Serious SIP Emissions Inventory

1. Introduction

This Preliminary Draft report documents the work performed to date on the Serious SIP emission inventory in accordance with EPA requirements for preparing both baseline and attainment emission inventories as specified in the provisions of the CAA. A number of EI elements are in-process and slated for completion later in 2018, most notably completion of control measure analysis and finalization of inventories based on additional measures to be adopted (beyond those currently adopted and implemented). However, this report contains a comprehensive structure that reflects inventory work currently in-progress or to be completed before finalization of the SIP for review. Those areas for which analysis and documentation has not yet been completed are denoted as such. This report also highlights specific items for which feedback or additional information is requested under the Preliminary Review phase using a text box such shown below.

Sample text box

1.1. Purpose of the Inventory

Title I of the Clean Air Act Amendments of 1990 (CAA) contains provisions requiring development of emission inventories for designated areas that fail to meet the National Ambient Air Quality Standards (NAAQS). The emissions inventory (subsequently referred to as the EI or simply "inventory") is a collection of emission estimates separately compiled for each potential source of air pollutants within the nonattainment area and surrounding regions and then integrated into a combined framework. Stated simply, the inventory is used to identify the key sources of emissions and contributions from all sources in the area and serves as a basis for determining how to best reduce pollutant emissions in order to reach or attain the NAAQS.

Relevant Regulatory Actions - A portion of the Fairbanks North Star Borough (FNSB) that includes the cities of Fairbanks and North Pole as well as surrounding areas was classified as a Moderate $PM_{2.5}$ nonattainment area in November 2009[1] for violation of the 24-hour average standard (35 $\mu g/m^3$) enacted in 2006. The State of Alaska was given until December 2014 to prepare and submit a State Implementation Plan (SIP) that included a strategy to attain the $PM_{2.5}$ NAAQS in Fairbanks. In compliance with EPA requirements, the Moderate Area SIP evaluated whether attainment could be demonstrated by December 31, 2015 or if not, explain why attainment by that date was impracticable. Emission inventories were prepared, control strategies were developed and evaluated, and air quality modeling was conducted under the Moderate SIP. This analysis led the State of Alaska to conclude that the level of emission reductions required to attain the $PM_{2.5}$ NAAQS could not be practicably achieved by that

[1] Federal Register, Vol. 74, No. 218, November 13, 2009 (74 FR 58688).

December 2015 attainment date. Thus, the Moderate SIP found that attainment of the 24-hour $PM_{2.5}$ standard by 2015 was impracticable (although possible by 2019).

As a result of Fairbanks' failure to attain the 24-hour $PM_{2.5}$ standard by 2015, EPA reclassified[2] the area (effective June 9, 2017) as a Serious $PM_{2.5}$ nonattainment area, for which attainment by 2019 must be evaluated and a more stringent analysis of control measures conducted and tracked within the inventory.

On September 8, 2017, EPA approved the Fairbanks $PM_{2.5}$ Moderate Area SIP (effective October 10, 2017) which was originally submitted by the State of Alaska in December 2014 (and included supplemental clarifying information). EPA found that the Moderate SIP met all statutory and regulatory requirements including those for base-year and projected emissions inventories as well as those associated with Reasonable Further Progress (RFP), Quantitative Milestone (QM) and Motor Vehicle Emission Budget (MVEB) requirements.

On July 29, 2016, EPA also promulgated[3] the $PM_{2.5}$ Implementation Rule (subsequently referred to as the PM Rule) which interprets the statutory requirements that apply to $PM_{2.5}$ NAAQS nonattainment areas under subparts 1 and 4 of the nonattainment provisions of the CAA. These requirements govern both attainment plans and nonattainment new source review (NNSR) permitting programs and specify planning requirements that include:

- plan due dates, attainment dates and attainment date extension criteria;
- the process for determining control strategies, including Reasonably Available Control Measures/Reasonably Available Control Technology (RACM/RACT) for Moderate areas; and Best Available Control Measures/Best Available Control Technology (BACM/BACT) and Most Stringent Measures (MSM) for Serious areas;
- guidelines for attainment demonstrations for areas that can attain by the statutory attainment date, and "impracticability" demonstrations for areas that cannot practicably attain by the statutory attainment date;
- RFP and quantitative milestones for demonstrating RFP;
- contingency measures for areas that fail to meet RFP or fail to attain the NAAQS by the attainment date.

As discussed in the following sub-section, a number of these PM Rule planning requirements affect the inventories required under the Serious SIP.

This report describes how emissions were first estimated for the 2013 base year and then projected forward to 2019 with technically and economically feasible controls implemented within that time to determine whether the area will reach attainment by 2019. This attainment analysis is based on atmospheric modeling that simulates the formation of ambient $PM_{2.5}$ given input emissions and meteorology as described in detail in the "Attainment Modeling" document.

[2] Federal Register, Vol. 82, No. 89, May 10, 2017 (82 FR 21711).
[3] Federal Register, Vol. 81, No. 164, August 24, 2016 (81 FR 58010).

Where applicable, it will also identify key revisions to the emission inventories prepared under the Moderate SIP based on additional collected data or updated methodologies.

The Fairbanks Serious Area SIP emission inventory is considered a Level II inventory, as classified under the Emission Inventory Improvement Program (EIIP).[4] It is a Level II inventory because it will provide supportive data for strategic decision making under the context of the SIP and is based on a combination of locally and regionally collected data.

1.2. Description of Inventories and Geographic Area

As described in EPA's guidance for emission inventory development[5], there are two classes of inventories based on their intended use as summarized below:

1. *Planning Inventories* – These inventories are developed to fulfill regulatory planning and reporting requirements. In the SIP context, they are intended to quantify emissions within the nonattainment area and they are used as a part of RFP analysis and transportation conformity. Under EPA terminology, they include *base year* inventories ("foundational" emission source and activity inventories upon which all others are based), *reasonable further progress (RFP)* inventories (developed and submitted to EPA to demonstrate sufficient progress toward NAAQS attainment) and *motor vehicle emission budgets* (which are used in transportation conformity to ensure growth in vehicle emission over time is consistent with SIP projections). SIP Planning inventories contain either annual or seasonal emission estimates depending on the averaging period for the NAAQS being exceeded. For annual standards, annual planning inventories are required; for the 24-hour $PM_{2.5}$ standard in Fairbanks, a seasonal inventory is appropriate since historical violations have been limited to the months from October through March. As described later in this sub-section, the PM Rule provides additional flexibility regarding the definition of a seasonal planning inventory.

2. *Modeling Inventories* – Modeling inventories are more spatially and temporally resolved in order to account for geographic- and day-specific variations in emissions that affect monitored ambient concentrations. For the Fairbanks SIP, modeling inventories were developed over a gridded modeling domain called "Grid 3," which encompasses an area of 201 × 201 grid cells, each 1.33 km square.

Figure 1 shows the size and location of the Grid 3 modeling domain within the state. As shown, the domain encompasses portions of four counties/boroughs: Fairbanks North Star, Denali, Southeast Fairbanks, and Yukon-Koyukuk. The Fairbanks $PM_{2.5}$ non-attainment area is also shown in Figure 1. It is much smaller than the modeling domain and covers a small portion of the Fairbanks North Star Borough, but the portion in which roughly 90% of the Borough's population resides.

[4] "Introduction to the Emission Inventory Improvement Program, Volume 1," prepared for Emission Inventory Improvement Program Steering Committee, prepared by Eastern Research Group, Inc., July 1997.

[5] "Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards," U.S. Environmental Protection Agency, EPA-454/B-17-003, July 2017.

Figure 1. Fairbanks Modeling Inventory Domain and $PM_{2.5}$ Non-Attainment Area

In conformance to 40 CFR[6] §51.1002(c), the applicable inventories include emissions estimates for the following pollutants: $PM_{2.5}$, PM_{10}, SO_2 (SOx), NOx, VOC, and NH_3. Emissions shown for $PM_{2.5}$ and PM_{10} refer to direct emissions of both filterable and condensable particulate matter.

For the Serious Area $PM_{2.5}$ SIP, a specific set of planning and modeling inventories were prepared to satisfy CAA and EPA regulatory requirements. Table 1 summarizes the inventories developed and submitted to satisfy these Serious Area SIP requirements.

[6] Code of Federal Regulations.

Table 1
Summary of Applicable Inventories for Serious Area $PM_{2.5}$ SIP

Class	Type	Geographic Area	Calendar Year	Regulatory Requirements
Planning	Base Year	Nonattainment Area	2013	CAA 172(c)(3)
	Projected, with controls	Nonattainment Area	2019	CAA 172(c)(3)
Modeling	Baseline	Modeling Domain	2013	CAA 189(b)(1)
	Projected, with controls	Modeling Domain	2019	CAA 189(b)(1)

Analysis is currently underway to determine if attainment can be reached by 2019 based on strengthening existing controls or adopting and implementing new control measures prior to that date. In the event attainment cannot be demonstrated by 2019, Table 2 describes the broader set of inventories that would need to be prepared in the event attainment by 2019 is found to be impracticable. "Mandatory" inventories needed to evaluate attainment by 2019 are denoted in boldface in the Calendar Year(s) column. If attainment is found to be impracticable by 2019, additional inventories are required for successive calendar years through 2024 until attainment is demonstrated. These contingent inventory years are shown in italics.

Table 2
Inventories Developed for Fairbanks Serious Area $PM_{2.5}$ SIP

Class	Inventory Type	Geographic Area	Calendar Year(s)	Resolution		New Controls?	Reporting Level
				Spatial	Temporal		
Planning	Base Year/ Baseline	Nonattainment Area	**2013**	NA Area Total *Fairbanks, North Pole*	Winter Season	No	Emission Inventory Sector (EIS) or Tier 1
	Attainment Projected	Nonattainment Area	**2019**, *2020-2024*	NA Area Total *Fairbanks, North Pole*		Yes	
	RFP	Nonattainment Area	**2017**, **2020**, *2023*	NA Area Total *Fairbanks, North Pole*	Winter Season	Yes	
	MVEB	Nonattainment Area	**2017**, **2020**, *2023*	NA Area Total *Fairbanks, North Pole*	Winter Season	Yes	
Modeling	Baseline	Modeling Domain	**2013**	1.3 km Grid Cell	Episodic (day and hour)	No	SCC
	Projected Baseline	Modeling Domain	**2019**, *2020-2024*			No	SCC
	Control	Modeling Domain	**2019**, *2020-2024*			Yes	SCC

n/a – Not applicable.
SCC – Source Classification Code (a detailed emission source classification scheme developed by EPA)
TBD – To be determined.

Contingent inventories also appear in italics under the Spatial Resolution column of Table 2. Based on existing ambient monitoring within the Fairbanks and North Pole portions of the nonattainment area that shows significantly different peak $PM_{2.5}$ levels, the State is evaluating a pending request to EPA to ultimately divide the nonattainment area into separate, but adjoining nonattainment areas. If this "split request" is granted, the Spatial Resolution column identifies the separate Fairbanks and North Pole area inventories that would need to be developed. (The Modeling inventories are not affected by the potential area split; modeling inventories are based on the gridded modeling domain that includes the entire nonattainment area.)

In addition to identifying those inventories supporting either planning or modeling requirements as described earlier, Table 2 identifies the other key attributes of each inventory including type, geographic area, calendar year, point source emission type, spatial and temporal resolution, and source reporting level, each of which is further explained below.

