanks and North Pole zones was established along jurisdictional boundaries on the eastern border of Fort Wainwright and includes residential areas to the east of the military establishment. The eastern boundary for Fairbanks largely follows the eastern boundary of Fort Wainwright and the City of Fairbanks (although two small areas of the City of Fairbanks extend into the recommended North Pole nonattainment area). The City of North Pole occupies a small portion of the requested North Pole

⁵⁵ Fairbanks North Star Borough, Proposition 4: Ordinance Enacting the Home Heating Reclamation Act (October 2, 2018).

⁵⁶ Fairbanks North Star Borough, Ordinance 2015-01. (February 27, 2015).

⁵⁷ SIP Appendix III D.7.03. (November 19, 2019). <https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/>.

annual PM_{2.5} nonattainment area. The designated boundaries of the North Pole Air Quality Control Zone are identical to DEC's recommended annual PM_{2.5} nonattainment boundary.

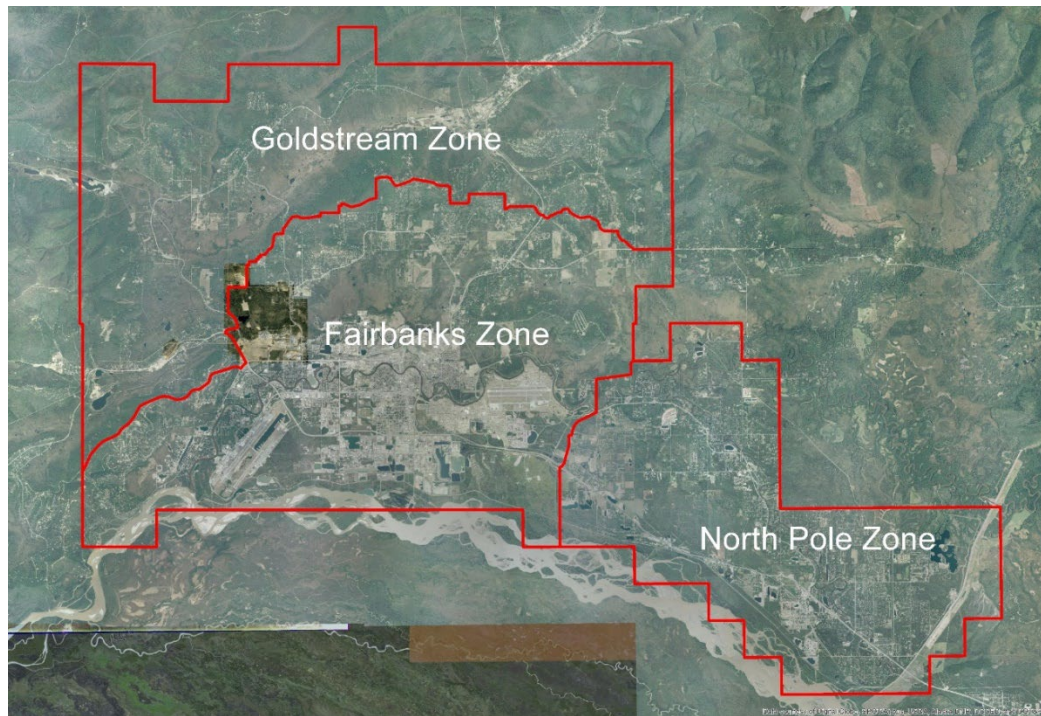


Figure 6-4 *Air Quality Control Zones within the existing PM_{2.5} Nonattainment Area. Designated areas include the Goldstream, Fairbanks and North Pole Zones.*

6.2 Summary

The boundaries requested to divide the Fairbanks North Star Borough 24-hr PM_{2.5} nonattainment area was specified by Borough staff and approved by the FNSB Assembly, a local elected body, to separate the FNSB 24-hr PM_{2.5} nonattainment area into three air quality control zones expected to have different air quality levels during winter months. These three areas currently act as three different regulatory control zones and are known as the North Pole Zone, Fairbanks Zone, and Goldstream Zone. The requested boundary for the annual PM_{2.5} nonattainment area is coterminous with the North Pole Zone, an already established jurisdictional area.

7. SUMMARY

The combination of monitoring and modeling data; emissions and meteorology trends; as well as geography, topography and jurisdictional boundary information has provided DEC with a multi-dimensional analysis of air quality in the Fairbanks North Star Borough area for the purpose of recommending an annual PM_{2.5} nonattainment boundary to EPA. DEC's data shows a violation of the revised annual PM_{2.5} NAAQS by only one community, North Pole, and supports that the neighboring communities surrounding North Pole do not contribute to its violation. DEC recommends that the nonattainment area for the annual PM_{2.5} NAAQS comprise the existing North Pole Air Quality Control Zone, which includes the North Pole urban center and nearby residential areas. Key findings from each evaluated factor aiding in this conclusion are included below.