- *Inventory Type* – Indicates the type of inventory. Base Year refers to the primary inventory that was developed based on actual source activity levels for a specified year and emission factors representative of that year. Baseline refers to the specific inventory calendar year chosen to meet applicable SIP requirements. As stated in 40 CFR 51.1008(a)(1)(i), the $PM_{2.5}$ baseline inventory year must be one of the three years for which monitored data were used for designating the area. For the Serious SIP, calendar year 2013 has been designated as the baseline year, which meets this requirement and coincides with the midpoint of the five-year baseline average design value period used the establish the anchor point based on existing ambient monitoring data for estimating projected future $PM_{2.5}$ concentrations in the attainment modeling. As its name implies, the Attainment Projected planning inventory represents projected emissions in the first year for which attainment is determined by a modeled attainment demonstration. It reflects both projected changes in source activity as well as emission benefits from additional control measures. The remaining planning inventories in Table 2 listed as RFP and MVEB (for Motor Vehicle Emissions Budget) are special inventories that must be developed within the SIP to satisfy Reasonable Further Progress and transportation conformity-related requirements. The RFP inventory encompasses all source categories and is used to ensure consistent progress toward attainment. The MVEB includes only on-road motor vehicle emissions (not all source categories). It is used to establish vehicle emission budgets for use in subsequent federal regional transportation conformity determinations. There are two basic types of modeling inventories for calendar years beyond the 2013 baseline year: (1) Projected Baseline, which accounts for source activity changes from forecasted population and economic growth and device turnover relative to the base year; and (2) Control, which accounts for emission reductions associated with new state and local control measures (over and above changes from population/economic growth).

- *Geographic Area* – The geographic area or extent of the sources included within each inventory is also listed in Table 2. Two different areas, shown earlier in Figure 1, are represented: Non-Attainment Area, and Modeling Domain. Planning inventories tabulate emissions within the boundaries of the nonattainment area. Modeling inventories contain source emissions across the larger modeling domain, spatially resolved or located within 1.3 kilometer square grid cells.

- *Calendar Year(s)* – The calendar years associated with each inventory are listed in this column. In addition to the 2013 base/baseline year, inventories for calendar years in boldface are required. Pending the attainment finding for the required 2019 target year for Serious 24-hour $PM_{2.5}$ nonattainment areas, additional inventories for calendar years will be required until attainment is demonstrated or to evaluate reasonable further progress toward attainment. The RFP inventory years are established based on

quantitative milestone dates of 7.5 and 10.5 years from the date of designation of the area (November 2009) for Serious SIPs as required under 40 CFR 51.1013(a)(2). If attainment is found to be impracticable by 2019, an RFP inventory will also be required for a 2023 quantitative milestone year. MVEBs must be prepared for the same quantitative milestone years required for the RFP inventories in accordance with 40 CFR 51.1012(a)(2).

- *Spatial & Temporal Resolution* – These columns refer to the levels of spatial and temporal resolution of each inventory. As listed in Table 2, the inventories reflect different levels of spatial resolution: (1) NA Area, for total emissions within the Fairbanks $PM_{2.5}$ non-attainment area (or subareas pending a potential split of the existing nonattainment area); and (2) 1.3 km Grid Cell, representing individual 1.3 km grid cell-level emissions within the modeling domain of 201 × 201 grid cells. The levels of temporal resolution reflected in the inventories as listed in Table 2 are: (1) Winter Season, reflecting average emissions over the winter non-attainment season (defined as October through March); and (2) Episodic, for which emissions are resolved by individual day and hour to support the episodic attainment modeling. As explained in the following "Seasonal Inventory Representation" sub-section, average emissions over the historical modeling episodes were assumed to be representative of the conditions within the October-March nonattainment season that cause violations of the ambient $PM_{2.5}$ standard, in accordance with seasonal inventory requirements and flexibilities provided under the PM Rule. This assumption greatly simplifies the number of individual inventories needed in the SIP and provides a degree of consistency in representing relative source sector contributions across both the Planning and Model inventory requirements for the Serious SIP.

- *Includes Controls* – This column simply identifies whether the inventory includes emission reductions resulting from additional state or local control measures slated for adoption under the Serious SIP. Emission benefits from existing control measures (or levels of compliance/enforcement) implemented prior to this plan and occur or accrue beyond the 2013 baseline year are accounted within the project baseline inventory.

- *Reporting Level* – Finally as noted in Table 2, the level for which individual source emissions were reported differed between the planning and modeling inventories. Emissions for all planning inventories were developed and reported at the major source sector (stationary point, stationary non-point, on-road, and non-road) or EPA "Tier 1" sector level. Emissions for all modeling inventories were compiled and reported at the individual Source Classification Code (SCC) level.

In addition to the elements listed in Table 2 and described above, it is noted that the PM Rule revised or superseded the following emission inventory requirements that applied to the Moderate SIP:

- *Statewide Planning Inventory* – The PM Rule superseded the need for a planning inventory of statewide emissions that were required based on earlier EPA

regulations/guidance.[7] Under the PM Rule, EPA no longer interprets the CAA to allow emission reductions from sources outside the nonattainment area for the purposes of evaluating RFP. Thus, a statewide planning inventory is no longer required and is not included in the Serious $PM_{2.5}$ SIP.

- *Actual Point Source Emissions* – The emission inventory requirements in place at the time the Moderate SIP was submitted included development of inventories for point source reflecting both actual and allowable emissions.[8] Regulatory revisions under the PM Rule no longer require separate inventories based on allowable emissions for point sources; inventories are to be based only on actual emissions. (It is noted here that the thresholds of annual emissions used to identify a stationary source as a point source are based on allowable or permitted emissions. In addition, Best Available Control Technologies analysis also required under the Serious SIP and described in a separate BACT document uses allowable emissions in evaluating cost effectiveness of applicable point source control technologies. However, emission reductions from BACT measures to be adopted under the Serious SIP must be translated to an actual emissions basis.)

1.3. Seasonal Inventory Representation

Background – As codified in codified in 40 CFR 51.1008(a)(1)(iii), the 2016 PM Rule contains specific guidance related to the time period (annual vs. seasonal) upon which $PM_{2.5}$ SIP planning inventories should be based. Section IV.B.2.c of the PM Rule preamble (Seasonal Inventories) explains where the use of seasonally versus annually-based emission inventories are appropriate as well as the factors to consider in definition the duration of the seasonal inventory. First, it points out that for the $PM_{2.5}$ NAAQS, annual inventories are required for the annual form of the NAAQS, while seasonal inventories are appropriate for the 24-hour NAAQS when *"monitored violations of the 24-hour $PM_{2.5}$ NAAQS in the area occur during an identifiable season."* Second, it states that *"for some source categories, it may be advisable to limit the 'season' considered in calculating emissions to an episodic period to reflect periods of higher emissions during periods of high ambient $PM_{2.5}$."* This latter rationale allows seasonal inventories to be not simply representative of an average day across the entire nonattainment season (which as noted earlier spans October through March in the Fairbanks nonattainment area), but based on episodic activity/emissions in areas where nonattainment conditions are more narrowly associated with peaks in emissions within specific source sectors or atmospheric conditions that vary across the nonattainment season.

This definition of the duration of the season for development of seasonal inventories in 24-hour $PM_{2.5}$ nonattainment areas is intended to help ensure the inventory reflects the conditions that led

[7] "Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS) and Regional Haze Regulations," U.S. Environmental Protection Agency, November 2005.

[8] Actual emissions are estimates of actual annual or episodic emissions based on historically recorded facility operating throughput or continuous emissions monitoring systems. Allowable emissions refers to permitted or Potential to Emit (PTE) emission limits associated with the facility operating permit. Actual emissions are generally lower than Allowable emissions (unless a facility is found to be in violation of its operating permit, which was not the case for point source facilities inventoried within the Fairbanks $PM_{2.5}$ SIP).

to an area's nonattainment designation, specifically reflecting temporal emissions variations within the entire nonattainment season that lead to violations of the NAAQS. The PM Rule also points out that the state needs to explain the rationale for the duration of the season used for the inventory as part of the SIP submission.

The State of Alaska choses to represent the seasonal planning inventory requirement for the 24-hour $PM_{2.5}$ NAAQS to be represented by the average of modeling episode day emissions for the three most significant source categories within the non-attainment area:

1. Space Heating (within the non-point Stationary Nonpoint/Area source sector);
2. Stationary Point Sources; and
3. On-Road Mobile Sources.

These three categories comprise over 98% of directly-emitted $PM_{2.5}$ within the nonattainment area and similarly dominant fractions for all applicable precursor pollutants. The remainder of this sub-section lays out the supporting rationale for use of episodic average day emissions to satisfy seasonal inventory requirements for the Fairbanks Serious $PM_{2.5}$ SIP.

Historical NAAQS Violations – As noted earlier, the nonattainment season consists of the six-month "winter" season from October through March based on those months within the years during which violations of the 24-hour $PM_{2.5}$ NAAQS were recorded in Fairbanks. To evaluate the variability of violations within this winter season, historical daily monitoring data from 2005 through September 2017 (the latest available data) for the nonattainment area were downloaded from EPA's AirData website and tabulated to determine the frequency that violations have been recorded within each month of the six-month season. The data were filtered to Federal Reference Method (FRM) monitoring at each historical site.

The results are presented in Table 3, along with the duration or period of record (in years) for each historical monitoring site within the nonattainment area. As shown in the highlighted cells in Table 3, almost all of the recorded 24-hour $PM_{2.5}$ concentrations over 35 $\mu g/m^3$ occur between November and February. Violations in October and March are rare and represent 6% or less of those observed at any of the sites listed in Table 3. December and January are the months with the highest likelihood of violations (for those sites with a multi-year history), although violations in November and February are not uncommon.

Table 3
Frequency of 24-Hour $PM_{2.5}$ NAAQS Violations by Monitoring Site and Month in Fairbanks Nonattainment Area (2005-2017)

Monitoring Site	% of Historical Violations (> 35 $\mu g/m^3$) by Month						Duration (years)
	Oct	Nov	Dec	Jan	Feb	Mar	
State Office Building	0%	13%	33%	33%	19%	3%	12.7
Borough Building (NCORE)	3%	13%	41%	28%	13%	3%	7.9
North Pole Fire Station #3	3%	23%	24%	29%	16%	3%	5.6
North Pole Elementary School	0%	10%	48%	31%	10%	0%	4.3
North Pole Water	0%	33%	22%	11%	33%	0%	0.5

Source: U.S. EPA Air Data web portal, https://www.epa.gov/outdoor-air-quality-data, accessed on January 31, 2018.

As clearly seen in Table 3, the frequency or likelihood of 24-hour $PM_{2.5}$ violations within the six-month nonattainment season are significantly skewed toward those four months (November through February) within the middle of the season. This non-uniformity in 24-hour $PM_{2.5}$ concentrations above the NAAQS is the result of variations in ambient factors and source activity and emissions, each of which is discussed separately as follows.

Meteorological and Atmospheric Factors – At its high latitude (lying just below the Arctic Circle) and interior location, the Fairbanks $PM_{2.5}$ nonattainment area exhibits significant variation in meteorological and atmospheric conditions within the six-month season that help explain why 24-hour $PM_{2.5}$ NAAQS violations are restricted to this period and occur more frequently during the middle of the period.

Ambient temperatures drop and then rise markedly between October and March. Figure 2 shows long-term (1929-2016) average daily maximum and minimum ambient temperatures by month recorded at the Fairbanks International Airport. The data are plotted from July through June for clarity; the six-month nonattainment season from October through March is highlighted. As seen in Figure 2, average monthly max/min temperatures vary dramatically within the nonattainment season, dropping by over 40°F to their lowest points in January and then rising again during this period.

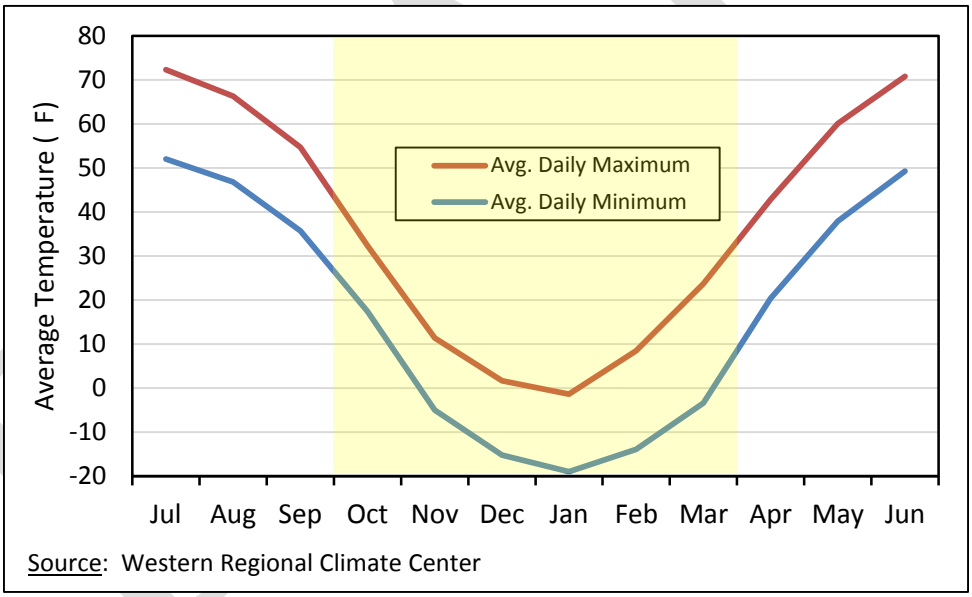

Figure 2. Fairbanks Int'l Airport Average Monthly Max/Min Temperatures

This variation in monthly ambient temperatures is driven by the dramatic differences in available sunlight at the high latitude of Fairbanks over the October-March nonattainment season, which is illustrated in Figure 3. As seen in Figure 3, there are over 11 hours of daylight on October 1 and over 13 hours by the end of March, but less than 4 hours at the winter solstice in late December. The variation in sunlight, both in terms of the amount of daylight hours and the angle of the sun above the horizon (which is low during the core winter months) directly affects average daily temperatures and explains the substantial temperature variation within the nonattainment season.

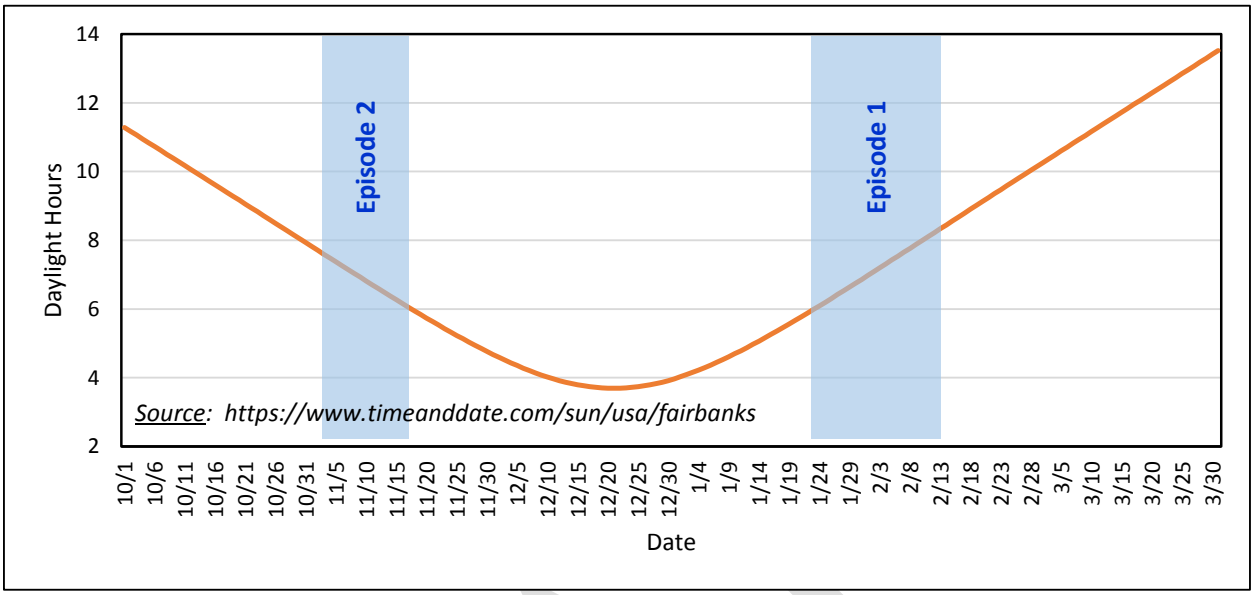

Figure 3. Fairbanks Daylight Hours vs. Calendar Day (October-March)

Figure 3 also highlights the November 2 – 17 and January 23 – February 10 time periods that correspond to the historical 2008 modeling episodes (Episodes 2 and 1, respectively) jointly selected by the Borough, ADEC and EPA to represent typical conditions in Fairbanks when concentrations exceed the standard at "design day" levels (i.e., near the 98th percentile of concentrations above the 24-hour NAAQS). (These modeling episodes are further discussed under the "Modeling Episode Characteristics" heading.)

The solar intensity and daylight duration variation which drives the significant drop and ascent in monthly average temperatures within the nonattainment season also directly affects the duration and strength of temperature inversions occurring in the nonattainment area from October-March. (A temperature inversion refers to an atmospheric condition under which air temperature increases, rather than decreases with height above the ground. Ground-based inversions are common during the low-daylight winter months in Fairbanks[9,10] when radiative cooling of the ground in turn cools the air close to the ground, resulting in lower surface temperatures than the air aloft. Within a temperature inversion, the vertical mixing of air is limited by the static stability caused by the inversion. This results in a disproportionate build-up in ground-level ambient $PM_{2.5}$ concentrations relative to other times of the year when inversions are less frequent or less severe, or during the winter season when other weather patterns such as storm fronts or high wind events occur in the area and disperse pollutant build-up.)

Finally, ambient temperatures also directly affect the heating demand required to keep indoor air temperatures constant above a defined base or reference level. Heating Degree Days (HDDs) are

[9] Brader, Jim et al, "Meteorology of Winter Air Pollution in Fairbanks," ftp://ftp.co.fairbanks.ak.us/AQ-Symposium/Symposium_Presentations_ftp/James_Brader_Weather.pdf

[10] Hartmann, Brian et al, "Climatology of the Winter Surface Temperature Inversion in Fairbanks, Alaska," Geophysical Institute, University of Alaska, Fairbanks, https://ams.confex.com/ams/pdfpapers/84504.pdf

a common metric used to compare space heating loads or demand across locations or by month/season within a specific area, and represent the number of degrees that a day's average temperature is below a base or reference temperature, typically 65°F.

Figure 4 shows long-term average Heating Degree Days by month based on average temperatures for each day at Fairbanks International Airport from 1997-2017 based on a 65°F reference temperature. Annual average HDDs total 13,430. From October through March average HDDs are 10,946 or 81% of total annual HDDs. Between November and February, there are 8,038 HDDs on average, representing 60% of annual heating demand.

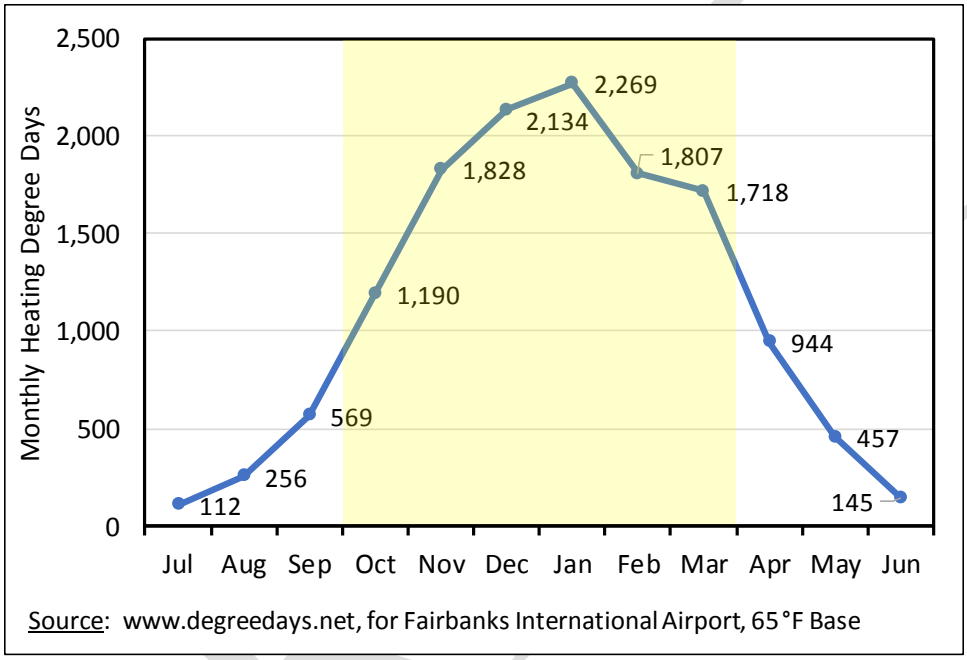

Figure 4. Fairbanks Int'l Airport Average Monthly Heating Degree Days (1997-2017)

The HDD metric clearly shows how the variation in outdoor ambient temperatures throughout the year and even within the nonattainment season affect monthly heating demand.

Seasonal Patterns in Key Source Activity and Emissions – Emissions from the aforementioned three largest source categories within the nonattainment area (Space Heating, Point Sources and On-Road Mobile Sources) are all heavily driven by month-by-month variations in ambient temperature and solar intensity/daylight hours just shown.

As described earlier, space heating demand (and therefore emissions) is directly related to the HDD metric by definition. In addition, local data collected on space heating fuel use patterns in Fairbanks during winter and discussed in detail later in this document indicate that daily wood use (which has higher $PM_{2.5}$ emissions that heating oil) tends to peak during the coldest months within the nonattainment season. Thus, emissions from this single largest source category are by no means constant between October and March and likely follow a steeper variation than indicated by monthly HDDs.

In addition, all of the point source facilities within the nonattainment area combust fuel to meet a combination of heating and electricity demand, which tend to track with the monthly HDD and daylight hour variations within the nonattainment season. Thus fuel-based point source activity also varies significantly from October through March.

Finally, emissions from on-road mobile source also tend to peak during mid-winter due to the fact that exhaust emissions for vehicles when they are first started increase significantly as ambient temperature decreases. Thus, even though vehicle activity (i.e., vehicle miles traveled) remains relatively stable over the nonattainment season, vehicle emissions do not.

Episodic Nature of $PM_{2.5}$ within the October-March Season - In the Fairbanks nonattainment area, wintertime violations of the 24-hour $PM_{2.5}$ NAAQS are triggered by meteorological conditions characterized by low ambient temperatures and low wind speeds. These conditions occur frequently, but not universally throughout the winter, and reflect stagnant atmospheric conditions that occur when synoptic-scale weather systems are not present in the Alaskan Interior. At times, these stagnant meteorological conditions can last for several days and end only when other meteorological conditions such as storm systems or higher wind circulation patterns move into the region and cleanse the air before the stagnation pattern begins again.

To see how these stagnant, colder temperature conditions relate to ambient $PM_{2.5}$, Figure 5 presents a scatter plot of 24-hour $PM_{2.5}$versus daily average temperature during the last three winters in Fairbanks (defined as October 2014 through March 2017). The 24-hour average values were developed from continuous BAM-based $PM_{2.5}$ measurements and hourly meteorological data. The upper panel shows results for the NCore monitor in downtown Fairbanks, the lower panel contains data for the North Pole Fire Station (NPFS) monitor in North Pole. As seen in Figure 5 for both monitors, higher ambient $PM_{2.5}$ levels are generally correlated with lower ambient temperatures.

Figure 6 provides a similar set of scatter plots of wintertime 24-hour average ambient $PM_{2.5}$ versus wind speed at the NCore and NPFS monitors. As seen from the data at both sites, elevated $PM_{2.5}$ concentrations only occur when average daily wind speeds are below a certain "cutoff" level, which is roughly 1.5 meters/second (or about 3 miles/hour) at both monitors.

Finally, Figure 7 illustrates how the stagnant atmospheric conditions characterized by low temperatures and wind speeds occur during the winter months in Fairbanks. In Figure 7, daily $PM_{2.5}$, temperature and wind speed are plotted as a continuous time series across the winter 2014-2017 period for each monitor (NCore in upper panel, NPFS in lower panel). In each plot, $PM_{2.5}$ and wind speed are plotted on the left axis, temperature on the right. (Wind speed is multiplied by 10 to better show its day-to-day range over the winter months.)