Factor 1, Air Quality Data – Out of all PM_{2.5} monitoring sites in Alaska, only one location is in violation of the revised annual PM_{2.5} NAAQS of 9.0 µg/m³. The Hurst Road monitoring unit in the City of North Pole exhibits a design value of 9.5 µg/m³ over the three-year period between 2021 and 2023, while the two neighboring monitors in Fairbanks show three-year design values of 7.5 and 6.9 µg/m³. Seasonal differences in design values are evident; violations of the annual NAAQS occur solely in the winter for both North Pole and Fairbanks when concentrations are highly impacted by inversion events. Additional analysis of chemical speciation of the PM_{2.5} mass strengthens the differences between winter and summer air quality by showing that chemical profiles in colder months are distinct and can be traced to winter sources of pollution. Summer months have higher levels of organic carbon, while winter months have high levels of sulfate and organic carbon due to woodstove and fuel oil space heating. Lastly, monitors in the more rural area of Denali National Park help understand the possible impacts of rural PM_{2.5} contributions. The rural areas show extremely low concentrations of PM_{2.5} with low possibilities of bulk transport to the North Pole and Fairbanks areas due to wind patterns during days when annual NAAQS were violated. In sum, North Pole is the only location in the State of Alaska in violation of the annual NAAQS, with violations occurring in winter-time months and no contribution from outside areas.

Factor 2, Emissions and Emissions-Related Data – Annual emissions inventories were developed for three extents within Interior Alaska to provide insight into the levels and locations of directly emitted PM_{2.5} and precursor pollutant emissions within each extent by source category. The three extents were called the Outer, Middle, and Inner Inventories. The Outer Inventory included the Fairbanks North Star Borough (FNSB) and the three surrounding boroughs: Denali, Southeast Fairbanks, and Yukon-Koyukuk. The Middle Inventory was defined as the FNSB and included spatial breakouts of emissions both within and outside the existing 24-hour PM_{2.5} nonattainment area (NAA). Finally, the Inner Inventory represented the NAA and examined sources within both the Fairbanks and North Pole portions of the NAA.

Emissions analyses from the Outer and Middle Inventories demonstrate that the nonattainment boundaries need not extend beyond the boundaries of the existing 24-hour NAA. Although emissions are greater in the Fairbanks subarea than the North Pole subarea, emissions of direct

PM_{2.5} and key precursor pollutants SO₂ and NO_x are significantly more concentrated (i.e., have higher emissions per square mile) in North Pole.

The Factor 2 evaluation also included analysis of population and occupied household densities, degree of urbanization, and traffic and commuting patterns that strongly indicate that emission sources that spatially align with these metrics are largely contained within the existing 24-hour NAA.

Factor 3, Meteorology – Seasonal and regional differences exist in the North Pole and Fairbanks areas and are influenced by topography and drainage flows. Origin and direction of air flows during winter months differ significantly between North Pole and Fairbanks. During inversions in the North Pole/Fairbanks area, surface drainage flows tend to remain aloft and follow the terrain, which pushes pollutants into the Chena River basin. Regional drainage flows during inversion periods provide the primary means of horizontal dispersion, especially in Fairbanks, where air is moved out of the city to the west and southwest along the Tanana River. North Pole experiences regional drainage from the Upper Chena River to the northeast and the Tanana River to the southeast. During inversions, this air typically rides up and over the inversion layer rather than dispersing pollutants at ground level, further supporting the conclusion that high concentrations of PM_{2.5} are largely from local sources in the North Pole area. Air flows from Fairbanks do not significantly influence North Pole, and vice versa. Pollutants remain largely confined within their respective areas during inversion periods and days when the annual PM_{2.5} NAAQS is exceeded.

Factor 4, Geography and Topography – North Pole and Fairbanks are located in the interior of Alaska, approximately 20 miles apart. The area is defined by geographic features on all sides of the urban areas. North Pole and Fairbanks lie in a valley at approximately 440 - 490 ft ASL with immediate surrounding ridges rising to 1,000 - 2,500 ft ASL on the East, North and West borders of the valley, forming a semicircular barrier. The Tanana River forms a barrier to the south. Small topographic changes and geographic features aid in the generation of an inversion layer in the low-lying urban areas. Drainage flow patterns follow the topographic changes during cold and calm conditions, generally draining from the East to West direction along the Tanana River. Analysis of topographical contours confirms that hydrologic drainage flows are consistent with the wind speed and direction measurements recorded under cold-temperature inverted conditions at monitors located in North Pole and Fairbanks. This geography and topography helps to establish the conditions of transport patterns and inversion formations in the area, and further explains why air quality differences observed between North Pole and Fairbanks are likely driven by local emissions.

Factor 5, Jurisdictional Boundaries – A portion of the Fairbanks North Star Borough is currently in nonattainment status for the 24-hr PM_{2.5} NAAQS, with the area split into three “Air Quality Control Zones” known as the Fairbanks Zone, the North Pole Zone and the Goldstream Zone. These regulatory zones were established based on geographical, residential, and current jurisdictional boundaries. Within this area are jurisdictional entities including the City of

Fairbanks, the City of North Pole, FAST Planning, and Fort Wainwright. DEC's recommended boundary for the annual PM_{2.5} NAAQS is the same as the North Pole Air Quality Control Zone.

These findings demonstrate differences in conditions between neighboring communities and in different seasons throughout the year. The findings show significant differences between Fairbanks and North Pole in the conditions producing elevated PM_{2.5} concentrations. North Pole's monitor violates the PM_{2.5} revised annual NAAQS, while the monitor in Fairbanks does not. Furthermore, emissions density in North Pole is significantly higher than in Fairbanks. Additional analysis into meteorological and geographical patterns highlight that PM_{2.5} concentrations in North Pole and Fairbanks are due to localized emissions. Finally, the North Pole area is a designated Air Quality Control Zone with already established jurisdictional boundaries. Collectively, these data and analyses support DEC's recommended nonattainment boundary for the revised annual PM_{2.5} NAAQS to be the North Pole Air Quality Control Zone.