As seen in Figure 7, the high spikes in $PM_{2.5}$ at both monitors generally coincide with lower temperatures and very low wind speeds, but on days with more mixing/ventilation (i.e., higher wind speeds) and higher temperatures, ambient $PM_{2.5}$ levels tend to be much lower. During the winter months, 24-hour average $PM_{2.5}$ levels can vary by an order of magnitude or more at each monitor. Thus, for Fairbanks it is reasonable to construct seasonal planning inventories in a

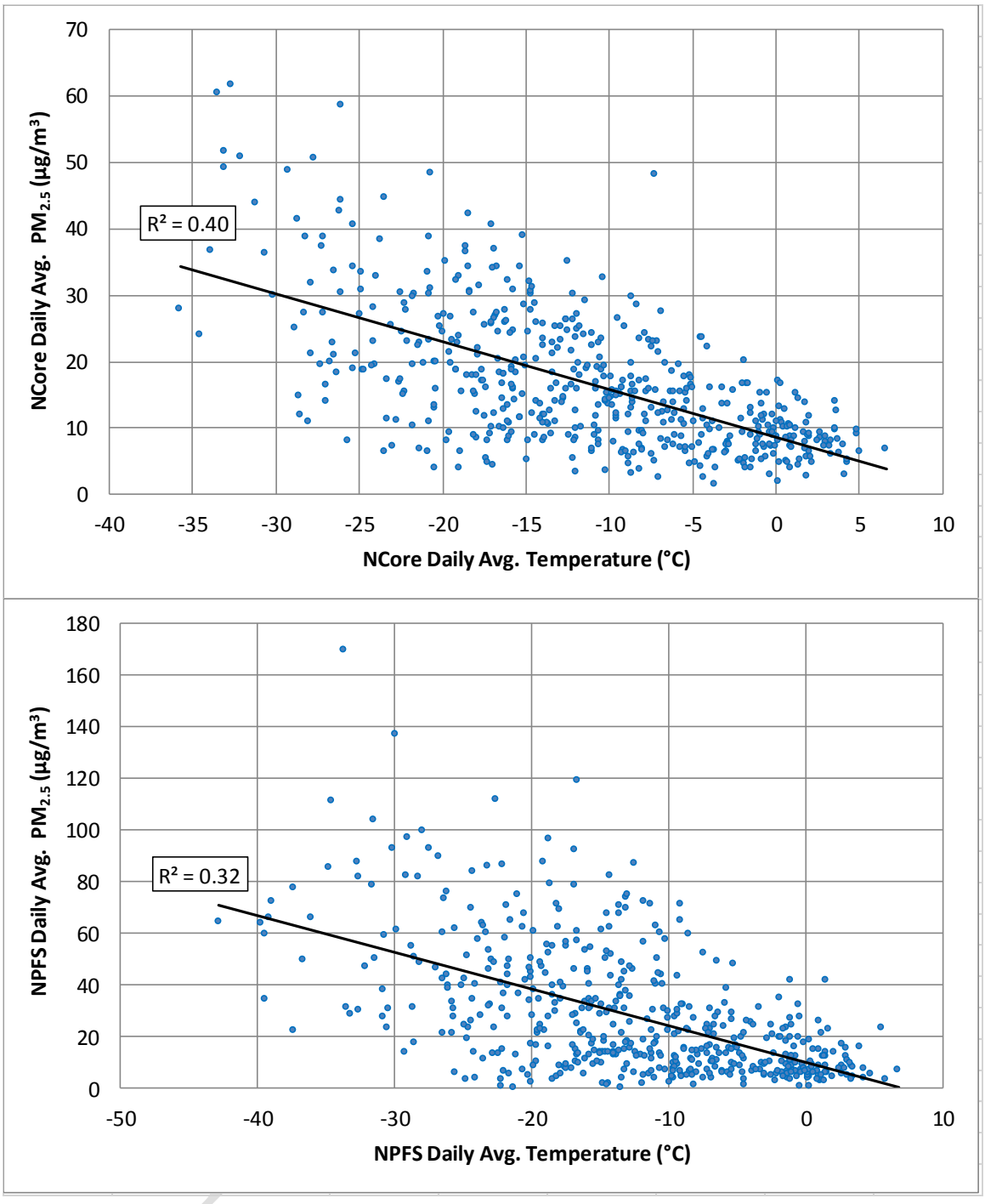

Figure 5. Fairbanks Daily $PM_{2.5}$ vs. Ambient Temperature (Winter 2014-2017)

manner that focuses on the periods during which high $PM_{2.5}$ levels occur given their regularity, but not universality, during the October through March period.

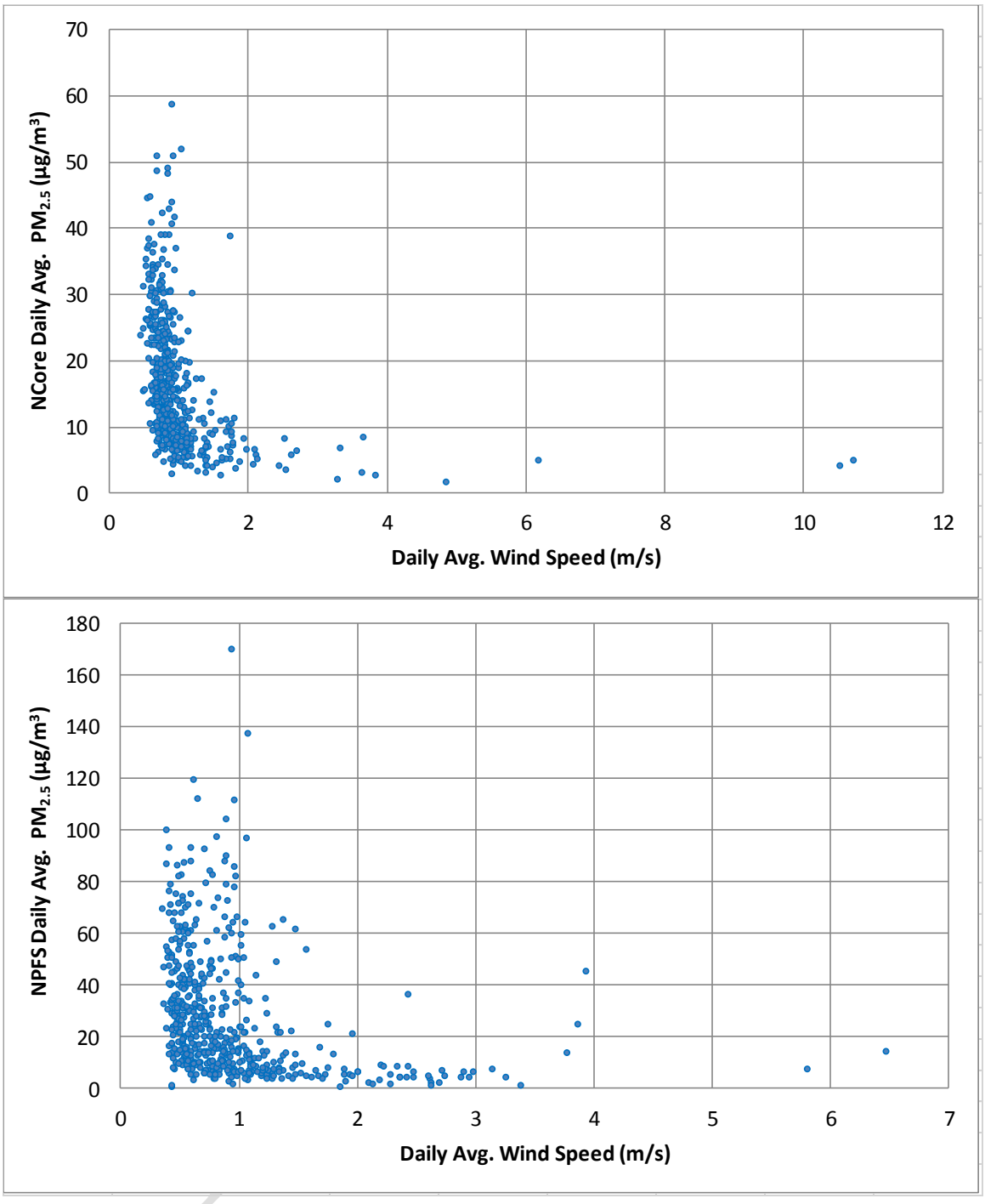

Figure 6. Fairbanks Daily $PM_{2.5}$ vs. Wind Speed (Winter 2014-2017)

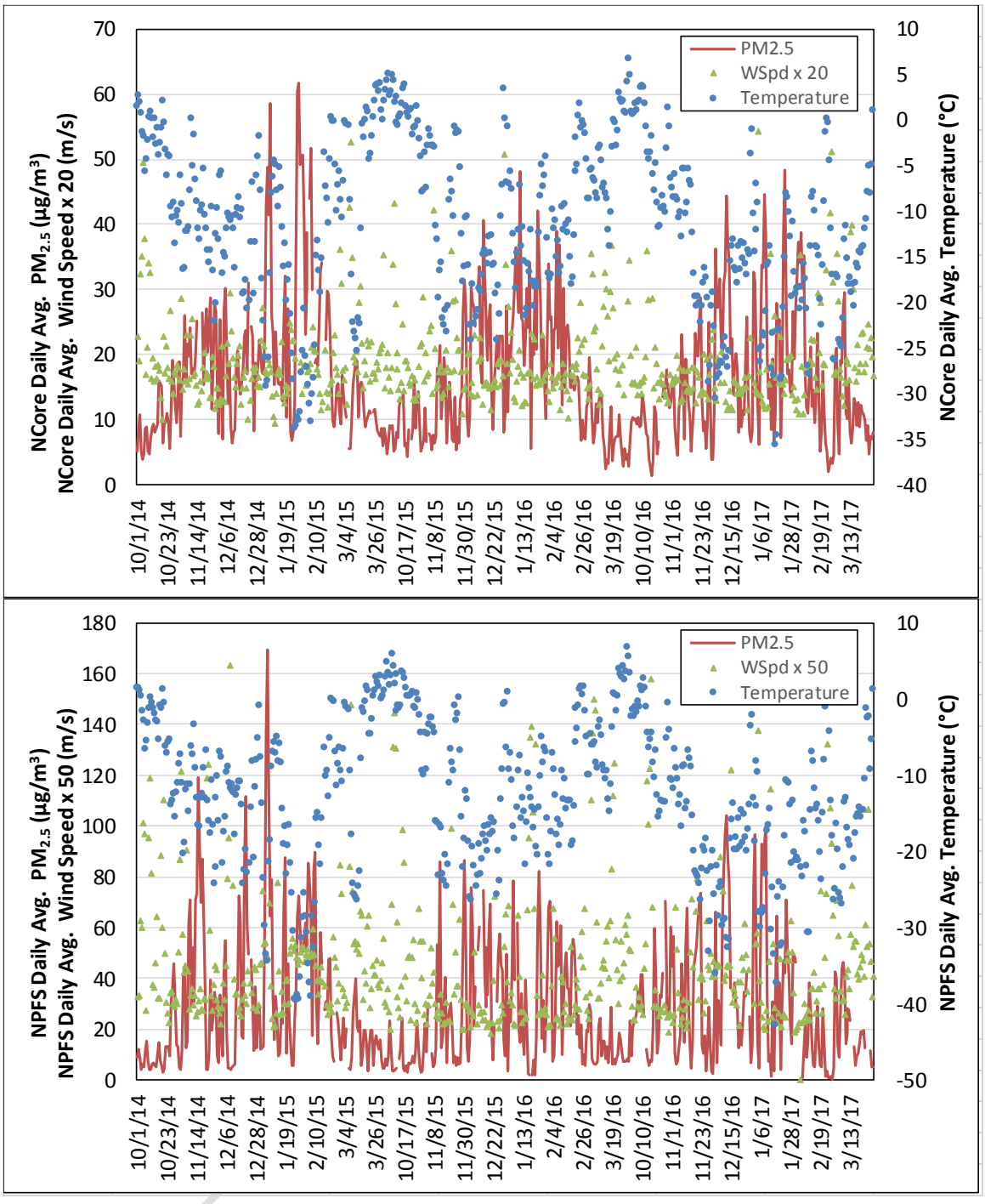

Figure 7. Fairbanks Winter 2014-2017 Time Series

Modeling Episode Characteristics – The attainment modeling inventories are based on day-specific emission estimates for two historical calendar year 2008 episodes:

- Episode 1 - January 23 through February 10 (19 days); and
- Episode 2 – November 2 through November 17 (16 days).

The Borough, ADEC and EPA collectively determined that these modeling episodes typify atmospheric/meteorological conditions and source activity/emission patterns within the nonattainment season when ambient $PM_{2.5}$ concentrations exceed the standard at design day or high percentile levels.

Episode 1 represented a period of extremely cold ambient temperatures (at Fairbanks International Airport) ranging from daily averages of +6°F to -40°F over the 19-day episode with an episode average temperature of -12°F. Spanning late January through early February, it is indicative of near mid-winter peaks in energy/fuel demand and troughs in ambient temperature and daylight/solar intensity.

Episode 2 in early November reflects milder ambient conditions and energy/fuel demand, although it also exhibited measured ambient $PM_{2.5}$ concentrations that exceeded the standard. Its daily average temperatures ranged from +10°F to -6°F, with a mean across the 16-day episode of +3°F.

Notably, both episodes fall within the narrower November through February period during which over 94% of historically recorded NAAQS violations occurred as shown earlier in Table 3. And as illustrated earlier in Figure 3, these historical modeling episodes occurred during periods within the six-month nonattainment season that do not represent either extreme in daylight hours, yet they reflect both severe and milder meteorological regimes that produce violations of the 24-hour $PM_{2.5}$ standard. Thus, based on the earlier joint agency review and selection of these episodes as being collectively representative of the range of factors that trigger $PM_{2.5}$ violations within the nonattainment period, they reflect combinations of meteorological/atmospheric conditions and key source sector activity and emission variations that have historically produces NAAQS violations.

Conclusions – Based on their representativeness of both ambient conditions and key emission source levels that have triggered 24-hour $PM_{2.5}$ NAAQS violations, ADEC believes that the average of emissions across the combined 35 days of the two historical episodes are well-suited not just for attainment modeling, but also to satisfy seasonal planning inventory requirements within the Serious SIP as provided in the PM Rule for 24-hour $PM_{2.5}$ nonattainment areas. The data presented earlier in this sub-section clearly shows that atmospheric conditions and emissions within the entire October through March nonattainment season are by no means constant. Based on these data, the modeling episode average emissions are more effectively representative of atmospherically-driven variations in source activity and emissions within the six-month nonattainment season that produce NAAQS violations than seasonal average day emission across the entire season. Use of episode day average emissions provides a more accurate representation of the emission levels and relative contributions from the largest source categories within the nonattainment season upon which to base control measure benefit Reasonable Further Progress evaluations within the planning inventory requirements of the Serious SIP.

For example, a planning inventory based on average daily emissions across the entire six-month nonattainment season will likely reflect a relatively lower fraction of wood use-based space heating emissions than one based on the modeling episode day average since wood use for space

heating Fairbanks tends to occur as a secondary heating source on top of a "base" demand typically met by cleaner home heating oil when ambient temperatures get colder. As a result, such a six-month average day inventory would likely discount or underrepresent the wood-based contribution to emissions and ambient $PM_{2.5}$ violations.

In addition, use of average modeling episode day emissions to meet planning inventory requirements provides a measure of consistency in source significance and emission levels across the planning and modeling inventories prepared to support the Serious SIP.

The state is seeking concurrence from EPA on the adequacy of this sub-section in providing the supporting rationale needed to represent seasonal planning inventory requirements using the modeling episode average emissions.

1.4. Sources Not Inventoried

All potential sources of $PM_{2.5}$ or significant precursor pollutants were evaluated for inclusion within the emission inventory. Generally speaking, sources were excluded from the inventory only under one of the following conditions:

- Data were unavailable; or
- Sources outside the non-attainment area were not believed significant or were well removed from the non-attainment area.

Sources for which data were not available were restricted to estimates of ammonia (NH_3) emissions for airplanes and area source categories other than space heating. Unlike the Moderate SIP, the Serious SIP inventory includes ammonia emissions for point sources.

Sources estimated to be not significant or well outside the non-attainment area included several specific point source facilities and stationary non-point (area) sources. As described in the Emission Inventory Technical Appendix, area source emissions were developed only for the Fairbanks North Star Borough portion of the modeling domain. Given the sparse population density of the other three counties within the modeling domain (Denali, Southeast Fairbanks, and Yukon-Koyukuk), area source emissions for these counties were assumed to be not significant in impacting ambient $PM_{2.5}$ within the nonattainment area and were excluded from the inventory.

1.5. Inventory Preparation Personnel and Responsibilities

Listed below are the agencies/organizations and key personnel involved in the preparation of the emission inventory and their respective roles.

To Be Completed

1.6. Organization of the Serious SIP Inventory Documentation

To Be Completed

2. 2013 Baseline Emission Inventory

This section presents and summarizes the sources and methods used to develop the 2013 Baseline modeling and the 2013 Base Year planning inventories.

These inventories were developed in a manner consistent with the EI requirements for Serious area plans specified in EPA's PM Rule. This included representation of planning inventory source activity and emissions on a seasonal, rather than annual basis as provided for under the PM Rule. As discussed in earlier Section 1.3, episode average daily emissions were used to satisfy seasonal planning inventory requirements since ADEC believes they better reflect atmospheric conditions and source activity/emissions that trigger violations of 24-hour $PM_{2.5}$ standard in Fairbanks within the entire six-month (October through March) nonattainment season.

The inventory was developed using the 2008 baseline emission inventory from the approved Fairbanks $PM_{2.5}$ Moderate Area SIP as its starting point and then updated based on additional source and activity data collected since preparation of that inventory. Where appropriate, the inventory was also projected forward to calendar year 2013, the baseline year for the Serious SIP.

As noted earlier in Section 1.2, emission estimates in planning and modeling inventories are compiled at different levels. The former contains estimates totaled across the nonattainment area on an appropriate seasonal basis; the latter is more highly resolved in space and time, representing emissions by individual 1.3 km square grid cell, day, and hour for each of the 35 winter days encompassing the two historical modeling episodes in the attainment modeling analysis listed below.

- Episode 1 – January 23 through February 10, 2008 (19 days)
- Episode 2 – November 2 through November 17, 2008 (16 days)

A detailed discussion of the 2013 Baseline modeling inventory is presented first because portions of the planning inventory were developed based on the more detailed modeling inventory. This is followed by a discussion of the Base Year planning inventory.

2.1. Baseline Modeling Inventory

Overview – Considerable effort was invested in developing the modeling inventories, starting with the foundational 2013 Baseline inventory. Because of strong variations in monthly, daily, and diurnal source activity and emission factors (largely driven by significant swings in ambient

conditions between very cold winters and warm summers within the Alaskan interior), it was critically important to account for these effects in developing the 2013 Baseline modeling inventory for each of the 35 winter episode days.

For all inventory sectors, episodic modeling inventory emissions were calculated using a "bottom-up" approach that relied on an exhaustive set of locally measured data used to support the emission estimates. For source types judged to be less significant[11] or for which local data were not available, estimates relied on EPA-developed NEI county-level activity data and emission factors from EPA's *Compilation of Air Pollutant Emission Factors*,[12] AP-42 database.

Table 4 briefly summarizes the data sources and methods used to develop episodic modeling inventory emissions by source type. It also highlights those elements based on locally collected data. As shown by the shaded regions in Table 4, the majority of both episodic wintertime activity and emission factor data supporting the 2013 Baseline modeling inventory was developed based on local data and test measurements.

As evidenced by source classification structure used to highlight utilization of key local data sources, development of detailed episodic emission estimates to support the attainment modeling focused on three key source types:

1. *Stationary Point Sources* – industrial facility emissions for "major" stationary sources as defined later in this sub-section developed from wintertime activity and fuel usage;

2. *Space Heating Area (Nonpoint) Sources* – residential and commercial heating of buildings with devices/fuels used under wintertime episodic ambient conditions; and

3. *On-Road Mobile Sources* – on-road vehicle emissions based on local activity and fleet characteristics with EPA-accepted adjustments to account for effects of wintertime vehicle/engine block heater "plug-in" use in Fairbanks using MOVES2014a (the latest version of MOVES at the time the SIP inventory work began).

As seen in emission summaries presented later in this sub-section, these three source types were the major contributors to both direct $PM_{2.5}$ emissions as well as emissions of potential precursor pollutants SO_2, NOx, VOC, and NH_3 within both the non-attainment area as well as the broader Grid 3 modeling domain.

Following this overview, expanded summaries are presented that describe the approaches used to generate episodic emission estimates for each of the source types/categories listed in Table 4 for the 2013 Baseline modeling inventory. In addition to these methodology summaries, the Emissions Inventory Technical Appendix provides detailed descriptions of the data sources,

[11] Assessments of source significance or relative share were not made "in isolation" but were evaluated and corroborated by other source apportionment techniques discussed in Section III.D.5.8 of the SIP, including Positive Matrix Factorization (PMF) and EPA-approved Chemical Mass Balance (CMB) statistical analysis.

[12] "Compilation of Air Pollutant Emission Factors," Fifth Edition and Supplements, AP-42, U.S. EPA, Research Triangle Park, NC. January 1995.

Table 4
Summary of Data/Methods Used in the Serious SIP 2013 Baseline Inventory

Source Type/Category	Source Activity	Emission Factors
Point Sources	Facility and stack-level fuel use and process throughput	Continuous emissions monitoring or facility/fuel-specific factors
Area (Nonpoint) Sources, Space Heating	Detailed wintertime Fairbanks non-attainment area residential heating device activity measurements and surveys	- Test measurements of common Fairbanks wood and oil heating devices using local fuels - AP-42 factors for local devices or fuels not tested (natural gas, coal)
Area Sources, All Others	- Seasonal, source category-specific activity from a combination of State/Borough sources - NEI-based activity for commercial cooking	AP-42 emission factors
On-Road Mobile Sources	Local estimates of seasonal vehicle miles traveled	- MOVES2014a emission factors based on local fleet/fuel characteristics - Augmented with Fairbanks wintertime vehicle warmup and plug-in emission testing data
Non-Road Mobile Sources	- Local activity estimates for key categories such as snowmobiles, aircraft and rail - MOVES2014a model-based activity for Fairbanks for other categories	- MOVES2014a model factors for non-road equipment - AEDT model factors for aircraft - EPA factors for locomotives

issues considered, and step-by-step methods and workflow used to generate modeling inventory emissions at the Source Classification Code (SCC) level.

Following these summaries, a series of detail tabulations and plots of the 2013 Baseline modeling inventory are presented.

Updating Moderate SIP Estimates – The Moderate SIP contained a 2008 Baseline inventory. This inventory was updated to the 2013 baseline year of the Serious Plan based on a combination of activity projections (for example population/housing growth) from 2008 to 2013 and new or revised activity estimates and emission factors/models which are summarized below for the key elements.

- *Point Sources* – 2008 activity and emissions data were projected to 2013 based on annual fuel use/process throughput by individual facility and emission unit. Fuel-based ammonia emissions for point sources were also included in the 2013 inventory.

- *Space Heating Area Sources* – Additional home heating survey data collected in winters 2012 through 2015 were used to augment the estimates of residential space heating device/fuel mix and usage in the Moderate SIP based on the singular 2011 Home Heating survey. This broader sample of survey data was combined to more robustly reflect residential space heating activity within the nonattainment area for calendar year 2013 (which is centered in the combined 2011-2015 home heating survey period). Additional survey data were also collected from commercial businesses in the nonattainment area to estimate the extent of space heating from solid fuel burning devices (wood or coal) in commercial buildings. (The Moderate SIP assumed all commercial space heating used only liquid (heating oil) or gaseous (natural gas) fuels).

- *Mobile Sources* – For both on-road and non-road vehicles, EPA's latest vehicle emissions model, MOVES2014a was used to replace emission estimates from the Moderate SIP based on its predecessor, MOVES2010a.[13] On-road vehicle activity (VMT and speeds) was based on 2013 baseline travel demand model outputs from the Fairbanks Metropolitan Area Transportation System (FMATS) 2040 Metropolitan Transportation Plan (MTP). (The Moderate SIP used travel model estimates for 2008 from a prior transportation plan.) For non-road vehicles/equipment MOVES2014a was used to calculate 2013 calendar year emissions. The Federal Aviation Administration's AEDT model was used to estimate aircraft/airfield emissions in 2013 based on activity data collected for that year. (The Moderate SIP used the predecessor model to AEDT, EDMS, based on 2008 activity).

Each of these key updates are described in greater detail in the source sector-specific sub-sections that follow.

Stationary Point Sources – For the 2013 Baseline modeling inventory, DEC queried facilities from its permits database to identify major and minor point source facilities within the modeling domain. ADEC uses the definition of a major source under Title V of the Clean Air Act (as specified in 40 CFR §51.20) to define the "major source" thresholds for reporting annual emissions. These thresholds are the potential to emit (PTE) annual emissions of 100 tons for all relevant criteria air pollutants. Natural minor and synthetic minor facilities (between 5 and 99 TPY) reporting emissions under either New Source Review (NSR) or Prevention of Significant Deterioration (PSD) requirements were also included in the query identify facilities down to the 70 TPY threshold required to classify stationary point sources under Serious Area inventory requirements.

A total of 14 facilities were identified. Of these, ADEC noted that three of the facilities—the Golden Valley Electric Association (GVEA) Healy Power Plant and the heating/power plants at Fort Greely (near Delta Junction) and Clear Air Force Base (near Anderson)—were excluded

[13] MOVES2014a models both on-road and non-road vehicles/equipment. MOVES2010a only modeled emissions from on-road vehicles; a separate model NONROAD2008 was used in the Moderate SIP to address non-road vehicle emissions.

from development of episodic emissions. These facilities were excluded because of their remoteness relative to Fairbanks (all are between 55 and 78 miles away)[14] or the fact that they were located generally downwind of the non-attainment area under episodic air flow patterns (Healy Power Plant and Clear AFB). Three others were identified as minor/synthetic minor sources: (1) Fort Knox Mine (26 miles northeast of Fairbanks), (2) Usibelli Coal Preparation Plant (in Healy), and (3) CMI Asphalt Plant (in Fairbanks); these were excluded from treatment as individual episodic point sources because they either were located outside the non-attainment area (Fort Knox and Usibelli) or exhibited insignificant wintertime activity (CMI Asphalt Plant).

(These excluded facilities were treated as stationary non-point or area sources within the inventory.)

The names and primary equipment and fuels of the eight remaining facilities for which episodic data were collected and developed are summarized in Table 5. One facility, Eielson Air Force Base, is located just outside the non-attainment area boundary on the southeast edge. All other facilities listed in Table 5 are located within the non-attainment area.

ADEC then requested additional actual day- and hour-specific activity and emissions data from each facility (as available) covering the two 2008 historical modeling episodes. Information was requested for both combustion and fugitive sources. Requested data elements included emission units, stack parameters (height, diameter, exit temperature and velocity/flowrate), release points (location coordinates), control devices (as applicable), seasonal and diurnal fuel properties, and throughput.

The submitted data were then assembled and reviewed for completeness, consistency, and validity prior to integrating the episodic data into the SIP inventories. Given the differences in structure and content of the submitted episodic data, the data were individually reviewed for each facility before being assembled into a consistent inventory structure.

Generally, most facilities provided hourly $PM_{2.5}$ and SO_2 emission rates by individual emission unit. As explained in greater detail below, Sierra then developed estimates of NOx and VOC emission rates from AP-42[15] based or facility source test emission factors (where fuel use data were explicitly provided) or from fuel-specific emission factor ratios.

Annual actual emissions by emission unit for each facility in calendar years 2008 and 2018 obtained from ADEC permit database (including facility operating reports and permit fee assessments) were then used to scale or project forward the day/hour specific 2008 episodic data provided by each facility from 2008 to 2013. Generally speaking there were modest changes in throughput/fuel use between 2008 and 2013 for most facilities.

[14] Individual point source plume modeling conducted by DEC in support of the SIP using the CALPUFF model found that under the episodic meteorological conditions, emissions from facilities located outside the Fairbanks $PM_{2.5}$ non-attainment area exhibited negligible contributions to ambient $PM_{2.5}$ concentrations in the area.

[15] "AP-42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources," Environmental Protection Agency, January 1995.

Table 5
Summary of SIP Modeling Inventory Point Source Facilities

Facility ID	Facility Name	Primary Equipment/Fuels
71	Flint Hills North Pole Refinery	11 crude & process heaters burning process gas/LPG (9 operated during episodes), plus 2 natural gas fired steam generators, gas flare
109	GVEA Zehnder (Illinois St) Power Plant	Two gas turbines burning HAGO[a], two diesel generators burning Jet A
110	GVEA North Pole Power Plant	Three gas turbines, two burning HAGO, one burning naphtha (plus an emergency generator and building heaters not used during episodes)
236	Fort Wainwright	Backup diesel boilers & generators (3 each) - none operated during episodes
264	Eielson Air Force Base	Over 70 combustion units - six coal-fired main boilers only operated during episodes
315	Aurora Energy Chena Power Plant	Four coal-fired boilers (1 large, 3 small), all exhausted through common stack
316	UAF Campus Power Plant	Two coal-fired, two oil-fired boilers (plus backup generators & incinerator not operated during episodes)
1121	Doyon Utilities (private Fort Wainwright units)	Six coal-fired boilers

[a] Heavy Atmospheric Gas Oil. HAGO is a crude distillate at the heavy end of typical refinery "cuts" with typical boiling points ranging from 610-800°F. Due to geographic proximity, GVEA seasonally uses HAGO, a by-product from Flint Hills Refinery.

Table to be added and discussion expanded on projection of 2008 to 2013 point source emissions

Space Heating Area Sources – Inventory assessments and source apportionment analysis performed to support initial development of the SIP identified space heating as the single largest source category of directly emitted $PM_{2.5}$. Thus, the 2013 Baseline modeling inventory incorporated an exhaustive set of locally collected data in Fairbanks that were used to estimate episodic wintertime space heating emissions by heating device type and fuel type. These local wintertime data and their use in generating space heating emissions are summarized below.

- *Fairbanks Winter Home Heating Energy Model* – A multivariate predictive model of household space heating energy use was developed based on highly resolved (down to five-minute intervals) actual instrumented measurements of heating device use in a sample of Fairbanks homes during winter 2011 collected by the Cold Climate Housing Research Center (CCHRC) in Fairbanks. The energy model was calibrated based on the CCHRC measurements and predicted energy use by day and hour as a function of

household size (sq ft), heating devices present (fireplaces, wood stoves, outdoor hydronic heaters, and oil heating devices) and day type (weekday/weekend).

- *Multiple Residential Heating Surveys* – Representations of area (ZIP code) specific wintertime heating device uses and practices were developed from a series of annual telephone-based surveys of residential households within the non-attainment area, ranging in size from 300-700 households per survey. The results of these surveys were used to develop estimates of the types and number of heating devices used during winter by ZIP code within the non-attainment area. The survey data were also used to cross-check the energy model-based fuel use predictions as well as to identify and apportion wood use within key subgroups (certified vs. non-certified devices and purchased vs. user-cut wood, the latter of which reflects differences in moisture content that affects emissions).

- *Fairbanks Wood Species Energy Content and Moisture Measurements* – CCHRC performed an additional study that measured wood drying practices and moisture content of commonly used wood species for space heating in Fairbanks. These measurements were combined with published wood species-specific energy content data and additional residential survey data (2013 Wood Tag Survey) under which respondents identified the types of wood they used to heat their homes. Birch, Spruce, and "Aspen" (i.e., Poplar) were identified as the three primary locally used wood species.

- *Laboratory-Measured Emission Factors for Fairbanks Heating Devices* – An accredited testing laboratory, OMNI-Test Laboratory (OMNI), was contracted to perform a series of heating device emission tests using a sample of wood-burning and oil heating devices commonly used in Fairbanks in conjunction with samples of locally collected wood and heating oil. The primary purpose of this testing was to evaluate and, if necessary, update AP-42-based emission factors that were generally based on heating device technology circa 1990. The OMNI study provided the first and most comprehensive systematic attempt to quantify Fairbanks-specific, current technology-based emission factors from space heating appliances and fuels. The laboratory-based emission testing study consisted of 35 tests of nine space heating appliances, using six typical Fairbanks fuels. Both direct PM and gaseous precursors (SO_2, NOx, NH_3) were measured, along with PM elemental profiles. All emission tests were conducted at OMNI's laboratory in Portland, Oregon. Supporting solid fuel, liquid fuel, and bottom ash analyses were performed by Twin Ports Testing, Southwest Research Institute (SwRI), and Columbia Analytical Services, respectively. PM profiles of deposits on Teflon filters from dilution tunnel sampling were analyzed by Research Triangle Institute using XRF, ion chromatography, and thermal/optical analysis.

Space heating emissions were estimated using OMNI-based results where available for specific devices and AP-42-based estimates for devices for which OMNI tests were not conducted. Table 6 shows the device and fuel types resolved in estimating space heating emissions for the modeling inventory, their assigned SCC codes, and the source of the emission factors (OMNI testing or AP-42-based) used in calculating emissions for each device.

Table 6
Fairbanks Space Heating Devices and Fuel Types and Source of Emission Factors

Device Type	SCC Code	Emission Factor
Wood-Burning Devices		
Fireplace, No Insert	2104008100	AP-42
Fireplace, With Insert - Non-EPA Certified	2104008210	AP-42
Fireplace, With Insert - EPA Certified Non-Catalytic	2104008220	AP-42
Fireplace, With Insert - EPA Certified Catalytic	2104008230	AP-42
Woodstove - Non-EPA Certified	2104008310	OMNI
Woodstove - EPA Certified Non-Catalytic	2104008320	OMNI
Woodstove - EPA Certified Catalytic	2104008330	OMNI
Pellet Stove (Exempt)	2104008410	OMNI
Pellet Stove (EPA Certified)	2104008420	OMNI
OWB (Hydronic Heater) - Unqualified	2104008610	OMNI
OWB (Hydronic Heater) - Phase 2	2104008640	OMNI
Other Heating Devices		
Central Oil (Weighted # 1 & #2), Residential	2104004000	OMNI
Central Oil (Weighted # 1 & #2), Commercial	2103004001	OMNI
Portable Heater: 43% Kerosene & 57% Fuel Oil	2104004000	AP-42
Direct Vent Oil Heater	2104007000	AP-42
Natural Gas - Residential	2104006010	AP-42
Natural Gas - Commercial, small uncontrolled	2103006000	AP-42
Coal Boiler	2104002000	OMNI
Waste Oil Burning	2102012000	OMNI

Episodic day- and hour-specific emissions from space heating fuel combustion were calculated by combining heating energy use estimates from the Fairbanks Energy Model with ZIP code-specific device distributions from the local survey data (along with wood species mix and moisture content data) and block-level GIS shapefile counts of housing units from the 2010 U.S. Census, along with emission factors for the devices listed in Table 6.

To Be Completed: Add text explaining key revisions to space heating inventory from Moderate SIP

Finally, as described in the Attainment Modeling document, the space heating emissions were passed to the SMOKE inventory pre-processing model on an episodic daily and hourly basis. Earlier versions of the SMOKE model accepted only nonpoint or area source emissions that were temporally resolved using independent monthly, day of week, and diurnal profiles. As described in the Attainment Modeling document, Sierra developed a modified version of SMOKE to also accept area source emissions in a similar fashion to which day- and hour-specific episodic point source emissions can be supplied to the model. This was critically important in preserving the actual historical temporal resolution reflected in the space heating portion of the modeling inventory when applied in the downstream attainment modeling.

All Other Area Sources – Modeling inventory emissions for all other stationary area sources other than those related to space heating were calculated more simply, although still using local

data where available. The primary data source used to estimate "Other" area source emissions was an earlier 2009 Alaska criteria pollutant inventory study[16] sponsored by DEC.

This DEC study, referred to as the "Big 3" inventories, consisted of the development of pollutant emission estimates for the three most populous counties in the state: the Municipality of Anchorage, the Fairbanks North Star Borough, and the Juneau Borough. The Big 3 inventories were developed for calendar years 2002, 2005, and 2018 using a combination of 2002 base year data and growth/control forecasts for 2005 and 2018. The inventories encompassed all source sectors (point, area, on-road, non-road) and the following criteria pollutants: VOC, NOx, CO, SOx, NH_3, PM_{10}, and $PM_{2.5}$. For each calendar year, annual emissions as well as winter and summer seasonal emissions were developed. The seasonal estimates reflected six-month winter (October through March) and summer (April through September) daily averages based on seasonal activity profiles developed using local data where available.

For use in this $PM_{2.5}$ SIP inventory, SCC-level summer and winter season emission estimates were extracted from National Emission Inventory (NEI) Input Format (NIF) spreadsheet structures developed under the Big 3 study to allow DEC to submit data to support the NEI. Only area source SCC records were extracted for the Fairbanks Borough in calendar year 2005, the nearest year to the SIP inventory 2013 base year.

The SCC-level winter 2005 emissions from the earlier inventory were projected to 2013 using historical year-to-year county-wide population estimates compiled by the Alaska Department of Labor and Workforce Development (ADLWD) for use in the 2013 Baseline modeling inventory for this SIP. The eight-year (2005-2013) population growth factor for Fairbanks from the historical ADLWD data was 1.069, reflecting the 6.9% increase applied to the 2005 Big 3 emissions for Fairbanks in projecting emissions for other area sources to the 2013 Baseline.

In compiling these other area source emission estimates, a series of SCC-level source category comparisons were made between the Big 3 inventory and EPA's 2011 and 2014 NEI inventories for Fairbanks nonpoint sources. In performing these comparisons, a gap was found in that commercial cooking emissions (e.g., from restaurant char broilers) had not been included in the Big 3 inventory. As a result, commercial cooking emissions within the Other Area Source sector of the 2008 Baseline modeling inventory were developed based on data from the 2014 NEI.

It is also noted that a number of source categories within the Other Area Source sector were estimated to have no emissions during episodic wintertime conditions. These "zeroed" wintertime source categories are listed below (with SCC codes in parentheses).

- Fugitive Dust, Paved Roads (2294000000)
- Fugitive Dust, Unpaved Roads (2296000000)
- Industrial Processes, Petroleum Refining, Asphalt Paving Materials (2306010000)
- Solvent Utilization, Surface Coating, Architectural Coatings (2401001000)

[16] L. Williams, et al., "Criteria Pollutant Inventory for Anchorage, Fairbanks, and Juneau in 2002, 2005 and 2018," prepared for Alaska Department of Environmental Conservation, Sierra Research Report No. SR2009-02-01, February 2009.

- Solvent Utilization, Miscellaneous Commercial, Asphalt Application (2461020000)
- Miscellaneous Area Sources, Other Combustion, Forest Wildfires (2810001000)
- Miscellaneous Area Sources, Other Combustion, Firefighting Training (2810035000)

Some of these source categories, notably those for fugitive dust and forest wildfires, have significant summer season (and annual average) emissions; however, emissions from these categories do not occur during winter conditions in Fairbanks when road and land surfaces are covered by snow and ice.

On-Road Mobile Sources – Emissions from on-road motor vehicles were developed within the 2013 Baseline modeling inventory using locally developed vehicle travel activity estimates and fleet characteristics as inputs to EPA's MOVES2014a vehicle emissions model. To support the gridded inventory structure and episodic (daily/hourly) emission estimates of the modeling inventory, MOVES2014a was used to generate detailed fleet emission rates and was combined with EPA's SMOKE-MOVES integration tool to pass the highly resolved and emission process-specific emission rates into input structures required by the SMOKE inventory pre-processing model.

For the 2013 Baseline inventory, MOVES inputs were based primarily on data gathered as part of the conformity analysis for the Fairbanks Metropolitan Area Transportation System (FMATS) 2040 Metropolitan Transportation Program (MTP)[17]. FMATS is the Metropolitan Planning Organization (MPO) for Fairbanks. Inputs were derived from local transportation modeling runs conducted to support the 2040 MTP, vehicle registration data, and other local data. The transportation and other vehicle activity data are discussed below. The remaining fleet characteristics and other MOVES inputs are discussed in the Emissions Inventory Technical Appendix.

Regional Travel Model Vehicle Activity – Vehicle activity on the FMATS transportation network was based on the TransCAD travel demand modeling performed for the 2040 MTPP. The TransCAD modeling network covers the entire Fairbanks $PM_{2.5}$ non-attainment area and its major links extend beyond the non-attainment area boundary, as illustrated in Figure 8.

The TransCAD model was configured using 2010 U.S. Census-based socioeconomic data. TransCAD modeling was performed for a 2013 base year and a projected 2040 horizon year. Projected population and household data relied on Census 2010 projections and a 1.1% annual growth rate in forecasted employment based on the information from the Institute of Social and Economic Research (ISER) at the University of Alaska, Anchorage.

[17] T. Carlson, R. Dulla, W. Zhang "Draft Conformity Analysis for the FMATS 2040 Metropolitan Transportation Plan (MTP)", prepared for Fairbanks Metropolitan Area Transportation System, November 17, 2014.

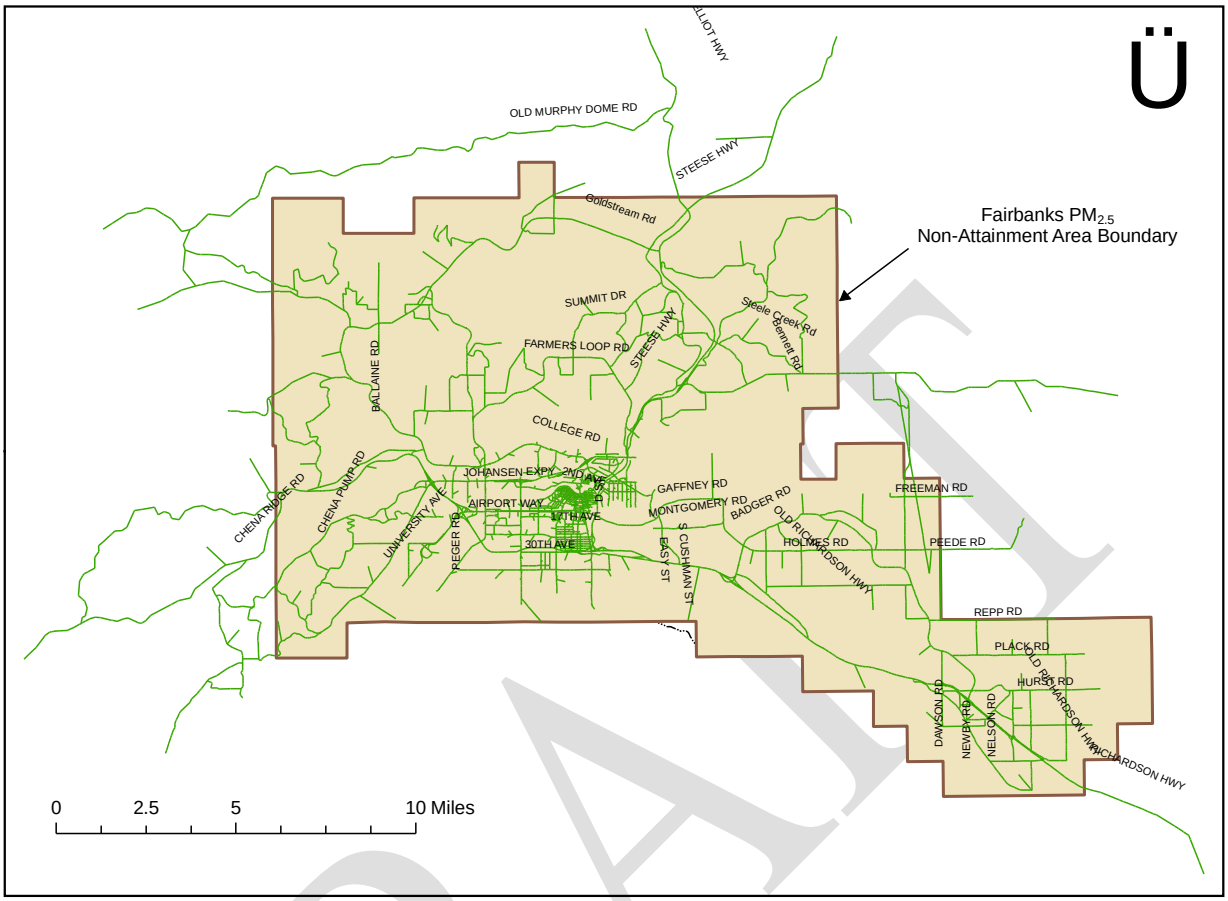

Figure 8. FMATS TransCAD Modeling Network

Link-level TransCAD outputs were processed to develop several of the travel activity related inputs required by MOVES. Vehicle miles traveled (VMT) tabulated across the TransCAD network for the 2013 base year and 2040 forecast year are presented in Table 7.

Table 7
TransCAD Average Daily VMT by Analysis Year, Daily Period and Fleet Category

Period / Vehicle Type	Entire Modeling Area (PM NA Area)		
	2013	2040	% Change
Daily Period[a]			
AM Peak (AM)	205,465	284,799	**38.6%**
PM Peak (PM)	400,283	580,003	**44.9%**
Off-Peak (OP)	1,092,896	1,567,255	**43.4%**
Vehicle Type			
Passenger VMT	1,600,732	2,325,965	**45.3%**
Truck VMT	97,913	106,091	**8.4%**
Total VMT	**1,698,644**	**2,432,057**	**43.2%**

[a] VMT by daily period was developed for the passenger fleet; truck VMT was modeled only on a daily basis.

Vehicle Activity Beyond FMATS Network – The geographic extent of the FMATS network covers a small portion of the entire Grid 3 attainment modeling domain. Traffic density in the broader Alaskan interior is likely to be less than that concentrated in Fairbanks (and have less impact on ambient air quality in Fairbanks). Nevertheless, for completeness, link-level travel estimates for major roadways beyond the FMATS network (and Fairbanks NA Area) were developed using a spatial (ArcGIS-compatible) "Road Centerline" polyline coverage for the Interior Alaska region developed by the Alaska Department of Transportation and Public Facilities (ADOT&PF). This GIS layer identified locations of major highway/arterial routes within the Grid 3 domain broken down into individual milepost (MP) segments.

These road centerline segments are shown in red in Figure 9 along with the smaller FMATS link network (green lines) and the extent of the SIP Grid 3 modeling domain (blue rectangle). Annual average daily traffic volumes (AADT) and VMT (determined by multiplying volume by segment length) were assigned to each segment based on a spreadsheet database of calendar year 2007, 2008, and 2009 traffic volume data compiled by ADOT&PF's Northern Region office. A Linear Reference System (LRS) approach was used to spatially assign volume and VMT data for each segment in the spreadsheet database to the links in the Road Centerline layer based on the route identifier number (CDS_NUM) and lineal milepost value.

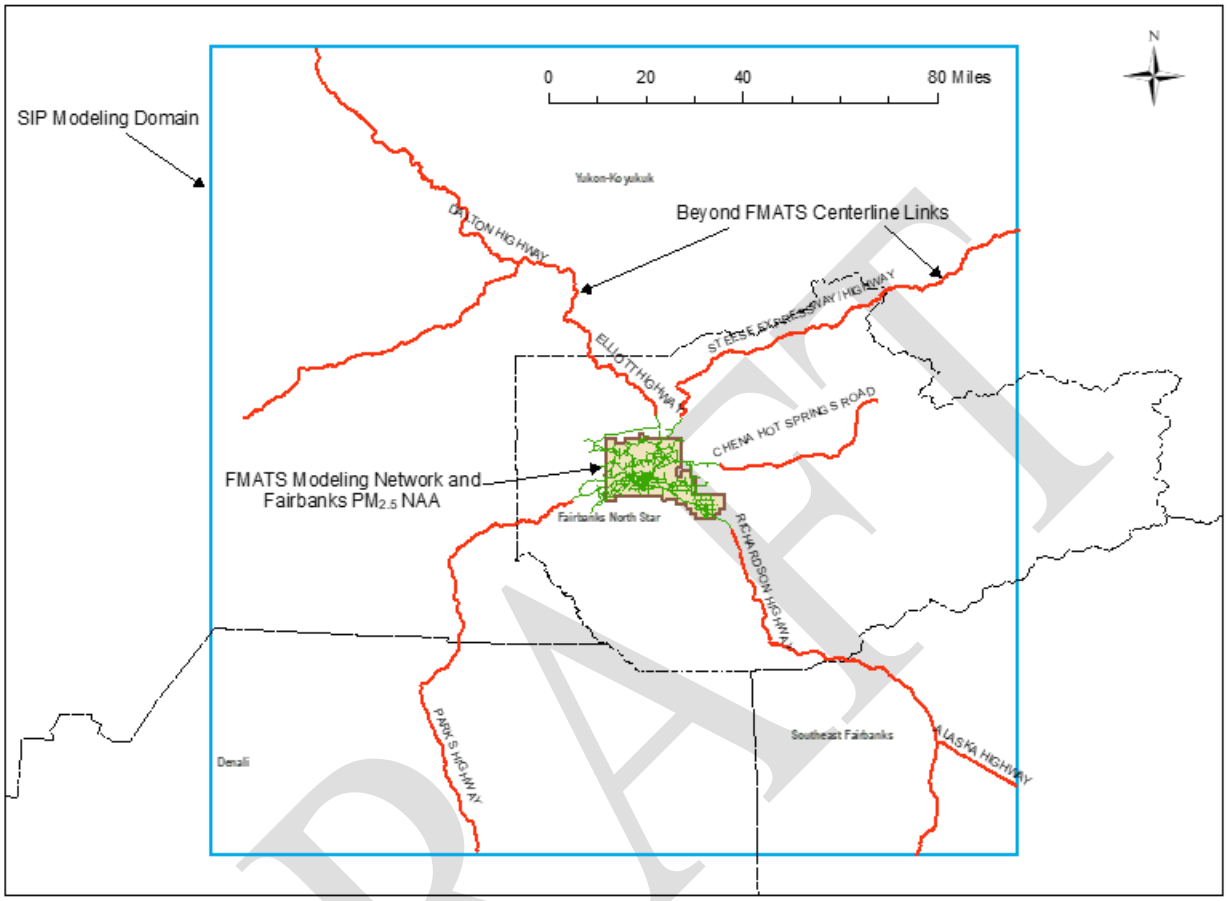

Figure 9. Additional ADOT&PF Roadway Links beyond FMATS Network

Non-Road Mobile Sources – Non-road sources encompass all mobile sources that are not on-road vehicles.[18] They include recreational and commercial off-road vehicles and equipment as well as aircraft, locomotives, recreational pleasure craft (boats) and marine vessels. (Neither commercial marine nor recreational vessel emissions are contained in the modeling inventory, as they do not operate in the arctic conditions experienced in the Fairbanks modeling domain during the winter.)

NONROAD Model-Based – EPA's latest NONROAD emissions model, NONROAD2008,[19] was used to generate emissions from the following types of non-road vehicles and equipment:

- Recreational vehicles (e.g., all-terrain vehicles, off-road motorcycles, snowmobiles);
- Logging equipment (e.g., chain saws);

[18] Although recent versions of EPA's NEI inventories (2008 and 2011) treat emissions for aircraft and supporting equipment and rail yard locomotive emissions as stationary point sources, emissions from these sources were "traditionally" located within the Non-Road source sector.
[19] U.S. EPA NONROAD Model, Version 2008a, released July 2009.

- Agricultural equipment (e.g., tractors);
- Commercial equipment (e.g., welders and compressors);
- Construction and mining equipment (e.g., graders and backhoes);
- Industrial equipment (e.g., forklifts and sweepers);
- Residential and commercial lawn and garden equipment (e.g., leaf and snow blowers);
- Locomotive support/railway maintenance equipment (but not locomotives); and
- Aircraft ground support equipment[20] (but not aircraft).

It is important to note that none of these non-road vehicle and equipment types listed above were federally regulated until the mid-1990s. (As parenthetically noted for the last two equipment categories in the list above, the NONROAD model estimates emissions of support equipment for the rail and air sectors, but emissions from locomotives and aircraft are not addressed by NONROAD and were calculated separately using other models/methods as described in the sub-sections that follow.)

Default equipment populations and activity levels in the NONROAD model are based on national averages, then scaled down to represent smaller geographic areas on the basis of human population and proximity to recreational, industrial, and commercial facilities. EPA recognizes the limitations inherent in this "top-down" approach, and realizes that locally generated inputs to the model will increase the accuracy of the resulting output. Therefore, in cases where data were available (most notably snowmobiles and snow blowers), locally derived inputs that more accurately reflect the equipment population, growth rates, and wintertime activity levels in the Fairbanks area were substituted for EPA's default input values.

Nonexistent Wintertime Activity – Due to the severe outdoor weather conditions present in Fairbanks during the winter months, Fairbanks Borough staff determined that there is zero wintertime activity for a number of different equipment categories. Therefore, all activity and corresponding emissions for the following non-road equipment categories were removed from the episodic wintertime modeling inventory:

- Lawn and Garden;
- Agricultural Equipment;
- Logging Equipment;
- Pleasure Craft (i.e., personal watercraft, inboard and sterndrive motor boats);
- Selected Recreational Equipment (i.e., golf carts, ATVs, off-road motorcycles); and
- Commercial Equipment (i.e., generator sets, pressure washers, welders, pumps, A/C refrigeration units).

Locomotive Emissions – Emissions for two types of locomotive activity were included in the emissions inventory:

[20] Although NONROAD can be configured to also estimate emissions from airport ground support equipment (GSE), GSE emissions were estimated using the EDMS model as described later.

1) *Line-Haul* – locomotive emissions along rail lines within the modeling domain (from Healy to Fairbanks and Fairbanks to Eielson Air Force Base); and

2) *Yard Switching* – locomotive emissions from train switching activities within the Fairbanks and Eielson rail yards.

Information on wintertime train activity (circa 2013) was obtained from the Alaska Railroad Corporation[21] (ARRC), the sole rail utility operating within the modeling domain, providing both passenger and freight service. These activity data were combined with locomotive emission factors published by EPA[22] to estimate rail emissions within the emissions inventory.

Aircraft and Associated Airfield Emissions – Emissions were estimated from aircraft operations at three regional airfields within the modeling domain: (1) Fairbanks International Airport (FAI); (2) Fort Wainwright Army Post[23] (FBK); and (3) Eielson Air Force Base (EIL). The aircraft emissions were developed using the Federal Aviation Administration's (FAA) AEDT emissions model. AEDT considers the physical characteristics of each airport along with detailed meteorological and operations information in order to estimate the overall emissions of aircraft, ground support equipment (GSE), and auxiliary power units (APUs) at each airport.

The AEDT model requires as input detailed information on landings and take-offs (LTO) for each aircraft type in order to assign GSE and estimate the associated emissions. Each LTO is assumed to comprise six distinct aircraft related emissions modes: startup, taxi out, take off, climb out, approach, and taxi in. The AEDT modeled defaults for time in mode and angle of climb out and approach were used for purposes of this analysis. In order to properly allocate aircraft emissions to each vertical layer of analysis (elevation above ground level), aircraft emissions were estimated for each mode and ascribed to a specific vertical layer.

The Emissions Inventory Technical Appendix provides detailed descriptions of the activity inputs and NONROAD, AEDT, and locomotive emission modeling used to generate emissions for the Non-Road sector of the modeling inventory.

Modeling Inventory Assembly and Pre-Processing – Emissions estimates across all sectors of the modeling inventory were generated at the SCC level and either directly gridded into the 1.3 km cells of the Grid 3 modeling domain (e.g., for point and space heating area sources) or assembled into spatial surrogate profiles for use within the SMOKE inventory pre-processing model.

For the three key source sectors (Point, Space Heating Area and On-Road Mobile), emissions were also temporally supplied to SMOKE on a day- and an hour-specific basis for each of the 35 historical days encompassing the two attainment modeling episodes. For the remaining two source sectors (Other Area and Non-Road Mobile), emissions were temporally supplied to

[21] Email from Greg Lotakis, Alaska Railroad Corporation to Bob Dulla, Sierra Research, May 10, 2011. <<< *The reference needs to be updated* >>>
[22] "Emission Factors for Locomotives," U.S. Environmental Protection Agency, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.
[23] Formerly Ladd Air Force Base.

SMOKE using SCC-specific monthly, day of week and diurnal profiles based on surrogates described in Appendix III.D.5.6.

2013 Baseline Modeling Inventory Emissions – 2013 Baseline modeling inventory emissions calculated using the data sources and methodologies summarized in the preceding paragraphs were tabulated by source sector and key subcategory and are presented as follows.

Table 8 shows 2013 Baseline emissions tabulated by source sector. (The Space Heating and On-Road sectors are further broken out into key subcategories.) Emissions are shown for both the entire Grid 3 modeling domain and the smaller $PM_{2.5}$ non-attainment area and are presented on an average daily basis over the 35 episode days.

Table 8
2013 Baseline Episode Average Daily Emissions (tons/day) by Source Sector

	Grid 3 Domain Emissions (tons/day)					*NA Area Emissions (tons/day)*				
Source Sector	**$PM_{2.5}$**	**NOx**	**SO_2**	**VOC**	**NH_3**	**$PM_{2.5}$**	**NOx**	**SO_2**	**VOC**	**NH_3**
Point Sources	1.26	10.70	7.62	0.21	0.051	1.25	10.58	7.44	0.21	0.051
Area, Space Heating	2.95	2.49	3.91	10.62	0.150	2.62	2.32	3.62	9.56	0.137
Area, Space Heat, Wood	2.77	0.44	0.09	10.39	0.104	2.46	0.39	0.08	9.35	0.092
Area, Space Heat, Oil	0.07	1.83	3.68	0.10	0.004	0.06	1.72	3.42	0.10	0.003
Area, Space Heat, Coal	0.10	0.06	0.11	0.12	0.015	0.09	0.05	0.10	0.11	0.013
Area, Space Heat, Other	0.01	0.16	0.02	0.01	0.028	0.01	0.16	0.02	0.01	0.028
Area, Other	0.05	0.00	0.00	0.33	0.000	0.05	0.00	0.00	0.33	0.000
On-Road Mobile	0.31	4.45	0.05	5.30	0.068	0.26	3.63	0.04	4.41	0.055
Non-Road Mobile	0.06	0.06	0.00	2.96	0.001	0.03	0.03	0.00	1.32	0.000
TOTALS	**4.62**	**17.70**	**11.58**	**19.42**	**0.271**	**4.20**	**16.56**	**11.10**	**15.82**	**0.244**

n/a – Not available.

To Be Completed: 2013 Baseline inventory source contribution pie charts to be prepared/inserted

To Be Completed: Gridded 2013 Baseline modeling inventory emission plots to be prepared/inserted

2.2. Base Year Planning Inventory

To Be Completed

3. Projected Baseline Inventories

To Be Completed

3.1. Emissions Projection Methodology

To Be Completed

3.2. Projected Baseline Inventory Summaries

To Be Completed

4. Control Inventories

To Be Completed

4.1. Incorporation of BACT and BACM Measures

To Be Completed

4.2. 2019 Control Inventory

To Be Completed

5. Reasonable Further Progress and Quantitative Milestone Requirements

To Be Completed

6. Motor Vehicle Emission Budgets

To Be Completed

7. Inventory Validation and Quality Assurance

To Be Completed

7.1. Introduction

To Be Completed

7.2. Responsible Personnel

To Be Completed

7.3. Data Collection and Analysis

To Be Completed

7.4. Data Handling and Validation

To Be Completed

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